The Emerging Greenium*

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Abstract

We examine whether and to what extent investors are willing to forego financial returns in exchange for non-pecuniary benefits in the United States municipal bond market. We match municipal green bonds to otherwise almost identical non-green bonds from 2013 to 2022. Comparing 1,027 pairs of exact matches, we find green bonds are issued at a lower yield after 2018, with the average greenium being 2.3 basis points. The underwriter discount difference between green bonds and their matches was positive before 2018 and has become negative in recent years. The increase in greenium and the decline in underwriter discount coincide with the increase in Environmental, Social, and Governance (ESG) investment. The size of greenium is positively correlated with state-level green preferences and bond-level greenness. The term structure of greenium is downward sloped.

Keywords: Municipal bonds; Green bonds; Socially responsible investing; Greenium
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1. Introduction

Are investors willing to pay a higher price for Environmental, Social, and Governance (ESG) investments than non-ESG investments? The answer to this question is at the core of the discussion of how the financial markets can contribute to ESG issues. One widely argued role of the financial markets in solving ESG issues is that investors with ESG preferences can lower green assets' cost of capital relative to brown assets and increase green investments. Many states (e.g., Florida and Texas) have enacted legislation against ESG investing and climate change considerations. Whether investors are willing to pay for ESG will also inform such legislation.

There are substantial empirical challenges to documenting the effect of ESG preferences on asset prices, largely stemming from the fact that green assets and brown assets typically differ in many aspects other than greenness. For example, across firms, green and brown firms tend to belong to different industries, adopt different production and abatement technologies and have different performances (e.g., Flammer, 2013; 2021). Green and brown assets also face different risks, such as different exposures to climate change (physical risk) and regulation change (transition risk).[1] Clearly identifying ESG preferences on asset prices relies on properly accounting for these differences, which, unfortunately, is hard to achieve.

This paper investigates whether ESG preferences affect asset prices using U.S. municipal bond market data. Specifically, we study whether there is a greenium in the municipal market. The

[1] Evidence documenting that physical risks and transition risks affect prices abunds (Hong, Li, and Xu, 2019; Choi, Gao, and Jiang, 2020; Engle, Giglio, Kelly, Lee, and Stroebel, 2020; Acharya, Johnson, Sundaresan, and Tomunen, 2022; Goldsmith-Pinkham, Gustafson, Lewis, and Schwert, 2023). For example, Choi et al. (2020) show that retail investors sell carbon-intensive stocks in extremely warm months, and Engle et al. (2020) report that green firms outperform brown firms in periods with negative climate news, both suggesting that brown assets have higher climate betas than green assets.

"greenium," or green premium, is the amount by which the yield on a green bond is lower than an otherwise identical conventional bond. Green bonds are debt instruments designated to finance environmentally friendly projects. A positive greenium will provide clear evidence that ESG preferences affect asset prices.

The U.S. municipal market is especially suitable for our purposes due to its unique institutional features (Larcker and Watts, 2020). First, municipal issuers typically price multiple tranches of securities on the same day. This allows us the opportunity to find exact matches of green and non-green bonds. In our empirical analysis, we perform matching by requiring the following variables to be identical between the green bonds and matched non-green bonds – issuer, issuance date, maturity date, credit ratings, call dates, source of repayment (revenue or general obligation), and tax status. The matched sample is specially balanced even for many characteristics (e.g., coupon rate) we do not explicitly match. Second, the credit for municipal green bonds is identical to the credit of their otherwise similar non-green counterparts (Fischer, Rogow, Sobel, and McGown, 2019; Woeppel, 2016). This implies that green and non-green bonds are identical in all facets except the use of proceeds, which allows us to argue that any greenium, if observed, can be attributed to investors' green preferences. Third, the municipal market has the largest number of green bonds and we are able to construct more than 1,000 pairs in the period between 2013 and 2022, enabling a large sample analysis. Such exact matches exist very sparsely in other markets.[2]

The headline finding is that the greenium has been positive in recent years. Consistent with Larker and Watts (2020), greenium barely exists in the U.S. municipal bond market by 2018. But importantly, we observe a significant positive greenium after 2018, with an average of 2.3 basis

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[2] For example, Pastor, Stambaugh, and Taylor (2022) study two German sovereign green bonds and document a greenium pf 4.6 basis points.

points (bps). These findings hold in most states and cannot be explained by difference in liquidity. These results support that investors care about ESG and are willing to pay for it. The trend is consistent with investors becoming increasingly ESG-sensitive in recent years (Stark, 2023).

In addition to issuance yields, underwriter discounts are another potential source of issuance cost differentials. Using the same matching methodology outlined above, we find that underwriters, on average, charge 3 bps higher for issuing green bonds as opposed to non-green bonds by 2018, but they charge 4 bps lower after 2018. A simple back-of-the-envelop calculation shows that, from the issuers' perspective, the savings from the lower underwriter discount are similar to those from the issuance yield difference.

The greenium exhibits significant cross-sectional heterogeneities in the post-2018 period. First, in the cross-section, the amount investors willing to pay is correlated with measures of state-level green preference and bond-level greenness. We also find that greenium is significantly higher when the uses of proceeds are different between a green bond and its match. Money is fungible. When proceeds are going to be used for the same project, investors may worry about greenwashing or not view the green bond differently from the non-green bond. Second, the term structure of greenium is downward sloped. In other words, greenium is higher for shorter-maturity bonds.

Our study of greenium in the U.S. municipal market has an important precedent in Larker and Watts (2020), who study the same question with a similar methodology. Our primary differences are studying an extended sample and observing very different results. Larker and Watts (2020) end their sample in 2018, while we extend it to early 2022. They report no greenium and little cross-sectional variation in greenium. We find a positive greenium, and greenium correlates with measures of greenness and green preferences in sensible ways. Larker and Watts (2020) find a higher underwriter discount for green bonds in their earlier sample period, while we find the opposite. We also conduct several tests that Larker and Watts (2020) do not do, such as the term structure and market segmentation tests.[3]

Our primary contribution to the literature is to provide direct evidence that investors are willing to pay a premium for green assets. Practitioners, regulators, and academics heatedly debate this question. While sizable literature has documented that equity, bond, real estate, and derivative markets appear to incorporate ESG considerations in portfolio choices and asset prices.[4] Many of them study different questions (portfolio choices (e.g., Hartzmark and Sussman, 2019), physical risks (e.g., Goldsmith-Pinkham et al., 2023; Acharya et al., 2022), or transition risks), or cannot differentiate ESG preferences and these different factors. A notable literature is studying ESG scores in the cross-section of stocks (Hong and Kacperczyk, 2009; Bolton and Kacperczyk, 2021; Pastor, Stambaugh, and Taylor, 2022; Zhang, 2023). While this literature provides many insights, as Pastor and Stambaugh, and Talor (2022) emphasized, realized returns can differ, even in signs, with the expected returns, and in this setting, even expected returns can be contaminated by different risk exposures between green assets and brown assets.

Most related are the studies on greenium. The literature has mixed findings regarding greenium. Larker and Watts (2020), Flammer (2021), and Tang and Zhang (2020) find no greenium, while Baker et al. (2022), Zerbib (2019), Caramichael and Rapp (2022), and Wang and Wu (2023) report a positive greenium. These studies differ in how to control for the differences between green and non-green bonds. Some use pooled regressions with fixed effects, and some match green bonds

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[3] Larker and Watts (2020, page 3) speculate that, “while a greenium does not current exist, as the market matures and gains momentum a greenium may emerge.” Our findings are consistent with their conjecture.

[4] See for example, Baldauf et al. (2020) , Ernstein et al. (2019), Bolton and Kacperczyk (2021) , Choi et al. (2020) , Engle et al. (2020) , Giglio et al. (2021) , Goldsmith-Pinkham et al. (2021) , Eichholtz et al.(2019) , Ilhan et al. (2021), Murfin and Spiegel (2020), Painter (2020), Hartzmark and Sussman (2019), Bialkowski and Starks (2016), Benson and Humphrey (2008), and Renneboog et al. (2011). See surveys by Giglio et al. (2020), Hong et al. (2020), and Stark (2023).

with similar non-green bonds. The fixed effects methodology implicitly assumes that a linear combination of the considered factors is sufficient to deal with differences between bonds. As Larker and Watts (2020) pointed out, such a methodology can have serious biases. In the same sample of municipal bonds, Larker and Watts (2020) find no greenium based on their exact matches, while a 7 bps greenium using the pooled regression method of Baker et al. (2022). Due to the lack of good matches, most studies adopting the matching methodology must rely on coarse matches – even after matching, the matched pairs differ in many characteristics, such as maturity differences in years, not even mention differences in coupon rate.[5] Please note that even small estimation errors can have an impact that dominates the magnitude of greenium.

In the end, we want to comment on the magnitude of the greenium. On the one hand, 2.3 bps may be considered small. On the other hand, the average municipal yield spread relative to Treasury is 25 bps, and 2.3 bps is about a 10% reduction in the credit spread. Additionally, the greenium is significantly higher for some subgroups. For example, it is 8−20 bps when the presence of greenwashing concern is mitigated, e.g., when the green and non-green bonds have different uses of proceeds. In addition, when the green and non-green bonds have different uses of proceeds, issuing green bonds saves about 25 bps underwriter discounts. The total savings from lower yields and lower underwriter discounts amount to 12−24 bps, which are 6%−12% of the average municipal yield in our sample.

