SEARCH FRICTIONS AND PRODUCT DESIGN IN THE MUNICIPAL BOND MARKET

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Abstract. This paper shows that product design shapes search frictions and that intermediaries leverage this channel to increase their rents in the context of the U.S. municipal bond market. The majority of bonds are designed via negotiations between a local government and its underwriter. They are then traded in a decentralized market, where the underwriter often also acts as an intermediary. Exploiting variations in state regulations that limit government officials' conflicts of interest, we provide evidence that bond design from the government's perspective involves a trade-off between flexibility and liquidity, but the underwriter benefits from designing and trading complex bonds. Motivated by these findings, we build and estimate a model of bond origination and trades to quantify market inefficiency driven by underwriters' role in intermediating trades and discuss policy implications.

Keywords: Complexity, Decentralized market, Intermediaries, Negotiation, Product design, Revolving-door regulation, Search frictions, Vertical relations

1. Introduction

Search frictions are present in many markets, including real estate, used goods, healthcare, and over-the-counter financial markets. In these markets, the search process may be more costly for niche products, those with unique features that are hard to evaluate and decide on. Do some producers benefit from designing such products at the expense of consumers? If so, can policies remedy it and improve market efficiency? This paper studies these questions in the context of the U.S. municipal bond

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market, with a $4 trillion market capitalization, on which state and local governments rely to finance public infrastructure projects like schools and bridges. Lessons from our study can be applicable to other markets; for example, the proliferation of highly customized and increasingly complex products in insurance, annuity, and mortgage markets has recently ignited a policy debate concerning whether a standardization mandate could be beneficial (Aguilar, 2015; Bernard, 2016).

One of the prominent features of the municipal bond market is its relatively low liquidity. This is costly for issuing governments, who need to offer higher yields to compensate the investors for their bonds' low liquidity. The policy community, such as the US Securities and Exchanges Commission, considers the complexity of municipal bonds as one of the culprits for the low liquidity. The simplest bonds only specify the length of maturity and fixed interest rate paid on a semiannual base, but many include nonstandard provisions to introduce features such as floating interest rates and unique redemption clauses. On the one hand, these provisions introduce flexibility valuable for the government. For example, redemption clauses may allow the government to refinance its debt at a low rate. On the one hand, the provisions are difficult to price and assess, increasing trading frictions for investors. This paper studies whether municipal bond design resolves this trade-off between flexibility and liquidity efficiently. In this respect we offer an important contribution to the policy debate on how to lower the cost of investment in public infrastructure, much needed to update the overstretched U.S. infrastructure that was built decades ago.

How the aforementioned trade-off in bond design is resolved depends on the origination process. Most municipal bonds are issued via negotiation, where an issuing government and an underwriter negotiate over bond design and the terms of sale. An underwriter is typically an investment bank, whose primary role is to purchase the entire bond from the government and resell it to investors. The underwriter is often also a leading intermediary in the trading market of the bonds it issues, since it can exploit its information on who initially purchased its bonds and who owns them to more easily locate interested investors (O'Hara, 2011). This advantage can be more pronounced when a bond is more complex and requires more involved communications with a potential new buyer. For this reason, an underwriter may benefit from adding nonstandard provisions to a bond by improving its competitive advantage over other intermediaries in the trading market. Our paper investigates how this incentive may affect bond design and shape search frictions.

We combine rich issue-level data with proprietary transaction-level data for bonds issued by local governments, such as county or city governments, school districts, or other special-purpose governments, via negotiation in 2010–2013. Using this data, we document key empirical patterns regarding the incentives of government officials and underwriters when negotiating over bond design. Here we face an empirical challenge: there may be unobserved factors that determine bond design, and also directly affect market outcomes. To address this challenge, we exploit variation in state-level conflict-of-interest regulations targeting government officials, across time and states. We argue that, while not directly affecting the demand for municipal bonds, these regulations may affect the incentives of government officials when negotiating with an underwriter, reducing the latter's influence over bond design. Given that gifts and political donations are regulated at the federal level, we focus on revolving-door practices, where a government official takes a job upon leaving office at a firm related to his/her work while in office. These practices are regulated at the state level, typically by setting a "cool-off" period during which such employment is not allowed. Using a difference-in-difference approach, we find that adopting revolving-door regulations in a state, especially those targeting local officials, reduces prevalence of nonstandard provisions in bonds issued by the local governments by 6% on average.

