Where's the Greenium?

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Abstract

This study investigates whether investors are willing to trade-off wealth for societal benefits. We take advantage of unique institutional features of the municipal securities market to provide insight into this question. Since 2013, over $23 billion Green Bonds have been issued to fund eco-friendly projects. Comparing Green securities to nearly identical securities issued for non-Green purposes by the same issuers on the same day, we observe economically identical pricing for Green and non-Green issues. In contrast to a number of recent theoretical and experimental studies, we find that in real market settings investors appear entirely unwilling to forgo wealth to invest in environmentally sustainable projects. When risk and payoffs are held constant, municipal investors view Green and non-Green securities by the same issuer as almost exact substitutes. Thus, the "greenium" is essentially zero.

JEL classification: G12, G14, G20.

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1. Introduction

Environmental, Social, and Governance (ESG) measurement, Corporate Social Responsibilty (CSR) activities, and Socially Responsible Investing (SRI) are increasingly important research topics in both academic and professional areas. This research focus is motivated by the fact that more than one-quarter of the $88 trillion of assets under management globally are now said to be invested in accordance with ESG principles (Bernow, Klempner, and Magnin, 2017).[1] As highlighted in Servaes and Tamayo (2013), while there is growing evidence of an association between ESG and CSR activities on security pricing (e.g., Dhaliwal, Li, Tsang, and Yang, 2011; Christensen, 2016; Christensen, Floyd, Liu, and Maffett, 2017), comparatively little is known about the channels through which ESG may affect asset prices.

A question of primary importance is this area is whether ESG investments have value to investors beyond the normal expected risk and return attributes of a security. For instance, if investors are presented with an high-ESG and low-ESG security whose risk and returns are identical, would investors pay more for the high-ESG security? While standard "no arbitrage" arguments suggest these securities should price identically, there is a growing literature that argues otherwise. For instance, a number of studies present theoretical models where investors are willing to give up pecuniary benefits to invest in environmentally friendly or socially responsible assets (e.g., Friedman and Heinle, 2016; Heinkel and Kraus, 2001; Geczy, Stambaugh, and Levin, 2005). Similar arguments can be found in the broader asset pricing literature which explores how investors' "tastes" for assets with particular characteristics can affect asset prices (e.g., Fama and French, 2007). Evidence consistent with this is provided by Hong and Kacperczyk (2009) who show that so-called "sin" stocks are shunned by socially conscious investors significantly outperform.

Martin and Moser (2016) provide evidence of these effects showing that both investors

[1] The increased importance of ESG investing is further highlighted by Larry Fink, CEO of Blackrock, who emphasized in his 2018 annual letter to CEOs that: "... a companys ability to manage environmental, social, and governance matters demonstrates the leadership and good governance that is so essential to sustainable growth, which is why we are increasingly integrating these issues into our investment process" (Fink, 2018).

and managers value Green investments for their societal (non-pecuniary) benefits. This study shows that, in experimental markets, investors respond positively to reports of Green investments even when it is independent of future cash flows and risk. They conclude that "... investors and managers trade-off wealth for societal benefits." The important question is whether such results generalize to actual market settings.

Our study uses a specific real market setting to access whether investors value the societal benefits associated with ESG activities. We provide compelling evidence that that so-called "greenium" – the premium that Green assets trade to otherwise identical non-Green securities – is exactly zero. In this analysis, we focus on U.S. municipal issuers as it provides a novel quasi-natural experiment in which to investigate this issue. Municipal issuers have been one of the largest issuers of "Green bonds." As seen in Figure 1, from 2013 to 2017, over $23 billion of self-labeled Green bonds have been issued in municipal markets, for more than 2,500 individual securities.[2] This provides an extensive sample of securities and issuers for our empirical tests.

More importantly, we take advantage of two unique institutional features of the U.S. municipal securities market to implement a methodological approach that is less prone to the standard correlated omitted variable critique of prior ESG research. The first feature is that municipal issuers commonly price multiple tranches of securities, both Green and non-Green securities, on the same day with similar maturities. This occurs because municipalities must track their use of funds to comply with IRS requirements (IRS, 2017), limits to bond issuance by state constitutional mandates, and issuer desires to ensure that funds generated by investors buying Green bonds are actually being used for environmentally friendly purposes. The second feature of municipal bonds is that the credit for these Green bonds is *identical* to the credit for their non-Green counterparts (Woeppel, 2016). Green bonds are identical to ordinary municipal bonds, with the key exception being that the use of proceeds is allocated for the purposes of "environmentally friendly projects" (e.g., sustainable water

[2]By comparison, over the same sample period, Flammer (2018a) reports approximately $14.3 billion in corporate securities in the U.S., but only 61 individual securities issued.

management and energy production). Thus, any differences in security pricing can be attributed to investor preferences for non-monetary security features, rather than differences in expectations about future cash flows or risk.

The primary result of our paper is that municipal investors appear entirely unwilling to give up monetary gains to support Green projects.[3] Our results are based on a sample of 640 matched pairs of Green and non-Green issues issued on the same day, with identical maturity and rating, and issued by the same municipality. Comparing these two samples, we observe an economically trivial difference in yield and spread between Green and non-Green bonds of approximately 0.45 basis points (indicating a slight Green bond discount).[4] In fact, in approximately 85% of matched cases, the differential yield is *exactly* zero. These results provide strong evidence that municipal bond investors are unwilling to sacrifice returns when funds are used for environmentally friendly projects: that is, the greenium is essentially equal to zero.[5]

We also explore whether there appear to be any benefits related to issuance costs for Green securities. Specifically, while we explore how much investment bankers charge to issue Green securities (or the underwriter's discount) may differ across securities. This is an interesting measure because it provides some evidence on whether underwriters consider Green securities as riskier to underwrite (e.g., Ederington, 1975; Joehnk and Kidwell, 1979), and one of the primary challenges attributed to the growth of Green bonds in municipal markets is the perceived cost of issuance (i.e., Chiang, 2017). For our matched sample, we find that the underwriting premium charged to issue Green bonds is higher than non-Green bonds. Specifically, borrowing costs are on average about 10% higher for Green securities

[3] In 2012 approximately 50% of the U.S. municipal securities market was held directly by retail investors, with an additional 25% held on behalf of individuals by mutual, money market, closed-end, and exchange-traded funds (SEC, 2012).

[4] As discussed in Appendix B, this estimated discount is produced by a handful of "outliers." In particular, these observations differ in a number of other ways that are likely to be driving their anomalous behavior. Specifically, these matches tend to differ across security size, as well as the coupon rate. After removing these outliers, the pricing differentials are exactly zero.

[5] The "greenium," or "Green bond premium" indicates that the yield and credit spread (price) for a Green bond is lower (higher) than its non-Green counterpart. This indicates a lower cost of debt for Green issues.

than almost identical non-Green securities. The combination of equivalent yield and higher transactions costs is not consistent with the existence of greenium.[6]

Next, we use nearest neighbors matching methods to show that our pricing result generalizes to using larger samples by relaxing our exact matching restrictions and creating matched treatment (Green) and control (non-Green) samples using nearest neighbors matches on bond and issuer characteristics. This alternative matching approach expands our sample size of securities by nearly 300%, and we again find nearly identical results of zero pricing differential between Green and non-Green samples. Interestingly, these tests also provide some evidence that the issuance of Green debt does not lead to pricing benefits at the municipality level.

Our final set of tests explore plausible alternative explanations for the lack of an observed premium. Specifically, we explore whether differences in liquidity between Green and non-Green securities, a lack of sufficient institutional ownership, or so-called "greenwashing"[7] behavior (e.g., Chiang, 2017; Grene, 2015) could explain our findings. We examine differences in three liquidity proxies across our matched samples using analyses similar to our pricing tests, and find no meaningful association between Green and non-Green bonds and market liquidity. In addition, despite the claims of industry professionals that the lack of institutional ownership is a significant barrier to pricing in green to Green bond markets (Chiang, 2017), we find little difference in institutional ownership levels between Green and non-Green securities.

Greenwashing concerns have arisen among investors due to the absence of a universal set of standards on whether a security is Green (e.g., Grene, 2015; Chiang, 2018). To mitigate these concerns, a new form of economic certification was created to ensure financing proceeds are actually used for environmentally friendly purposes. While there have been a number of entrants into this space, including Standard & Poors and Moody's, the Climate Bonds

[6]However, in approximately 68% of the cases, the differential underwriting cost is equal to zero.

[7]"Greenwashing" occurs when the use of funding proceeds are for purposes that have little environmental value (Climate Bonds Initiative, 2017).

Initiative (CBI) is the main provider of these services and has been used by a number of municipalities to provide third-party certification.[8] We explore the pricing effects of this certification, and find no evidence that this leads to incremental yield benefits to municipalities which mitigates concerns that greenwashing is repsonsible for our documented lack of premium.[9] Additional tests related to the underlying use of proceeds (i.e., exploring whether the money was used for new money Green projects) also supports these inferences.

The primary contribution of this study is to provide direct estimates of whether investors are willing trade-off wealth for societal benefits. Rather than eliciting preferences from experimental or survey data as in prior studies (e.g., Martin and Moser, 2016; Riedl and Smeets, 2017), we use the municipal Green bond market as a real market laboratory to explore these issues. At least for investors in municipal securities, our results cast doubt on the idea that investors are willing trade-off wealth for societal benefits.[10]

This study also contributes to a burgeoning literature that attempts to disentangle the channels through which ESG and CSR activities impact securities prices. Specifically, we present evidence that investor non-pecuniary preferences, or their tastes for assets as consumption goods, are unlikely to drive the asset pricing differentials previously found in the literature. Rather, it is much more likely that asset prices are a function of the impact of ESG and CSR on future firm profitability and risk. These results are consistent with a number of recent studies that show relations between CSR investment and future performance (e.g., Lys, Naughton, and Wang, 2015; Chen, Hung, and Wang, 2018; Flammer, 2018b).

Finally, this study provides new policy relevant insights on the pricing of Green securities of municipal markets and the benefits of third-party certification. Based on prior studies that claim to document a greenium, some policy analysts are calling for *more* Green bond issuance to reduce the cost of government borrowing (e.g., Saha, 2018). Our results suggest just the opposite conclusion – not only is there no pricing differential, but investment banks

[8] See: `https://www.climatebonds.net/certification`.

[9] Among securities that are CBI Climate Certified in our matched sample, the differential between Green and matched non-Green issues is exactly zero in 91% of cases.

[10] We discuss the external validity of our findings in the final section of this study.

also appear to charge slightly more to issue Green bonds on average. Combined with the fact that external certification adds additional costs of issuance for municipalities (without any apparent cost savings), our results suggest that municipalities actually increase their borrowing costs by issuing Green bonds.

While the magnitude of the differential costs of Green bond issuance are not economically large, they are clearly value decreasing in this setting. This presents a puzzle as to why a municipality would choose to issue these Green securities in the first place, given that these cost differentials appear to be well known (Chiang, 2017). One potential explanation for this is that what we observe is a more innocuous version of previous findings that decision makers at municipalities are willing pay higher fees for political gain (Butler, Fauver, and Mortal, 2009). In this case, the issuing municipality may benefit from the political benefits associated with marketing their focus on sustainability through the use of Green bonds (i.e., Derra, 2016).

The remainder of the paper consists of six sections. The next section discusses the prior literature most pertinent to our research question. Section 3 outlines and justifies our methodological approach. Section 4 describes the sample construction, data sources, and measures used in the empirical analyses. The primary empirical results of the paper are provided in Section 5. Section 6 explores a number of potential alternative explanations for our documented findings. Finally, Section 7 provides an interpretation of the results and concluding remarks.

