Green Investor Clientele Effects

Antti Yang*

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Abstract

Investors with pro-environmental preferences alleviate search frictions in over-the-counter markets. I show that green bonds are more liquid than conventional bonds of the same issuer across several dimensions of market liquidity. These effects are stronger when there is more climate-related regulatory pressure and potential buyers of green securities have more assets under management. Green bonds are also more resilient to liquidity shocks. The green investor clientele effect implies that controlling for liquidity in empirical studies of the "greenium" leads to underestimation of the aggregate benefits associated with issuing green bonds.

Keywords: *climate finance, green bonds, market liquidity, clientele effects*

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*Antti Yang is from De Nederlandsche Bank and Erasmus School of Economics. E-mail: a.yang@ese.eur.nl. I am grateful to my PhD advisor Patrick Verwijmeren for his guidance and support. I also thank Dion Bongaerts, Robin Dottling, Rex Wang Renjie, Esad Smajlbegovic, and seminar participants at the Erasmus University Rotterdam and De Nederlandsche Bank for helpful comments.

1. Introduction

Human activities are responsible for a level of global warming that is unprecedented in the last 2000 years (IPCC, 2021). Climate finance aims to mitigate the risks of climate change through investments in the transition to a low-carbon economy (Hong, Karolyi, and Scheinkman, 2020). Green bonds have emerged as the main instrument of financial markets in the fight against climate change. The proceeds of green bonds are fully committed towards financing activities dedicated to climate change mitigation. Global green bond issuance has increased from just $40 billion in 2013 to $270 billion in 2020 (CBI, 2021).

In this paper, I study whether green bonds are more liquid than conventional (non-green) bonds that are otherwise identical. The analysis relies on the theoretical framework of over-the-counter (OTC) markets developed by Duffie, Garleanu, and Pedersen (2005). In OTC markets, traders must first locate a counterparty before a transaction is executed. Duffie, Garleanu, and Pedersen (2005) show that transaction costs are lower when search frictions are lower, i.e., counterparties are easier to find. The key assumption is that green bond labels attract a larger and more diverse investor base, which alleviates search frictions. For example, some sustainability-oriented investment funds may invest primarily in green bonds to fulfill their investment mandate. A dealer that is looking to sell a green bond could then choose between green and conventional investors, whereas the options would be limited to conventional investors if the bond did not have a green label. Febi et al. (2018) argue that liquidity is particularly relevant in the green bond market because of excess demand from investors and shortage of supply from issuers, and practitioner reports confirm that green bond offerings are indeed often more oversubscribed than conventional bond offerings (CBI, 2020b).

The increasing popularity of green bonds has also caught the attention of academic researchers. Existing academic studies of green bonds mainly concentrate on the green bond premium or “greenium”, a theoretical yield reduction that lowers issuers’ costs of capital with respect to conventional bonds. However, the empirical evidence on the existence of a greenium is mixed. Zerbib (2019) documents a statistically significant but economically small greenium of 2 bps on average. Other studies, like Larcker and Watts (2020) and Flammer (2021), examine offering yields and find no greenium. Moreover, green bonds are associated with higher issuance costs. Firms must carefully identify assets and projects that comply with relevant guidelines and taxonomies. Issuers also often seek third-party certification to enhance their credibility, which are accompanied by extensive pre- and post-issuance screening procedures and the risk of reputational damage in the event of a "green default".[1] Finally, the proceeds are earmarked for eligible environmentally-friendly projects, which reduces the issuer's financial flexibility.

Without any significant financial incentives to issue green bonds, the exponential growth of the green bond market appears puzzling. A recent survey conducted by the Climate Bonds Initiative (CBI) suggests that "*broadening the investor base*" is one of the key benefits of issuing green bonds (CBI, 2020a). Empirical evidence supports the importance of investor clientele effects. Flammer (2021) finds that green bond announcements are accompanied by positive abnormal stock returns, and green bond issuers attract more sustainable shareholders in the following years. Tang and Zhang (2020) document increases in investor attention by examining Google search volumes and stock turnover. While these studies focus on *indirect* clientele effects related to the shareholder base of the firm, the goal of this paper is to examine *direct* clientele effects related to the bondholder base.

To test my hypotheses, I collect a Bloomberg sample of green bonds issued between 2013 and 2019. My analysis is restricted to bonds covered by the TRACE database, which contains transaction-level information on US corporate bonds traded in OTC markets. Despite the limited size of the US corporate green bond market, the granularity of the TRACE database allows for a more comprehensive analysis of liquidity than what is currently possible with data of non-US bonds.[2]

I find that green bonds are more liquid than conventional bonds issued by the same firm across multiple dimensions. Green bonds have a significant bid-ask spread advantage of 10.9 bps when the imputed roundtrip cost (*IRC*) measure developed by Feldhutter (2012) is used as proxy for the bid-ask spread. This implies that the green label reduces the average *IRC* of conventional bonds by roughly 50%. The relative reduction in transaction cost is 12% using the *High-Low* spread measure of Corwin and Schutz (2012), but the effect remains statistically significant and economically meaningful. Green bonds also experience lower price impact, trade on a larger number of trading days, and have higher turnover ratios than conventional bonds. The regression analysis includes issuer-month fixed effects that absorb all factors related to time-varying firm

[1] In May 2017, Spanish oil company Repsol issued a €500 million green bond but was denied certification by the Climate Bonds Initiative because the proposed efficiency improvements were not aligned with the steep trajectory set out by the Paris Climate Agreement. As a result, Repsol was heavily criticized, and the green bond was excluded in most green bond indices.

[2] Studies of green bonds, such as Zerbib (2019), must often rely on low-frequency liquidity measures such as the Bloomberg quoted bid-ask spread.

characteristics, including credit risk and information asymmetry. I also include bond age, time to maturity, and offering size in the regressions to control for other bond characteristics that could affect liquidity.

The liquidity differential associated with the green label could be driven by various forces, including regulatory pressure, non-financial objectives of investors, and pressure from environmental activists. The Paris Agreement of 2015 was an important step in establishing a global binding commitment to climate change mitigation. However, former President Trump announced the withdrawal of the US from the Agreement in June 2017. In line with the relevance of regulatory pressure, the effect of the green label on measures of transaction costs and price impact weakens after the Trump election. The effects are stronger when green bond investment funds, which are specialized in trading green bonds that fulfill certain eligibility requirements, have more assets under management. These findings are consistent with the importance of buy-side conditions in the green bond market. Finally, the bid-ask spread reduction is largest for customer sell transactions, which supports the idea that the effect mainly originates from excess demand for green bonds.

The green investor clientele effect has implications for the pricing of green bonds. Duffie, Garleanu, and Pedersen (2007) show that illiquidity-induced price crashes are larger and more persistent for securities with greater search frictions. Bond markets have experienced various stress episodes in the past. For example, Mitchell, Pedersen, and Pulvino (2007) and Mitchell and Pulvino (2012) document substantial and persistent price dislocations in the convertible bond market following capital shocks to convertible arbitrage hedge funds. Corporate bond markets were also severely disrupted at the beginning of the COVID-19 pandemic (Haddad, Moreira, and Muir, 2020). I find that the green investor base makes green bonds more resilient in times of market distress. Green bonds outperformed conventional bonds in March 2020, particularly in the weeks preceding the announcements of intervention policies by the Federal Reserve.

The effects documented in this paper suggest that green bonds could present a win-win opportunity for issuers and investors. The issuance of more liquid and resilient green bonds facilitates the transition to a greener economy by reducing the cost of capital of firms with viable green projects. At the same time, investors do not necessarily need to sacrifice financial returns for buying green bonds because the decrease in yield can be offset by lower expected future transaction costs. This implies that controlling for liquidity in analyses of the greenium could lead to underestimation of the aggregate cost reduction associated with issuing green bonds. To test whether this is the case, I estimate the greenium in my sample of US corporate green bonds using a panel regression specification. Without controlling for liquidity, I find a statistically significant greenium of 8.2 bps. The estimated greenium decreases by 20% after controlling for liquidity. This suggests that both the liquidity clientele effect and non-financial objectives of investors play a role in reducing the cost of capital for green bond issuers.