Exploiting revolving door regulations as an instrument, we provide evidence for the trade-off between flexibility and liquidity involved in bond design, focusing especially on the prevalence of nonstandard provisions. We find that the flexibility introduced by these provisions is valuable for the government, since adding these provisions in a bond decreases its default risk. However, they increase trading frictions that investors face, possibly raising the government costs. Do underwriters have an incentive to complicate bond design? We show that when a bond includes more nonstandard provisions, the underwriter intermediates a larger share of the bond's trades and reaps a higher gross profit, measured as the difference between the value of bonds sold and purchased, from the secondary market. These results, combined with the finding that revolving-door regulations reduce nonstandard provisions, illustrate that underwriters benefit from these provisions.

These empirical findings point to a potential distortion in bond design that increases trading frictions and the government's cost of paying debt. To quantify the extent of this distortion and its implications for the welfare of each market participant, we build and estimate a model of bond design and decentralized trading with intermediaries. In the model, a forward-looking underwriter and a government official, who acts on behalf of a bond-issuing government, negotiate over the bond's price, the coupon rate, and its complexity, driven by nonstandard provisions. The underwriter then buys the bond at the agreed price and resells it to investors and other dealers. Investors and dealers trade the bond in continuous time until its maturity. The underwriter's payoff is the profit from the initial resale and intermediation of subsequent trades of the bond. The payoff of the government official reflects the cost of paying the (endogenous) interest and returning the principal to investors. This cost is allowed to differ by the bond's complexity, in order to capture the benefits of flexibility afforded by nonstandard provisions. In addition, the official may partially internalize the underwriter's payoff, depending on revolving-door regulations.

In this model, a dealer chooses the rate at which to meet investors, given a search cost. Search costs and the bond's valuations by investors and dealers may depend on the bond complexity, as well as other observed and unobserved attributes such as the coupon rate and the financial health of the issuer. This feature of the model adds to the literature on product design and search frictions, which studies how product design may change with the extent of search frictions.[1] Our model, however, treats search frictions as endogenous: we allow for the various provisions in a bond, which are determined at origination, to directly affect a dealer's costs of finding investors and helping them learn whether that bond suits their financial goals. Anecdotal evidence from the industry suggests that it is easier for a dealer to trade a bond with an investor if they have already traded it. In light of this, we allow a dealer's search costs to depend on the size of its client network, which we measure by its cumulative trade. Note that the model is agnostic about whether and how bond complexity affects the incentives of underwriters, investors, and issuers. Our structural analysis, employing this flexible model, helps us understand and quantify these incentives.

To estimate the model, we follow a multi-step strategy. First, we estimate bond-specific dealer costs and investor demand by matching the predicted trading prices and quantities to their counterparts in the data and by exploiting the optimality in the endogenously chosen rate of meeting for each dealer and the observed timing of trades. Second, we estimate how these model primitives depend on bond attributes, including endogenous ones—the coupon rate and complexity— using the revolving-door regulations as instruments. Importantly, this approach enables us to incorporate

[1]See Bar-Isaac, Caruana and Cuñat (2012); Menzio (2021); Albrecht, Menzio and Vroman (2022).

rich unobserved heterogeneity. Third, we rely on the first order conditions characterizing the equilibrium coupon rate and complexity to estimate the preferences of government officials involved in the negotiations, including both the marginal cost of paying bond obligations and the extent to which these officials internalize the underwriter's payoff during negotiations.