2. Related Literature

There are several contemporaneous studies that provide estimates for the "Green bond premium." The results of these prior studies are quite mixed and in most cases the analysis is based on only a small set of securities (e.g. Ehlers and Packer, 2017; Climate Bonds Initiative, 2017). Studies most closely related to our paper are Karpf and Mandel (2017) and

Baker, Bergstresser, Serafeim, and Wurgler (2018). Both of these studies use a large sample of issued Green bonds in the municipal market (consisting of approximately two thirds of our sample). Karpf and Mandel (2017) find a Green bound discount (positive yield differential) of approximately eight basis points, whereas Baker et al. (2018) find a Green bond premium of about six basis points. Though both studies are provocative, one indicating that municipal investors are willing to give up returns to invest in Green projects while the other arguing municipal investors require higher yields on Green projects, both are inconsistent with discussions by industry practitioners. For instance, participants responding to a survey by the State Treasurers Office of California on Green bonds are noted as unanimously stating "their firms would not accept a lower yield for a green bond" (Chiang, 2017).[11]

We believe that the mixed evidence in prior research is the result of methodological design misspecifications that produce biased inferences. These concerns are not unique to our setting, and have been prevalent in the ESG and CSR literature (e.g., Servaes and Tamayo, 2013; McWilliams and Siegel, 2000). As we show that the Green bond premium is effectively zero even small amounts of bias in either direction lead to large changes in inference.

As noted in Baker et al. (2018), Karpf and Mandel (2017) appear to find a Green bond discount, but they compare taxable to non-taxable securities in their tests (i.e., they ignore the important role of taxation in the municipal securities market). Baker et al. (2018) use a pooled fixed effects model in their tests.[12] Nevertheless, as we show in Section 5.4, this is insufficient to effectively control for non-linearities and issuer-specific time variation which ultimately leads to spurious inferences.

The primary difference between our study, and these contemporaneous studies, is one of

[11]Our conversations with a number of traders, portfolio managers, and bankers focused on municipal securities mirror these sentiments. This includes a Managing Director, and Head of Tax-Exempt Securities at a large fund group; investment bankers at a large bulge bracket bank; and a Portfolio Manager in charge of tax-exempt securities at a municipal hedge fund.

[12]They also include a number of securities from the Clean Renewable Energy Bonds (CREB) and Qualified Energy Conservation Bonds (QECB) programs with special tax issues which makes cross-asset comparability difficult. This issue is discussed in Section 4.

approach. While prior studies attempt to use fixed effects models or pooled regressions to estimate the Green bond premium, we take advantage of the fact that the unique institutional features of municipal securities market give us a nearly perfect counterfactual security. Therefore, as noted by Crabbe and Turner (1995), it is possible to use a model-free matching method in our setting to estimate treatment effects.[13] Specifically, we can compare nearly identical securities from the same issuer on the same issue date, and thus avoid the myriad of selection and measurement issues inherent in the pooled regressions of prior studies.

In the subsequent analysis, we develop a methodological design that enables us to rigorously assess whether municipal investors forgo returns for securities when the funds raised are used for Green investments. Although arguably limited in scope to municipal securities and investors in high tax brackets, these results provide fundamental insights into how ESG attributes affect asset prices and investor perceptions of risk and return for assets that have Green attributes.[14]

3. Methodology

Our methodological approach is similar to that used in Crabbe and Turner (1995) and Schwert (2018). To illustrate our methodology, consider as an example the $362 million deal by Arizona State University. As shown in Panel A of Figure 2 (the header of the cover page of the offering statement), the deal was brought to the market on the same day with three series of securities tranches for investors. The funds raised by the three securities were to be used to refinance outstanding debt, refurbish existing buildings, and construct new buildings. The securities also gave investors the opportunity to invest directly in the creation in sustainable buildings. The official statement makes the uses of these funds explicit (italics added for emphasis):

[13]We use the phrase "model-free" to mean that results do not depend on any parametric assumptions about functional form (i.e., Loumioti and Vasvari, 2018).

[14]We discuss external validity in Section 7.

> The purpose of labeling the Series 2015A Bonds as Green Bonds *is to allow investors to invest directly in projects which the University has identified as promoting environmental sustainability on the University's campuses.* The University intends to pursue LEED (Leadership in Energy & Environmental Design) certification for the Green Bond Project. LEED is a Green building certification program offered by the U.S. Green Building Council. Projects submitted for LEED certification are reviewed by the Green Building Certification Institute, a third-party organization, and assigned points based on the project's implementation of strategies and solutions aimed at achieving high performance in: sustainable site development, water efficiency, energy efficiency, materials selection and indoor environmental quality, among other sustainable qualities.

Panel B in Figure 2 presents the pricing information for these securities. We see that there are a number of overlapping maturities in both the Series 2015B (Green Bonds) tranche, and the non-Green 2015B tranche. For each bond in the Series 2015B (Green Bonds) tranche of securities, our matching procedure selects every security in the non-Green 2015B tranche with a similar maturity. The securities outlined in red indicate one such match. This procedure is repeated for every identified Green bond in our sample described in Section 4.

Using this approach on various outcome variables, we are able to measure the effects of raising funds for Green purposes, using group comparisons on the matched samples on various outcome variables. The average treatment effect of a security being Green over for various outcome variables is:

$$\hat{\tau} = \frac{1}{N}\sum_{i=1}^{N} Y_i^G - Y_i^{NG}$$

where N represents the total number of matches in our sample, Y_i^G the outcome variable for the Green bond in match i, and similarly Y_i^{NG} the outcome variable for the associated non-Green bond. In essence, our design is similar to a behavioral experiment where a Green bond and a similar non-Green bond are presented for sale to market participants and we capture the price paid for the purchase of both bonds. The key assumption is that the matching of the two securities issued by the same municipality, at the same date, and having essentially the same terms of coupon and maturity size will effectively control for the primary confounding factors that could lead to spurious inferences. As with any observational study, there is always the possibility of unobserved correlated omitted variables, but we believe our methodological approach mitigates most validity threats.

4. Sample Selection

4.1. Data Cleaning

Our sample of Green bonds is identified using Bloomberg's comprehensive sample of self-labeled Green bonds in the municipal market. Industry professionals consider this source to be the most comprehensive publicly available list of Green municipal securities. We acknowledge that there are some incorrectly marked securities in these data. For example, there are a number of securities identified as Green prior to 2013, despite the fact that the first self-labeled Green bond was marketed in June 2013 (S&P Global Ratings, 2018). Therefore, we perform a number of data cleaning steps outlined in Panel A of Table 1 to construct our final sample.

We begin by restricting our sample to fixed-rate coupon bonds to simplify yield calculations. Municipal issues before June 2013 are dropped because they are unlikely to have been originally marketed as Green bonds. Aside from the fact that this isolates bonds that were most likely to be marketed to investors as being for environmental purposes, it also removes a number of securities subject to special tax credits which make yield comparisons impossible. Specifically, bonds associated with the Clean Renewable Energy Bonds (CREB) and Qualified Energy Conservation Bonds (QECB) programs, which comprise almost the entirety of the pre-2013 sample, allow a credit to investors which counts against their taxable income (IRS, 2018). If a premium were found among these securities, it would be impossible to disentangle whether this was due to the tax credit or investor inherent desires to invest in the underlying Green projects.

To ensure similar tax treatment across our sample, we remove all federally taxable securities (i.e. Schwert, 2017). The Mergent match step restricts our sample to the time period for which we have issuance data on (up to July 2018). To remove mislabeled securities, our final data cleaning step selects only those securities which are labeled as Green by both Bloomberg and Mergent. This removes 22 individual deals, and we confirm that these securities were in fact mislabeled as Green bonds in the Bloomberg data.

4.2. Matched Set Creation

After the data cleaning stage, we are left with 2,896 Green bonds across 226 separate issues from 90 unique issuers. We attempt to match these Green securities to the remaining 652,391 securities issued during this time period in the Mergent database to construct our matched treatment securities (Green bonds) and control securities (non-Green bonds from the same issuer). Following Crabbe and Turner (1995), we use a simple matching procedure in which we select issues that are identical in terms of structure and issued by the same issuer on the same day. Specifically, for each Green bond we search our non-Green control sample for a security identical in the following ways: issuer, rating, and call dates. We drop any matched pairs in which the securities are callable and the coupons are unequal, because these features have a substantial effect on the value of the internal interest rate option which makes comparability difficult across securities.

Our final selection restriction is to limit the differentials in maturity to be within one year. We do this to maximize the number of securities for which we can obtain matches, while also minimizing the differences in the slope of the credit spread. For securities where an exact maturity match can be found, the non-exact maturity matches are omitted from our sample. Similar to Crabbe and Turner (1995), we allow any Green bond to be matched to multiple control bonds so long as they meet the above restrictions. The final sample of matches contain 640 matched pairs, over 568 individual Green bonds across 78 separate offerings for 30 unique issuers.[15] As shown in Panel A of Table 1, of the 640 matched pairs, 627 are identified as exact matches in that they have the absolute same structure (identical

[15]For comparative purposes, Crabbe and Turner (1995) uses a sample of 605 matched pairs over 4 issuers while the primary sample used in Schwert (2018) contain 245 matched pairs over 124 issuers.

maturities).

4.3. Descriptive Statistics

Panels B and C of Table 1 present descriptive statistics on various characteristics and outcome variables used in this study. As shown, both the Green bond sample and non-Green control sample are of similar issuance size with a mean (median) of $5.35 ($5.65) million, respectively. Average prices and coupons are also quantitatively similar with an average coupon rate of 3.9% and 4.06% and price of 111.41 and 112.42 percent of par, for the Green and control samples respectively.[16] Because we have restricted all securities that have an embedded call option to have identical coupons, these slight differences across coupon should have minimal impact on differences in pricing. Comparing issuance yields, spreads, underwriter's discount, and turnover across samples gives some preview of our main results. Specifically, yield and spread are nearly identical across samples. For instance, the sample mean for yield (spread) in basis points is 224.2 and 223.76 (25.01 and 24.57) for the Green and matched non-Green samples, respectively. This is indicative of an economically insignificant premium for non-Green securities, although we evaluate this further in Section 5. Sample differences for turnover and underwriters discounts also suggest similar inferences, although there does appear to be a slightly higher underwriter's discount for the Green sample with an average underwriter's discount of 0.416% versus 0.366% for the non-Green sample.[17]

4.4. Sample Comparisons

Since we only select matched pairs of securities, we are dropping a large portion of the outstanding Green securities. In Table 2, we consider how our sample differs from both the

[16] We note that nearly all tax-exempt municipal bonds are issued at a premium to par for tax reasons (Landoni, 2018). Observing a issuance price premium in this setting tells us nothing about whether Green or non-Green securities from the same issuer are issued with preferable pricing.

[17] The difference in observations for Underwriters Discounts and Turnover is caused by missing observations from the Bloomberg database and/or insufficient secondary market data. All analyses are performed for each matched set where we have information for both the Green and non-Green securities.

universe of Green securities and the overall sample of municipal securities. These comparative results provide insight into whether it is appropriate to generalize our results to other relevant samples of municipal bonds.[18]

From Table 2, we see that our sample of municipal securities exhibits a number of differences from the general Green bond universe. While many of these comparisons are statistically significant, the differences are very modest in substantive economic terms. For instance, our sample of securities is of slightly lower credit quality with differences in aggregate rating of about -0.13. This maps into approximately a one-tenth of a one notch downgrade (i.e. from A+ to A) by Standard and Poors. We slightly underweight issuance in years 2016, while over-weighting deals later in the sample in years 2017 and 2018. Finally, our sample of securities is about 1.2 years shorter in maturity than the general Green bond sample.

The main ways in which our sample appears to differ from the general universe of Green bonds is that we overweight securities issued by large issuers and the total deal and maturity sizes are smaller. While large issuers comprise 73.2% of securities, 96.6% of the matched Green bond sample are large issuers. This is not an unexpected result as we would expect the primary issuers needing to issue for multiple purposes simultaneously would be larger municipalities (e.g., large cities or universities). The differences in offering amounts and maturity sizes are most likely attributable to the fact they have chosen to carve the deal up into multiple series. There is no obvious reason to believe that these comparative differences would affect the generalizability of our inferences to the general universe of municipal Green bonds.