My paper contributes to the upcoming literature on sustainable finance and climate finance. Policymakers are increasingly relying on financial markets to tackle the climate crisis, and green bonds have emerged as the foremost green financing instrument. Nevertheless, the exact benefits of issuing green bonds remain difficult to quantify as researchers have not discovered an economically sizable greenium. The liquidity effects documented in this paper could provide green issuers the opportunity to raise capital at lower costs and incentivize them to engage in investments that are friendly to the environment. Investors, on the other hand, are rewarded with more liquid securities. Where effects of sustainability are usually difficult to identify because of endogeneity issues, the unique green bond setting allows for a within-firm analysis that controls for most of those issues.

I also contribute to the literature on intermediary frictions in OTC markets by demonstrating that the presence of green investors alleviates search frictions. The green bond market provides the ideal setting to test this effect. I show that green bonds indeed have lower transaction costs, price impact, and number of idle trading days compared to conventional bonds. Furthermore, the green investor clientele provides price support during aggregate liquidity shocks.

Climate finance can only be effective in combating climate change under certain conditions. First, capital should be allocated in a way that is consistent with contributions to climate change mitigation. Clear and uniform taxonomies about the “greenness” of corporate activities are important to facilitate an efficient allocation of capital by asset managers with pro-environmental preferences. Asset managers should in turn disclose information on the climate impact of their investments to prevent greenwashing, which could also disrupt the transition to a net zero economy. The European Union’s Taxonomy for Sustainable Activities, Green Bond Standard, and the Sustainable Finance Disclosure Regulation are examples of policies that address these issues. Future research should shed more light on the transmission mechanisms of climate finance to corporate behavior.

The remainder of this paper is organized as follows. In Section 2, I review the literature and develop my hypotheses. Section 3 describes the data and methodology. The main results are presented in Section 4. Section 5 analyzes implications for the pricing of green bonds. Section 6 concludes, discusses implications for policymakers, and proposes several directions for future research.

2. Literature and Hypotheses

2.1 Green bonds

At first, green bonds were primarily issued by supranational organizations. The first bond with green characteristics was the "climate-awareness bond" issued by the European Investment Bank in 2007. The World Bank issued the first green bond in 2008. The capital that was raised were committed to lending projects that were friendly to the environment, such as renewable energy and energy efficiency. In more recent years, green bonds have also become an increasingly popular financing tool among corporates.

The green label is self-reported, which means that any bond issuer can claim that their bond is a green bond. As a result, skeptics have raised concerns that green bonds could be subject to "greenwashing". Various standards have been introduced to improve disclosure and transparency in the green bond market. The Green Bond Principles (GBP), developed by the International Capital Markets Association, is the most popular and constitute voluntary guidelines for issuers that relate mostly to credibility and transparency. The Climate Bond Initiative (CBI) is a London-based not-for-profit organization that provides external certification to green bond issuers conditional on stringent pre- and post-issuance screening procedures by independent third-party reviewers.

The rising popularity of green bonds has attracted the interest of academics. Most academic studies have focused on the pricing aspects of green bonds. Since green and conventional (non-green) bonds are identical except for their label and use of proceeds, they provide an ideal setting for determining whether non-pecuniary investor preferences affect asset prices (see, e.g., Fama and French, 2007). However, the empirical evidence on the existence of such a green bond premium is mixed. Zerbib (2019) studies a large sample of green bonds and documents a significant green bond premium (or "greenium") of 2 bps. Baker et al. (2018) study a sample of corporate and municipal green bonds and document a greenium of 6 bps. Kapraun and Scheins (2019) show that there is heterogeneity across issuers and the size of the premium depends largely on the credibility of commitment towards the environment. On the other hand, Larcker and Watts (2020) study pricing in municipal bond offerings. By comparing bonds issued at the same time by the same issuer, they find that the yield differential between green and brown bonds is exactly zero in most cases. Flammer (2021) and Tang and Zhang (2020) also examine initial pricing and draw similar conclusions. Even if a small pricing differential exists in secondary markets, issuers do not appear to benefit from them through lower offering yields.

Cost of capital considerations are thus unlikely to explain the exponential growth of the green bond market. The rise in popularity is even more striking considering that the certification process can be costly, and the earmarking of proceeds limits financial flexibility. Furthermore, concerns have been raised that financing green projects with separate bonds fragments bond issues, which could increase the cost of capital at the firm-level (Bongaerts and Schoenmaker, 2020). At first sight, issuing a conventional bond to finance the same projects appears to be a strictly dominant strategy for the issuer.

Issuers of green bonds indicate that attracting green investors is an important rationale for issuing green bonds. Along a similar line of reasoning, Flammer (2021) proposes an issuance rationale based on signaling: Firms issue green bonds to signal their commitment to the environment to the market. Green bond issuance is associated with positive announcement stock returns. There is also a long-term improvement in environmental performance, which makes it unlikely that green bond issuance is merely a form of greenwashing. Furthermore, green bond issuance seems to attract institutional investors that have longer investment horizons and are more committed to the environment. Tang and Zhang (2020) also find positive stock returns surrounding announcements dates, and document peaks in stock turnover and Google search volumes that reflect increased investor attention following green bond announcements. These studies have focused on *indirect* investor clientele effects in the shareholder base of the firm. The objective of this paper is to learn more about *direct* investor clientele effects in the bondholder base. By doing that, this paper also proposes a mechanism through which these effects can translate to value-creation for issuers.

2.2 Market liquidity and shocks in bond markets

Corporate bonds are typically traded in over-the-counter (OTC) markets, where traders must first locate a counterparty through intermediaries before negotiating the terms of the trade. Duffie, Garleanu, and Pedersen (2005) develop a model with search frictions and show that market makers possess inferior bargaining positions when investors can easily find other investors. They derive the following expression for the bid-ask spread (see Theorem 2 on p. 1824):

$$A - B = \frac{z\delta}{r + \lambda_u + \lambda_d + 2\lambda(\mu_{lo}(1-q) + \mu_{hn}q) + \rho(1-z)}, \quad (1)$$

where z is the bargaining power of the market maker, δ is the holding cost of the security, r is the discount rate, q is the seller's bargaining power, ρ describes the availability of dealers, and λ_u, λ_d, μ_{lo}, and μ_{hn} describe the investor composition. Most importantly, the bid-ask spread $A - B$ has an inverse relation with λ, which represent the rate at which an investor can be contacted.

Green bonds attract investments from green investors on top of the existing bondholder base of the firm. These green investors could be investors with pro-environmental preferences, investment funds with explicit green mandates, or green bond index funds and ETFs. One example of such a fund is the iShares Global Green Bond ETF managed by BlackRock, which tracks the performance of the Bloomberg Barclays MSCI Global Green Bond Index. Bonds are only included in this index if they fulfill certain requirements, such as alignment with the Green Bond Principles. Academic and practitioner studies have also observed excess demand for green bonds (Febi et al., 2018; CBI, 2020b). A dealer could place a green bond with both green and conventional investors, whereas an otherwise identical conventional bond is not an eligible investment product for green investors and can thus only be placed with conventional investors. In theory, the larger base of investors that are interested in trading the green asset should thus alleviate search frictions. This implies that $\lambda^{Green\ Bond} > \lambda^{Conventional\ Bond}$, such that the bid-ask spread of the green bond is lower than the bid-ask spread of the conventional bond.

The intuition behind this green investor clientele effect resembles that documented in earlier studies of green investors and asset prices. For example, Heinkel, Kraus, and Zechner (2001) develop a model where green investors that employ exclusion criteria to polluting firms can drive down the asset prices of those firms, inducing some of them to substitute to clean technologies. In the model, a larger number of green investors implies that polluting firms are held by a smaller number of conventional investors, increasing the cost of capital of polluting firms and resulting in an equilibrium with moree green firms.

A diversified investor base could also provide benefits in times of market stress. Duffie, Garleanu, and Pedersen (2007) show that price crashes induced by liquidity shocks are less severe for securities with lower search frictions. Both the magnitude of the price crash and the recovery time depend on the ease at which the securities can be reallocated. Liquidity-driven stress episodes have occurred several times in the history of bond markets. For example, the convertible bond market experienced large and persistent price dislocations following capital shocks to convertible arbitrage hedge funds (Mitchell, Pedersen, and Pulvino, 2007; Mitchell and Pulvino, 2012).

