Financial Innovation, Investor ESG Preferences, and the Cost of Public Financing*

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November 18, 2024

Abstract

We study green and non-green bond issuance and pricing dynamics using a novel measurement of bond level ESG characteristics in the municipal market. Using a dynamic difference-in-differences approach, we provide new evidence that investors are willing to pay more (i.e., a *greenium*) for securities with verified underlying ESG characteristics, even for securities without an explicit ESG label from the issuer. Bonds that do not qualify for ESG labels still benefit from increased transparency and third-party verification, particularly when credit risk is material. Despite these benefits, we find that most municipal bonds eligible for ESG labels are issued without them. A selection model demonstrates that local demographics, political preferences, and issuance terms represent frictions limiting adoption of financial innovation such as green labeling even conditional on eligibility. Taken together, these results suggest investors value ESG-related information and that adoption of financial innovation on this margin is subject to important selection.

Keywords: Environmental, Social, and Governance (ESG) Investing, Public Finance, Investments, Municipal Bonds, Fiscal Federalism

*We are very grateful for comments from Andrew Chen, Daniel Bergstresser, Zihan Ye, Steve Zamsky and from seminar participants at Auburn University . We thank Irene Kim, Jisun Hwang, and Angela Gao for outstanding research assistance. We are grateful to the Wharton ESG Initiative for their financial support of this project. Wharton Research Data Services (WRDS) was used in preparing this paper. This service and the data available thereon constitute valuable intellectual property and trade secrets of WRDS and/or its third-party suppliers. Any remaining errors are our own.

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1 Introduction

Investor demand for financial instruments addressing environmental and social impacts and risks has grown substantially over the past two decades. Similarly, public calls to fund environmentally and socially beneficial projects have intensified. In response, some state and local governments have issued green, social, and sustainability bonds to finance such initiatives. By labeling bonds according to their ESG characteristics, issuers have introduced a form of financial innovation in that these newly labeled financial products cater to investors that value these potentially non-financial characteristics. However, many issuers have not adopted this recent innovation.

The municipal bond market provides an ideal laboratory to examine the drivers and consequences of this financial innovation and its role in capital allocation. First, it allows us to assess investor responses to ESG-related bond features, as municipal bonds often finance projects with direct social or environmental impacts. Historically, bonds issued by municipal entities have funded investments in schools, water systems, hospitals, and general improvements in public infrastructure across the US. As public entities in the US raise capital to adapt and become more resilient to future environmental and social risks, they will continue turning to the municipal market — allowing observers to measure whether investors exhibit preferences to fund these types of projects. Second, the $4 trillion municipal market features over 30,000 unique issuers with different goals and frictions when interacting with the market. These heterogeneous municipal issuers with different goals and constraints have the choice of whether to self-select into labeling an issue as a "green," "social," or "sustainability" bond. This complexity may lead to distortions that hinder investors from matching with projects with specific ESG characteristics.

We exploit an exogenous and unexpected external certification of novel ESG ratings for over $1 trillion of the municipal bond market to explore whether investors value such information and why municipalities often choose not to highlight it. Using a within-bond identification strategy and the timing of these new ratings, we find evidence of a *greenium*—a premium paid for green assets—that amounts to about 3 basis points (bps) for bonds that qualify as green and sustainability bonds, regardless of whether an issue is originally labeled it as such. Further, our estimates imply that

even bonds that do not score particularly well and are not eligible for any ESG-related designation may also have a pricing benefit from the information intervention, especially if they have lower credit ratings. This greenium suggests issuers could lower borrowing costs by labeling eligible bonds. Strikingly, we find that most of the newly rated bonds that are eligible for an ESG-related label did not adopt one at issuance. Using the underlying eligibility opinions of these new ratings, we estimate a selection model that suggests there are social, political, and financial frictions that discourage issuers from leveraging ESG labeling, even when it could reduce borrowing costs.

The new ratings that we study come from Kestrel Sustainability Insight (Kestrel). In March 2022, these ratings became available to select institutional investors by subscription, and on March 6, 2023, they were broadly distributed via the Bloomberg Terminal. Kestrel has been a large verifier of individual municipal bonds since 2018 but engaged in a substantially larger scale rating of many unlabeled and already labeled bonds, creating the basis for this study. Kestrel's analysis includes quantitative ratings on environmental, social, and transparency issues, aggregated to determine eligibility for green, social, or sustainability labels under International Capital Market Association (ICMA) standards.[1] After March 2023, Kestrel's ESG Score ratings for all covered issues became visible to all Bloomberg users and can be accessed on the same screens as basic information about the bond. This new data source significantly reduces the costs of acquiring information about the ESG-related impact and risk of municipal bonds for any given investor. This information intervention has the potential to influence both investor demand and market-wide pricing based on these characteristics.

This two-staged information release process allows us to partially disentangle the price impact of large institutional investors with explicit ESG investing goals from the impact of the broader public. During the first 12 months, only select institutional investors had access to Kestrel's ratings and ICMA eligibility opinions. Using a dynamic difference-in-differences approach, we track the dynamic transition in bond spreads as the market incorporates this information. During the initial period, when only institutions had access, we observe small and statistically noisy impacts on the

[1] See ICMA (2021) and ICMA (2023).

spreads for treated bonds. However, after March 6, 2024, when the quantitative ratings became available to all Bloomberg users, the effects on spreads are much larger and more statistically significant, especially for green and sustainability bonds.

Most of the bonds that Kestrel rates are not eligible for labeling under ICMA guidelines. We also measure how the availability of Kestrel information impacts spreads for these bonds. Surprisingly, the spread impacts we estimate extend beyond bonds deemed as ICMA-eligible for ESG-related labeling by Kestrel. We find that spreads decline substantially relative to bonds that were not assessed by Kestrel and, thus, receive no information intervention. It is unclear on the face why information that is not particularly positive (i.e., a mid-range ESG score without a rating asserting the bond is ICMA eligible) positively impacts asset value. To further investigate, we test whether this result is related to credit and liquidity risk. We do not find any differential pricing impact for bonds based on ex ante observed liquidity risk, proxied by the gap between customer purchase prices and customer sale prices in 2021. The largest decrease in spreads among rated but ICMA-ineligible bonds occurs for those with relatively low credit ratings. Bonds rated A1 or below (using Moody's scale) experience tax-adjusted spread reductions exceeding 10 basis points by the end of 2023.

A causal interpretation of our estimates requires strong evidence that the parallel trends assumption holds. In this case, that means that spreads for bonds receiving Kestrel ratings and eligibility opinions would have moved in parallel to similar bonds without such information, absent the intervention. We provide several assessments of this ultimately untestable hypothesis. First, in our dynamic difference-in-differences approach, we do not observe a difference in monthly spreads for the 14 months prior to the information release. Second, the information shock was exogenous to both issuers and investors—neither group was aware of the data project or the exact scope of rated issues, eliminating self-selection concerns typical in comparisons of "green" and non-green securities. Third, issuers had no control over the timing of this release. While Kestrel now rates bonds at issuance, its ratings at the time were limited to secondary market bonds with characteristics that were already fixed. Fourth, we include a comprehensive set of fixed effects, including

a CUSIP-level fixed effect, to help eliminate potential confounding factors that may have affected bond prices concurrently with the release of the ratings. These fixed effects, all of which are further interacted with time fixed effects, include state-by-tax, time to maturity, credit rating, issue size bins, trade size bins, liquidity, and coupon size bins. Finally, a battery of additional tests demonstrate that our findings are robust and not a function of key features of bonds within the sample. We rule out that these results are not driven by the creditworthiness of the borrower, the liquidity of the issue, call provisions that are often attached to longer maturity bonds, issuances in states that comprise a large portion of the sample (i.e., California, Texas), the choice of controls, or the functional form of the specification.

Next, we examine issuers' decisions to label bonds as green, using Kestrel's ratings as a proxy for true eligibility. Notably, most eligible bonds are not labeled at issuance. Among bonds eligible for ICMA green or sustainable labeling, the primary determinant of self-labeling is the "greenness" of the project. A one-standard-deviation increase in Kestrel's environmental benefit score for the project is associated with a 14 percentage point (pp) increase in the likelihood of self-labeling, relative to a baseline likelihood of 17.6%. While this result is intuitive, it also suggests there is a potential information friction—issuers may not fully understand their eligibility.

Beyond this project-specific factor, political and demographic characteristics are also predictive of green labeling, conditional on eligibility. Specifically, for green and sustainability bond labeling, a one-standard-deviation increase in the share of Hispanic or Nonwhite population or the share of Republican voters reduces the probability of labeling a bond as green or sustainability by approximately 8pp and 5pp, respectively. These effects hold after controlling for project greenness and other demographic variables.

This paper provides novel insights for several different literatures. First, we advance the understanding of investors' willingness to pay a greenium by demonstrating that equilibrium pricing within bonds is sensitive to the ESG information environment. The recent literature on this topic, which is focused mainly on the municipal bond market, has featured an ongoing debate about the existence of a greenium. By studying observably similar bonds with and without green labels, Zer-

bib (2019) and Baker, Bergstresser, Serafeim and Wurgler (2022) both show evidence of a price premium for green assets. Conversely, Larcker and Watts (2020) find no difference in offering yields for green bonds using a twin-bond methodology, while Baker, Bergstresser, Serafeim and Wurgler (2022) observe a small greenium in secondary market trading with the same method. Li, Wang and Yu (2023) shows that the original within issuer-day comparison results in a small greenium in more recent years, although it is still precisely zero for many observations. Similarly, Tomunen and Yi (2023) also argue there is no greenium using an intermediary relationship-driven instrument available to certain insured issues.[2] We provide evidence that such a greenium does exist in the municipal market, especially for green and sustainability-labeled bonds, while social labels only have marginal impacts. Substantial information frictions have previously distorted pricing dynamics and asset allocations, limiting outside observers' ability to detect a greenium.

We also characterize municipal issuers' decision to adopt new and potentially beneficial financial innovation as a form of financial innovation. In this sense, we contribute to the literature on the causes and consequences of financial innovation, especially for local and state governments. Studies like Pérignon and Vallée (2017) and Ang, Bhansali and Xing (2010) demonstrate that state and local governments engage in financial innovation, which can influence both cost and risk margins of their borrowings. Conceptually, financial innovation can impact market efficiency, risk-sharing mechanisms, or capital allocation depending on what factors drive the adoption of the new innovation. Our results suggest that green bond issuance is indeed innovative and provides novel information. Green labeling, or its absence, has real consequences for capital flows and investment accessibility in the municipal bond market. This result complements Hartzmark and Sussman (2019) who show that improved green labeling of mutual funds induces capital flows to greener funds from browner funds, reflecting some investors' preferences for non-pecuniary factors.

Another related stream of literature profiles the reasons for taking on ESG-related commitments

[2]Papers focusing on corporate bonds show a similar pattern of results. Flammer (2021) does not find evidence of a greenium at issuance, while Aswani and Rajgopal (2022) documents a greenium in secondary market trading of approximately 8% concentrated in financial firms' bonds. This secondary market effect may be, in part, explained by liquidity. Amel-Zadeh, Lustermans, Pieterse-Bloem, Dekker and Christopoulos (2024) show that green bonds are more liquid, less volatile, and have better execution than conventional bonds

or labels more broadly. Beyond attempting to capture a potentially lower cost source of capital, issuers may use ESG-labeled bonds to signal a firm's commitment to the environment (Flammer, 2021) or to signal general firm quality (Tang and Zhang, 2020). These signals are often credible, as some firms increase real investments in green projects after issuing green-labeled bonds (Devine, Kok, Özgür and Yönder, 2024), though the generalizability of such findings is debated (Lam and Wurgler, 2024). Board composition and capital structure are also related to corporate green bond issuance (Cicchiello, Cotugno, Monferrà and Perdichizzi, 2022) and firms may adopt ESG labels to please stakeholders or attract institutional investors (Baker, Larcker, McClure, Saraph and Watts, 2022). A closely related study on the determinants of green bond labeling shows that local political preferences shape the supply and demand for green bonds by pooling all green and non-green labeled municipal bonds in selection and pricing models (Chang, Hu and Shen, 2024). The advantage of our setting is that Kestrel's ratings allow us to compare the choice to label bonds only among bonds with similar underlying ESG characteristics — greatly simplifying the structure of the selection problem. In doing so, we are able to offer new insights into how social, political, and financial factors shape the adoption of innovation in the municipal finance market while holding constant the relevant ESG characteristics of the underlying project.

This study also contributes to the understanding of the value of ESG disclosure and information intermediaries in the municipal bond market——an area less explored than corporate disclosures. In equity markets, disagreement among information intermediaries (i.e., ESG rating agencies) contributes to risk and influences investors' reactions to ESG news (Avramov, Cheng, Lioui and Tarelli, 2022; Serafeim and Yoon, 2023). Conversely, improved transparency around firms' non-financial disclosures improves market efficiency (Krueger, Sautner, Tang and Zhong, 2021) and has real outcomes for institutional investment and firm financial policy (Gibbons, 2023). We document that the fragmented nature of the municipal bond market, coupled with the substantial cost of gathering information about the underlying green attributes of these innovative green bond instruments, has led to frictions in matching investors with green projects. Comparable ESG disclosures provided by a credible intermediary improve pricing in this market and help to alleviate

such frictions.

Finally, we contribute to the municipal finance literature regarding how investors price environmental, social, and transparency-related risks. On the environmental side, there is evidence investors price sea level rise risk (Painter, 2020; Goldsmith-Pinkham, Gustafson, Lewis and Schwert, 2023), heat exposure (Acharya, Johnson, Sundaresan and Tomunen, 2022), and access to renewable energy resources (Cornaggia and Iliev, 2024). On the social side, research shows that investors consider risks related to healthcare interventions (Gao, Lee and Murphy, 2022; Cornaggia, Li and Ye, 2024), opioid-exposure (Cornaggia, Hund, Nguyen and Ye, 2022), and racial animus when pricing bonds (Dougal, Gao, Mayew and Parsons, 2019). Concerns over transparency also are priced, including recent newspaper closures leading to less oversight over local fiscal planning (Gao, Lee and Murphy, 2020). We extend this literature by showing that investors' willingness to pay increases with third-party verification of ESG characteristics and risks, providing further evidence of the broad-based impact of ESG factors on municipal bond pricing.

2 Empirical Context

Public projects in the United States, including those with important implications for the environment, have been financed by issuing municipal bonds since a canal project in New York City in 1812. By 2024, the municipal bond market encompasses over $4 trillion dollars of bonds outstanding with an average flow of new issuance in the range of $300-$500 billion per year. This borrowing pays for investments in public assets like bridges, schools, water treatment plants, energy infrastructure, and hospitals. Future public investments in renewable energy infrastructure, transportation infrastructure, energy-efficient buildings, land conservation, stormwater and flood management, and infrastructure for the circular economy will also continue be funded by capital raised in this market.