In contrast, we see much more significant differences between the universe of Green bonds and the universe of other municipal securities. In particular, we observe a number of differences in Green issues from the general universe of municipal securities related to the size and credit quality of the issuers. For instance, Green bonds are on average approximately

[18] To be clear, by construction, our matched non-Green sample (not considered in Table 2) is economically identical across all variables considered here with the exception of Issue Amount. As discussed in the prior section, there are no statistical differences over this variable between our matched Green Bond sample and non-Green Bond sample.

one notch higher in credit quality. Additionally, despite the fact that Green bonds are on average 2.4 years longer than the general universe of standard issues, their yields are 5.4 basis points lower. Finally, Green bonds are much more likely to come from a large issuers, with a statistically significant difference of approximately 51.8% between the Green and non-Green samples. This is also evident in the large differences in the size of the deal, where Green bond deals are on average more than three times larger than non-Green bond deals. As we show below, it can be difficult to effectively control for these differences using the fixed effects regressions used in prior studies that pool Green and non-Green municipal securities.

Overall, our matched sample of Green bonds exhibit very small differences across a variety of covariates from the general universe of municipal Green bonds. We have little reason to believe this impacts the our ability to generalize our results to the entire universe of municipal Green bonds. However, the observed differences between Green and non-Green samples are substantial. This highlights likely difficulty of dealing with selection and omitted variable bias when comparing Green to non-Green issuers to make inferences about the effects of being Green. For these reasons, we rely on a within-issuer, as opposed to across-issuer, design.

5. Estimating the Greenium

5.1. Kernel Density Estimates of Differences

We begin our analyses by considering the univariate distribution of differences between our matched pairs of Green and non-Green bonds for our variables of interest ($Y_i^G - Y_i^{NG}$). Examining these distributions provides insight into the frequency with which these measures differ as well as their magnitudes. We present kernel density estimates for each of our four variables of primary interest in Figure 3.

The top two panels present pricing evidence based on offering yields and spreads. This visual evidence is consistent with there being little pricing differential between Green and non-Green securities. We see a large mass directly at zero which is indicative of zero pricing differential (at issuance) between Green and non-Green securities. The estimated density is extremely right-skewed, with thin tails indicating a select number of extreme observations (perhaps "outliers") in these matched pairs where there exists a positive pricing differential. We discuss this issue in Appendix B and conclude that these observations are quite unusual. For the purposes of consistency, we have kept these securities in our sample given they leave our general inference largely unchanged.

In terms of underwriter's discounts and post-issuance turnover, we again see a distribution essentially centered around zero differential between Green and non-Green bonds. It is important to highlight that this result is observed despite the fact that underwriter's discounts and post-issuance turnover are calculated and determined in an entirely different manner than yield and spread. Specifically, the underwriter's discount is typically negotiated between the issuer and the underwriter, while post-issuance turnover is derived from the amount of trading in the calendar quarter after issuance.

Overall, issuance yields, spreads, underwriting discounts, and after market liquidity are virtually identical between Green and non-Green municipal securities. We also observe a large mass of observations where the differential is precisely zero.

5.2. Analysis of Matched-Pairs of Green and Non-Green Bonds

Panels A and B of Table 3 present the mean and median pricing differentials between the two samples, along with t-tests and Wilcoxon tests for the statistical significance in differences between the matched sample. For our sample of exact matches, as defined in Section 4, the difference between mean (median) yield and spread is a statistically significant 0.459 and 0.459 (1.0 and 0.5) respectively. When looking the difference between mean

[18] In untabulated multivariate analyses, we check to see if any inferences in this section could be caused by the minor differences we observe in coupon rate or issue amount. Our inferences related to spread and yield are robust to the inclusion of these variables as controls. Specifically, we observe no statistically or economically significant difference in pricing between Green and non-Green securities. Unsurprisingly given our limited sample, our documented results of a slightly higher underwriters discount becomes statistically insignificant.

(median) yield and spread for all matches, we estimate a statistically significant difference of 0.436 and 0.441 (-0.5 and 0.5) respectively. Rather than implying a Green bond premium, this slightly positive differential implies a Green bond discount.

As shown in Figure 3, the economically insignificant 0.4 basis point yield differential appears to be largely the result of handful of unusual observations or "outliers." In fact, for around 85% of cases, this differential is *exactly* zero. Moreover, among the remaining 15% of securities, approximately 40% imply a negative differential (or a Green bond *premium*), while the other 60% imply a positive differential (a Green bond *discount*). To our knowledge, there is no theory which suggests that a Green bond should trade at a discount to their non-Green counterparts. Moreover, the fact that this appears to be driven by a handful of issues examined in Appendix B leads us to conclude that the greenium is essentially zero. Our result is inconsistent with some concurrent papers (e.g., Baker et al., 2018), but it is completely inline with insights provided to us by industry professionals.

Our next set of tests explore whether there appears to be any differential in the amount investment bankers charge to issue Green securities, or the underwriter's discount. This is an interesting consideration for two reasons. First, prior studies assert that one of the major portions of underwriter spreads represents underwriter's compensation for risk of an unsuccessful offering (e.g., Ederington, 1975; Joehnk and Kidwell, 1979). To the extent that demand for securities outpaces supply, as some proponents of Green bonds have asserted, we might expect this to show up in the fees charged to underwrite the issue. Second, to the extent that Green bonds are less expensive to issue, it gives some indication as to why, despite the lack of apparent pricing benefits, municipalities choose to issue Green bonds. This is an important consideration, given that one of the primary challenges attributed to the growth of Green bonds in municipal markets is perceived cost of issuance (Chiang, 2017).

Panel C of Table 3 reports results for the differences in underwriter's discount for our sample of matched securities. Like our results for initial offering yields and spreads, we estimate a statistically significant positive differential between Green and non-Green securities.

In economic terms, differences in underwriter's discount appear significantly larger than our estimates for yields and spreads. The mean (median) positive differentials of 4.47 (1.3) basis points are indicative of firms charging approximately 12% (3.5%) more than non-Green average (median) bonds in our sample. Given the average deal size of $156.128 MM in our sample, this would equate to an additional $69.7 thousand in borrowing costs on average – a nontrivial amount given the numerous fiscal challenges facing many municipal issuers.[19]

Despite the fact that the estimated differentials appear significantly larger than those related to yield or spread (approximately 10 times larger), these results appear to be driven by a sample of outliers. In 70% of cases, the differentials are exactly zero, indicating that in most situations, underwriters tend to view these securities as identical. However, given the 23.8% of cases which indicate a positive differential to only 6% of deals with a negative differential, it does seem like the prevalence of positive differentials is significantly larger for underwriter's discounts.

Overall, the results of this sections support the notion that there are no substantive price differentials between Green and non-Green securities. Where differentials are statistically significant, these results are driven by a handful of outliers and estimated differences are economically small. Moreover, our results related to underwriter's discounts indicate a slight premium that investment banks charge to issue Green bonds. This gives important evidence confirming industry professionals' suggestions that added costs to issuance are a legitimate threat to the future of Green bonds in municipal securities markets (e.g, Chiang (2017, 2018)).

5.3. Nearest Neighbors Matching

There are many ways one might match a treatment sample of municipal bonds to a control sample of municipal bonds. Although the stated expected returns are straightfor-

[19] We note that, typically, the schedule of Underwriters Discounts is assigned on a per bond basis (i.e., not as a lump sum per maturity). Therefore, any differentials in the size of the maturity, which we show to be negligible, cannot be responsible for this finding.

ward for fixed income securities, it is quite difficult to find appropriate comparison groups for these securities. For instance, in addition to matching on credit quality and tax treatment, it is also necessary to account for structural differences between securities such as differences in maturity and whether the securities contain an embedded call option (MSRB, 2018). Adding to these complications is the fact that the value of these embedded call options, which are extremely prevalent in municipal securities, depends on a myriad of other variables such as the shape of the entire yield curve, the years to the first call date, and the coupon (i.e., Kalotay, Williams, and Fabozzi (1993)). The difficulty of finding an appropriate match further highlights the advantage associated with the exact matches used above.[20] Nevertheless, this advantage comes at the cost of severely limiting the sample size for the statistical tests. In order to assess the impact of exact matching on our results, we implement a nearest neighbors matching approach by constructing three separate matched samples and performing similar tests to those in the prior section.

Our first two matched samples, denoted “Same Month” and “Same Week” in Table 4, are constructed from the least rigid rules in an attempt to maximize the number of Green securities used in our analyses. For each Green security, the matching rule begins by matching on state, whether the security has an embedded call option, issuer size, and either issuance month (Same Month) or week (Same Week). Controlling for issuance state is important given differences in state taxation which affect asset prices (i.e., Schwert (2017)), while controlling for callability is vital given the large pricing effects that embedded call options can have (i.e., Kalotay et al. (1993)). Limiting our set of matches to the same issuance month or week holds constant aggregate market conditions such as the general shape of the yield curve and credit curve. Finally, controlling for size is necessary given that vast majority of Green bond have been issued by large issuers, who are typically significantly more sophisticated and well known than comparable small issuers.

[20] This is particularly important in our setting because the size of the spread and yield effects may be fairly small. Thus, modest errors in matching in either direction setting can easily lead to substantial changes in inferences.

For each Green security, we find a non-Green control security by minimizing the global distance on the following: years to maturity, years to the call, coupon, and aggregate rating.[21] The first three of these variables is important because of its large effects on the pricing of the internal call option. Aggregate ratings is of obvious importance to control for differences in issuer credit quality. A third matched set more closely resembles the main matched set used in this study. Specifically, we match exactly on callability, but we also require the issuer, rating, and issuance date to be exactly the same. We then select the nearest match based on years to call, years to maturity, and coupon. This matched set is denoted "Same Issuer-Day" in Table 4.

We create treatment and control samples based on the aforementioned matching procedures, and we run univariate pricing analyses similar to those found in Section 5.2. Results appear in Table 4. Panel A provides differences in means for select covariates between treatment (Green) and control (non-Green) securities in our three matched samples, and the original sample. As seen, our matched samples of treatment and control securities are significantly more balanced (although not perfectly), across various measures of credit quality (issuer size and aggregate credit rating) and securities structure (coupon, maturity, etc.), than the original sample of treatment (Green bonds) and control securities (all non-Green bonds issued during the same time period).[22]

In Panel C, we provide univariate pricing tests for our results related to initial offering credit spreads.[23] In every specification, we see that the estimated difference across means and medians is economically small and statistically insignificant, mirroring our earlier results

[21]All matching variables are standardized, and given equal weighting in our nearest neighbors matching based on a logistic regression, and a caliper width of 0.1 standard deviations to minimize potential bias (i.e., Rosenbaum and Rubin, 1985; Rajeev and Wahba, 2002). Each match is created without replacement, using a greedy algorithm.

[22]It is important to point out that in our main analysis, we effectively have perfect balance over these covariates by focusing on within issuer matches, and requiring the bonds to be identical in terms of maturity and callability. Our method is also somewhat more flexible in that we allow coupons to differ when there is no embedded call option, as differing coupons should have limited effect on pricing in these cases (i.e., Kalotay et al., 1993).

[23]Because we are now comparing securities over different issuance days, we focus our discussion on credit spreads to isolate effects on issuer-specific components of municipal borrowing costs.

of no pricing differential. For instance, we see statistically insignificant mean (median) differences between the monthly and weekly matched samples of -1.19 (1.00) and -1.67 (0.00), respectively. The results related to initial offering yields in Panel B are similar.

We also see that by relaxing our matching restrictions, we are able to expand the sample of treatment securities considerably (and presumably increase the power of our statistical tests). In comparison to our main sample which include 568 individual green bonds, 78 separate deals, and 30 issuers, the extended samples considered in these tests include significantly more securities and deals. For instance, the results related to issuer month expand the sample of Green bonds, deals and issuers by 296%, 188%, and 250%, respectively. This helps to alleviate concerns that our inferences might not extend to the larger municipal Green bond universe.

Overall, our results using nearest neighbors matching methods and a significantly larger sample of securities support our main results. Specifically, there is no statistically reliable relationship between bond pricing and a security being issued for environmentally friendly purposes.