More recently, academic studies have examined fragility in the corporate bond market during the outbreak of the COVID-19 pandemic. Increases in selling pressure resulted in significant bond price dislocations, with bond credit spreads trading below CDS spreads and bond funds trading below net asset value (Haddad, Moreira, and Muir, 2020). Falato, Goldstein, and Hortacsu (2020) find that large outflows from bond investment funds was an important source of fragility. Bond investment funds have gained in popularity since the Global Financial Crisis and provide a more liquid investment product in fixed income securities. However, the portfolio holdings of these funds are illiquid and vulnerable to fire sales. Kargar et al. (2020) show that dealers were reluctant to absorb inventory on their own balance sheets when the number of distressed sellers increased. As a result, dealers began charging higher bid-ask spreads. Interestingly, the corporate bond market recovered swiftly after the Federal Reserve announced their intervention policy. I predict that the presence of green investors for green bonds could contribute to mitigating the adverse effects in periods of market distress by absorbing part of the selling pressure. The dislocation in the US corporate bond market at the beginning of the pandemic presents an interesting setting to test this hypothesis, especially because investment funds with higher sustainability ratings performed relatively well over that period (Pastor and Vorsatz, 2020).

3. Data

3.1 Sample description

I follow Flammer (2021) and use a sample of corporate green bonds issued between 2013 and 2020 from Bloomberg. Bonds are labeled "green" by Bloomberg if they are aligned with the Green Bond Principles, so the dataset covers a large fraction of the green bond universe. I exclude green bonds issued by governments and supra-national entities. The sample consists of 2,637 corporate green bonds issued by 907 unique corporates from 59 countries. Figure 1 illustrates the issuance of corporate green bonds over time. The figure shows that annual corporate green bond issuance has increased exponentially since 2013, when just $5 billion was raised by corporations in 16 green bond issues. In 2020, issuance reached a record high amount as firms raised over $180 billion in 769 green bond issues, which is even more impressive considering lower issuance levels during the outbreak of the pandemic in March 2020.

[FIGURE 1 ABOUT HERE]

Because the TRACE transaction-level database only covers US corporate bonds, the analysis in this paper concentrates on these bonds that are issued between 2013 and 2019. Ending the sample in 2019 facilitates the analysis of the bond market turmoil in the first half of 2020. Figure 1 also illustrates issuance numbers of US corporate bonds only. Issuance reached a peak in 2015, although this was mainly driven by one frequent issuer (SolarCity, now Tesla Energy Operations). Issuance remained at stable and relatively low levels between 2016 and 2018 but caught up with the increasing global trend in the recent years.

Table 1 contains summary statistics of the top five countries and industries by green bond issuance. The countries with the highest amount of green bonds issued are China ($125 billion), the United States ($87 billion), the Netherlands ($68 billion), France ($58 billion), and Germany ($53 billion). Most green bond issuers operate in the financial or utilities sectors. Firms from different sectors have different uses for the green bond proceeds: Financial institutions typically use the proceeds to provide green loans and mortgages, whereas utilities and energy companies tend to use the proceeds for investments in renewable energy.

[TABLE 1 ABOUT HERE]

Green bonds are included in the analysis if two criteria are met. First, there is data on a conventional bond issued by the same issuer. Data on conventional bonds are downloaded from the Mergent Fixed Income Securities Database (FISD). Convertible bonds, bonds without fixed coupon payments, and (junior) subordinated bonds are excluded from the analysis. Second, there is transaction-level data in TRACE for both the green bond and the conventional bond. The final sample includes 70 green bonds and 589 conventional bonds issued by 41 firms. Table 2 contains summary statistics on various issuance characteristics for green (Panel A) and conventional (Panel B) bonds.

[TABLE 2 ABOUT HERE]

Compared to conventional bonds, green bonds are issued with slightly lower years to maturity and coupon rates. The offering size appears to be substantially smaller: The average (median) green bond offering size is $542 million ($500 million), whereas the average (median) offering size of a conventional bond is $1 billion ($750 million). Green bonds are likely to have smaller offering size because the proceeds are earmarked for green activities and cannot be employed for general purposes. Bongaerts and Schoenmaker (2020) argue that this leads to fragmentation of bond offerings, which in turn could reduce liquidity and increase firms' cost of capital. Finally, green bonds are more likely to contain bond covenants. One important caveat is that the reported differences could partly be driven by the composition of the green and conventional bond samples.

In the liquidity analysis, I include various control variables to account for the observed differences in bond characteristics. The first control variable is $\log(Offering\,Size)$. Larger offerings are generally more liquid, and offering size was a popular static proxy of liquidity before trading-level data became available (see, e.g., Longstaff, Mithal, and Neis, 2005). Second, I include dummy variables that control for differences in liquidity across bonds with different years to maturity. Bonds with longer maturities are generally bought by investors with longer investment horizons, which could result in lower liquidity. I also include $OnTheRun$, which equals 1 in the first 12 months after issuance. This controls for a phenomenon documented in the US Treasury bond market where recently issued bonds tend to be more liquid than older bond issues. This could be a particularly important control variable given that green bond issuance is concentrated in more recent years. The main analyses do not include controls for coupon rates and bond covenants as doing so would reduce the number of observations. However, unreported analyses indicate that the results remain qualitatively and quantitatively similar if controls for coupon rates and bond covenants are included.

3.2 Liquidity measures

The empirical measurement of liquidity is complex because it has different dimensions that are impossible to capture with a single variable. The academic literature has proposed various measures of liquidity suitable for corporate bond markets (Schestag, Schuster, and Uhrig-Homburg, 2016). I consider two proxies that measure the effective bid-ask spread. The Imputed Roundtrip Costs (*IRC*) identifies roundtrip trades between investors and dealers to obtain an estimate of the bid-ask spread (Feldhutter, 2012). These roundtrip trades usually occur within a short time interval and have identical trading volumes. I identify roundtrip trades as two or three trades with identical volumes and executed within the same 30-minute interval. The *IRC* is then calculated as the difference between the highest and lowest price divided by the midpoint price. Feldhutter (2012) shows that around 90% of the trades consists of interdealer trades combined with either a buy or a sell transaction. Therefore, it is more appropriate to interpret the *IRC* as a half-spread. To ensure comparability with spreads documented in other studies, the measure is multiplied by 2. The disadvantage of the *IRC* is that it only uses information from roundtrip trades, and all remaining trades are neglected.

The second proxy is the *High-Low* measure of Corwin and Schultz (2012), which uses the difference between the highest and lowest transaction price in consecutive trading days. The measure relies on the assumption that the highest (lowest) transaction prices correspond to sell (buy) transactions. The difference between daily high and low prices can be driven by both spreads and variance. The *High-Low* measure filters out the bid-ask spread by removing the variance component.

I also consider liquidity measures that are not directly related to the bid-ask spread. The *Amihud* (2002) illiquidity measure captures the price impact of trades. The *Zero* measure counts the number of days where a bond was not traded and divides it by the maximum number of trading days in that month. Finally, *Turnover* is the monthly par trading volume scaled by the total par amount that was issued.

The five measures are estimated with transaction-level bond data from the TRACE Enhanced database. I follow the procedure of Dick-Nielsen (2009; 2014) to remove erroneous and redundant trades from the data. Tiny trades with sizes below $10,000 are also removed since they are likely to have substantially higher transaction costs (Bongaerts, De Jong, and Driessen, 2017).

Table 3, Panel A contains summary statistics of green bond liquidity for 1,659 bond-month observations. The monthly liquidity variables are constructed using the volume-weighted average of the daily estimates within that month. The average bid-ask spread of a green bond is 12.1 bps according to the *IRC* measure, and 36.6 bps according to the *High-Low* measure. The *Amihud* estimate indicates that trading $1 million in par value moves the green bond price by 0.842% on average. Green bonds remain untraded on 36% of trading days and have a monthly turnover ratio of 8%.

[TABLE 3 ABOUT HERE]

Panel B contains summary statistics of the conventional bonds. The average *IRC* and *High-Low* is higher than that of the green bond sample and suggests that green bonds enjoy a spread reduction between 3.7 and 9.5 bps. This spread reduction is economically meaningful and translates to up to 44% of the average spread of conventional bonds. Green bonds also have lower mean values for the *Amihud* and *Zero* measures and a higher *Turnover* ratio. Thus, green bonds appear to be more liquid than conventional bonds in several dimensions despite lower offering amounts. However, these findings do not consider differences between green and conventional bonds across other dimensions that could affect bond liquidity. The next section describes regression analyses that controls for these other factors.