When a municipal entity issues a bond, an underwriter or syndicate of underwriters will give the issuer cash on the issuance date in order to receive claims on a series of coupon payments

and a principal payment in return, which are then sold to investors. Many of these investors are individual retail investors or intermediaries like mutual funds that are going to hold the bonds on behalf of individual investors. Individual investors who pay top marginal tax rates find these bonds particularly valuable because the interest payments are exempt from personal income taxes, which lowers the pre-tax compensation these investors require relative to buying otherwise similar taxable assets (Longstaff, 2011; Garrett, Ordin, Roberts and Suárez Serrato, 2023). The cost of financing in the market matters theoretically, with the marginal cost of public funds determining the efficient level of public amenity production, as well as empirically as several recent papers have shown that municipal borrowers with lower costs can sometimes borrow and invest more (Adelino, Cunha and Ferreira, 2017; Dagostino, 2018; Yi, 2021; St. Clair, 2024). To this end, the federal government and the states have tried to create a regulatory framework that encourages borrowing costs to be low and that tries to provide oversight to deter borrowing that is unnecessarily expensive for issuers.[3] Part of this regulatory and disclosure framework requires strict reporting of how proceeds will be used, so investors have a better sense of what projects they are investing in, and so constituents are able to tell how their tax dollars are being spent.

Bond labels by use of proceeds—sometimes referred to as the "issue purpose"—have been employed in the municipal market since it's inception. Further, research has found that these sorts of labels do have pricing implications,[4] although the reason for such pricing impact could be due to difference in risk or differences in investor preference.[5] The Commonwealth of Massachusetts issued the first large municipal bond labeled as a "green bond" in the US with their $100 million

[3]For example, many states encourage or require the use of auction sales especially for small issuers to encourage underwriter competition (Cestau, Green, Hollifield and Schürhoff, 2019), provide additional bond insurance for certain borrowers (Yang, 2024), and engage in active fiscal monitoring (Nakhmurina, 2024). Meanwhile, federal interventions through real-time trade reporting requirements and support (Schultz, 2012), new guidelines through Dodd-Frank (Garrett, 2024), and innovation in the way in which federal subsidies can be applied (Luby, 2012; Cestau, Green and Schürhoff, 2013; Liu and Denison, 2014) also have the goal of trying to make local public borrowing relatively less expensive.

[4]The earliest empirical exploration of the pricing impact of municipal bond purpose labeling, to our knowledge, was Heins (1962) who found that bonds carried different yields on average when issued for different purposes, with bond funding toll roads and bridges and utilities being more expensive than bonds issued for other purposes. More recent studies using more modern methods such as Guzman and Moldogaziev (2012) continue to find that purpose labeling of municipal bonds continues to be associated with large differences in pricing.

[5]For example, Kidwell and Koch (1982) sort different purposes into categories of riskiness of the project, arguing that much of the relative difference in pricing by bond purpose is related to a risk premium instead of a preference.

Series D issue in 2013. The bonds in this series were issued to finance a variety of projects including the reduction of water pollution, efficiency improvements in government buildings, Superfund cleanup, land protection, and habitat restoration. Within the bond indenture, the issuer explicitly states that the purpose of labeling this bonds as green "is to allow investors to invest directly in environmentally beneficial projects." The Series B and C bonds within the same issue were not labeled as such.

We show the patterns of ex ante labeled bond issuance in Figure 1. Although the 2013 Massachusetts issuance is widely seen as the first green municipal bond, funds from other issuances in the muni market were used for similar purposes without being explicitly self-labeled as *green* previously. One example of a such project is Vicksburg, Michigan Community Schools' 2007 *Energy Conservation Improvement Bonds*. These bonds had the purpose of making "energy conservation improvements to school district facilities", but were not specifically self-labeled as *green*. Likewise, Bloomberg has labeled some bonds with similar purposes as *green* without these bonds being self-labeled. For example, Bloomberg labeled the State of Florida's Department of Environmental Protection Series A and B 2010 issue of $349 million as a green bond, which included funds for waterway restoration and conservation. This bond self-labeled as a "Florida Forever Bond" instead of as a green bond.[6] Bloomberg assigns such labels after its analysts review offering documents for whether the issuer states that the proceeds will be used for environmental or social purposes.[7]

The majority of public investments in renewable energy infrastructure, transportation infrastructure, energy-efficient buildings, land conservation, stormwater and flood management, and claim infrastructure will likely be funded through this market. However, Figure 1 shows that the relative size of bonds that choose to label themselves as environmentally beneficial, or with limited environmental risk, is quite modest. In 2019, only $13.5 billion of municipal borrowing in

[6] According to the bond issue's official statement, available on MSRB EMMA, the applicability of such as a designation is because the bonds are "issued to acquire and improve land, water areas and related property interests and resources for the purpose of conservation, outdoor recreation, water resource development, restoration of natural systems, and historic preservation" in accordance with Florida Forever Laws—Florida's largest land conservation and acquisition program.

[7] The definition given by Bloomberg for its Green/Sustainability/Social bond labels, for each of these three label categories, respectively, is that "the issuer states that the net proceeds of the instrument include environmental/environmental and social/social projects or activities" .

the US were self-labeled as green—just 2.9% of the annual issuance proceeds. Including social and sustainability labeled bonds as well, ESG labeled bonds made up 3.7% of 2019 issuance. By 2022, we find that the share of borrowing that is labeled with some sort of ESG label increased to 11.5% of bonds, with 5.5% being labeled green, 1.1% being labeled sustainability, and 4.9% being labeled as social. Although most issuers have never issued a bond with these explicit labels, most have likely financed projects with some environmental or social benefits.

Differentiating a bond only matters to investors insofar as they think the label is a valuable on it's own or a signal of some underlying characteristic that they value. For the current incarnation of labels that have been more widely used since 2013, investors, issuers, and third party investors have been using the Green, Social, and Sustainability bond labels and the related definitions endorsed by the International Capital Markets Association (ICMA, 2021, 2023). ICMA's guidelines provide simple and consistent measures of labeling eligibility that can be used to compare the relative ESG-related impacts and risks associated with a given bond across contexts. The guidelines outlined in ICMA (2021) regarding the eligibility of a "green" bond, for example, is a function of four characteristics: (1) use of proceeds, (2) process for project evaluation and selection, (3) management of proceeds, and (4) reporting. The use of proceeds categories that are allowed include measurements of environmental impact, such as *pollution prevention and control*,[8] as well as measurements related to the mitigation of environmental risks such as *climate change adaption*.[9]

The first labeled bonds with the recent incarnation of ESG-related labels engaged in self labeling, the issuers would try to provide addition information to investors in line with the issuer's understanding of the ICMA or related guidelines and would self certify that the guidelines were met for a certain bond issue. Given that investor demands were changing over time, as were the ICMA and related labeling guidelines, financial services firms like Build America Mutual, as studied in Tomunen and Yi (2023), and Kestrel Sustainability Intelligence, which we focus on here, began selling third party opinions to clients who had eligible bonds but didn't want to go through

[8]Page 4 of ICMA (2021): "[R]eduction of air emissions, greenhouse gas control, soil remediation, waste prevention, waste reduction, waste recycling and energy/emission-efficient waste to energy."

[9]Page 5 of ICMA (2021): "[E]fforts to make infrastructure more resilient to impacts of climate change, as well as information support systems, such as climate observation and early warning systems."

the process of trying to convince investors of such eligibility on their own.

The shock that we study comes from an institutional investor driven push to get ESG-related labeling eligibility information for a broader set of bonds. By 2022, only a small portion of outstanding bonds had chosen to engage in the innovation of labeling themselves with an ESG-related label or with providing any third party information on the relative ESG characteristics of the bond. Several institutional investors and Bloomberg began acquiring relevant ESG-related information and opinions on ICMA label eligibility from Kestrel. Kestrel first began selling this information to selected institutional subscribers around March of 2022, and Bloomberg began posting these new quantitative measures on March 6, 2024. Importantly, the issuers who issued these bonds did not have any say in whether the ratings are posted, and Kestrel focused on rating large bonds that lots of investors may have an interest in first, focusing on newer, particularly those issued since 2022, and larger, particularly those with more than $20 million in par value, bonds. We display the time pattern of when bonds were issued that received the new Kestrel labeling in Figure 2.

Kestrel employs biologists, engineers, architects, and financial analysts to evaluate the underlying project's environmental, social, and governance characteristics for municipal bond issues. Its methodology produces "ESG Impact Scores" for issues in the municipal bond market. These scores include an individual 1 (low) to 5 (high) score on the environmental, social, and governance (transparency) impacts for the use of proceeds for a bond, as well as an overall weighted ESG score. Kestrel Data Sustainability Analysis and ESG Impact Scores became available to market participants broadly through the Bloomberg Terminal on March 6, 2023. We discuss more details regarding how this information is available to investors in Appendix B. The headline scores for these categories are available to all Bloomberg users, regardless if they have a subscription to Kestrel's more detailed data product, much like a rating from a credit rating agency. In addition, all Bloomberg users see these headline scores on the "Impact" tab when searching for any individual municipal bond. Importantly for this analysis, Kestrel's ratings and analysis allow investors to screen for bonds that meet internationally recognized standards for "green", "social", or "sustainability" bonds, even if those bonds were not labeled as such at the time of issuance.

3 Data

To facilitate our exploration of the uptake and importance of ESG information and labeling in the public finance market, we gather data from a variety of sources about the structure and trading of bonds.

First, we gather information on the universe of municipal bond trades from January 1, 2021, through December 31, 2023, as reported through the Municipal Securities Rulemaking Board (MSRB). The MSRB's Historical Transaction Data contains information on all trades including the CUSIP of the traded bond, the date and time of the trade, the par value traded, the price of the trade, the yield to worst, whether the trade is a customer purchase, customer sale, or an interdealer trade, and whether there is any non-transaction based compensation to the dealer. We limit our analysis to the universe of customer purchase transactions that do no include any sort of non-transaction based compensation to understand the customer willingness to pay for municipal securities where the prices we observe are exactly the prices that customers pay. We aggregate the transaction data to the bond-month level by finding the weighted average customer purchase price for each bond within a given month. Following Green, Hollifield and Schürhoff (2007) and Schwert (2017), we also limit ourselves to examining transactions that take place at least 90 days after the issuance date and more than a year before maturity. We also include the distance between customer purchase prices and customer sale prices within a given bond and month, which is a proxy for inverse liquidity, as a control variable in most specifications.

We obtain issue-level ratings on a project's environmental, social, and governance (i.e., transparency) impact from Kestrel Sustainability Intelligence. Kestrel assigns a score for many primary municipal bond issuances, including munis not specifically self-labeled as with any sort of ESG credential. Kestrel primarily rates bonds with a par value above $20 million and a credit rating of "A" or greater and has a goal of covering all of the primary market that reaches the size threshold. However, coverage is still not universal, even among large bonds. Kestrel covers approximately a quarter of the notional value of outstanding bonds in the US municipal bond market, and a higher proportion of recently issued bonds. The Kestrel ratings universe used in this study to covers

125,509 individual bonds from 9,864 unique issues by 3,845 unique issuers. The total dollar value of these rated bonds that we are able to match to the transaction data amounts to $1.8 trillion in financing for public investment. Kestrel uses the definitions put forward by ICMA (2021) and ICMA (2023) and provides an opinion on whether each bond meets the necessary criteria to call itself a "green," "sustainability," or "social" bond. In addition to these binary labeling opinions, Kestrel publishes quantitative ratings on the margins of "environmental benefits," "social benefits," and "transparency benefits" that are correlated with the ratings. Non-subscribers on Bloomberg cannot see the specific opinions about ICMA eligibility, but the quantitative ratings are correlated with the eligibility opinions. We use the formal Kestrel opinions as our measure of information intervention and treatment although the public information to non-subscribers through Bloomberg could be perceived as slightly different.

In order to estimate a pricing model that assesses the impact of the information intervention we study, we also match bonds to the Mergent Municipal Database based on 9-digit CUSIP numbers. Mergent provides a large number of standardized bond- and issue-level characteristics including security size, issue size, issuer name and state, maturity schedule, coupon type and amount, use of proceeds, credit rating (historical), tax exemption status, callability and schedule, and self-labeled ESG status. In the results in the paper, we follow Schwert (2017) and drop all callable bonds and provide a robustness check to their inclusion in Appendix C. We also drop bonds with variable coupon rates, remarketings, bonds with missing par value or maturity dates, and putable bonds.

In order to calculate tax adjusted spreads and other outcomes, we augment our bond cross-section and our bond-transaction panel with additional data sources. We match each transaction of a municipal bond with the estimates of a zero-coupon treasury yield curve developed by Liu and Wu (2021). We use a linear interpolation of the yield curve at different monthly maturities to get as exact a correspondence as possible between the municipal bond transaction we observe and the yield an investor could have received if they had purchased a risk-free asset instead. We also use the NBER TAXSIM estimates of state and federal tax rates for high income individuals to calculate the after-tax spread that a municipal bond earns over a maturity matched treasury. Most municipal

bond income is exempt from state and federal taxation and treasury bonds are exempt from state level taxation, with the exception of Tennessee. We calculate the tax adjusted spread of each bond i of maturity m transacted at time t as

$$\text{spread}_{imt} = \text{yield}_{imt}(1 - \mathbb{1}(\text{federal tax})\tau_t^{Fed} - \mathbb{1}(\text{state tax})\tau_t^{State}) - \text{treasury yield}_{mt}(1 - \tau_t^{Fed}),$$

where τ_t^{Fed} and τ_t^{State} are the marginal federal and state tax rates for an individual earning \$1 beyond an income of \$1.5 million. This measurement of after-tax spreads captures how much more an investor has to be compensated to purchase a municipal bond relative to a treasury of the same maturity.

We also gather mutual fund holding data from the CRSP Mutual Fund Holdings database. We match this data to Mergent by CUSIP to measure holdings of all current municipal bonds at the end of each quarter. Bonds from Mergent that do not appear in the CRSP database are coded as zeros to create a balanced quarterly panel of holdings data.

4 Identifying the Greenium

A fundamental problem with figuring out how much investors care about the ESG-related labeling of fixed income securities is that issuers have the choice of whether or not to label the bond. This selection leaves few arguably exogenous comparisons one can make within the the set of existing labeled bonds, such as the within issuer-date comparisons of Larcker and Watts (2020) and Li, Wang and Yu (2023) or with a financial intermediary relationship instrument as in Tomunen and Yi (2023). Our approach builds on the existing literature by using the exogenous and unexpected provision of external information about bonds that already exist and are currently being traded.

The difference-in-differences method allows us to compare outcomes for bonds that receive ESG-related information interventions to bonds that do not receive any new information. Within bond, we hold the selection of the project fixed and allow the bonds that Kestrel rates to receive disclosure that is not self selected.