The model estimates reveal that trading frictions in the market are sizeable. For a median bond, the average dealer's search costs amount to 10% of its gross profits. Moreover, we find that there are strong network effects in search. These network effects create a cost advantage for the underwriter, whose exclusive initial sales lower its own search cost by 21% compared to that of an average dealer. This result is striking because, absent the network effects, the underwriter would have higher search costs compared to other dealers: for 72% of the bonds in our estimated sample, the underwriter's search cost, before its initial sales, is higher than the median dealer, who tends to have more prior local trading experience than the underwriter. Another notable finding is that collusion between the underwriter and the government officials, if any, is negligible when a revolving-door regulation is in place.

The estimates also allow us to isolate the impact of bond design on search costs, investor demand, and government costs. We find that nonstandard bond provisions increase search costs for dealers, including the underwriter. However, these provisions also magnify the benefit of a large client network when searching for investors, and thus the value of underwriters' initial sales. The demand estimates suggest that complex bonds are niche products that investors "either love or loathe": complexity increases the dispersion of investor valuations, with little changes in the average valuations. Lastly, we find that the government cost of paying back an extra dollar to investors is convex in bond complexity and is 42% larger when a median bond is stripped off of all its nonstandard provisions, reflecting the value of flexibility.

We study a "standardization mandate", under which a bond is not allowed to include any nonstandard provisions. The direct effect of this policy is an increase in market liquidity, which enables the issuer to decrease the coupon rate from 2.81% to 2.16%, leading to a saving of 7.8% of the total debt payments. Moreover, this policy increases the investor surplus by 13.3%, despite the decrease in interest payments, reflecting investors' preferences for liquid assets. However, such a stark, one-size-fits-all policy ignores the benefits of nonstandard provisions in providing flexibility, and the marginal cost of paying back to an investor increases by 41%. These results speak to the broader debate on standardization in financial markets, highlighting the trade-off between flexibility and liquidity.

Next, we consider two policies intended to reduce underwriters' influence over bond design. First, the issuer sets the level of bond complexity to minimize the total cost of debt payment, anticipating the negotiations with the underwriter on the coupon rate. In line with the result of the first policy, we find that the resulting bond does have some nonstandard provisions, but not as many as in the baseline. The results suggests that this policy can benefit both taxpayers and investors by lowering government costs, including the amount of interest, and improving market liquidity. Second, we quantify the impact of banning underwriters from participating in the bond's trading market six months after origination. This ban reduces the underwriter's incentive to distort bond design, leading to a reduction in the number of nonstandard provisions. This, in turn, lowers the interest rate and government costs. However, the ban has an important downside: limiting the underwriter's ability to leverage the information acquired during the initial sales lowers liquidity, offsetting the benefits of having a less complex bond.

Related Literature. The paper focuses on the incentives of underwriters to increase search frictions by adding various nonstandard provisions at origination. The idea that producers may benefit from an increase in search costs is not new (Diamond, 1971). One way of raising search costs is to make shopping complicated, difficult, or confusing as documented by Ellison and Ellison (2009) in the context of online retail practices, and Ellison and Wolitzky (2012) argue that engaging in such obfuscation practices can be individually rational.[2] In financial markets, evidence suggests that more complex retail products yield higher markups to the banks that issue them (Célérier and Vallée, 2017) and lower realized returns to investors (Ghent, Torous and Valkanov, 2019). Our paper contributes to this literature, by providing consistent empirical findings in the context of the municipal bond market.

In addition, we shed a light on a novel mechanism explaining why market participants might want to increase frictions. While the extant literature has focused on competition among producers, we study competition among intermediaries, and show that nonstandard bond provisions help position the bond's underwriter at an

[2]See also Bonelli, Buyalskaya and Yao (2021), which studies product differentiation of mutual funds.

advantage, compared to other dealers. In this regard, we also contribute to the literature on how vertical relations affect product design (Asker and Bar-Isaac, 2014; Ho and Lee, 2019; Hristakeva, 2019).

We show that this novel mechanism is amplified when government officials' private interests are aligned with those of the underwriter, exploiting time-varying state-level regulations on revolving-door practices. These findings add to the literature on conflict of interest in financial markets (Lucca, Seru and Trebbi, 2014; DeHaan, Kedia, Koh and Rajgopal, 2015; Shive and Forster, 2017; Egan, 2019; Egan, Matvos and Seru, 2019; Bhattacharya, Illanes and Padi, 2019; Tenekedjieva, 2020).

