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“Do carbon emissions affect the cost of capital? Primary versus secondary corporate bond markets”

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Do carbon emissions affect the cost of capital? Primary versus secondary corporate bond markets *

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Abstract

We empirically study whether carbon emissions affect firms' cost of capital raised on conventional bond markets. We find that firms with higher carbon emissions face higher spreads in the secondary market but not in the primary market. We show that this gap is related to uncertainty about climate concerns that affects differently primary and secondary market. This gap is also affected by the reputation of underwriting dealers: high reputation promotes the incorporation of climate concerns into bond yields. Our findings imply that, on average, carbon emissions do not affect the cost of capital in bond markets, thereby reducing firms' financial incentives for decarbonization.

JEL classification: G12, G41

Keywords: Climate finance, Carbon premium, Bond markets, Green investors, Underwriting dealers

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1 Introduction

The corporate sector is the largest source of carbon dioxide (CO2) and other greenhouse gases emissions (CDP, 2017). To limit global warming, the Intergovernmental Panel on Climate Change recommends net zero carbon emissions by 2050 (IPCC, 2021). However, there is currently no international tax or regulation of carbon emissions to align corporate and societal interests. Financial markets can fill part of this gap by requiring a larger expected return from brown firms, i.e., by imposing a carbon premium on firms with large carbon emissions.[1] This premium would imply a higher cost of capital for brown firms than for green firms.[2]

Several recent papers document a carbon premium in secondary equity markets. In one of the earliest analyses, Bolton and Kacperczyk (2021) find that US firms with larger absolute emissions display higher realized stock returns. Extending their analysis to stock markets around the world, they find that the carbon premium arises for all sectors and almost all countries in their sample (Bolton and Kacperczyk, 2023b). Recent work by Aswani, Raghunandan, and Rajgopal (2023) and Zhang (2025) raises methodological concerns about the carbon premium in equity markets, including issues with estimated emissions data and disclosure timing.[3] However, using implied cost of capital as a proxy for expected returns, Chava (2014) and Pastor, Stambaugh, and Taylor (2022) also find higher stock returns for firms with lower environmental performances.

[1] The question of why a carbon premium arises on financial markets is outside the scope of this paper. The carbon premium may arise due to social norms or reputation issues (see, e.g., Riedl and Smeets (2017)) that we summarize as tastes following Fama and French (2007), but it may also be due to climate-related physical and transition risk (see, e.g., Pankratz and Schiller (2024) and Seltzer, Starks, and Zhu (2025)). We summarize all these different motives for favoring green assets with low carbon emissions under the umbrella term of climate concerns, keeping in mind that these concerns can refer to both tastes and beliefs regarding risk.

[2] See, e.g., the theoretical analysis of Pedersen (2025). For recent review papers on climate finance, see Hong, Karolyi, and Scheinkman (2020) and Giglio, Kelly, and Stroebel (2021), and on sustainable finance, see Edmans and Kacperczyk (2022).

[3] Aswani, Raghunandan, and Rajgopal (2023) point to a bias in carbon emissions estimated by the data vendor. Abstracting from estimated emissions, they find no link between absolute carbon emissions and stock returns in the US market. Moreover, when using carbon intensity, the ratio of carbon emissions to revenues, instead of absolute carbon emissions, they find no carbon premium. Zhang (2025) points to a potential look-ahead bias due to lags in the disclosure of carbon emissions data. After accounting for this lag, Zhang (2025) does not find a carbon premium in global stock markets including the US. See also, Bolton and Kacperczyk (2023a) and Aswani, Raghunandan, and Rajgopal (2024).

Other recent papers examine whether green bonds, whose proceeds are used for environmentally sensitive purposes, are priced as conventional bonds by financial markets. Larcker and Watts (2020) finds no evidence of greenium in the primary market for green bonds issued by municipalities in the United States. On the other hand, Aswani and Rajgopal (2025) show that green bonds issued by financial firms' trade at a greenium. Such greenium is also found by Zerbib (2019) in secondary markets for green bonds issued by a wide variety of agents including municipalities and supra-sovereign agencies.

We shed new light on these issues by studying whether carbon emissions affect firms' cost of capital raised on bond markets. We focus on US corporate bond markets from 2005 to 2022 to examine the existence and magnitude of a carbon premium for conventional corporate bonds, both on the primary and the secondary markets. The primary market, on which firms issue new financial assets, is the only point at which, if investors have a preference for green over brown projects, firms with low carbon emissions can directly benefit from a lower cost of capital and/or firms with high carbon emissions can be penalized by a higher cost of capital. However, underwriting dealers act as intermediaries between issuing firms and investors, similar to the standard practice for Initial Public Offerings (IPO) on equity markets (Bessembinder, Spatt, and Venkataraman, 2020). This raises the question of whether financial intermediaries pass on the carbon premium that they can anticipate on the secondary market to the issuing firms on the primary market, or instead whether markets are segmented. To address this question, we measure the carbon premium on the primary bond market and compare it to the carbon premium on the secondary market. This comparison is one of the main contributions of our paper.

We focus on the corporate bond market instead of the equity market for three reasons. First, bonds are an important source of financing for firms. According to the SIFMA (2024), US bond issuance in 2023 amounted to $1,444.7 billion versus $139.1 billion for the US equity markets. Second, this focus enables us to study primary markets to offer new evidence on an important issue, mostly studied for secondary equity markets. Third, it is relatively easier to estimate the expected returns required by investors to hold financial assets for bonds, that have fixed-income characteristics, than for equity, for which future potential cash flows are not predetermined.[4]

Our focus on conventional rather than green bonds allows us to analyze firm level carbon emissions, which represent the fundamental source of environmental impact, rather than bond level green designations that may not reflect a firm's overall emissions profile. Assessing "greenness" at the bond level can be misleading because firms often have discretion in defining the use of proceeds. They can allocate funds to narrowly defined projects labeled as green while leaving the rest of their operations, and thus their total emissions, largely unchanged. For example, a firm might issue a green bond to finance a small renewable project while continuing to operate carbon intensive core activities. By studying emissions at the firm level, we provide a more comprehensive and economically meaningful view of environmental performance, allowing us to assess whether investors' sustainability preferences translate into actual reductions in firms' total carbon footprints. This distinction sets our study apart from prior research on green bonds and positions our analysis at the level where investors can most directly achieve genuine environmental impact.

Studying conventional bonds also addresses external validity concerns: we examine a substantially larger and more representative sample of assets traded in financial markets. Green bonds constitute a very small proportion of bonds issued and outstanding, and they are typically issued by a distinct set of firms, limiting the generalizability of findings from that market.[5] As Aswani and Rajgopal (2025) document, 55% of green bonds in their sample are issued by financial institutions, often to finance climate-related investments. In contrast, only 34% of general bonds in our sample come from financial institutions, while over 30% are issued by manufacturing firms. This compositional difference is consequential: investor demand for green bonds

[4]Credit risk and liquidity issues may be an important concern and are addressed in our empirical methodology, presented below.

[5]Green bonds constitute just 0.3% of our sample; our results remain robust whether or not they are included.

issued by financial institutions to fund renewable projects may differ substantially from demand for general bonds issued by manufacturing firms with embedded carbon exposure. Moreover, as Cohen, Gurun, and Nguyen (2024) argue, green innovation is often spearheaded by brown firms in sectors like oil and gas—precisely the firms more prevalent in the general bond market. Conventional bonds thus provide a more comprehensive view of how carbon considerations affect corporate bond pricing across the broader economy.

Our sample consists of 4,744 bonds issued by 334 US firms active on the market from 2005 to 2022.[6] We document that firms with higher carbon emissions face higher spreads on the secondary market. However, the carbon premium on the primary market represents only 0% to 25% of the carbon premium observed on the secondary market. Specifically, we measure the carbon premium as the (positive) sensitivity of corporate bond spreads to the carbon intensity of the issuing firms.[7][8]

We use various empirical strategies to estimate carbon premium. We first estimate the carbon premium separately on the primary and secondary markets by running a panel regression on the bond-level dataset, incorporating industry fixed effects as commonly practiced in the literature; see, e.g., Bolton and Kacperczyk (2021) and Seltzer, Starks, and Zhu (2025). On the primary market, we estimate a statistically insignificant difference in yield between green and brown firms, i.e., between firms with Scope 1, 2 and 3 carbon intensity one standard deviation below and above average, respectively. On the secondary market, the difference in yield between green and brown firms is around 11.22 basis points and is statistically significant.

[6] In robustness checks, we apply less filter in constructing our sample and run our cross-section analysis on 8,524 bonds issued by 625 firms.

[7] The presence of a carbon premium on bond markets echoes findings in the experimental finance literature suggesting that subjects in investment situations are willing to sacrifice some expected returns in exchange for a responsible firm's conduct, see, Riedl and Smeets (2017); Bonnefon, Landier, Sastry, and Thesmar (2025); Brodback, Guenster, Pouget, and Wang (2025); Humphrey, Kogan, Sagi, and Starks (2025). These papers link the premium phenomenon to pro-social tastes or social norms. As already mentioned, in our empirical analysis, we do not take a stance regarding the origin of the carbon premium: it could be driven by taste or risk considerations.

[8] Our results differ from those of Duan, Li, and Wen (2025) who study realized bond returns instead of expected returns as we do. We focus on expected returns because they are a better measure of the cost of capital.

The difference in carbon premium between primary and secondary bond markets has economically significant consequences for capital raising. We offer back-of-the-envelope computations for 2023. We consider that green firms, defined as the top 15% of firms by carbon efficiency, issued approximately $216.7 billion in bonds.[9] Our empirical results indicate these bonds were issued at yields consistent with no statistically significant carbon premium on the primary market. Had primary market yields incorporated the 5.62 basis point carbon premium we observe in secondary markets, these same green firms would have raised $217.75 billion, $1.04 billion more in issuance proceeds.[10] The absence of a primary market carbon premium thus represents forgone proceeds for environmentally efficient issuers, as they borrowed at higher yields than secondary market pricing would justify. Conversely, brown firms, those in the bottom 15% by carbon efficiency, benefited from approximately $1.04 billion in additional proceeds compared to a scenario where primary markets fully reflected the carbon premium observed in secondary markets. Recall that a carbon premium implies higher expected returns for brown relative to green bonds. For a given set of future cash flows, this translates to lower current valuations for carbon-intensive issuers. The attenuated primary market premium therefore allowed brown firms to issue bonds at more favorable terms—lower yields and higher proceeds—than secondary market pricing would warrant.

The carbon premium estimate is robust to a host of different empirical strategies. It is robust to whether we allow bond yield's sensitivities to controls to differ or remain the same between the primary and secondary markets. Moreover, in order to address omitted variable problems that arise due to time-varying effects at the firm level, we use pooled panel regressions with firm-time fixed effects and our results hold. Last, we set up a novel identification strategy: for a given firm at a given bond issuance date, we compare the carbon premium on the bond issued

[9]We calculate this as 15% of total 2023 bond issuance ($1,444.7 billion). The 15% threshold corresponds approximately to firms more than one standard deviation above the mean in carbon efficiency for normal distributions.

[10]These back-of-the-envelope computations assume bonds issued with a 3% yield, 10 years to maturity, and a 3% coupon rate, close to the conditions prevailing on average during our sample period. With a face value of $216.7 billion, the present value is $216.71 billion at a 3% yield versus $217.75 billion at a 2.9438% yield (3% - 0.0562%).

on the primary market to the carbon premium on the secondary market, i.e., for bond(s) that were issued by the same firm at a previous date and that are trading on the same day.[11]

To further investigate our main finding, we offer evidence indicating that the carbon premium is mediated by uncertainty about future climate concerns. We measure uncertainty in investors' future climate change concerns by applying an ARCH model to the Media Climate Change Concerns index of Ardia et al. (2022). The presence of this uncertainty echoes the empirical findings of Avramov, Cheng, Lioui, and Tarelli (2022) on ESG ratings uncertainty and Pastor, Stambaugh, and Taylor (2022) on demand shocks.[12] We find that the carbon premium arises on the secondary market when uncertainty is high. On the other hand, a smaller effect is observed on the primary market. We also show that underwriting dealers' reputation matters for the carbon premium observed on the primary bond market. Indeed, we find that this carbon premium is larger when the lead underwriter has a higher reputation.

The main implications of our investigation for climate finance are fourfold. First, firms' financial incentives to become greener via a reduction in cost of capital appear lower than implied by secondary market outcomes. This is because spreads on the primary market are, on average, barely affected by carbon emissions. As a result, there is not much direct financial incentives for firms to decarbonize. Second, segmentation between the primary and secondary markets erode incentives for firms to reduce their carbon emissions. Third, impact/ESG/green investors should try and participate more directly in primary bond markets if they want to increase their impact on firms' financial incentives to become greener. Fourth, the absolute level of the carbon premium, even at its maximum level on the secondary market, appears lower than needed to provide adequate incentives for corporations to reform and become greener (see Pedersen (2025), for an estimate of the required carbon premium).