Our main research design is a dynamic difference-in-differences regression, which we estimate using the following model:

$$Y_{ijt} = \alpha_i + \sum_{k=0}^{T} \beta_k \times \text{rated}_i \times \mathbb{1}(t = k)_t + X_{ijt} + \varepsilon_{ijt} \tag{1}$$

where i denotes the CUSIP, j denotes the issuer, and t denotes the month between January 2021 and December 2023. Our outcome variable Y measures the monthly trade-size weighted average tax-adjusted spread over a maturity-matched treasury. X includes an extensive set of fixed effects to capture unrelated phenomena that impact spreads over the sample period. These controls include month-by-maturity (in years), month-by-state-by-taxability, month-by-maturity, month-by-credit rating, month-by-coupon size quintile, and month-by-issuance size decile fixed effects, as well as a continuous proxy of liquidity interacted with month fixed effects. Each of these controls captures a known pricing determinant of municipal bonds that we allow to have flexible impacts over time. For example, the classic "muni puzzle" is that spreads for munis increase faster with increases in maturity than in other asset classes (Bergstresser, 2023). Our month-by-maturity fixed effects account for the existence of this–potentially time varying–phenomenon.

The coefficients of interest are the monthly β_k estimates that show how much more or less investors require to be compensated to purchase a bond with the new Kestrel ratings. $rated_i$ is an factor variable that describes what Kestrel's ex post opinion of the ICMA eligibility is for a given bond. For the sake of creating sample sizes that provide sufficient power, we allocated bonds to one of six categories and display the β_k estimates separately:

1. Ex ante labeled bonds. These bonds selected into receiving green, sustainability, or social labels when they were issued.

2. Ex post green and sustainability bonds. These bonds were not originally labeled, but receive an opinion from Kestrel that they could have been labeled as green or sustainability bonds.

3. Ex post social bonds. These bonds were not originally labeled, but receive an opinion from Kestrel that they could have been labeled as social bonds.

4. Ex post ineligible. These bonds were not originally labeled and receive a rating from Kestrel indicating that these bonds are not eligible for any ICMA label.

5. Ex post low score. These bonds were not originally labeled as anything and receive a rating from Kestrel. These bonds are not eligible for any ICMA labeling, and they also score below 3.[10]

6. Not assessed. These bonds were not originally labeled as anything and Kestrel did not provide new ratings for these bonds.

The not assessed group serves as the omitted group, so each β_k coefficient describes pricing of the focal group relative to those bonds that have no information intervention.

We double cluster standard errors in our main specification by issuer j and month t. This approach accounts for factors that could lead to correlated errors over time and cross-sectionally within periods. Such factors might include local fiscal policy and economic conditions affecting the risk of the issuer across the sample, or broader macroeconomic shocks that affect the municipal bond market within a given month. We also present estimates with two-way clustering by issue and month. This choice would be more appropriate if the error structure is driven more by bond-specific features than municipality-wide factors. We find, however, that confidence intervals are slightly less conservative at this level. We use the more conservative issuer and time clustering for tables and display both clustering approaches on graphs.

The primary assumption behind a causal interpretation of this dynamic difference-in-differences approach is one of parallel trends: without the information intervention that began in 2022, bonds that receive new Kestrel ratings and eligibility opinions would have had spreads move in parallel to similar bonds that did not receive such information.

[10]The pricing dynamics of these bonds are not captured well by the our model and control group, likely because these bonds are often issued on behalf of private companies like local utilities. We discuss these bonds and their results more in Appendix D.

5 Greenium Discussion and Mechanisms

In this Section, we discuss the results of the dynamic difference-in-differences analysis of the information intervention due to the emergence and distribution of Kestrel's new ratings and ESG labeling opinions. The discussion is organized to focus on one eligibility group at a time, beginning with ex post green and sustainability bonds. Table 2 displays pooled estimates for each of the focal groups discussed below.

Ex post green and sustainability bonds

Figure 4, panel A, displays estimates of β_k from equation 1 and the related 95% confidence intervals for the bonds that receive new information that they were eligible for green or sustainability labels after February 2022. The outcome variable is the tax-adjusted spread relative to maturity matched treasuries. The graph area is divided into three time periods that correspond to the information environment. Starting from the left with January 2021, these bonds did not have any available third party information about their potential for ESG labeling and they had also chosen to not be self-labeled. During this initial 14-month period, we do not find any differential pricing trends for these bonds.

Starting in March 2022 after the dashed vertical line, Kestrel began providing information about these bonds to select institutional subscribers, including ratings that would later be published on Bloomberg and the associated ICMA eligibility opinions. During this partial treatment period, we find a slight decline in spreads for the bonds receiving an information intervention, but only one month is statistically significant with the more conservative issuer and time standard error clustering.

The Kestrel ratings were published on Bloomberg on March 6, 2024, and we shade this period a darker gray. During this period, we find that investors pay an additional 2.8bps for bonds that Kestrel identifies as eligible for labeling as "green" or "sustainability" bonds according to the standards set by ICMA, but were not explicitly labeled as such in the first place.[11] This premium only

[11] Point estimates and standard errors are listed in Table 2.

emerges during the public information period. The dynamics of how this effect emerges suggests that well-resourced large institutional investors may be able to effectively identify "quasi-green" bonds. However, information frictions prevent other smaller investors from fully valuing the green features of these bonds. The introduction of these ratings, at least partially, alleviated these information frictions.

Ex post social bonds

Figure 4, panel B, displays estimates of β_k from equation 1 and the related 95% confidence intervals for the bonds that receive new information that they were eligible for social labels after February 2022. While the design of the regressions, timing, and control group is identical to the ex post green and sustainability bonds, the transition path and long run pricing impact that emerges is quite different.

These bonds, which also selected not to have any label originally, also do not show differential pricing trends relative to never assessed bonds before February 2022. During the middle period when only select institutions had access to the information, we also do not find any change in pricing for the informationally treated bonds relative to not assessed bonds. Finally, after the quantitative Kestrel ratings are posted on Bloomberg, we continue to find very little visual impact on spreads for bonds receiving new information. The pooled estimate in Table 2 shows a 1bp decline in spreads relative to the pre-period, but this is only statistically significant at the 10% level.

Ex ante labeled bonds

We show the corresponding dynamic difference-in-differences estimate for ex ante labeled bonds in panel A of Figure 5 and present the pooled estimates in Table 2. While there is a visual trend in spreads upward after the availability of the Kestrel eligibility opinions and scores, the pooled comparison of post information intervention to the pre-period is not statistically significant. This lack of statistical power is twofold. First, there are not very many ex ante labeled bonds. Only 641 of these bond issues have coverage in both the Kestrel and the transaction data. Second, given

that these bonds already have ESG labels from their issuance, they may be sensitive to factors in the pre-period that our model is not well suited to capture. Therefore, the evidence of whether the availability of Kestrel ratings and eligibility opinions matters for the ex ante labeled bonds inconclusive and we cannot reject the null hypothesis of no impact.

Ex post ineligible bonds

Panel B of Figure 5 shows the analogous regression estimates for the sample of bonds that are ineligible for any label ex post and that were never labeled in the first place. Much like the other non-labeled bonds, these bonds do not have a differential trend in pricing during the first 14 months of our sample before any information intervention. But after the start of institutional investor period around March 2022, we estimate that spreads for these bonds fall before other investors get access to the public rating information through Bloomberg. After public information is available with the Kestrel ratings, the spreads stay similarly depressed, suggesting that the select institutional investors basically agree with the rest of the market about the value of the additional third party verification of information related to ESG risks and impacts. The pooled difference-in-differences estimates in column 4 of Table 2 show that spreads drop by 3.3bps during the institutional period and by 5.5bps after public information. Both point estimates are statistically significant at the 1% level.

Assessing identification

The primary identification assumption for the results discussed in this sections is that treated bonds and control bonds would have had spreads that evolved in parallel in the absence of treatment. We now discuss the empirical evidence of whether this assumption could be true. First, with the exception of the ex ante labeled bonds, the spreads were evolving in parallel before any information was released, so we think it is plausible that the spreads could have continued evolving in parallel.

A threat to identification could be a time-varying shock that is correlated with treatment that

manifests around March 2023 for ex post green, social, and sustainability bonds, but that emerges in mid-2022 for ex post ineligible bonds. There are a number of market phenomenon that could provide such a shock, such as changes in the pricing of duration risk, credit risk, liquidity risk, or real or perceived changes in state fiscal policies. We saturate our regressions with controls that are allowed to be time varying to capture such risks. Insofar as credit ratings are still a reasonable measure of credit risk, we allow credit risk pricing to evolve flexibly over time with a credit rating by time fixed effect. Our primary specifications indirectly control for a time-varying price of duration risk by including maturity and coupon fixed effects interacted with months. But, we also directly include duration interacted with time fixed effects in Appendix C and find nearly identical quantitative results. Liquidity risk is harder to directly observe. But we use a proxy for liquidity by measuring the gap between customer purchases and sales following Jankowitsch, Nashikkar and Subrahmanyam (2011). We interact this measure with time fixed effects, as well. In the Fleckenstein and Longstaff (2023) model, liquidity is a function of age, maturity, trading amounts and sizes, and credit risk as measured by a CDS spread. Our sample of bonds, almost uniformly, do not have CDS spreads available. We do, however, include direct measures or proxies of other liquidity premium impacting variables and interact all of these controls with time fixed effects. To rule out confounding changes to state policy, we also include a state-by-time-by-taxability fixed effect that limits comparisons to bonds in the same state with the same tax treatment trading at the same time.

Appendix C includes another set of robustness checks including dropping California, dropping Texas, including callable bonds, including continuous controls instead of discretized fixed effects, incluing use of funds by time fixed effects, and measuring measuring the outcome as yields or pre-tax spreads instead of after-tax spreads. The results for the informationally treated bonds are very similar across all of these specifications, and statistical significance is unchanged.

5.1 Potential mechanisms for ineligible bond response

There are several explanations why bonds that receive new information about their ESG characteristics even though they are not actually eligible for an ESG-related label by international standards experience such changes in yields.

One such theory is that the ratings information that is provided by Kestrel and through Bloomberg provides a coordinating mechanism to investors. There are more than 1.2 million CUSIPs outstanding, and finding a counterparty to trade any given bond can be extremely costly. It could be the case that the additional 125 thousand ratings available from Kestrel allows investors to focus on a narrower set of bonds and that these bonds become more liquid. If these non-eligible bond ratings are mostly providing a coordination mechanism, we expect that most of the decline in spreads would happen among the most illiquid bonds. To test this hypothesis, we sort all bonds according to the gap between customer purchase and sale prices in the first 14 months of the sample and split at the median. Bonds that generally have low liquidity should have higher spreads in the preperiod.

Re-estimating the regression equation with all β_k terms additionally interacted with an indicator for being high or low liquidity proxy leads to the results shown in panel A of Figure 6. We fail to find a systematic difference between the pricing impact for bonds that have low vs. high liquidity, which is not consistent with the new ratings providing value to borrowers through coordination.

Another potential theory is that the ESG-related information verified by Kestrel provides information that is related to default risk. For example, if the information that Kestrel provides is correlated with exposure to real environmental risks like sea level rise, or a community's activities to abate such risks, then verifying degrees of risk could be very valuable. To test whether the ESG-related information could be valuable because it is related to default risk in some way, we split the sample of bonds into those with very high credit ratings (Aa1 and above according to Moody's) and those with lower or no credit rating at issuance. Again, we interact our main dynamic difference-in-differences interaction term with whether a bond had a high or low rating and show the estimated coefficients and 95% confidence intervals in panel B of Figure 6. Here, we find an effect that is approximately three times larger for low rated bonds that high rated bonds.

This result is consistent with the information that Kestrel provides being perceived as related to default risk and it is most valuable for bonds where default risk is more material.[12]

6 Selection into Issuing ESG-Labeled Securities

So far, we have shown new evidence that there is a greenium in the municipal bond market and, further, that the provisioning of ESG-related information verification can be beneficial even for issues that do no directly qualify for such a label. We now turn our attention to the decisions of municipalities to label their projects with ESG-related information.

In our sample of bonds, Kestrel developed its ratings after the projects were initiated. So, municipal entities had no ability to adjust their projects in order to meet the relevant rating thresholds. Assuming that Kestrel accurately measures the fundamentals of the projects and their eligibility to ESG-related labels according to ICMA standards, we can estimate how much local population, project, and bond characteristics impact the likelihood of seeking such a label. The baseline rates of labeling conditional on labeling eligibility are low: of 2,197 eligible green and sustainability bond issues only 386 (17.6%) label as such, and of 3,874 eligible social bond issues only 255 (6.7%) label as such.

We estimate a logistic regression to describe what characteristics are associated with the decision of using an ESG-related label, conditional on being eligible for such a label. To do this, we restrict the sample to bonds that Kestrel determines are eligible for an ICMA ESG-related label—either green, sustainability, or social. Let $Y_i = 1$ if an issuer chose to label their bond i in a given category. Then further let $\pi_i = \Pr(Y_i = 1)$ be the probability that that a given bond was issued with an ESG label. Then, we use local characteristics to try to explain the log of the odds ratio,

[12] That the presence of ESG-related information verification through the new Kestrel ratings and eligibility opinions carry the most impact for low-rated bonds is consistent with the idea that ESG-related information verification has default risk implications. Since Tomunen and Yi (2023) study the portion of the market where bonds are already receiving credit enhancement through bond insurance, this relationship with credit risk could explain part of why our context shows pricing impact of ESG information when they estimate null impacts for relationship-driven labeling.

$$\ln\left(\frac{\pi_i}{1-\pi_i}\right) = X_i\beta + \varepsilon_i, \tag{2}$$

where X_i is a vector of local, project, and bond characteristics. We begin with a simple model that only includes the bond's environmental benefits or social benefits score for green/sustainability or social bonds, respectively. We sequentially add controls for local income (adjusted gross income per taxpayer), local economic health (unemployment rate and share itemizing tax deductions), local demographics and politics (share hispanic or nonwhite, share elderly, share with at least a college degree, and share voting Republican in 2020), and bond size. Since each bond is only issued once, we do not have a time dimension in this regression and also only cluster standard errors at the issuer level. We display point estimates from all of these logistic regressions in Table 3 for eligible green and sustainability bonds and in Table 4 for eligible social bonds. Marginal impacts estimated at population means are displayed in Figure 7. We discuss green and sustainability bonds first.

There are many potential frictions that municipalities may face in terms of choosing to label a security as having an green or sustainability label. The most obvious potential friction is uncertainty over eligibility. While the ICMA guidelines and Kestrel's interpretation of those guidelines attempt to be precise and quantitative, issuers with projects near the margin of eligibility may be reticent to label their bonds if there is uncertainty around the cutoff point and a cost associated with labeling or being rejected from a label.

