

Deciphering Greenium: The Role of Investor Demand*

Liying Wang

Juan (Julie) Wu

This Version: September 2025

Abstract

Using security-level bookbuilding data, we examine the pricing dynamics and demand of green bond offerings (GBOs) relative to their conventional counterparts. We show that greenium arises from ESG-focused investors' almost exclusive demand for GBOs. GBOs typically receive significantly larger order books, allowing underwriters to compress offering spreads more for GBOs than for comparable conventional offerings. Even at the same level of investor demand, underwriters tighten spreads more for GBOs, suggesting that ESG-focused investors exhibit lower price sensitivity. These results remain robust when we proxy for ESG-focused investor demand in the primary market using their holdings of similar bonds in the secondary market. Further analyses rule out the temporary price pressure or liquidity preference explanations. Our study provides direct evidence to support investor-tastes models.

Keywords: Green bond pricing, primary market, ESG, investor demand, investor tastes, price sensitivity, greenium

JEL classifications: G12, G14, G23, G24, G30

*Liying Wang is with the University of Nebraska-Lincoln (Email: liying.wang@unl.edu). Julie Wu is with the University of Nebraska-Lincoln (Email: juliewu@unl.edu). We thank Travis Box, Maria Chaderina, Rui Dai, Winston Dou, Jean Helwege, Edith Hotchkiss, Philipp Illeditsch, Ravi Jagannathan, Oğuzhan Karakaş, Paul Koch, Mina Lee, Jerry Parwada, Ellen Quigley, Dragon Tang, Alex Zhou, and seminar and conference participants at Case Western Reserve University, Central University of Finance and Economics, George Mason University, Lingnan University, McMaster University, University of Dayton, University of Louisville, University of Michigan, University of Nebraska-Lincoln, University of Nevada-Las Vegas, University of Oregon, University of Texas Rio Grande Valley, the 5th Conference on CSR, the Economy and Financial Markets, the 8th Women in Market Microstructure Conference, 2022 Silicon Prairie Finance conference, 2022 FMA conference, 2022 SFS Cavalcade Asia-Pacific conference, 2023 Bretton Woods Accounting and Finance Ski conference, 2023 MFA conference, 2023 WFA conference, 2024 EFA conference, 2024 IBEFA conference, and 2024 SFA conference for helpful feedback. We thank Loc Tan Bui and Brandon Moe for their excellent research assistance. A previous version is circulated as "Investor ESG Tastes and Asset Pricing: Evidence from the Primary Bond Market".

1. Introduction

Since its inception in 2007, the green bond market has grown rapidly and reached a total amount of \$2.2 trillion in 2022.¹ Green bonds are almost identical to their conventional counterparts except for their use of proceeds, which makes them eligible for Environment, Social, and Governance (ESG) investing. The investor-tastes asset pricing theoretical framework predicts that green bonds should have lower yields (i.e., greenium) because ESG-focused investors are willing to sacrifice financial returns for societal benefits (e.g., Baker et al. (2022), Pastor, Stambaugh, and Taylor (2021), Zerbib (2022)). Yet, empirical evidence is mixed.² Furthermore, some survey evidence questions whether greenium should exist because institutional investors, the dominant investors in fixed-income markets, appear unwilling to invest in green bonds if prices are not competitive (Chiang (2017), Larcker and Watts (2020), Flammer (2021)), calling for a deeper understanding of greenium.

In this study, we investigate the role of investor demand in explaining greenium using a unique setting: the primary bond market. This setting has several distinct advantages that enable us to gain insights into this inquiry. First and foremost, we are able to measure security-level investor demand for a large sample of bonds, providing direct empirical evidence of how investor tastes influence green bond pricing. Second, by studying offering spread adjustments during bookbuilding, we address a key critique of prior studies: when comparing the prices of green and conventional bonds, empirical models may fail to control for unobservable confounding factors, leading to spurious inferences (Larcker and Watts (2020)).³ Underwriters set the initial offering spread before bookbuilding and update

¹https://www.climatebonds.net/files/reports/cbi_sotm_2022_03e.pdf

²For example, Larcker and Watts (2020), Flammer (2021), and Tang and Zhang (2020) find no greenium, but some others, like Baker et al. (2022) and Fatica et al. (2021), report greenium.

³Larcker and Watts (2020) address this issue by studying municipal green and conventional bonds issued by the same issuer on the same day. Their findings indicate no evidence of greenium. Different from corporate and sovereign bonds, municipal bonds are typically much smaller in size, and their investors may pay different prices for the same municipal offering (Schultz (2012), Nikolova, Wang, and Wu (2020)). D’Amico, Klausmann, and Pancost (2022) study seven German “twin” bonds and employ a dynamic term structure model to isolate the differences between sovereign green and conventional bonds, including the convenience yield associated with conventional sovereign bonds.

it based on investor demand learned during the few hours of bookbuilding, such that the spread compression (i.e., the difference between the offering spread and the initial offering spread) primarily reflects new demand information rather than preexisting bond characteristics or market conditions. Spread compression, thus, is less affected by noise and potential confounding factors than the offering yield, providing a cleaner assessment of the impact of demand on green bond pricing. Lastly, analyzing the process leading to the emergence of greenium in the primary market allows us to study multifaceted primary market outcomes in the bookbuilding process. This holistic approach can shed light on the mixed findings on greenium in the literature.

To isolate the pricing effect of investor tastes from that of the differences in exposures to climate risk across issuers (e.g., Pedersen, Fitzgibbons, and Pomorski (2021), Seltzer, Starks, and Zhu (2020)), we compare green bonds with conventional bonds offered by the same issuers. Our sample comprises 637 green and 4,271 conventional USD- and EUR-denominated corporate and sovereign, supranational, and agency (SSA) bonds offered through the underwriting method by 306 unique green bond issuers between 1/1/2013 and 5/31/2021. Investment-grade bond offerings constitute 94% of our sample.

We first establish the presence of greenium in our sample. Holding other factors constant, the offering spread over the government benchmark rate is 5.4 basis points (bps) lower for green than for conventional bond offerings issued by the same issuer.⁴ Examining the pricing dynamics, we find that the initial offering spread of green bond offerings is 2.8 bps lower compared to conventional offerings. Although this difference accounts for about half of the greenium, it is not statistically significant. After bookbuilding, underwriters tighten the offering spread for green bonds to a greater extent than for conventional bonds, with a significant difference of 2.4 bps. These pricing patterns are robust to various alternative specifications, including the control of issuer-year fixed effects and a matched-sample

⁴Considering the large amount and long maturity of these bond offerings, practitioners typically view savings from greenium as meaningful. For example, Chris Bauer, Duke Energy’s director of corporate finance, states, “A couple of basis points over 30 years... that’s real economic savings ...” See, Chan, M. (June 24, 2023). US energy companies hit pause on ESG bonds. IFR.

analysis. These results suggest that underwriters expect greenium before bookbuilding but remain uncertain about investor demand for each new offering. As a result, they propose a slightly lower initial offering spread to investors. Once bookbuilding reveals investor demand, underwriters tighten the offering spread accordingly, and greenium emerges.

Next, we leverage order book size data to examine the role of investor demand more closely. According to investor-tastes asset pricing models, green bond offerings should receive higher investor demand because of the participation of investors with ESG tastes, *ceteris paribus*. We examine this prediction using the oversubscription ratio, defined as the order book size scaled by the proposed offering amount, as a direct measure of investor demand. We find that the average oversubscription ratio of green bond offerings is always greater than that of conventional offerings, but the difference fluctuates over time. This pattern indicates uncertainty associated with the excess demand for green bond offerings, consistent with the pricing dynamics. Furthermore, the difference in demand is small prior to 2018, which helps reconcile the presence of greenium in our sample with weaker evidence reported in previous studies primarily using bonds offered before 2018. A multivariate analysis suggests that the average oversubscription ratio for green bonds is 0.4 (or about 15%) greater than for conventional bonds from the same issuer. This estimate likely represents the lower bound on the difference in investor demand, as green bonds typically have a lower offering spread relative to conventional bonds, which dampens demand.

To further substantiate the argument that green bonds receive a greater oversubscription ratio because of ESG-focused investors' demand, we utilize eMAXX data on global corporate bond holdings. This data reveal that for ESG-focused investors, the holdings of sample green bonds are about seven times those of sample conventional bonds. Assuming that ESG-focused investors' collective demand for a new bond offering is positively correlated with their holdings of similar bonds, we proxy for their demand in the primary market using their percentage holding of similar bonds in the secondary market during the offering quarter. We find that larger ESG-focused investors' holdings of similar bonds are associ-

ated with a greater oversubscription ratio for the new offering. In particular, the estimated difference in the oversubscription ratio due to ESG-focused investor demand between green and conventional bond offerings closely aligns with the estimate obtained from regressing the oversubscription ratio on the green bond indicator. These results strongly support our interpretation that ESG-focused investor demand drives the higher oversubscription ratio of green bonds.

The influence of ESG-focused investors extends beyond increasing the order book size. Anecdotal evidence suggests that these investors become less price-sensitive when competing for green bonds to meet their investment mandates, allowing underwriters to tighten offering spreads more aggressively.⁵ However, this potential mechanism behind greenium has yet to be examined in the literature. Building on this premise, underwriters should be able to set lower offering spreads for green bond offerings than for their conventional counterparts at the same level of demand. To test this, we analyze the sensitivity of offering spread to oversubscription ratio. Our analysis indicates that a one standard deviation increase in the natural logarithm of the oversubscription ratio allows underwriters to decrease the offering spread by 3.8 (2.3) bps for green (conventional) bond offerings. These results are robust to using ESG-focused investors' holdings of similar bonds as a proxy for their participation in a bond offering. These findings suggest that ESG-focused investors have lower price sensitivity for green bond offerings, reinforcing their role in the emergence of greenium.

Our analysis shows that investors' tastes for green bonds explain greenium. To rule out the possibility that high investor demand at issuance only leads to temporary price pressure and, thus, temporary greenium, we examine underpricing (i.e., the change from the offering yield to secondary-market trade yield) for up to a month after the issuance date to investigate whether greenium is reversed post-issuance. We find that it is not, which is incon-

⁵For example, Adam Bothamley, Global Co-Head of Debt Capital Markets at HSBC, states, "These assets are continuing to see higher demand, and are still relatively scarce. We are seeing larger order books, everything else equal, for ESG-themed securities relative to conventional bonds... Investors have less ability to be overly price-sensitive, given it's a relatively scarce asset class. That translates into better pricing for borrowers." See, Hurley, M. (April 06, 2021). Growing "greenium" in labeled bond market divides opinions. Environmental Finance.

sistent with the temporary price pressure argument but in line with the sustained investor tastes explanation. Furthermore, we examine whether green bonds have better liquidity in the secondary market. If so, some investors' preference for liquidity might help explain greenium. Using a subsample of bonds whose trades are reported to the Trade Reporting and Compliance Engine (TRACE), we find that the bid-ask spread of green bonds does not differ significantly from conventional bonds. Hence, neither temporary price pressure nor liquidity preference explains the greenium we document.

Finally, we analyze the oversubscription ratio of sample green bonds only to shed some light on the heterogeneity in investor demand for these offerings. We first find that an issuer's first green bond offering experiences a higher oversubscription ratio than its subsequent green bond offerings, supporting the notion that offerings from new issuers increase bond investors' portfolio diversification and, thus, receive greater demand. Second, green bond offerings in more recent years have greater oversubscription ratios, consistent with the increasing trend of sustainable investing. Third, the type or greenness of the use of proceeds does not appear to affect the oversubscription ratio, neither does the issuer's E and ESG scores, suggesting that investors pay for green but do not pay more for greener investments (Hartzmark and Sussman (2019), Heeb et al. (2023)) or potential noise in ESG rating measurement (e.g., Berg et al. (2022)). Across issuers, the oversubscription ratio increases significantly as the issue rating decreases from AAA to BBB, suggesting that institutional investors chase for yield (Becker and Ivashina (2015), Choi and Kronlund (2017)) even within the ESG space.

We make several important contributions to the literature. While theories argue that financial assets with better ESG profiles command lower expected returns, the prior empirical literature on the relation between ESG tastes and asset returns provides mixed evidence. In the fixed income markets, it is even unclear whether institutional investors exhibit tastes for green bonds (Larcker and Watts (2020), Flammer (2021)). Our paper presents the first empirical evidence that investor demand for green bond offerings is significantly higher than their conventional counterparts on average, providing the basis for applying investor-

tastes asset pricing models to bonds.⁶ Also, we find evidence that the impact of ESG-focused investors on pricing extends beyond the revealed higher level of demand: their lower price sensitivity for green bond offerings also contributes to greenium. Additionally, our study helps explain mixed findings on greenium by demonstrating its dependence on investor demand, which varies significantly over time and across bonds.

Our study also speaks to the broad literature on ESG premia. Previous studies on ESG premia in the stock market have yielded mixed results (e.g., Aswani, Raghunandan, and Rajgopal (2023), Bolton and Kacperczyk (2021), Hsu, Li, and Tsou (2023), Li et al. (2023), Ramelli et al. (2018), and Sautner et al. (2023)). An empirical challenge in these studies is to infer expected returns from realized returns, which are influenced by changing ESG concerns over time (Ardia et al. (2020), Pastor et al. (2021), and Pástor et al. (2022)). Our study of primary bond market pricing circumvents this issue, as yields represent expected returns to maturity rather than realized returns. Another challenge in establishing the impact of investor tastes on ESG premia is to disentangle investor demand due to values or value, which can be influenced by financial considerations of ESG risks and realized returns due to shifts in ESG concerns (Starks (2023)). We provide evidence that green bonds attract greater investor demand despite offering lower expected returns (i.e., greenium) than conventional bonds offered by the same entity. Furthermore, we show that this greater investor demand is driven by ESG-focused investors' almost exclusive demand for green bonds. These results demonstrate a clear investor preference for ESG assets due to values.

Furthermore, our study contributes to the recent literature on the importance of heterogeneous demand on asset pricing (e.g., Koijen and Yogo (2019), Davis, Kargar, and Li (2023))). For fixed-income securities, Bretscher et al. (2022) show that the mix of insurance companies and mutual funds shifts credit spreads. Siani (2022) models long- and short-term

⁶Following our approach, Caramichael and Rapp (2024) compare the oversubscription ratios of green and conventional bonds for a subsample of 105 green and matched conventional bonds in their latest version. They confirm our finding that green bonds have higher oversubscription ratios. However, they attribute greenium to demand pressure at issuance but do not examine whether a subsequent price reversal occurs once the demand pressure subsides in the secondary market. We study underpricing and find no price reversal, supporting the investor-tastes explanation over demand pressure argument.

investors in the primary bond market and reports the implications on underpricing. Chaudhary et al. (2022) find a negative relation between demand elasticity and the aggregation level of bond securities. Our paper shows at the security level that the emergence of ESG-focused investors results in different price sensitivity for green and conventional bond offerings. Our paper complements existing studies and highlights the impact of investor heterogeneity in demand on the pricing of fixed-income securities.

To the extent that greenium reduces public debt financing costs, our study also complements research on the relation between ESG and private debt (e.g., Chava (2014), Correa et al. (2020), Javadi and Masum (2021), Degryse et al. (2023), Reghezza et al. (2022), Houston and Shan (2022), Kim et al. (2025)) and has implications on the benefits and costs of ESG engagements (e.g., Ferrell, Liang, and Renneboog (2016), Butler and Cornaggia (2011), Ramadorai and Zeni (2023), and Li, Shan, Tang, and Yao (2023)).

Lastly, our study shows that the emergence of greenium depends on the realization of investor demand and investor preferences for green bonds. This finding complements recent studies that use COVID-19 to examine the sensitivity of investor demand for sustainable investments. Döttling and Kim (2024) show that institutional investors' demand for socially responsible investment funds is less fragile than retail mutual fund investors during COVID-19. Capotă et al. (2022) observe that ESG funds experience smaller outflows than non-ESG counterparts in March 2020. At the bond level, Fatica and Panzica (2024) find that institutional investors' demand for green bonds is resilient during the pandemic. Consistent with these findings, Chava, Efremenko, and Salva (2023) find that bonds of high E&S issuers experience less selling pressure during COVID-19.

2. Hypothesis development

The theoretical framework most relevant to our work is the tastes-based models, which feature a set of investors with a nonpecuniary component of utility (e.g., Baker et al. (2022), Pastor et al. (2021), Pedersen, Fitzgibbons, and Pomorski (2021), and Zerbib (2022)).