[5] Bonds with different coupon rates can have different yields when the term structure is not flat, even when the bonds are identical otherwise.

2. Data

2.1 Data sources

Our main data sets are the Mergent municipal database which provides bond-level information, including the primary market pricing information. We also collected bond-level data from Bloomberg as a supplement. The Municipal Securities Rulemaking Board (MSRB) dataset has secondary market trading data. We use Municipal Securities Transaction Data published by Municipal Securities Rulemaking Board (MSRB) to construct our liquidity and trading activity measures.

The municipal green rating data are from HIP Investor. HIP, founded in 2006, is one of the leading providers of ESG data to investors. The company compiles data to provide ratings (scaled from 0 to 100), across various ESG categories, for approximately 200,000 bond issuances. Like Larker and Watts (2020), we obtain two data sets from HIP Investor. The first data includes the "Earth" ratings of all census-designated places (CDPs) rated by HIP Investor in all states. HIP Investor designed this measure to capture the level of environmental consciousness of local governments based on various inputs such as a city's use of recycled water and many other similar metrics. Second, we obtain bond-level Earth ratings of all green bond issues in our matched sample (where available from HIP Investor). These ratings are project-specific, and higher values indicate that the project makes a more significant impact in terms of improving the environment.

2.2 Data cleaning

This section introduces the procedures for data collection and cleaning. Unless explicitly mentioned, we strictly follow Larker and Watts (2020). Larker and Watts (2020) study municipal bonds in the period until July 2018, whereas we extend the sample to May 2022.

We first identify the set of self-labeled green bonds from Bloomberg's municipal bond database from June 2013 to May 2022.[6] To simplify yield calculations, we restrict our sample to bonds with either a fixed rate or a zero coupon. We remove federally taxable securities to ensure similar tax treatment across the sample.

Bond issuance data come from the Mergent municipal database. After matching Bloomberg green bond data with the Mergent database, we require the bonds also to be identified as green in Mergent. This step aims to remove any potentially mislabeled securities in the two databases. The resulting sample contains 9,345 green bonds across 636 deals and 404 unique issuers.

Figure 1 presents the time series trend of municipal green bond issuance. Larker and Watts (2020) show that municipal green bond issuance increased significantly from 2013 to 2017, both in terms of the number of bonds and the total issuance amount. Our results first confirm their findings and further show a drop in issuance in 2018, but the upward momentum immediately resumed and remained since 2019, with the total issuance amount of municipal green bonds topping $16 billion in 2021. We note that the temporary decline in issuance in 2018 is likely due to the passing of the Tax Cuts and Jobs Act in late 2017 by Congress, which eliminates issuers'

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[6] In addition to the "Self Green" label, Bloomberg has another indicator for green bonds named "Green Instrument Indicator." These two indicators largely overlap with one another, with the exception of 30 pairs in exact-maturity matches. In these pairs, the non-green match has "Self Green" equal to "NA" and "Green Instrument Indicator" equal to "Y."

ability to issue advance refunding bonds on a tax-exempt basis. This increases the overall cost of debt financing for borrowers and, in turn, leads to lower issuance for green bonds and municipal bonds in general.

2.3 Matched set creation

We match green bonds with other 1,117,248 non-green bonds in the Mergent database. Specifically, for each green bond, we select non-green bonds that are identical on the following dimensions: issuer, issuance date, maturity date, ratings, call dates, and source of repayment (revenue or general obligation). For callable bond matches, we also require the matched pairs to have the same coupon rate. The value of the embedded call option depends on the coupon rate. Requiring the same coupon rate for callable bonds is to ensure comparability between green bonds and their matches. For non-callable bonds, even though we do not require the same coupon rate. In the data, close to 80% of the matched pairs have the same coupon rate. Our results are almost identical if we focus on the pairs with the same coupon rate. We allow a green bond to be matched to multiple non-green bonds so long as they meet the above requirements.

Our matching procedure is the same as the "exact match" method by Larker and Watts (2020), except for the following changes. First, Larker and Watts (2020) do not require the matched bonds to have the same source of repayment. We add this additional requirement to increase the comparability between the green bonds and their matches. However, the results are very similar without this requirement.[7] Second, besides the exact match method, Larker and Watts (2020) also

[7] Without the general obligation or revenue status matching, we will get 61 additional matched pairs. These additional pairs have an average greenium of 0.115 bps. Out of the 61 pairs, 40 pairs have a greenium exactly equal to zero.

adopt a less stringent matching method. Specifically, they relax the requirement of having the exact maturity and allow bonds to match if the difference in maturity is within one year. As shown by Larker and Watts (2020), the relaxation in matching criteria has minimal impact on the sample: in their sample period, it only increases the sample from 627 pairs to 640 pairs. Our results are very similar if we include the non-exact matches. Given these considerations, we do not report such tests in the paper. Third, we remove one deal in which the difference in underwriter discount between the green bonds and their matches is 171 bps.[8]

Our final sample consists of 1,027 exactly matched pairs, with the first pair being issued in September 2014 and the last in Mach 2022.

2.4 Descriptive statistics

Table 1 presents the descriptive statistics on the key characteristics and outcome variables. Comparing the green bonds (Panel A) and non-green controls (Panel B) in our matched sample, we see that green bonds are issued in smaller sizes. The coupon rate and issuing price are qualitatively similar for green and non-green bonds. It is not immediately obvious to conclude whether green or non-green bonds have higher secondary market liquidity, as green bonds have lower turnover (0.92 vs. 1.02) but a higher number of trades (9.35 vs. 9.18). We follow Larker and Watts (2020) and calculate turnover as the total sum of par value trades over the quarter (90 days) after issuance and the number of trades as the total number of trades over the same period.

[8] The green bonds in the deal have an average issue amount of $0.72 million, while the average issue amount of the matched non-green bonds is $10.42 million. As discussed by Larker and Watts (2020), a likely explanation for this stark discrepancy in issuance size is that underwriters are able to allocate a significantly smaller tranche of securities in a single deal to price-insensitive retail investors.

Institutional ownership for both groups is approximately 85%. Non-green bonds, however, seem to be held by more concentrated investors, with the Herfinadahl-Hirschman Index (HHI) being 0.65 compared to 0.58 for green bonds.[9] Institutional ownership is defined as the total sum of institutional primary market purchases (those greater than or equal to $100,000) divided by the total securities outstanding. HHI is calculated as

$$HHI_i = \sum_{k=1}^{N} \left(\frac{P_k}{O_i}\right)^2,$$

where P_k represents the par value of primary market purchase k, O_i is the total issuance amount for bond i, and N represents the number of primary market purchases for bond i.

The key insight of our paper builds on the comparison of issuance yield. Noticeably, green bonds have lower yields than non-green bonds on average. In the matched sample from 2013 to 2022, the sample mean of issuance yield is 204.75 bps and 205.36 bps for green and non-green bonds, respectively.

3. Greenium

3.1 Time trend

Greenium is defined as the difference in the issuance yield between a green bond and its exact match. We first calculate the average greenium by year. As presented in Panel A of Table 2, the

[9] Notice that the number of observations for Underwriter Discount and Institutional Ownership is lower. This is due to incomplete information for these two variables from Bloomberg and MSRB. The following analysis on these two variables is performed on the sample where information is available for both the green bonds and their non-green matches.

average greenium is slightly positive at the beginning of our sample period. It turns negative from 2016 to 2018. In the most recent years, however, the average greenium has increased significantly and stayed positive. Regarding the number of matched pairs, the proportion of pairs with a negative greenium has been exceeding the proportion of pairs with a positive greenium by a large margin since 2019.

Larker and Watts (2020) focus on the sample period of June 2013 to July 2018. As presented in Section A of the Appendix, our replication results are very close to the results in their paper. The difference between the two sub-samples is even more striking when we divide our sample period into 2014-2018 and 2019-2022. In the first half of the sample, the average greenium is -0.22 bps. It becomes 2.3 bps in the second half, which represents a total increase of 2.5 bps. There are also more matched pairs where we observe a negative greenium compared to before (the proportion increases from 9.02% to 16.76%). Panel A of Figure 2 provides a visualization of such change. There is clearly an upward shift in the cumulative probability function. In other words, as we move from the first half to the second half of the sample, the proportion of matched pairs with a negative greenium has significantly increased. The proportion of matched pairs with a positive greenium has also increased, although not to the same degree.

In addition to issuance yield, investors' green preferences may also be manifested in underwriter discounts. Panel B of Table 2 presents the average underwriter discount difference (i.e., $Underwriter\ Discount_{Green} - Underwriter\ Discount_{Non-Green}$) over time. Like greenium, the difference in underwriter discounts has become significantly negative in recent years, implying that underwriters charge lower fees for issuing green bonds than otherwise identical non-green bonds. Based on the comparison of the two sub-samples, underwriter discount difference decreases from about 3 bps in the first half of the sample to -4 bps in the second half.

From Panel B of Figure 2, one can see a clear gap between the two cumulative probability functions, indicating that the proportion of matched pairs where the underwriter discount is lower for the green bond is increasing over time.