Lastly, our methods relate to the literature on the structural analyses of decentralized asset markets (Gavazza, 2016; Allen, Clark and Houde, 2019; Pinter and Uslu, 2022). Our model for over-the-counter (OTC) market is based on Üslü (2019), which incorporates (time-varying) heterogeneity across dealers and investors that hold continuous, unrestricted amounts of assets. These features are not only empirically relevant, but also important for understanding liquidity in the market, a key part of the trade-off determining bond design.

2. Institutional Background: Designing Municipal Bonds

When designing a bond, its issuer has various options, from employing a simple bond with a fixed interest rate and maturity date to a more complex version with several nonstandard features, such as flexible maturity periods through call options, and variable or floating interest rate, to name a few. This practice is not limited to municipal bonds; corporations and other government agencies such as Fannie Mae and Freddie Mac issue bonds that incorporate nonstandard features listed above (Edwards, Harris and Piwowar, 2007). The present section discusses a key trade-off when designing a bond: including a nonstandard provision may reduce the financial cost of paying back the bond's principal and interest, while complicating bond valuation which may, in turn, increase trading frictions and reduce the value of the bond at origination, possibly raising the interest cost for the issuing government (Harris and Piwowar, 2006; Wang, Wu and Zhang, 2008). We then describe who designs a municipal bond and how, and two important factors—the underwriter's dual role and conflicts of interest—in the bond issuance process that may distort bond designs.

2.1. **Trade-offs: Flexibility vs. Liquidity.** An issuing government can include nonstandard features when designing a bond to introduce flexibility in paying its debt. As an example, a call provision allows the issuer to redeem bonds before the maturity date under stated conditions. A sinking fund provision, which requires that the issuer retire a specified portion of debt each year by purchasing it on the open market, helps the issuer spread the costs of retiring bonds over time, as opposed to making one large payment at maturity. Another example is to set a nonstandard interest payment schedule, which may help balance the issuer's cash flows.

Such flexibility gains from nonstandard provisions may come at a cost. In particular, nonstandard features may make it costly to understand the risks associated with a bond's cash flows, thus complicating pricing and making the trading process difficult for investors. Anecdotally, purchasing a municipal bond often entails meetings between an investor and a sales representative at a dealer firm. During such a meeting, the investor learns about the bond attributes, how they affect the bond's market value, and how they interact with his financial needs and the risk of his portfolio. When a bond includes more nonstandard provisions, these meetings become more lengthy and involved, thus increasing trading frictions.

The notion that nonstandard provisions can adversely affect liquidity has been brought up in the policy community. For example, the following excerpt from a 2014 speech of a then-commissioner at the US Securities and Exchanges Commission (SEC), Michael S. Piwowar, illustrates it lucidly:

> "Despite the potential benefits of increased standardization for both investors and issuers, municipalities continue to issue exceedingly complex bond offerings. [...] improvements to liquidity from issuing simpler bonds should result in higher valuations and lower issuance costs. These factors alone should help drive the municipal bond market towards greater standardization rather than into the complexity that we see in current issuances."[3]

In turn, low liquidity can increase the issuer's interest costs to the extent that investors value their resale opportunities. Investors typically buy and hold municipal bonds until maturity, but many sell them before maturity as their value get adjusted due to, for example, changes in interest rates of other securities.[4] In addition, changes in the investor's financial circumstances or tax considerations can also trigger sales.

[3]The speech was made at the 2014 Municipal Finance Conference presented by The Bond Buyer and Brandeis International Business School.

[4]According to a Moody's report, "US Municipal Bond Defaults and Recoveries, 1970-2016," the 10-year cumulative default rate is 0.15% for rated municipal bonds, and is 10.29% for rated global corporate bonds.

Thus, a bond's low liquidity must be compensated by its high yields, leading to high interest costs to its issuer.