Our work is related to two recent papers on carbon risk in corporate bond markets. First, Seltzer,

[11]We undertake several additional analyses to demonstrate the robustness of our findings.
[12]See also the model developed by Avramov, Lioui, Liu, and Tarelli (2025).

Starks, and Zhu (2025) study whether secondary bond spreads reflect climate regulatory risk. However, they also estimate the carbon premium on the primary bond market based on carbon emissions as we do. We complement their work on the primary market by comparing primary and secondary markets. Since our primary interest lies in the differential carbon premium between the secondary and primary markets, our approach helps mitigate omitted variable bias stemming from time-varying firm-level effects. Specifically, as one of our specifications, we employ pooled panel regressions with firm-time fixed effects, a more granular specification than firm fixed effects. Both firm fixed effects specification and more granular level of fixed effects are not feasible in Seltzer, Starks, and Zhu (2025) and related studies, as imposing such fixed effects would eliminate much of the variation in highly persistent carbon intensity, required to identify the carbon premium. Moreover, we further attempt to address omitted variable bias by including a larger set of control variables: coupon rate, credit rating, number of underwriting dealers, daily VIX, and fixed effects of lead underwriter identity in addition to the variables that are controlled for in Seltzer, Starks, and Zhu (2025). While Seltzer, Starks, and Zhu (2025) relies on the sample period (2009–2017), our analysis covers a more recent sample period (2005–2022), yielding results that are more relevant and applicable to current market conditions. Lastly, we account for the methodological concerns raised by Aswani, Raghunandan, and Rajgopal (2023) by excluding emissions estimated by the data vendor, thereby helping to mitigate potential biases introduced by vendor-estimated data.

Second, Duan, Li, and Wen (2025) study how realized returns on the secondary corporate bond market depend on carbon intensity. They find that, controlling for various risk factors, portfolios including bonds issued by firms with higher carbon intensity earn lower realized returns. Their analysis suggests that this result is related to both changes in institutional ownership and to investors' underreaction to the informational content of high carbon intensity (which is correlated with future firm fundamentals). Our approach is based on expected returns and is thus closer in spirit to Chava (2014) and Pastor, Stambaugh, and Taylor (2022). Moreover, our main contribution is the comparison of primary and secondary bond market carbon premia and the economic reasons for why they differ.

Our paper contributes to the growing literature that underscores the limited impact of sustainable finance in public financial markets. Using an instrumental variable methodology based on exogenous changes in Morningstar's fund ratings, Heath, Macciocchi, Michaely, and Ringgenberg (2023) finds that the impact of socially responsible funds on firms' environmental and social performance appears limited. Moreover, using inclusion and exclusion from sustainable indices, various papers find modest impact of responsible investors on stock prices, see, e.g., Hawn, Chatterji, and Mitchell (2018) and Durand, Paugam, and Stolowy (2019), for the DJSI World, and Berk and van Binsbergen (2025), for the FTSE4Good USA index. Finally, Angelis, Tankov, and Zerbib (2022) calibrate a theoretical model on US equity markets and show that the impact of green investors remains limited given the size of their assets under management and the uncertainty regarding future climate risks. Our paper points to market imperfections as one of the determinants of the lack of impact of sustainable investing.

Our work is also related to three strands of literature on bond markets. First, a number of empirical papers study corporate bond market microstructure; see, e.g., Goldstein, Hotchkiss, and Nikolova (2021) on bond dealers' trading; Nikolova and Wang (2024) on flipping; Nagler and Ottonello (2022) on parking; Helwege and Wang (2021) on mega-bond issues; Hendershott, Li, Livdan, and Schürhoff (2019) on secondary market trading networks; Dick-Nielsen, Feldhütter, and Lando (2012); Bao, O'Hara, and Zhou (2018); Bessembinder, Jacobsen, Maxwell, and Venkataraman (2018); Dick-Nielsen and Rossi (2019) on cost of liquidity provision; Cai, Helwege, and Warga (2007) on bond issuance underpricing. Our focus is different and complementary to these papers since we study the carbon premium and how it is affected by market imperfections.

Second, there is a growing literature on green bonds; see, e.g., Zerbib (2019) on green bonds issued by a variety of supranational, sovereign, municipal and corporate institutions; Tang and

Zhang (2020) on the stock price reaction to green bond issuance, Flammer (2021) on corporate green bonds, Baker, Bergstresser, Serafeim, and Wurgler (2018) on municipal green bonds, Pastor, Stambaugh, and Taylor (2022) on sovereign green bonds, Daubanes, Mitali, and Rochet (2022) on the reasons why firms issue green bonds. Green bonds are issued by firms, whether green or brown, with a promise, potentially certified, that the proceeds are used to finance green projects. As indicated above, Aswani and Rajgopal (2025) finds a positive greenium for corporate green bonds in the secondary market, while Larcker and Watts (2020) report no greenium for municipal green bonds in the primary market.

Third, several papers focus on the link between ESG issues and bond spreads. For example, Seltzer, Starks, and Zhu (2025) show that corporate bond credit ratings and spreads react to issuing firms' environmental profile, especially when environmental regulations are strictly enforced. Jiraporn, Jiraporn, Boeprasert, and Chang (2014) and Amiraslani, Lins, Servaes, and Tamayo (2022) study how corporate social responsibility affects credit ratings and bond spreads during the great financial crisis. On municipal bond markets, Painter (2020) assesses the impact of physical climate risk on spreads. Garrett and Ivanov (2024) evaluate the additional bond issuance cost paid by municipalities who decide to exclude ESG-friendly underwriters. These papers do not study, as we do, the different impact of investors' climate concerns on primary and secondary markets.

2 Data

2.1 Data construction

We use four different data sources to construct our main data. We first use S&P Global Trucost to get data on corporate carbon emissions. We rely on Mergent FISD to obtain data on corporate bond characteristics and issuance price. We get secondary market prices and trading volume data from TRACE. Lastly, we use COMPUSTAT/CRSP to get data on firm characteristics and stock returns. Our main data sample spans eighteen years, from January 2005 to March 2022. We account for inflation by converting all nominal dollar amounts into 2020 dollars.

We build on Bolton and Kacperczyk (2021) to set up our measures of a firm's environmental profiles regarding climate change. We use a firm's Scope 1, Scope 2, and Scope 3 (upstream) carbon emissions provided by Trucost. Scope 1, also known as direct emissions, refers to carbon emitted by entities that are owned or controlled by the firm. Carbon emissions in the value chain are referred to as indirect emissions. They include Scope 2 that refers to carbon emitted by the firm's energy suppliers, and Scope 3 that refers to emissions by all other agents in the value chain. Scope 3 is itself divided into an upstream segment, that measures emissions from activities deployed to create firm's products, and a downstream segment, that measures emissions from activities that use firm's products. Similar to Bolton and Kacperczyk (2021), we leave out Scope 3 downstream due to its lack of data.

We then construct three complementary measures of carbon emissions: Scope 1 only; summing up Scope 1 and Scope 2; summing up Scope 1, Scope 2, and Scope 3 (upstream). We use them to compute a firm's carbon intensity as the ratio of carbon emissions on sales' revenue. Our main analysis favors carbon intensity over absolute carbon emissions for three reasons highlighted by Aswani, Raghunandan, and Rajgopal (2023). First, carbon intensity is closely related to energy efficiency, an important element to reduce the social cost of the current energy transition. Second, climate regulations are likely to affect firms independently from their size. For instance, a large firm that pollutes a lot may pay a high carbon tax but, if it has large revenues, it may spread the tax over a large income. Finally, investors when tilting their portfolios towards climate-friendly firms are also unlikely to let their ranking of firms be affected by size.

We use Mergent FISD database to obtain bond-level data on corporate bond characteristics and credit ratings (by Moody's). Bond characteristics include a flag indicating that the bond is redeemable under certain circumstances, maturity in years, and the total amount issued (logged). As typically done in the literature, we transform the letter ratings to a numerical value so that the lowest rating ("C") is assigned 1 and one notch increase gets a number larger by 1, leading the highest rating ("Aaa") to be assigned 21.[13]

Moreover, using offering terms available from Mergent FISD database, we define offering spread as the difference between a bond's offering yield and the yield of a cash flow-matched synthetic Treasury bond. The discount rates of varying maturities derive from the U.S. Treasury yield curve provided by Gurkaynaka, Sack, and Wright (2007).

We use secondary market outcomes from TRACE to construct an illiquidity measure. We follow Amihud (2002) and Lin, Wang, and Wu (2011) to construct Amihud's illiquidity measure as follows:

$$ILLIQ_{i,t} = \frac{|r_{i,t}|}{Vol_{i,t}},$$

where $r_{i,t}$ is the daily return between the last day with a transaction and day t, computed on median daily prices, and $Vol_{i,t}$ is the average trading volume across these days in million dollars.[14]

We use trading data from TRACE and bond characteristics data from Mergent FISD to construct bond spreads on the secondary market. We calculate a bond's daily yield as the trading-volume weighted average of the reported yields in a given day. Then, we use a similar approach as above to construct the yield of a cash flow-matched synthetic Treasury bond. We subtract the latter from the former to get corporate bond spreads on the secondary market. In addition, as standard in the literature (see, e.g., Liao, 2020), we exclude securities with a remaining maturity of less than a year. Lastly, for our main analysis, we focus only on the secondary market transactions that occur within two years since issuance to make the situation as comparable as possible between issuance and secondary trading.

[13]Our results hold if we use dummy variables associated with the different ratings.

[14]In studying liquidity risk in corporate bond returns, Lin, Wang, and Wu (2011) used two measures, introduced by Amihud (2002) and by Pastor and Stambaugh (2003), at monthly frequency. Pastor-Stambaugh measure is appropriate to construct an illiquidity measure at monthly frequency while our main analysis is at the daily level. We thus use only the Amihud measure.

Merging corporate bond data with firm-level carbon emissions yields a sample of 9,003 bonds issued by 627 unique firms. From this sample, we exclude green bonds to focus on carbon emissions measured at the firm level, rather than green designations defined at the bond level. This distinction sets our study apart from prior work on green bonds (Baker et al., 2018; Tang and Zhang, 2020; Flammer, 2021; Pastor et al., 2022; Daubanes et al., 2022; Aswani and Rajgopal, 2025). Based on data available from Refinitiv, 539 corporate bonds are designated as green between 2005 and 2022. [15] However, after merging with the emissions data, only 24 green bonds remain in our sample—representing just 0.3% of the sample on both an equal-weighted and offering-amount-weighted basis. Excluding these bonds leaves us with a final sample of 8,979 bonds issued by 626 firms. Nonetheless, in untabulated results, we confirm that our findings are robust to including green bonds.

For our main analysis, we impose two additional data filters. First, as pointed out in Aswani, Raghunandan, and Rajgopal (2023), some reported carbon emissions were estimated by the data vendor and these estimated emissions can potentially bias our empirical estimates. Thus, we follow Aswani, Raghunandan, and Rajgopal (2023) to exclude those emissions that are estimated. More specifically, we exclude all the data with precision level 1 and 2 (See Table A8 for exact definitions of the different levels of precision). This yields 4,879 bonds issued by 337 unique firms.

The second filter pertains to bond seniority. Our sample includes six types: senior secured, senior, senior subordinated, subordinated, junior, and junior subordinated. To ensure our main results are not influenced by variation in seniority, we restrict the sample to senior bonds, which represent 96% of the total. This restriction removes 135 bonds and 3 unique firms.

[15] Specifically, we exclude bonds for which Refinitiv's "green bond flag" is marked as Y. Refinitiv defines green bonds as fixed income instruments whose proceeds are used or earmarked for environmentally beneficial projects, including ESG bonds with proceeds exclusively directed toward environmental initiatives. This is consistent with the classification used in Aswani and Rajgopal (2025), who identify 455 U.S. green corporate bonds between 2013 and 2022.

2.2 Summary statistics

Our main sample covers 4,744 bonds issued by 334 unique US firms. In order to limit the impact of outliers, similar to Bolton and Kacperczyk (2021), we winsorize all the variables at top and bottom 1%.

Insert Table 1

The related summary statistics are shown in Table 1. The natural log of carbon emissions indicate that Scope 1, 2 and 3 emissions are of the same magnitude. After taking logs, carbon emissions are not heavily skewed since the median is close to the mean. Carbon intensity measures (Scope 1, 2 and 3) indicate that a firm, on average, emits 356.9 tons of CO2 to generate one million of 2020 dollars of sales revenue.