5.4. Reconciling with Baker et. al (2018)

As discussed in Section 2, the study most related to ours in Baker et al. (2018). With the exception of the inclusion of a number of securities with special tax credits issued in the early 2010's which we have omitted, their sample is largely similar to ours. Using a sample of Bloomberg-identified Green bonds from 2010 to 2016 and a pooled regression approach with fixed effects, they report a statistically and economically significant discount (a negative differential in yield between Green and non-Green securities) of 8 basis points for Green bonds. Moreover, they show these estimated premium are significantly stronger for bonds with the CBI Climate Certification.

While fixed effects models are sometimes effective in controlling for unobserved time invariant heterogeneity that is both additive and linear, these models are insufficient to control for many variables that are time-variant or non-linear and correlated with offering yield. It is quite possible that their model which includes month, maturity, rating interacted fixed effects, issuer specific, and a number of bond characteristic fixed effects do not control for some of the key confounding factors. For example, over the six-year time period they explore, Green issuers (which tend to be significantly larger) may simply outperform non-Green issuers, even when controlling for rating-maturity-issuance month fixed effects and issuer fixed effects.

It is also important to note that these regressions effectively compare securities with embedded call options as though they were the same as securities without these options. The complications of this issue are well documented, and discussed in the prior section. This is a real issue, as we see in Table 2 that Green bonds have a higher tendency to have an embedded call option. Because municipal securities are quoted "yield-to-worst," this is typically the yield to call for callable municipal securities given that municipal bonds are nearly always issued at a premium (i.e., Landoni (2018)). In comparing a callable Green security to a non-callable non-Green security, a fixed effects regression may estimate a Green bond discount despite the fact that the Green security may have the same or potentially higher option adjusted yield.[24]

In general, fixed effects will not effectively control for a myriad of selection and pricing issues specific to municipal securities. The large covariate differences observed between Green and non-Green bond issues in Table 2 clearly suggest that the Baker et al. (2018) results may be confounded by omitted variable bias and model misspecification.[25] We believe that our documented result of a zero pricing differential is persuasive given the near perfect matches we create of Green and non-Green securities. Nevertheless, we attempt to reconcile our

[24]In untabulated analyses, we find evidence consistent with this logic. Specifically, we run the same specifications in Panel A of Table 5 on just the sample of non-callable bonds. The economic magnitude of the coefficient estimates on the *Green Bond* indicator shrinks *at least* 47% in all specifications. The coefficient becomes statistically insignificant once we control for Issuer FEs and Month × Maturity × Rating FEs.

[25]As we mention in prior sections, there is also the issue of their inclusion of bonds associated with the Clean Renewable Energy Bonds (CREB) and Qualified Energy Conservation Bonds (QECB) programs which allow for special tax credits to investors which counts against their taxable income (IRS, 2018).

results with this prior study in this section.

We first attempt to replicate the Baker et al. (2018) results using the same fixed effects methodology for our sample of all tax-exempt Green bonds and our matched sample of Green bonds. These results are presented in Panels A and B of Table 5. The first three columns use the exact sample years of the Baker et al. (2018), while the last three columns extend their results to the end of our sample in June 2018.

Using all Green securities in Panel A, we are able to match Baker et al. (2018) quite closely. While the economic magnitudes differ slightly, likely due to minor differences in our sample construction, our results are quite close to those found in Baker et al. (2018). For instance, in Column 2 we calculate a Green bond premium of 6.98 basis points with CBI Climate Certified bonds exhibiting a premium of an addition 14.78 basis points. The same specification in Baker et al. (2018) yield inferences remarkably similar – a Green bond premium of 7 basis points and CBI Climate Certified bonds exhibiting an additional premium of 16.9 basis points.

Extending their methodology to the more recent years leaves their main inference unchanged, but it shows those related to the CBI Climate Certification become sensitive to specification. Specifically, their methodology continues to yield an estimated Green bond premium ranging from 11.85 basis points to 5.46 basis points depending on specification. The estimates related to the CBI Climate Certification are significantly smaller and statistically insignificant in some cases. This may be attributable to the fact that there were only four CBI Certified deals during this earlier sample period, with 11 done since then. These earlier deals may have been simply issued during a stronger market.

Our next set of results, presented in Panel B of Table 5, use the same methodology on our sample of matched securities. For our sample of Green securities, we estimate a Green bond premium using their methodology. In fact, in most specifications we yield significantly larger premium than those in Baker et al. (2018). However, we know from our exact matching tests, that there is no difference in premiums for Green and non-Green securities. One plausible explanation for this inconsistency is that larger issuers tended to outperform over this time period (i.e., in untabulated analysis, we find evidence of a large issuer time trend of approximately two basis points per year). As shown in Table 2, our sample of Green securities are more likely to be issued by larger issuers, and therefore yield larger estimated premiums. However, there are likely to be many explanations for the inconsistency of results between the exact matching tests and the pooled regression approach.

Finally, we examine the pricing results for a placebo sample of the *non-Green* securities – those non-Green bonds from our matched sets. These securities are "placebo" in the sense that, as discussed in prior sections, they have no Green attributes. In Panel B of Table 5, we show that the coefficients on the placebo bond variable are virtually identical to the corresponding coefficients on the Green bond variable. This shows that using this fixed effects methodology to estimate premiums is likely picking up issuer-related omitted variables associated with issuance costs rather than an actual Green bond premium.

In summary, this section shows that we are able to generate the result from Baker et al. (2018) that there exists a Green bond premium, using their fixed effects specifications. However, we find a similar result when we estimate the premium on a group of placebo bonds (non-Green securities from Green issuers). Moreover, if the pooled regression model is well specified, the results should closely mimic the results of the exact matching approach. Interestingly, we find little correspondence between results produced by the regression and matching approaches. Therefore, we conclude that the fixed effects approach is unable to control for other time variant heterogeneity in this research setting.

6. Alternative Explanations

6.1. Differences in After-Issuance Liquidity

As discussed previously, one of the cited explanations for the lack of a pricing difference is that the Green bond market has poor liquidity. Although we have shown in Section 4 that securities from Green issuers may be, on average, more liquid than securities from non-Green issuers, it is possible that Green and non-Green securities from the same issuer show liquidity differentials. We now examine whether there are liquidity differentials between bonds in our within issuer matched pairs.

We construct liquidity and trading activity metrics derived from the comprehensive historical data set of municipal bond transaction prices from the Municipal Securities Rulemaking Board (MSRB) accessed through WRDS. After data cleaning procedures outlined in Green, Hollifield, and Schürhoff (2007b), we construct three separate trading activity and liquidity metrics commonly used for OTC bonds. Our choice in metrics is to maximize the number of matched pairs for which we are able to retain observations. As noted in previous studies (e.g., Schwert, 2017), the municipal securities market is by nature extremely illiquid with limited trading. Because of this, many commonly-used liquidity metrics, such as bid-ask spread which require both a buy and sell prices are not always available. The selected metrics enable us to retain the largest proportion of our sample.[26] All variables are described in the Appendix.

Our first metric, quarterly bond turnover, is a commonly-used liquidity metric from extant studies on bonds (e.g., Bessembinder, Jacobsen, Maxwell, and Venkataraman, 2018; Oehmke and Zawadowski, 2017). As discussed in this prior literature, this variable gives an issuance size-weighted (by the number of securities outstanding) assessment of the total volume transacted on in the post-issuance period. A higher value of quarterly turnover is indicative of greater market liquidity.

Panel A of Table 6 presents our univariate results comparing quarterly turnover between our matched Green and non-Green securities. The estimates confirm a limited difference in turnover between Green and non-Green securities. The mean (median) difference is -1.3% (-5.6%) in the exact matched sample and these differences are not statistically significant at conventional levels. Moreover, in approximately 17% of cases, this difference is exactly zero,

[26]Note that the difference in sample size is attributable to: (1) the fact that the MSRB transactions data set only runs through June 2018 and (2) some variable creation requires multiple trades on the same day.

while the ratio of positive to negative differentials is approximately one. These findings do not indicate any differences in liquidity between Green and non-Green securities.

We next explore a similar metric based on the total number of trades in the quarter following bond issuance. This has been used in prior literature as a measure of both market liquidity and trading activity (e.g., Schwert, 2017; Mahanti, Nashikkar, Subrahmanyam, Chacko, and Mallik, 2008) for similar reasons to turnover. We again find no statistically significant differential in the number of trades between Green and non-Green securities: the estimated mean (median) differences are also quite small at -1.6 (0.0) trades per quarter. The distribution of these is again roughly split between positive and negative differentials, with a large mass of observations at exactly zero differential.

Finally, we consider the price dispersion metric proposed by Jankowitsch, Nashikkar, and Subrahmanyam (2011) and used in prior literature on the municipal securities market (e.g., Schwert, 2017). This measure offers advantages over traditional measures of bid-ask spreads in that it can be calculated for a significantly larger portion of our matched sample because it only requires two trades in a day rather than a customer buy (ask-price) and customer sell (bid-price). Similar to the results related to trading turnover and number of trades, we see no statistical or economically significant difference in price dispersion between Green and non-Green securities. The distributions are nearly equal between positive and negative differentials with a large mass directly at zero.

The results of this sub-section strongly suggest that there is no liquidity differential between Green and non-Green securities. Combined with our findings in Section 4 that Green bond issues are on average significantly larger than average non-Green deals (which tend to be more liquid securities), liquidity differentials do not appear to be an explanation for our documented lack of a Green bond premium.

6.2. *Differences in Ownership*

The lack of institutional participation has been one of the cited barriers in the municipal Green bond market. For instance, as suggested in Chiang (2018), weak institutional support may be responsible for the illiquidity traditionally associated with Green bond issues which has a number of aforementioned pricing implications. Moreover, since institutional investor ownership has been linked to ESG scores by Dyck, Lins, Roth, and Wagner (2018), large differences in institutional ownership may explain the observed lack of a pricing differential. Specifically, to the extent that institutional investors are the drivers behind ESG scores, they may also be the main drivers behind ESG pricing as well. Therefore, the lack of a Green bond premium that we observe could be due to differentials in institutional ownership, rather than investors innate unwillingness to sacrifice returns to invest in Green securities.

To examine this issue, we construct holdings proxies using the comprehensive MSRB transactions database. For each security, we identify the initial placement of securities by looking at all customer purchases labeled as a primary market transaction.[27] Prior studies (i.e., Chernenko, Hanson, and Sunderam (2016); Manconi, Massa, and Yasuda (2012)) have leveraged the Thomson Reuters eMAXX to identify bond ownership, primarily for taxable securities. Our choice to construct ownership proxies from the MSRB transactions data is twofold. First, the eMAXX Thomson Reuters database is expensive, whereas the MSRB transaction data are free. Second, since reported holdings of individual bonds are not mandatory and only include institutional holdings, the eMAXX database is far from complete. This is particularly problematic for measures of ownership concentration in municipal markets given the large retail investor base whose ownership levels would not be reflected using the eMAXX database.

We construct two ownership measures. Following prior studies (e.g., Green, Hollifield, and Schürhoff, 2007a; Dick-Nielsen, Feldhütter, and Lando, 2012), our first measure is based

[27] We do this by considering all trades labeled with the "price takedown indicator." As described on the MSRB Transaction Data document on WRDS, this variable is "an indicator showing that the transaction price was reported as a primary market sale transaction executed on the first day of trading of a new issue...".

on the idea that institutional (retail) purchases are assigned to be purchases with par volume greater than or equal (less than) to \$100,000. Institutional ownership is defined as total sum of institutional purchases divided by total securities outstanding. Our second measure, following Baker et al. (2018), uses the Herfindahl-Hirschman index (HHI) of ownership concentration which we calculate as:

$$HHI_i = \sum_{k=1}^{N} \frac{P_k}{O_i}$$

where P_k is the total par value of primary market customer purchase k, and O_i is the total par value of bonds outstanding. A larger value of HHI indicates more concentrated ownership levels.

We present the ownership analyses for our matched-pairs in Table 7. In general, we find little difference in institutional ownership. As we see in Panel A, average institutional ownership differences are 0.25% (-0.25%) and statistically insignificant for our sample of exact matches. Similar inferences follow from looking at the difference in means for our full matched sample.