In the municipal market, the negative effects of nonstandard, complex bond features on liquidity can be pronounced for two reasons. First, pricing municipal bonds is nontrivial because trades occur in an over-the-counter market with a relatively low frequency. The average daily trading volume in 2019 is $11.5 billion, about 0.3 percent of the market size. Second, individual investors are dominant and the cost of collecting and processing information on bonds is likely to be higher for individual investors than institutions. Out of $3.7 trillion municipal bond outstanding in 2012, a large fraction (74%) is owned by individual retail investors, through both direct investment in individual municipal securities (45%) and indirect investment via mutual funds and exchange-traded funds (29%).[5] This is in part because most municipal bond interest payments are exempt from federal and state income taxes (for in-state residents), as well as local income taxes in some cases. These tax advantages are attractive to individual investors, especially those who fall into high tax brackets, while lowering yields to institutions. This point relates to the importance of dealers' knowledge of potential buyers or sellers in this market. An industry textbook, O'Hara (2011), describes how salespeople in a dealer firm facilitate trades by offering their clients the right security to match client needs, given their knowledge on client portfolio and goals.

2.2. **Who design bonds and how?** The issuing government is primarily involved in designing a bond issue, determining maturity structure, redemption provisions, security provisions, and other features. At origination, an underwriter (or the syndicate of underwriters) purchases the entirety of the bonds and undertake initial marketing. Depending on the mode of sale—a competitive bidding or negotiation— the underwriter can also play a substantial role in designing the bond issue. In a competitive sale, the issuer designs a bond issue prior to posting a notice of sale. Upon the notice, financial institutions may bid to purchase the bond issue as is, and the one providing the lowest interest cost gets awarded the bonds. In a negotiated sale, the issuer selects an underwriter without (sealed) bidding, but typically through a (competitive) request for proposal process, and sells the bonds directly to the underwriter.[6] As

[5]The rest is owned by banks and insurance companies (10% and 12% each). These statistics are based on the "Financial Accounts of the United States" by the Federal Reserve.

[6]In a negotiated sale, the criteria for selecting an underwriter can include subjective factors such as the quality of proposal, credentials and experience. In addition, the underwriter's prior experience with similar projects and/or the issuing government can also be a factor.

we describe below, in this type of deals, the underwriter is heavily involved in bond design. This study focuses on negotiated deals. Negotiated sales are prominent and growing in relevance: in 1975, 40% of the $29.3 billion bond issues were negotiated; in 2005, 81% of the $408 billion issues were negotiated (Feldstein and Fabozzi, 2008).

In negotiated sales, prior to purchasing the bonds, the underwriter usually spends several months during which it negotiates with the issuer and/or its financial advisor, pricing the bonds and deciding which attributes to include in the bonds. This way, the bonds are designed to meet the demands of the underwriter and its clients, as well as the needs of the issuer. During this process, the underwriter may seek orders by investors to buy the bonds through a presale, before their terms have been fully set, which may help the underwriter and the issuer gauge the demand and establish the final bond pricing and terms.

We find that for negotiated deals the underwriting market is fairly concentrated, especially for smaller issuers.[7] Regardless of issue sizes, repeat relationship between an issuer and an underwriter is common: we find 41% of bonds issued in 2011–2017 were handled by an underwriter who had underwritten another bond of the same issuer in the past five years. Repeat relationship may not necessarily imply favoritism, and may reflect the value of local presence as an underwriter, driven by factors such as informational advantage on issuers, individual investors, and other intermediaries who could assist in the placement of the securities (Butler, 2008).