Given that both issuance yield and underwriter discount are important in reflecting investors' green preferences, we combine the two variables into a single measure of total issuance cost, which is defined as the following –

$$Total\ Issuance\ Cost = Issuance\ Yield + \frac{Underwriter\ Discount}{Modified\ Duration}.$$

For those pairs with missing underwriter discount differences, we assume it to be zero when calculating the total issuance cost difference.[10] Panel C of Table 2 presents the average total issuance cost difference (i.e., $Total\ Issuance\ Cost_{Green} - Total\ Issuance\ Cost_{Non-Green}$) over time. Since 2019, green bonds have been consistently cheaper to issue than their non-green counterparts; further, such a gap has been widening recently. Comparing the first and second half of the sample, one can see a total decrease of 4.4 bps in total issuance cost difference. Noticeably, 21% of all matched pairs in 2014-2018 have a negative difference. This number has doubled to 42% in 2019-2022. This, again, can be seen from the cumulative density functions presented in Panel C of Figure 2.

The time trends in greenium and underwriter discounts coincide with a strong increase in the interest in ESG investment. In Figure 3, we present the monthly Google Search Volume index of the keyword ESG. A similar graph shows up in Starks (2023). It is clear that attention to ESG started to increase in 2019, coinciding with the emergence of greenium. Consistent with Starks (2023), the use of "Corporate social responsibility" and "Socially responsible investing" has been

[10] The results are very similar if we exclude these pairs from the total issuance cost difference calculation.

stable, consistent with the observation that many people switch from using CSR and SRI to ESG. As easily seen from Figure 3, if we combine the three keywords and construct a new attention index, we would have seen a very similar trend as that of ESG.

3.3 Time trend by state

Given the differences across states, a natural question is whether the positive greenium in recent years concentrates in a small number of states or a widely-spred phenomenon. Table 3 presents the average greenium, underwriter discount difference, and total issuance cost difference for each of the states in our matched sample. All the states with fewer than 50 observations are combined (as shown in Panel G).

In California and New York, the two largest states in our sample in terms of the number of matched pairs, there has been a steady decrease in greenium, underwriter discount difference, and total issuance cost difference from the first half to the second half of the sample period. In California, especially, the decrease is quite significant both statistically and economically (6.9 bps in greenium, 6.9 bps in underwriter discount difference, and 7.6 bps in total issuance cost difference). Massachusetts has an average of -25 bps in underwriter discount difference in the second half of the sample, compared to zero difference in the first half. This drastic drop and the slight increase in average greenium translates into a decrease of 4.3 bps in total issuance cost over the sample period. A similar trend exists in Texas and the combined group, where the total issuance cost difference drops by 2 bps and 5 bps, respectively.

Overall, the findings of decreasing greenium, underwriter discount difference, and total issuance cost over time in Section 3.1 are not specific to any state. Rather, the time trend holds across different states, although the magnitude varies.

3.4 Time trend in other outcomes

Prior literature has identified after-issuance liquidity as one of the sources that may impact issuing yield (e.g., Chen, Lesmond, and Wei, 2007, Schwert, 2017). To understand whether our findings of greenium are confounded by secondary market trading activity, we first construct liquidity measures from Municipal Securities Transaction Data published by Municipal Securities Rulemaking Board (MSRB). The data cleaning procedure follows Green, Hollifield, and Schürhoff (2007b). Following Larker and Watts (2020), we construct two measures of liquidity – quarterly bond turnover and quarterly number of trades, both of which are commonly-used liquidity measures in prior literature (e.g., Bessembinder, Jacobsen, Maxwell, and Venkataraman, 2018; Oehmke and Zawadowski, 2017, Schwert, 2017, Mahanti et al., 2008).

To construct our first measure, quarterly bond turnover, we calculate the total sum of the par value of all after-issuance trades over the quarter after issuance, weighted by the total issuance amount. The second measure, quarterly number of trades, is constructed by simply calculating the number of trades for each bond over the quarter after issuance. The comparison of these two measures between green and non-green bonds is presented in Panel A of Table 4. There is no obvious time-series trend for either of the two measures. In fact, the magnitude of differentials stays relatively small over time. Such results suggest that there is no liquidity difference between green bonds and non-green matches.

In Larker and Watts (2020), where no greenium is found, they try to understand why green bonds are used by municipalities when there is no issuance price discount. In our study, we analyze the same variables as Larker and Watts (2020) to see if there exists any interesting time trend in ownership concentration.

The first measure of ownership concentration is institutional ownership. This is constructed by calculating the total sum of institutional primary market purchases (those greater than or equal to \$100,000) divided by the total issuance outstanding. The second measure is the Herfindahl-Hirschman index (HHI) of ownership concentration, which is calculated as the following –

$$HHI_i = \sum_{k=1}^{N} \left(\frac{P_k}{O_i}\right)^2,$$

where P_k represents the par value of primary market purchase k, O_i is the total issuance amount for bond i, and N represents the number of primary market purchases for bond i.

Panel B of Table 4 presents these two measures of ownership concentration differences. Institutional ownership difference has some large fluctuations over time (maximum of 16.7 in 2018 and minimum of -15.24), but there is not a clear time trend. The HHI difference between green and non-green bonds stays negative for most of the sample period. This confirms the findings from Larker and Watts (2020) that green bonds appear to have a more diverse ownership base. Further, such a gap in ownership concentration seems to persist over time.

3.5 Greenium, green preferences, and greenness

If greenium is driven by green preferences, we expect to see a higher greenium in states with stronger green preferences and from green bonds that are considered with a higher level of greenness and are less of the greenwashing concerns. In Table 5, we test these hypotheses. Given that there is little greenium in the early period, in this section, we focus on the 2019-2022 sample period.

We follow Larker and Watts (2020) to construct the state-level green preference variable. For each state s, we construct the state-level Green preference measure as $SGP_s = \frac{1}{N_s}\sum_{i=1}^{N_s} Earth_i$, where $Earth_i$ is assigned HIP score for the eco-friendliness of each census-designated place i, and N_s is the number of census-designated places in the HIP database for state s. Our bond level greenness measure is the HIP green rating—the environmental impact rating of the bond assigned by HIP.

Our third measure is whether the green bond and the matched conventional bond have the same use of proceeds. If a green bond and a non-green bond are used for the same purpose (e.g., the same building), as money is fungible, investors may not treat the green bond differently from the non-green bond. The Mergent database has a categorical variable called "use of proceeds," which is a "code indicating how the money will be spent." One limitation of this variable is that sometimes it does not identify any information at the project level. To illustrate, let us consider the 2014 deal issued by the University of Cincinnati in our matched sample. Within this deal, there are two tranches of municipal bonds that are being issued – series 2014C (Green Bonds) and series 2014D. Mergent identifies the use of proceeds for both tranches to be "higher education," while information on the specific projects is not captured. According to the issuance prospectus, the proceeds of the series 2014C bonds (Green Bonds) are used to finance a portion of the Scioto Hall Renovation Project, whereas the proceeds of the series 2014D bonds are used to finance a portion of the Medical Sciences Building Rehabilitation Project and to refund some previously issued bonds. This clearly indicates that the green and non-green bonds are issued to finance different projects. To have a more accurate understanding of the use of proceeds, we perform a manual check of the prospectus of each deal issuance in our matched sample. Out of our matched sample of 1,027 pairs of bonds, Mergent labels 908 pairs as having the same use of proceeds. Based on the information from bond issuance prospectuses, we identify 615 out of such 908 pairs as financing different projects.

Panel A of Table 5 reports the results on greenium. In column (1), the coefficient of *State Green Preferences* is -0.242 (t = - 2.85), indicating that states with a higher green preference has a bigger greenium. In column (2), the coefficient of *Earth Rating Difference* is -0.417 (t = -5.47), suggesting that when the difference between a green bond's earth rating and its matched conventional bond's earth rating is bigger, the greenium is bigger. Columns (3) and (4) report the results based on the two use of proceeds variables. In column (3), *Different Use of Proceeds* (*Mergent*) is defined based on the information from Mergent and in column (4), it is defined based on our manual reading of the prospectuses. Both coefficients are negative and statistically significant, indicating a bigger greenium for green bonds when the uses of proceeds differ.

Panel B of Table 5 reports the results on underwriter discounts. The dependent variable is the difference in the underwriter discounts between green and the matched conventional bond. Although state green preferences and earthing rating difference do not play a significant role, *Different Use of Proceeds* predicts lower discount differences. In other words, when a green bond and its match have different uses of proceeds, underwriters charge a smaller amount than when the uses of proceeds are the same, perhaps because the marketing of such green bonds are easier as investors' greenwashing concerns are mitigated.

Overall, these results are consistent with our conjectures that greenium is bigger for states with stronger green preferences, for bonds with better green rating, and when the greenwashing concerns are mitigated.

3.6 The term structure of greenium

Are investors willing to pay the same level of greenium to different maturities? In this section, we examine whether there is a term structure of greenium. Specifically, we sort all the pairs into five maturity buckets: <= 5 years, between 5 and 10 years, between 10 and 15 years, between 15 and 20 years, and higher than 20 years. We calculate the average greenium and underwriter discount difference within each category. The results in Table 6 show that greenium is significantly higher for lower maturities and in fact insignificantly for the >20 year maturity bucket. We are the first one to document such a downward sloped term structure of greenium. Panel B of Table 6 shows that the term structure of the underwriter discount differences is close to be flat.