Assets with better ESG performance are expected to be priced at a premium and offer lower expected returns. These models predict that green bonds should exhibit greenium. However, as discussed earlier, the empirical evidence is mixed.

The setting of primary bond markets allows us to examine multifaceted bookbuilding outcomes, informing the nature of greenium and the role of investor tastes in green bond pricing. Bond offerings are repeated games for underwriters. If green bond offerings consistently display greenium, underwriters should incorporate this information into pricing by proposing a lower initial offering spread before bookbuilding. Setting the initial offering spread lower also helps avoid tightening the offering spread too aggressively after bookbuilding, which would annoy investors.⁷ However, if greenium tends to vary across offerings and exhibits considerable uncertainty, underwriters might not propose an initial offering spread low enough to fully reflect the expected greenium.⁸ Instead, they may prefer to wait until after bookbuilding to compress the offering spread of green bonds to match realized investor demand. The above discussion leads to our *price formation* hypothesis:

H1: Underwriters propose a lower initial offering spread and compress it to a greater extent after bookbuilding for green bond offerings than for their conventional counterparts, resulting in greenium.

According to tastes-based asset pricing models, greenium, if present, should arise from investors' tastes for ESG assets. However, an institutional difference between stock and bond markets may hinder the application of tastes-based pricing models to fixed-income securities. Fixed-income markets are mainly institutional markets, and institutional investors might not have a nonpecuniary component of utility as assumed in the models. Empirical evidence of investors' willingness to trade off financial returns for societal benefits is mainly on fund

⁷Wilson, H, Vaughan, L, and Griffin, D. (November 2019), "Bond Investors Fume at Price Talk Some Call 'Bait and Switch'," Bloomberg.

⁸Alternatively, underwriters could propose an initial offering spread low enough to fully reflect the expected (or average) greenium, and then adjust the spread upwards when the realized investor demand is below the average level. However, for investment-grade bonds, which constitute 94% of our sample, adjusting the initial offering spread upwards is rare and signals a cold offering (Wang (2021), Hotchkiss et al. (2021)).

investors and on the equity side (e.g., Riedl and Smeets (2017), Hartzmark and Sussman (2019), Barber et al. (2021), Baker et al. (2024), and Giglio et al. (2023)).

On the fixed-income side, survey evidence suggests that institutional investors do not appear to trade off returns for nonpecuniary benefits. For example, the municipal bond institutional investors surveyed and interviewed by Chiang (2017) and Larcker and Watts (2020), as well as the four institutional investors with a focus on sustainable securities interviewed by Flammer (2021), expressed that they are not willing to invest in green bonds if returns were not competitive. Thus, institutional investors may not directly enjoy nonpecuniary benefits.

However, to the extent that institutional investors follow their investment mandate, ESG-fund investors' tastes will translate into ESG-fund managers' (almost) exclusive demand for green bonds.⁹ This does not necessarily contradict ESG-focused fund managers' desire to acquire green bonds at a competitive price. Thus, green bond offerings, which attract both ESG-focused and ESG-neutral institutional investors, should receive higher investor demand than their conventional counterparts, which only attract ESG-neutral institutional investors. This reasoning leads to our *investor demand* hypothesis:

H2: Green bond offerings receive more demand than their conventional counterparts.

In addition to directly contributing to higher demand for green bond offerings, ESG-focused investors may also affect pricing via their different price sensitivity for green bonds. Demand-based asset pricing theories argue that institutional constraints faced by investors and uniqueness of financial assets may make their demand less elastic than suggested by theories (Koijen and Yogo (2019), Davis, Kargar, and Li (2023)). Recent fixed-income literature recognizes that investors' different investment mandates and the imperfect substitutability between bonds lead to significant changes to asset prices (Bretscher et al. (2022), Chaudhary

⁹For example, the prospectus of iShares Global Green Bond ETF, dated March 1, 2021, specifies that, "[t]he Fund generally will invest at least 90% of its assets in the component securities and other instruments of the Underlying Index," which is the Bloomberg Barclays MSCI Global Green Bond Select (USD Hedged) Index.

et al. (2022)). For ESG-focused investors, green bond offerings cannot be easily substituted by conventional offerings because of their investment mandate, whereas ESG-neutral investors are indifferent between otherwise identical green and conventional bond offerings. The non-substitutability between green and conventional bond offerings for ESG-focused investors and the relative scarcity of green bonds presumably decrease their price sensitivity for green bond offerings, compared to ESG-neutral investors. Thereby, the bond-level investor demand for green bond offerings, which comes from both ESG-focused and ESG-neutral investors, is expected to be less price sensitive than that for conventional bond offerings, which comes from only ESG-neutral investors. If so, at the same level of investor demand, underwriters can tighten the offering spread more for green than for conventional bond offerings. This discussion leads to our *price sensitivity* hypothesis:

H3: Underwriters lower the offering spread more for green bond offerings than for their conventional counterparts at the same level of investor demand.

3. Data

3.1. Sample construction

Since we focus on primary market activities in the green bond market, we obtain primary market information, such as the initial price talk (IPT; the initial offering yield or spread underwriters disclose to investors before bookbuilding commences), order book size, and offering spread from Refinitiv IFR. Bond offerings with order book size available typically also have offering price update (i.e., the change from the IPT to the offering yield or spread) information available, but not the other way around. To understand the pricing dynamics, we require sample bonds to have non-missing information about price updates.

We rely on Bloomberg to identify green bonds.¹⁰ From Bloomberg, we extract 1,416

¹⁰Following the Green Bonds Principles (GBP) and other organizations' pioneering issuance and analysis, Bloomberg defines green bonds as fixed income instruments for which the proceeds will be applied towards projects or activities that promote climate change mitigation or adaptation or other environmental sustainability purposes. For more details, see https://data.bloomberglp.com/bnef/sites/4/2015/09/BNEF_Green-Bonds-Terminal-Guide_H2-2015-update.pdf. In Appendix A, we provide excerpts from the Voluntary Pro-

USD- and EUR-denominated government (non-municipal) and corporate fixed- or variable-coupon nonperpetual green bond offerings announced between 1/1/2013 and 5/31/2021, with non-missing offering amount and positive coupon rate.^{11,12} The primary market data covers 776 (88% in terms of the offering amount) of these 1,416 green bonds. Next, for green bond issuers we obtain primary market information for their USD- and EUR-denominated conventional bonds. Because we compare green bonds with conventional bonds offered by the same issuer, our final sample only includes issuers that have offered both green and conventional bonds. This criterion reduces the number of sample green bonds to 637.

Table 1 compares the 637 sample green bonds with the 1,416 green bonds extracted from Bloomberg by year and by currency. There has been exponential growth in the green bond market in the past few years. Most sample green bonds (60% both in number and volume) are offered in or after 2019. The average offering amount of sample green bonds is USD 751 million, whereas those not covered by our sample are much smaller, with an offering amount of USD 196 million. This pattern holds for both USD- and EUR-denominated offerings.¹³

3.2. Primary market outcome variables

At the beginning of the bookbuilding process, underwriters announce the preliminary terms of the offering, including the IPT, before the sales force starts to solicit indications of

cess Guidelines for Issuing Green Bonds, published by GBP in June 2021, to illustrate the recommended practices to issue and maintain green bonds.

¹¹We focus on USD- and EUR-denominated green bonds, which account for 71% of total offering amount of green bonds of all currencies issued in the same period, because the lack of liquid benchmark securities that span the whole yield curve for non-USD and non-EUR bond offerings makes it difficult to compare bonds of different currencies on the basis of spreads. For how institutional investors manage currency risk, see Sialm and Zhu (2023).

¹²Many green bonds are both Rule 144A eligible and Reg S eligible. When a bond is issued both to US investors through Rule 144A and non-US investors through Reg S, Bloomberg records two different bonds (e.g., with different ISIN, FIGI, and CUSIP) for the same issue. To avoid double counting, we only keep one when two green bonds have the same issuer name, pricing date, maturity date, issuing amount, coupon, and currency.

¹³Because the offering amount of green bond offerings not covered by our sample is small, they may not meet the inclusion threshold of green bond indexes and, thus, attract less investor demand. For example, the Bloomberg Barclays MSCI Global Green Bond Index requires the outstanding amount of a USD- or EUR-denominated bond to exceed 300 million.

interest from potential investors to build the book. The underwriters collect all indications of interest and record the aggregate order amount as the order book size. Appendix C provides an example of the typical pricing process using Apple Inc’s \$1 billion 10-year green bond announced and priced on June 13, 2017. The IPT is quoted as either a spread over a benchmark rate or as a yield. Within our sample bonds, the IPT of 94% (4%) [2%] of EUR-denominated bonds is expressed as a spread over the mid-swap rate (spread over the government security benchmark rate) [yield], and the IPT of 28% (63%) [9%] of USD-denominated bonds is expressed as a spread over the mid-swap rate (spread over the Treasury benchmark rate) [yield]. For the USD-denominated bonds whose IPT is expressed as a spread over the mid-swap rate, the issuers of all but five of these bonds are non-US entities. The differences in benchmark choices likely reflect the most liquid benchmark instruments denominated in a currency. After bookbuilding, underwriters announce the offering price, which typically follows the IPT regarding whether it is in a spread over the mid-swap rate, spread over the government benchmark rate, or a yield.

Given these different quoting conventions in bond offerings, we first introduce the price update measure, whose value does not depend on quoting conventions. To measure the price update, we calculate the change in quotes and refer to it as the *spread compression*. In particular, when the IPT and offering price are quoted as spreads over mid-swap rate or spreads over the government security benchmark rate, the spread compression is the offering spread subtracting the midpoint of the IPT spread; when the IPT and offering price are in yields, the spread compression is the offering yield subtracting the midpoint of the IPT yield.¹⁴ A more negative value of *Spread compression* suggests that underwriters tighten the offering spread/yield more aggressively. To compare the offering price of all bonds, we obtain

¹⁴Some IPT includes expressions such as “high”, “mid”, or “low” (10.5% of sample bonds). For example, the IPT could be “High T +90 bps,” followed by the offering price of “T +95 bps.” In this case, omitting these adjectives in the IPT underestimate the magnitude of the spread compression. Thus, when the IPT includes the string of “very high”, “high”, “mid-high”, “mid” (excluding the cases where the string stands for the mid-swap benchmark), “mid-low”, “low”, “very low”, we add 8.75, 7.5, 6.25, 5, 3.75, 2.5, 1.25 bps to the number in the IPT price when the number is in 10s, respectively, to calculate the mid-point of the initial spread/yield. For example, if the IPT is quoted as “High T +90 bps”, we adjust the IPT to be T+97.5 bps. In a robustness test, we exclude offerings whose IPT contains these adjectives.

the offering spread over the government benchmark rate from IFR for sample bonds, and refer to it as the *offering spread*.¹⁵ When this variable is missing from IFR, we supplement it with the offering spread over the government benchmark rate obtained from Bloomberg.¹⁶ After obtaining spread compression and offering spread, we calculate the initial pricing by subtracting the spread compression from the offering spread, and refer to it as the *initial offering spread*. To measure the demand for a bond offering, we calculate its *oversubscription ratio*, which is the dollar amount of the book size scaled by the proposed offering amount. A larger value of the *oversubscription ratio* indicates higher investor demand.

3.3. Summary statistics

Table 2, Panel A presents statistics of bond characteristics for the full sample, including green bonds and their conventional counterparts. Due to data availability, not all 4,908 sample bonds have initial offering spread, offering spread, order book size, and rating information. We winsorize all continuous variables at the 1st and 99th percentile of the sample.

Green bonds account for 13% of the sample. The average offering spread is 107.030 bps, reflecting that most of our sample bonds (94%) are investment grade. Among the full sample, 99% of the bond offerings are rated with the median rating of A. The average spread compression is -12.552 bps, indicating that a typical sample bond experiences about 13 bps drop from the initial to the final offering spread. The mean (median) oversubscription ratio of our sample bonds is 2.737 (2.2), consistent with the underwriters' view that the book size

¹⁵We prefer offering spreads to offering yields. The latter has a risk-free rate component, which varies by currency and time and cannot be adequately controlled for by time fixed effects. Importantly, in most cases, underwriters express the initial and final offering pricing in terms of spreads rather than yields for investment grade offerings. Robustness tests using offering yields are reported in Table D1, Appendix D. In general, using the offering yield generates larger greenium than using the offering spread.

¹⁶We do not calculate the offering spread for bonds with missing values. Calculating the spread by subtracting the daily benchmark rate from the offering yield could be problematic because the daily benchmark rate could be different from the benchmark rate at the pricing time, especially when the market is volatile. We do not use i-spreads or other spreads from Bloomberg either, because Bloomberg often does not provide these spreads calculated on the pricing date, which is a few days before the offering date for our sample bonds. For example, 91% of sample bonds are priced on the announcement date, but the median interval between the pricing and the offering dates is 7 days.

should be at least 1.5 to 2 times the offering amount such that underwriters can have some room to tighten the offering yield and still get all bonds sold (Feldstein and Fabozzi (2008)). Among the sample bonds, 71.7% are listed: 1.5% of USD-denominated bonds issued by U.S. companies and 85% of the EUR-denominated bonds are listed.

Panel B and Panel C of Table 2 display statistics for green and conventional bond subsamples, respectively. Notably, green bonds are typically smaller than conventional bonds (\$739 million vs. \$1,281 million on average), likely because green bonds' proceeds are restricted to specific green projects rather than general corporate use. To account for potential differences in pricing that are associated with differential bond characteristics, we control for bond features in our multivariate regressions and conduct a matched sample analysis.

4. Price formation of greenium

4.1. Multivariate regressions

4.1.1. Baseline results

We begin by estimating the following regression model to investigate the *price formation* hypothesis:

$$Price\ var_i = \alpha + \lambda Green\ bond_i + \beta Control_i + FE + \epsilon_i, \quad (1)$$

where i indexes a bond. *Price var* is *Offering spread*, *Initial offering spread*, or *Spread compression*, as defined in Section 3.2. *Green bond* is an indicator variable equal to one if an offering is labeled as a green bond by Bloomberg, and zero otherwise. Control variables include bond characteristics and market conditions. Bond characteristics include the natural logarithm of the offering amount, the natural logarithm of maturity in years, an indicator of whether the bond is listed on an exchange, indicators of the format of the bond (e.g., Rule 144A (including Rule 144A/Reg S), Reg S, Public, and other), seniority indicators (senior unsecured, secured, and subordinated), indicators of letter ratings (AAA, AA, A, BBB, BB, B, and unrated), and indicators of the denominated currency of the offering. Market conditions include the 10-year swap rate of the denominated currency of the offering and

the slope of the swap rate (i.e., 10-year - 1-year swap rate). FE includes issuer and year fixed effects. We estimate this equation using an ordinary least squares (OLS) regression and cluster the standard errors at the issuer level.

Results in Table 3 support our *price formation* hypothesis. In particular, column (1) shows that the offering spread of green bonds is 5.419 bps smaller than that of similar conventional bonds offered by the same issuer on average, accounting for about 5% of the offering spread. Regarding the economic significance, for the average green bond in our sample with an offering amount of \$739 million and a maturity of 9 years, a reduction in the offering spread of 5.419 bps would save the issuer \$3.6 million (i.e., $5.419 \text{ bps} \times \$739 \text{ million} \times 9$) in coupon payments.¹⁷ Columns (2) and (3) show that greenium exists for both corporate and SSA bond offerings.

Columns (4)-(6) of Table 3 report the results of the initial offering spread. Column (4) shows that for the full sample, the initial offering spread of green bonds is -2.804 bps lower compared to their conventional counterparts. Although this difference accounts for more than half of the greenium shown in column (1), it is not statistically significant. The subsample analyses of corporate bonds in column (5) and SSA bonds in column (6) present similar patterns.

Columns (7)-(9) reveal that the spread compression for green bond offerings exceeds their conventional counterparts. Specifically, in the full sample (column (7)), the magnitude of the spread compression of green bonds is 2.352 bps larger than that of conventional bonds, suggesting that green bond offerings receive more positive information during bookbuilding despite their lower initial offering spread compared to conventional bond offerings. The subsample results reported in column (8) for corporate bonds and column (9) for SSA bonds reach similar conclusions.