4. Green Bond Liquidity

4.1 Green bonds and market liquidity

This section examines whether the green label affects bond liquidity. Attracting a larger and more diverse investor base with green preferences is an important reason for firms to issue green bonds. In theory, a larger investor base is associated with lower search frictions and reduces the effective bid-ask spreads in OTC markets. To test this prediction, I estimate the following regression model:

$$Liquidity_{i,j,t} = \beta * Green_i + \gamma * X_{i,j,t} + \mu_{j,t} + \varepsilon_{i,j,t}, \quad (2)$$

where $Liquidity$ is one of the measures described in Section 3.2 and $Green$ indicates whether the bond is a green bond. The green investor clientele effect predicts $\beta < 0$ for the *IRC*, *High-Low*, *Amihud*, and *Zero* measures of liquidity, and $\beta > 0$ for *Turnover*. The subscripts i, j, t denote the bond, issuing firm, and the month, respectively. X is a vector of bond-level control variables that were described in Section 3.1. $\mu_{j,t}$ are firm-month fixed effects, and standard errors are clustered at the bond-level.

The empirical identification of causal effects related to sustainability is often challenging due to endogeneity concerns. Sustainable firms are likely to differ from unsustainable firms across unobservable dimensions that are difficult to control for. By including firm-month fixed effects, my identification strategy circumvents most endogeneity concerns by exploiting variation across multiple bonds issued by the same firm. The fixed effects absorb all variation related to time-variant firm characteristics, such as credit risk and information asymmetry.[3] Like conventional bonds, green bonds are backed by the entire balance sheet of the issuer and not just the environmental project that the bond is financing. The estimated coefficient β should thus be accurate in isolating the effects that are driven by the green label only.

The regression results are reported in Table 4 and are in line with the prediction that green bonds are more liquid than conventional bonds. Model (1) estimates the effect of the green label on the *IRC* liquidity measure of Feldhutter (2012). After controlling for heterogeneity across bonds, firms, and time, green bonds enjoy a bid-ask spread reduction of 10.9 bps with respect to conventional bonds. The coefficient is statistically significant at the 1% level. The effect is also economically significant, as it represents approximately 50% of the average conventional bond *IRC* spread in this sample. Given an average monthly green bond trading

[3] Dependent on the priority of repayment in case of default, credit ratings could still differ across bonds issued by the same firm. Since we remove junior and subordinated bonds from the control sample of conventional bonds, this is unlikely to affect our findings.

volume of $68 million, the spread reduction translates to monthly transaction cost savings of over $70,000 per bond.

[TABLE 4 ABOUT HERE]

The reduction of the *High-Low* spread is just 4.9 bps in Model (2) but remains significant at the 10% level and represents 12% of the average conventional bond *High-Low* spread. The results are also consistent across other liquidity dimensions. The *Amihud* measure of green bonds is 20.8 bps (or 25%) lower than that of conventional bonds and statistically significant at the 1% level. Furthermore, a green bond is over 4 p.p. more likely to trade on any given trading day, and the monthly turnover ratio is 1.72 p.p. higher. In addition to lower transaction costs, green bonds appear more liquid in terms of price impact and trading activity as well.

The coefficients of the control variables are largely in line with the expectations. Recently issued bonds with larger offering sizes are more liquid when considering the *IRC*, *Amihud*, and *Zero* liquidity measures. Surprisingly, these bonds trade at higher *High-Low* spreads, which suggest that the two measures of bid-ask spreads do not always capture the same dimension of transaction costs. Bonds with higher maturities also tend to be less liquid, although the relation between liquidity and maturity is not linear. Bonds with maturities between 10 and 20 years appear the most illiquid.

Overall, the regression results are in line with the hypothesis that the green label brings liquidity benefits. The effects are statistically and economically significant and robust across measures of different dimensions of liquidity. The findings suggest that the green label and associated investor clientele effects facilitate the search for counterparties, which are translated to lower transaction costs, lower price impact, and higher trading activity. In the following two sections, I further analyze heterogeneity of the effects documented in this section.

4.2 The green investor clientele effect and regulatory pressure

Global awareness around climate change has varied over time. The United Nations Climate Change Conference in 2015 (also known as COP21 or Paris Climate Conference) was a landmark in the global fight against climate change, as countries committed to the goal of keeping global warming below 2 degrees Celsius by 2050. With the prospect of increased regulation around climate change mitigation, large asset managers were also likely to be pushed towards integrating climate considerations into their investment decisions. However, former President Trump announced the withdrawal of the United States from the Paris Agreement in June 2017. The US withdrawal could have important implications for asset managers heavily invested in climate policy relevant sectors. This could also explain why the issuance of green bonds in the US was slow to catch up with global issuance trends, as shown in Figure 1.

To test whether the effect of the green label on market liquidity varies over time, I repeat the analysis of Section 4.1 but interact the *Green* indicator with a dummy that equals one from November 2016 onward, the month that Donald Trump was elected president of the US.[4] The results are reported in Table 5. The effect of the green label on *IRC*, *High-Low*, and *Amihud* are substantially larger before November 2016. The interaction effects are also large and statistically significant, indicating that the green investor clientele effect became weaker over time. This is consistent with the notion that climate awareness and regulatory pressure in the US decreased following the Trump election and US withdrawal from the Paris Agreement.

[TABLE 5 ABOUT HERE]

The pattern is different for the trading activity variables *Zero* and *Turnover*, where the standalone and interaction effects of the green label become insignificant. An unreported analysis with yearly interaction effects suggests that the effect of the green label on these trading activity variables is concentrated in 2019 and 2020. The increasing effect size in recent years could reflect an increasing sense of urgency around the climate crisis, driven by increasing numbers of natural disasters like wildfires, new temperature records around the world, and additional warnings from leading climate scientists.[5] This awareness could increase trading activity in green bonds without lowering their transaction costs.

[4] While it would also be interesting to focus on the effects of the Paris Climate Agreement, the exact date of a policy shock is much more difficult to determine as they are often implemented gradually.
[5] The European Bank for Reconstruction and Development named 2019 “the year the world woke up to climate change”: https://www.ebrd.com/news/2019/2019-the-year-the-world-woke-up-to-climate-change.html.

4.3 Green bond investment funds

An important assumption underlying my hypothesis is that green bonds attract investments from investors with pro-environmental preferences and mandates in addition to conventional investors that would also invest in the firm's conventional bonds. One obvious example of such an investor is a green bond investment fund. The Dutch asset management firm NN Investment Partners manages such a green bond fund. The fund only invests in bonds that are fully aligned with the Green Bond Principles and excludes bonds from issuers that are involved in highly polluting activities. There are also specialized green bond ETFs, such as the iShares Global Green Bond ETF managed by BlackRock, that replicate the performance of green bond indices.

The sustainable investment fund industry has grown rapidly since 2019 (IMF, 2021). Figure 2 illustrates the end-of-year assets under management (AUM) by green bond investment funds over time. The data is collected from Morningstar. The number of green bond funds increased from 13 in 2013 to 24 in 2018, but total AUM has remained stable around $2.5 billion in those years. Green bond investment funds attracted substantial inflows in the following years, with AUM increasing fourfold to $11.0 billion in 2020, while the number of funds increased to 34.

[FIGURE 2 ABOUT HERE]

In the following analysis, I test whether the size of the green bond investment fund sector affects the green investor clientele effect. The regression is identical to the one presented in Table 5 but includes an interaction effect between the *Green* dummy and a monthly estimate of green bond investment funds' total AUM. I also control for regulatory pressure by including the effect of the Trump election, as discussed in Section 4.2. The regression results are reported in Table 6.

[TABLE 6 ABOUT HERE]

The interaction effect between *Green* and the AUM of green bond funds is significantly negative in Models (2), (3), and (4), but insignificant in Models (1) and (5). This indicates that the effect of the green label on the *High-Low* bid-ask spread measure, the *Amihud* illiquidity measure, and the *Zero* measure is stronger when green bond investment funds have more capital under management. Thus, a larger investment fund sector specialized in green bonds appears to strengthen the green investor clientele effect along certain dimensions of market liquidity. This finding establishes a closer relation between the results presented in the previous sections and capital supply conditions on the side of the investors, which is a crucial element of the green investor clientele effect.