Bond spread is on average 0.67% on the primary market, and 0.565% on the secondary market. A bond issue is underwritten by 2.763 lead underwriters on average. Amihud-illiquidity measure is low, at 0.0342 on average, but has a high standard deviation of 0.313. The average rating is between "A2" and "A3", i.e., in the investment grade category. 88.7% of the bonds are redeemable and the average number of years remaining till maturity is 10.77 years. The amount outstanding is on average around one billion dollars. The table shows the fraction of bonds that are issued by various top lead-underwriters. For instance, Morgan Stanley is lead-underwriter for 21% of the bonds issued in our sample.

3 Carbon premium: Primary vs. secondary market

This section presents the main result of the paper, namely carbon premium is larger on the secondary market than it is on the primary market. We show that our main result is robust to various identification strategies. Additional robustness checks are presented in Appendix

A.[16]

3.1 Full sample analysis

We estimate the carbon premium for the primary market and for the secondary market. To that end, we separately estimate the following specification for both markets:

$$Spread_{f,i,t} = \alpha + \beta \cdot CO2_{f,t} + BondControls_{f,i,t} + FirmControls_{f,t} + FE + \varepsilon_{f,i,t}. \qquad (1)$$

where t refers to an issuance date, $Spread_{f,i,t}$ is the spread of bond i of firm f that is issued or traded at time t. $CO2_{f,t}$ is firm f's latest carbon intensity measure available at time t. CO2 emissions are reported on an annual basis and we use the one that is publicly available at time t.[17] For similar reasons, we control for firm characteristics using the latest measures available, reported on a yearly basis.

Firm controls include book leverage (COMPUSTAT item: (DLC+DLTT)/AT), pre-tax interest coverage ratio (COMPUSTAT item: XINT/OIBDP), the natural log of total assets (COMPUSTAT item: AT), profitability (COMPUSTAT item: OIBDP/(lagged AT)), the natural log of sales revenue (COMPUSTAT item: SALE), annual average of stock returns, annualized standard deviation of stock returns. Bond controls include coupon rate, daily VIX, the Amihud-illiquidity measure on the secondary market, the remaining years to maturity, the natural log of amount outstanding as of time t, a dummy variable indicating whether the bond is redeemable or not, credit ratings issued by Moody's at the issuance, and number of all (both lead and non-lead) underwriters. Lastly, we account for lead underwriter fixed effects by including a dummy for each of the 10 major lead underwriters based on the dollar amount of bonds underwritten in our

[16] These additional robustness tests focus on investment-grade bonds, additional time lags, the level of precision of the carbon measurement, and nonlinear relation between spread and CO2.

[17] We account for reporting lag as advised by Zhang (2025): in our main analysis we consider the same reporting lag for CO2 and for financial data. For financial data, we use the year indicated in COMPUSTAT item DATADATE to assess in what year financial data has been made available. We use the previous such year to make sure that data was available to financial market participants. In a robustness analysis, we check that our results hold if we add an additional year of lag for the CO2 variable. We merge Trucost and COMPUSTAT data on a fiscal year basis.

sample period. These include high profile investment banks such as J.P. Morgan, Citi, and Goldman Sachs. Similar to the literature, e.g., Bolton and Kacperczyk (2021) and Seltzer, Starks, and Zhu (2025), we use industry fixed effects (at the first-digit SIC code level). We cluster the standard errors at the firm level.

The results are summarized in Table 2.

Insert Table 2

Table 2, Columns (5) and (6) focus on the primary and secondary market, respectively. They display the results of our main regression of corporate bond spreads on carbon intensity based on the sum of Scope 1, 2 and 3 emissions. While spreads exhibit a positive sensitivity to carbon intensity on the secondary market, they do not exhibit any sensitivity to carbon intensity on the primary market. The difference in the sensitivity is statistically significant with t-stat of 2.24. This suggests the presence of a positive carbon premium for the secondary bond markets and no carbon premium for the primary market. The similar patterns are observed when we use scope 1 measures (Table 2, Columns (1) and (2)) and scope 1 and 2 (Table 2, Columns (3) and (4)).

Combining these results with the summary statistics offered in Table 1 enables us to assess the economic significance of these results. On the primary market, change in carbon intensity leads to no change in spread. On the secondary market, one standard deviation increase in carbon intensity leads to a 5.62 bps increase in the secondary market ($= 0.00832 \cdot 6.752 \cdot 100$). Our results indicate that bond spreads on the secondary market are significantly more sensitive to issuing firms' carbon intensity than those on the primary market. This is the main contribution of our paper. Firms' financial incentives to become greener are related to primary market outcomes that directly affect the cost of capital. Our main result has important implications for the strength of these incentives. Indeed, our main result suggests that the direct incentives financial markets provide firms for becoming greener appear to be lower than one could think by looking at secondary markets. This is particularly relevant given that studies measuring the carbon premium (on the equity market) focus on the secondary market (see, e.g., Bolton and Kacperczyk, 2021, 2023b; Chava, 2014; Pastor et al., 2022).

It is worth discussing how our results relate to the literature that documents underpricing in the corporate bond issuance. Cai, Helwege, and Warga (2007) show that offering spreads (on the primary market) are larger than the trading spread (on secondary market), in a similar spirit to the equity IPO underpricing. Our main results show that spread sensitivity to carbon intensity is lower on the primary than on the secondary market. Our results are complementary to the underpricing result. They indeed show that, on the primary market, bonds of green and brown firms tend to trade at the same (under-valued) price, but that, on the secondary market, bonds of green firms trade on average at a larger price than bonds of brown firms.

Although the documented results are significant, both economically and statistically, caution should be exercised in their interpretation. First, by running Model 1 separately for the primary and secondary markets, we implicitly assume that bond spread's sensitivities to all the controls are different between the two markets. Section 3.2 shows that our results are robust to such an assumption by restricting bond spread's sensitivities to all the controls to remain the same for the two markets. Second, we follow the literature and use industry fixed effects as opposed to firm fixed effects. Ideally, it would be interesting to include firm-level fixed effects. However, carbon intensity measure is very persistent at firm level with an AR(1) coefficient of 0.951. Imposing firm fixed effects would thus wipe out the variation in carbon intensity that is needed to identify β in Model 1. In Section 3.3, we offer an alternative specification to address this persistence issue and show that our results hold even when we use firm-time fixed effects where time is measured on a weekly basis. Section 3.4 conducts a natural experiment by matching the secondary and primary market data based on the issuance days, yielding much comparable sample sizes between the two markets.

3.2 Full sample with restrictions

As discussed, the previous section implicitly assumes that bond spread's sensitivities to all the controls are different between the two markets. However, one may argue that the above conclusion could have been mechanically driven by allowing sensitivities to controls (e.g., years to maturity) to differ between the primary and secondary market. To fix the spread's sensitivity to controls to remain the same between the primary and secondary market, we adopt the following approach. We first stack the primary market data and secondary market data together. We then generate an indicator variable, called $Secondary_{f,i,t}$, and we set it to 1 for a secondary market observation and 0 otherwise. Then, we interact the indicator variable with carbon intensity. The coefficient on the interaction term between $Secondary_{f,i,t}$ and $CO2_{f,t}$ shows the difference between the sensitivity to carbon intensity on the secondary and on the primary market:

$$\begin{aligned} Spread_{f,i,t} =& \alpha + \beta_1 \cdot CO2_{f,t} + \beta_2 \cdot Secondary_{f,i,t} \times CO2_{f,t} + BondControls_{f,i,t} \\ &+ FirmControls_{f,t} + FE + \varepsilon_{f,i,t} \end{aligned} \tag{2}$$

The results of this constrained pooled regression are in Table 3. Focusing on the Scope 1, 2 and 3 carbon intensity measure, the main coefficient of interest, β_2, is positive and statistically significant: it is estimated to be 0.00625 with a t-statistics of 2.063. Our main results thus hold even if we restrict all the control variables to have the same effect on primary and secondary bond markets. Moreover, the spread sensitivity to CO2 on the primary market (β_1) is positive at 0.00206 although it is not statistically significant (t-statistics of 1.09).

Insert Table 3

The sensitivity of bond spreads to the issuing firms' carbon intensity is 0.00206 ($= \beta_1$) on the primary market whereas it is 0.00831 ($= \beta_1 + \beta_2$) on the secondary market. The corporate bond spread sensitivity to carbon intensity is around 4 times larger on the secondary than on the primary market. In other words, the carbon premium is much larger on the secondary than on the primary market. For completeness, we also display the results for other emission measures separately. Table 3, Columns (1) and (2) show our estimate of β_2 in Model 2 for Scope 1 and Scope 1 and 2, respectively. As shown, our main result applies to different scopes of carbon emissions: bond spreads are significantly more sensitive to carbon intensity on the secondary than on the primary market.

3.3 Firm-by-time fixed effects

Our specifications so far only account for industry fixed effects. Thus, they can potentially suffer from omitted variables problems that arise due to time-varying fixed effects at the firm level. Unfortunately, as discussed in Section 3.1, our main regressor, carbon intensity measure, is very persistent at firm level. Thus, imposing more granular level of fixed effects (e.g., firm fixed effects) would wipe out any variation in carbon intensity that is needed to identify sensitivity of yield to carbon intensity, β_1 in Model 2. This problem can be alleviated if we are not interested in measuring carbon premium on the primary market itself but in identifying a difference in the carbon premium between the primary and the secondary market only, i.e., identifying β_2 in Model 2. Accordingly, we estimate the following specification:

$$\begin{aligned} Spread_{f,i,t} = &\alpha + \beta_1 \cdot Secondary_{f,i,t} + \beta_2 \cdot Secondary_{f,i,t} \times CO2_{f,t} + BondControls_{f,i,t} \\ &+ Secondary_{f,i,t} \times BondControls_{f,i,t} + FE + \varepsilon_{f,i,t} \end{aligned} \tag{3}$$

Here, we allow for firm-by-week fixed effects to account for heterogeneity at the firm and week level. These are more granular form of fixed effects than time-invariant firm fixed effects. We do not control for firm characteristics because those are already accounted for by firm-by-week fixed effects. Following our main specification, Model 1, we allow bond spread's sensitivities to the bond controls to differ between the two markets.

In order to estimate firm-time fixed effects, we need to have sufficient data at firm-time level.

Volume on the corporate bond market declines quickly after issuance. In our sample, 40% of the outstanding amount is traded during the first month after issuance, but less than 10% in subsequent months. Thus, for the secondary market, we focus on transactions occurring in the first month since the issuance. The related summary statistics are shown in Table A6. The results are summarized in Table 4.[18]

Insert Table 4

Our coefficient of interest is β_2. Table 4, Column (3) shows that β_2 is estimated to be 0.00880 and statistically significant when one uses scope 1, 2 and 3 measure. This estimate is similar in magnitude to the estimate obtained via entirely different specification and documented in Table 3 at 0.00625, showing robustness of our estimates. Similar results hold for Scope 1 and Scope 1 and 2, respectively as shown in Table 4, Column (1) and (2).

3.4 Natural experiment: Issuance days

Although the fixed effects model helps address omitted variable bias related to the level of bond spreads (our outcome variable), it does not fully resolve potential biases in estimating the differential sensitivity between bond spreads and carbon intensity. In particular, calendar day effects may introduce bias. Bond issuance dates often differ from the trading dates in the secondary market, making calendar dates inherently correlated with whether an observation comes from the primary or secondary market.

One source of concern is the daily fluctuation in investors' climate change concerns, which can affect price sensitivity to carbon emissions. Ardia, Bluteau, Boudt, and Inghelbrecht (2022) construct the Media Climate Change Concerns (MCCC) index and show that its unexpected time-series variations are positively correlated with changes in equity prices at the daily level (see Pastor, Stambaugh, and Taylor (2022) for evidence at the monthly level). Calendar date

[18] Nonetheless, omitting this filter yields qualitatively similar but statistically weaker results: the β_2 coefficient for Scope 1 emissions is significant at the 10% level, while the β_2 coefficients for the other two scopes are positive but not statistically significant.

fixed effects will not address this issue because they would only deal with the impact of particular days on the level of bond spreads.

Another source of concern is the daily fluctuation in firms' credit risk. Credit risk impacts bond spreads. It is challenging to empirically study this impact because credit risk is not directly observable. Credit ratings are one of the best available proxies for credit risk but their validity is less than perfect. For this reason, a number of papers (Helwege and Turner, 1999; Eom, Helwege, and Huang, 2004; Teixeira, 2007) take structural approaches. Firms could have different credit risk when they issue new bonds and when they do not. Such different credit risk, one might argue, could affect bond spreads and their sensitivity to carbon emissions.

In order to address these issues, we design an identification strategy that mimics as closely as possible the ideal strategy of comparing identical bonds that differ only in one dimension, i.e., the market in which they are traded (primary versus secondary market).

More specifically, we consider all the dates at which firms have issued bonds. On these dates, we collect data from the bonds newly issued on the primary market and data from the bonds of the same firms issued in the past and trading on the secondary market on the issuance days.[19] This enables us to better control for time fixed effects at the daily level while still measuring the carbon premium on the primary and on the secondary market.