A simple test of such a friction is to measure whether the continuous environmental benefits score is a predictor of self-selecting into a green or sustainability label *conditional on being eligible*. Column (1) of Table 3 shows that a standard deviation increase (0.93 on a 5 point scale) in the environmental benefits score, conditional on being eligible, raises the likelihood ratio of labeling the bond as green or sustainability by 125%, which is statistically significant at the 1% level. The estimates lie between 1.1 and 1.3 and are significant across all specifications. This effect is consistent with many issuers choosing not to label because of a worry about overclaiming if they perceive their projects on the margin of labeling eligibility.

Another set of potential frictions relates to the attitudes and beliefs of local constituents. It

may be the case that, just like investors may have preferences over the environmental or social impacts of their investments, local communities may have preferences over the use of ESG-related labeling. We find evidence that this is the case. Measures for both the share of non-white or Hispanic and Republican presidential vote share show economically and statistically significant declines in the likelihood of labeling a bond green. This effect is conditional on eligibility for such a label by inclusion in this sample and also holds constant Kestrel's environmental benefits score. ESG-related bond labels are more likely to be applied by municipal entities in areas where a larger share of the constituents are white and where a larger share of constituents did not vote Republican in 2020.

There also may be financial frictions related to income or to the general costs and benefits of labeling a bond as green. First, labeling a bond as green usually requires having the capacity and credibility to provide information about the underlying greenness to investors. If one cannot self label, they will need to hire a third party verifier, which is not free. While we do not have specific pricing information about such services, similar types of third party verification such as credit ratings and credit enhancements seem to have a large fixed cost component, which means the net benefit of verifying is bigger for larger issues (Joffe, 2017). We do find evidence of the fixed cost of verifying deterring many issuers from labeling their bonds: a one standard deviation increase in ln(par value) (1.17 log points), leads to a 0.294 increase in the log of the odds ratio of labeling the bond when eligible according to the specification in column 5 of Table 3. Finally, we do not find specific evidence that municipal issuers in richer or more economically prosperous locations are more likely to label their bonds after we add all of the controls in columns 5 and 6. These results suggest that engaging in the innovation of labeling ESG-related securities is not simply a luxury good.

The marginal impacts for each of these effects displayed in columns 5 and 6 of Table 3 evaluated at average characteristics are displayed in panel A of Figure 7. The upper (blue) estimates are the marginal impacts from column 5, which includes the environmental benefits score, and the lower (magenta) estimates are the marginal impacts from column 6, omitting the variation in eligi-

ble bond environmental benefits. The sample is still restricted to only bonds that qualify as either green or sustainability bonds according to ICMA guidelines in Kestrel's opinion. A one standard deviation increase in the environmental benefits score is associated with a 14pp higher likelihood of labeling a bond as green or sustainability. Focusing on the most saturated estimates from column 5, we find that a standard deviation increase in bond size increases labeling likelihood by 4pp, that a standard deviation increase in Republican vote share (15.7%) lowers labeling likelihood by 5pp, and that a standard deviation increase in the share of Hispanic or non-white population (19.1%) lowers labeling likelihood by 8pp. Given that the baseline rate of labeling in this sample is 17.6%, these are economically massive effects.

We find broadly similar patterns for social bond labeling in estimates displayed in Table 4 and panel B of Figure 7. Bonds with higher social benefits score are more likely to label, although the result is statistically marginal and economically smaller then for green bonds. Municipalities in locations with more Republicans and less non-Hispanic white residents are less likely to give bonds that qualify as social with such a label. Larger bonds, for which it makes more sense to pay a fixed cost to get a marginal benefit, are more likely to be labeled as social bonds. The biggest difference from the green and sustainability bond selection model is that places with an additional standard deviation of college graduates (11.2%) are 5pp less likely to label their eligible issues as social bonds. Given that the baseline rate of social bond labeling is only 6.7%, these are strikingly large magnitudes.

7 Conclusion

There has been mixed evidence of investors' willingness to pay a premium for specific ESG characteristics of financial instruments, especially in the municipal bond market—a setting where such a greenium should be more easily identified. The sudden and exogenous release of ratings by Kestrel Sustainability Insights provided measurements of the ESG-related impacts and risks of a large portion of the projects funded in the US municipal market, significantly lowering informa-

tion acquisition costs for investors. We leverage this shock to investors' information set and study investors' ESG preferences and dynamics surrounding issuers' choices to self-label projects as ESG.

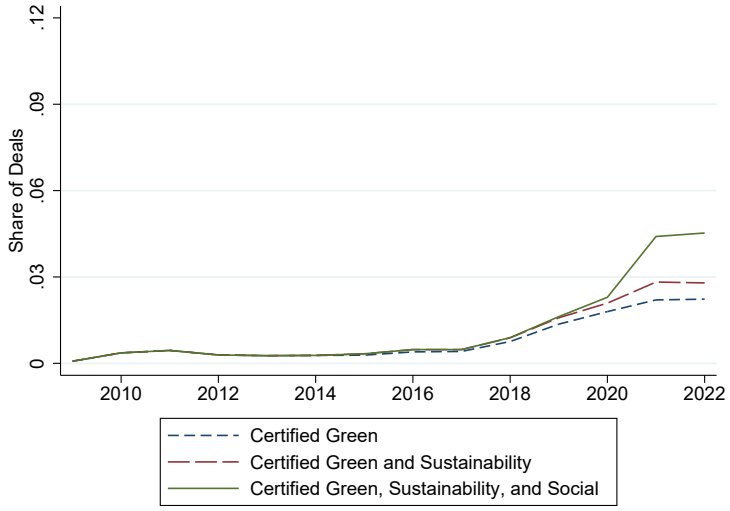
Robust evidence supports the conclusion that investors are willing to pay a material greenium when information costs are lowered. These results highlight the role of information intermediaries and the value of credible and comparable disclosure in addressing ESG-related information frictions in the municipal bond market. They also uncover a mechanism for why prior studies have found mixed evidence of a greenium—the lack of accessible ESG data beyond self-labeled green projects made comparisons difficult and distorted investors' willingness to pay. This distortion hindered capital allocation towards beneficial projects and investors' ability to assess and manage ESG-related risks.

Our findings likewise contribute to our understanding of the adoption of financial innovation by state and local governments. We illustrate that financial, political, and social factors can substantially impede the adoption of beneficial financial innovation that has direct financial benefits for the borrower. The transition from issuer-paid labeling to investor-paid labeling in this market likely alleviates some of these issuer-specific frictions. Given this, future municipal issuances that have recognizable green or sustainable features and receive a favorable ESG score will capture this greenium at issuance, lowering the cost of capital of the project, even if such bonds are not explicitly labeled as "ESG" by the issuer themselves.

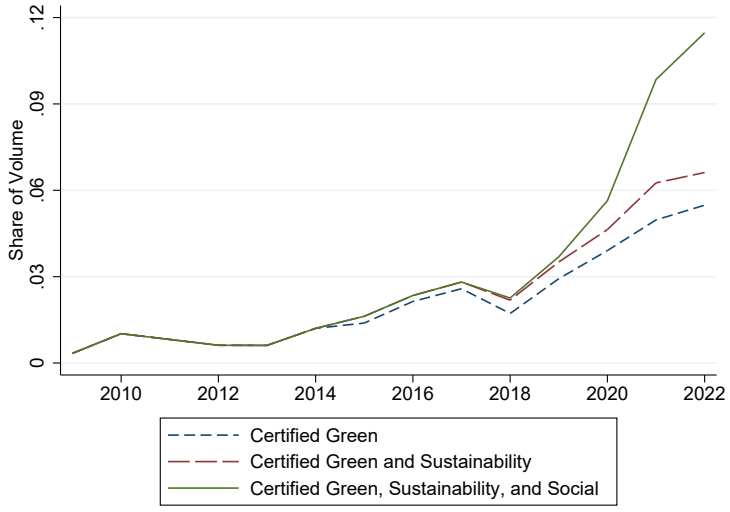
Figures

Figure 1: Historical Use of Ex Ante ESG-Related Bond Labels

A. Share of Deals with Labels

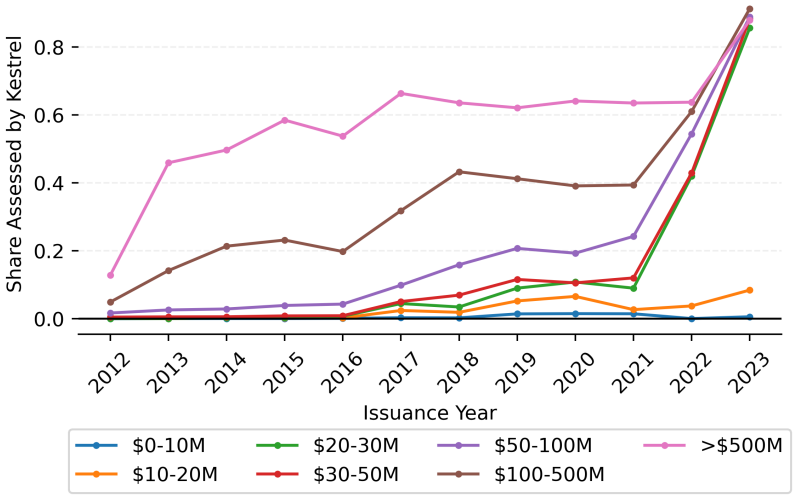


B. Volume of Deals with Labels



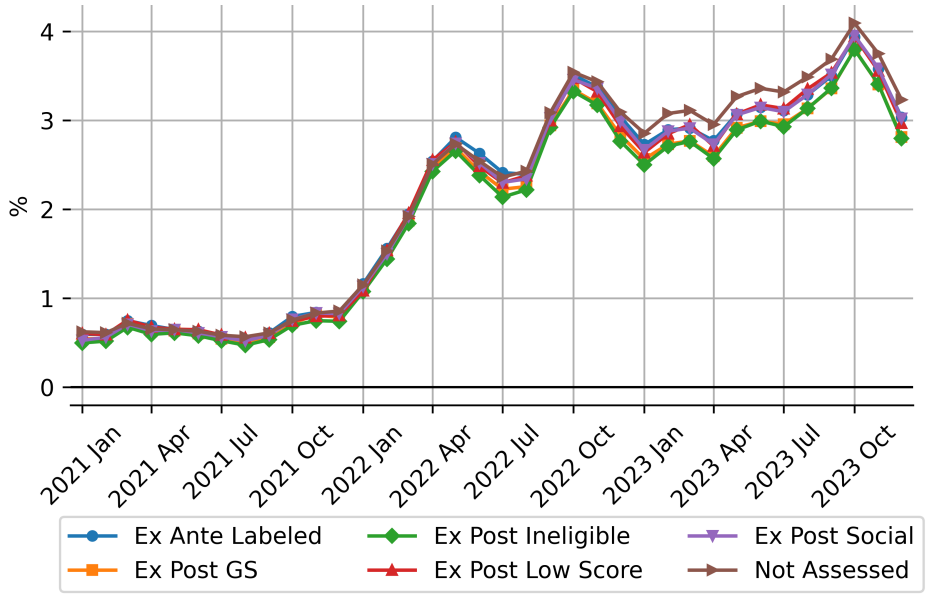
Note: This figure shows the count (panel A) and volume (panel B) of the primary municipal bond market issues that choose to use some sort of ESG-related label according to Bloomberg from 2009 through 2022. The labeled bonds before 2013 were not using "green" labels but were using related labels that noted funds were going to projects with environmental benefits or extra investment to avoid environmental risks. ICMA adopted the first *Green Bond Principles* in 2014, which to our knowledge is when participants started coalescing around the currently used labels. The grand majority of municipal bonds historically, by count and by volume, did not receive any such label.
Source: Mergent and Bloomberg

Figure 2: Presence of Kestrel Rating by Size and Issuance Year



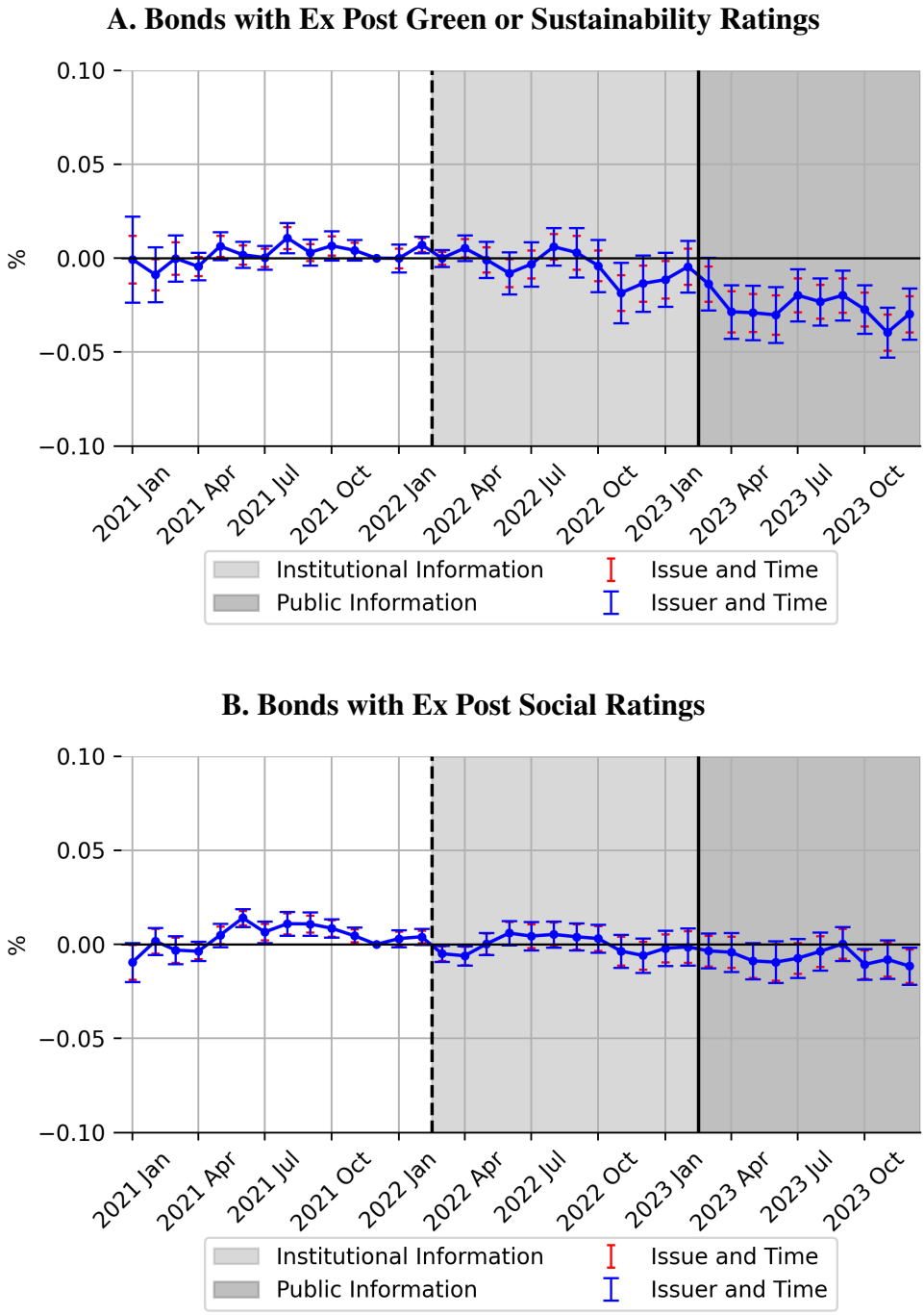
Note: This figure shows the share of bonds in our transaction sample, bonds that trade a least once in the years 2021 through 2023, that have ESG characteristics assessed by Kestrel and posted on Bloomberg terminals. There are two dimensions that drive most of our information intervention. The first is that larger bonds, across all years are more likely to be rated. This makes our ability to control for time-varying size premia very important. Second, the new mony market started getting much more complete Kestrel ESG-data compilation and verification in 2022 at the same time ratings began being made available for institutional investors. This increase in ratings in 2022 is almost entirely concentrated among bond issues where the par value is greater than $20 million.
Source: MSRB Transaction Data, Mergent, and Kestrel

Figure 3: Average Yield to Maturity of Municipal Bonds with Differently Evolving ESG Information



Note: This figure shows the average yield of transactions in the MSRB data conditional on the available ESG information after the information intervention. *Ex Ante Labeled* bonds are those that had a green, sustainability, or social label when they were issued. *Ex Post GS* bonds are those that qualify as green or sustainability bonds but that did not label themselves as such. *Ex Post Social* bonds are those that qualify as social bonds but that did not label themselves as such. *Ex Post Ineligible* and *Ex Post Low Score* bonds are bonds that are ineligible for ICMA certifications in Kestrel's opinion but which have scores equal to 3 or above out of 5, or below 3, respectively. The *Not Assessed* bonds are those that never labeled themselves and that do not have any additional information provided by Kestrel or on Bloomberg regarding their ESG characteristics. All of these categories follow the same broad trends over time, with yields increasing dramatically in the first few months of 2022, matching the secular trends in interest rates in other markets. This sample is restricted to bonds without call options.