4.4 The green investor clientele effect for buy and sell transactions

Another feature of the green bond market is that demand from investors exceeds supply by issuers (Febi et al., 2018; CBI, 2020b). Although the expanded investor base could alleviate search frictions for all investors, it is expected that the effect is particularly large for investors looking to sell their green bonds. To test this hypothesis, I re-estimate the *IRC* measure using imputed roundtrip trades with (i) only customer buy transactions and no customer sells, (ii) only customer sell transactions and no customer buys, and (iii) both customer buy and customer sell transactions. Feldhutter (2012) finds that over 75% of imputed roundtrip trades only contain customer sells and no buys, nearly 20% only contain customer buys and no sells, and just 4% contain both a buy and sell transaction.

The results of the regression are documented in Table 7. The green label reduces *IRC* by 20.1 bps for “sell-only” roundtrip trades (Model 1), which is substantially larger than the 12.5 bps reduction estimated using “buy-only” roundtrip trades (Model 2). In absolute terms, the green labeling effect is thus indeed larger for investors selling green bonds. It is, however, important to note that the average *IRC* of “buy-only” transactions (20.6 bps) in the conventional bond sample are also lower than that of “sell-only” transactions (44.7 bps). The relative magnitudes of the two effects are thus similar.

[TABLE 7 ABOUT HERE]

The effect of the green indicator is small and insignificant in Model (3), where *IRC* is estimated using roundtrip trades that contain both a buy and a sell transaction. These transactions are agency trades where the dealer pre-arranges a counterparty before executing the trade. This version of the *IRC* resembles the modified *IRC* measure used by Kargar et al. (2020). For agency transactions, the dealer does not assume any inventory risk. Search frictions are thus less relevant, which could explain the absence of an effect. The average *IRC* of agency trades is 15.7 bps,[6] which is substantially lower than the transaction costs between 20 and 45 bps of trades that contain either a buy or a sell transaction.

5. Implications for Green Bond Pricing

5.1 Green bond resilience during market crashes

The outbreak of the COVID-19 pandemic in February and March of 2020 led to severe price dislocations in the corporate bond market. Haddad, Moreira, and Muir (2020) document sharp drops in bond prices that reflect the deterioration in firm fundamentals caused by lockdowns and, perhaps even more important, the inability of the market to absorb sudden surges in selling pressure. Corporate bonds, especially those in the investment grade segment, began trading at a discount with respect to CDS spreads. Falato, Goldstein, and Hortacsu (2020) find evidence of large redemptions in the corporate bond investment fund sector, which were most likely one of the key sources of selling pressure.

This stress episode provides an interesting setting to test the resilience of financial assets with green characteristics. Duffie, Garleanu, and Pedersen (2007) show that price reactions to aggregate liquidity shocks are smaller and price recovery is faster for securities with higher search intensities. If the inability for the market to absorb selling pressure is the main reason for price dislocations, the diverse investor base of green bonds could play a role in diminishing the magnitude of the crash. Sustainable investors were particularly suitable candidates to act as liquidity providers in this period because investment funds with higher sustainability ratings suffered less substantial losses and outflows over the course of the COVID-19 pandemic (Pastor and Vorsatz, 2020).

Figure 3 shows the median credit spread of the green and conventional bonds in my sample. Starting from the 25th of February, credit spreads start increasing as COVID-19 infections started increasing globally. Credit spreads continued increasing until the Federal Reserve announced their intervention policy to purchase investment grade corporate bonds on

[6] As discussed in Section 3.2, the *IRC* spread is multiplied by 2 because in most instances it is more appropriate to interpret the *IRC* as a half-spread. This argument, however, does not hold for imputed roundtrip transactions that contain both a buy and a sell transaction. The real *IRC* of agency trades should be even lower (approximately half of the reported spread, or 7.8 bps). The size of the *IRC* spread is similar to those reported in Kargar et al. (2020).

March 23rd. On April 9th, the Fed expanded the intervention policies for bond ETFs and certain high yield bonds. Bond yields recovered quickly following these announcements. As shown by the grey line in Figure 3, the median green bond traded at a higher yield than the median conventional bond at the beginning of 2020. This difference disappeared from March onwards. By the time credit spreads peaked on March 23rd, the credit spreads of green bonds turned substantially lower than that of conventional bonds. This evidence supports the hypothesis that green bonds are more resilient in crisis times.

[FIGURE 3 ABOUT HERE]

To formally test the effect of the green label on resilience, I perform the following regression:

$$\Delta CreditSpread_{i,j,t} = \beta * Green_i * COVID19_t + \nu_i + \mu_{j,t} + \varepsilon_{i,j}, \quad (4)$$

where $\Delta CreditSpread$ represent the weekly changes of credit spreads between January and June 2020. The credit spread is defined as the difference between the bond yield and the treasury yield, where the treasury yield is interpolated using the constant maturity Treasury rates of the two neighboring maturities. The key independent variable is the interaction between the green bond indicator and a dummy that equals 1 after the outbreak of the COVID-19 pandemic and the corresponding crash on the equity market on February 25th. The bond fixed effects ν_i and firm-week fixed effects $\mu_{j,t}$ control for bond-specific factors and changes in firm fundamentals that were relevant to credit risk over the course of the pandemic. For the convenience of defining a crisis (and subsequent recovery) period, the weeks are defined in such a way that March 23rd corresponds with the end of a week.

The regression results are documented in Table 8. Model (1) includes the interactions of the green bond indicator with a pandemic period dummy that equals 1 after February 25th. Over this period, green bonds on average outperformed their non-green counterparts by 1.3 bps per week. The coefficient is weakly significant at the 10% level and supports the hypothesis that the green label increases the resilience of bonds when selling pressure increases.

[TABLE 8 ABOUT HERE]

In Model (2), I divide the pandemic period into a crisis period starting from February 25th and a recovery period starting from March 24th. Over the crisis period, the effect of the green label is negative and statistically significant at the 5% level. The size of the effect is also substantially larger compared to Model (1), as green bonds outperformed conventional bonds by 7 bps per week. The effect of the green label during the recovery period is slightly positive and insignificant, so there is no evidence that green bonds also recovered more quickly following the initial shock. This could be because the recovery in the overall corporate bond market was quick and driven by the announcements of the intervention policy by the Federal Reserve. These findings provide further support for the hypothesis that the green label attracts an investor base that brings additional resilience in periods of market stress.

5.2 Green bond liquidity and the greenium

A series of recent papers (including Baker et al., 2018; Zerbib, 2019; Kapraun and Scheins, 2019) have studied the existence of a green bond premium or "greenium", a theoretical yield reduction associated with the green label of the bond. The findings of this paper could also have implications for these analyses. Existing studies control for bond liquidity using static or low-frequency measures like Bloomberg quoted bid-ask spreads. Since green bonds are more liquid than conventional bonds and liquid securities tend to trade at higher prices, controlling for liquidity could understate the aggregate reduction in cost of capital associated with issuing a green bond. Investors might be willing to pay higher prices for the green bonds, not only because of non-financial preferences for investments that make a positive contribution to the environment, but also because they will receive more liquid securities. On the other hand, imperfect controls of liquidity could also overstate the estimated size of the greenium.

I follow Baker et al. (2018) and estimate the greenium in my sample of US corporate green bonds using a regression model with fixed effects:

$$CreditSpread_{i,j,t} = \beta_1 * Green_i + \beta_2 * Liquidity_{i,j,t} + \gamma * X_{i,j,t} + \mu_{j,t} + \varepsilon_{i,j,t}. \quad (3)$$

The credit spread, liquidity measures, and control variables are identical to the ones described in Sections 4.1 and 5.1, except that I now use the natural logarithm of years to maturity instead of categorical dummies to control for a continuous relationship between yields and maturity.

The results are documented in Table 9. Model (1) does not include the liquidity variables as controls. The effect of the green indicator is significantly negative and indicates that green bonds trade at credit spreads that are 8.5 bps lower. This estimate is substantially larger than the 2.3 bps greenium of USD-denominated green bonds reported by Zerbib (2019). One explanation of this could be that the greenium has increased in recent years. In unreported analyses with yearly *Green* dummies, I do find that the average greenium in the first half of 2020 is relatively high (12.8 bps). The large greenium in 2020 could be related to the crash in bond prices at the beginning of March, as explained in Section 5.1.