Restricting the sample to bonds for which our identification strategy can be applied yields 3,586 bonds issued by 219 unique firms on 1,073 such unique issuance days. Table 5 shows the related summary statistics. Panel A and Panel B report summary statistics for firms common to both the primary and secondary market samples. Panel C presents summary statistics for bond characteristics in the primary market sample, while Panel D reports those for the matched secondary market bonds. Comparing Panels C and D reveals that bonds in the two samples differ along several dimensions. The average offering yield is 0.641% in the primary market sample,

[19]We thus only include, in our primary market sample, bonds issued by firms that have already issued bonds in the past.

compared with 0.775% for the secondary market counterpart, whose average current yield is 0.741%. The average coupon rate is 3.435% for primary market bonds and 3.958% for secondary market bonds. The average amount outstanding is $800.5 million in the primary market sample versus $1,059 million in the secondary market sample. The two samples also differ in other bond characteristics, including remaining years to maturity, redeemability, Moody's credit ratings, and the number of underwriters. These differences underscore the importance of controlling for bond-level characteristics in our empirical specifications.[20]

Insert Table 5

Specifically, we employ the identification sample to estimate Model 1, incorporating both firm-level and bond-level controls. The corresponding results are reported in Table 6.

Insert Table 6

Table 6, Columns (5) and (6) focus on the primary and secondary market, respectively. They display the results of our main regression of corporate bond spreads on carbon intensity based on the sum of Scope 1, 2 and 3 emissions. While spreads exhibit a positive sensitivity to carbon intensity on the secondary market, they do not exhibit any sensitivity to carbon intensity on the primary market. The difference in the sensitivity is 0.0156 and statistically significant with t-stat of 1.86. This suggests the presence of a positive carbon premium for the secondary bond markets and no carbon premium observed on the primary market. While the sensitivity in the primary market is comparable to the full sample analysis results summarized in Table 3, the difference in the sensitivity is twice as large. This illustrates that full sample's estimates can potentially be biased due to various reasons and our identification strategy seems to address the bias. The similar patterns are observed when we use scope 1 measures (Table 6, Columns (1) and (2)) or when we use scope 1 and 2 (Table 6, Columns (3) and (4)).

[20]To further demonstrate that our main results are not driven by differences in bond characteristics across the two samples, we apply entropy balancing to equalize the distributions of key bond attributes and re-estimate our baseline specification. Table A7 presents the results, which confirm that our main findings remain robust under this alternative approach.

4 Empirical evidence on the economic channels

Our main empirical analyses show that corporate bond spreads are less sensitive to carbon intensity in the primary market than in the secondary market. In other words, the carbon premium is lower at issuance than in subsequent trading. This difference may arise from phenomena occurring in either market. In this section, we provide empirical evidence on two distinct economic channels, each associated with one of the two markets.

First, we show that secondary market traders respond more strongly to uncertainty about future climate concerns, contributing to the observed gap in carbon premium. Second, we demonstrate that lead underwriters play a role in shaping the difference in carbon premium. We rule out an alternative explanation based on competition among lead underwriters by showing that it has no discernible impact on the carbon premium in either market. Instead, we argue that underwriter reputation helps narrow the carbon premium gap between the primary and secondary markets by increasing the carbon premium at issuance, while leaving the secondary market premium effectively unchanged. The following subsections present the supporting empirical evidence.

4.1 Channel: Uncertainty about future climate concerns

We study whether investors on the secondary market are more responsive to uncertainty about future climate concerns than primary market participants. This differential sensitivity could contribute to the larger gap between the carbon premium in the secondary and the primary market.

In order to investigate this issue, we construct a dummy variable HV_t that indicates high shocks at time t regarding future climate concerns. For this, we use daily Media Climate Change Concerns index (MCCC) constructed and made available to download by Ardia, Bluteau, Boudt, and Inghelbrecht (2022) for the period 2005-2018. To estimate the conditional volatility at day

t, we use an ARCH model with 30 lags, from $t-30$ and $t-1$. This measure of conditional volatility simultaneously captures uncertainty about future climate concerns.[21] Then, we set $HV_t = 1$ if the conditional volatility is above the median. Otherwise, we set it to 0.

Before conducting our channel analysis, we first verify that our main result–that corporate bond spreads are less sensitive to carbon intensity in the primary market than in the secondary market–continues to hold in our restricted sample, which spans 2005 to 2018 when HV_t is available and document the corresponding findings in Table A5. We then estimate the following model with interaction terms, using the proxy introduced above:

$$\begin{aligned} Spread_{f,i,t} =& \alpha + \beta_1 \cdot CO2_{f,t} + \beta_2 \cdot HV_t + \beta_3 \cdot CO2_{f,t} \times HV_t \\ &+ BondCtrl_{f,i,t} + FirmCtrl_{f,t} + FE + \varepsilon_{f,i,t} \end{aligned} \tag{4}$$

$Spread_{f,i,t}$ is the spread of bond i issued on day t by firm f. Our main variable of interest is the interaction term, $CO2_{f,t} \times HV_t$. Testing our prediction is equivalent to testing whether secondary market's β_3 is larger than primary market's β_3. Table 7 summarizes the relevant results.

Insert Table 7

We begin by examining Columns (5) and (6) of Table 7, which report the uncertainty channel results using carbon intensity based on the sum of Scope 1, 2, and 3 emissions. The coefficient β_3 is positive and statistically significantly different from 0 with t-stat of 3.481. More interestingly, the coefficient β_3 is statistically significantly larger in the secondary market than in the primary market with t-stat of 2.42. The difference remains statistically significant for the other two measures of CO2 emissions with t-stats of 2.33 (scope 1) and 2.60 (scope 1 and 2). This finding suggests that uncertainty about future climate concerns mediates the formation of the

[21]The 1-day lag is the most statistically significant predictor of current volatility. Other lags, specifically the 2-day, 3-day, 4-day, 6-day, 7-day, 8-day, 13-day, 20-day, and 21-day lags, also contribute statistically significantly to volatility prediction.

carbon premium. Since sensitivity to this uncertainty is lower in the primary than in the secondary market, the carbon premium is on average smaller in the primary than in the secondary market.

4.2 Channel: Lead Underwriters

We explore what aspects of lead underwriters, price setters in the primary market, help explain the gap between the carbon premium in the secondary and in the primary market. To that end, we study two potential phenomena: the impact of imperfect competition and of dealer reputation.

We first test whether the difference between the sensitivity to carbon intensity on the secondary and the primary market increases as the level of competition between lead underwriting dealers diminishes. We construct a dummy variable, $LC_{f,i}$, that indicates a low level of competition among lead underwriters for bond i issued by firm f. Moreover, because bonds with larger offered amount have a larger number of lead underwriters, we scale this number by the amount issued and compute:

$$Ratio_{f,i} = \frac{\text{Number of lead underwriters}_{f,i}}{\text{Amount offered}_{f,i}}.$$

We set $LC_{f,i} = 1$ if $Ratio_{f,i}$ is below the median. Otherwise, we set it to 0.[22] Using the proxy introduced above, we test the predictions by estimating the following model with interaction term:

$$\begin{aligned} Spread_{f,i,t} =& \alpha + \beta_1 \cdot CO2_{f,t} + \beta_2 \cdot LC_{f,i} + \beta_3 \cdot CO2_{f,t} \times LC_{f,i} \\ &+ BondCtrl_{f,i,t} + FirmCtrl_{f,t} + FE + \varepsilon_{f,i,t} \end{aligned} \tag{5}$$

Our main variable of interest is the interaction term, $CO2_{f,t} \times LC_{f,i}$. Testing our prediction amounts to examining whether β_3 is negative in the primary market and not statistically dif-

[22] The correlation between the two dummy variables, HV_t and $LC_{f,i}$, appears low and equal to 0.055.

ferent from zero across all three measures of CO2 emissions. Table 8 summarizes the relevant results.

Insert Table 8

The coefficient β_3 is not statistically different from zero for both markets across all three measures of CO2 emissions. This rules out a lack of competition among lead underwriters as a channel behind our main result.

We then test whether the difference in sensitivity to carbon intensity between the secondary and primary markets decreases as the lead underwriter's reputation increases. Highly reputable underwriters may price the carbon premium in the primary market more in line with how it is priced in the secondary market, which in turn may reinforce their strong reputation.

To test this conjecture, we restrict the sample to bonds with a single lead underwriter, allowing for a cleaner identification of reputation-driven effects by mitigating potential confounding influences from interactions among multiple underwriters. We then construct a dummy variable, $HR_{f,i}$, which indicates whether the sole lead underwriter for bond i, issued by firm f, has a high level of reputation. The construction of this dummy variable is detailed below.

Closely following the existing literature (Carter and Manaster, 1990; Booth and II, 1986; Drucker and Puri, 2005), we first calculate underwriter u's market share in bond offerings for year t as follows:

$$\text{MarketShare}_{u,t} = \frac{\text{Total Bond Offering}_{u,t}}{\text{Total Bond Offering}_{t}},$$

where the numerator denotes the total dollar amount of bonds underwritten by underwriter u in year t, and the denominator denotes the total dollar amount of all bond offerings in that year. We then define a dummy variable $HR_{f,i}$ that equals 1 if the lead underwriter u for bond i, issued by firm f, has a market share in year $t-1$ above the 85th percentile. Similarly, we set $HR_{f,i} = 0$ if $\text{MarketShare}_{u,t-1}$ falls below the 15th percentile.[23] We use market share from year

[23]The results remain similar even when we define a dummy variable $HR_{f,i}$ that equals 1 if $\text{MarketShare}_{u,t-1}$ is

$t-1$, the year prior to bond issuance, to avoid look-ahead bias. Then, we test our conjecture by estimating the following model with interaction term:

$$\begin{aligned} Spread_{f,i,t} = & \alpha + \beta_1 \cdot CO2_{f,t} + \beta_2 \cdot HR_{f,i} + \beta_3 \cdot CO2_{f,t} \times HR_{f,i} \\ & + BondCtrl_{f,i,t} + FirmCtrl_{f,t} + FE + \varepsilon_{f,i,t} \end{aligned} \quad (6)$$

Our main variable of interest is the interaction term $CO2_{f,t} \times HR_{f,i}$. Testing our prediction involves examining whether the coefficient β_3 is positive and statistically significant in the primary market, while statistically indistinguishable from zero in the secondary market. Table 9 summarizes the relevant results.

Insert Table 9

We find results that are consistent with our conjecture. For scope 1,2, and 3 measure, the coefficient β_3 in the primary market is estimated to be 0.0288 and is statistically significantly different from zero. The coefficient β_1 in the primary market is estimated to be -0.0277, also statistically significant. As a result, the sum $\beta_1 + \beta_3$ is not statistically different from zero, which aligns with one of our main findings that the carbon premium is effectively zero in the primary market. In contrast, β_3 in the secondary market is not statistically different from zero. Taken together, these findings suggest that the reputation channel plays a meaningful role in the primary market but not in the secondary market: high-reputation dealers induce climate concerns to be better priced in primary market yields.

5 Conclusion

Do green firms with low carbon emissions benefit from a lower cost of capital than brown firms? Is the carbon premium, that has been observed on secondary equity markets, also present on bond markets, especially on the primary bond market that affects firms' cost of capital? We

above the 75th percentile while we set $HR_{f,i} = 0$ if $\text{MarketShare}_{u,t-1}$ falls below the 25th percentile.

address these issues by comparing the carbon premium on primary and secondary bond markets. Using a sample of 4,744 bonds issued by 334 US firms active in the bond market from 2005 to 2022, we establish our main result: there is a carbon premium on the secondary market but not on the primary market. The difference in carbon premium is mediated by uncertainty on future climate concerns: high uncertainty is associated with a carbon premium on the secondary market but significantly less on the primary market. We also show that high-reputation dealers promote the incorporation of climate concerns in primary bond yields. Finally, the level of competition between dealers appears not to affect the difference in carbon premium on the primary and the secondary market.

The main implications of our investigation are fourfold. First, the impact of investors with climate concerns on firms' financial incentives to become green is lower than implied by secondary market outcomes. Second, segmentation between the primary and secondary markets erode incentives for firms to reduce their carbon emissions. Third, green investors should try and participate more directly in primary bond markets if they want to increase their impact on firms' financial incentives to become green. Fourth, the carbon premium observed in bond markets appears much lower than what is needed to make firms internalize their social impact related to climate change.

In future research, it could be interesting to document the formation of fund families' orders on the primary market from the aggregation of individual funds' instructions. This could shed some light on why climate concerns appear less prevalent on the primary than on the secondary bond market.