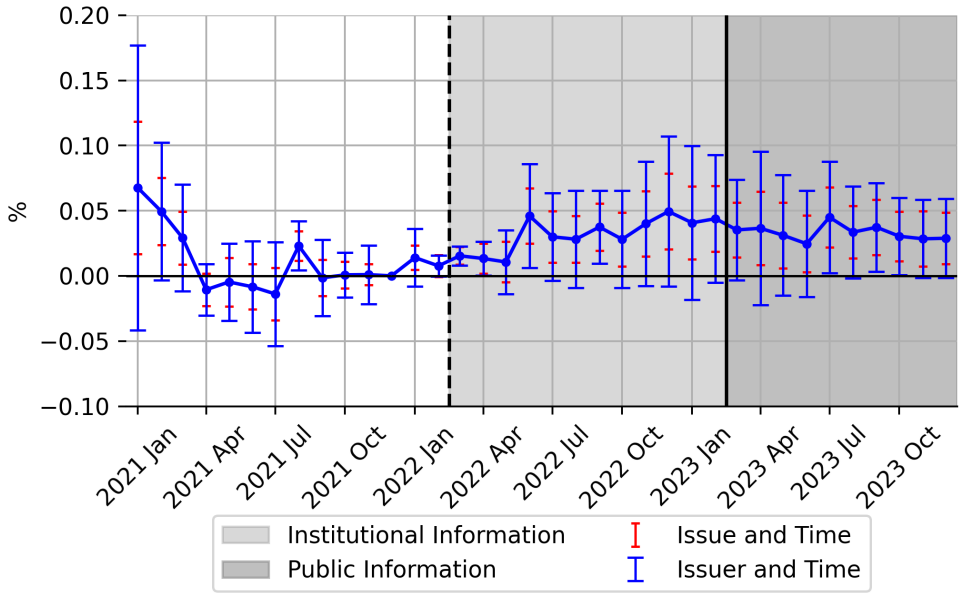
Figure 4: Main Specification, Bonds Receiving Positive Information Revelation



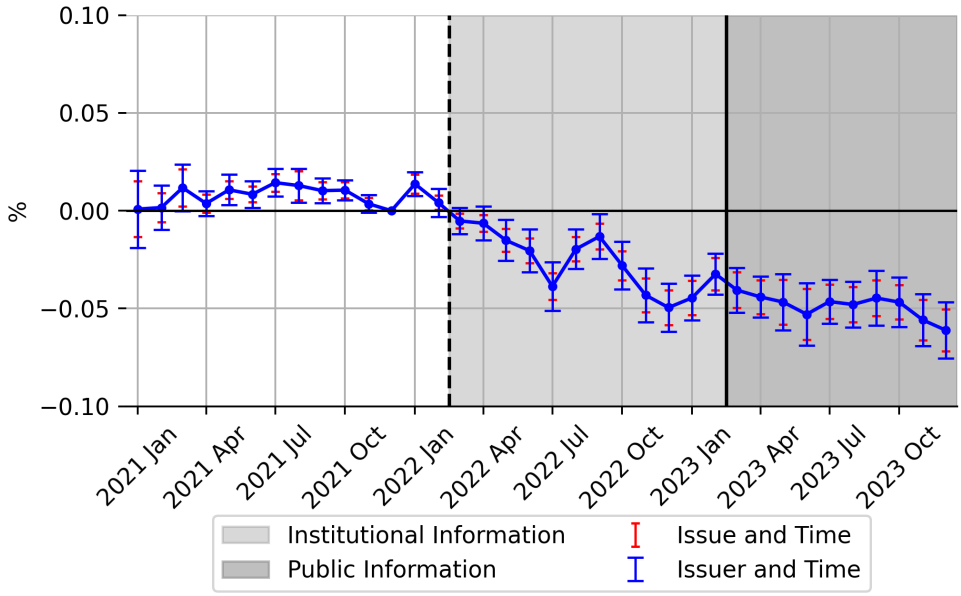
Note: This figure shows how the ESG-related information intervention impacts spreads for affected municipal bonds. In particular, we plot the coefficient estimates from the dynamic difference-in-differences regression specified in equation 1 that explains tax-adjusted spreads of municipal bonds relative to maturity matched treasuries. These coefficients describe how the pricing evolves for municipal bonds who receive an ESG-related information intervention relative to those bonds that did not. The light grey (middle) region denotes months when Kestrel ratings were available to select institutional subscribers. The dark grey (right) region denotes months when Kestrel numerical scores were disseminated widely through Bloomberg Terminals. Panel A shows marginal pricing coefficients for CUSIPs that did not self-label as green or sustainability bonds but received an eligibility opinion from Kestrel, ex-post, for their green or sustainable characteristics. Panel B includes all CUSIPs that did not self-label as social bonds but received an eligibility opinion from Kestrel ex-post for its their social characteristics. All controls and fixed effects from Table 2 are included in these specifications. 95% confidence intervals for standard errors two-way clustered on bond issue and month (issuer and month) are given by the red (blue) bars.

Figure 5: Main Specification, Bonds Receiving Redundant or Neutral Information Revelation

A. Bonds with Self-Selected Ex Ante Green, Sustainability, or Social Labels

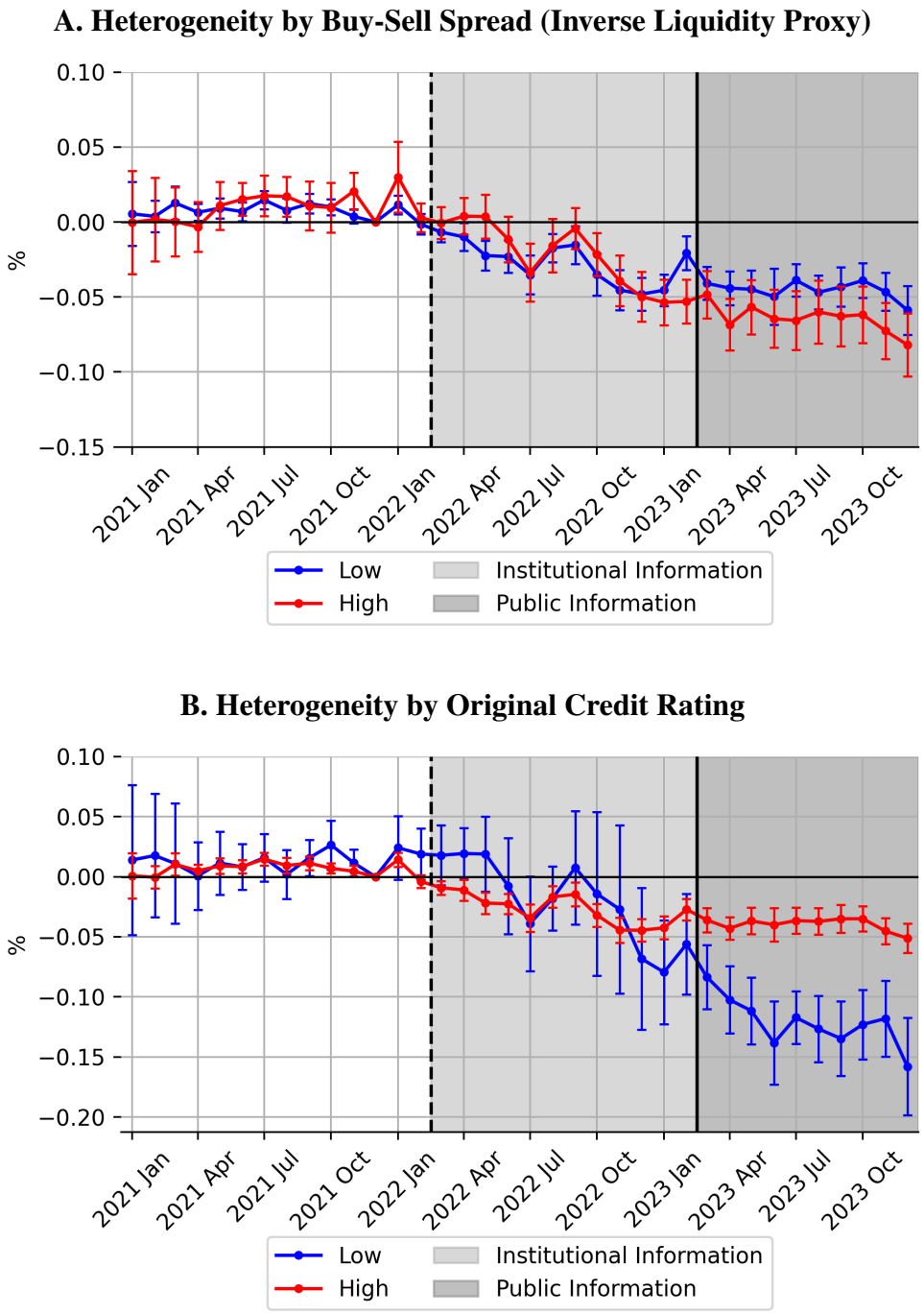


B. Newly Rated Non-Green Bonds that do not qualify as Ex Post Green, Sustainability, or Social Bonds



Note: This figure shows how the ESG-related information intervention impacts spreads for affected municipal bonds. In particular, we plot the coefficient estimates from the dynamic difference-in-differences regression specified in equation 1 that explains tax-adjusted spreads of municipal bonds relative to maturity matched treasuries. These coefficients describe how the pricing evolves for municipal bonds that were either labeled as ESG securities ex ante or were not eligible for such a label relative to municipal bonds that were not assessed. The light grey (middle) region denotes months when Kestrel ratings were available to select institutional subscribers. The dark grey (right) region denotes months when Kestrel numerical scores were disseminated widely through Bloomberg Terminals. Panel A shows marginal pricing coefficients for CUSIPs that did self-label as green, sustainability, or social bonds. Panel B includes all CUSIPs that did not self-label as green, sustainability, or social bonds but received at least a neutral score (3/5) on their Kestrel Total Weighted ESG Score. All controls and fixed effects from Table 2 are included in these specifications. 95% confidence intervals for standard errors two-way clustered on bond issue and month (issuer and month) are given by the red (blue) bars.

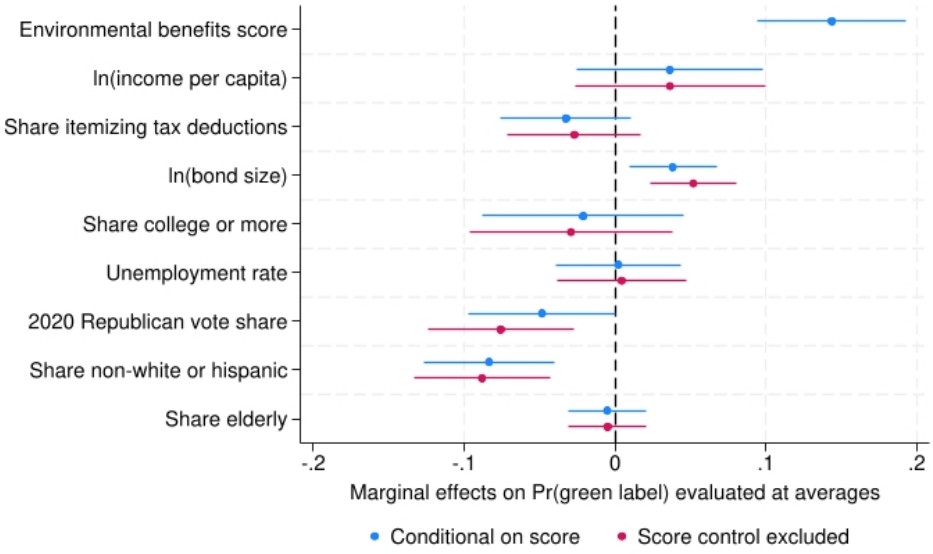
Figure 6: Newly Rated Bonds that Do Not Qualify as Green, Sustainability, or Social



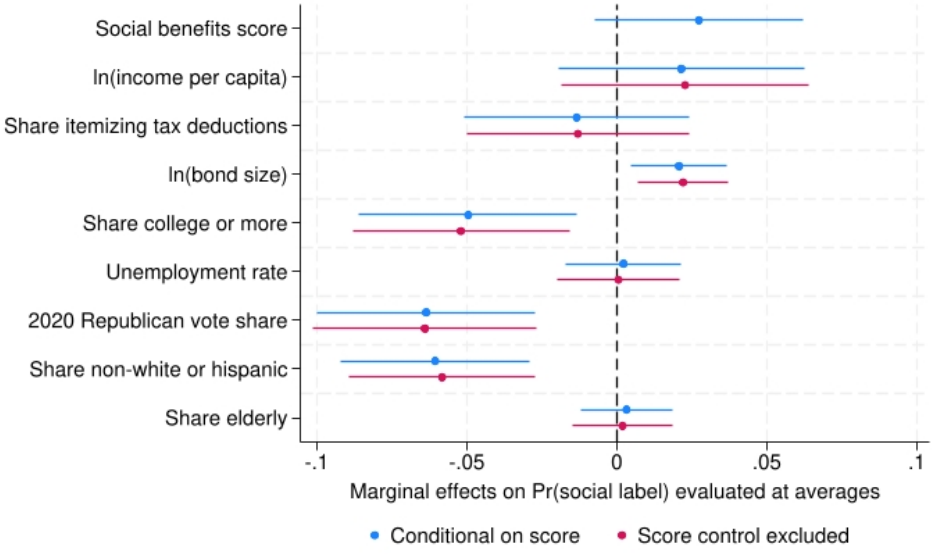
Note: This figure plots the results of the dynamic difference-in-differences regression specified in equation 1 conditional on a proxies of the liquidity risk and credit risk of the bonds. The sub-sample includes all CUSIPs that did not self-label as green, sustainability, or social and that did not receive a high enough rating from Kestrel on these characteristics in order to be eligible, ex-post. The light grey (middle) region denotes months when Kestrel ratings were available to select institutional subscribers. The dark grey (right) region notes when Kestrel ratings were disseminated widely through Bloomberg Terminals. Panel A presents estimates conditional on a proxy of liquidity—the spread between customer purchase and sale prices before March of 2022. We split the sample at the median and consider bonds with above median spreads as "high buy-sell spread," which are bond with low liquidity. Panel B presents estimates conditional on credit quality, measured by original credit ratings. Bonds with a Aa3 or better rating according to Moody's are considered to have a "high credit rating" (ratings from other agencies are converted to comparable categories using language of "high quality" and "very low credit risk"). Bonds with no credit rating are considered to be in the low credit rating category. All controls and fixed effects from Table 2 are included in these specifications. Coefficient estimates include 95% confidence intervals for standard errors two-way clustered by issuer and month.