[TABLE 9 ABOUT HERE]

To make sure that sample selection effects do not have a large impact on the estimated greenium, I re-estimate the regression conditional on the availability of liquidity variables in Model (2). The greenium decreases slightly to 8.2 bps. In Model (3), all five liquidity variables are included as control variables.[7] The liquidity variables have a positive and significant effect on credit spreads. This is consistent with liquid bonds trading at higher prices for all variables except *Turnover*. The effects also demonstrate that different variables measure different dimensions of liquidity relevant for pricing. The estimate of the greenium decreases to 6.6 bps but remains statistically significant at the 1% level. Thus, differences in liquidity explain nearly 20% of the greenium in my sample. This supports Zerbib's (2019) finding that investors are willing to sacrifice an economically small portion of yield to pursue non-financial objectives, but also demonstrates that the green bond liquidity benefits could contribute further to reducing the cost of capital of green bonds issuers.

[7] The absolute values of the correlations among the monthly liquidity estimates are between 0.02 and 0.38. In unreported analyses, I performed regressions with different pairwise combinations of the five liquidity variables. The estimated greenium was always between the 6.6 and 8.5 bps that were reported in Table 9.

6. Discussion and Conclusion

Green bonds are becoming increasingly important instruments in the fight against climate change. In 2020, green bond issuers around the world raised a record-breaking $270 billion. However, the benefits of issuing green bonds remain difficult to quantify. The green label itself does not seem to bring significant cost reductions to issuers but does limit financial flexibility as the proceeds are earmarked for environmentally-friendly project. Various studies have suggested that firms issue green bonds because it attracts investors that care about the environment (e.g., Flammer, 2021; Tang and Zhang, 2020). This paper quantifies this rationale by examining the effect of the green label on bond liquidity. Controlling for time-varying firm characteristics and heterogeneity across bonds, I find that corporate green bonds are more liquid than bonds without the green label. Furthermore, the green investor base diminishes the impact of liquidity shocks driven by sudden surges in selling pressure on prices. The green investor clientele effect demonstrates why studies of the green bond premium that control for liquidity might underestimate the aggregate benefits of issuing green bonds, and it could be part of the explanation why green bonds have become increasingly popular in recent years.

These findings have implications for policymakers that are concerned with climate change mitigation through climate finance. The green investor clientele effect establishes a clear link between climate finance and capital market conditions. The primary goal of climate finance is easing financial conditions for green issuers. The capital market effects should thus be an accurate reflection of firms' contributions to climate change mitigation. One of the key obstacles is the lack of a clear definition of what constitutes "green". Taxonomies are important to help sustainable asset managers channel capital flows to firms that are actually green. The green bond market provides an interesting case study for policymakers, as guidelines and certification procedures have already been implemented by private parties like ICMA and CBI. Existing research has demonstrated that alignment with these guidelines strengthen the environmental benefits associated with green bonds (e.g., Flammer, 2021). The European Commission has already taken steps in creating uniform standards, including the EU Taxonomy for Sustainable Activities that was launched in 2020 and a European Green Bond Standard that is currently under development.

The green investor clientele effect presented in this paper also stresses the importance of a large and efficient climate finance asset management sector. The analysis in Section 4.3

demonstrates that a growing share of investors that prefer green investments could increase both the liquidity and prices of green bonds. However, the asset management sector also adds an additional layer of complexity as it faces similar challenges with respect to disclosure and definitions. For example, Amenc, Goltz, and Liu (2021) show that investment strategies that incorporate climate considerations are often not aligned with the objective to reduce emissions. Regulators are increasingly paying attention to greenwashing by financial firms. In August 2021, the German authority BaFin launched an investigation following greenwashing allegations against investment firm DWS. The recently launched EU Sustainable Finance Disclosure Regulation requires asset managers to disclose more sustainability-related information on their investments. These initiatives are important to prevent inefficient allocation of capital because of large-scale greenwashing by asset managers.

Finally, climate finance can only be effective if it induces firms to change their behavior. Future research should deepen our understanding of the transmission mechanisms between financial markets and the real economy. Researchers could examine the optimal capital market conditions that stimulate firms to substitute conventional financing for green financing and reduce greenhouse gas emissions. Another interesting avenue for research is the role of corporate governance mechanisms like shareholder activism and executive compensation, which could alleviate agency frictions between investors and management. Finally, researchers could evaluate the effectiveness of existing climate policies, such as those recently proposed by the EU.

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Figures

Figure 1: Corporate green bond issuance over the years.

This figure contains yearly global corporate green bond issuance in USD billions (red bars, left axis), global number of corporate green bonds issued (blue line, right axis), US corporate green bond issuance in USD billions (green bars, left axis), and US number of corporate green bonds issued (yellow line, right axis). The green bond sample is obtained from Bloomberg.

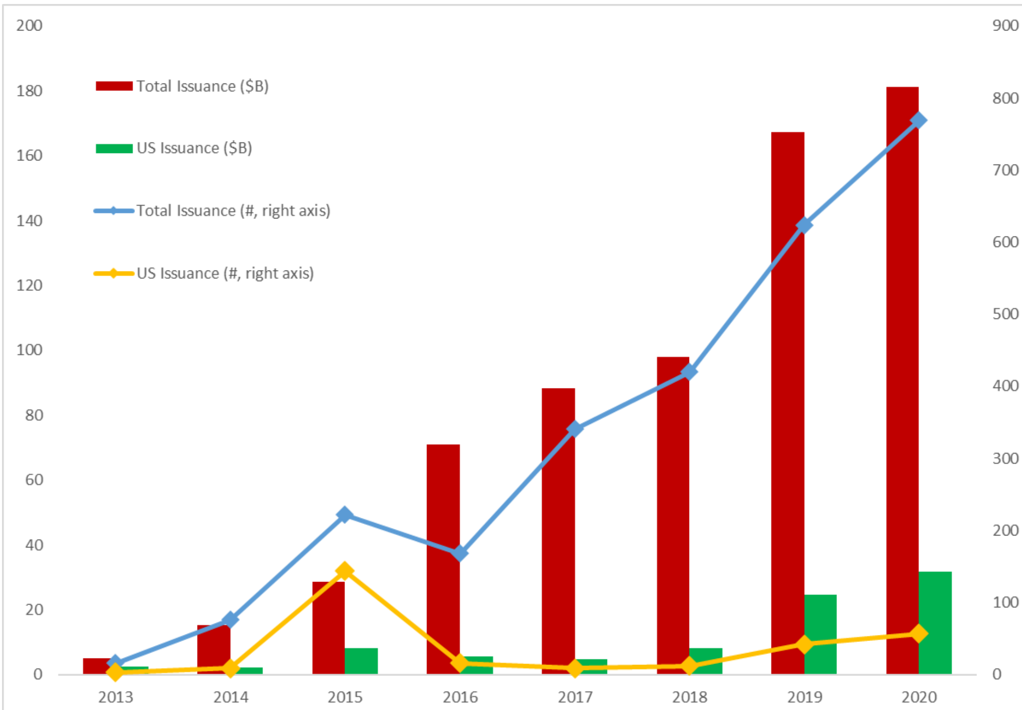


Figure 2: Assets under management of green bond investment funds over the years.
This figure contains end-of-year total assets under management of green bond investment funds in USD trillions (green bars, left axis) and the number of green bond investment funds (red line, right axis). The green bond fund sample is obtained from Morningstar.