4. Conclusion

One of the fundamental questions in the area of socially responsible investing is whether investors make tradeoff between financial returns and non-pecuniary returns based on their ESG preferences. In this paper, we examine this question using the U.S. municipal bond market as our research setting. We match municipal green bonds, whose proceeds are used exclusively to finance green projects, with conventional non-green bonds based on a battery of bond characteristics.

We document an average greenium of 2.3 bps post-2018 in contrast to a 0 greenium in the earlier period. Comparing secondary market liquidity, ownership concentration, and other bond characteristics like issuance size and maturity between green and non-green bonds, we do not find any meaningful differences. Such green and non-green differences do not exhibit any significant time trend. We also find that greenium is more significant in states where people have stronger green preferences, for bonds with better green rating, and when the greenwashing concerns are mitigated. We also document a downward sloped term structure of greenium. Additionally, underwriters used to charge a higher fee in issuing green bonds as opposed to conventional bonds before 2018. In the recent years, issuing green bonds has become cheaper.

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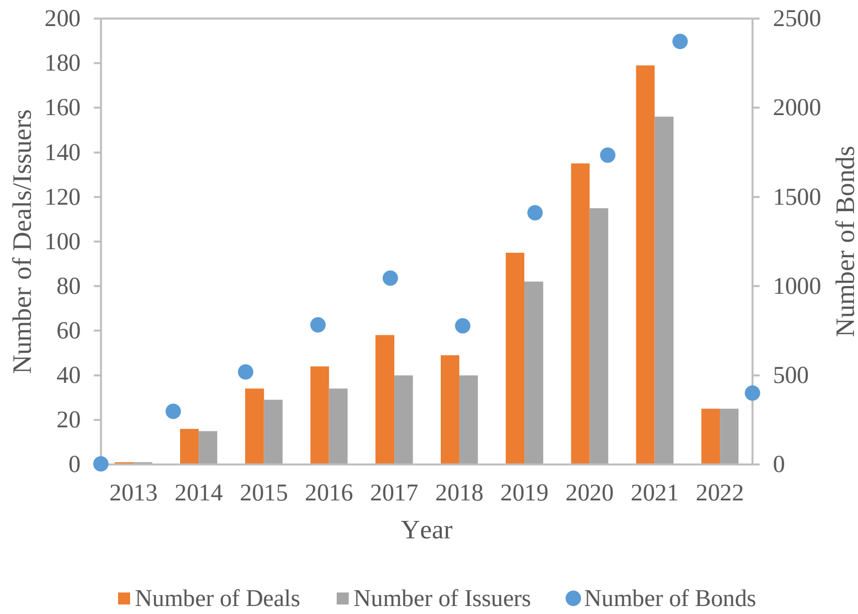
Figure 1. Trends in municipal green bond issuance by year.

Panel A presents the total annual number of municipal green bonds issued (blue dots; right vertical axis), number of deals (orange bars, left vertical axis), and number of issuers (grey bars, left vertical axis). Panel B presents the total annual issuance amount of municipal green bonds and total annual issuance amount of all tax-exempt municipal bonds.

Panel A. Trend in the number of deals, issuers, and bonds



Panel B. Trend in the total issuance amount of municipal green bonds and all tax-exempt municipal bonds

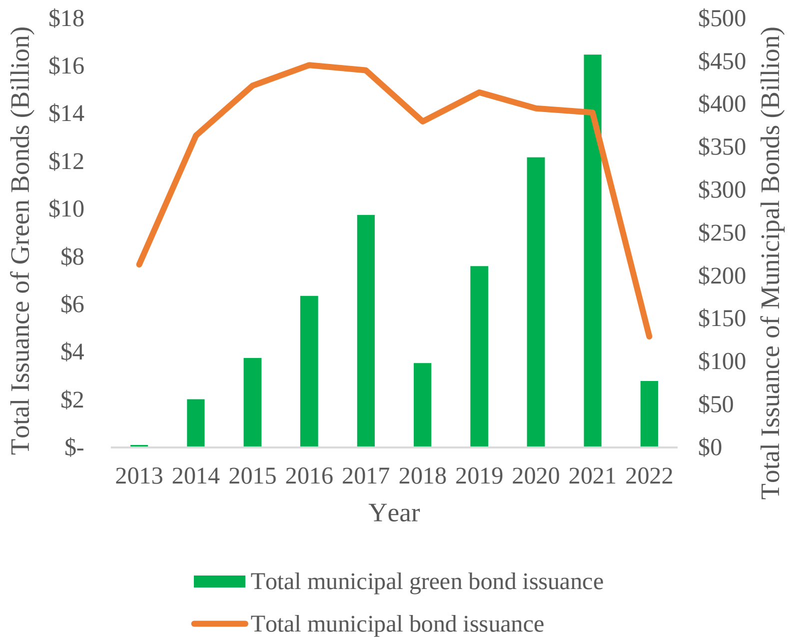
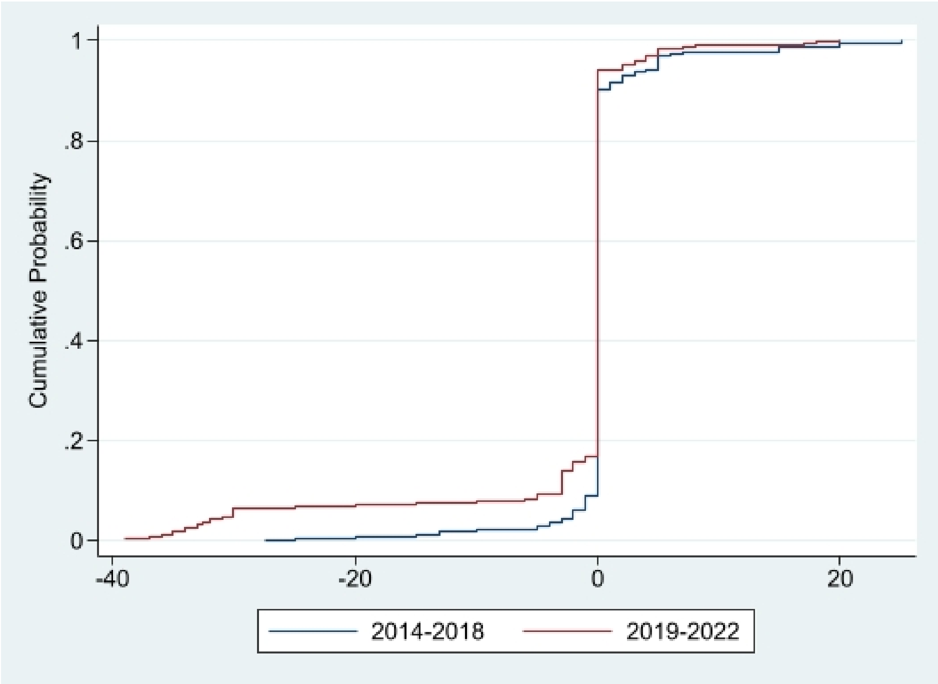


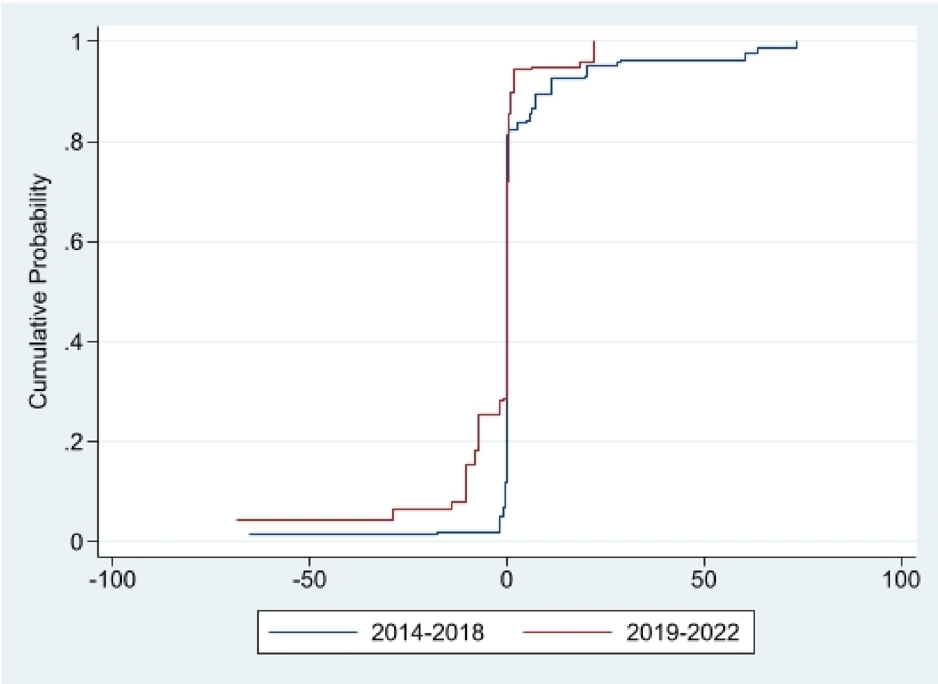
Figure 2. Cumulative densities for green and non-green differences

This figure presents cumulative probability functions for three issuance cost differential measures (from top to bottom: greenium, underwriter discount difference, and total issuance cost difference). The blue line is for the 2014-2018 period and the red line is from the 2019-2022 period.