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Table 1: Summary Statistics

Our data sample covers 4,744 bond issues from 334 unique US firms. The sample spans from 2005 to 2022. We winsorize all the variables at top and bottom 1%. The first panel summarizes CO2 emission measures. We use firms' Scope 1, Scope 2, and Scope 3 (upstream) carbon emissions. Scope 1 and Scope 2 are correlated at 0.263, Scope 1 and Scope 3 are correlated at 0.297 and Scope 2 and Scope 3 are correlated at 0.277. We normalize them by firms' sales to get carbon intensity measures. The second panel shows firm characteristics. The third panel summarizes bond characteristics. We define offering/secondary spread as the difference between a bond's yield and the yield of a cash flow-matched synthetic Treasury bond. We transform the letter ratings to a numerical value so that one notch increase gets a number larger by 1 (e.g. "C" is assigned 1 and "Aaa" is assigned 21). We use Amihud's illiquidity measure.

	N	Mean	SD	Median
Panel A: CO2 emission measures				
Log(Carbon Emission Scope 1 (tons CO2e))	334	12.48	2.460	12.50
Log(Carbon Emission Scope 1 and 2 (tons CO2e))	334	13.98	1.796	13.94
Log(Carbon Emission Scope 1, 2 and 3 (tons CO2e))	334	15.44	1.414	15.61
Carbon intensity Scope 1 (tons CO2e/USD m.)/100	334	1.689	5.733	0.0649
Carbon intensity Scope 1 and 2 (tons CO2e/USD m.)/100	334	2.079	6.068	0.295
Carbon intensity Scope 1, 2 and 3 (tons CO2e/USD m.)/100	334	3.569	6.752	1.238
Panel B: Firm characteristics				
Book leverage	334	0.321	0.157	0.304
Interest coverage ratio	334	0.112	0.133	0.0794
Firm size (Log of USD m.)	334	11.38	1.583	11.16
ROA	334	0.140	0.0915	0.140
Firm sale (Log of USD m.)	334	10.44	1.120	10.53
Equity return mean	334	0.116	0.250	0.137
Log(Equity return vol)	334	-1.563	0.420	-1.581
Panel C: Bond characteristics				
Offering spread (%)	3,388	0.670	0.627	0.491
Secondary spread (%)	4,652	0.565	1.167	0.476
Number of lead underwriters	4,744	2.763	1.331	3
Number of all underwriters	4,744	5.255	1.248	6
Illiquidity	4,744	0.0342	0.313	0.00142
Rating (Moody's)	4,744	15.16	2.699	15
$\mathbb{1}${Redeemable}	4,744	0.887	0.316	1
Years to maturity	4,744	10.77	9.594	8.403
Amount outstanding (million $)	4,744	1,082	768.9	875.4
Coupon (%)	4,744	3.533	1.414	3.400
$\mathbb{1}${Lead underwritten by J.P. Morgan}	4,744	0.395	0.489	0
$\mathbb{1}${Lead underwritten by Citi}	4,744	0.318	0.466	0
$\mathbb{1}${Lead underwritten by Merrill Lynch}	4,744	0.298	0.457	0
$\mathbb{1}${Lead underwritten by Barclays}	4,744	0.194	0.395	0
$\mathbb{1}${Lead underwritten by Morgan Stanley}	4,744	0.210	0.407	0
$\mathbb{1}${Lead underwritten by Goldman Sachs}	4,744	0.179	0.383	0
$\mathbb{1}${Lead underwritten by Wells Fargo}	4,744	0.130	0.337	0
$\mathbb{1}${Lead underwritten by Deutsche bank}	4,744	0.145	0.352	0
$\mathbb{1}${Lead underwritten by Bank of America}	4,744	0.0744	0.262	0

Table 2: Full Sample

The table reports the estimates of Model 1. (1), (3), and (5) report the results when the model is estimated on the primary market whereas (2), (4), and (6) report the results on the secondary market. T-stats are in parenthesis where robust standard errors are used. Standard errors are clustered at firm level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	-0.000101	0.00936**	4.47e-05	0.00996**	8.76e-05	0.00832**
	(-0.0858)	(2.303)	(0.0400)	(2.547)	(0.0808)	(2.259)
Years to maturity	0.0147***	0.0492***	0.0147***	0.0492***	0.0147***	0.0492***
	(10.08)	(17.51)	(10.10)	(17.54)	(10.10)	(17.46)
Log(Amount)	0.0147	-0.0112	0.0147	-0.0109	0.0147	-0.0110
	(1.275)	(-0.561)	(1.274)	(-0.546)	(1.274)	(-0.552)
$\mathbb{1}\{$Redeemable$\}$	0.0186	-0.0105	0.0187	-0.0103	0.0188	-0.00924
	(0.654)	(-0.175)	(0.658)	(-0.171)	(0.660)	(-0.154)
Rating (Moody's)	-0.0130***	-0.0598***	-0.0130***	-0.0596***	-0.0131***	-0.0596***
	(-2.704)	(-4.711)	(-2.706)	(-4.712)	(-2.707)	(-4.709)
Number of all underwriters	-0.00116	-0.0176	-0.00117	-0.0176	-0.00117	-0.0180
	(-0.173)	(-1.358)	(-0.174)	(-1.365)	(-0.175)	(-1.391)
Illiquidity		0.146***		0.146***		0.146***
		(3.459)		(3.457)		(3.462)
Coupon	0.372***	0.0165	0.372***	0.0160	0.372***	0.0157
	(20.56)	(0.750)	(20.58)	(0.726)	(20.57)	(0.711)
VIX (daily)	0.00611***	0.0353***	0.00611***	0.0353***	0.00611***	0.0353***
	(5.574)	(9.092)	(5.569)	(9.099)	(5.571)	(9.101)
Equity return mean	-0.0328	-0.799***	-0.0328	-0.798***	-0.0327	-0.795***
	(-0.795)	(-7.301)	(-0.794)	(-7.308)	(-0.791)	(-7.240)
Log(Equity return vol)	0.0380*	0.370***	0.0382*	0.371***	0.0382*	0.372***
	(1.823)	(6.387)	(1.829)	(6.409)	(1.830)	(6.407)
Book leverage	0.105	0.446**	0.105	0.448**	0.105	0.434**
	(1.231)	(2.433)	(1.235)	(2.446)	(1.231)	(2.362)
ROA	-0.116	-1.060***	-0.115	-1.045***	-0.114	-1.031***
	(-0.725)	(-3.297)	(-0.714)	(-3.272)	(-0.702)	(-3.217)
Interest coverage ratio	-0.0689	-0.0844	-0.0699	-0.0918	-0.0703	-0.0827
	(-0.540)	(-0.290)	(-0.549)	(-0.316)	(-0.554)	(-0.284)
Firm sale	0.0125	0.0411	0.0127	0.0424	0.0127	0.0375
	(1.218)	(1.294)	(1.234)	(1.336)	(1.243)	(1.207)
Firm size	-0.000121	-0.0384	-0.000108	-0.0380	-6.38e-05	-0.0342
	(-0.0111)	(-1.435)	(-0.00986)	(-1.418)	(-0.00577)	(-1.296)
Observations	2,516	879,256	2,516	879,256	2,516	879,256
R-squared	0.837	0.487	0.837	0.488	0.837	0.487
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table 3: Full Sample With Restrictions

The table reports the estimates of Model 2. T-stats are in parenthesis where robust standard errors are used. Standard errors are clustered at firm level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1) Scope 1 Primary + Secondary	(2) Scope 1 and 2 Primary + Secondary	(3) Scope 1, 2 and 3 Primary + Secondary
CO2	0.00238	0.00240	0.00206
	(1.088)	(1.179)	(1.090)
CO2 X Secondary	0.00697**	0.00756**	0.00625**
	(2.155)	(2.369)	(2.063)
Years to maturity	0.0491***	0.0491***	0.0491***
	(17.51)	(17.53)	(17.45)
Log(Amount)	-0.0110	-0.0107	-0.0109
	(-0.555)	(-0.540)	(-0.546)
$\mathbb{1}\{\text{Redeemable}\}$	-0.0104	-0.0102	-0.00913
	(-0.174)	(-0.169)	(-0.153)
Rating (Moody's)	-0.0596***	-0.0595***	-0.0595***
	(-4.712)	(-4.713)	(-4.710)
Number of all underwriters	-0.0176	-0.0176	-0.0179
	(-1.359)	(-1.366)	(-1.392)
Illiquidity	0.146***	0.146***	0.146***
	(3.461)	(3.459)	(3.464)
Coupon	0.0174	0.0169	0.0166
	(0.792)	(0.768)	(0.752)
VIX (daily)	0.0352***	0.0352***	0.0352***
	(9.100)	(9.107)	(9.109)
Equity return mean	-0.797***	-0.796***	-0.794***
	(-7.301)	(-7.308)	(-7.240)
Log(Equity return vol)	0.370***	0.371***	0.371***
	(6.387)	(6.409)	(6.407)
Book leverage	0.446**	0.448**	0.433**
	(2.436)	(2.448)	(2.364)
ROA	-1.059***	-1.044***	-1.030***
	(-3.298)	(-3.273)	(-3.219)
Interest coverage ratio	-0.0852	-0.0926	-0.0835
	(-0.293)	(-0.320)	(-0.288)
Firm sale	0.0411	0.0423	0.0375
	(1.296)	(1.338)	(1.209)
Firm size	-0.0383	-0.0379	-0.0341
	(-1.436)	(-1.420)	(-1.298)
Observations	881,772	881,772	881,772
R-squared	0.487	0.488	0.487
FE	YES	YES	YES

Table 4: Robustness: Firm X Time (Year, Week) Fixed Effects

The table reports the estimates of Model 3. Standard errors are clustered at firm level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Primary + Secondary

	(1) Scope 1	(2) Scope 1 and 2	(3) Scope 1, 2 and 3
CO2 X Secondary	0.0120***	0.0107***	0.00880***
	(3.708)	(3.695)	(3.196)
Years to maturity	0.0247***	0.0247***	0.0248***
	(10.60)	(10.57)	(10.54)
Log(Amount)	0.109***	0.109***	0.109***
	(7.882)	(7.893)	(7.883)
$\mathbb{1}\{$Redeemable$\}$	0.123	0.124	0.127
	(1.467)	(1.480)	(1.525)
Rating (Moody's)	0.00314	0.00310	0.00335
	(0.240)	(0.237)	(0.255)
#(Underwriters)	-0.0314*	-0.0312	-0.0310
	(-1.650)	(-1.639)	(-1.630)
Illiquidity	0.0747***	0.0747***	0.0748***
	(3.770)	(3.766)	(3.764)
Coupon	0.224***	0.224***	0.224***
	(7.662)	(7.655)	(7.603)
VIX (daily)	0.00171	0.00162	0.00165
	(0.573)	(0.541)	(0.552)
Secondary	0.843*	0.842*	0.867**
	(1.905)	(1.902)	(1.971)
(Years to maturity) X Secondary	0.00423**	0.00424**	0.00419**
	(2.190)	(2.186)	(2.154)
Log(Amount) X Secondary	-0.128***	-0.128***	-0.128***
	(-9.013)	(-8.979)	(-9.060)
$\mathbb{1}\{$Redeemable$\}$ X Secondary	-0.114*	-0.115*	-0.119*
	(-1.688)	(-1.702)	(-1.757)
Rating (Moody's) X Secondary	0.0273	0.0273	0.0266
	(1.007)	(1.009)	(0.992)
#(Underwriters) X Secondary	0.0243	0.0241	0.0238
	(1.455)	(1.440)	(1.421)
Coupon X Secondary	-0.0402*	-0.0406*	-0.0400*
	(-1.683)	(-1.692)	(-1.662)
VIX (daily) X Secondary	0.00187	0.00195	0.00191
	(0.609)	(0.638)	(0.625)
Observations	44,597	44,597	44,597
R-squared	0.823	0.823	0.822
(Firm X Week) FE	YES	YES	YES

Table 5: Summary statistics for issuance days analysis

Table shows summary statistics for the sample used in our issuance days analysis (see Section 3.4). Our data sample covers 3,586 bond issues from 219 unique US firms. The sample spans 2005–2022. We winsorize all variables at the top and bottom 1%. Variable definitions follow Table 1.