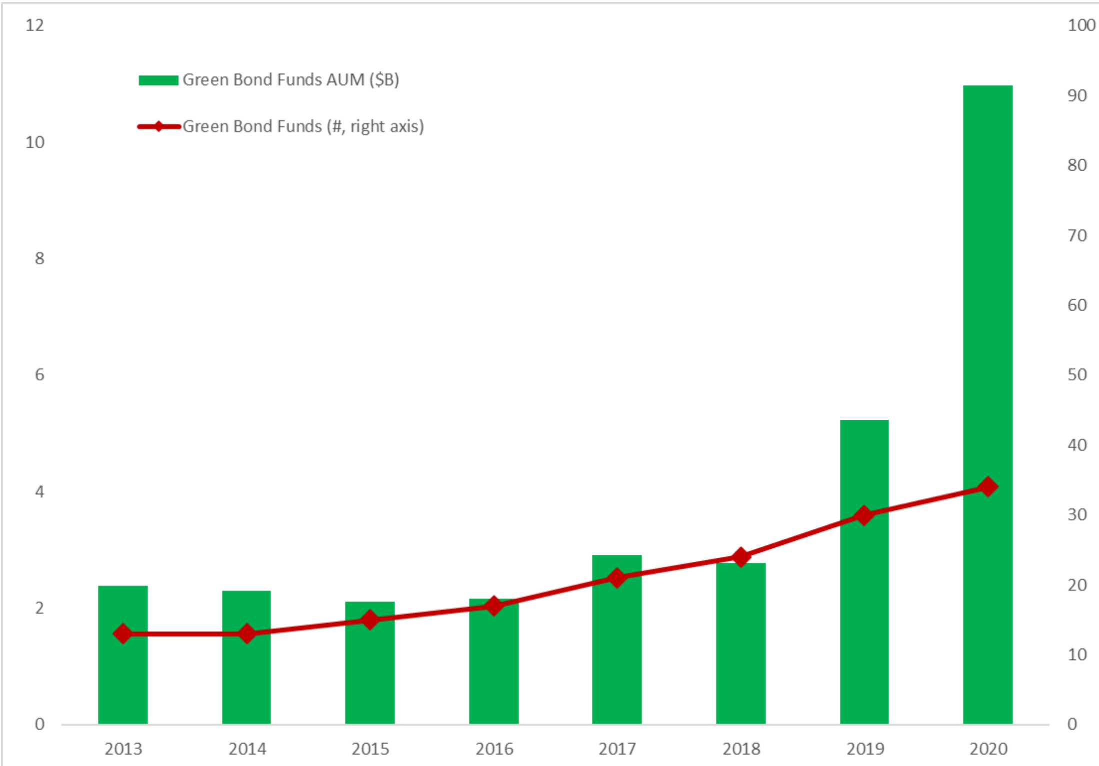
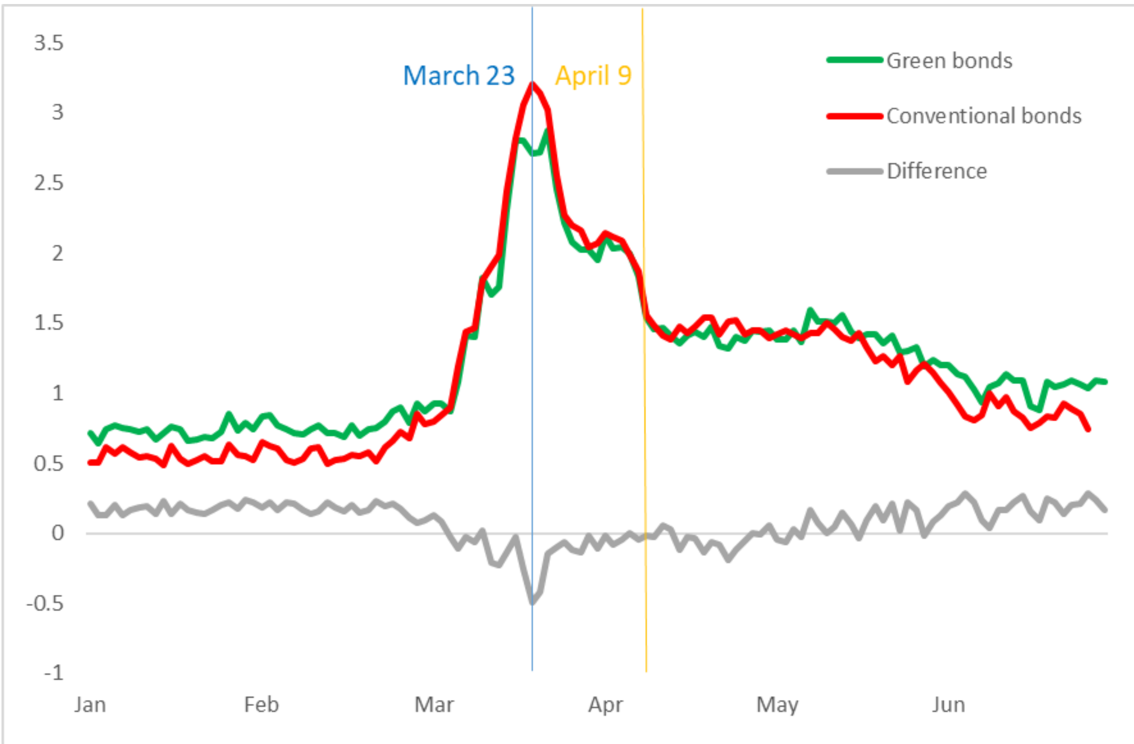


Figure 3: Bond credit spreads during the outbreak of the COVID-19 pandemic.

This figure contains daily corporate bond credit spreads (in percentages) between January and June 2020. The credit spreads are defined as the difference between the bond yield and the treasury yield, where the treasury yield is interpolated using the constant maturity Treasury rates of two neighboring maturities. The sample consists of US corporate green bonds (green line) and conventional bonds issued by green bond issuers (red line). The difference between the credit spreads of green and conventional bonds is shown using the grey line.



Tables

Table 1: Corporate green bond issuance by country and industry.

This table contains the corporate green bond issuance statistics of the top five countries and top five industries by issuance amount. Industries are based on the Bloomberg BICS Level 1 classification.

Green bond issuance	**($B)**	**(#)**
China	125.1	350
United States	87.3	292
Netherlands	67.9	98
France	57.7	261
Germany	53.4	228
Financials	315.7	1,356
Utilities	189.6	584
Industrials	46.9	175
Consumer Discretionary	32.5	104
Energy	26.1	304

Table 2: Issuance characteristics of green and conventional bonds.

This table contains statistics of green and conventional bond on the following issuance characteristics: years to maturity, offering size, coupon rate, and whether the bond contains covenants. Panel A contains a sample of 70 green bonds issued by 41 firms. Panel B contains a sample of 589 non-green bonds issued by the same 41 firms.

Measure	Mean	Median	Std. Dev.	$Q_{0.05}$	$Q_{0.95}$	N
Panel A: Green bonds						
Years to Maturity	11.3	10	9.24	3	30	70
Offering Size ($mln)	542	500	402	1.91	1,000	70
Coupon Rate (%)	3.33	3.36	0.807	1.95	4.50	68
Covenant	0.776	1	0.421	0	1	58
Panel B: Conventional bonds by green issuers						
Years to Maturity	11.9	10	11.5	3	30	589
Offering Size ($mln)	1,000	750	1,150	23.7	2,750	589
Coupon Rate (%)	3.56	3.41	1.66	1.30	6.40	589
Covenant	0.686	1	0.465	0	1	586

Table 3: Market liquidity of green and conventional bonds.

This table contains monthly summary statistics of bond liquidity. The liquidity measures are IRC (Feldhutter, 2012), High-Low (Corwin and Schultz, 2012), Amihud (2002), the proportion of trading days with zero trades, and the turnover ratio. The columns represent the mean, median, standard deviation, 5th percentile, 95th percentile, and number of monthly observations, respectively. Panel A contains a sample of 70 green bonds issued by 41 firms. Panel B contains a sample of 589 non-green bonds issued by the same 41 firms.

Measure	Mean	Median	Std. Dev.	$Q_{0.05}$	$Q_{0.95}$	N
Panel A: Green bonds						
IRC (bps)	12.1	1.78	25.6	0	55.0	1,479
High-Low (bps)	36.6	18.7	48.2	0	143	1,659
Amihud (bps)	84.2	41.6	138	3.68	290	1,488
Zero (%)	35.9	30.0	28.7	0	90.5	1,659
Turnover (%)	8.01	5.25	8.51	0.29	26.2	1,659
Panel B: Conventional bonds by green issuers						
IRC (bps)	21.6	11.3	37.2	0.04	79.6	23,053
High-Low (bps)	40.3	16.5	56.3	0	165	27,004
Amihud (bps)	83.0	31.4	151	2.14	340	23,297
Zero (%)	37.1	31.8	31.2	0	90.5	27,004
Turnover (%)	5.24	3.22	6.89	0.14	16.9	27,004

Table 4: The effect of the green label on market liquidity.

This table contains the results of five regressions. The dependent variables are the liquidity measures described in Table 3. The key independent variable is Green, a dummy that indicates whether the bond is a green bond. Control variables are log(OfferingSize), a dummy that indicates whether the bond was issued in the past year (OnTheRun), and dummies for different maturity classes. All regressions include firm-month fixed effects, and standard errors are clustered at the bond-level.