Panel A. Greenium — difference in the issuance yield



Panel B. Difference in underwriter discount



Panel C. Difference in total issuance cost

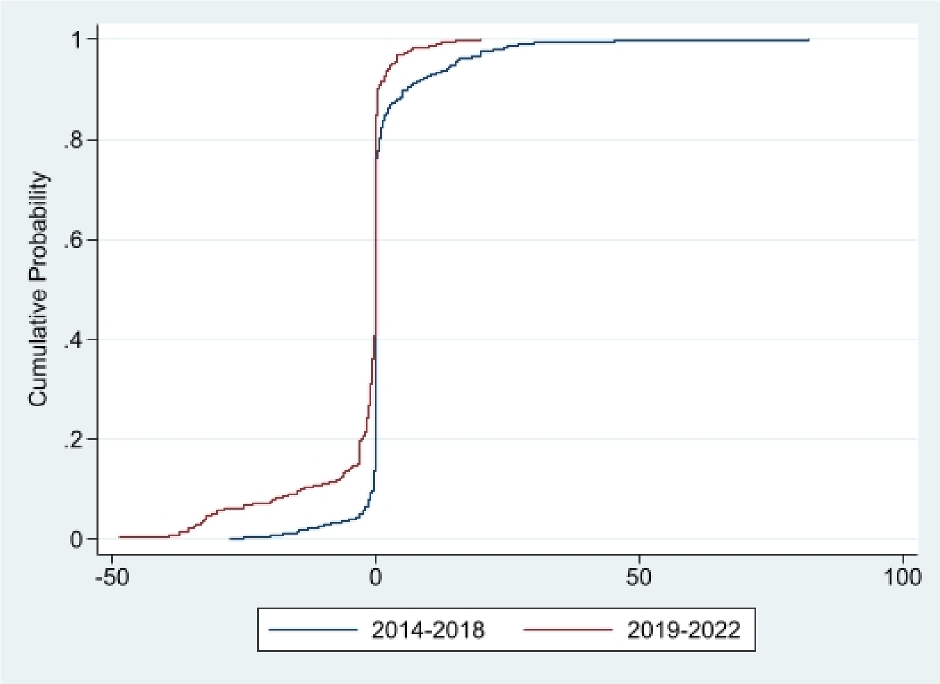


Figure 3. Attention to ESG

This figure presents the monthly Google Search Volume index of three ESG-related keywords: (1) Environmental, Social, and Governance, (2) Corporate social responsibility, and (3) Socially responsible investing.

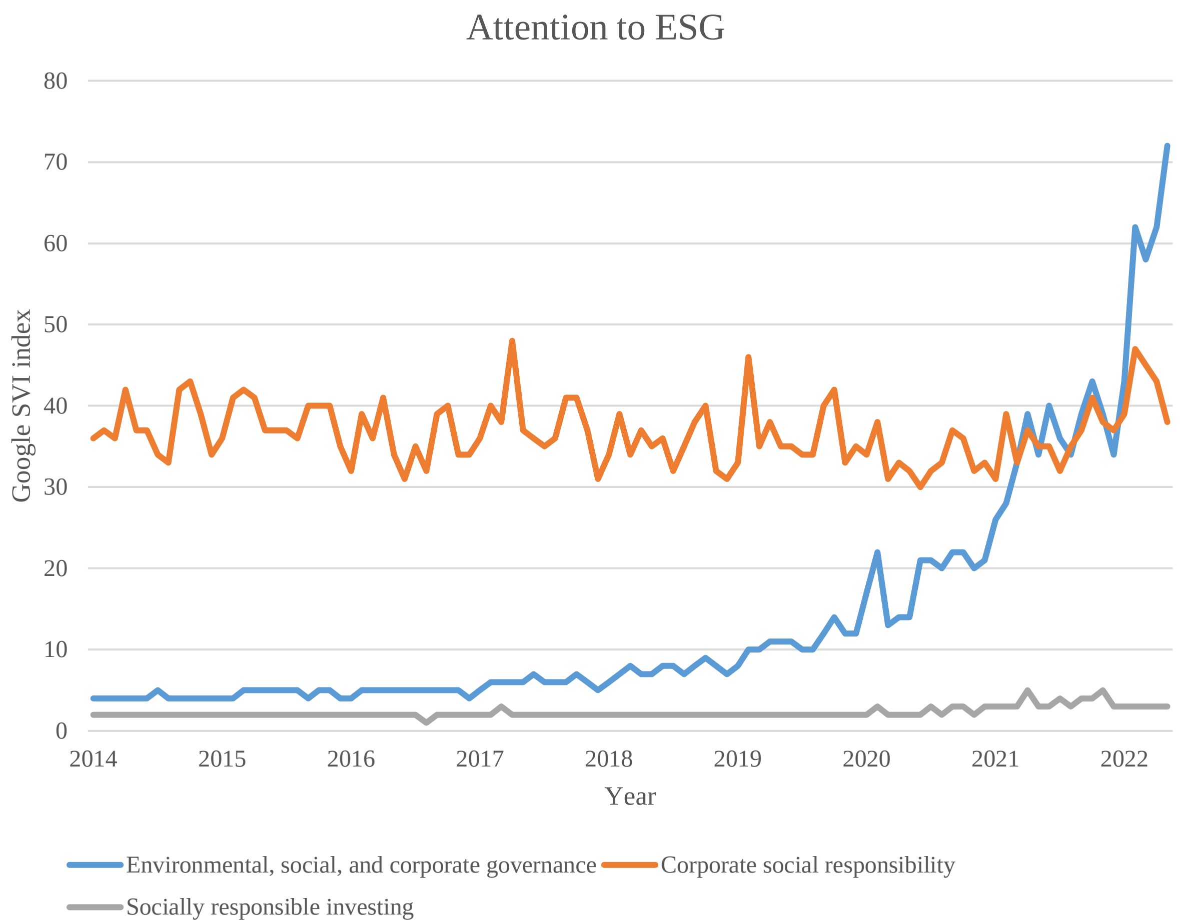


Table 1. Summary statistics of matched green sample and matched non-green sample

This table reports the summary statistics of the bonds in our matched sample: the green bonds in Panel A and the matched non-green bonds in Panel B. For each bond characteristic, we report the mean, standard deviation (SD), the first, the 25th, the 50th, the 75th, and the 99th percentiles, and the number of bonds with available data. See Appendix A for variable definitions.

	Mean	SD	P1	P25	P50	P75	P99	N
Panel A. Matched Green Sample								
Issue Amount ($MM)	4.872	9.125	0.005	0.545	2.100	4.730	46.450	1027
Coupon Rate (%)	3.957	1.223	1.400	3.000	5.000	5.000	5.000	1027
Yield (bps)	204.748	81.771	20.000	150.000	204.000	257.000	400.000	1027
Price (% Par)	112.609	10.863	97.796	100.000	114.552	121.561	134.553	1027
Underwriter Discount (%)	0.509	0.496	0.088	0.229	0.393	0.549	2.992	1012
Turnover	0.922	1.313	0.000	0.000	0.330	1.293	6.062	1027
Number of trades	9.352	18.060	0.000	0.000	2.000	10.000	80.000	1027
Institutional Ownership (%)	84.986	31.457	0.000	93.113	100.000	100.000	100.000	805
HHI	0.581	0.327	0.067	0.278	0.503	1.000	1.000	805
Panel B. Matched Non-Green Sample								
Issue Amount ($MM)	5.263	9.793	0.050	0.490	2.115	6.310	41.685	1027
Coupon Rate (%)	4.029	1.211	1.350	3.000	5.000	5.000	5.000	1027
Yield (bps)	205.356	80.967	25.000	150.000	204.000	255.000	400.000	1027
Price (% Par)	112.974	10.779	97.796	100.000	115.409	121.760	134.617	1027
Underwriter Discount (%)	0.501	0.537	0.076	0.190	0.391	0.542	2.998	984
Turnover	1.015	1.339	0.000	0.000	0.501	1.535	5.556	1027
Number of trades	9.180	23.758	0.000	0.000	3.000	9.000	93.000	1027
Institutional Ownership (%)	84.846	32.924	0.000	96.429	100.000	100.000	100.000	770
HHI	0.648	0.328	0.091	0.335	0.625	1.000	1.000	770

Table 2. Greenium by year

This table reports the average greenium, underwriter discount difference, and turnover difference by year. Averages are calculated for 2014-2018 and 2019-2022, respectively. Differences between the two sub-periods are calculated and reported, along with a standard two-sided t-test.