The only test indicating a statistically significant difference between Green and non-Green securities is the Wilcoxon test of differences in medians for the full matched sample. However, differences are only marginally significant at the 10% level, and the estimated differences are also quite small. Overall, we conclude little difference in institutional ownership between Green and non-Green securities from the same issuer.

Baker et al. (2018) also predict that ownership concentration of Green securities should be higher than non-Green securities. Our results in Panel C of Table 7 are inconsistent with this conjecture. Specifically, we find significantly greater differences in ownership for non-Green securities: the mean (median) level of HHI is 0.573 (0.500) for our sample of green-securities, the mean (median) HHI is 0.646 (0.608) for non-Green securities. These differences are statistically significant across all specifications and imply that non-Green securities are around 12% to 20% more concentrated than Green securities.[28]

6.3. *Greenwashing*

Greenwashing – the issuance of securities labeled as Green that lack genuine environmental benefits – is a concern for investors in the Green bonds market (e.g., Grene, 2015). This is mainly attributable to the fact there are no universally agreed-on criteria for what makes a bond "Green." In theory, any municipality can issue a bond under a Green label, so long as it can convince investors it is used for eco-friendly purposes. This type of measurement error is a threat to our inferences, because the lack of pricing differential we document could instead be due to investors' uncertainty about whether the funds generated by the bond issuance would actually be used to benefit for the environment, rather than their unwillingness to give up returns to invest in eco-friendly projects.

To investigate this issue, we explore whether the lack of differences in borrowing costs documented in previous sections are associated with two variables that practitioners suggest are related to greenwashing. First, we consider whether these differences are related to whether the Green issue was used for an economic refunding. Many market participants are divided over whether issuing Green bonds for refundings to finance existing projects is acceptable (e.g., Chiang, 2017; Grene, 2015). It is possible, given approximately 31% of our sample of Green bonds have been used for refunding purposes, that our lack of a documented greenium is being driven by this subset of securities. To the extent that this is true, we would expect there to be a positive relationship between our various cost of borrowing differentials and an indicator for whether the Green security was issued for refunding purposes. This would imply that Green bonds used for refundings exhibit a zero, or even a positive, differential, while our set of non-refunding Green bonds exhibit a negative

[28] While the development of an alternative theoretical foundation for this finding is outside of the scope of this paper, we pose one simple explanation of these findings. It is conceivable that Green securities attracts both the standard investor base that participates in primary municipal offerings, in addition to issuers who would not normally participate (Green-specific investors). Underwriters may allocate these securities equally among participating parties, which leads to a lower HHI.

differential implying a Green bond premium.

Second, as a result of the lack of standardization in this market on what constitutes a Green bond, several third-party certification providers have emerged to allay investors' fears that their funds are being used for non eco-friendly purposes. At a cost (ranging up to $50,000), these services provide verification that bond issues comply with their standards to ensure that the assets and projects of the issue will contribute to a low carbon economy (Saha, 2018). In particular, they typically verify that the funds are used for eligible project types, and that internal processes and controls are in place to ensure the bond proceeds are used accordingly.[29] Among municipal Green bonds, the CBI Climate Certification is the primary certification that municipalities have purchased for these purposes (Chiang, 2017). We identify 15 such deals issued with this certification in our sample of Green securities. Because of the rigorous standards these securities must meet to qualify for the certification, there should be little doubt among investors on whether their funds are used for Green purposes. These certified securities are precisely the the cases where we would expect to see a negative relationship (if it exists) between the cost of borrowing differentials.

To examine the impact of certification, we regress each cost of borrowing differential on indicators of whether the bond was used for the purposes of refunding or obtained the CBI Climate Certification. We present the results of these tests in Table 8, and two interesting patterns emerge. First, there appears to be a positive association between cost of borrowing differentials and whether the proceeds of the Green issuance were used for refunding purposes. However, the economic significance of this result is again extremely small. For instance, in the case of exact matches in Columns 4 and 5, the coefficients indicate that yield and spread differentials are less than 0.5% of our sample averages. Moreover, we observe that 76% of the economic refundings in our sample show differential of exactly zero. Therefore, we conclude that there is to be little economic relation between the cost of borrowing differentials and whether the Green security was used for a refunding.

[29] For instance, see `https://www.climatebonds.net/certification`.

Our second finding is that, in our sub-sample of matched securities, the CBI Climate Certification appears to have a statistically positive association with yield differentials. Nevertheless, these estimates (approximately 0.7 bps) are very small relative to the average yields (spreads) of approximately 224 (25) basis points in our matched sample. Moreover, of the 56 CBI Climate Certification securities in our matched sample, 91% of them have identical yields to their non-Green counterparts.Therefore we conclude that CBI Climate Certification appears to make little substantive difference in Green bond pricing. It also appears to make no statistical difference in what investment banks charge to underwrite the securities. Importantly, since third-party certification is costly, our results suggest that CBI Climate Certification is welfare decreasing for municipalities.

The results in this section suggest that greenwashing is an unlikely explanation for our documented lack of a Green bond premium. There appears to be little economic relationship between our between cost of borrowing differentials and two variables that have traditionally been associated with greenwashing, namely third-party Green certification and the uses of proceeds for refinancing purposes. Any relationship we do find is either economically small, or in the opposite direction to what would predicted by greenwashing.[30]

7. Summary and Concluding Remarks

This paper examines whether investors are willing to forgo pecuniary benefits to invest in environmentally friendly projects. Using a matched sample of nearly identical Green and non-Green municipal securities, we find little evidence of a pricing differential between Green and non-Green assets. This pattern is robust to perceived differences in liquidity or institutional ownership. We also show that our findings are inconsistent with this being related to "greenwashing." Overall, our results strongly suggest that U.S. municipal investors are entirely unwilling to sacrifice returns to invest in Green securities.

[30] In addition, these relationships appear to be largely driven by a handful of outliers (as we explored in Appendix B).

In considering whether our results might apply to corporate securities, it is important to understand that the municipal securities market is institutionally quite different than others securities markets. Specifically, the municipal market is heavily dominated by U.S. based retail investors. A Green premium may exist in markets with higher levels of institutional ownership a premium might arise, consistent with Dyck et al. (2018) who reported an association between country institutional equity holdings and firm level ESG scores.

While possible, we view this conjecture as unlikely given the high levels of institutional ownership that we see in our sample of matched securities. Moreover, there are also a number of reasons to believe that the municipal securities market might be a setting where we would be *most* likely to find a pricing differential between Green and non-Green assets. For instance, while not traditionally modeled in prior papers on asset pricing with non-pecuniary benefits (e.g., Heinkel and Kraus, 2001), the existence of arbitragers could collapse any pricing differential between these securities in secondary markets given the identical cash flows. However, the inability to take short positions in the municipal market prevent this type of arbitrage, which would preserve any Green pricing differential (Duyne and Bullock, 2011).

In addition, because municipals are generally held by high net-worth individuals who are neither financially constrained nor competing for asset flows, they may be investors with some of the most latitude to sacrifice returns to invest in Green projects. This is consistent with prior findings that less financially-constrained firms spend more on corporate socially responsible activities (Hong, Kubik, and Scheinkman, 2012), and that socially responsible investing appears to be a luxury good (Bansal, Wu, and Rayon, 2018). Recent work by *Standard and Poors* also suggests that the projects backed by Green municipal securities exhibit, on average, higher environmental benefit than the general universe of Green bonds (S&P Global Ratings, 2018). If investors wish to benefit the environment through their purchase of Green securities, the municipal securities in our sample are prime candidates for acquisition by these investors. Thus, our sample should have the power to uncover a greenium if it really exists in the market. Overall, the greenium appears to be essentially equal to zero.

Appendix A. Variable Definitions

Variable	Description	Data Source
Aggregate Rating	The median long-term rating assigned by Fitch, Moodys and S&P at issuance. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent
Callable	An indicator which takes the value of one if the bond contains an embedded call option.	Mergent
CBI Climate Bond Certified	An indicator variable which takes a value of one if the bond was issued with the Climate Bond Initative's climate bond certification.	Mergent
Coupon	The coupon rate of the bond (measured in %).	Mergent
Deal Size ($ MM)	The total dollar amount outstanding of all securities issued as part of the same deal of the bond.	Mergent
Fitch LT Rating	The long-term rating of the security assigned by Fitch at the date of issuance. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent
Green Bond	An indicator variable which takes a value of one if the bond was issued as a self-labeled green bond.	Bloomberg, Mergent
Herfindahl-Hirschman Index (HHI)	Calculated as: $HHI_i = \sum_{k=1}^{N} \frac{P_k}{O_i}$ where P_k is the total par value of primary market customer purchase k, and O_i is the total number of bonds outstanding.	MSRB
Initial Offering Spread ($Spread$)	This is calculated as the initial offering yield less the matched benchmark maturity yield derived from the Municipal Market Advisors (MMA) 5% AAA G.O. benchmark yield.	Mergent, Bloomberg
Initial Offering Yield ($Yield$)	Yield to maturity at the time of issuance, based on the coupon and any discount or premium to par value.	Mergent
Institutional Ownership	Defined as total sum of institutional primary market purchases (those greater than or equal to $100,000) divided by total securities outstanding.	MSRB

Variable	Description	Data Source
Issue Amount ($ MM)	The total dollar amount outstanding of the bond at issuance.	Mergent
Large Issuer	An indicator variable which takes the value of one if the issuer is in the upper quartile of total issuance in the Mergent database.	Mergent
Moodys LT Rating	The long-term rating of the security assigned by Moodys at the date of issuance. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent
Number of Trades	Caculated as the total number of trades over the quarter (90-days) after issuance.	MSRB
Offering Year X	An indicator which takes the value of one if the bonds issuance date is in the year X.	Mergent
Placebo Bond	An indicator variable which takes a value of one if the bond is a non-green security from our matched sample.	Bloomberg, Mergent
Price Dispersion	Jankowitsch et al. (2011) propose a measure of transaction costs based on the dispersion of traded prices around the market consensus valuation. For each day, we calculate daily price dispersion following Schwert (2017). Quarterly estimates of the price dispersion measure are obtained by taking the mean of the daily estimates over the quarter (90-days) after the initial bond issuance.	MSRB
Refunding	An indicator variable which takes a value of one if the bond was issued for the purposes of refinancing outstanding debt.	Mergent
S&P LT Rating	The long-term rating of the security assigned by Standard and Poors at the date of issuance. Converted to a numerical scale from 1 (highest rated) to 22 (lowest rated or unrated).	Mergent
Turnover	Calculated as the total sum of par value trades over the quarter (90-days) after issuance divided by the total issuance amount.	MSRB
Underwriters Discount (*Takedown*)	The fee paid to the investment bank for selling the bonds. Calculated as a % of par.	Bloomberg
Years to Call	Years to the first call date at issuance.	Mergent
Years to Maturity	Years to the maturity date at issuance.	Mergent

Appendix B. Discussion of Outliers

As shown in Figure 3, the small positive yield differential (implying a Green bond discount) that we estimate in Section 5 appears to be driven by small number of unusual observations or outliers. In the Table B-1, we report the matched pairs associated with the largest *absolute* deviations in spread and yield in our sample. Specifically, we report all matched pairs in which the deviation in spread differentials is in the upper 5% of all absolute spread differences – the very right and left tails of Panels A and B of Figure 3.

The matching procedure used to construct the primary sample in this paper selected Green and non-Green issues matched on issuer, issuance day, maturity, and whether the bond was issued with an embedded option. Coupons are allowed to differ so long as this does not affect the option adjusted yield of the security, as investors should generally be indifferent so long as the yield is the same. Similarly, issuance size has been allowed to differ given prior evidence that bond pricing is generally unaffected by it (Crabbe and Turner, 1995).

While these structural differences generally do not affect pricing, both anecdotal evidence and prior research suggest they *can* affect pricing. For instance, there may be outsized demand for specific coupons by particular investors (e.g., Albano, 2016). Extreme differences in issuance size can change the index eligibility of a bond issue (Barclays, 2017), which can have significant effects on pricing (e.g., Chen, Lookman, Schürhoff, and Seppi, 2014). Alternatively, underwriters may structure some portion of a deal for retail investors who are generally less price sensitive than institutional investors (e.g., Green, Li, and Schürhoff, 2010).