	(1) IRC	(2) High-Low	(3) Amihud	(4) Zero	(5) Turnover
Green	-0.109***	-0.049*	-0.208***	-4.150**	1.719***
	(0.018)	(0.028)	(0.067)	(1.880)	(0.525)
log(OfferingSize)	-0.069***	0.126***	-0.441***	-15.314***	0.393
	(0.014)	(0.018)	(0.083)	(1.143)	(0.252)
OnTheRun	-0.037***	0.092***	-0.269***	-8.046***	5.353***
	(0.010)	(0.024)	(0.038)	(1.033)	(0.383)
Maturity:					
5Y-10Y	0.087***	0.291***	0.230***	2.551**	0.074
	(0.011)	(0.030)	(0.047)	(1.101)	(0.278)
10Y-20Y	0.216***	0.160**	1.392***	21.795***	-1.632***
	(0.055)	(0.063)	(0.341)	(5.095)	(0.487)
20Y+	0.092***	0.190***	0.994***	8.020***	-0.145
	(0.017)	(0.041)	(0.082)	(1.489)	(0.384)
Firm-Month FE	Y	Y	Y	Y	Y
Observations	11,661	13,189	11,656	13,189	13,189
R-squared	0.212	0.398	0.350	0.758	0.276

Table 5: The green investor clientele effect over time.

This table contains the same regression as in Table 4 but includes an interaction effect between the green label and a dummy that equals one in months following the Trump election (November 2016). The dependent and remaining independent variables are described in Tables 3 and 4. All regressions include firm-month fixed effects, and standard errors are clustered at the bond-level.

	(1) IRC	(2) High-Low	(3) Amihud	(4) Zero	(5) Turnover
Green	-0.191***	-0.186***	-0.410***	-0.220	1.156
	(0.043)	(0.060)	(0.156)	(2.969)	(1.610)
Green*Trump	0.093**	0.157***	0.230*	-4.531	0.649
	(0.040)	(0.056)	(0.138)	(3.111)	(1.609)
log(OfferingSize)	-0.071***	0.123***	-0.449***	-15.229***	0.381
	(0.014)	(0.018)	(0.084)	(1.155)	(0.249)
OnTheRun	-0.036***	0.094***	-0.265***	-8.122***	5.364***
	(0.009)	(0.023)	(0.038)	(1.031)	(0.387)
Maturity:					
5Y-10Y	0.085***	0.290***	0.227***	2.593**	0.068
	(0.011)	(0.030)	(0.047)	(1.107)	(0.276)
10Y-20Y	0.215***	0.160**	1.391***	21.810***	-1.634***
	(0.055)	(0.063)	(0.341)	(5.095)	(0.487)
20Y+	0.092***	0.190***	0.994***	8.011***	-0.144
	(0.017)	(0.041)	(0.082)	(1.488)	(0.385)
Firm-Month FE	Y	Y	Y	Y	Y
Observations	11,661	13,189	11,656	13,189	13,189
R-squared	0.213	0.399	0.350	0.758	0.276

Table 6: The green investor clientele effect and green bond investment funds.

This table contains the same regression as in Table 5 but includes an interaction effect between the green label and the assets under management of green bond funds. The dependent and remaining independent variables are described in Tables 3 and 4. All regressions include firm-month fixed effects, and standard errors are clustered at the bond-level.

	(1) IRC	(2) High-Low	(3) Amihud	(4) Zero	(5) Turnover
Green*GB Fund AUM	0.0110	-0.0186*	-0.0823**	-1.361**	0.243
	(0.00693)	(0.0111)	(0.0410)	(0.648)	(0.210)
Green	-0.216***	-0.144**	-0.222	2.856	0.607
	(0.0501)	(0.0693)	(0.193)	(3.514)	(1.687)
Green*Trump	0.0749*	0.188***	0.368***	-2.290	0.249
	(0.0390)	(0.0578)	(0.139)	(3.293)	(1.683)
log(OfferingSize)	-0.0716***	0.123***	-0.445***	-15.19***	0.374
	(0.0140)	(0.0180)	(0.0842)	(1.153)	(0.248)
OnTheRun	-0.0360***	0.0947***	-0.264***	-8.091***	5.358***
	(0.00944)	(0.0235)	(0.0379)	(1.020)	(0.387)
Maturity:					
5Y-10Y	0.0850***	0.291***	0.230***	2.651**	0.0573
	(0.0110)	(0.0298)	(0.0463)	(1.120)	(0.275)
10Y-20Y	0.215***	0.160**	1.393***	21.79***	-1.631***
	(0.0554)	(0.0631)	(0.341)	(5.090)	(0.486)
20Y+	0.0912***	0.191***	0.997***	8.062***	-0.153
	(0.0171)	(0.0409)	(0.0819)	(1.487)	(0.385)
Firm-Month FE	Y	Y	Y	Y	Y
Observations	11,661	13,189	11,656	13,189	13,189
R-squared	0.213	0.400	0.351	0.759	0.277

Table 7: The green investor clientele effect across buyers and sellers.

This table contains the results of three regressions. The dependent variables are variants of the IRC measure developed by Feldhutter (2012) estimated in different subsamples. In Model (1), the IRC is estimated using imputed roundtrip trades that only contain customer buys and interdealer transactions. In Model (2), the IRC is estimated using imputed roundtrip trades that only contain customer sells and interdealer transactions. In Model (3), the IRC is estimated using imputed roundtrip trades that contain a customer buy and customer sell. The independent variables are described in Table 4. All regressions include firm-month fixed effects, and standard errors are clustered at the bond-level.

	(1) Buy Only	(2) Sell Only	(3) Buy-Sell
Green	-0.125***	-0.201***	-0.006
	(0.0247)	(0.049)	(0.017)
log(OfferingSize)	-0.0454***	-0.093***	-0.031
	(0.0170)	(0.026)	(0.030)
OnTheRun	-0.0782***	-0.043*	-0.023**
	(0.0121)	(0.023)	(0.012)
Maturity:			
5Y-10Y	0.0756***	0.215***	0.096***
	(0.0137)	(0.029)	(0.013)
10Y-20Y	0.153***	0.442***	0.093***
	(0.0483)	(0.096)	(0.017)
20Y+	0.104***	0.254***	0.165***
	(0.0229)	(0.048)	(0.016)
Firm-Month FE	Y	Y	Y
Observations	8,756	9,498	6,510
R-squared	0.194	0.221	0.205

Table 8: The effect of the green label on credit spreads during market crashes.

This table contains the results of 2 regressions. The dependent variables are weekly changes in credit spread. In Model 1, the key independent variable is the interaction between the Green indicator and a dummy that equals 1 after the outbreak of the COVID-19 pandemic (February 25th). In Model 2, the key independent variables are interactions between the Green indicator and dummies that equal 1 in the crisis period (between February 25th and March 23rd) and recovery period (after March 24th). The sample contains only weekly observations in the first half of 2020. All regressions include bond and firm-month fixed effects, and standard errors clustered at the bond-level are reported in parentheses.

	(1) *Δ*Credit Spread	(2) *Δ*Credit Spread
Green*COVID-19	-0.013*	
	(0.007)	
Green*Crisis		-0.070**
		(0.028)
Green*Recovery		0.002
		(0.011)
Bond FE	Y	Y
Firm-Week FE	Y	Y
Observations	9,247	9,247
R-squared	0.630	0.630

Table 9: The green investor clientele effect and the greenium.

This table contains the results of three regressions. The dependent variable is the credit spread of the bond. The description of the independent variables can be found in Tables 3 and 4. Model (2) conditions on the availability of liquidity data. All regressions include firm-month fixed effects, and standard errors are clustered at the bond-level.

	(1)	(2)	(3)
Green	-0.085***	-0.082***	-0.066***
	(0.017)	(0.018)	(0.017)
IRC			0.044***
			(0.012)
High-Low			0.070***
			(0.010)
Amihud			0.041***
			(0.005)
Zero			0.001***
			(0.000)
Turnover			0.002***
			(0.000)
log(OfferingSize)	-0.037**	-0.006	0.020
	(0.015)	(0.015)	(0.016)
OnTheRun	-0.058***	-0.054***	-0.046***
	(0.010)	(0.009)	(0.010)
log(Maturity)	0.323***	0.322***	0.294***
	(0.007)	(0.008)	(0.007)
Firm-Month FE	Y	Y	Y
Observations	11,378	9,788	9,788
R-squared	0.839	0.862	0.875