	N	Mean	SD	Median
Panel A: CO2 emission measures				
Log(Carbon Emission Scope 1 (tons CO2e))	219	11.67	2.104	11.50
Log(Carbon Emission Scope 1 and 2 (tons CO2e))	219	13.81	1.514	13.84
Log(Carbon Emission Scope 1, 2 and 3 (tons CO2e))	219	15.16	1.229	15.17
Carbon intensity Scope 1 (tons CO2e/USD m.)/100	219	0.746	3.912	0.010
Carbon intensity Scope 1 and 2 (tons CO2e/USD m.)/100	219	0.979	4.092	0.133
Carbon intensity Scope 1, 2 and 3 (tons CO2e/USD m.)/100	219	1.796	4.662	0.429
Panel B: Firm characteristics				
Book leverage	219	0.354	0.160	0.364
Interest coverage ratio	219	0.189	0.216	0.118
Firm size	219	12.67	1.521	13.21
ROA	219	0.094	0.092	0.034
Firm sale	219	10.89	0.873	10.83
Equity return mean	219	0.109	0.278	0.125
Log(Equity return vol)	219	-1.523	0.415	-1.594
Panel C: **Primary market** bond characteristics				
Offering spread (%)	2536	0.641	0.599	0.471
Number of lead underwriters	2536	2.510	1.324	3
Number of all underwriters	2536	4.658	1.825	5
Rating (Moody's)	2536	15.05	2.571	15
$\mathbb{1}$\{Redeemable\}	2536	0.812	0.391	1
Years to maturity	2536	12.47	10.13	10.02
Amount outstanding (million $)	2536	800.5	777.1	607.7
Coupon (%)	2536	3.435	1.355	3.375
$\mathbb{1}$\{Lead underwritten by J.P. Morgan\}	2536	0.326	0.469	0
$\mathbb{1}$\{Lead underwritten by Citi\}	2536	0.269	0.443	0
$\mathbb{1}$\{Lead underwritten by Merrill Lynch\}	2536	0.215	0.411	0
$\mathbb{1}$\{Lead underwritten by Barclays\}	2536	0.164	0.370	0
$\mathbb{1}$\{Lead underwritten by Morgan Stanley\}	2536	0.229	0.420	0
$\mathbb{1}$\{Lead underwritten by Goldman Sachs\}	2536	0.139	0.346	0
$\mathbb{1}$\{Lead underwritten by Wells Fargo\}	2536	0.105	0.307	0
$\mathbb{1}$\{Lead underwritten by Deutsche Bank\}	2536	0.118	0.323	0
$\mathbb{1}$\{Lead underwritten by Bank of America\}	2536	0.110	0.312	0
Panel D: **Secondary market** bond characteristics				
Offering spread (%)	2579	0.775	0.622	0.623
Secondary spread (%)	2579	0.741	1.046	0.702
Number of lead underwriters	2579	2.066	1.267	1
Number of all underwriters	2579	4.449	1.671	5
Illiquidity	2579	0.125	0.669	0.00175
Rating (Moody's)	2579	15.29	2.116	15

Continued on next page

Table 5 (continued)

	N	Mean	SD	Median
$\mathbb{1}\{$Redeemable$\}$	2579	0.634	0.482	1
Years to maturity	2579	11.67	9.810	8.619
Amount outstanding (million $)	2579	1,059	990.9	884.9
Coupon (%)	2579	3.958	1.460	4
$\mathbb{1}\{$Lead underwritten by J.P. Morgan$\}$	2579	0.179	0.383	0
$\mathbb{1}\{$Lead underwritten by Citi$\}$	2579	0.160	0.366	0
$\mathbb{1}\{$Lead underwritten by Merrill Lynch$\}$	2579	0.214	0.410	0
$\mathbb{1}\{$Lead underwritten by Barclays$\}$	2579	0.0972	0.296	0
$\mathbb{1}\{$Lead underwritten by Morgan Stanley$\}$	2579	0.249	0.432	0
$\mathbb{1}\{$Lead underwritten by Goldman Sachs$\}$	2579	0.172	0.377	0
$\mathbb{1}\{$Lead underwritten by Wells Fargo$\}$	2579	0.0646	0.246	0
$\mathbb{1}\{$Lead underwritten by Deutsche Bank$\}$	2579	0.0735	0.261	0
$\mathbb{1}\{$Lead underwritten by Bank of America$\}$	2579	0.0213	0.144	0

Table 6: Robustness: Issuance days analysis

The table reports the estimates of Model 1 for issuance days matched sample. (1), (3), and (5) report the results when the model is estimated on the primary market whereas (2), (4), and (6) report the results on the secondary market. Standard errors are clustered at firm X trade date level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	0.00251	0.0158*	0.00273*	0.0180**	0.00267*	0.0183**
	(1.637)	(1.949)	(1.829)	(2.091)	(1.908)	(2.209)
Years to maturity	0.0154***	0.0543***	0.0154***	0.0544***	0.0154***	0.0545***
	(9.776)	(11.66)	(9.846)	(11.68)	(9.892)	(11.68)
Log(Amount)	0.0305***	-0.0243*	0.0304***	-0.0245*	0.0304***	-0.0246*
	(7.303)	(-1.916)	(7.345)	(-1.929)	(7.345)	(-1.946)
$\mathbb{1}\{\text{Redeemable}\}$	0.0588**	0.173***	0.0588**	0.174***	0.0589**	0.175***
	(2.296)	(3.437)	(2.300)	(3.452)	(2.299)	(3.479)
Rating (Moody's)	-0.0156***	-0.0611***	-0.0156***	-0.0609***	-0.0156***	-0.0603***
	(-3.383)	(-2.754)	(-3.398)	(-2.749)	(-3.411)	(-2.738)
Number of all underwriters	-0.00564	-0.0160	-0.00563	-0.0160	-0.00564	-0.0159
	(-1.125)	(-1.262)	(-1.124)	(-1.260)	(-1.127)	(-1.255)
Illiquidity		0.0242***		0.0243***		0.0244***
		(2.920)		(2.917)		(2.917)
Coupon	0.342***	-0.00491	0.342***	-0.00553	0.342***	-0.00582
	(19.33)	(-0.157)	(19.41)	(-0.176)	(19.49)	(-0.185)
VIX (daily)	0.00688***	0.0325***	0.00689***	0.0325***	0.00689***	0.0325***
	(6.093)	(6.515)	(6.111)	(6.511)	(6.095)	(6.519)
Equity return mean	-0.0943**	-0.466***	-0.0940**	-0.462***	-0.0934**	-0.460***
	(-2.359)	(-3.752)	(-2.350)	(-3.735)	(-2.327)	(-3.710)
Log(Equity return vol)	0.0699***	0.282***	0.0703***	0.283***	0.0708***	0.287***
	(2.987)	(3.679)	(3.002)	(3.684)	(3.017)	(3.703)
Book leverage	0.0749	0.303	0.0747	0.303	0.0706	0.288
	(1.075)	(1.295)	(1.070)	(1.292)	(1.011)	(1.228)
ROA	-0.0335	-0.763	-0.0267	-0.717	-0.0189	-0.666
	(-0.267)	(-1.488)	(-0.213)	(-1.405)	(-0.150)	(-1.305)
Interest coverage ratio	-0.205**	-0.662***	-0.206**	-0.661***	-0.205**	-0.656***
	(-2.493)	(-3.010)	(-2.504)	(-2.985)	(-2.491)	(-2.956)
Firm sale	0.0150	0.0200	0.0154	0.0235	0.0149	0.0219
	(1.313)	(0.423)	(1.350)	(0.493)	(1.327)	(0.469)
Firm size	-0.00204	-0.000757	-0.00179	0.000530	-0.000956	0.00553
	(-0.189)	(-0.0163)	(-0.166)	(0.0113)	(-0.0881)	(0.119)
Observations	2,428	8,525	2,428	8,525	2,428	8,525
R-squared	0.839	0.630	0.839	0.631	0.839	0.631
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table 7: Channel: Uncertainty about future climate concerns

Table tests uncertainty channel. We first construct HV_t where HV_t proxies the uncertainty of future climate concerns at time t. For this, we use daily Media Climate Change Concerns index that was constructed and was made available to download by Ardia, Bluteau, Boudt, and Inghelbrecht (2022). We use ARCH model to estimate the conditional volatility at day t conditioned on all the daily data between $t-1$ and $t-30$. Then, we set $HV_t = 1$ if the measure is above the median. Otherwise, we set it to 0. Then, we estimate the following model:

$$Spread_{f,i,t} = \alpha + \beta_1 \cdot CO2_{f,t} + \beta_2 \cdot HV_t + \beta_3 \cdot CO2_{f,t} \times HV_t + BondCtrl_{f,i,t} + FirmCtrl_{f,t} + FE + \varepsilon_{f,i,t}$$

where $Spread_{f,i,t}$ is spread of the bond i that is issued at time t by firm f. Table reports the estimates of β's. Standard errors are clustered at firm level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	-0.000281	-0.000898	-0.000309	-0.00104	-0.000467	-0.000712
	(-0.239)	(-0.299)	(-0.280)	(-0.363)	(-0.446)	(-0.267)
HV	0.0113	0.0390	0.0118	0.0409	0.0122	0.0474
	(0.603)	(1.257)	(0.629)	(1.314)	(0.654)	(1.516)
CO2 X HV	0.00592**	0.0254***	0.00536*	0.0253***	0.00501*	0.0215***
	(1.976)	(3.262)	(1.795)	(3.587)	(1.849)	(3.481)
Years to maturity	0.0152***	0.0463***	0.0152***	0.0465***	0.0151***	0.0464***
	(7.987)	(14.23)	(7.966)	(14.28)	(7.957)	(14.23)
Log(Amount)	0.0288***	-0.0296	0.0290***	-0.0298*	0.0291***	-0.0300*
	(6.078)	(-1.647)	(6.120)	(-1.654)	(6.124)	(-1.668)
$\mathbb{1}\{\text{Redeemable}\}$	0.0530*	0.0390	0.0531*	0.0393	0.0530*	0.0408
	(1.858)	(0.629)	(1.862)	(0.635)	(1.866)	(0.662)
Rating (Moody's)	-0.0187***	-0.0503***	-0.0187***	-0.0498***	-0.0186***	-0.0496***
	(-4.087)	(-3.888)	(-4.100)	(-3.859)	(-4.095)	(-3.831)
Number of all underwriters	-0.00434	-0.000291	-0.00445	-0.000550	-0.00472	-0.000890
	(-0.767)	(-0.0259)	(-0.788)	(-0.0492)	(-0.841)	(-0.0796)
Illiquidity		0.138***		0.138***		0.138***
		(4.418)		(4.413)		(4.420)
Coupon	0.340***	0.0603**	0.340***	0.0590**	0.340***	0.0585**
	(18.82)	(2.450)	(18.81)	(2.401)	(18.83)	(2.363)
VIX (daily)	0.00798***	0.0479***	0.00798***	0.0479***	0.00800***	0.0479***
	(4.410)	(6.720)	(4.402)	(6.719)	(4.400)	(6.717)
Equity return mean	-0.0317	-0.881***	-0.0320	-0.878***	-0.0319	-0.879***
	(-0.688)	(-6.922)	(-0.693)	(-6.937)	(-0.691)	(-6.935)
Log(Equity return vol)	0.0365	0.344***	0.0361	0.343***	0.0347	0.339***
	(1.449)	(4.878)	(1.438)	(4.894)	(1.385)	(4.829)
Book leverage	0.117	0.525***	0.116	0.524***	0.117	0.529***
	(1.243)	(2.680)	(1.232)	(2.677)	(1.246)	(2.696)
ROA	-0.213	-1.298***	-0.211	-1.280***	-0.211	-1.269***
	(-1.172)	(-3.610)	(-1.151)	(-3.568)	(-1.130)	(-3.506)
Interest coverage ratio	-0.156	-0.337	-0.155	-0.336	-0.154	-0.335
	(-1.498)	(-1.136)	(-1.491)	(-1.133)	(-1.487)	(-1.129)
Firm sale	0.0272*	0.0356	0.0273*	0.0353	0.0261*	0.0302
	(1.829)	(1.040)	(1.832)	(1.036)	(1.757)	(0.890)

Firm size	-0.00373	-0.0342	-0.00381	-0.0331	-0.00303	-0.0288
	(-0.258)	(-1.224)	(-0.263)	(-1.188)	(-0.205)	(-1.026)
Observations	2,248	629,248	2,248	629,248	2,248	629,248
R-squared	0.842	0.497	0.842	0.498	0.842	0.497
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table 8: Channel: Competition among lead underwriters

Table tests competition channel. We construct $LC_{f,i}$ where it proxies the degree of competition among the lead underwriters for the bond i that is issued by firm f. We define

$$Ratio_{f,i} = \frac{\text{Number of lead underwriters}_{f,i}}{\text{Amount offered}_{f,i}}.$$

And we set $LC_{f,i} = 1$ if the ratio is below the median. Otherwise, we set it to 0. Then, we estimate the following:

$$Spread_{f,i,t} = \alpha + \beta_1 \cdot CO2_{f,t} + \beta_2 \cdot LC_{f,i} + \beta_3 \cdot CO2_{f,t} \times LC_{f,i} + BondCtrl_{f,i,t} + FirmCtrl_{f,t} + FE + \varepsilon_{f,i,t}$$