Consistent with the above, we see in Table B-1 that, for each matched set where we observe the largest pricing differentials, we also observe *significant* structural differences across issuance size and/or coupon structure. We forgo an in-depth discussion of each outlier, but as a salient example consider the first outlier reported. The Green bond is a New York State Housing Authority $25.15 million bond issued at par with a 1.65% coupon; the matched non-Green bond is a $60 thousand bond issued at par with a 1.4% coupon. Considering the frequency in which we observe a zero yield differential between Green and non-Green matched securities, we find it highly unlikely that the securities Green label would drive this Green bond discount. We asked several industry professionals about this anomaly, and they indicated that the more likely explanation for this aberrant behavior is that the underwriter was able to allocate a significantly smaller tranche of securities to price-insensitive retail investors.

Once we remove unusual observations, the average mean (median) yield differential is 0.01 (0.00) basis points, while the mean (median) spread differential is 0.00 (0.00) basis points. The yield (spread) differentials are exactly zero in 88% (88%) of cases with occurrences of positive and negative equally split at 6%.

Table B-1
Outliers

$Cusip_g$	$Cusip_c$	$Size\ Diff(\%)$	$Cpn.\ Diff(\%)$	$CBI\ Cert.$	$Spread\ Diff.(bps)$
64987B3G1	64987B3N6	49.762	4.098	0.000	25.000
64987B3H9	64987B3N6	49.641	4.098	0.000	25.000
64987DNA8	64987DNK6	48.026	2.381	1.000	20.000
64987DNB6	64987DNK6	49.063	2.381	1.000	20.000
64987DNC4	64987DNK6	49.347	2.381	1.000	20.000
64987DJF2	64987DKJ2	49.577	1.579	0.000	15.000
64987DFV1	64987DHC1	49.245	1.899	1.000	15.000
64987DGA6	64987DHF4	49.631	1.648	1.000	15.000
64987DJD7	64987DKH6	49.864	1.648	0.000	15.000
64987BM54	64987BN46	46.699	2.239	0.000	15.000
64987BL71	64987BN20	34.793	1.724	0.000	10.000
79768HCQ9	79768HDL9	28.023	0.000	0.000	10.000
93974DQH4	93974DSC3	27.689	12.500	0.000	9.000
93974DQH4	93974DQW1	31.609	12.500	0.000	7.000
93974DQK7	93974DSE9	44.709	16.667	0.000	6.000
645791V92	6457912D5	34.514	5.556	0.000	6.000
645791V92	645791Z49	31.931	5.556	0.000	6.000
93974DQJ0	93974DSD1	30.909	5.556	0.000	6.000
645791V76	6457912B9	34.527	0.000	0.000	5.000
645791V84	6457912C7	34.388	5.556	0.000	5.000
645791W26	6457912E3	34.013	5.556	0.000	5.000
645791V50	645791Y81	35.869	0.000	0.000	5.000
645791V76	645791Z23	35.326	0.000	0.000	5.000
645791V84	645791Z31	32.565	5.556	0.000	5.000
645791W26	645791Z56	31.030	2.941	0.000	5.000
645791V50	645791Z98	34.530	0.000	0.000	5.000
93974DQG6	93974DQV3	6.163	21.429	0.000	5.000
93974DQJ0	93974DQX9	13.993	5.556	0.000	5.000
93974DQK7	93974DQY7	36.535	16.667	0.000	5.000
645791H31	645791K60	45.298	0.000	0.000	-5.000
64987BL89	64987BN46	15.083	0.794	0.000	-5.000
64987BL71	64987BQ50	37.990	0.820	0.000	-5.000
357172YZ2	357172XZ3	28.023	0.000	0.000	-6.000

This table reports presents all matches with spread differentials in the top 5% of our matched sample described in Section 4. We report the associated Green and non-Green CUSIPS ($Cusip_g$ and $Cusip_c$), percentage difference in the maturity size ($Size\ Diff$), percentage differentials in the coupon ($Cpn.\ Diff$), whether the security attained the CBI Climate Certification ($CBI\ Cert.$) and the spread differential ($Spread\ Diff.$).

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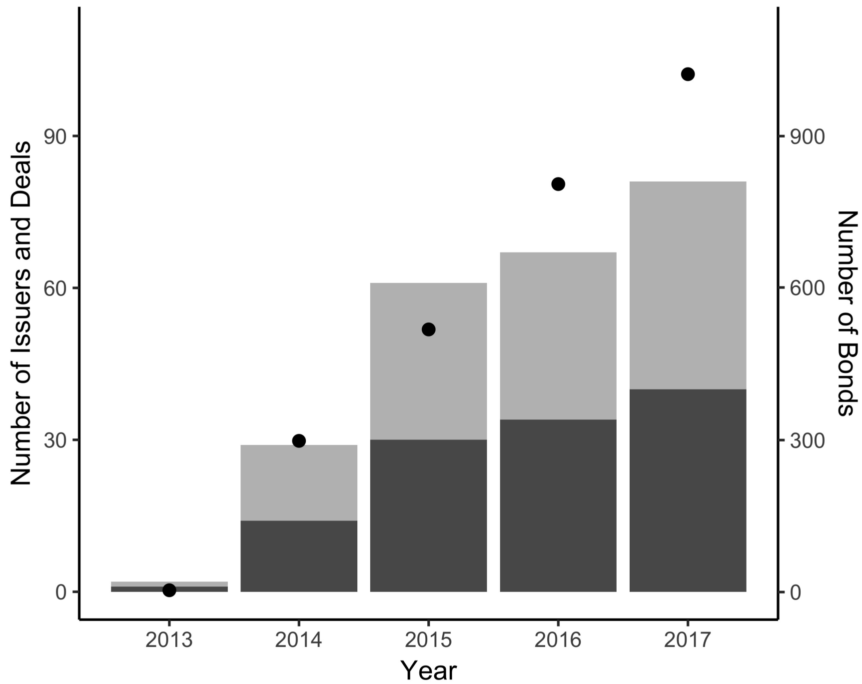
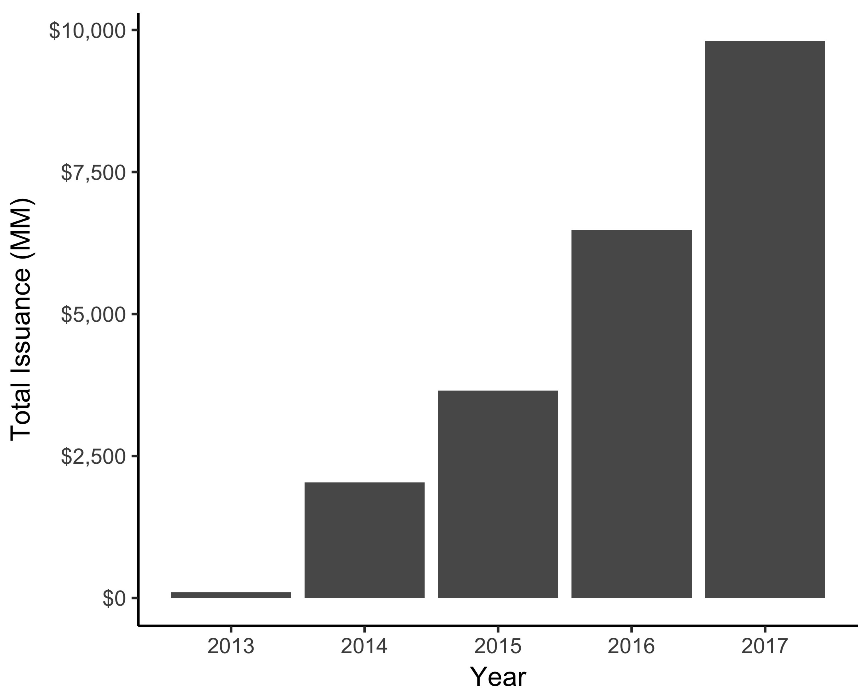


(a) Growth in Issuers, Deals and Bonds



(b) Growth in Total Dollar Issuance

Fig. 1 Trends in municipal Green bond issuance. Panel (a) presents total annual municipal tax-exempt, fixed-rated Green bond issuance statistics on the number of issuers (dark grey bar; left-axis), number of individual deals (dark grey + light grey bars; left-axis), and number of individual bonds (black dots; right-axis). Panel (b) presents total tax-exempt, fixed-rated issuance volume (by par value) of self-labeled Green bond issues by year.

OFFICIAL STATEMENT

NEW ISSUE – BOOK–ENTRY–ONLY **RATINGS: See "Ratings" Herein**

In the opinion of Ballard Spahr LLP, Phoenix, Arizona, Bond Counsel, interest on the Tax-Exempt Series 2015 Bonds is excludable from gross income for Federal income tax purposes, assuming continuing compliance by the Arizona Board of Regents and Arizona State University with the requirements of Federal tax laws. Interest on the Tax-Exempt Series 2015 Bonds is not a preference item for either individual or corporate Federal alternative minimum tax purposes; however, interest paid to corporate holders of the Tax-Exempt Series 2015 Bonds may be indirectly subject to alternative minimum tax under the circumstances described in "TAX MATTERS" herein. Interest on the Taxable Series 2015C Bonds is taxable as ordinary income for Federal income tax purposes. Interest on the Series 2015 Bonds is exempt from taxable income for State of Arizona income tax purposes. See "TAX MATTERS" herein.

ARIZONA BOARD OF REGENTS
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$182,645,000 SYSTEM REVENUE AND REFUNDING BONDS, SERIES 2015A (GREEN BONDS)	**$164,615,000 SYSTEM REVENUE AND REFUNDING BONDS, SERIES 2015B**	**$15,000,000 SYSTEM REVENUE BONDS, TAXABLE SERIES 2015C**

Dated: Date of Delivery **Due: July 1, as shown on the inside front cover page**

(a) Green and non-Green Issuance on the Same Day

$182,645,000
SYSTEM REVENUE AND REFUNDING BONDS,
SERIES 2015A
(GREEN BONDS)

Maturity (July 1)	Principal Amount	Interest Rate	Yield	CUSIP[a] (04048R)	Maturity (July 1)	Principal Amount	Interest Rate	Yield	CUSIP[a] (04048R)
2015	$1,610,000	2.00%	0.10%	KW5	2027	$12,850,000	5.00%	2.70%[b]	LF1
					2028	14,460,000	5.00	2.83[b]	LG9
2019	25,000	2.00	1.32	KX3	2029	3,305,000	5.00	2.91[b]	LH7
2020	7,345,000	5.00	1.58	KY1	2030	3,475,000	5.00	2.97[b]	LJ3
2021	8,100,000	5.00	1.74	KZ8	2031	3,645,000	5.00	3.02[b]	LK0
2022	10,065,000	5.00	2.00	LA2	2032	3,835,000	5.00	3.07[b]	LL8
2023	10,565,000	5.00	2.16	LB0	2033	4,025,000	5.00	3.11[b]	LM6
2024	11,105,000	5.00	2.34	LC8	2034	4,230,000	5.00	3.15[b]	LN4
2025	11,655,000	5.00	2.44	LD6	2035	4,435,000	5.00	3.19[b]	LP9
2026	12,230,000	5.00	2.59[b]	LE4	2036	4,655,000	5.00	3.22[b]	LQ7

$22,670,000 5.00% Term Bond due July 1, 2041 at a yield of 3.31%[b] CUSIP[a]: 04048RLR5

$28,360,000 4.00% Term Bond due July 1, 2046 at a yield of 3.80%[b] CUSIP[a]: 04048RLS3