Figure 7: Marginal Impacts on Bond Label Selection Likelihood Conditional on Eligibility

A. Green and Sustainability Bonds



B. Social Bonds



Note: This figure plots the the marginal effects on the likelihood of selecting a green, sustainability, or social bond label conditional on being eligible for such a label according to Kestrel's opinion. The estimates in each panel come from logistic regressions of an indicator equal to one for bonds that were issued with relevant labels while the sample is restricted to the set of bonds that Kestrel states are eligible for such a label. The demographic and economic control variables are measured at the local county level, or at the state level for state and state agency issuers. Controls are normalized to standard deviations with mean zero. The unit of observation is a bond package level (i.e. a series of bonds). Marginal effect estimates include 95% confidence intervals for standard errors clustered at the issuer level. The associated logistic point estimates from which we derive marginal effects for panel A are displayed in columns 5 and 6 of Table 3 and for panel B are displayed in columns 5 and 6 of Table 4.

Tables

Table 1: Characteristics of the bond-month transaction sample

	Mean	SD	Obs	25^{th}	50^{th}	75^{th}
Yield	2.32	1.30	1,131,123	1.09	2.58	3.18
Labeled or assessed	2.34	1.16	295,998	1.42	2.60	3.12
Not labeled, not assessed	2.32	1.34	835,125	1.00	2.56	3.20
Tax adjusted spread	0.38	0.43	1,131,123	0.12	0.31	0.58
Labeled or assessed	0.32	0.36	295,998	0.07	0.27	0.53
Not labeled, not assessed	0.41	0.45	835,125	0.14	0.33	0.60
Years to maturity	4.01	2.17	1,131,123	2.17	3.64	5.50
Labeled or assessed	4.48	2.21	295,998	2.64	4.24	6.09
Not labeled, not assessed	3.84	2.13	835,125	2.05	3.42	5.26
Coupon	4.38	1.19	1,131,122	4.00	5.00	5.00
Labeled or assessed	4.67	0.93	295,998	5.00	5.00	5.00
Not labeled, not assessed	4.27	1.25	835,124	4.00	5.00	5.00
Issue Size (Millions)	149.90	274.13	1,131,083	23.36	60.00	160.00
Labeled or assessed	291.49	361.77	295,978	81.26	167.76	350.08
Not labeled, not assessed	99.72	213.95	835,105	18.03	41.93	100.65
Monthly transaction volume	293,025	1,526,800	1,131,123	20,000	50,000	150,000
Labeled or assessed	471,892	1,965,879	295,998	30,000	85,000	250,000
Not labeled, not assessed	229,628	1,331,245	835,125	20,000	50,000	120,000

Note: This table shows the basic characteristics of the bond transactions that are included in our sample. This sample includes the universe of customer bond purchases reported in MSRB for bonds that have fixed coupons and that do not include call functions. We also restrict the sample to bond-months where bonds have been trading for at least 90 days and they have at least one year left before maturity. Yield is measured as yield to maturity for these bonds since they don't have call options. The tax adjusted spread compares after-tax returns on the muni transaction with a maturity matched treasury, assuming that the owner is a very high income individual in the state of issuance. This table, and our sample more broadly, does not include bond-months where we don't observe any trades.

Table 2: Pooled difference-in-differences estimates of information intervention on spreads

	Ex Post Green	Ex Post Social	Ex Ante Labeled	Ex Post Not Eligible
Institutional Information Period	-0.006	-0.004	0.022	-0.033***
	(0.005)	(0.004)	(0.017)	(0.006)
	[0.242]	[0.324]	[0.212]	[0.000]
Public Information Period	-0.028***	-0.010*	0.022	-0.055***
	(0.007)	(0.005)	(0.019)	(0.007)
	[0.000]	[0.051]	[0.264]	[0.000]
Observations	758950	758950	758950	758950
CUSIP Fixed Effects	Y	Y	Y	Y
State by tax by Month Fixed Effects	Y	Y	Y	Y
Maturity (Years) by Month Fixed Effects	Y	Y	Y	Y
Credit Rating by Month Fixed Effects	Y	Y	Y	Y
Issue Size Bins by Month Fixed Effects	Y	Y	Y	Y
Trade Size Bins by Month Fixed Effects	Y	Y	Y	Y
Liquidity by Month Fixed Effects	Y	Y	Y	Y
Coupon Bins by Month Fixed Effects	Y	Y	Y	Y

Note: This table displays pooled difference-in-differences estimates describing how the observed spread of certain types of municipal bonds change relative to other municipal bonds after the ESG-related information intervention. The institutional information period includes months from March 2022 through February 2023 and the public information period begins in March 2023. The outcome variable is the tax-adjusted spread relative to a maturity matched treasury weighted according to total par value traded. The unit of observation is a bond-month. Estimates in the first column correspond to how the tax adjusted spread changes for ex post green and sustainability bonds after information is shared with institutions in the first row and with public investors through Bloomberg in the second row. The second through fourth columns show analogous estimates for ex post social bonds, ex ante labeled bonds, and ex post newly rated ineligible bonds, respectively. Standard errors are presented in parentheses and are double clustered at the issuer and time levels, matching the larger standard errors from Figure 4. p-values are presented in brackets. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Logistic Model Estimates Describing Selection of Green and Sustainability Bond Labels Among Eligible Bonds

	(1)	(2)	(3)	(4)	(5)	(6)
Environmental score	1.253***	1.128***	1.219***	1.192***	1.107***	
	(0.201)	(0.195)	(0.193)	(0.192)	(0.198)	
	0.000	0.000	0.000	0.000	0.000	
ln(AGI per taxpayer)		0.195	0.467**	0.370	0.280	0.272
		(0.132)	(0.184)	(0.235)	(0.237)	(0.237)
		0.139	0.011	0.116	0.239	0.250
Unemployment Rate			-0.107	0.060	0.017	0.033
			(0.128)	(0.155)	(0.164)	(0.163)
			0.403	0.700	0.920	0.837
Share Itemizing			-0.542***	-0.287*	-0.250	-0.202
			(0.188)	(0.165)	(0.168)	(0.166)
			0.004	0.082	0.136	0.223
Share Hispanic or Nonwhite				-0.654***	-0.644***	-0.661***
				(0.165)	(0.164)	(0.166)
				0.000	0.000	0.000
Share Elderly				-0.106	-0.040	-0.036
				(0.098)	(0.101)	(0.099)
				0.278	0.693	0.715
Share College				-0.174	-0.163	-0.219
				(0.257)	(0.259)	(0.254)
				0.498	0.529	0.388
Share Republican				-0.350*	-0.373*	-0.568***
				(0.181)	(0.190)	(0.184)
				0.053	0.050	0.002
ln(Par Value)					0.294***	0.389***
					(0.109)	(0.104)
					0.007	0.000
Observations	2,197	2,170	2,170	2,170	2,170	2,170

Note: This table displays logistic regression estimates explaining the likelihood of labeling a bond issue as either green or sustainability conditional on being eligible for such a label in Kestrel's opinion. The unit of observation is a bond issue (i.e., a package of bonds issued in series). The demographic and economic control variables are measured at the local county level, or at the state level for state and state agency issuers. All control variables are normalized to standard deviations with mean zero. We display a version of these estimates that are rescaled to be interpretable as marginal effects at population average measurements in panel A of Figure 7. Standard errors are presented in parentheses and are clustered at the issuer level. p-values are presented below. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Logistic Model Estimates Describing Selection of Social Bond Labels Among Eligible Bonds

	(1)	(2)	(3)	(4)	(5)	(6)
Social score	0.268	0.267	0.273	0.510*	0.469*	
	(0.254)	(0.255)	(0.266)	(0.283)	(0.283)	
	0.290	0.296	0.305	0.071	0.097	
ln(AGI per taxpayer)		-0.073	0.368	0.487	0.369	0.388
		(0.140)	(0.293)	(0.363)	(0.360)	(0.362)
		0.603	0.209	0.180	0.305	0.284
Unemployment Rate			-0.011	0.068	0.038	0.010
			(0.186)	(0.163)	(0.170)	(0.178)
			0.954	0.677	0.824	0.957
Share Itemizing			-0.527	-0.253	-0.229	-0.221
			(0.352)	(0.324)	(0.329)	(0.324)
			0.135	0.436	0.486	0.496
Share Hispanic or Nonwhite				-1.008***	-1.037***	-0.991***
				(0.202)	(0.203)	(0.195)
				0.000	0.000	0.000
Share Elderly				0.007	0.055	0.033
				(0.121)	(0.134)	(0.146)
				0.954	0.681	0.821
Share College				-0.859***	-0.849***	-0.885***
				(0.284)	(0.296)	(0.292)
				0.002	0.004	0.002
Share Republican				-1.051***	-1.090***	-1.089***
				(0.236)	(0.244)	(0.250)
				0.000	0.000	0.000
ln(Par Value)					0.355**	0.376***
					(0.144)	(0.136)
					0.014	0.006
Observations	3,874	3,867	3,867	3,865	3,865	3,865

Note: This table displays logistic regression estimates explaining the likelihood of labeling a bond issue as a social bond conditional on being eligible for such a label in Kestrel's opinion. The unit of observation is a bond issue (i.e., a package of bonds issued in series). The demographic and economic control variables are measured at the local county level, or at the state level for state and state agency issuers. All control variables are normalized to standard deviations with mean zero. We display a version of these estimates that are rescaled to be interpretable as marginal effects at population average measurements in panel B of Figure 7. Standard errors are presented in parentheses and are clustered at the issuer level. p-values are presented below. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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Internet Appendix: Not For Publication

This appendix includes several sections of supplemental information. Appendix A contains definitions for all the variables used in the paper. Appendix B describes the Kestrel ratings and the related projects with several examples. We present additional robustness checks to the main results in Appendix C. We separately discuss bonds with the lowest Kestrel Total ESG scores in Appendix D and describe how and why our pricing model comparing with unrated munis may not fit such bonds well.

A Variable Definitions

Variable Name	**Description**
CUSIP	The 9-digit identifier that identifies individual bonds in both the MSRB transaction data and Mergent.
Month	The month in which a given bond trades. *Source:* MSRB
Issue	This is a variable that identifies groups of bonds identified by CUSIP that are all issued at the same time for the same purpose. *Source:* Mergent
Issuer	This is the name of the municipal entity that issues a bond. We use the *issuer_long_name* and *state* variables in Mergent in order to identify the issuer. *Source:* Mergent
State	The state in which the issuer resides. *Source:* Mergent
ICMA Eligibility	Kestrel rates each bond on a large number of margins and aggregates these ratings into opinions on eligibility of a green, sustainability, or social claim according to International Capital Markets Association standards documented in ICMA (2021) or ICMA (2023). *Source:* Kestrel
Existing bond label	Kestrel and Mergent both report whether bonds have any sort of self-selected label either by their own claim or by external verification. *Source:* Kestrel and Mergent
Ex Ante Labeled	This is an indicator variable that is equal to one for bonds thathave any label listed in either Kestrel or Mergent. This nests green, sustainability, and social bonds. *Source:* Kestrel and Mergent
Ex Post Green	This is an indicator equal to one if a bond is ICMA eligible as either a green or sustainability bond according to Kestrel's opinion and the bond is not ex ante labeled. These are bonds that receive new, positive information about their relative greenness with the initiation and availability of the Kestrel opinions to different types of investors and parts of the market. *Source:* Kestrel and Mergent

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Table A.1 – *Continued from previous page*

Variable	**Description**
Ex Post Social	This is an indicator equal to one if a bond is ICMA eligible as social bond according to Kestrel's opinion and the bond is not ex ante labeled. These are bonds that receive new, positive information about their relative social impact with the initiation and availability of the Kestrel opinions to different types of investors and parts of the market. *Source:* Kestrel and Mergent
Ex Post Not Eligible	This is an indicator equal to one if a bond is not ICMA eligible as green, social, or sustainability bond according to Kestrel's opinion and the bond is not ex ante labeled. These are bonds that receive new information about their relative greenness and social impact with the initiation and availability of the Kestrel opinions to different types of investors and parts of the market, but that information is not sufficient to meet international guidelines. *Source:* Kestrel and Mergent
Kestrel Environmental Benefits Score	This is the quantitative measure of greenness that is provided by Kestrel and reported publicly by Bloomberg. This is not a direct measure of ICMA eligibility, although it is correlated. We *Source:* Kestrel
Kestrel Social Benefits Score	This is the quantitative measure of social impact that is provided by Kestrel and reported publicly by Bloomberg. This is not a direct measure of ICMA eligibility, although it is correlated. *Source:* Kestrel
Kestrel Total Weighted ESG Score	This is the aggregated quantitative measure of environmental, social, and transparency benefits that are calculated by Kestrel and published in the first column by Bloomberg. This is not a direct measure of ICMA eligibility, although it is correlated. We restrict the primary sample to bonds that at least score a 3 out of Kestrel's 5 point scale. The bonds with lower scores are discussed in Appendix D. *Source:* Kestrel
Yield	The return that an investor will receive for an observed transaction. This is stated in terms of yield to worst, but we restrict the sample to non-callable bonds in the baseline analysis, so this is also equivalent to the yield to maturity in sample. *Source:* MSRB