¹⁷An alternative way to gauge the economic significance of the greenium is to compare it with the well-documented underpricing of corporate bond offerings (e.g., Cai, Helwege, and Warga (2007), Wang (2021), Flanagan, Kedia, and Zhou (2021), Nagler and Ottonello (2019), Nikolova, Wang, and Wu (2020), Bessembinder et al. (2022), and Siani (2022)). Our estimated greenium of 5.419 bps is almost twice the magnitude of the sample mean underpricing (2.9 bps).

Taken together, the greenium (5.419 bps in column (1)) is split into a lower initial offering spread (2.804 bps in column (4)) and a greater spread compression after bookbuilding (2.352 bps in column (7)). These results indicate that underwriters anticipate green bonds to be priced at a lower offering spread, so they set the initial offering spread somewhat lower to incorporate this expectation. Still, underwriters do not set an initial offering spread low enough to reflect the entire expected greenium. This is likely due to the uncertainty associated with investor demand in the offering process, which we examine in Section 5. After bookbuilding reveals investor demand for green bond offerings, underwriters further tighten the offering spread of these offerings accordingly, leading to greenium.

4.1.2. Robustness tests

We conduct a series of robustness tests to examine the formation of greenium. First, we carry out two tests to address the concern that issuer characteristics may drive our results. We begin with re-examining equation (1) by including issuer-level controls, such as total assets, leverage, and profitability (return on assets). We obtain these issuer-level accounting variables, measured the year before the bond issuance date, from WorldScope. Because SSA issuers do not have issuer-level controls, we only conduct these tests among corporate bond offerings. Also, we lose some observations because not all corporate issuers have these accounting variables available. Table 4, columns (1)-(3) show that our main findings are robust to the inclusion of issuer fundamentals. Among the newly added control variables, a higher leverage is associated with higher offering and initial offering spreads. Next, to maintain our sample size but still address the concern of omitted time-varying issuer characteristics, we include issuer-year fixed effects in our full sample. The estimation results reported in columns (4)-(6) of Table 4 suggest that our conclusions remain the same. To the extent that each issuer's default probability and loss given default remain similar during the same year, these results also confirm that green bonds have a lower expected return, which is the difference between yield and required compensation for expected default loss (i.e., the product of default probability and loss given default), than their conventional

counterparts.

Second, we examine some subsamples commonly studied in the literature (e.g., Fatica et al. (2021), Kapraun et al. (2021), and Caramichael and Rapp (2024)), namely EUR- vs. USD-denominated offerings and non-financial vs. financial corporate bond offerings.¹⁸ We expect to observe a greenium across all subsamples if ESG-focused investors exhibit a preference for all green bond offerings. However, the division of this greenium between a lower initial offering spread and greater subsequent spread compression may vary across subsamples, particularly if underwriters encounter differing degrees of uncertainty depending on bond characteristics. To illustrate this point, for these subsample analyses, we further require the observations to have non-missing offering spread and initial offering spread. Results presented in Table D2, Appendix D, suggest that greenium exists in all the subsamples except for the financial green bonds subsample, for which the estimated offering spread of green bond offerings relative to their conventional counterparts is -4.19 bps with a t-stat of 1.48. As expected, how greenium splits between a lower initial offering spread and greater subsequent spread compression varies across subsamples.

Interestingly, compared to their conventional counterparts, financial green bonds have a lower initial offering spread (-2.308 bps) and a significantly greater spread compression (-1.897 bps). These results suggest that financial green bond offerings should benefit from greenium, contradicting the insignificant coefficient on *Green Bond* when the dependent variable is the *offering spread* (i.e., insignificant greenium). These findings imply that noise in measuring offering spreads, combined with a moderate effect, can affect inference on greenium. We further discuss the implications of our findings in Section 7.4.

Third, it is plausible that the credit risk of bond issuers decreases after they issue green bonds. Choosing to issue green bonds could signal to investors that the issuer has become more aware of climate-related risks and is more committed to reducing such risks

¹⁸The literature provides mixed results on which subsamples display greenium. For example, Fatica, Panzica, and Rancan (2021) document no greenium for green bonds offered by financial companies, whereas Caramichael and Rapp (2024) find greenium for green bonds offered by banks.

(Flammer (2021)). Recent literature also suggests that credit rating agencies consider an issuer’s environmental performance when assigning ratings (Seltzer et al. (2020)). Along this line, the credit quality of issuers may improve once they offer green bonds, which could lead to a lower offering spread of the green and subsequent conventional bonds. To address this concern, we re-estimate equation (1) with a subsample consisting of bonds issued on or after the date when the first green bond is offered. If the credit risk conjecture explains our results, the pricing dynamics of green bonds should not be different from their conventional counterparts in this subsample. In Appendix D, Table D3 reports the estimation results and suggests that our results of greenium formation are not driven by this alternative explanation.

Fourth, to control for time-invariant features associated with bond underwriters who differ in reputation and expertise, we include underwriter fixed effects in our regressions. Appendix D, Table D4 shows that our findings are robust to underwriter fixed effects.

Fifth, we examine whether the restrictiveness of covenants of bond offerings affects our conclusion and find that it does not. In particular, we retrieve from Bloomberg the covenant information pertaining to negative pledge, M&A restriction, restriction, cross-default, change of control, fundamental change, coverage ratio, asset sales, debt limit, and restricted payment. We then calculate the restrictiveness of covenants by adding up the number of covenants that take the value of “Y”. Appendix D, Table D5 shows that our results are robust to controlling for the restrictiveness of covenants.

Next, we conduct a test to mitigate potential noises associated with initial pricing in our data. Specifically, we exclude the offerings for which the IPT contains ambiguous strings discussed in Section 3.2. Table D6 in Appendix D shows that the results are similar to those reported in the main paper.

Lastly, a larger proportion of our sample green bonds are issued after 2019, raising the concern whether some specific market conditions other than green preferences during this period drive our results. To address this concern, we estimate our baseline regressions by excluding bonds offered in 2019, 2020, or 2021, in addition to controlling for year fixed

effects. The estimation results (untabulated) are similar to those using the full sample, suggesting greenium is not driven by bonds offered under specific market conditions in a particular year.

4.2. Matched sample analysis

To further address the potential concern that the differences in pricing between green and conventional bonds might arise from some uncontrolled factors in the regression (Larcker and Watts (2020)), we conduct a matched sample analysis as in Flammer (2021). Specifically, for each green bond, we first find from the same issuer the conventional bonds offered within three years, with the same letter rating, currency, and seniority, and with a maturity within three years and offering amount between 50% and 200% that of the green bond. When a green bond is matched to multiple conventional bonds, we keep the conventional bond with the closest pricing date. These requirements yield 442 pairs of green and conventional bonds.

Table 5 reports the mean and median of offering spread, initial offering spread, and spread compression for green bonds and their matched conventional bonds, as well as the pairwise differences. These results are consistent with our multivariate regression results in Table 3, confirming that green bonds command a premium over their conventional counterparts. This premium is realized through a lower initial offering spread and a larger magnitude of spread compression. For example, among the 442 matched pairs in the full sample, the mean and median pairwise differences in the offering spread are -5.441 and -4.600 bps, respectively, significant at the 5% and 1% level, respectively. The mean and median pairwise differences in the initial offering spread are -2.351 and -1.615 bps, respectively, accounting for about half of the size of greenium but not statistically significant. Finally, the mean and median pairwise differences in the spread compression are -2.897 and -1.375 bps, respectively, both significant at the 1% level. The histogram plots of the pairwise differences presented in Figure 1 suggest that the above results are unlikely due to outliers. To further control for differences in bond characteristics and market conditions, we re-estimate equation (1) using the matched sample. Results shown in Table D7, Appendix D, are similar to those using our

full sample (Table 3). Overall, results from the matched sample analysis further support the *price formation* hypothesis.

5. The role of investor demand

5.1. Investor tastes

5.1.1. Oversubscription ratio

Our *investor demand* hypothesis posits that some investors’ tastes for ESG assets should translate to greater investor demand for green bond offerings. In this section, we test this hypothesis by examining the oversubscription ratio.

Panel A of Figure 2 presents the density distribution of the oversubscription ratio, showing that it is greater for green than conventional bond offerings. Panel B of Figure 2 graphs the average oversubscription ratios of green and conventional bond offerings by calendar quarter. Because green bond offerings are relatively sparse before 2016, we group all green (and conventional) bonds issued on or before 2016 together. This figure reveals that although the average oversubscription ratio of green bond offerings is always greater compared to conventional offerings, the difference fluctuates over time, indicating sizable uncertainty associated with the demand for green bond offerings. This observation is consistent with our findings in Section 4 that underwriters do not propose an initial offering spread that is low enough to incorporate the expected greenium for green bond offerings. Instead, they propose a somewhat lower initial offering spread and tighten it to a lower offering spread once bookbuilding resolves uncertainty.

To control for differences in issuer and bond characteristics, as well as market conditions, we conduct a multivariate analysis by re-estimating equation (1), but replace the dependent variable with the oversubscription ratio. Results in Table 6 support our *investor demand* hypothesis. Specifically, column (1) suggest that the oversubscription ratio of green bonds is significantly greater (0.397 or 14.7%) than otherwise similar conventional bonds issued by the same issuer on average. Since the offering spread of green bond offerings is lower

compared to their conventional counterparts on average (Table 3), which dampens demand, this is a lower bound estimate for the excess investor demand for green bond offerings.

Column (2) of Table 6 shows robust result within the subsample of corporate bonds. For SSA bonds, column (3) reports that the coefficient on *Green bond* remains positive but is not statistically significant. One possible explanation is that SSA green bonds are typically larger than corporate green bonds (\$998 million vs. \$662 million), diluting the potential impact of green bond investors. These results are consistent with our findings that greenium is more prominent for corporate bonds than for SSA bonds.

For control variables, column (1) shows that larger offerings exhibit a smaller oversubscription ratio, consistent with the findings in the literature that larger offerings require a greater pool of investors to absorb (Nikolova et al. (2020), Bessembinder et al. (2022), Helwege and Wang (2021)).¹⁹ Longer maturity is associated with a higher oversubscription ratio, possibly because longer maturity bonds have higher yields, and investors reach for yield (at least partially by reaching for maturity (Murray and Nikolova (2022))).

To evaluate the robustness of our findings on investor demand, we repeat the robustness tests discussed in Section 4.1.2 using the oversubscription ratio as the dependent variable and reach similar conclusions (untabulated). We also apply the matched sample method discussed in Section 4.2. For the 289 pairs of green bond offerings and their conventional matches with non-missing order book size information, we find that the mean and median pairwise differences in the oversubscription ratio are 0.712 and 0.550, respectively, both significant at the 1% level.

Overall, our results suggest that strong investor demand for green bonds, presumably from ESG-focused investors, increases the oversubscription ratio of green bonds relative to conventional bonds.

¹⁹Because of the importance of the offering amount in determining the oversubscription ratio, in untabulated tables we control for offering amount, as opposed to the natural logarithm of the offering amount. Our results remain robust.

5.1.2. ESG-focused investors' demand in the primary market

We attribute the larger oversubscription ratio of green bond offerings to ESG-focused investors because these offerings are almost identical to their conventional counterparts except for their use of proceeds, which makes them eligible for ESG investing. Ideally, comprehensive order book data with detailed bid information and investor identities for all sample bonds would offer the most direct evidence of the impact of ESG-focused investors' demand (or subscriptions) on pricing. However, obtaining such data in large scale has not been possible for security offerings (e.g., Cornelli and Goldreich (2001), Nikolova et al. (2020)). Nonetheless, to shed some light on this issue, we utilize ESG-focused investors' holdings in the secondary market to proxy for their demand in the primary market.²⁰ When these investors hold more bonds similar to the new offering, they as a group would presumably subscribe more to the offering in the primary market.

Specifically, we identify bond ownership using eMAXX data (e.g., Bodnaruk and Rossi (2016), Baker et al. (2022)) on global quarterly holdings of EUR- and USD-denominated *corporate* bonds between 1/1/2018 and 6/30/2021 from Refinitiv.²¹ We match our sample *corporate* bonds, regardless of the offering date, with the eMAXX holdings data and find that 90% of sample bonds are covered in eMAXX. The average percentage holding of a sample bond, calculated as the quarterly total par amount held by all institutions in eMAXX scaled by the offering amount, is 26% and 22% for green and conventional bonds, respectively. A further examination reveals that the difference is mainly due to ESG-focused investors'

²⁰We do not use ESG-focused investors' offering-quarter-end holdings of the new offering to proxy for their subscription in the primary market for the following reasons. First, when bond offerings are oversubscribed, underwriters exercise their discretion in bond allocation and favor their relationship customers (Nikolova et al. (2020)). Thus, the offering-quarter-end holding of ESG-focused investors may not properly reflect their interests in the primary market. Second, many investors flip their primary market allocations in the secondary market, so the offering-quarter-end holding data may not reflect investors' actual allocations (Nikolova and Wang (2022)). Third, we find that eMAXX percentage holdings change quite a bit from the issuing quarter to the following quarter, from 22.4% to 27.6%. This change could be a result of delayed reporting by investors. It could also be that many investors interested in a bond cannot obtain it in the primary or the immediate secondary market. Therefore, ESG-focused investors' offering-quarter-end holdings of the new offering cannot properly proxy for their interests and subscription in the primary market.

²¹Our institution's subscription of the global version of eMAXX data begins from 1/1/2018 and only includes corporate bond holdings. Table 1 shows that 69% of our sample green bond offerings are issued on or after 2018.

almost exclusive investment in green bonds.²² Specifically, on average ESG-focused investors hold a significantly higher proportion of the offering amount of green bonds than that of conventional bonds (5.2% vs. 0.7%).

We then calculate the proxy for ESG-focused investors' demand in the primary market for a bond offering as follows:

$$Demand_i^{ESG} = \frac{\sum_{j=1}^{j=N} \%ESG_j}{N}, \quad (2)$$

where i indexes a bond offering. j indexes a similar bond, including outstanding corporate bonds that share the same green/non-green label, currency, and credit quality as the new offering, as well as a time-to-maturity within three years of the new offering.²³ N is the total number of similar bonds. $\%ESG_j$ is the total amount of bond j held by ESG-focused investors in the offering quarter of the new offering scaled by its offering amount.²⁴

ESG-focused investors in our sample are primarily mutual funds, raising the concern of whether the difference between green and conventional bond offerings is due to green bond offerings attracting more mutual funds investors, as opposed to ESG-focused investors. To address this concern, we similarly calculate a proxy for mutual fund investors' demand in the primary market using equation (2) but replace holdings of ESG-focused investors with those

²²To identify ESG-focused investors, we first find the institutions whose name contains variations of ESG-related key words, including green, renewable, planet, sustainability, climate, responsibility, ethic, carbon, environment, impact, net zero, conscious, ESG, SRI, and CSR. Then, we manually examine the list to exclude false matches. This results in 858 ESG-focused investors at the fund level, 854 of which are mutual funds.

²³Our requirements for credit quality and maturity are based on the Morningstar fixed-income style box (<https://www.morningstar.com/content/dam/marketing/shared/research/foundational/Fixed-Income-Style-Box-Methodology-Paper.pdf>), which assists investors and advisors in determining a fund's investment style. Morningstar classifies bond funds within its style box based on interest-rate sensitivity and average credit quality (i.e., AAA- and AA-rating is high credit quality, A- and BBB-rating is medium credit quality, and BB-rating and below is low credit quality). Institutional investors with a target style box are more likely to invest in bonds with similar interest-rate sensitivity, which is largely determined by maturity, and credit quality to the bonds already held in their portfolios. These requirements are also consistent with the literature that credit quality and maturity are important considerations of fixed income investors (e.g., Becker and Ivashina (2015), Choi and Kronlund (2017)). In robustness tests, we require similar bonds to have the same letter credit rating, rather than the same credit quality category, as the new offering and find similar results (untabulated).

²⁴We use $Demand_i^{ESG}$ constructed in the offering quarter to proxy for the concurrent ESG-focused investors' demand and expect to find that it decreases offering spreads. Because bond investors chase for yield (Becker and Ivashina (2015), Choi and Kronlund (2017)), the reverse causality of lower spreads leading to more demand is less of a concern.

of all mutual funds ($Demand^{MF}$). On average, $Demand^{MF}$ is 19.3% (15.2% if we exclude ESG-focused investors) for green bond offerings and 15.4% for conventional bond offerings.