$Spread_{f,i,t}$ is spread of the bond i that is issued at time t by firm f. Table reports the estimates of β's. Standard errors are clustered at firm level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	0.000670	0.00623	0.000555	0.00628	0.000522	0.00546
	(0.526)	(1.270)	(0.452)	(1.367)	(0.455)	(1.299)
LC	0.00523	0.0422	0.00463	0.0396	0.00377	0.0372
	(0.216)	(1.101)	(0.190)	(1.038)	(0.152)	(0.979)
CO2 X LC	0.00348	0.00961	0.00291	0.00963	0.00238	0.00840
	(1.487)	(1.182)	(1.310)	(1.286)	(1.096)	(1.234)
Years to maturity	0.0151***	0.0461***	0.0150***	0.0462***	0.0150***	0.0462***
	(8.048)	(14.21)	(8.037)	(14.24)	(8.021)	(14.23)
Log(Amount)	0.0289***	-0.0380*	0.0291***	-0.0368*	0.0295***	-0.0353*
	(4.271)	(-1.943)	(4.274)	(-1.881)	(4.226)	(-1.798)
$\mathbb{1}\{\text{Redeemable}\}$	0.0527*	0.0374	0.0527*	0.0375	0.0528*	0.0383
	(1.836)	(0.595)	(1.837)	(0.598)	(1.838)	(0.611)
Rating (Moody's)	-0.0193***	-0.0528***	-0.0194***	-0.0524***	-0.0194***	-0.0525***
	(-4.219)	(-4.068)	(-4.235)	(-4.043)	(-4.248)	(-4.055)
Number of all underwriters	-0.00430	0.000633	-0.00441	0.000405	-0.00441	5.14e-05
	(-0.779)	(0.0543)	(-0.801)	(0.0349)	(-0.800)	(0.00445)
Illiquidity		0.137***		0.137***		0.137***
		(4.411)		(4.413)		(4.410)
Coupon	0.342***	0.0644***	0.342***	0.0633**	0.342***	0.0627**
	(19.28)	(2.630)	(19.30)	(2.581)	(19.28)	(2.541)
VIX (daily)	0.00796***	0.0483***	0.00794***	0.0483***	0.00794***	0.0483***
	(4.549)	(6.833)	(4.537)	(6.835)	(4.519)	(6.840)
Equity return mean	-0.0367	-0.895***	-0.0372	-0.893***	-0.0372	-0.892***
	(-0.808)	(-7.048)	(-0.817)	(-7.050)	(-0.815)	(-7.014)
Log(Equity return vol)	0.0419*	0.368***	0.0416*	0.367***	0.0419*	0.369***
	(1.728)	(5.369)	(1.719)	(5.384)	(1.728)	(5.418)
Book leverage	0.113	0.516***	0.111	0.514***	0.109	0.501**
	(1.199)	(2.612)	(1.174)	(2.599)	(1.147)	(2.522)
ROA	-0.192	-1.248***	-0.190	-1.234***	-0.184	-1.200***
	(-1.055)	(-3.401)	(-1.038)	(-3.373)	(-0.981)	(-3.253)
Interest coverage ratio	-0.156	-0.337	-0.154	-0.340	-0.154	-0.333
	(-1.504)	(-1.136)	(-1.494)	(-1.144)	(-1.486)	(-1.123)

Firm sale	0.0280*	0.0401	0.0279*	0.0398	0.0270*	0.0331
	(1.903)	(1.144)	(1.905)	(1.142)	(1.829)	(0.951)
Firm size	-0.00386	-0.0375	-0.00382	-0.0364	-0.00293	-0.0304
	(-0.265)	(-1.317)	(-0.261)	(-1.277)	(-0.195)	(-1.067)
Observations	2,248	628,586	2,248	628,586	2,248	628,586
R-squared	0.842	0.494	0.841	0.495	0.841	0.494
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table 9: Channel: Lead underwriters' reputation

Table tests reputation channel. We construct $HR_{f,i}$ which indicates whether the sole lead underwriter for bond i, issued by firm f, has a high level of reputation. We calculate underwriter u's market share in bond offerings for year t as follows:

$$\text{MarketShare}_{u,t} = \frac{\text{Total Bond Offering}_{u,t}}{\text{Total Bond Offering}_{t}},$$

where the numerator denotes the total dollar amount of bonds underwritten by underwriter u in year t, and the denominator denotes the total dollar amount of all bond offerings in that year. We then define a dummy variable $HR_{f,i}$ that equals 1 if the lead underwriter u for bond i, issued by firm f, has a market share in year $t-1$ above the 85th percentile. Similarly, we set $HR_{f,i} = 0$ if $\text{MarketShare}_{u,t-1}$ falls below the 15th percentile. Then, we estimate the following:

$$Spread_{f,i,t} = \alpha + \beta_1 \cdot CO2_{f,t} + \beta_2 \cdot HR_{f,i} + \beta_3 \cdot CO2_{f,t} \times HR_{f,i} + BondCtrl_{f,i,t} + FirmCtrl_{f,t} + FE + \varepsilon_{f,i,t}$$

$Spread_{f,i,t}$ is spread of the bond i that is issued at time t by firm f. Table reports the estimates of β's. Standard errors are clustered at firm level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	-0.0352*	0.0311***	-0.0324*	0.0315***	-0.0277**	0.0252***
	(-1.886)	(3.183)	(-1.972)	(3.413)	(-2.426)	(3.233)
HR	0.239*	-0.151	0.235	-0.157	0.229	-0.151
	(1.687)	(-1.040)	(1.641)	(-1.073)	(1.560)	(-1.024)
CO2 X HR	0.0373*	-0.0113	0.0349**	-0.0146	0.0288**	-0.0102
	(1.958)	(-1.023)	(2.081)	(-1.463)	(2.595)	(-1.250)
Years to maturity	0.0212***	0.0438***	0.0213***	0.0439***	0.0212***	0.0440***
	(3.691)	(7.924)	(3.708)	(7.910)	(3.768)	(7.933)
Log(Amount)	0.0318	0.0591*	0.0315	0.0594*	0.0334	0.0594*
	(1.518)	(1.914)	(1.497)	(1.923)	(1.614)	(1.904)
$\mathbb{1}\{\text{Redeemable}\}$	-0.0772	0.000296	-0.0773	0.000158	-0.0765	0.00253
	(-1.231)	(0.00269)	(-1.230)	(0.00143)	(-1.239)	(0.0229)
Rating (Moody's)	-0.00369	-0.0347*	-0.00413	-0.0343*	-0.00699	-0.0337*
	(-0.462)	(-1.816)	(-0.518)	(-1.805)	(-0.859)	(-1.785)
Number of all underwriters	-0.0240*	0.0596*	-0.0232	0.0584*	-0.0226	0.0589*
	(-1.707)	(1.956)	(-1.662)	(1.932)	(-1.608)	(1.938)
Illiquidity		0.0730		0.0730		0.0725
		(0.956)		(0.956)		(0.947)
Coupon	0.315***	0.0897**	0.315***	0.0891**	0.314***	0.0863**
	(7.067)	(2.489)	(7.053)	(2.461)	(7.175)	(2.418)
VIX (daily)	0.00977**	0.0628***	0.00977**	0.0628***	0.00958**	0.0628***
	(2.382)	(5.331)	(2.405)	(5.333)	(2.436)	(5.337)
Equity return mean	0.0957	-0.723***	0.0961	-0.724***	0.0658	-0.714***
	(0.641)	(-3.746)	(0.644)	(-3.762)	(0.442)	(-3.671)
Log(Equity return vol)	0.0785	0.197	0.0750	0.205*	0.0726	0.198
	(0.870)	(1.608)	(0.833)	(1.666)	(0.808)	(1.603)
Book leverage	-0.126	0.0111	-0.113	-0.0154	-0.101	-0.0146
	(-0.590)	(0.0383)	(-0.528)	(-0.0532)	(-0.482)	(-0.0509)
ROA	-0.519	-4.219***	-0.483	-4.253***	-0.367	-4.315***

	(-0.885)	(-5.313)	(-0.824)	(-5.371)	(-0.630)	(-5.475)
Interest coverage ratio	0.157	0.132	0.151	0.144	0.164	0.151
	(0.726)	(0.480)	(0.706)	(0.523)	(0.760)	(0.548)
Firm sale	0.0524	0.224***	0.0510	0.226***	0.0589*	0.219***
	(1.662)	(4.214)	(1.623)	(4.263)	(1.900)	(4.055)
Firm size	-0.0515*	-0.173***	-0.0503	-0.173***	-0.0559*	-0.168***
	(-1.705)	(-3.176)	(-1.664)	(-3.191)	(-1.952)	(-3.064)
Observations	273	66,890	273	66,890	273	66,890
R-squared	0.932	0.640	0.932	0.639	0.933	0.639
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Internet Appendix for
"Do carbon emissions affect the cost of capital? Primary versus secondary corporate bond markets"

A Robustness Check

This section offers additional analyses that refine our main insights and that test the robustness of our main results. All the tests of difference between the primary and the secondary market carbon premium are based on the pooled regression model indicated in Model 2.

Table A1: Alternative channel: Bonds' creditworthiness

The table shows how our main result depend on the creditworthiness of the bonds. The table reports the estimates of Model 2 for investment grade bonds. Column (1) reports the results when Scope 1 intensity measure is used whereas column (2) (columns (3)) reports the results when Scope 1 and 2 (Scope 1,2, and 3) is used. Standard errors are clustered at firm level. T-statistics are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	0.000112	0.00663*	0.000253	0.00789**	0.000399	0.00669**
	(0.0850)	(1.768)	(0.209)	(2.135)	(0.345)	(1.994)
Observations	2,420	845,299	2,420	845,299	2,420	845,299
R-squared	0.837	0.534	0.837	0.535	0.837	0.535
Bond controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table A2: Robustness: Additional lags

The table shows how our main result is robust to lagging CO2 emission measure by one extra year to address an issue pointed out by Zhang (2025). The table reports the estimates of Model 2 where CO2 is lagged by two years. Column (1) reports the results when Scope 1, 2 and 3 intensity measure is used whereas column (2) ((3)) reports the results when Scope 1 (Scope 1 and 2) is used. Standard errors are clustered at firm level. T-statistics are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	0.000181	0.00782*	0.000201	0.00788**	0.000207	0.00640*
	(0.147)	(1.926)	(0.173)	(2.022)	(0.187)	(1.761)
Observations	2,509	877,858	2,509	877,858	2,509	877,858
R-squared	0.837	0.484	0.837	0.484	0.837	0.484
Bond controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
Seniority FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table A3: Robustness: More precise definition of CO2 emission

The table shows that our main result is robust to different precision levels of CO2 emission definitions. The table reports the estimates of Model 2. Precision level classifications are in Table A8. Column (1) reports the results when Scope 1, 2 and 3 intensity measure is used whereas column (2) ((3)) reports the results when Scope 1 (Scope 1 and 2) is used. Panel A focus on the sample with precision level 4 or above. Panel B focus on the sample with precision level 5. Standard errors are clustered at firm level. T-statistics are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Panel A: Precision level 4 or above						
CO2	-0.000252	0.0101**	-6.12e-05	0.0106***	1.80e-06	0.00928**
	(-0.228)	(2.453)	(-0.0578)	(2.718)	(0.00174)	(2.551)
Observations	2,465	864,465	2,465	864,465	2,465	864,465
R-squared	0.841	0.512	0.841	0.512	0.841	0.512
Panel B: Precision level 5						
CO2	-0.000364	0.0101**	-0.000160	0.0106***	-6.67e-05	0.00927**
	(-0.325)	(2.443)	(-0.149)	(2.706)	(-0.0634)	(2.536)
Observations	2,425	847,382	2,425	847,382	2,425	847,382
R-squared	0.841	0.512	0.841	0.513	0.841	0.512
Bond controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table A4: Robustness: CO2 squared as additional control

The table shows how our main result is robust to controlling for the nonlinear relation between CO2 and the outcome variable. The table reports the estimates of Model 2 where we additionally control for CO2 squared. Column (1) reports the results when Scope 1, 2 and 3 intensity measure is used whereas column (2) ((3)) reports the results when Scope 1 (Scope 1 and 2) is used. Standard errors are clustered at firm level. T-statistics are in parentheses.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	-0.000318	0.00597	-0.000281	0.00756*	9.69e-05	0.00993**
	(-0.235)	(1.437)	(-0.242)	(1.917)	(0.0820)	(2.534)
CO2 X CO2	0.00821	0.120*	0.0123	0.0857	-0.000349	-0.0560
	(0.196)	(1.734)	(0.334)	(1.514)	(-0.0115)	(-0.886)
Observations	2,516	879,256	2,516	879,256	2,516	879,256
R-squared	0.837	0.488	0.837	0.488	0.837	0.487
Bond controls	YES	YES	YES	YES	YES	YES
Firm controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
Seniority FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table A5: Full Sample Among Uncertainty Channel Sample