Panel A. Greenium

	Greenium (bps)					
Year	N	Mean	t-stat	% difference = 0	% difference < 0	% difference > 0
2014	48	-0.042	-1.00	97.92	2.08	0
2015	103	-0.330	-1.80	64.08	28.16	7.77
2016	108	0.213	0.55	72.22	6.48	21.30
2017	265	0.111	0.54	86.04	5.28	8.68
2018	163	0.816	1.66	84.66	6.75	8.59
2019	92	-1.364	-1.89	92.39	6.52	1.09
2020	69	-0.188	-0.95	84.06	11.59	4.35
2021-2022	179	-3.550	-4.43	67.04	24.02	8.94
2014-2018	687	0.218	1.39	81.08	9.02	9.90
2019-2022	340	-2.276	-4.82	77.35	16.76	5.88
Diff		-2.494	-6.24			

Panel B. Underwriter discount difference

	Underwriter discount difference (bps)					
Year	N	Mean	t-stat	% difference = 0	% difference < 0	% difference > 0
2014	38	0.105	1.00	97.37	0	2.63
2015	102	10.861	5.09	71.57	0	28.43
2016	108	3.284	1.15	54.63	8.33	37.04
2017	265	1.442	4.79	56.23	20.38	23.40
2018	136	0.524	1.72	82.35	10.29	7.35
2019	92	0.824	2.03	52.17	10.87	36.96
2020	69	-4.878	-4.15	47.83	30.43	21.74
2021-2022	174	-6.101	-3.99	28.74	37.36	33.91
2014-2018	649	2.958	4.82	66.26	11.86	21.88
2019-2022	335	-3.947	-4.64	39.10	28.66	32.24
Diff		-6.906	-4.85			

Panel C. Total issuance cost

	Total issuance cost difference (bps)					
Year	N	Mean	t-stat	% difference = 0	% difference < 0	% difference > 0
2014	48	-0.047	-1.05	85.42	8.33	6.25
2015	103	2.437	2.50	42.72	28.16	29.13
2016	108	0.829	1.06	49.07	16.67	34.26
2017	265	0.286	1.27	48.30	25.28	26.42
2018	163	3.274	4.24	57.67	14.72	27.61
2019	92	-1.088	-1.65	36.96	18.48	44.57
2020	69	-1.490	-2.39	40.58	34.78	24.64
2021-2022	179	-4.687	-5.52	21.23	56.98	21.79
2014-2018	687	1.379	4.89	52.40	20.67	26.93
2019-2022	340	-3.064	-6.06	29.41	42.06	28.53
Diff		-4.444	-8.29			

Table 3. Greenium by states

This table reports the average greenium, underwriter discount difference, and turnover difference for each state over 2014-2018 and 2019-2022, respectively. States with fewer than 50 bond issuances in our sample period are combined to form the "All other states" group (Panel G). Differences between the two sub-periods are calculated and reported, along with a standard two-sided t-test.

		Greenium		Underwriter discount difference		Total issuance cost difference	
Year	N	Mean	t-stat	Mean	t-stat	Mean	t-stat
				Panel A. CA			
2014-2018	171	0.105	1.87	4.475	8.32	0.650	4.34
2019-2022	85	-6.800	-4.60	-2.456	-5.26	-6.932	-4.78
Diff		-6.905	-6.61	-6.932	-8.34	-7.581	-7.27
				Panel B. NY			
2014-2018	219	0.765	1.78	0.052	1.42	2.192	3.98
2019-2022	8	-0.313	-0.09	0.000		-0.313	-0.09
Diff		-1.077	-0.46	-0.052	-0.29	-2.505	-0.85
				Panel C. MA			
2014-2018	52	0		0		0.008	1.38
2019-2022	38	0.868	1.20	-25.237	-4.65	-4.270	-2.58
Diff		0.868	1.41	-25.237	-5.23	-4.278	-3.03
				Panel D. TX			
2014-2018	36	-0.444	-1.00	-1.403	-10.94	-0.712	-1.57
2019-2022	54	-1.991	-2.21	-0.337	-0.13	-2.691	-2.17
Diff		-1.546	-1.33	1.066	0.36	-1.980	-1.26
				Panel E. AZ			
2014-2018	52	0		-11.354	-3.27	-2.133	-2.99
2019-2022	34	0		0.000		0.002	1.00
Diff		0		11.354	2.64	2.135	2.41
				Panel F. MD			
2014-2018	0						
2019-2022	56	0		0.207	7.69	0.047	2.76
Diff							
				Panel G. All other states			
2014-2018	157	-0.127	-0.42	11.903	5.87	3.139	3.55
2019-2022	65	-1.831	-1.95	-2.303	-2.65	-2.243	-2.58
Diff		-1.703	-2.23	-14.206	-4.53	-5.382	-3.62

Table 4. Trends in other outcomes

This table reports the average differences in turnover, number of trades, institutional ownership, and HHI over the sample period. Averages are calculated for 2014-2018 and 2019-2022, respectively. Differences between the two sub-periods are calculated and reported, along with a standard two-sided t-test.

Panel A	Turnover difference			Number of trades difference		
Year	N	Mean	t-stat	N	Mean	t-stat
2014	48	-0.059	-0.30	48	0.500	0.15
2015	103	0.319	1.64	103	-3.320	-0.67
2016	108	-0.002	-0.02	108	-1.852	-1.13
2017	265	-0.125	-1.92	265	-0.060	-0.05
2018	163	-0.479	-4.84	163	2.620	2.03
2019	92	0.099	0.60	92	1.250	0.64
2020	69	0.028	0.17	69	-0.406	-0.31
2021-2022	179	-0.145	-1.49	179	1.101	1.91
2014-2018	687	-0.119	-2.25	687	-0.156	-0.16
2019-2022	340	-0.044	-0.58	340	0.835	1.26
Diff		0.075	0.82		0.991	0.66

Panel B	Institutional ownership difference (%)			HHI difference		
Year	N	Mean	t-stat	N	Mean	t-stat
2014	35	2.971	0.61	35	-0.089	-1.14
2015	68	-15.241	-3.38	68	-0.044	-0.88
2016	76	-1.918	-0.57	76	0.010	0.22
2017	198	0.782	0.37	198	-0.047	-1.88
2018	113	16.672	3.85	113	-0.241	-7.31
2019	60	-7.480	-2.32	60	-0.025	-0.60
2020	52	15.082	3.06	52	0.128	3.70
2021-2022	99	1.735	0.86	99	-0.178	-6.25
2014-2018	490	1.960	1.20	490	-0.085	-4.89
2019-2022	211	2.404	1.28	211	-0.059	-2.75
Diff		0.443	0.16		0.027	0.88

Table 5. Greenium, green preferences, and greenness

This table reports the cross-sectional regressions. The unit of analysis is bond pair. The dependent variables are greenium in Panel A and underwriter discount differences in Panel B. The sample period is from 2019 to 2022. The robust t-statistics are reported in parentheses.

Panel A. Greenium

	(1)	(2)	(3)	(4)
State green preferences	-0.242**			
	(-2.85)			
Earth rating difference		-0.417***		
		(-5.47)		
Different use of proceeds (Mergent)			-18.38***	
			(-7.16)	
Different use of proceeds (Manual)				-6.130***
				(-3.61)
State FE	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	340	277	339	339
Adj R2	0.0595	0.134	0.402	0.141

Panel B. Underwriter discount differences

	(1)	(2)	(3)	(4)
State green preferences	0.0141			
	(0.33)			
Earth rating difference		-0.118		
		(-1.36)		
Different use of proceeds (Mergent)			-25.65***	
			(-5.32)	
Different use of proceeds (Manual)				-23.15***
				(-4.57)
State FE	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
N	272	335	334	334
Adj R2	0.311	0.0459	0.413	0.373

Table 6. The term structure of greenium

This table reports the term structure of greenium (Panel A) and underwrite discount differences (Panel B). The unit of analysis is bond pair.

Panel A. Greenium

	2014-2018			2019-2022		
Maturity	N	Mean	t-stat	N	Mean	t-stat
<= 5 years	153	1.265	2.04	77	-5.026	-3.87
5-10 years	251	-0.135	-0.86	94	-1.745	-2.02
10-15 years	141	-0.014	-0.08	68	-1.721	-1.55
15-20 years	77	0.000		61	-2.049	-2.45
> 20 years	65	-0.123	-0.48	40	0.475	1.38
Diff		-1.388	-1.44		5.500	3.02

Panel B. Underwriter discount differences

	2014-2018			2019-2022		
Maturity	N	Mean	t-stat	N	Mean	t-stat
<= 5 years	146	3.082	2.15	72	-4.664	-2.14
5-10 years	232	4.057	3.12	94	-5.236	-2.99
10-15 years	134	1.457	1.41	68	-2.074	-1.21
15-20 years	75	1.751	2.93	61	-3.949	-1.95
> 20 years	62	3.258	3.91	40	-2.813	-3.51
Diff		0.176	0.08		1.851	0.62

Appendix

Table A1. Variable definition

Variable	**Definition**	**Data Source (*Variable name*)**
Aggregate Rating	The median long-term rating assigned by Fitch, Moodys, and S&P at issuance. For those bonds without a rating on the issuance, the first rating after issuance is used. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent (*rating_c* from either *current_rating* file or *historical_rating* file*)*
Callable	An indicator variable that takes the value of one if the bond contains an embedded call option.	Mergent (*optional_call_flag_i*)
CBI Climate Bond Certified	An indicator variable that takes a value of one if the bond was issued with the Climate Bond Initiative's climate bond certification.	Mergent (*project_name_c*)
Coupon	The coupon rate of the bond. Measured in %.	Mergent (*coupon_f*)
Deal Size ($ MM)	The total par value of all securities initially issued as part of the same deal as the bond.	Mergent (*total_offering_amount_f*)
Fitch LT Rating	The long-term rating of the security assigned by Fitch at the date of issuance or the first date with data available after issuance. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent (*rating_c* from either *current_rating* file or *historical_rating* file)
Green Bond	An indicator variable that takes the value of one if the bond is self-labeled as a green bond at issuance.	Bloomberg (*self-lable green*), Mergent (*green_bond_i*)