$164,615,000
SYSTEM REVENUE AND REFUNDING BONDS,
SERIES 2015B

Maturity (July 1)	Principal Amount	Interest Rate	Yield	CUSIP[a] (04048R)	Maturity (July 1)	Principal Amount	Interest Rate	Yield	CUSIP[a] (04048R)
2015	$1,405,000	2.00%	0.10%	LT1	2026	11,640,000	5.00%	2.59%[b]	MB9
2016	185,000	3.00	0.40	MQ6	2027	9,545,000	5.00	2.70[b]	MC7
2017	220,000	3.00	0.75	MR4	2028	4,745,000	5.00	2.83[b]	MD5
2018	250,000	3.00	1.13	MS2	2029	4,930,000	5.00	2.91[b]	ME3
2019	8,475,000	5.00	1.32	LU8	2030	5,195,000	5.00	2.97[b]	MF0
2020	9,790,000	5.00	1.58	LV6	2031	5,505,000	5.00	3.02[b]	MG8
2021	11,515,000	5.00	1.74	LW4	2032	5,815,000	5.00	3.07[b]	MH6
2022	7,080,000	5.00	2.00	LX2	2033	6,140,000	5.00	3.11[b]	MJ2
2023	7,475,000	5.00	2.16	LY0	2034	6,485,000	5.00	3.15[b]	MK9
2024	7,860,000	5.00	2.34	LZ7	2035	6,830,000	5.00	3.19[b]	ML7
2025	8,305,000	5.00	2.44	MA1	2036	2,985,000	5.00	3.22[b]	MM5

$14,320,000 5.00% Term Bond due July 1, 2041 at a yield of 3.31%[b] CUSIP[a]: 04048RMN3

$17,920,000 4.00% Term Bond due July 1, 2046 at a yield of 3.80%[b] CUSIP[a]: 04048RMP8

(b) Example of an "Exact Match"

Fig. 2 Methodological Illustration. This figure presents an illustration of the matching procedure used in this study. Panel (a) presents the header of the official statement showing a Green and non-Green tranche of securities from the same issuer simultaneously being priced on the same day. Panel (b) presents the pricing for the securities in both the Green and non-Green issues, with the red outlines highlighting one example of a matched set in our sample.

Table 1
Sample Construction

Panel A: Sample Construction

	Bonds	Deals	Issuers	Matches
Full Bloomberg Green bond sample	4321	575	261	
Remove adjustable rate and tender offer bond issues	4200	553	257	
Drop issues dated before June 2013	3694	359	161	
Remove federally taxable securities	3142	257	107	
Mergent match	3097	248	104	
Drop bonds labeled as non-Green by Mergent	2896	226	90	
Total matches	568	78	30	640
Same issuer/rating/structure/issuance day match	555	72	28	627
Same issuer, rating and issuance day match	13	22	10	13

Panel B: Bond Characteristics (Matched Green Sample)

	Mean	SD	$p^{1\%}$	$p^{25\%}$	$p^{50\%}$	$p^{75\%}$	$p^{99\%}$	N
Issue Amount ($MM)	5.355	10.054	0.067	0.429	2.127	4.709	50.552	640
Coupon Rate (%)	3.903	1.204	1.400	3.000	4.000	5.000	5.000	640
Yield (bps)	224.196	74.948	62.000	173.750	223.000	278.000	400.000	640
Price (% Par)	111.406	9.857	98.676	100.000	113.402	120.287	128.701	640
Issuance Spread (bps)	25.010	26.063	-33.610	5.500	23.500	43.000	92.000	640
Underwriter Discount (%)	0.418	0.219	0.087	0.234	0.393	0.545	1.203	629
Turnover	0.919	1.241	0.000	0.000	0.427	1.328	6.019	627

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

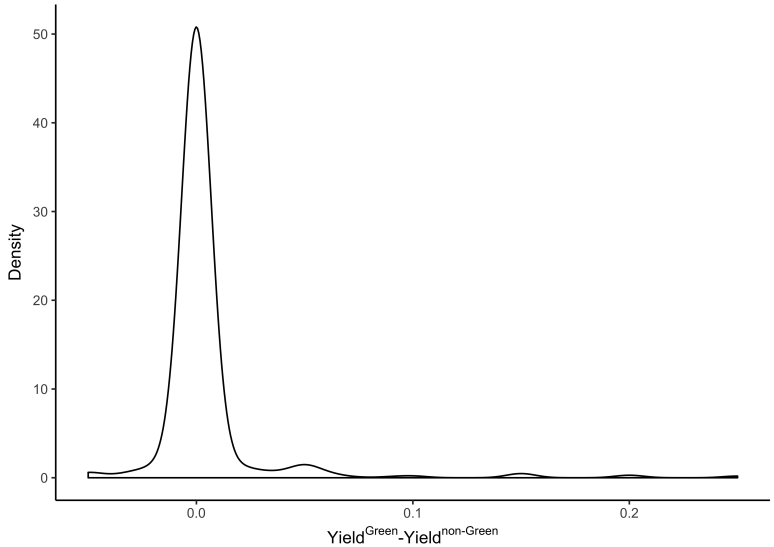
	Mean	SD	$p^{1\%}$	$p^{25\%}$	$p^{50\%}$	$p^{75\%}$	$p^{99\%}$	N
Issue Amount ($MM)	5.645	10.868	0.062	0.629	2.345	5.836	40.511	640
Coupon Rate (%)	4.063	1.197	1.400	3.000	5.000	5.000	5.000	640
Yield (bps)	223.760	75.261	62.000	172.750	223.500	277.250	400.000	640
Price (% Par)	112.418	9.985	99.479	100.000	115.545	121.216	129.062	640
Issuance Spread (bps)	24.569	26.107	-33.610	6.000	23.000	43.000	92.000	640
Underwriter Discount (%)	0.366	0.199	0.086	0.175	0.373	0.533	0.951	601
Turnover	0.975	1.351	0.000	0.000	0.500	1.395	5.438	627

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. See Section 4 for a description all steps used in the sample construction. 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.

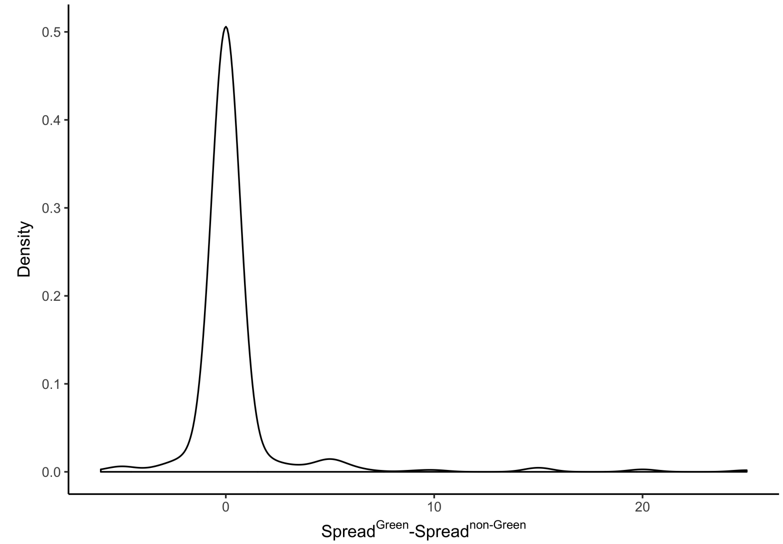
Table 2
Sample Characteristic Comparisons

Variable	Full GB (1)	Matched GB (2)	Mergent (3)	(1)-(2)	(1)-(3)
Aggregate Rating	2.492	2.622	3.620	-0.13*	-1.128***
CBI Climate Certification	0.097	0.088	0.000	0.01	0.097***
Large Issuer	0.732	0.966	0.213	-0.234***	0.518***
Offering Year 2013	0.001	0.000	0.104	0.001·	-0.103***
Offering Year 2014	0.103	0.084	0.179	0.019	-0.076***
Offering Year 2015	0.179	0.183	0.216	-0.004	-0.037***
Offering Year 2016	0.278	0.195	0.228	0.083***	0.05***
Offering Year 2017	0.353	0.406	0.194	-0.053*	0.159***
Offering Year 2018	0.086	0.131	0.078	-0.045**	0.008
Issuance Yield	2.304	2.242	2.250	0.062·	0.054***
Callable	0.547	0.445	0.460	0.101***	0.087***
Fitch LT Rating	2.086	1.797	3.135	0.289***	-1.049***
Moodys LT Rating	2.429	2.827	3.499	-0.399***	-1.07***
S&P LT Rating	2.342	2.387	3.550	-0.045	-1.208***
Refunding	0.313	0.300	0.507	0.013	-0.194***
Issue Amount ($ MM)	8.051	5.355	2.925	2.696***	5.126***
Deal Size ($ MM)	156.128	107.557	43.673	48.571***	112.454***
Years to Maturity	12.011	10.829	9.564	1.182***	2.447***
N	2,896	640	652,391		

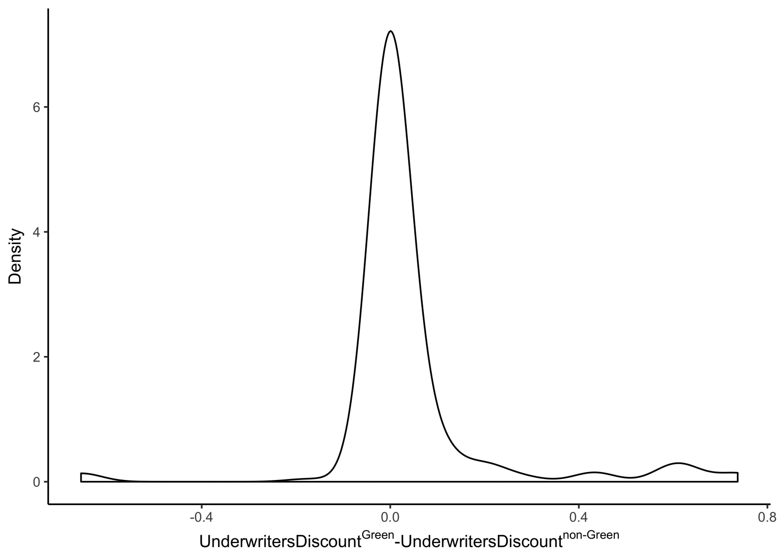
This table presents average sample characteristics of the full Green bond sample (Full GB), matched Green bond sample described in Section 4 (Matched GB) and the universe of non-Green issues (Mergent) as described in Section 4. All measures are as defined in the Appendix and measured in basis points. The differences in sample average between samples is calculated using a standard two-sided t-test. Levels of significance are presented as follows: p<0.1*; p<0.05**; p<0.01***.



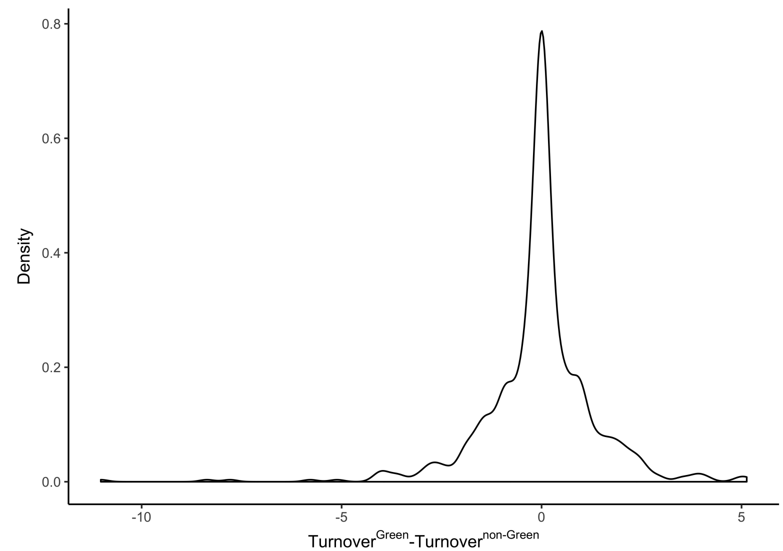
(a) Issuance Yields



(b) Spread



(c) Underwriters Discount (%)



(d) Secondary Market Acitivity

Fig. 3 Kernel density estimates for Green and non-Green differentials. These figures provide the estimated kernel densities for the yield, spread, underwriters discounts and total quarterly turnover differentials for the matched sets described in Section 4. Each plot uses a Gaussian kernel and the Silverman rule for bandwidth selection.