2.3. **A Potential Source of Distortion: the Underwriter's Dual Role.** This study focuses on negotiated deals, where the underwriter of an issue determines bond designs. We argue that underwriters may prefer more nonstandard provisions in a bond than issuers and their taxpayers because of their dual role: they participate both in the origination process and in the secondary market as dealers. According to US Government Accountability Office (2012), the top 10 underwriting firms underwrote over 70% of primary market volume in 2010–11, and these top 10 broker-dealer firms executed about 55% of secondary market trades during the same period. The revenues from the secondary market are not negligible compared to the underwriter fee: the average underwriter's fee on negotiated bonds in 2012 is 0.54% of the face value of a bond (Braun, 2015), and the average dealer markups on round-trip transactions

[7]The mean state-level Herfindahl-Hirschman index (HHI) per year during 2006–2017 is 0.12, and top 3 firms in a state cover 45% of the market on average. Many underwriters with the largest market share in a state are renowned investment companies, operating across states (e.g., Citigroup, JP Morgan, etc.). When focusing on relatively small deals only (less than $10 million), we find the market becomes more concentrated: mean HHI is 0.24, and top 3 firms covering 64% on average.

as estimated by Li and Schürhoff (2019) based on data from 1998–2012 is 2%. It is notable that underwriters do not have a fiduciary duty to their issuer clients, although they must deal fairly with and not deceive or defraud their clients.

In this market, electronic trading is not widespread. Therefore, if one wants to buy or sell a municipal bond through secondary market, it is typical to use dealers who are familiar with the bond, especially the (lead) underwriting firm, which has information on who bought the bonds at origination and who owns the bonds long after the issue date (O'Hara, 2011). This advantage of the underwriter as a dealer in the secondary market may be larger as the bond is more complex. A part of trading costs for dealers is time and efforts to educate and persuade their investor clients (Feldstein and Fabozzi, 2008), and the additional costs associated with a complex bond can be higher for dealers other than the underwriter because they are more likely to face investors who do not own or even are unaware of the bond.

2.4. **Conflict of Interest and Revolving-door Regulations.** Bond design may also be affected by the incentives of the government officials involved in bond issuance. The officials may not necessarily represent the interests of taxpayers, and one possible reason is that they may be captured by the underwriters.[8] Besides gifts and political donations, underwriters may also influence government officials through "revolving-door" practices, i.e., hiring them when they leave office. These practices may benefit the underwriter through two channels: first, the implicit or explicit promise of a lucrative job in the private sector can be essentially equivalent to a bribe; second, firms may have special access and inside information or connections to sitting government officials via their government hires. Some ex-government officials are hired for government relations. For example, some of the registered lobbyists hired by financial companies in the 2010 Chicago lobbying records include bankers involved in municipal bond underwriting with a prior government experience, as a Cook County Treasurer or a Program Coordinator at the Illinois Development Finance Authority.[9]

It is notable that regulations of revolving-door practices differ across states, while regulations of gifts and campaign contributions are governed by federal institutions

[8]We abstract away from the conflict of interest between underwriters and financial advisors. A financial advisor may help an issuer select and monitor the underwriter. Moreover, in rare cases (below 0.2% in our sample) a financial advisor also serves as an underwriter.

[9]Quantitative studies on municipal government lobbying are very scant. For example, we reviewed the list of lobbyists registered in the city of Chicago in 2010 and obtained a lobbyist's employment history at LinkedIn. Out of twelve lobbyists hired by financial companies involved in municipal bond underwriting, we find that three previously worked at the local government.

(the MSRB, the FINRA, and the SEC).[10] Specifically, some state laws restrict a former public officer or employee from engaging in lobbying activities on a matter in which he was involved while in office for a period of time, typically one or two years, after leaving public service. We exploit variations of state-level revolving-door regulations across states and time and study how these affect negotiations between underwriters and officials of the bond issuing government.

3. Data

We draw data on bond attributes from Mergent and transaction data from Municipal Securities Rulemaking Board (MSRB). We complement these data with various attributes of the bond issuing government, sourced from multiple databases. We obtain government finances from the Census, demographic and economic attributes of the residents associated with the issuer from the American Community Survey, and political environment measured by the voting records for the recent Presidential elections from CQ Press Voting and Elections Collection. Lastly, based on Ethics and Lobbying State Law and Legislation Database by National Conference of State Legislatures, we compile state revolving-door regulations.