To evaluate the impact of ESG-focused investors' demand on primary market outcomes controlling for the demand from mutual funds, we estimate the following equation:

$$Outcome_i = \alpha + \theta Demand_i^{ESG} + \kappa Demand_i^{MF} + \beta Control_i + FE + \epsilon_i, \quad (3)$$

where *Outcome* is one of the following four variables: *Oversubscription*, *Initial offering spread*, *Spread compression*, and *Offering spread*. $Demand_i^{ESG}$ and $Demand_i^{MF}$ are in percentage points. Control variables, fixed effects, and other model specifications are the same as equation (1).

Table 7 reports the results. Column (1) shows that a one percentage point increase in ESG-focused investors' demand increases the oversubscription ratio by 0.19. Given that the average $Demand^{ESG}$ is 3.9% for green bond offerings and 0.4% for conventional bond offerings, this coefficient implies that due to ESG-focused investor demand, the oversubscription ratio of green bond offerings is 0.67 (i.e., $0.19 \times (3.9 - 0.4)$) greater relative to their conventional counterparts. This effect is close to the excess oversubscription ratio of green bond offerings relative to their conventional counterparts (0.72) obtained by re-estimating equation (1) using the oversubscription ratio as dependent variable in this subsample (untabulated). These results support our argument that the higher oversubscription ratio of green bond offerings is mainly driven by ESG-focused investors' almost exclusive demand for ESG assets. Consistent with findings in column (1), results in columns (2)-(4) show that higher $Demand^{ESG}$ is associated with lower initial offering spreads, greater magnitude of spread compressions, and lower offering spreads.

Taken together, these results suggest that the difference in primary market outcomes between green bond offerings and their conventional counterparts is mostly due to ESG-focused investors' tastes for ESG assets. Furthermore, our analysis reveals an empirical link between the oversubscription ratio in the primary market and ESG-focused investors'

holdings of similar bonds in the secondary market, pointing out a potentially useful direction for future researchers to study how ESG-focused investors affect bond pricing in the absence of the order book data.

5.2. Price sensitivity

We proceed to investigate the *price sensitivity* hypothesis – underwriters lower the offering spread more for green than for conventional bond offerings at the same level of investor demand.

When using investor demand to explain the offering spread, we note that fixed-income investors reach for yield (Becker and Ivashina (2015), Choi and Kronlund (2017)), which can lead to a counter-intuitive positive relation between investor demand and the offering spread. To circumvent this issue, we use the initial offering spread to capture the attractiveness of an offering to investors and estimate the following equation:

$$\begin{aligned} Offering\ spread_i = & \alpha + (\theta + \pi ESG\ Investors_i) \times \log(Oversubscription\ ratio_i) + \lambda ESG\ Investors_i \\ & + \mu Initial\ offering\ spread_i + \beta Control_i + FE + \epsilon_i, \end{aligned} \quad (4)$$

where i indexes a bond. *ESG Investors* is either the green bond indicator or $Demand^{ESG}$. $\log(Oversubscription\ ratio)$ is the natural logarithm of the oversubscription ratio. Other control variables, fixed effects, and model specifications are the same as in equation (1), except that we also include *Initial offering spread* as a control variable.

Results in Table 8 show that higher investor demand is associated with a lower offering spread, and more so for green than conventional bond offerings. In particular, column (1) suggests that a one standard deviation increase in $\log(Oversubscription\ ratio)$ (0.510) enables underwriters to decrease the offering spread by 2.26 bps (i.e., $(-4.431) \times 0.51$) for conventional bond offerings and 3.79 bps (i.e., $(-4.431 - 3.004) \times 0.51$) for green bond offerings. These results indicate that with the participation of ESG-focused investors, who are less sensitive to the offering spread of green bond offerings, underwriters can compress the offering spread of

these offerings more aggressively, all else equal. Results in columns (2) and (3) show that the difference in price sensitivity is statistically significant for corporate offerings but less so for SSA offerings, consistent with the patterns of pricing dynamics and investor demand discussed earlier.

Column (4) shows that measuring ESG-focused investors' participation in the primary market using $Demand^{ESG}$ rather than the green bond indicator yields a similar conclusion. The coefficient on the interaction term between $\log(Oversubscription\ ratio)$ and $Demand^{ESG}$ is significantly negative. To assess whether the observed effect is driven by the fact that ESG investors are predominantly mutual funds, we further replace $Demand^{ESG}$ with the ratio of $Demand^{ESG}$ relative to $Demand^{MF}$.²⁵ Results in column (5) suggest that this is not the case - when $Demand^{ESG}$ accounts for a higher proportion of $Demand^{MF}$, underwriters compress the offering yields more aggressively for a given level of oversubscription ratio.

Overall, these findings support our *price sensitivity* hypothesis. They are also in line with the practitioners' view that to obtain scarce green bonds to fulfill their investment mandate, ESG-focused investors cannot afford to be too price sensitive, reinforcing their contribution to greenium.

5.3. Alternative explanations

5.3.1. Investor tastes vs. temporary price pressure

The tastes-based models suggest sustained investor tastes for green bonds and, thus, a lasting greenium. Conversely, if the higher investor demand in the primary market were merely a temporary shock, it would likely be absorbed in the secondary market. The fixed income literature demonstrates that temporary price pressure affects the offering price in both the Treasury and corporate bond markets (Lou, Yan, and Zhang (2013), Helwege and Wang (2021)), with these pricing effects typically reversing soon in the secondary market. If

²⁵We do not simultaneously control for the interaction term between $\log(Oversubscription\ ratio)$ and $Demand^{ESG}$ and that between $\log(Oversubscription\ ratio)$ and $Demand^{MF}$. Because ESG investors in eMAXX are mostly mutual funds, $Demand^{MF}$ increases with $Demand^{ESG}$. This multicollinearity problem becomes more severe when interacting both variables with $\log(Oversubscription\ ratio)$.

greenium results from temporary price pressure in the primary market, it should be reversed in the secondary market when the price pressure is resolved.

To distinguish between the investor tastes mechanism and the temporary price pressure mechanism, we examine whether greenium is reversed in the secondary market by investigating underpricing. We calculate underpricing as the yield change from the offering yield to the secondary market trade yield, adjusted for yield changes in benchmark indexes (Wang (2021)).²⁶ We compute underpricing on the offering date, as well as 7 and 28 days after the offering date to consider that the capital needed to reverse price pressure might be slow-moving. Because the offering yield is generally higher than the secondary market trade yield, the average underpricing (in terms of yield change) is negative. If greenium is due to temporary price pressure in the primary market, green bond offerings should experience *a smaller* decrease in yield after issuance compared to conventional offerings, reversing the temporary pricing effects. That is, green bonds should have a smaller magnitude of underpricing than conventional offerings if temporary price pressure is at play. Tastes-based asset pricing models do not have such an implication. Moreover, green bonds, which have a larger order book size than conventional bonds, could even display greater (i.e., more negative) underpricing if investors who do not get primary market allocations seek to purchase the bonds in the secondary market, driving up the price (i.e., driving down the yield).

Results presented in Table 9 indicate that temporary price pressure does not explain greenium. In particular, the negative coefficients on the *Green Bond* indicator in columns (1) and (2) suggest that compared to conventional bond offerings, the underpricing of green bond offerings is larger on the offering date in the full sample and in the corporate subsample, contrary to the prediction of the temporary price pressure argument. These coefficients

²⁶Specifically, we measure the secondary market yield as the mid-quote of the yield to maturity obtained from Bloomberg. We further adjust the yield change by changes in currency-, rating-, and maturity-matched ICE BofA indexes from the pricing date to the respective trade date. Possibly because the trade yield is proxied by the mid-quote, the calculated underpricing has long tails at both ends. For example, the 1st, 5th, 25th, 50th, 75th, 95th, and 99th percentile of underpricing as of the offering date is -45.7, -19, -6.5, -2.5, 0.9, 14.1, and 84.5 bps. To mitigate the impact of tail values, we winsorize underpricing at 5th and 95th percentile.

become insignificant by the end of the first week after issuance (columns (4) and (5)), and remain insignificant throughout the first month after issuance (columns (7) and (8)). For the SSA subsample, the underpricing of green bond offerings is not significantly different from conventional offerings consistently (columns (3), (6), and (9)).²⁷ These results suggest that greenium is not driven by temporary price pressure but rather reflects investors' persistent preference for ESG assets.

5.3.2. Investor tastes vs. liquidity preference

Because green bonds are more sought after by ESG-focused investors, these bonds might have better liquidity in the secondary market, which in turn could attract more ESG-neutral and liquidity-seeking investors in the primary market. If so, some investors' preference for liquidity might explain greenium. This conjecture presumes that higher demand translates to greater liquidity, which is not necessarily true (Johnson (2008)). Although we can not carry out a comprehensive study of the impact of ESG tastes on liquidity due to data limitations, we obtain a subsample of bonds whose trades are reported to TRACE to examine whether liquidity differs between green bonds and their conventional counterparts. The caption for Table D8, Appendix D, describes data and sample details. Results in this table indicate that green bonds do not have greater liquidity, proxied by bid-ask spreads, in the secondary market compared to conventional bonds.

Furthermore, even if investors' ESG tastes in the secondary market increase liquidity, it is unclear whether and how it further feeds back to the order book size because of bond investors' heterogeneous preference for liquidity. For example, long-term investors may prefer to hold illiquid bonds to earn an illiquidity premium (Chen et al. (2020), Murray and Nikolova (2022)). Overall, our findings do not support the conjecture that investor preference for liquidity is responsible for greenium.

²⁷ We similarly do not find evidence of price reversal using underpricing 180-day and 365-day after issuance (untabulated).

6. Heterogeneous demand for green bonds

In this section, we focus on green bond offerings only and analyze investors' heterogeneous demand within this group. Because all green bonds qualify as ESG assets, this analysis can help better understand investor preferences in choosing green bonds. Several features of green bond offerings may affect investor demand. First, bonds with higher yields are more appealing to reaching-for-yield investors and, thus, may attract more demand. Second, green bonds are still relatively new financial instruments that only a portion of bond issuers employ. Including green bonds offered by first-time issuers in a portfolio could significantly increase diversification benefits to institutional investors. Hence, we examine if an issuer's first green bond offering attracts more investor demand than seasoned green bond offerings. Third, the awareness of environmental issues (e.g., Dou et al. (2022)) has increased over the past decade, which can translate to higher investor demand for green bonds offered in more recent years. Fourth, we study whether the degree of greenness of an offering affects its demand. On the one hand, darker green projects could have a greater impact on improving the environment, attracting more demand. On the other hand, these projects are more likely to be issued by brown issuers, decreasing the demand from investors if they care more about an issuer's overall ESG profile. It could also be that asset managers in general do not have enough incentives to pay close attention to the greenness of bonds because investors tend to focus on discrete (i.e., green vs. conventional) rather than continuous measures (i.e., shades of green; Hartzmark and Sussman (2019)). Also, investors who are willing to pay for sustainable investments may not pay more for more impact (Heeb et al. (2023)). Lastly, we examine if investor demand for green bonds is related to the presence of external reviews. Since investors are concerned about greenwashing, an external review by Second-Party Opinion (SPO) providers may mitigate the concern, increasing investor demand.

To examine whether the above features affect investor demand for green bonds, we conduct a regression analysis using the subsample of green bond offerings. Specifically, we estimate the following model:

$$\text{Oversubscription ratio}_i = \alpha + \lambda \text{Features}_i + \beta \text{Control}_i + FE + \epsilon_i, \quad (5)$$

where i indexes a bond. Features include *Relative initial spread*, letter rating indicators, *First green*, *Post-2018*, *Greenness*, and *Second-party opinion*. *Relative initial spread* is the offering’s initial yield over the yield of currency- and rating-matched Barclays’ index (Choi and Kronlund (2017)), and letter ratings refer to AAA, AA, ..., and B. *First green* is an indicator variable that equals one if the green bond is the first offered by an issuer, and zero for subsequent green offerings. *Post-2018* takes the value of one if a bond is offered between 2019 and 2021, and zero otherwise. *Greenness* includes indicators of *Dark* (the omitted group), *Medium*, *Light*, and *Unclassified green*, which equals one if the ESG project categories of the bond offering obtained from Bloomberg are renewable energy; green buildings and infrastructure or energy smart technologies and energy efficiency; other projects; and unclassified, respectively, and zero otherwise. *Second-party opinion* is an indicator variable that equals one if the green bond has an assurance provider, and zero otherwise. Other controls, fixed effects, and model specifications are the same as in equation (1), except that we use *Post-2018* in lieu of year fixed effects. Also, non-rated bond offerings are excluded from the sample because we are interested in how ratings might affect investor demand.

Table 10 reports the estimation results. Columns (1) and (2) differ in that the latter controls for issuer fixed effects, whereas the former does not. Several interesting findings emerge in column (1). First, there is strong evidence of chasing for yield. Specifically, within IG bond offerings (96% of this sample), as the rating quality of the green bonds decreases from AAA to BBB, the oversubscription ratio steadily and significantly increases, suggesting that fund managers actively acquire bonds that offer higher expected returns. Second, an issuer’s first green bond offering attracts larger investor demand than subsequent green bond offerings, consistent with the notion that ESG fund managers seek better diversification for their portfolio.²⁸ Third, green bond offerings issued after 2018 receive higher investor de-

²⁸This finding implies that the impact of investor tastes on primary market outcomes is much weaker for subsequent green bond offerings. To examine this implication, we re-estimate our primary market outcome regressions by excluding the first green bond offerings. Results in Table D9 of Appendix D show that on

mand, consistent with the pattern illustrated in Panel B of Figure 2. These results imply that our findings are stronger for the later years. To test this conjecture, we modify our baseline pricing regressions by replacing the green bond indicator with two indicator variables: green bond pre-2018 indicator and green bond post-2018 indicator. Consistent with this conjecture, results in Table D10 of Appendix D show that the pricing differences between green and conventional bond offerings are more prominent after 2018.

We do not find evidence that investors consider shades of green when investing in green bonds. Specifically, the coefficients on *Medium green*, *Light Green*, and *Unclassified green* are mostly not statistically different from that on *Dark green*, the omitted group. For a subsample of corporate bonds with issuers' ESG characteristics from Asset4, a data set that provides ESG data for companies worldwide (Dai, Liang, and Ng (2021)), we also examine if an issuer's environmental (E) or overall ESG score affects investors' demand for green bonds. We do not find significant results using the raw score or the decile rank of E(SG) score (untabulated). These results are consistent with the notion that brown issuers can issue green bonds of dark shades, that investors often focus on discrete rather than continuous measures, and that investors do not pay more for more impact. Another possibility is potential noises in ESG scores (Berg et al. (2022)). Lastly, we do not find evidence that the second-party opinion affects investor demand. A closer look into the data reveals that 86% of sample green bond issuers get second-party opinion.

7. Discussions

7.1. Why do ESG-neutral investors tolerate greenium in the primary market?

We document an average greenium of 5.4 bps and show that this is primarily driven by investor demand for green bonds. It is reasonable to question why ESG-neutral investors are

average, the relative oversubscription ratio for subsequent green bond offerings is less pronounced (0.266, significant at the 10% level) than that in our full sample (0.397, significant at the 1% level). The difference in the spread compression remains economically and statistically strong (-2.396 bps), likely due to its smaller noise and thus smaller standard error. Not surprisingly, the difference in the offering spread becomes smaller (-3.561 bps as opposed to -5.419 bps in the full sample) and not statistically significant (t-stat = 1.40).

willing to accept the greenium in the primary market. Several factors may explain why for some ESG-neutral investors, obtaining green bond offerings at such a greenium is better than not getting allocations and subsequently purchasing conventional bonds in the secondary market. First, bonds offered through the bookbuilding process are typically underpriced. For our sample bonds, the average underpricing is -2.9 bps, meaning that investors on average gain 2.9 bps in yields by purchasing from the primary market compared to buying from the immediate secondary market. Second, new offerings tend to provide higher yields than comparable bonds traded on the secondary market, known as “new issue concession (NIC)”. For example, Siani (2022) shows that the average NIC is 4.6 bps for corporate bonds. Third, purchasing bonds from the secondary market incurs sizable transaction costs.²⁹ For example, the average bid-ask spread we calculate in Section 5.3.2 is 24 bps (in terms of trading price rather than yield) at the trade level. That is, investors who do not receive an allocation in the primary market would have to incur substantial trading costs to obtain it in the secondary market (Flanagan, Kedia, and Zhou (2021)). Possibly due to these reasons, new offerings are mostly oversubscribed, and ESG-neutral investors may still be better off getting allocations of green bond offerings than not.