The table reports the estimates of Model 1 in our restricted sample, which spans 2005 to 2018 when uncertainty channel proxies are available as discussed in Section 4.1. (1), (3), and (5) report the results when the model is estimated on the primary market whereas (2), (4), and (6) report the results on the secondary market. T-stats are in parenthesis where robust standard errors are used. Standard errors are clustered at firm level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	0.00199	0.0111**	0.00174	0.0114**	0.00154	0.0101**
	(1.267)	(2.077)	(1.122)	(2.257)	(1.021)	(2.181)
Years to maturity	0.0150***	0.0460***	0.0150***	0.0460***	0.0150***	0.0461***
	(8.031)	(14.27)	(8.018)	(14.31)	(8.003)	(14.29)
Log(Amount)	0.0292***	-0.0283	0.0293***	-0.0283	0.0293***	-0.0281
	(6.109)	(-1.565)	(6.139)	(-1.557)	(6.133)	(-1.549)
$\mathbb{1}\{\text{Redeemable}\}$	0.0522*	0.0361	0.0521*	0.0364	0.0523*	0.0376
	(1.810)	(0.569)	(1.809)	(0.576)	(1.814)	(0.598)
Rating (Moody's)	-0.0199***	-0.0542***	-0.0199***	-0.0539***	-0.0199***	-0.0540***
	(-4.403)	(-4.157)	(-4.405)	(-4.150)	(-4.409)	(-4.161)
Number of all underwriters	-0.00452	-0.00102	-0.00460	-0.00117	-0.00466	-0.00161
	(-0.796)	(-0.0868)	(-0.810)	(-0.100)	(-0.822)	(-0.138)
Illiquidity		0.138***		0.138***		0.138***
		(4.431)		(4.430)		(4.432)
Coupon	0.343***	0.0663***	0.343***	0.0655***	0.343***	0.0650***
	(19.46)	(2.730)	(19.46)	(2.697)	(19.43)	(2.671)
VIX (daily)	0.00763***	0.0482***	0.00763***	0.0482***	0.00764***	0.0482***
	(4.256)	(6.824)	(4.256)	(6.825)	(4.253)	(6.829)
Equity return mean	-0.0351	-0.898***	-0.0352	-0.896***	-0.0354	-0.895***
	(-0.772)	(-7.050)	(-0.772)	(-7.049)	(-0.778)	(-7.019)
Log(Equity return vol)	0.0426*	0.371***	0.0424*	0.371***	0.0425*	0.372***
	(1.772)	(5.368)	(1.760)	(5.380)	(1.762)	(5.398)
Book leverage	0.106	0.507**	0.105	0.506**	0.103	0.489**
	(1.144)	(2.558)	(1.130)	(2.550)	(1.096)	(2.455)
ROA	-0.190	-1.262***	-0.190	-1.244***	-0.188	-1.224***
	(-1.032)	(-3.449)	(-1.019)	(-3.416)	(-0.992)	(-3.343)
Interest coverage ratio	-0.154	-0.334	-0.153	-0.337	-0.152	-0.331
	(-1.504)	(-1.127)	(-1.497)	(-1.138)	(-1.487)	(-1.117)
Firm sale	0.0302**	0.0483	0.0300**	0.0487	0.0293**	0.0432
	(2.104)	(1.351)	(2.092)	(1.371)	(2.054)	(1.231)
Firm size	-0.00473	-0.0397	-0.00466	-0.0389	-0.00409	-0.0340
	(-0.334)	(-1.352)	(-0.328)	(-1.328)	(-0.284)	(-1.165)
Observations	2,251	629,374	2,251	629,374	2,251	629,374
R-squared	0.841	0.494	0.841	0.494	0.841	0.494
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table A6: Summary statistics for firm-by-time fixed effects analysis

Table show summary statistics for the sample that are used in our analysis with firm-time fixed effects (see Section 3.3). Our data sample covers 3,406 bond issues from 313 unique US firms. The sample spans from 2005 to 2022. We winsorize all the variables at top and bottom 1%. Variable definitions are similar to what is described in Table 1.

	N	Mean	SD	Median
CO2 emission measures				
Log(Carbon Emission Scope 1 (tons CO2e))	313	12.54	2.505	12.58
Log(Carbon Emission Scope 1 and 2 (tons CO2e))	313	13.99	1.847	13.96
Log(Carbon Emission Scope 1, 2 and 3 (tons CO2e))	313	15.42	1.460	15.62
Carbon intensity Scope 1 (tons CO2e/USD m.)/100	313	1.829	6.007	0.0692
Carbon intensity Scope 1 and 2 (tons CO2e/USD m.)/100	313	2.252	6.501	0.330
Carbon intensity Scope 1, 2 and 3 (tons CO2e/USD m.)/100	313	3.798	7.197	1.264
Firm characteristics				
Book leverage	313	0.306	0.155	0.284
Interest coverage ratio	313	0.107	0.128	0.0768
Firm size	313	11.24	1.583	11.00
ROA	313	0.145	0.0920	0.144
Firm Sale	313	10.37	1.142	10.46
Equity return mean	313	0.121	0.245	0.145
Log(Equity return vol)	313	-1.585	0.409	-1.606
Bond characteristics				
Offering spread (%)	3,388	0.670	0.627	0.491
Secondary spread (%)	3,144	0.523	0.729	0.376
Number of lead underwriters	3,406	2.767	1.243	3
Number of all underwriters	3,406	5.292	1.279	6
Illiquidity	3,406	0.00564	0.0917	0.000202
Rating (Moody's)	3,406	14.97	2.660	15
$\mathbb{1}$\{Redeemable\}	3,406	0.909	0.288	1
Years to maturity	3,406	12.55	10.17	9.974
Amount outstanding (million $)	3,406	979.0	723.0	765.5
Coupon (%)	3,406	3.428	1.381	3.350
$\mathbb{1}$\{Lead underwritten by J.P. Morgan\}	3,406	0.398	0.489	0
$\mathbb{1}$\{Lead underwritten by Citi\}	3,406	0.339	0.473	0
$\mathbb{1}$\{Lead underwritten by Merrill Lynch\}	3,406	0.267	0.442	0
$\mathbb{1}$\{Lead underwritten by Barclays\}	3,406	0.199	0.400	0
$\mathbb{1}$\{Lead underwritten by Morgan Stanley\}	3,406	0.208	0.406	0
$\mathbb{1}$\{Lead underwritten by Goldman Sachs\}	3,406	0.144	0.351	0
$\mathbb{1}$\{Lead underwritten by Wells Fargo\}	3,406	0.127	0.333	0
$\mathbb{1}$\{Lead underwritten by Deutsche bank\}	3,406	0.132	0.339	0
$\mathbb{1}$\{Lead underwritten by Bank of America\}	3,406	0.143	0.350	0

Table A7: Robustness: Issuance days analysis based on entropy-balanced sample

The table reports the estimates of Model 1 for issuance days matched and entropy-balanced sample. Primary and secondary sample are entropy-balanced based on bond characteristics. (1), (3), and (5) report the results when the model is estimated on the primary market whereas (2), (4), and (6) report the results on the secondary market. Standard errors are clustered at firm X trade date level. T-statistics are in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

	(1)	(2)	(3)	(4)	(5)	(6)
	Scope 1		Scope 1 and 2		Scope 1, 2 and 3	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
CO2	0.00395*	0.0158*	0.00395*	0.0180**	0.00386*	0.0183**
	(1.891)	(1.949)	(1.864)	(2.091)	(1.869)	(2.209)
Years to maturity	0.0147***	0.0543***	0.0147***	0.0544***	0.0148***	0.0545***
	(8.578)	(11.66)	(8.598)	(11.68)	(8.693)	(11.68)
Log(Amount)	0.0392***	-0.0243*	0.0392***	-0.0245*	0.0392***	-0.0246*
	(7.458)	(-1.916)	(7.487)	(-1.929)	(7.465)	(-1.946)
$\mathbb{1}\{\text{Redeemable}\}$	0.0324	0.173***	0.0326	0.174***	0.0327	0.175***
	(0.968)	(3.437)	(0.975)	(3.452)	(0.980)	(3.479)
Rating (Moody's)	-0.0184***	-0.0611***	-0.0184***	-0.0609***	-0.0183***	-0.0603***
	(-3.425)	(-2.754)	(-3.423)	(-2.749)	(-3.421)	(-2.738)
Number of all underwriters	-0.00268	-0.0160	-0.00279	-0.0160	-0.00285	-0.0159
	(-0.478)	(-1.262)	(-0.499)	(-1.260)	(-0.509)	(-1.255)
Illiquidity		0.0242***		0.0243***		0.0244***
		(2.920)		(2.917)		(2.917)
Coupon	0.373***	-0.00491	0.373***	-0.00553	0.372***	-0.00582
	(19.51)	(-0.157)	(19.56)	(-0.176)	(19.71)	(-0.185)
VIX (daily)	0.00916***	0.0325***	0.00916***	0.0325***	0.00916***	0.0325***
	(6.050)	(6.515)	(6.032)	(6.511)	(6.015)	(6.519)
Equity return mean	-0.0895*	-0.466***	-0.0894*	-0.462***	-0.0883*	-0.460***
	(-1.870)	(-3.752)	(-1.866)	(-3.735)	(-1.832)	(-3.710)
Log(Equity return vol)	0.0761***	0.282***	0.0760***	0.283***	0.0765***	0.287***
	(2.873)	(3.679)	(2.867)	(3.684)	(2.882)	(3.703)
Book leverage	0.0420	0.303	0.0411	0.303	0.0371	0.288
	(0.444)	(1.295)	(0.434)	(1.292)	(0.393)	(1.228)
ROA	-0.0236	-0.763	-0.0164	-0.717	-0.00645	-0.666
	(-0.142)	(-1.488)	(-0.0985)	(-1.405)	(-0.0379)	(-1.305)
Interest coverage ratio	-0.192**	-0.662***	-0.191**	-0.661***	-0.190**	-0.656***
	(-2.348)	(-3.010)	(-2.339)	(-2.985)	(-2.319)	(-2.956)
Firm sale	0.0258	0.0200	0.0258	0.0235	0.0250	0.0219
	(1.637)	(0.423)	(1.644)	(0.493)	(1.613)	(0.469)
Firm size	-0.00383	-0.000757	-0.00356	0.000530	-0.00236	0.00553
	(-0.271)	(-0.0163)	(-0.252)	(0.0113)	(-0.165)	(0.119)
Observations	2,428	8,525	2,428	8,525	2,428	8,525
R-squared	0.849	0.630	0.849	0.631	0.849	0.631
Industry FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES
DOW FE	YES	YES	YES	YES	YES	YES
LeadUnderwriter1-10 FE	YES	YES	YES	YES	YES	YES

Table A8: Trucost's carbon disclosure

Table summarizes the precision levels of CO2 emission definition. Trucost documents how the reported CO2 emissions were derived and there are 32 different types in total. We assign each type to different precision level and the following table reports our classification. Precision level 1 corresponds to the most imprecise one whereas precision level 5 corresponds to the most precise one. Our classification is more granular but consistent with the one used by Aswani, Raghunandan, and Rajgopal (2023): our level-5 precision corresponds to their type ii): directly disclosed total emissions.

Trucost's carbon disclosure	Precision
Derived from previous year	1
Estimate based on partial data disclosure in Annual Report/10-K/Financial Accounts	1
Estimate based on partial data disclosure in CDP	1
Estimate based on partial data disclosure in Environmental/CSR	1
Estimate based on partial data disclosure in personal communication	1
Estimate derived from production data	1
Estimate scaled according to company-specific data	1
Estimate used instead of disclosure - data does not cover global operations	1
Estimate used instead of disclosure - data is normalised and no aggregating factor is available	1
Estimated data	1
Value derived from data provided in Annual Report/Financial Accounts Disclosure	2
Value derived from data provided in CDP	2
Value derived from data provided in Environmental/CSR	2
Value derived from data provided in personal communication	2
Value derived from fuel use provided in Annual Report/Financial Accounts Disclosure	2
Value derived from fuel use provided in CDP	2
Value derived from fuel use provided in Environmental/CSR	2
Value derived from fuel use provided in personal communication	2
Value split from data provided in Annual Report/Financial Accounts Disclosure	3
Value split from data provided in CDP	3
Value split from data provided in Environmental/CSR	3
Value split from data provided in personal communication	3
Value summed up from data provided in Annual Report/Financial Accounts Disclosure	4
Value summed up from data provided in CDP	4
Value summed up from data provided in Environmental/CSR	4
Value summed up from data provided in personal communication	4
Data approximated from chart/graph in Annual Report/10-K/Financial Accounts	5
Data approximated from chart/graph in Environmental Report/CSR Report/Website	5
Exact Value from Annual Report/10K/Financial Accounts Disclosure	5
Exact Value from CDP	5
Exact Value from Environmental/CSR	5
Exact Value from personal communication	5