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Table A.1 – *Continued from previous page*

Variable	**Description**
Tax-adjusted Yield Spread	Most municipal bonds are tax exempt at the federal and state level, while treasury bonds are only taxable at the federal level. For most bonds i with time to maturity m traded at time t that are exempt at the state and federal level, the $$\text{Spread}_{imt} = \text{muni yield}_{imt} - (1 - \tau_t^{Fed}) \times \text{treasury yield}_{mt}.$$ If the muni bond is taxable at the state and/or federal level, the yield is lowered accordingly. For state and federal tax rates, we use marginal individual rates at the first dollar after $1.5 million in earnings following Schwert (2017) and Garrett, Ordin, Roberts and Suárez Serrato (2023), which is the standard TAXSIM definition. For treasury rates, we use the reconstructed yield curves developed by Liu and Wu (2021). *Source:* MSRB, Mergent, TAXSIM, and Liu and Wu (2021)
Maturity	From the trade month, how many years will a bond be outstanding before it matures. The primary regressions use the floor of years to maturity from the time time trade to put bonds into groups. *Source:* Mergent and MSRB
Credit Rating	This is the lowest credit rating reported by any of the 3 major credit rating agencies (Moody's, S&P, and Fitch) at issuance. *Source:* Mergent
Issuance Size	The total par value of each bond issue (i.e., related bonds issued in series). *Source:* Mergent
Par Value	The total par value of each individual bond. *Source:* Mergent
Trade Size	Each transaction is reported with an amount of par value traded. The fixed effects in the primary specification average trade size for all transactions observed in each month and *Source:* MSRB
Liquidity	We define a proxy of liquidity as the spread between customer purchase prices and customer sale prices in each month. *Source:* MSRB
Coupon	Bonds pay a coupon rate that is reported in percentage points of par value. The measurement for the fixed effects in the primary specification puts transactions into deciles. *Source:* Mergent and MSRB
AGI per taxpayer	Total AGI at the county level divided by the number of returns filed. *Source:* 2021 IRS Statistics of Income
Share itemizers	Number of returns filed that itemize deductions divided by the total number of returns within a county. *Source:* 2021 IRS Statistics of Income

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Table A.1 – *Continued from previous page*

Variable	**Description**
Share elderly	Number of tax returns filed with the primary filer who is 60 or older divided by the total number of returns within a county. *Source:* 2021 IRS Statistics of Income
Share Republican	The 2020 vote share for the Republican presidential candidate at the county level. The denominator includes all votes submitted regardless of party. *Source:* MIT Election Data and Science Lab (2017)
Share Hispanic or nonwhite	This is the share of individuals of any age within a county who do not identify as white and non-hispanic. $1 - b01001h_001e/b01001_001e$ *Source:* 2021 ACS 5-Year Data
Unemployment rate	The number of unemployed individuals divided by the size of the local labor force. $b23025_005e/b23025_002e$ *Source:* 2021 ACS 5-Year Data
Share college	Number of inidividuals with a college or higher education divided by the number of individuals estimated for any education group. $b16010_041e/(b16010_002e + b16010_015e + b16010_028e + b16010_041e)$ *Source:* 2021 ACS 5-Year Data

B Examples of Bonds and Related Projects

Municipal bonds, which have more than 1.2 million CUSIPs outstanding issued by more than 30,000 municipal issuers, finance many different types of projects. Many of these projects are intended for the public good, but that doesn't necessarily mean that they meet ICMA guidelines to be labeled as green, social, or sustainability bonds.

In Figure B.1, we show what a small sample of the newly rated bonds look like on a Bloomberg Terminal. This screenshot of a random sample from the Kestrel ESG Universe, taken September 22, 2024, shows that investors can see the CUSIP, the state, issuers, purpose, BBG composite credit rating, total issue size, sale date, and the four categories of Kestrel ratings. The very furthest left column is a marker for self-selected green labeling. The "Kestrel Tot ESG" column highlights scores in green that are 4 or higher, but this does not mean that Kestrel's opinion is that the bond meets a labeling requirement by ICMA standards.

Figure B.1: Kestrel ESG Universe as Viewed on a Bloomberg Terminal



C Information Intervention Robustness Tests

In this appendix, we describe a series of robustness checks to the primary result that ex post green and sustainability bonds experience a decline in spreads relative to maturity matched treasuries after information is shared about their relative ESG-related characteristics and that the same pattern does not show up for social bonds. We separate robustness tests into categories: (1) robustness to sample construction, (2) robustness to control measurement decisions, and (3) robustness to outcome and other measurement decisions.

Robustness to Sample Construction and Inclusion

We display dynamic difference-in-differences estimates from additional specifications with different samples in Figure C.1.

We first test whether the inclusion of certain very large states as part of our estimation sample is driving our results. In panel A, we drop California, the largest liberal-leaning state in the US by bond issuance and by economic output. In panel B, we analogously drop Texas, which is the largest conservative leaning state in our sample by bond issuance and economic output. Texas also engaged in novel restrictions on municipal bond issuance insofar as it relates to local ESG outcomes and the related disclosure during the sample period in 2021 and 2022 (Garrett and Ivanov, 2024), which we do not want to contaminate our estimates of the market response to the information intervention from Kestrel and Bloomberg. In both panels, we find that the omission of the most economically important states that lean toward either side of the political spectrum does not impact our estimates. In both cases, we continue to find no differential pretrends, a long-run decrease in spreads for green and sustainability bonds, and no economically significant impact on the spreads of social bonds. The long-run spreads for ex post social bonds are negative and marginally statistically significant relative to the pre-period in a few months when omitting California, but the average magnitude is less than 1bp.

In panel C of Figure C.1, we adjust the sample to include callable bonds. For these bonds, we

measure spreads as after-tax "yield to first par call" minus the yield on a treasury that matures on the date at which the bond is first callable at par, which is generally the worst yield that an investor can receive. Following the existing literature such as Green, Hollifield and Schürhoff (2007) and Schwert (2017), we drop these callable bonds in the primary analysis because they include options that are not trivial to price and that may be subject to other issues including exercise at negative NPV (Ang, Green, Longstaff and Xing, 2017) or failure to exercise when value is maximized (Chen, Cohen and Liu, 2022). The MSRB therefore reports yields for callable bonds as "yields to worst," which estimates what the worst return an investor could get on a bond if it is called when possible. Our spread measure for callable bonds follows suit and is intended to approximate this yield to worst, which we then adjust for any relevant taxes and from which we subtract the after-tax yield on a treasury that matures at the same time. A shortcoming of such an approach is that the option value may be changing over time and across bonds in a way that we are not able to capture well with available data. Therefore, it is most appropriate to drop these bonds in the primary analysis and show robustness to their inclusion panel C of Figure C.1. When we include callable bonds, we find the same basic patterns: there is no differential pretrend for green, sustainability, or social bonds, but a 4bp greenium emerges for green and sustainability bonds after the information intervention. In this robustness check, we do find a similar but smaller premium for social bonds emerges as well. Including callable bonds does increase the uncertainty of our estimates substantially, especially in 2022 when interest rates were rising and the potential for mismeasurement of the option value of these callable bonds is largest.

Robustness to Control Variable Construction and Inclusion

We display dynamic difference-in-differences estimates from additional specifications with differently defined controls in Figures C.2 and C.3.

The baseline regressions described in equation 1 include a large number of fixed effects for bond characteristics interacted with time fixed effects to allow for differential time trends for bonds that fall in different observable categories. In panels A and B of C.2 we allow a parametric relationship to exist with respect to underlying continuous variables by including linear and higher order controls interacted with time fixed effects. In particular, we remove the issue size decile, coupon decile, and maturity (years) fixed effects interacted with monthly indicators and replace them with continuous variables interacted with time indicators. In panel A, the maturity, coupon and size interaction terms are linear. This approach uses all of the available continuous variation on these margins, and allows the pricing associated with each control to have a slope that varies by month. The other time varying fixed effects are all still included (state by taxability, credit rating, and trade size group). In panel B, we additionally include maturity squared and cubed, issue size squared and cubed, and coupon rate squared and cubed each interacted with month indicators so that the pricing impact is allowed to have curvature approximated by a third order polynomial. Both specifications continue to replicate the baseline results quantitatively: there are no differential pre-trends for spreads on ex post green, sustainability, or social bonds, and spreads decline for ex post green and sustainability bonds after the information intervention.

We add additional time varying controls to the baseline specification in C.3. In panel A, we add a direct control for linear modified duration interacted with time fixed effects. This allows duration risk to be priced more directly and for that price to vary by month. In panel B, we include fixed effects for the use of funds interacted with time fixed effects. This second panel allows for

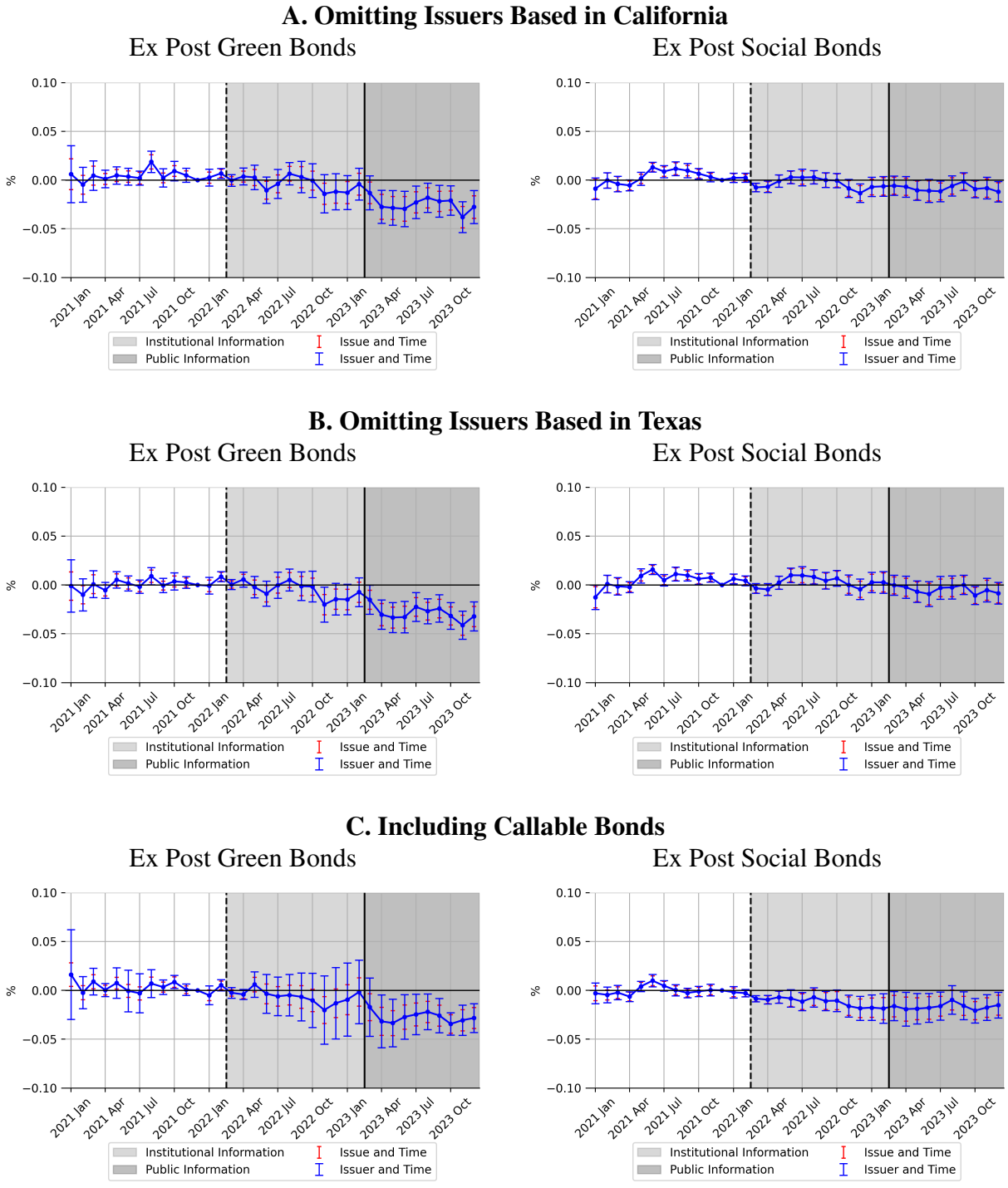
differential investor preferences by use of funds as measured beyond the ESG-related margins that Kestrel measures and Bloomberg reports. The use of funds categories are defined according to the Mergent data, with categories (1) general purpose, (2) education, (3) healthcare, (4) water and utilities, and (5) everything else.[13] Again, we find results that are in line with the baseline estimates in Figure 4, suggesting that our highly saturated model is already successfully capturing most of the relevant pricing factors.

Robustness to Outcome Variable Construction

We display dynamic difference-in-differences estimates from additional specifications with differently defined controls in Figure C.4. Our baseline model uses an after-tax spread of the municipal bond relative to a maturity matched treasury. This baseline measurement captures the after tax return that an investor requires to hold a muni over a risk-free asset. However, existing papers in the literature use different measures of the cost of borrowing including the pre-tax spread over maturity matched treasuries (muni yield minus treasury yield) or simply use the yield to maturity on the municipal bond. While the after-tax spread is the economically appropriate measure, we also show robustness to using the pre-tax spread and the unadjusted yield in panels A and B of Figure C.4, respectively. While the use of pre-tax spreads does shrink the estimated magnitudes of the green and sustainability bond premium slightly, the qualitative patterns are similar across all specifications.

[13] Each of these categories are author created using manual examination from the more granular use of proceeds categories in Mergent. General purpose includes *GPPI*. Education includes *HIED*, *EDEV*, *CSED*, *PSED*, and *OTED*. Healthcare includes *HOSP*, *NURS*, *OHCA*, and *CIVC*. Water and utilities includes *WTR*, *ELEC*, *AIR*, *GAS*, and *SANI*. Other includes all other use of proceeds categories.

Figure C.1: Sample Inclusion Robustness Tests

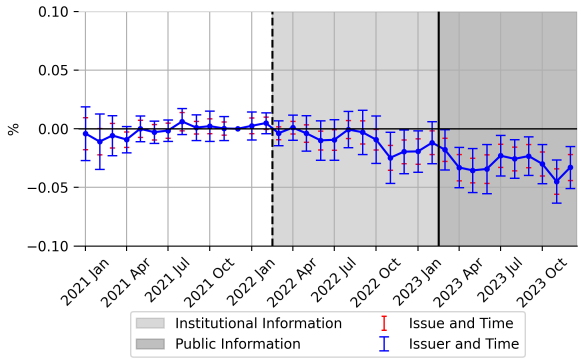


Note: This figure repeats the estimations given in Figure 4 for different samples. Panels A and B exclude California and Texas-based issuers, respectively. Panel C includes callable municipal bonds. 95% confidence intervals are shown for standard errors double clustered at the issue and time (red, inner) and issuer and time (blue, outer) levels.