7.2. Realized returns vs. expected returns

Pastor et al. (2021) and Pástor et al. (2022) point out that unexpected aggregate shifts in investor tastes for stocks with better ESG profiles lead to higher *realized* returns, despite lower *expected* returns. A related question is whether green bonds have higher realized returns in the secondary market. To answer this question, it is critical to note a key difference between stocks and bonds: stocks do not have a redemption date, whereas bonds do, and the value of bonds converges to the face value as the maturity date approaches. Hence, green bonds can periodically exhibit higher realized returns in the secondary market but cannot

²⁹For estimates of trading costs in corporate bonds, see Schultz (2001), Bessembinder, Maxwell, and Venkataraman (2006), Edwards, Harris, and Piwowar (2007), Bao, Pan, and Wang (2011), and Goldstein and Hotchkiss (2020), among others.

always deliver higher realized returns.³⁰

7.3. On the “lack” of supply

Our results suggest that despite the rapid expansion of the green bond market, the growth of investor demand for green bonds outpaces that of the supply. This finding leads to the question of why issuers are relatively “slow” in taking advantage of greenium and offering more green bonds. One factor that offsets the benefits of greenium is issuers’ operational costs associated with issuing green bonds. Due to the greenwashing scrutiny, Green Bond Principles (GBP) has recommended that issuers establish green bond frameworks and hire external reviewers pre- and post-bond issuance (see Appendix A for details). These costs can impose obstacles for issuers.

Our analysis also suggests sizable uncertainty in investor demand for green bond offerings, implying that greenium is not guaranteed. Consistent with our findings, Jon Haygood, assistant treasurer of Southern Company, states, “[w]hen markets are extremely volatile, spending a day [to line up the requirements for a green bond] could eliminate valuable flexibility to access the market at times that would be favorable to us.”³¹ Survey evidence further suggests that greenium is not the only determinant of issuing green bonds: achieving long-term sustainability goals, broadening the investor base, and enhancing visibility are the

³⁰To fix ideas, consider two 2-year green and conventional bonds offered by the same issuer on the same date. Suppose both bonds are offered at \$100, and the coupon is C_g for the green bond and C_c for the conventional bond. C_c is greater than C_g in the presence of greenium. At the end of the first year, the trading price for the green and conventional bonds changes by ΔP_g and ΔP_c , respectively. Due to a positive demand shock to sustainable investing, ΔP_g is greater than ΔP_c . If the greater capital appreciation of the green bond more than offsets its lower coupon payment (i.e., $\Delta P_g - \Delta P_c + (C_g - C_c) > 0$), then the green bond has a higher realized return for the first year after issuance. At the end of the second year when both bonds mature, all investors will get the face value of \$100 regardless of shifts in tastes during the year. That is, the trading prices for the green and conventional bonds change by $-\Delta P_g$ and $-\Delta P_c$ in the second year, respectively. In this case, compared to conventional bond investors, green bond investors incur both a larger loss associated with value changes in capital (i.e., $-\Delta P_g < -\Delta P_c$) and a lower coupon payment (i.e., $C_g < C_c$) on their greater initial investment (i.e., $\$100 + \Delta P_g > \$100 + \Delta P_c$). Thus, green bond investors have a lower realized return for the second year after issuance. This simplified example illustrates that green bonds cannot always outperform conventional bonds in the secondary market even if investor tastes for ESG assets are constantly upward shifting. Importantly, the cumulative realized return *over the life of the bond* for green bond investors is lower than that for investors of conventional bonds offered by the same issuer when greenium exists.

³¹Chan, M. (June 24, 2023). US energy companies hit pause on ESG bonds. IFR.

main motivations (Climate Bond Initiative (2020)).

7.4. Empirical implications

Several aspects of our findings help explain the mixed evidence on greenium in the literature. First, we demonstrate that the emergence of greenium depends critically on the realization of investor demand and investor preferences for green bonds. Panel B of Figure 2 shows that while green bonds consistently exhibit higher oversubscription ratio than conventional bonds, the difference remains small prior to 2018. Thus, even when greenium exists, it may have been too small to reach statistical significance in earlier studies that primarily analyzed pre-2018 bond issuances. Similarly, if ESG concerns diminish in the future and ESG-focused investor demand weakens, greenium may also lose significance. To the extent that equity and bonds are likely influenced by similar shifts in investor preferences, ESG premia within equity markets may exhibit a parallel pattern.

Second, both Figure 2 and our results on pricing dynamics highlight substantial uncertainty and variation in investor demand for green bond offerings, both over time and in the cross section. As a result, studies focusing on specific time periods, sectors, or markets may detect greenium in certain subsamples but not in others.

Third, when examining the subsample of financial corporate bond offerings in Section 4.1.2., we find that although financial green bonds have lower initial offering spreads and significantly larger spread compressions compared to their conventional counterparts, their offering spreads are not statistically different (Panel B of Table D2, Appendix D). We also find that all else equal, the oversubscription ratio of financial green bonds is 0.709 higher (significant at the 1% level) than that of conventional financial bonds (untabulated), suggesting strong investor tastes for these green bonds and supporting the presence of greenium. We observe a similar pattern when removing the first green bond offering from our full sample (Table D9 of Appendix D). These findings highlight the challenges of empirically assessing greenium and have broader implications, as much of the existing literature on green bonds draws conclusions based solely on offering or secondary market yields (spreads). Using yields

or yield spreads to measure greenium is inherently noisy. Specifically, studies on green bonds often involve heterogeneous samples spanning multiple currencies and regions, largely due to the relatively small number of green bond offerings and their global significance. This contrasts with research on conventional fixed-income securities, which typically relies on more homogeneous samples, often denominated in a single currency. Yields or spreads, influenced by bond characteristics and market conditions, are particularly susceptible to noise arising from sample heterogeneity, which can lead to insignificant results, especially when greenium is moderate.³² This susceptibility may contribute to the mixed evidence reported in the literature. Therefore, to overcome the empirical challenges posed by the inherently complex nature of green bond samples, it is crucial to employ a multifaceted approach to studying the underwriting process—one that incorporates other primary market outcomes to provide a more comprehensive assessment of green bond pricing.

8. Conclusion

There is a mounting interest in how green assets should be priced. Investor-tastes asset pricing models predict that green bonds should exhibit lower yields than their conventional counterparts. However, the empirical evidence on whether greenium exists is mixed, and the evidence on the mechanisms behind greenium is lacking. We explore pricing dynamics and investor demand in the primary bond market to fill these gaps.

We find evidence supporting the investor ESG tastes framework. The pricing dynamics reveal that greenium stems from a somewhat lower initial offering spread before bookbuilding and a significantly larger spread compression afterward. These results suggest that the magnitude of greenium relies on the realization of investor demand in the primary market, which varies over time and across offerings. Using security-level book size data, we show that green bond offerings attract higher investor demand than comparable conventional

³²Greenium should not be large. As discussed in Section 7.1, if greenium significantly exceeds the combined value of underpricing and the secondary market bid-ask spread, ESG-neutral investors are likely to lose interest in green bonds. This decline in interest would reduce total investor demand and consequently lower greenium.

bonds, allowing underwriters to price green bonds at a lower offering spread. Analysis of corporate bond holdings data further indicates that the greater demand for green bonds is driven by ESG-focused investors' almost exclusive demand for these bonds.

We also find that underwriters compress the offering yield of green bond offerings more aggressively than that of conventional bonds at the same level of investor demand. This finding aligns with anecdotal evidence that ESG-focused investors are less price-sensitive when competing for green bond offerings to meet their investment mandates.

Our study highlights the dynamic nature of greenium driven by fluctuations in investor demand for green bonds. Before 2018, the relatively small excess demand for green bonds over conventional bonds aligns with prior studies that find no significant greenium during that period. In the future, if ESG concerns decline and demand for green bonds diminishes, greenium may similarly fade. More broadly, our results emphasize the need for a multifaceted approach to studying green bond pricing, as the inherent complexity and noise in green bond markets can obscure findings, particularly when greenium is moderate.

References

- Ardia, D., Bluteau, K., Boudt, K., Inghelbrecht, K., 2020. Climate change concerns and the performance of green versus brown stocks. National Bank of Belgium, Working Paper .
- Aswani, J., Raghunandan, A., Rajgopal, S., 2023. Are carbon emissions associated with stock returns? Review of Finance, forthcoming .
- Baker, M., Bergstresser, D., Serafeim, G., Wurgler, J., 2022. The pricing and ownership of us green bonds. Annual Review of Financial Economics 14, 415–437.
- Baker, M. P., Egan, M., Sarkar, S. K., 2024. Demand for esg. NBER working paper .
- Bao, J., Pan, J., Wang, J., 2011. The illiquidity of corporate bonds. The Journal of Finance 66, 911–946.
- Barber, B. M., Morse, A., Yasuda, A., 2021. Impact investing. Journal of Financial Economics 139, 162–185.
- Becker, B., Ivashina, V., 2015. Reaching for yield in the bond market. Journal of Finance 70, 1863–1902.
- Berg, F., Koelbel, J. F., Pavlova, A., Rigobon, R., 2022. ESG confusion and stock returns: Tackling the problem of noise. National Bureau of Economic Research .
- Bessembinder, H., Jacobsen, S., Maxwell, W., Venkataraman, K., 2022. Overallocation and secondary market outcomes in corporate bond offerings. Journal of Financial Economics 146, 444–474.
- Bessembinder, H., Maxwell, W., Venkataraman, K., 2006. Market transparency, liquidity externalities, and institutional trading costs in corporate bonds. Journal of Financial Economics 82, 251–288.
- Bodnaruk, A., Rossi, M., 2016. Dual ownership, returns, and voting in mergers. Journal of Financial Economics 120, 58–80.
- Bolton, P., Kacperczyk, M., 2021. Do investors care about carbon risk? Journal of Financial Economics 142, 517–549.
- Bretscher, L., Schmid, L., Sen, I., Sharma, V., 2022. Institutional corporate bond pricing. Swiss Finance Institute Research Paper .
- Butler, A. W., Cornaggia, J., 2011. Does access to external finance improve productivity? evidence from a natural experiment. Journal of Financial Economics 99, 184–203.
- Cai, N., Helwege, J., Warga, A., 2007. Underpricing in the corporate bond market. Review of Financial Studies 20, 2021–2046.
- Capotă, L.-D., Giuzio, M., Kapadia, S., Salakhova, D., 2022. Are ethical and green investment funds more resilient? .

- Caramichael, J., Rapp, A. C., 2024. The green corporate bond issuance premium. *Journal of Banking & Finance* 162, 107126.
- Chaudhary, M., Fu, Z., Li, J., 2022. Corporate bond elasticities: Substitutes matter. Available at SSRN 4292266 .
- Chava, S., 2014. Environmental externalities and cost of capital. *Management Science* 60, 2223–2247.
- Chava, S., Efremenko, P., Salva, C., 2023. Esg and bond market resilience: Evidence from the covid crisis. Georgia Tech Scheller College of Business Research Paper .
- Chen, X., Huang, J.-Z., Sun, Z., Yao, T., Yu, T., 2020. Liquidity premium in the eye of the beholder: An analysis of the clientele effect in the corporate bond market. *Management Science* 66, 932–957.
- Chiang, J., 2017. Growing the US green bond market. California State Treasurer .
- Choi, J., Huh, Y., Shin, S. S., 2024. Customer liquidity provision: implications for corporate bond transaction costs. *Management Science* 70, 187–208.
- Choi, J., Kronlund, M., 2017. Reaching for yield in corporate bond mutual funds. *The Review of Financial Studies* 31, 1930–1965.
- Climate Bond Initiative, 2020. Green bond treasurer survey .
- Cornelli, F., Goldreich, D., 2001. Bookbuilding and strategic allocation. *Journal of Finance* 56, 2337–2369.
- Correa, R., He, A., Herpfer, C., Lel, U., 2020. The rising tide lifts some interest rates: climate change, natural disasters, and loan pricing. *Natural Disasters and Loan Pricing* .
- Dai, R., Liang, H., Ng, L., 2021. Socially responsible corporate customers. *Journal of Financial Economics* 142, 598–626.
- D’Amico, S., Klausmann, J., Pancost, N. A., 2022. The benchmark greenium. Available at SSRN 4128109 .
- Davis, C., Kargar, M., Li, J., 2023. Why is asset demand inelastic? .
- Degryse, H., Goncharenko, R., Theunisz, C., Vadasz, T., 2023. When green meets green. *Journal of Corporate Finance* 78, 102355.
- Dick-Nielsen, J., 2009. Liquidity biases in trace. *The Journal of Fixed Income* 19, 43–55.
- Döttling, R., Kim, S., 2024. Sustainability preferences under stress: Evidence from covid-19. *Journal of Financial and Quantitative Analysis* 59, 435–473.
- Dou, W. W., Johnson, S. A., Wu, W., 2022. Competition network: Distress spillovers and predictable industry returns. Working Paper, University of Pennsylvania .

- Edwards, A. K., Harris, L. E., Piwowar, M. S., 2007. Corporate bond market transaction costs and transparency. *Journal of Finance* 62, 1421–1451.
- Fatica, S., Panzica, R., 2024. Sustainable investing in times of crisis: evidence from bond holdings and the covid-19 pandemic. *Journal of Banking & Finance* 166, 107238.
- Fatica, S., Panzica, R., Rancan, M., 2021. The pricing of green bonds: are financial institutions special? *Journal of Financial Stability* 54, 100873.
- Feldstein, S. G., Fabozzi, F. J., 2008. The handbook of municipal bonds, vol. 155. John Wiley & Sons.
- Ferrell, A., Liang, H., Renneboog, L., 2016. Socially responsible firms. *Journal of Financial Economics* 122, 585–606.
- Flammer, C., 2021. Corporate green bonds. *Journal of Financial Economics* 142, 499–516.
- Flanagan, T., Kedia, S., Zhou, X. A., 2021. Assessing gains from primary market allocations in corporate bonds. Available at SSRN 3859063 .
- Giglio, S., Maggiori, M., Stroebe, J., Tan, Z., Utkus, S., Xu, X., 2023. Four facts about ESG beliefs and investor portfolios. National Bureau of Economic Research .
- Goldstein, M., Hotchkiss, E., 2020. Providing liquidity in an illiquid market: Dealer behavior in us corporate bonds. *Journal of Financial Economics* 135, 16–40.
- Goldstein, M., Hotchkiss, E., Nikolova, S., 2019. Dealer behavior and the trading of newly issued corporate bonds. Working paper, Babson College.
- Hartzmark, S. M., Sussman, A. B., 2019. Do investors value sustainability? a natural experiment examining ranking and fund flows. *The Journal of Finance* 74, 2789–2837.
- Heeb, F., Kölbel, J. F., Paetzold, F., Zeisberger, S., 2023. Do investors care about impact? *The Review of Financial Studies* 36, 1737–1787.
- Helwege, J., Wang, L., 2021. Liquidity and price pressure in the corporate bond market: Evidence from mega-bonds. *Journal of Financial Intermediation* 48, 100922.
- Hotchkiss, E., Jostova, G., 2017. Determinants of corporate bond trading: A comprehensive analysis. *Quarterly Journal of Finance* 7, 1750003.
- Hotchkiss, E., Sun, H., Wang, L., Zhao, Y., 2021. Reaching for (safer) yield, credit supply, and capital raising: Evidence from upsized corporate bond offerings. Working paper .
- Houston, J. F., Shan, H., 2022. Corporate esg profiles and banking relationships. *The Review of Financial Studies* 35, 3373–3417.
- Hsu, P.-h., Li, K., Tsou, C.-y., 2023. The pollution premium. *The Journal of Finance* 78, 1343–1392.