Herfindahl-Hirschman Index (HHI)	Calculated as: $HHI_i = \sum_{k=1}^{N} \left(\frac{P_k}{O_i}\right)^2$, where P_k represents the par value of primary market purchase k, O_i is the total issuance amount for bond i, and N represents the number of primary market purchases for bond i.	MSRB (*PAR_TRADED*, *OFFER_PRICE_TAKEDOWN_INDICATOR*), Mergent (*total_maturity_offering_amt_f*)
Initial Offering Yield (Yield)	Yield to maturity at the time of issuance, based on the coupon and any discount or premium to par value at the time of sale. Measured in basis points.	Mergent (*offering_yield_f*)
Institutional Ownership	Defined as total sum of institutional primary market purchases (those greater than or equal to $100,000) divided by total issuance outstanding (in cases where the total amount of primary market purchases do not match the total issuance outstanding, we divide by total amount of primary market purchases).	MSBR (*PAR_TRADED*, *OFFER_PRICE_TAKEDOWN_INDICATOR*), Mergent (*total_maturity_offering_amt_f*)
Issue Amount ($ MM)	The total dollar amount outstanding of the bond at issuance.	Mergent (*total_maturity_offering_amt_f*)
Large Issuer	An indicator variable that takes the value of one if a bond is in the upper quartile of issuer-level total issuance in the Mergent database up to May 2022.	Mergent (*total_maturity_offering_amt_f*)
Moody's LT Rating	The long-term rating of the security assigned by Moody's at the date of issuance or the first date with data available after issuance. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent (*rating_c* from either *current_rating* file or *historical_rating* file)
Non-green Bond	An indicator variable that takes the value of one if the bond is not identified as green by either Bloomerg or Mergent.	Bloomberg (*self-lable green*), Mergent (*green_bond_i*)

Number of Trades	Calculated as the total number of trades over the quarter (90 days) after issuance.	MSRB (*SETTLEMENT_DATE, DATED_DATE*)
Offering Year X	An indicator variable that takes the value of one if the bond is issued in the year X.	Mergent (*offering_date_d*)
Refunding	An indicator variable that takes the value of one if the bond was issued for the purpose of refinancing outstanding debt.	Mergent (*capital_purpose_c*)
Search Volume Index (SVI)	Scaled index measuring relative popularity on the topic of climate change.	Google Trends
S&P LT Rating	The long-term rating of the security assigned by S&P at the date of issuance or the first date with data available after issuance. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent (*rating_c* from either *current_rating* file or *historical_rating* file)
Turnover	Calculated as the total sum of par value of all after-issuance trades over the quarter (90 days) after issuance divided by the total issuance amount. Settlement date is within 90 days of dated date.	MSRB (*PAR_TRADED, SETTLEMENT_DATE, DATED_DATE*), Mergent (*total_maturity_offering_amt_f*)
Underwriter Discount	The fee paid to the underwriter for marketing and selling the bonds. Measured as a % of par.	Bloomberg (*ISSUANCE_DISCOUNT_PCT*)
Years to Maturity	Number of years to the maturity date at issuance.	Mergent (*maturity_date_d*, *offering_date_d*)

Internet Appendix

Section A. More results on replicating Larker and Watts (2020)

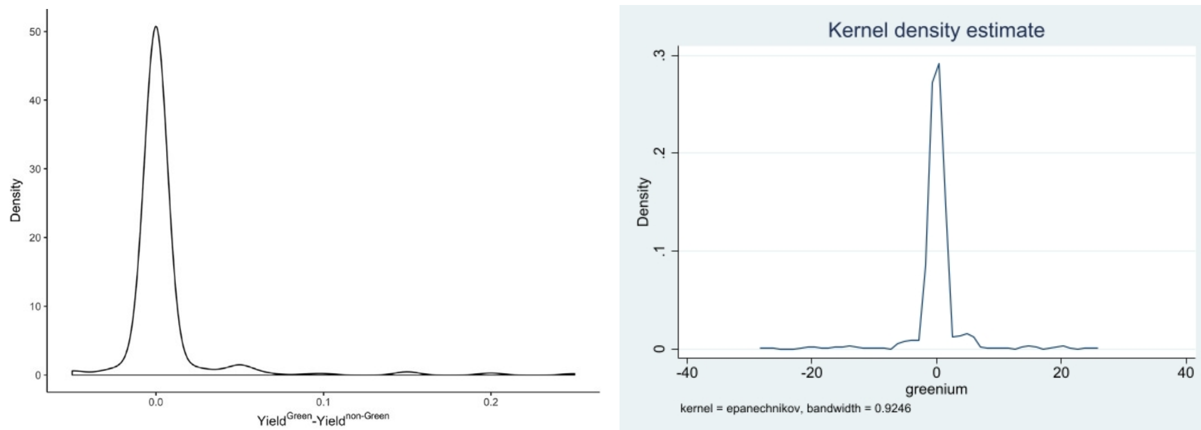
This section reports some additional replications of Larker and Watts (2020). Specifically, the kernel density of greenium, underwriter discount difference, and turnover difference (Figure 3 of Larker and Watts (2020)), the sample construction table (Table 1 of Larker and Watts (2020)), the sample characteristic comparisons (Table 2 of Larker and Watts (2020)), and the comparison between green and matched non-green bonds for initial offering yields and underwriter discount (Table 3 of Larker and Watts (2020)).

Larker and Watts (2020) compare green bonds and the matched non-green bonds for four characteristics: initial offering yield, initial offer yield spread (relative to the matched maturity yield derived from the Municipal Market Advisors (MMA) 5% AAA G.O. benchmark yield), underwriter discount, and turnover. For each of the characteristics, they calculate the difference between green and matched bonds and present the kernel density of the differences. As we only include the exact matches, the difference between the initial offering yield and the difference between the initial offering yield spread is identical. We omit the results for the initial offering yield spread.

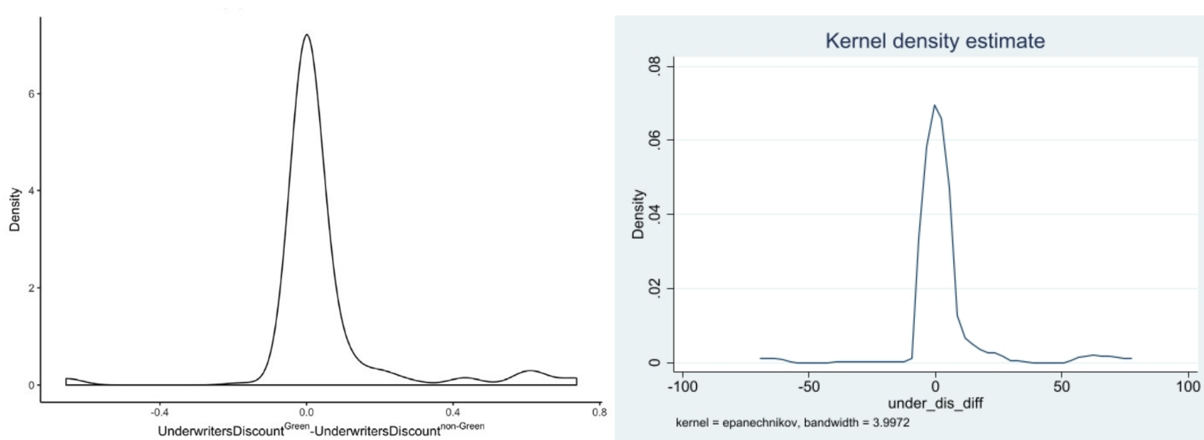
Figure IA1. Replicating Larker and Watts Figure 3 (Kernel density estimates for green and non-green differentials)

This figure presents the kernel density plots from Larker and Watts (2020) (on the left side) and our replication (on the right side) for three main variables: greenium (Panel A), underwriter discount difference (Panel B), and turnover difference (Panel C).

Panel A. Greenium



Panel B. Underwriter discount difference



Panel C: Turnover difference

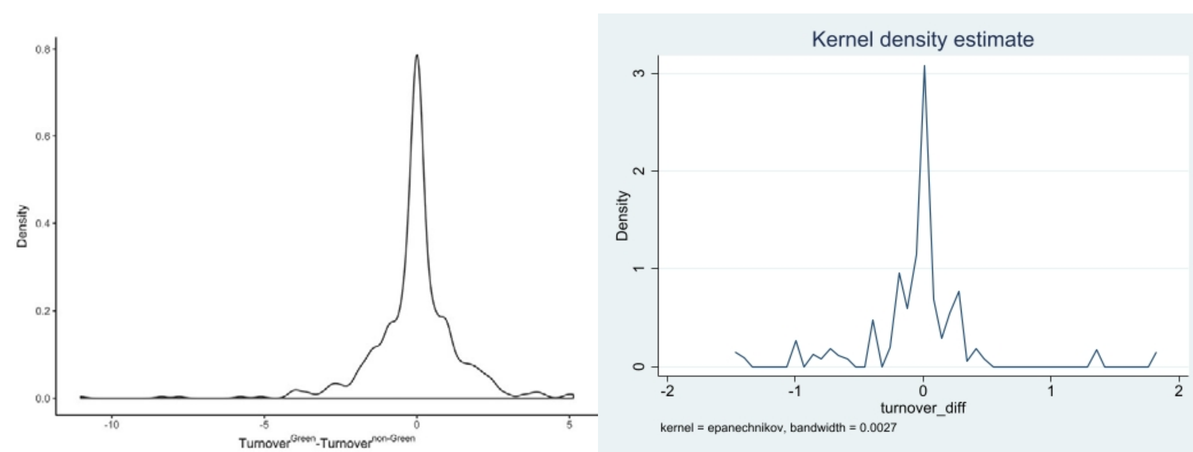


Table IA1. Replicating Larker and Watts Table 1 (sample construction)

This table summarizes the construction of the municipal bond transaction sample used throughout this study. Panel A describes the steps in selecting our matched sample. Panel B describes the distribution of bond characteristics for all green bonds used in our matched sample. Panel C describes the distribution of bond characteristics for all matched non-green bonds.