Table 3
Matched Sets Tests for a Relationship between Green-label and Costs of Borrowing

Panel A: Initial Offering Yields

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	222.874	222.000	224.196	223.000
Non-Green	222.415	221.000	223.760	223.500
Difference	0.459	1.000	0.436	-0.500
Statistic	4.217	-3.784	3.797	-3.421
(p-value)	(< .01***)	(< .01***)	(< .01***)	(< .01***)
Total Matches	627		640	
% Matches Zero Difference	84.848		83.438	
% Matches Neg. Difference	5.742		6.406	
% Matches Pos. Difference	9.410		10.156	

Panel B: Initial Offering Spreads

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	24.929	23.500	25.010	23.500
Non-Green	24.470	23.000	24.569	23.000
Difference	0.459	0.500	0.441	0.500
Statistic	4.217	-3.827	4.101	-3.499
(p-value)	(< .01***)	(< .01***)	(< .01***)	(< .01***)
Total Matches	627		640	
% Matches Zero Difference	84.848		83.594	
% Matches Neg. Difference	5.742		6.250	
% Matches Pos. Difference	9.410		10.156	

Panel C: Underwriters Discount

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	41.087	38.600	40.957	38.600
Non-Green	36.623	37.300	36.591	37.300
Difference	4.465	1.300	4.366	1.300
Statistic	6.060	-6.928	6.025	-6.852
(p-value)	(< .01***)	(< .01***)	(< .01***)	(< .01***)
Total Matches	590		601	
% Matches Zero Difference	67.627		67.72	
% Matches Neg. Difference	9.492		9.651	
% Matches Pos. Difference	22.881		22.629	

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. Green bonds are assigned to a matched (exact matched) set if they are issued on the same day, have a maturity date within one-year (same maturity date) of a non-Green bond, the same rating and are issued by the same issuer. 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).

Table 4
Nearest Neighbors Matching Tests

Panel A: Covariate Balance

	Orig. Sample	Same Month Match	Same Week Match	Same Issuer-Day Match
Aggregate Rating	-1.120	-0.201	-0.148	0.000
Years to Maturity	2.150	-0.156	-0.044	-0.051
Years to Call	1.076	0.045	-0.119	-0.071
Coupon	0.638	-0.125	-0.080	-0.127
Large Issuer	0.504	0.000	0.000	0.000
Callable	0.083	0.000	0.000	0.000

Panel B: Intial Offering Yields

	Same Month		**Same Week**		**Same Issuer-Day**	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**
Green	221.508	225	222.426	225.000	228.424	229.000
Non-Green	225.246	228.000	225.832	226.000	228.409	229.000
Difference	-3.738	-3.000	-3.406	-1.000	0.015	0
Statistic	-1.264	-0.624	-0.926	0.044	0.004	2.140
(p-value)	(0.206)	(0.266)	(0.355)	(0.518)	(0.997)	(0.984)
Green Bonds	1685		1035		680	
Green Deals	167		147		88	
Green Issuers	75		66		38	

Panel C: Intial Offering Spreads

	Same Month		**Same Week**		**Same Issuer-Day**	
	Mean	**Median**	**Mean**	**Median**	**Mean**	**Median**
Green	26.405	24	26.381	24.000	26.980	26.000
Non-Green	27.598	23.000	28.047	24.000	25.983	23.000
Difference	-1.194	1	-1.666	0.000	0.997	3.000
Statistic	-1.231	-0.336	-1.351	-1.029	0.699	-0.110
(p-value)	(0.218)	(0.368)	(0.177)	(0.152)	(0.484)	(0.456)
Green Bonds	1685		1035		680	
Green Deals	167		147		88	
Green Issuers	75		66		38	

This table presents nearest neighbors matched samples tests of the pricing differentials of Green and non-Green securities. Panel A presents differences in means between Green and non-Green securities for select matching covariates across the original sample, and our three matched samples. As described in in Section 5.3, the "Same Month" ("Same Week") sample is constructed by finding a nearest neighbors (NN) match for each Green bond without replacement based on: issue month (issue week), state, issuer size, callability, years to maturity and call, rating, and coupon. The "Same Issuer-Day" matched sample is similarly constructed matching on: issuer (exact), offering date (exact), callability, years to call and maturity, and coupon. In Panel B and C, for each matched set, the differences in mean (median) issuance yields and spreads between Green and non-Green securities are calculated using a standard two-sided t-test (Wilcoxon test).

Table 5
Estimating Green Bond Premiums with Fixed Effect Regressions

Panel A: All Green Bonds

	Dependent variable:					
	Offering Yield					
	2010-2016			Full Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond	−11.035	−6.975	−5.587	−11.846	−8.780	−5.464
	(−4.151)***	(−4.447)***	(−1.669)*	(−5.079)***	(−5.140)***	(−2.567)**
CBI Climate Certified	−15.517	−14.778	−12.384	−6.399	−8.115	−2.243
	(−3.506)***	(−5.270)***	(−2.918)***	(−1.785)*	(−2.245)**	(−0.706)
Rating FEs	Yes	No	No	Yes	No	No
Maturity FEs	Yes	No	No	Yes	No	No
Month FEs	Yes	No	No	Yes	No	No
Month × Maturity × Rating FEs	No	Yes	Yes	No	Yes	Yes
Issuer FEs	No	No	Yes	No	No	Yes
Observations	784,225	784,225	784,225	939,850	939,850	939,850
Adjusted R^2	0.894	0.932	0.928	0.880	0.931	0.960

Panel B: Matched Green Bonds

	Dependent variable:					
	Offering Yield					
	2010-2016			Full Sample		
	(1)	(2)	(3)	(4)	(5)	(6)
Green Bond	−15.346	−11.807	−9.442	−17.326	−15.509	−4.845
	(−2.828)***	(−2.764)***	(−2.095)**	(−3.200)***	(−4.024)***	(−2.247)**
Placebo Bond	−15.089	−12.095	−9.141	−17.566	−16.029	−5.288
	(−2.683)***	(−2.779)***	(−1.979)**	(−3.199)***	(−4.151)***	(−2.453)**
Rating FEs	Yes	No	No	Yes	No	No
Maturity FEs	Yes	No	No	Yes	No	No
Month FEs	Yes	No	No	Yes	No	No
Month × Maturity × Rating FEs	No	Yes	Yes	No	Yes	Yes
Issuer FEs	No	No	Yes	No	No	Yes
Observations	782,863	782,863	782,863	937,536	937,536	937,536
Adjusted R^2	0.894	0.932	0.928	0.881	0.931	0.960

This table presents regressions of bond yields at issue on Green bond indicators and other bond characteristic fixed effects. Panel A presents estimates using the full sample of Green bonds, and Panel B presents estimates using just the sample with matching non-Green bonds as described in Section 4. *Green Bond* is an indicator if the bond is a marketed Green bond, *CBI Climate Certified* an indicator if the Green bond obtained the CBI climate certification, and *Placebo Bond* an indicator if it is a non-Green bond from a Green issuer in our matched sample. All specifications include fixed effects for use of proceeds, insurance, AMT, bank qualified, new money, and issuer size. Two-way cluster robust t-statistics, by issuer and offering month, are included in parentheses. Levels of significance are presented as follows: $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$.

Table 6
Matched Sets Tests for a Relationship between Green-label and After-Issuance Liquidity

Panel A: Turnover

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	0.92	0.418	0.919	0.427
Non-Green	0.980	0.500	0.975	0.500
Difference	-0.059	-0.083	-0.056	-0.073
Statistic	-1.042	0.268	-0.995	0.632
(p-value)	(0.298)	(0.606)	(0.320)	(0.736)
Total Matches	614		627	
% Matches Zero Difference	15.798		15.470	
% Matches Neg. Difference	42.020		41.946	
% Matches Pos. Difference	42.182		42.584	

Panel B: Number of Trades

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	10.700	3.000	10.879	3
Non-Green	11.292	3.000	11.453	3.000
Difference	-0.591	0.000	-0.574	0.000
Statistic	-0.552	-0.534	-0.543	-0.406
(p-value)	(0.581)	(0.297)	(0.588)	(0.343)
Total Matches	614		627	
% Matches Zero Difference	19.544		19.139	
% Matches Neg. Difference	37.459		37.959	
% Matches Pos. Difference	42.997		42.903	

Panel C: Price Dispersion

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	0.209	0.124	0.211	0.125
Non-Green	0.216	0.100	0.219	0.109
Difference	-0.007	0.024	-0.008	0.016
Statistic	-0.478	1.634	-0.516	1.951
(p-value)	(0.633)	(0.949)	(0.606)	(0.974)
Total Matches	274		280	
% Matches Zero Difference	12.044		11.786	
% Matches Neg. Difference	41.241		41.429	
% Matches Pos. Difference	46.715		46.786	

This table presents matched sample tests on the issuance cost differentials between Green and non-Green securities. All measures are as defined in the Appendix. Green bonds are assigned to a matched (exact matched) set if they are issued on the same day, have a maturity date within one-year (same maturity date) of a non-Green bond, and are issued by the same issuer. 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).

Table 7

Matched Sets Tests for a Relationship between Green-label and Ownership Structures

Panel A: Institutional Ownership

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	76.310	97.974	76.846	98.253
Non-Green	76.566	100.000	77.179	100.000
Difference	-0.256	-2.026	-0.333	-1.747
Statistic	-0.148	-1.155	-0.198	-1.297
(p-value)	(0.882)	(0.124)	(0.843)	(0.097)*
Total Matches	458		471	
% Matches Zero Difference	39.738		39.915	
% Matches Neg. Difference	35.590		35.456	
% Matches Pos. Difference	24.672		24.628	

Panel B: Herfindahl-Hirschman Index

	Exact Matches		All Matches	
	Mean	**Median**	**Mean**	**Median**
Green	0.573	0.500	0.571	0.500
Non-Green	0.646	0.608	0.641	0.594
Difference	-0.073	-0.108	-0.070	-0.094
Statistic	-4.002	-3.718	-3.895	-3.582
(p-value)	(< .01***)	(< .01***)	(< .01***)	(< .01***)
Total Matches	458		471	
% Matches Zero Difference	15.284		14.862	
% Matches Neg. Difference	50.000		49.682	
% Matches Pos. Difference	34.716		35.456	

This table presents matched sample tests on the ownership differentials between Green and non-Green securities. All measures are as defined in the Appendix. Green bonds are assigned to a matched (exact matched) set if they are issued on the same day, have a maturity date within one-year (same maturity date) of a non-Green bond, and are issued by the same issuer. 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).

Table 8

Determinants on Differences in Issuance Cost Premiums: Evidence of Greenwashing

	Dependent variable:					
	All Matches			Exact Matches		
	Yield	*Spread*	*Takedown*	*Yield*	*Spread*	*Takedown*
	(1)	(2)	(3)	(4)	(5)	(6)
CBI Climate Certified	0.711	0.711	0.000	0.702	0.702	0.000
	(10.043)***	(10.043)***	(0.000)	(10.341)***	(10.341)***	(0.000)
Refunding	0.351	0.194	0.009	0.085	0.085	0.008
	(1.741)*	(2.754)***	(0.236)	(3.109)***	(3.109)***	(0.184)
Use of Proceeds FEs	Yes	Yes	Yes	Yes	Yes	Yes
Observations	640	640	601	627	627	590
Adjusted R^2	0.030	0.027	0.347	0.024	0.024	0.351

This table reports determinants of the differences in borrowing costs of Green and non-Green matched bond pairs discussed in Section 4. Each dependent variable, described in the appendix, is regressed on various characteristics of the Green bond, as well as differences between Green and non-Green bonds for each matched pair. Regressions are run using the full sample of matches (All Matches), as well as exact matches with the same maturity (Exact Matches) described in Section 4. Two-way cluster robust t-statistics, by issuer and offering month, are included in parentheses. Levels of significance are presented as follows: *p<0.1; **p<0.05; ***p<0.01.