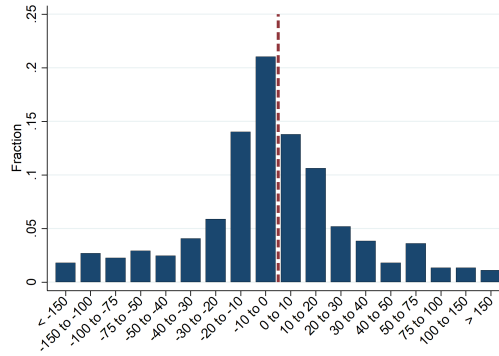
- Javadi, S., Masum, A. A., 2021. The impact of climate change on the cost of bank loans. *Journal of Corporate Finance* 69, 102019.
- Johnson, T. C., 2008. Volume, liquidity, and liquidity risk. *Journal of Financial Economics* 87, 388–417.
- Kapraun, J., Latino, C., Scheins, C., Schlag, C., 2021. (in)-credibly green: which bonds trade at a green bond premium? *Proceedings of Paris December 2019 Finance Meeting EUROFIDAI-ESSEC* .
- Kim, S., Kumar, N., Lee, J., Oh, J., 2025. Esg lending. *Journal of Financial Economics*, forthcoming .
- Koijen, R. S., Yogo, M., 2019. A demand system approach to asset pricing. *Journal of Political Economy* 127, 1475–1515.
- Larcker, D. F., Watts, E. M., 2020. Where’s the greenium? *Journal of Accounting and Economics* 69, 101312.
- Li, Q., Shan, H., Tang, Y., Yao, V., 2023. Corporate climate risk: Measurements and responses. *Review of Financial Studies*, forthcoming .
- Lou, D., Yan, H., Zhang, J., 2013. Anticipated and repeated shocks in liquid markets. *The Review of Financial Studies* 26, 1891–1912.
- Murray, S., Nikolova, S., 2022. The bond-pricing implications of rating-based capital requirements. *Journal of Financial and Quantitative Analysis* 57, 2177–2207.
- Nagler, F., Ottonello, G., 2019. Structural changes in corporate bond underpricing. Unpublished working paper. Bocconi University and Vienna Graduate School of Finance.
- Nikolova, S., Wang, L., Wu, J. J., 2020. Institutional allocations in the primary market for corporate bonds. *Journal of Financial Economics* 137, 470–490.
- Nikolova, S. S., Wang, L., 2022. Corporate bond flipping. Working paper .
- Pastor, L., Stambaugh, R. F., Taylor, L. A., 2021. Sustainable investing in equilibrium. *Journal of Financial Economics* 142, 550–571.
- Pástor, L., Stambaugh, R. F., Taylor, L. A., 2022. Dissecting green returns. *Journal of Financial Economics* 146, 403–424.
- Pedersen, L. H., Fitzgibbons, S., Pomorski, L., 2021. Responsible investing: The esg-efficient frontier. *Journal of Financial Economics* 142, 572–597.
- Ramadorai, T., Zeni, F., 2023. Climate regulation and emissions abatement: Theory and evidence from firms’ disclosures. *Management Science*, forthcoming .
- Ramelli, S., Wagner, A. F., Zeckhauser, R. J., Ziegler, A., 2018. Investor rewards to climate responsibility: Evidence from the 2016 climate policy shock. Tech. rep., National Bureau of Economic Research.

- Reghezza, A., Altunbas, Y., Marques-Ibanez, D., d'Acri, C. R., Spaggiari, M., 2022. Do banks fuel climate change? *Journal of Financial Stability* 62, 101049.
- Riedl, A., Smeets, P., 2017. Why do investors hold socially responsible mutual funds? *The Journal of Finance* 72, 2505–2550.
- Sautner, Z., Van Lent, L., Vilkov, G., Zhang, R., 2023. Pricing climate change exposure. *Management Science*, forthcoming .
- Schultz, P., 2001. Corporate bond trading costs: A peek behind the curtain. *The Journal of Finance* 56, 677–698.
- Schultz, P., 2012. The market for new issues of municipal bonds: The roles of transparency and limited access to retail investors. *Journal of Financial Economics* 106, 492–512.
- Seltzer, L., Starks, L. T., Zhu, Q., 2020. Climate regulatory risks and corporate bonds. Available at SSRN 3563271 .
- Sialm, C., Zhu, Q., 2023. Currency management by international fixed income mutual funds. *Journal of Finance*, forthcoming .
- Siani, K., 2022. Raising bond capital in segmented markets. Available at SSRN 4239841 .
- Starks, L. T., 2023. Presidential address: Sustainable finance and esg issues - value versus values. *The Journal of Finance* 78, 1837–1872.
- Tang, D. Y., Zhang, Y., 2020. Do shareholders benefit from green bonds? *Journal of Corporate Finance* 61, 101427.
- Wang, L., 2021. Lifting the veil: The price formation of corporate bond offerings. *Journal of Financial Economics* 142, 1340–1358.
- Zerbib, O. D., 2022. A sustainable capital asset pricing model (s-capm): Evidence from environmental integration and sin stock exclusion. *Review of Finance* 26, 1345–1388.

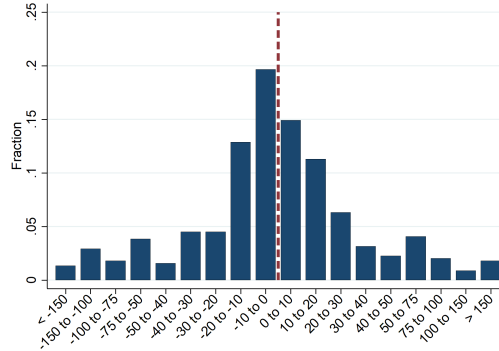
Figure 1: Pairwise differences: Matched sample

For green bonds and matched conventional bonds, this figure presents the histogram of their pairwise differences in *offering spread* (Panel A), *initial offering spread* (Panel B), and *spread compression* (Panel C). To construct the matched pairs, we first find for each green bond the conventional bonds from the same issuer offered within three years, with the same rating, currency, and seniority, and with a maturity within three years and offering amount between 50% and 200% that of the green bond. When a green bond is matched to multiple conventional bonds, we keep the conventional bond with the closest pricing date. The bins on the x-axis are in bps, whereas the y-axis shows the fraction of matched pairs in each bin. The vertical dash line locates where the x-variable equals zero. All variables are defined in Appendix B. The sample period is from January 1, 2013 to May 31, 2021.

Panel A. Pairwise differences in offering spread



Panel B. Pairwise differences in initial offering spread



Panel C. Pairwise differences in spread compression

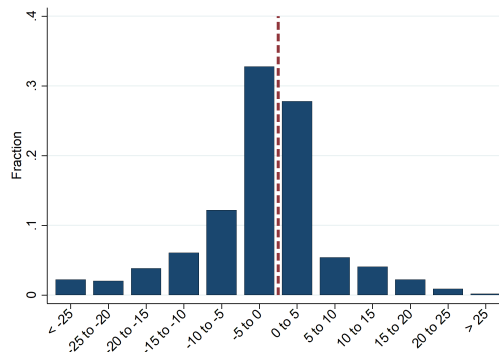
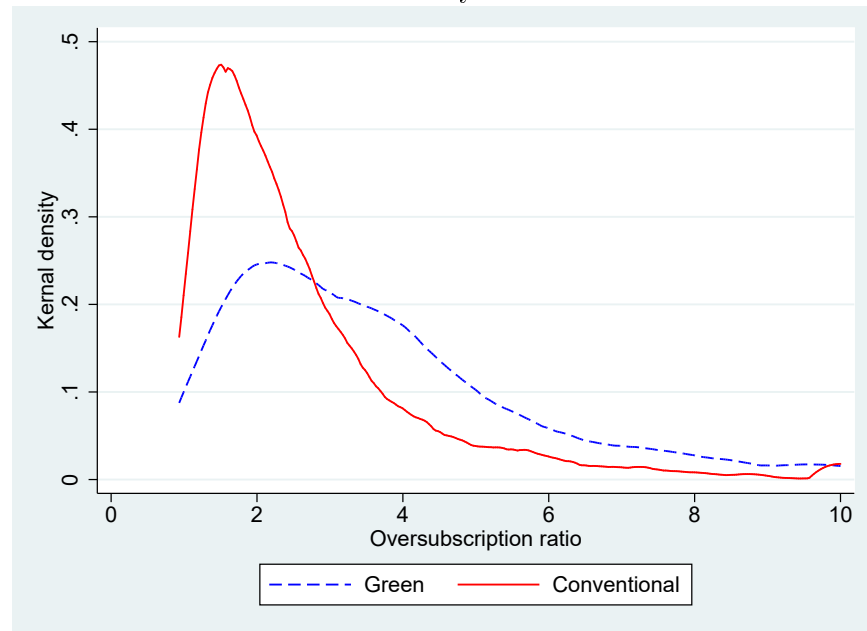


Figure 2: Investor demand

Panel A presents the density distribution of the oversubscription ratio of sample green and conventional bond offerings. *Oversubscription ratio* is the order book size scaled by the proposed offering amount. Panel B shows the quarterly average *oversubscription ratio* by green and conventional bond offerings. Green bonds offered in or before 2016 are grouped together. The sample period is from January 1, 2013 to May 31, 2021.

Panel A. Density distribution



Panel B. Average oversubscription ratio by quarter

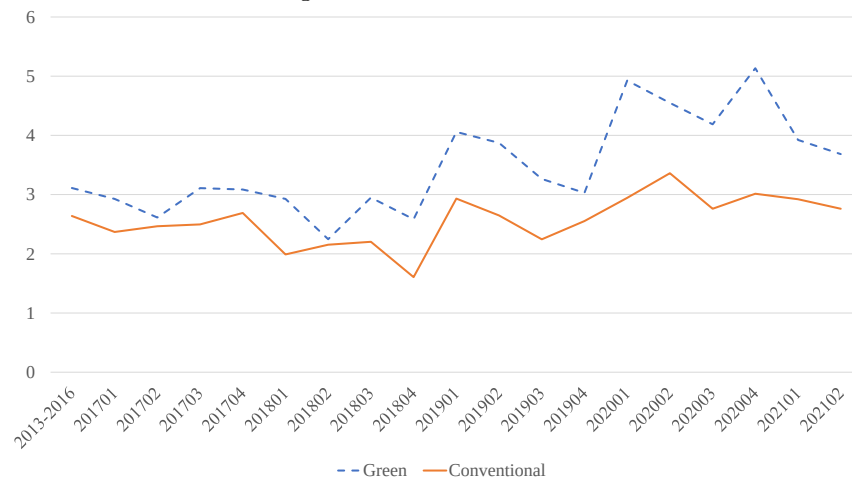


Table 1: Sample coverage

This table reports the coverage of green bonds in Bloomberg and our sample. Panels A and B display the comparison by year and by currency, respectively. *All green bonds* include all government (non-municipal) and corporate fixed- or variable-coupon nonperpetual EUR- and USD-denominated green bonds identified by Bloomberg, with non-missing offering amount and positive coupon rate. *Mean* is the average offering amount (in \$mn), and *Sum* is the total offering amount (in \$mn). *%volume covered* is the total offering amount of green bonds covered by our sample scaled by the total offering amount of *All green bonds*. The sample period is from January 1, 2013 to May 31, 2021.

Panel A. By year										
	All green bonds			Not covered by sample			Covered by sample			%volume covered
	N	Mean	Sum	N	Mean	Sum	N	Mean	Sum	
2013	16	587	9,387	6	321	1,929	10	746	7,458	79%
2014	39	487	18,991	21	131	2,757	18	902	16,234	85%
2015	199	145	28,833	162	40	6,408	37	606	22,425	78%
2016	84	527	44,232	37	316	11,699	47	692	32,533	74%
2017	107	644	68,867	35	341	11,930	72	791	56,937	83%
2018	123	579	71,245	50	231	11,555	73	818	59,690	84%
2019	236	539	127,244	107	310	33,192	129	729	94,052	74%
2020	336	408	137,189	205	206	42,328	131	724	94,860	69%
2021	276	455	125,503	156	199	31,047	120	787	94,455	75%
Total	1,416	446	631,489	779	196	152,845	637	751	478,644	76%

Panel B. By currency										
	All green bonds			Not covered by sample			Covered by sample			%volume covered
	N	Mean	Sum	N	Mean	Sum	N	Mean	Sum	
EUR	767	520	398,732	378	194	73,514	389	836	325,217	82%
USD	649	359	232,757	401	198	79,330	248	619	153,427	66%

Table 2: Summary statistics

This table presents summary statistics of bond characteristics. Each sample bond issuer has offered at least one green and one conventional bond during our sample period. All sample bonds have *spread compression* information available. Rating represents the numerical equivalent of letter ratings, with 1 corresponding to AAA, 2 to AA, and so forth. All other variables are defined in Appendix B. Panel A is for all sample bond offerings, and Panels B and C are for green and conventional bond offerings, respectively. The sample period is from January 1, 2013 to May 31, 2021.

Panel A. Full sample						
	N	Mean	25th	Median	75th	Std Dev
Green bond	4908	0.130	0.000	0.000	0.000	0.336
Initial offering spread	4672	119.031	52.050	105.000	153.450	86.463
Offering spread	4672	107.030	47.550	90.800	135.800	80.468
Spread compression	4908	-12.552	-20.000	-10.000	-2.500	11.472
Oversubscription ratio	3767	2.737	1.600	2.200	3.300	1.696
Offering amt (in \$mn)	4908	1210.680	577.748	1000.000	1411.170	999.476
Maturity (in years)	4908	8.701	5.022	7.025	10.030	6.579
Listing dummy	4908	0.717	0.000	1.000	1.000	0.451
10-year swap rate	4908	138.821	69.265	141.190	214.825	92.839
Swap rate slope	4908	92.825	46.840	87.810	128.130	64.035
Rating	4866	2.755	2.000	3.000	4.000	1.273

Panel B. Green bonds						
	N	Mean	25th	Median	75th	Std Dev
Initial offering spread	603	128.550	65.000	116.650	160.000	88.137
Offering spread	603	110.762	58.000	96.500	135.000	80.313
Spread compression	637	-18.333	-27.000	-17.500	-5.500	13.537
Oversubscription ratio	503	3.622	2.000	3.200	4.571	2.000
Offering amt (in \$mn)	637	738.563	500.000	590.405	840.630	545.951
Maturity (in years)	637	9.002	5.025	7.036	10.030	6.096
Listing dummy	637	0.830	1.000	1.000	1.000	0.376
10-year swap rate	637	92.834	9.880	81.650	160.320	90.883
Swap rate slope	637	71.125	34.910	61.000	105.100	50.030
Rating	630	3.087	2.000	3.000	4.000	1.242

Table 2: Summary statistics - continued

	Panel C. Conventional bonds					
	N	Mean	25th	Median	75th	Std Dev
Initial offering spread	4069	117.621	50.750	103.000	152.500	86.134
Offering spread	4069	106.477	47.000	90.000	136.000	80.486
Spread compression	4271	-11.689	-17.500	-10.000	-2.500	10.873
Oversubscription ratio	3264	2.600	1.533	2.100	3.000	1.601
Offering amt (in \$mn)	4271	1281.090	600.000	1000.000	1500.000	1032.170
Maturity (in years)	4271	8.656	5.022	7.022	10.027	6.647
Listing dummy	4271	0.700	0.000	1.000	1.000	0.458
10-year swap rate	4271	145.679	73.620	153.710	220.850	91.171
Swap rate slope	4271	96.062	49.530	90.080	133.280	65.258
Rating	4236	2.705	2.000	3.000	4.000	1.270

Table 3: Price formation

This table presents estimation results of the pricing dynamics in the primary market. The dependent variable is *offering spread* in columns (1)-(3), *initial offering spread* in columns (4)-(6), and *spread compression* in columns (7)-(9). Columns (1), (4), and (7) present results for the full sample, columns (2), (5), and (8) present results for the corporate subsample, and columns (3), (6), and (9) present results for the SSA subsample. All variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread			Initial offering spread			Spread compression		
	All (1)	Corporate (2)	SSA (3)	All (4)	Corporate (5)	SSA (6)	All (7)	Corporate (8)	SSA (9)
Green bond	-5.419*** (1.891)	-6.250*** (2.387)	-4.193* (2.245)	-2.804 (1.947)	-3.807 (2.445)	-2.967 (2.278)	-2.352*** (0.385)	-1.966*** (0.458)	-1.499*** (0.487)
log(offering amount)	6.616*** (1.862)	10.163*** (2.128)	-1.171 (2.811)	8.088*** (1.936)	12.439*** (2.169)	-0.791 (2.943)	-1.477*** (0.355)	-2.313*** (0.457)	-0.504* (0.281)
log(maturity)	22.553*** (1.925)	27.719*** (1.934)	7.087*** (1.507)	22.332*** (1.903)	27.211*** (1.914)	7.426*** (1.629)	0.128 (0.246)	0.521* (0.293)	-0.695 (0.446)
Listing dummy	2.392 (2.985)	0.109 (3.760)	-8.973** (3.717)	1.785 (3.095)	-0.215 (3.865)	-7.995** (3.897)	0.680 (0.541)	0.306 (0.703)	-0.897 (0.814)
10-year swap rate	0.073*** (0.020)	0.098*** (0.026)	-0.017 (0.016)	0.068*** (0.020)	0.091*** (0.026)	-0.021 (0.020)	0.007** (0.003)	0.009** (0.004)	0.006 (0.005)
Swap rate slope	0.055*** (0.014)	0.061*** (0.018)	0.045*** (0.015)	0.061*** (0.014)	0.068*** (0.018)	0.040** (0.016)	-0.006** (0.003)	-0.006* (0.004)	0.003 (0.002)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Format FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,668	3,552	1,114	4,668	3,552	1,114	4,907	3,748	1,157
R-squared	0.830	0.780	0.919	0.847	0.794	0.930	0.709	0.640	0.882