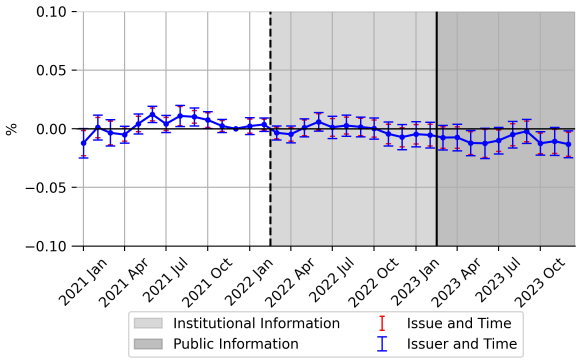
Figure C.2: Control Definition Robustness Tests, Variable Construction

A. Including time-varying continuous controls instead of FE

Ex Post Green Bonds

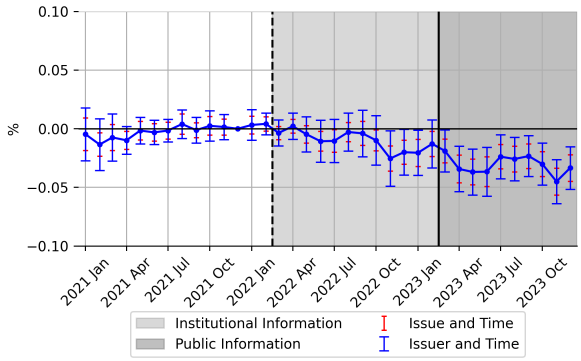


Ex Post Social Bonds

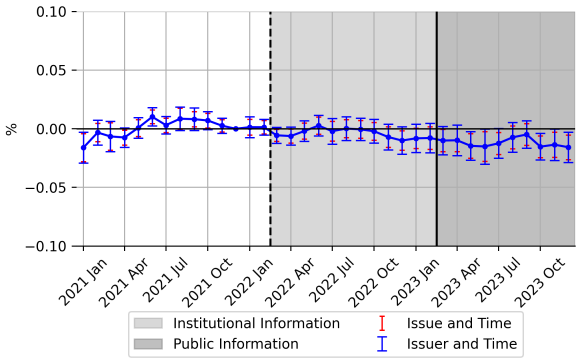


B. Including time-varying continuous controls allowing higher order (cubic) impacts

Ex Post Green Bonds

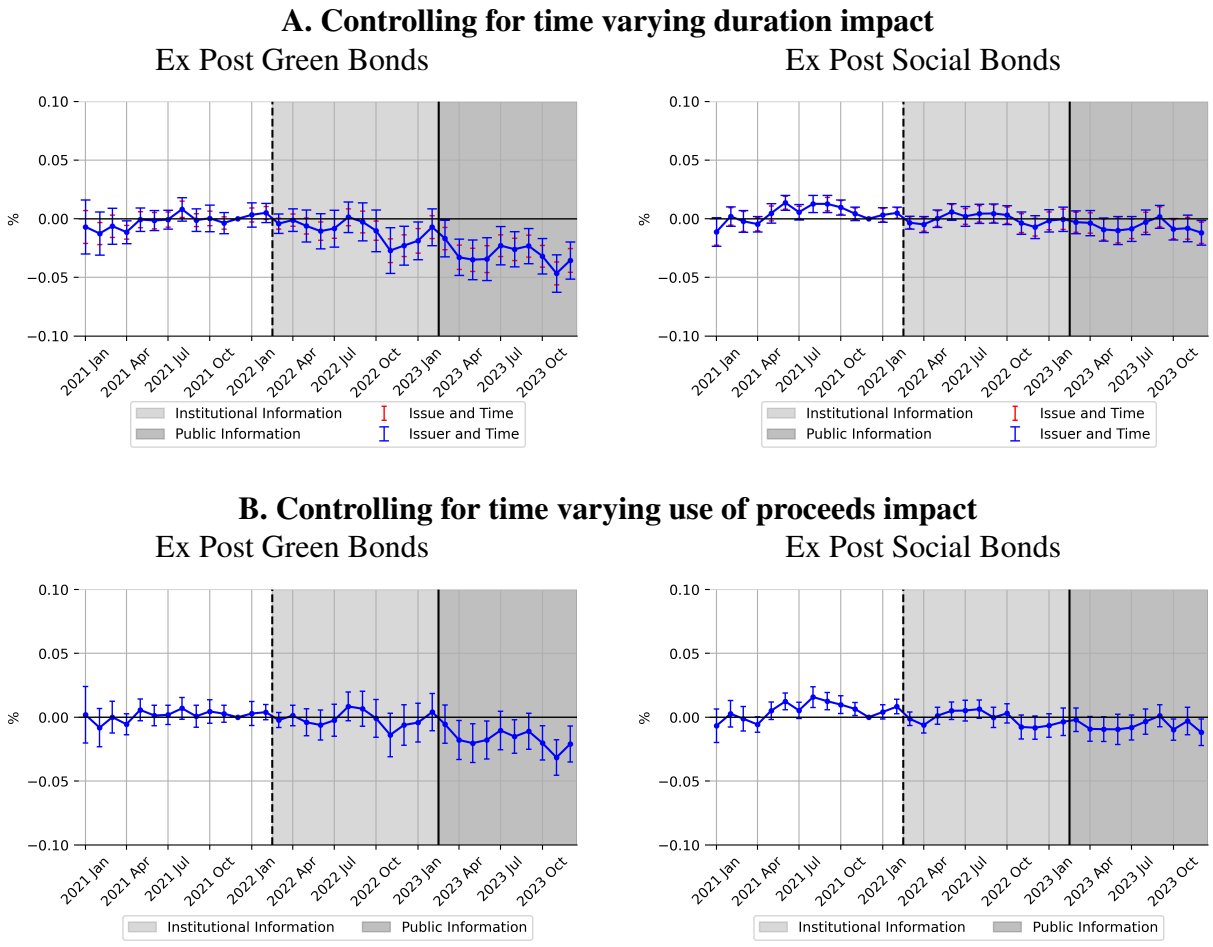


Ex Post Social Bonds



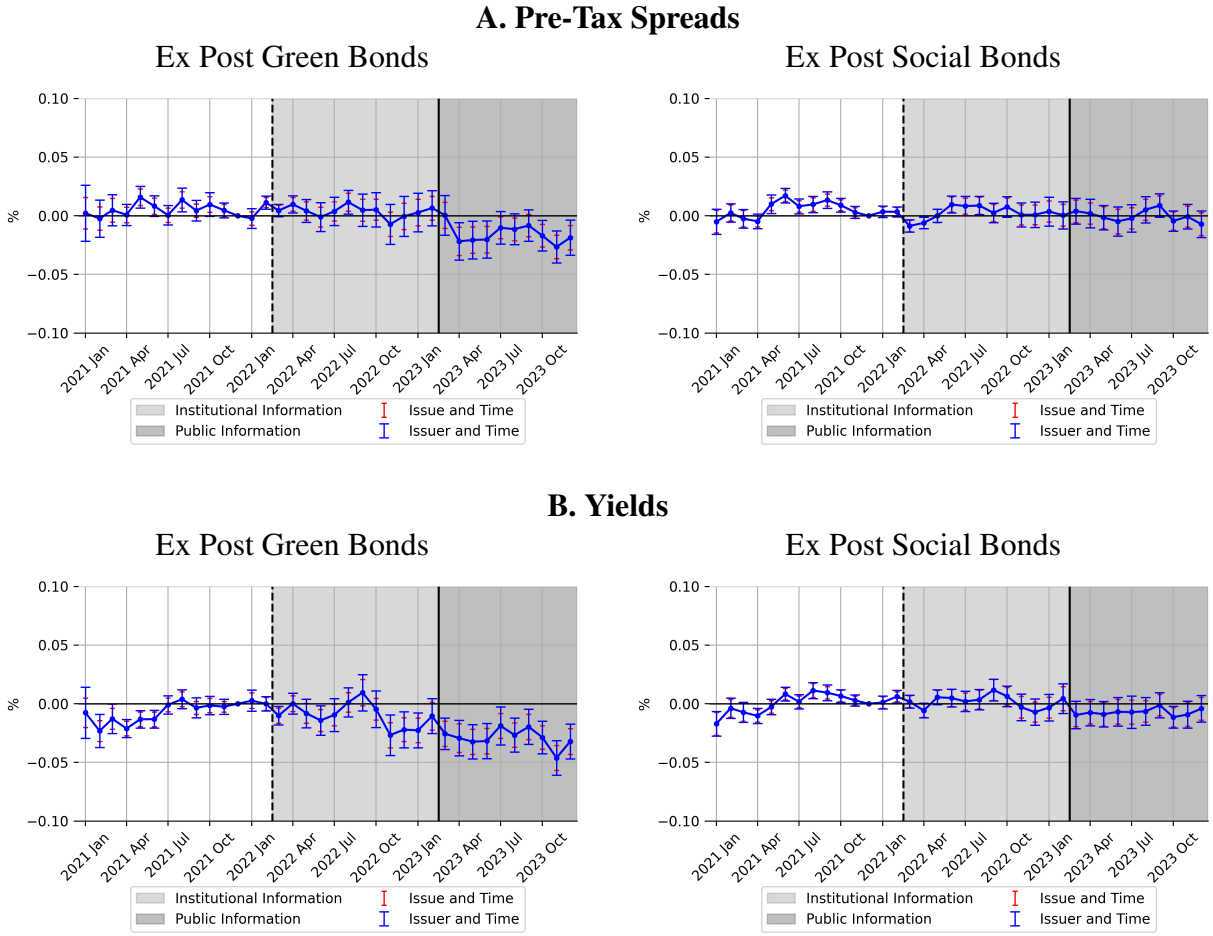
Note: This figure repeats the estimations given in Figure 4 but changes the functional form of controls. Panel A replaces fixed effects for issue size, coupon, and years to maturity with continuous control measures that are interacted with time fixed effects. Panel B follows the same specification as Panel A but includes the quadratic and cubic terms to allow non-linear pricing of each characteristic. 95% confidence intervals are shown for standard errors double clustered at the issue and time (red, inner) and issuer and time (blue, outer) levels.

Figure C.3: Control Definition Robustness Tests, Variable Inclusion



Note: This figure repeats the estimations given in Figure 4 but includes additional controls. Panel A adds a continuous control for modified duration interacted with time fixed effects. Panel B adds a control for the use of funds interacted with a time fixed effect. 95% confidence intervals are shown for standard errors double clustered at the issue and time (red, inner) and issuer and time (blue, outer) levels.

Figure C.4: Outcome Variable Robustness Tests

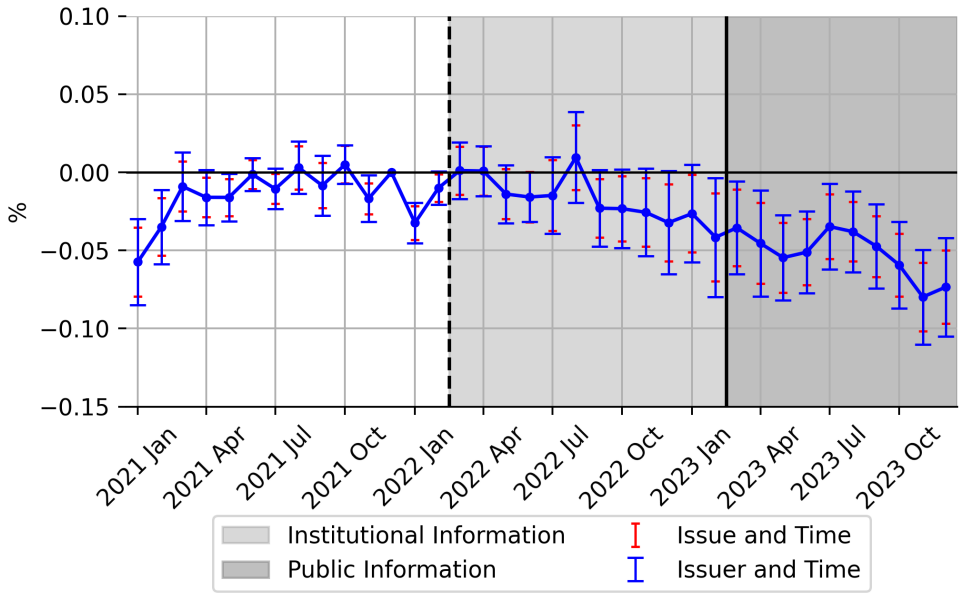


Note: This figure repeats the estimations given in Figure 4 but changes the dependent variable. Panels A replaces the monthly trade-size weighted average after-tax spread over a maturity-matched treasury with the monthly trade-size weighted average pre-tax spread over a maturity-matched treasury. Panel B uses the monthly trade-size weighted average yield. 95% confidence intervals are shown for standard errors double clustered at the issue and time (red, inner) and issuer and time (blue, outer) levels.

D Discussion of bonds with low ratings provided by Kestrel

In this appendix, we discuss the municipal bonds that Kestrel provides new ratings for that have composite ESG ratings less than 3 on their 5-point scale. Many of these bonds are observably different than the rest of the ex ante labeled, ex post eligible, or unassessed bonds. Many of these bonds are issued by local utility companies, either publicly owned or private issuers accessing private activity bonds, and they are directly involved in hydrocarbon business in in road construction. The Bloomberg "purpose" listing for many of these bonds are either *natural gas utility improvements* or *highway improvements*, of which there are relatively few bonds to estimate our model on these very small categories. This relative disconnect from the rest of the muni market makes our pricing model fit this sample of bonds poorly. We display the main specification, corresponding to Figure 4, for this sample of bonds that are not ex ante labeled but are assessed and receive very low scores. We find that this sample of bonds had tax-adjusted spreads that were trending differently than the rest of the municipal market in 2021, and thus we don't attempt to interpret the changes in spreads after the information intervention as causal.

Figure D.1: Main Specification, Bonds Receiving Information Intervention with Scores Below 3



Note: This figure shows how the ESG-related information intervention impacts spreads for affected municipal bonds. In particular, we plot the coefficient estimates from the dynamic difference-in-differences regression specified in equation 1 that explains tax-adjusted spreads of municipal bonds relative to maturity matched treasuries. These coefficients describe how the pricing evolves for municipal bonds who receive an ESG-related information intervention relative to those bonds that did not. The light grey (middle) region denotes months when Kestrel ratings were available to select institutional subscribers. The dark grey (right) region denotes months when Kestrel numerical scores were disseminated widely through Bloomberg Terminals. This figure shows the marginal pricing coefficients for bonds that are ex ante not labeled and that receive potentially negative ESG-related information. All controls and fixed effects from Table 2 are included in this specification. 95% confidence intervals for standard errors two-way clustered on bond issue and month (issuer and month) are given by the red (blue) bars.