Panel A. Sample Construction

	Larker and Watts				Replication			
	Bonds	Deals	Issuers	Matches	Bonds	Deals	Issuers	Matches
Full Bloomberg Green bond sample	4321	386	261					
Remove adjustable rate and tender offer bond issues	4200	351	257					
Drop issues dated before June 2013	3694	240	161					
Remove federally taxable securities	3142	175	107					
Mergent match	3097	169	104		2968	176	98	
Drop bonds labeled as non-Green by Mergent	2896	154	90		2917	172	94	
Total matches	568	48	30	640	642	62	39	787
Same issuer/structure/issuance day match	555	44	28	627	563	50	32	670
Same issuer and issuance day match	13	12	10	13	79	35	25	117

Panel B. Bond Characteristics (Matched Green Sample)

	Mean	SD	p1	p25	p50	p75	p99	N	Mean	SD	p1	p25	p50	p75	p99	N
Issue Amount ($ MM)	5.355	10.054	0.067	0.429	2.127	4.709	50.552	640	4.998	9.572	0.055	0.445	2.02	4.47	50	670
Coupon Rate (%)	3.903	1.204	1.4	3	4	5	5	640	3.931	1.223	1.35	3	5	5	5	670
Yield (bps)	224.196	74.948	62	173.75	223	278	400	640	221.718	73.026	62	172	220	270	400	670
Price (% Par)	111.406	9.857	98.676	100	113.402	120.287	128.701	640	111.767	9.969	98.67	100	114.004	120.867	128.742	670
Issuance Spread (bps)	25.01	26.063	-33.61	5.5	23.5	43	92	640								
Underwriter Discount (%)	0.418	0.219	0.087	0.234	0.393	0.545	1.203	629	0.403	0.225	0.087	0.212	0.386	0.545	1.333	660
Turnover	0.919	1.241	0	0	0.427	1.328	6.019	627	0.914	1.239	0	0	0.415	1.277	6.062	670
Institutional Ownership (%)	74.515	38.955	0	59.167	97.955	100	100	543	80.775	34.864	0	84.56	99.665	100	100	568

Panel C. Bond Characteristics (Matched Non-Green Sample)

	Mean	SD	p1	p25	p50	p75	p99	N	Mean	SD	p1	p25	p50	p75	p99	N
Issue Amount ($ MM)	5.645	10.868	0.062	0.629	2.345	5.836	40.511	640	5.901	11.018	0.06	0.66	2.513	6.13	43.77	670
Coupon Rate (%)	4.063	1.197	1.4	3	5	5	5	640	4.08	1.21	1.375	3	5	5	5	670
Yield (bps)	223.76	75.261	62	172.75	223.5	277.25	400	640	221.555	73.131	62	173	220	270	400	670
Price (% Par)	112.418	9.985	99.479	100	115.545	121.216	129.062	640	112.694	10.031	99.461	100	116.065	121.539	129.245	670
Issuance Spread (bps)	24.569	26.107	-33.61	6	23	43	92	640								
Underwriter Discount (%)	0.366	0.199	0.086	0.175	0.373	0.533	0.951	601	0.353	0.199	0.086	0.16	0.323	0.527	0.951	611
Turnover	0.975	1.351	0	0	0.5	1.395	5.438	627	0.97	1.261	0	0	0.527	1.398	5.682	669
Institutional Ownership (%)	77.686	38.377	0	79.818	100	100	100	508	82.632	34.207	0	91.96	100	100	100	530

Table IA2. Replicating Larker and Watts Table 2 (sample characteristic comparisons)

This table presents the average sample characteristics of all tax-exempt municipal green bonds, the subsample of green bonds used in this study, and all municipal bonds. The column labeled "All GB" presents the average characteristics of all municipal green bonds from Bloomberg's comprehensive sample of self-labeled green bonds. Column "Matched GB" presents the average characteristics of all municipal green bonds for which we are able to identify the same issuer, issuance day, and structure matches. Column "All Bonds" presents the average sample characteristics of the full universe of municipal issues (in the Mergent municipal database). All variables are as defined in the Appendix. The differences in sample average between samples are calculated using a standard two-sided t-test. Levels of significance are presented as follows: p<0.1*; p<0.05**; p<0.01***.

	Larker and Watts					Replication				
Variable	All GB (1)	Matched GB (2)	All Bonds (3)	(1)-(2)	(1)-(3)	All GB (1)	Matched GB (2)	All Bonds (3)	(1)-(2)	(1)-(3)
Aggregate Rating	2.492	2.622	3.62	-0.13*	-1.128***	3.097	2.887	3.717	0.210***	-0.620***
CBI Climate Certification	0.097	0.088	0	0.01	0.097***	0.114	0.128	0	-0.015	0.113***
Large Issuer	0.732	0.966	0.213	-0.234***	0.518***	0.777	0.979	0.250	-0.202***	0.527***
Offering Year 2013	0.001	0	0.104	0.001	-0.103***	0.001	0	0.093	0.001	-0.092***
Offering Year 2014	0.103	0.084	0.179	0.019	-0.076***	0.103	0.082	0.179	0.02	-0.077***
Offering Year 2015	0.179	0.183	0.216	-0.004	-0.037***	0.178	0.169	0.216	0.009	-0.038***
Offering Year 2016	0.278	0.195	0.228	0.083***	0.050***	0.268	0.188	0.227	0.08***	0.042***
Offering Year 2017	0.353	0.406	0.194	-0.053*	0.159***	0.358	0.406	0.193	-0.048*	0.165***
Offering Year 2018	0.086	0.131	0.078	-0.045**	0.008	0.092	0.155	0.092	-0.063***	0
Issuance Yield	2.304	2.242	2.25	0.062	0.054***	2.288	2.217	2.271	0.071*	0.017
Callable	0.547	0.445	0.46	0.101***	0.087***	0.54	0.415	0.47	0.125***	0.071***
Fitch LT Rating	2.086	1.797	3.135	0.289***	-1.049***	4.757	6	3.831	-1.243	0.927***
Moody's LT Rating	2.429	2.827	3.499	-0.399***	-1.07***	2.864	3.134	3.571	-0.269***	-0.706***
S&P LT Rating	2.342	2.387	3.55	-0.045	-1.208***	3.072	2.723	3.689	0.349***	-0.617***
Refunding	0.313	0.3	0.507	0.013	-0.194***	0.342	0.291	0.497	0.051*	-0.155***
Issue Amount ($ MM)	8.051	5.355	2.925	2.696***	5.126***	8.184	4.998	3.148	3.186***	5.036***
Deal Size ($ MM)	156.128	107.557	43.673	48.571***	112.454***	162.66	104.75	43.67	57.91***	118.99***
Years to Maturity	12.011	10.829	9.564	1.182***	2.447***	12.046	10.405	9.807	1.641***	2.239***
N	2,896	640	652,391			2,917	670	666,585		

Table IA3. Replicating Larker and Watts Table 3 (Matched sets tests for a relationship between green-label and costs of borrowing)

This table presents matched sample tests on the borrowing cost differentials between green and non-green securities. All measures are as defined in the Appendix and measured in basis points. For each matched set, the differences in mean (median) between green and non-green securities is calculated using a standard paired two-sided t-test (Wilcoxon test). Levels of significance are presented as follows: p<0.1∗; p<0.05∗∗; p<0.01∗∗∗.

	Larker and Watts		Replication	
	Exact Matches		**Exact Matches**	
	Mean	Median	Mean	Median
Panel A: Initial offering yields				
Green	222.874	222.000	221.718	220.000
Non-Green	222.415	221.000	221.555	220.000
Mean difference	0.459	1.000	0.163	
t-statistic	4.217	-3.784	1.120	
(p-value)	(<0.01)	(<0.01)	(0.263)	
Median difference			0.000	
M-statistic			5.000	
(p-value)			(0.44)	
S-statistic			931.500	
(p-value)			(0.042)	
Total Matches	627		670	
% Matches Zero Difference	84.848		79.700	
% Matches Neg. Difference	5.742		9.400	
% Matches Pos. Difference	9.410		10.900	
Panel B: Underwriter Discount				
Green	41.087	38.600	38.295	37.700
Non-Green	36.623	37.300	35.268	32.300
Mean difference	4.465	1.300	3.027	
t-statistic	6.060	-6.928	4.670	
(p-value)	(<0.01)	(<0.01)	(<0.0001)	
Median difference			0.000	
M-statistic			38.500	
(p-value)			(<0.0001)	
S-statistic			5189.500	
(p-value)			(<0.0001)	
Total Matches	590		611	
% Matches Zero Difference	67.627		66.780	
% Matches Neg. Difference	9.492		10.310	
% Matches Pos. Difference	22.881		22.910	