Table 4: Robustness - Control for issuer characteristics and issuer-year fixed effects

This table shows the robustness of our price formation results after controlling for issuer characteristics for corporate bond offerings in columns (1)-(3) and controlling for issuer-year fixed effects for all sample bond offerings in columns (4)-(6). The dependent variable is *offering spread* in columns (1) and (4), *initial offering spread* in columns (2) and (5), and *spread compression* in columns (3) and (6). $\log(\text{Asset})$ is the natural logarithm of the total asset of the issuer, *Return on assets* is the issuer's net income over total assets, and *Leverage* is the issuer's total debt over total assets. Other controls include $\log(\text{Offering amount})$, $\log(\text{Maturity})$, *Listing dummy*, *10-year swap rate*, and *Swap rate slope*, and are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Corporate bond subsample			Full sample		
	Offering spread (1)	Initial offering spread (2)	Spread compression (3)	Offering spread (4)	Initial offering spread (5)	Spread compression (6)
Green bond	-8.023** (3.561)	-5.363 (3.614)	-2.280*** (0.610)	-6.010*** (2.268)	-4.106* (2.370)	-1.426*** (0.400)
$\log(\text{Assets})$	-10.675 (13.956)	-8.647 (13.632)	-3.821* (2.024)			
Return on assets	-175.611 (141.193)	-138.283 (130.852)	-38.780 (27.280)			
Leverage	125.392*** (42.957)	128.448*** (41.532)	1.079 (8.073)			
Other controls	Yes	Yes	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes	Yes	Yes
Format FE	Yes	Yes	Yes	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	No	No	No
Year FE	Yes	Yes	Yes	No	No	No
Issuer-year FE	No	No	No	Yes	Yes	Yes
Observations	2,100	2,100	2,189	3,975	3,975	4,169
R-squared	0.752	0.762	0.609	0.896	0.907	0.840

Table 5: Price formation: Matched sample

For green bonds and matched conventional bonds, this table reports their pairwise differences in mean and median of *offering spread*, *initial offering spread*, and *spread compression*. For each green bond, we first find from the same issuer the conventional bonds offered within three years, with the same letter rating, currency, and seniority, and with a maturity within three years and offering amount between 50% and 200% that of the green bond. When a green bond is matched to multiple conventional bonds, we keep the conventional bond with the closest pricing date. All variables are defined in Appendix B. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	N	Green		Conventional		Pairwise dif	Pairwise dif
	(1)	Mean	Median	Mean	Median	in mean	in median
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
All							
Offering spread	442	107.148	95.600	112.589	100.000	-5.441**	-4.600***
Initial offering spread	442	124.443	115.200	126.795	115.000	-2.351	-1.615
Spread compression	442	-17.166	-17.000	-14.269	-14.500	-2.897***	-1.375***
Corporate							
Offering spread	342	125.366	106.950	132.235	110.650	-6.869**	-4.650***
Initial offering spread	342	146.423	130.000	149.682	127.750	-3.259	-0.600
Spread compression	342	-20.720	-20.000	-17.361	-15.500	-3.359***	-2.500***
SSA							
Offering spread	100	44.840	25.150	45.401	28.025	-0.560	-4.375**
Initial offering spread	100	49.274	26.850	48.520	29.500	0.754	-3.575
Spread compression	100	-5.010	-2.000	-3.695	-1.000	-1.315***	-1.000***

Table 6: Investor demand

This table presents estimation results of investor demand in the primary market. The dependent variable is *oversubscription ratio*. Columns (1), (2), and (3) present results for the full sample, the corporate subsample, and the SSA subsample, respectively. All variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Oversubscription		
	All (1)	Corporate (2)	SSA (3)
Green bond	0.397*** (0.111)	0.538*** (0.104)	0.302 (0.264)
log(offering amount)	-0.571*** (0.095)	-0.714*** (0.093)	-0.178 (0.186)
log(maturity)	0.229*** (0.052)	0.233*** (0.063)	0.215** (0.106)
Listing dummy	-0.247** (0.122)	-0.072 (0.112)	-0.037 (0.156)
10-year swap rate	0.002*** (0.001)	0.002** (0.001)	0.001 (0.001)
Swap rate slope	0.000 (0.001)	0.001 (0.001)	-0.001 (0.001)
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	3,746	2,887	856
R-squared	0.474	0.470	0.553

Table 7: ESG-focused investors and primary market outcomes

This table presents the impact of ESG-focused investors' demand on primary market outcomes. The dependent variable is *oversubscription ratio*, *initial offering spread*, *spread compression*, and *offering spread* in columns (1)-(4), respectively. $Demand^{ESG}$ ($Demand^{MF}$) is a proxy for ESG-focused investors' (mutual funds') demand in the primary market for a bond offering, calculated as the average holdings of similar bonds by ESG-focused investors (mutual funds) in the offering quarter of the new offering in eMAXX data on global corporate bond holdings. Similar bonds include outstanding corporate bonds that share the same green/non-green label, currency, and credit quality as the new offering, with a time-to-maturity within three years of the new offering. $Demand^{ESG}$ and $Demand^{MF}$ are in percentage points. All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. This sample includes corporate bonds, and the sample period is from January 1, 2018 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Oversubscription (1)	Initial offering spread (2)	Spread compression (3)	Offering spread (4)
$Demand^{ESG}$	0.190*** (0.047)	-2.403** (0.948)	-0.570*** (0.183)	-3.149*** (0.928)
$Demand^{MF}$	-0.030* (0.016)	-0.090 (0.271)	0.012 (0.064)	0.007 (0.274)
log(offering amount)	-0.788*** (0.142)	6.506 (4.119)	-1.937*** (0.699)	4.913 (4.072)
log(maturity)	-0.013 (0.105)	26.811*** (2.546)	0.979** (0.437)	27.963*** (2.596)
Listing dummy	-0.081 (0.227)	7.929 (6.312)	-1.638 (1.371)	5.930 (6.257)
10-year swap rate	0.003** (0.002)	0.112** (0.043)	0.010 (0.006)	0.119*** (0.044)
Swap rate slope	0.006*** (0.001)	-0.032 (0.031)	0.002 (0.007)	-0.034 (0.030)
Rating FE	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes
Format FE	Yes	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	1,360	1,600	1,722	1,600
R-squared	0.565	0.777	0.691	0.758

Table 8: Price sensitivity to demand

This table shows the impact of ESG-focused investors on the price-to-demand sensitivity of bond offerings. The dependent variable is *offering spread*. Columns (1) to (3) cover our full sample between 1/1/2013 and 5/31/2021. Columns (4) and (5) include corporate bond offerings issued between 1/1/2018 and 5/31/2021 for which we can construct proxies for ESG-focused investors' and mutual funds' demand in the primary market for a corporate bond offering using eMAXX data on global corporate bond holdings. $Demand^{ESG}$ ($Demand^{MF}$) is calculated as the average holdings of similar bonds by ESG-focused investors (mutual funds) in the offering quarter. Similar bonds include outstanding corporate bonds that share the same green/non-green label, currency, and credit quality as the new offering, with a time-to-maturity within three years of the new offering. $Demand^{ESG}$ and $Demand^{MF}$ are in percentage points. $\log(\text{Oversubscription ratio})$ is the natural logarithm of the oversubscription ratio. Other controls include $\log(\text{Offering amount})$, $\log(\text{Maturity})$, *Listing dummy*, *10-year swap rate*, and *Swap rate slope*. FEs include Rating, Currency, Format, Seniority, Issuer, and Year fixed effects. All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread				
	All (1)	Corporate (2)	SSA (3)	Corporate (4)	Corporate (5)
Initial offering spread	0.961*** (0.005)	0.965*** (0.005)	0.981*** (0.019)	0.968*** (0.009)	0.969*** (0.009)
$\log(\text{Oversubscription})$	-4.431*** (0.601)	-6.458*** (0.474)	-2.048*** (0.575)	-7.558*** (0.671)	-7.582*** (0.754)
$\log(\text{Oversubscription}) \times \text{Green bond}$	-3.004*** (0.881)	-2.756*** (1.044)	-1.220 (1.650)		
Green bond	1.161 (0.821)	1.819* (1.082)	0.053 (1.101)		
$\log(\text{Oversubscription}) \times Demand^{ESG}$				-0.570** (0.231)	
$Demand^{ESG}$				0.360 (0.292)	
$\log(\text{Oversubscription}) \times \frac{Demand^{ESG}}{Demand^{MF}}$					-0.094* (0.053)
$\frac{Demand^{ESG}}{Demand^{MF}}$					0.078 (0.061)
Other controls	Yes	Yes	Yes	Yes	Yes
FEs	Yes	Yes	Yes	Yes	Yes
Observations	3,618	2,788	826	1,293	1,293
R-squared	0.995	0.994	0.998	0.995	0.995

Table 9: Underpricing

This table examines whether greenium is reversed in the secondary market. The dependent variable, *underpricing*, is the yield change from the offering yield to the secondary market yield on (7 days after) [28 days after] the offering date in columns (1)-(3) (columns (4)-(6)) [columns (7)-(9)], adjusted for changes of currency-, rating-, and maturity-matched ICE BofA indexes. Secondary market yield is the mid-quote of yield to maturity obtained from Bloomberg. All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	On the offering date			7 days after offering			28 days after offering		
	All (1)	Corporate (2)	SSA (3)	All (4)	Corporate (5)	SSA (6)	All (7)	Corporate (8)	SSA (9)
Green bond	-0.807** (0.376)	-0.762* (0.457)	-0.630 (0.727)	-0.674 (0.725)	-1.095 (0.923)	0.410 (1.108)	-0.284 (0.866)	-0.279 (1.103)	-0.064 (1.435)
log(offering amount)	-0.086 (0.338)	-0.067 (0.440)	-0.086 (0.592)	0.183 (0.684)	0.651 (0.905)	0.333 (0.882)	0.463 (0.853)	0.344 (1.137)	1.173 (1.137)
log(maturity)	0.245 (0.267)	0.519 (0.346)	-0.172 (0.443)	-0.191 (0.882)	-0.650 (1.236)	0.118 (0.859)	-0.410 (0.961)	-0.911 (1.324)	0.138 (0.928)
Listing dummy	0.392 (0.534)	0.759 (0.766)	-0.332 (1.161)	2.215 (1.465)	3.418 (2.274)	-0.902 (1.851)	1.123 (1.587)	1.574 (2.411)	-3.674 (4.013)
10-year swap rate	-0.010** (0.005)	-0.014** (0.006)	-0.003 (0.007)	-0.004 (0.010)	0.011 (0.011)	-0.041** (0.017)	-0.009 (0.012)	0.013 (0.014)	-0.062*** (0.022)
Swap rate slope	-0.000 (0.004)	0.005 (0.005)	-0.012** (0.006)	-0.029*** (0.008)	-0.032*** (0.010)	-0.024** (0.011)	-0.032*** (0.009)	-0.033*** (0.012)	-0.031*** (0.011)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Format FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4,006	2,961	1,044	3,446	2,579	864	3,461	2,588	870
R-squared	0.227	0.260	0.107	0.407	0.436	0.147	0.392	0.428	0.157

Table 10: Heterogeneous demand for green bonds

This table examines the heterogeneity of investor demand using the subsample of green bond offerings. The dependent variable is *oversubscription ratio*. *Relative initial spread* is the offering's initial yield over the yield of currency- and rating-matched Barclays' index. AAA, AA,..., and B are letter rating indicators. *First green* is an indicator variable that equals one if the green bond is the first offered by an issuer, and zero for subsequent green offerings. *Post-2018* equals one if a bond is offered between 2019 and 2021, and zero otherwise. *Dark* (the omitted group), *Medium*, *Light*, and *Unclassified green* equal one if the ESG project categories of the bond offering obtained from Bloomberg are renewable energy; green buildings and infrastructure or energy smart technologies and energy efficiency; other projects; and unclassified, respectively, and zero otherwise. *Second-party opinion* is an indicator variable that equals one if the green bond has an assurance provider, and zero otherwise. Other controls include *log(Offering amount)*, *log(Maturity)*, *Listing dummy*, *10-year swap rate*, *Swap rate slope*, and an indicator of whether the issuer is SSA. Other FEs include Currency, Format, and Seniority fixed effects. All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Oversubscription	
	(1)	(2)
Relative initial spread	0.002 (0.002)	0.006 (0.005)
AA	0.895** (0.365)	0.303 (0.579)
A	1.070*** (0.390)	-0.611 (0.713)
BBB	1.428*** (0.394)	-0.615 (0.997)
BB	0.718 (0.512)	-0.273 (1.652)
B	3.690*** (0.860)	
First green	0.513*** (0.183)	0.880*** (0.265)
Post-2018	0.724*** (0.275)	0.916** (0.364)
Medium green	-0.083 (0.280)	-0.584 (0.403)
Light green	-0.096 (0.416)	-0.881 (0.587)
Unclassified green	-0.092 (0.199)	-0.575** (0.229)
Second party opinion	-0.165 (0.309)	-0.682 (0.418)
Other controls	Yes	Yes
Issuer FE	No	Yes
Other FEs	Yes	Yes
Observations	475	338
R-squared	0.276	0.609

Appendix

Appendix A. Excerpts from Voluntary Process Guidelines for Issuing Green Bonds

The Voluntary Process Guidelines for Issuing Green Bonds, published by Green Bond Principles (GBP) in June 2021, establish the principles for issuing green bonds. We provide excerpts from the guidelines to illustrate the recommended practice for issuing and maintaining green bonds.³³

Core Components

1. Use of Proceeds: The cornerstone of a Green Bond is the utilization of the proceeds of the bond for eligible Green Projects, which should be appropriately described in the legal documentation of the security. All designated eligible Green Projects should provide clear environmental benefits, which will be assessed and, where feasible, quantified by the issuer.
2. Process for Project Evaluation and Selection: The issuer of a Green Bond should clearly communicate to investors the environmental sustainability objectives of the eligible Green Projects; the process by which the issuer determines how the projects fit within the eligible Green Projects categories; and complementary information on processes by which the issuer identifies and manages perceived social and environmental risks associated with the relevant project(s).
3. Management of Proceeds: The net proceeds of the Green Bond, or an amount equal to these net proceeds, should be credited to a sub-account, moved to a sub-portfolio or otherwise tracked by the issuer in an appropriate manner, and attested to by the issuer in a formal internal process linked to the issuer's lending and investment operations for eligible Green Projects.
4. Reporting: Issuers should make, and keep, readily available up to date information on the use of proceeds to be renewed annually until full allocation, and on a timely basis in case of material developments. The annual report should include a list of the projects to which Green Bond proceeds have been allocated, as well as a brief description of the projects, the amounts allocated, and their expected impact.

Key Recommendations

1. Bond Frameworks: Issuers should explain the alignment of their Green Bond or Green Bond programme with the four core components of the GBP in a Green Bond Framework or in their legal documentation.

³³For the full document, see <https://www.icmagroup.org/assets/documents/Sustainable-finance/2021-updates/Green-Bond-Principles-June-2021-140621.pdf>

2. External Reviews: It is recommended that issuers appoint (an) external review provider(s) to assess through a pre-issuance external review the alignment of their Green Bond or Green Bond programme and/or Framework with the four core components of the GBP as defined above. Post issuance, it is recommended that an issuer's management of proceeds be supplemented by the use of an external auditor, or other third party, to verify the internal tracking and the allocation of funds from the Green Bond proceeds to eligible Green Projects.

Appendix B. Variable definitions

Green bond is a indicator of whether a bond is labeled as a green instrument by Bloomberg.

Data source: Bloomberg

Offering yield is the yield at issuance. Data source: IFR and Bloomberg

Offering spread is the offering yield over the government benchmark rate at issuance.

Data source: IFR and Bloomberg

Oversubscription ratio is the the order book size scaled by the proposed offering amount.

Data source: IFR

Spread compression is the spread change from the midpoint of the initial spread/yield range to the offering spread/yield. Data source: IFR and Bloomberg

Initial offering spread (yield) is offering spread (yield) minus spread compression.

Offering amount is the USD-equivalent offering amount in millions. Data source: IFR and Bloomberg

Maturity is the maturity at issuance in years. Data source: IFR

Listing dummy is an indicator of whether an offering is listed. Data source: IFR

10-year swap rate is the 10-year interest rate swap rate of the denominated currency of the bond. Data source: Bloomberg

Swap rate slope is the difference between the 10- and 1-year interest rate swap rates of the denominated currency of the bond. Data source: Bloomberg

Rating represents the numerical equivalent of letter ratings, with 1 corresponding to AAA, 2 to AA, and so forth. Data source: IFR

Format includes SEC registered, Reg S only, Rule 144A/Reg S and Rule 144A, and others. Data source: IFR

Currency includes USD and EUR. Data source: IFR

Relative initial spread is the difference between the offering's initial offering yield and the yield of currency- and rating-matched Barclays' index. Data source: IFR and Bloomberg

Underpricing on (7 days after) [28 days after] the offering date is the yield change from the offering yield to the secondary market yield on (7 days after) [28 days after] the offering date, adjusted for changes of currency-, rating-, and maturity- matched ICE BofA indexes. Secondary market yield is the mid-quote of yield to maturity obtained from Bloomberg. Data source: IFR and Bloomberg

Appendix C. An example of green bond offerings

This appendix shows the excerpts of IFR's news related to Apple Inc's \$1 billion 10-year green bond announced and priced on June 13, 2017. This bond is an SEC-registered senior unsecured offering. The use of proceeds is as follows, "An amount equal to such net proceeds will be allocated to one or more Eligible Projects (as defined below). Eligible Projects may include projects of our subsidiaries that meet the Eligibility Criteria (as defined below) set forth below. We plan to identify Eligible Projects that fall within three environmental priorities where we believe we can make the most environmentally positive impact: 1. Reduce our impact on climate change by using renewable energy sources and driving energy efficiency in our facilities, products and supply chain. 2. Pioneer the use of greener materials in our products and processes. 3. Conserve resources."

4:46 am - The bond offering is announced, with the details about the offering amount, tenor, credit rating, format, callable features, bookrunners, and use of proceeds. The IPT is T+95-100 bps.

7:23 am - An update states, "The nearest comparable for the new bonds is an outstanding Apple 3.2% May 2027 that were trading at a G spread of 83bp. ..., the IPT levels imply 12bp-17bp in new issue concessions. These levels are very likely to be tightened during bookbuilding so bankers expect the bonds to end up pricing with little to no new issue concessions, as has become the norm in the hot high-grade primary market."

8:51 am - Guidance is announced, with the price range updated to T+85 area.

9:43 am - Launch is announced, with the offering spread set at T+82 bps.

12:09 pm - The bond is announced to be priced, with the coupon and bond price set that the offering spread is 82 bps over the benchmark Treasuries.

15:52 pm - IFR provides another update on the offering with the following information, "[t]ech giant Apple notched up a US\$3.5bn book for its new US\$1bn 10-year Green bond on Tuesday which priced with no new issue premium."

Appendix D. Additional tests

Table D1: Offering yield

This table reports robustness tests of greenium. Columns (1)-(3) are the same as columns (1)-(3) of Table 3, except that the left-hand side variable is the offering yield. All variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	All (1)	Corporate (2)	SSA (3)
Green bond	-7.486*** (2.342)	-9.820*** (2.954)	-2.478 (3.080)
log(offering amount)	10.151*** (2.316)	10.062*** (2.682)	10.277** (4.428)
log(maturity)	86.615*** (2.456)	89.039*** (3.104)	83.027*** (3.865)
Listing dummy	-1.992 (4.420)	-2.361 (6.405)	-10.350 (10.255)
10-year swap rate	1.176*** (0.030)	1.174*** (0.038)	1.148*** (0.051)
Swap rate slope	-0.376*** (0.026)	-0.310*** (0.035)	-0.497*** (0.036)
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,229	3,114	1,113
R-squared	0.915	0.913	0.926

Table D2: Subsample analysis

This table shows estimation results of the pricing dynamics in the primary market for subsamples. Panel A shows estimation results for EUR-denominated bond offerings (columns (1)-(3)) and USD-denominated bond offerings (columns (4)-(6)). Panel B shows estimation results for non-financial corporate bond offerings (columns (1)-(3)) and financial corporate bond offerings (columns (4)-(6)). The dependent variables include *offering spread* in columns (1) and (4), *initial offering spread* in columns (2) and (5), and *spread compression* in columns (3) and (6). These regressions include all control variables and fixed effects shown in Table 3. Robust standard errors clustered at the issuer level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Panel A. Subsamples by denomination currency						
	EUR-denominated bonds			USD-denominated bonds		
	Offering spread (1)	Initial offering spread (2)	Spread compression (3)	Offering spread (4)	Initial offering spread (5)	Spread compression (6)
Green Bond	-5.162** (2.380)	-1.757 (2.409)	-3.286*** (0.509)	-4.917* (2.786)	-3.151 (2.950)	-1.778*** (0.519)
Controls and FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,334	2,334	2,334	2,303	2,303	2,303
R-squared	0.833	0.849	0.726	0.868	0.883	0.767
Panel B. Subsamples by industry						
	Corporate - nonfinancial			Corporate - financial		
	Offering spread (1)	Initial offering spread (2)	Spread compression (3)	Offering spread (4)	Initial offering spread (5)	Spread compression (6)
Green bond	-10.099** (4.372)	-8.274* (4.421)	-1.548** (0.717)	-4.190 (2.823)	-2.308 (2.947)	-1.897*** (0.481)
Controls and FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,307	1,307	1,307	2,240	2,240	2,240
R-squared	0.771	0.777	0.596	0.774	0.791	0.645

Table D3: Robustness - Compared to post-green conventional bonds

This table shows the robustness of our price formation results using the green bonds and the conventional bonds offered on or after the date when the issuer's first green bond is offered. The dependent variables include *offering spread* in column (1), *initial offering spread* in column (2), and *spread compression* in column (3). All variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread (1)	Initial offering spread (2)	Spread compression (3)
Green bond	-5.509*** (2.046)	-4.063* (2.145)	-1.167*** (0.370)
log(offering amount)	3.680* (1.877)	4.673** (1.920)	-0.883** (0.346)
log(maturity)	22.056*** (2.586)	21.703*** (2.542)	0.310 (0.292)
Listing dummy	3.374 (4.175)	3.518 (4.201)	0.362 (0.734)
10-year swap rate	0.053** (0.026)	0.048* (0.027)	0.006 (0.005)
Swap rate slope	0.057*** (0.019)	0.061*** (0.019)	-0.002 (0.004)
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	2,459	2,459	2,530
R-squared	0.813	0.841	0.799

Table D4: Robustness - Control for underwriter fixed effects

This table reports robustness tests of our price formation results, controlling for underwriter fixed effects. The dependent variables include *offering spread* in column (1), *initial offering spread* in column (2), and *spread compression* in column (3). All variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread (1)	Initial offering spread (2)	Spread compression (3)
Green bond	-4.487* (2.345)	-1.983 (2.424)	-2.374*** (0.398)
log(offering amount)	4.479** (1.863)	6.065*** (1.943)	-1.530*** (0.319)
log(maturity)	22.429*** (1.954)	22.105*** (1.941)	0.216 (0.229)
Listing dummy	2.567 (2.990)	1.788 (3.082)	0.659 (0.551)
10-year swap rate	0.080*** (0.020)	0.078*** (0.019)	0.004 (0.003)
Swap rate slope	0.045*** (0.015)	0.050*** (0.015)	-0.007** (0.003)
UW FE	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,661	4,661	4,900
R-squared	0.843	0.858	0.741

Table D5: Robustness - Control for covenants

This table reports robustness tests of our price formation results, controlling for the number of covenants. The dependent variables include *offering spread* in column (1), *initial offering spread* in column (2), and *spread compression* in column (3). Covenants in this table include negative pledge, M&A restriction, restriction, cross-default, change of control, fundamental change, coverage ratio, asset sales, debt limit, and restricted payment. We calculate the number of covenants by counting the number of covenants that take the value of “Y”. All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread (1)	Initial offering spread (2)	Spread compression (3)
Green bond	-5.713** (2.311)	-2.917 (2.370)	-2.474*** (0.458)
log(offering amount)	7.442*** (1.588)	8.810*** (1.604)	-1.448*** (0.380)
log(maturity)	24.917*** (2.079)	24.867*** (2.063)	-0.064 (0.266)
Listing dummy	-0.281 (3.080)	-1.376 (3.162)	1.007 (0.619)
10-year swap rate	0.062*** (0.023)	0.056** (0.023)	0.007** (0.004)
Swap rate slope	0.065*** (0.016)	0.074*** (0.016)	-0.008** (0.003)
Number of covenants	-0.466 (0.761)	-0.593 (0.766)	0.131 (0.164)
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	3,543	3,543	3,751
R-squared	0.844	0.859	0.707

Table D6: Robustness - Exclude offerings with ambiguous IPT

This table reports robustness tests of our price formation results, excluding offerings whose initial offering pricing is ambiguous. In particular, we exclude offerings when ambiguous words such as “high”, “medium”, and “low” show in the initial offering pricing. The dependent variables include *offering spread* in column (1), *initial offering spread* in column (2), and *spread compression* in column (3). All variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread (1)	Initial offering spread (2)	Spread compression (3)
Green bond	-6.351*** (2.013)	-3.799* (2.063)	-2.310*** (0.393)
log(offering amount)	5.999*** (1.934)	6.935*** (1.977)	-1.094*** (0.323)
log(maturity)	22.585*** (1.970)	22.375*** (1.961)	0.124 (0.244)
Listing dummy	2.023 (3.272)	1.882 (3.413)	0.363 (0.553)
10-year swap rate	0.094*** (0.024)	0.090*** (0.024)	0.006* (0.003)
Swap rate slope	0.054*** (0.016)	0.065*** (0.016)	-0.010*** (0.003)
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,158	4,158	4,377
R-squared	0.825	0.843	0.733

Table D7: Matched sample analysis - Multivariate results

This table reports robustness results of estimating equation (1) using the matched sample. All variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread (1)	Initial offering spread (2)	Spread compression (3)
Green bond	-6.269** (2.812)	-3.575 (2.798)	-2.503*** (0.508)
log(offering amount)	1.083 (4.748)	2.132 (4.870)	-1.179 (0.759)
log(maturity)	22.204*** (5.551)	21.456*** (5.844)	0.745 (0.732)
Listing dummy	5.930 (7.011)	7.887 (7.210)	-1.592 (1.360)
10-year swap rate	0.036 (0.059)	0.021 (0.060)	0.011 (0.010)
Swap rate slope	-0.020 (0.041)	-0.018 (0.041)	0.001 (0.007)
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	884	884	884
R-squared	0.867	0.883	0.838

Table D8: Liquidity

This table examines whether green bonds have better liquidity than conventional bonds. For all sample bonds whose trades are reported in TRACE, we obtain their trade information for the second half year post issuance. This way, all bonds are of similar age, one of the most important determinants of liquidity (Hotchkiss and Jostova (2017)). Also, we can avoid the immediate secondary market when bonds are most actively traded and, thus, have abnormal liquidity (Helwege and Wang (2021), Goldstein et al. (2019)). After the standard data cleaning process (Dick-Nielsen (2009)) and excluding retail-sized trades (<\$100,000), we calculate the trade-level bid-ask spread as $2Q \times \frac{\text{traded price} - \text{reference price}}{\text{reference price}}$, where Q is +1 for a customer buy and -1 for a customer sell (Choi, Huh, and Shin (2024)). For each customer trade, its reference price is the volume-weighted average price of inter-dealer trades in the same trading day. The dependent variable is trade-level bid-ask spread in bps in column (1) and bond-day level bid-ask spread in bps in column (2), calculated by taking the daily volume-weighted average bid-ask spread. Age is calculated as (trade date - offering date)/365, and time-to-maturity is (maturity date - trade date)/365. $\log(\text{trade volume})$ is the natural logarithm of the trade volume. Customer buy dummy equals one if RPT_SIDE_CD is "S", and zero otherwise. All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. This sample consists of 100 green bonds and 1,147 conventional bonds from our main sample. The sample period is from January 1, 2013 to May 31, 2021. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Bid-ask spread	
	Trade-level (1)	Bond-day level (2)
Green bond	-2.000 (1.613)	-0.909 (1.734)
$\log(\text{offering amount})$	-1.977 (1.212)	-4.379*** (1.084)
Age	1.772 (1.503)	4.402** (1.680)
Time-to-maturity	0.556*** (0.072)	0.594*** (0.075)
$\log(\text{trade volume})$	-5.059*** (0.655)	
Customer buy dummy	8.032*** (0.985)	
Issuer FE	Yes	Yes
Trade date FE	Yes	Yes
Rating FE	Yes	Yes
Format FE	Yes	Yes
Seniority FE	Yes	Yes
Observations	173,354	47,199
R-squared	0.084	0.114

Table D9: Removing the first green bond offerings

This table shows primary bond market outcomes after removing the first green bond offerings from our full sample. The dependent variables include *oversubscription ratio* in column (1), *offering spread* in column (2), *initial offering spread* in column (3), and *spread compression* in column (4). All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Oversubscription (1)	Offering spread (2)	Initial offering spread (3)	Spread compression (4)
Green bond	0.266* (0.136)	-3.561 (2.546)	-0.702 (2.605)	-2.396*** (0.513)
log(offering amount)	-0.507*** (0.094)	7.126*** (1.900)	8.517*** (1.972)	-1.416*** (0.362)
log(maturity)	0.239*** (0.053)	22.529*** (1.980)	22.327*** (1.963)	0.070 (0.254)
Listing dummy	-0.270** (0.117)	2.741 (3.052)	2.249 (3.164)	0.506 (0.554)
10-year swap rate	0.002** (0.001)	0.076*** (0.021)	0.071*** (0.020)	0.007** (0.003)
Swap rate slope	0.000 (0.001)	0.058*** (0.014)	0.064*** (0.014)	-0.006* (0.003)
Rating FE	Yes	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes	Yes
Format FE	Yes	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Observations	3,532	4,392	4,392	4,618
R-squared	0.468	0.825	0.842	0.706

Table D10: Greenium before and after 2018

This table shows pricing dynamics before and after 2018. The dependent variables include *offering spread* in column (1), *initial offering spread* in column (2), and *spread compression* in column (3). *Green bond pre-2018 (post-2018)* equals one if the green bond is offered in or before (after) 2018, and zero otherwise. All other variables are defined in Appendix B. Robust standard errors clustered at the issuer level are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	Offering spread (1)	Initial offering spread (2)	Spread compression (3)
Green bond pre-2018	-4.494** (2.207)	-3.725 (2.293)	-0.925** (0.414)
Green bond post-2018	-6.152** (2.888)	-2.074 (2.984)	-3.418*** (0.581)
log(offering amount)	6.665*** (1.875)	8.039*** (1.954)	-1.401*** (0.357)
log(maturity)	22.554*** (1.926)	22.331*** (1.903)	0.131 (0.247)
Listing dummy	2.375 (2.986)	1.802 (3.093)	0.651 (0.543)
10-year swap rate	0.073*** (0.020)	0.068*** (0.020)	0.007** (0.003)
Swap rate slope	0.055*** (0.014)	0.062*** (0.014)	-0.006** (0.003)
Rating FE	Yes	Yes	Yes
Currency FE	Yes	Yes	Yes
Format FE	Yes	Yes	Yes
Seniority FE	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Observations	4,668	4,668	4,907
R-squared	0.830	0.847	0.710