3.1. **Scope of the Study.** We focus on tax-exempt general obligation or revenue bonds, issued in 2010–2013 by local governments, which were sold via a negotiation process. We follow all secondary-market transactions of these bonds during 2010–2014. By focusing on negotiated bonds, we study the role of underwriters in the determination of bond design and search frictions in the secondary market. Out of 26,623 issues of tax-exempt general obligation or revenue bonds by local governments during the period of study, 55% of them (14,582) were sold via a negotiation, 42% (11,208) via a competitive bidding, 1% (320) via other methods such as a private placement, and the sale method for the rest (2%, 514) is not specified. We further narrow down our sample by focusing on bond issues with at least one trade in the secondary market, leading to the final sample of 13,118 bond issues, with the total face value $266.9 billion, in nominal USD.

3.2. **Summary Statistics and Bond Complexity.** Table 1 presents summary statistics of the key variables used in our analyses for the final sample of 13,118 bond

[10]MSRB Rules G-20 and G-37 regulate municipal securities dealers' giving gifts to government officials and campaign contributions. These rules are enforced by the FINRA and the SEC, and based on the FINRA's online database since 2005, we identify 43 cases violating these two rules.

Table 1. Summary Statistics

	Mean	SD		Mean	SD
Key issue attributes			*Underwriting*		
Face value (in million USD)	20.345	53.878	Number of underwriters[c]	153.11	59.61
Maturity (in years)[a]	8.366	4.335	Repeat underwriter[d]	0.349	0.477
Revenue bond	0.208	0.406	Hiring a financial advisor	0.516	0.500
Newly issued (vs. refunding)	0.250	0.433	HHI, financial advisors[c]	0.153	0.081
Interest rate (in %)[a]	2.960	1.045	Offering price[a]	102.70	9.395
Nonstandard, complex features			*Trading*		
Multiple bonds in an issue	0.972	0.166	Intermediation spread[e]	0.012	0.022
Call options	5.017	5.227	Number of active dealers[f]	30.88	32.94
Sinking fund provisions	0.931	1.735	Underwriter market share[e]	0.122	0.240
Nonstandard interest frequency	0.007	0.099	Underwriter gross profit[e]	1.752	5.526
Variable/floating interest rate	0.028	0.306	Credit watch events[e]	0.074	0.303
Num. of nonstandard features	6.953	5.937	*Revolving-door regulation*		
Complexity index[b]	1.463	0.456	Affecting state officials	0.829	0.376
			Affecting local officials	0.281	0.450

Notes: This table is based on the 13,118 negotiated issues of general obligation or revenue bonds with any secondary market trades originated by local governments in 2010–2013. *a*. When an issue contains multiple bonds, we take a simple average across the bonds within the issue. *b*. This index is the simple average number of nonstandard provisions (in terms of call and sinking fund provisions, as well as interest payment frequency and type), plus a dummy indicating that the issue includes multiple bonds. *c*. To measure the market competition, we look at all bonds issued by the state for three calendar years prior to the origination of a given issue. *d*. This variable indicates that an underwriter of an issue underwrote at least one of the bonds issued by the same issuer within five years prior to the issue. *e*. These variables are the outcome variables in the regressions discussed in Section 4.2. See the respective section for the definition of each variable. *f*. We count the number of dealers appearing as a trading party of any transactions regarding a given issue within three years since its origination.

issues. The average size of capital raised by a bond issue is $20.3 million, and the length of maturity is on average 8.4 years. Most bonds are backed by the credit and taxing power of the issuing government; the rest, 21%, are supported by the revenue from a specific project. The funds raised by 25% of the bonds in our sample are for new money, while the rest is for refunding. The average coupon rate is 2.96%, slightly higher than the average 10-year treasury rates during the same period, 2.54%.

A bond issue, on average, comprises with 12.1 bonds with different maturities and attributes. Following Harris and Piwowar (2006), we focus on five different bond attributes that are particularly difficult to price and evaluate for investors: (i) multiple or serial bonds (as opposed to a single bond) per issue, (ii) provisions that allow the government to redeem or "call" the bond, (iii) sinking fund provisions,

(iv) interest payment frequencies other than every six months, and (v) a floating or variable interest rate. We call these features "complex" or "nonstandard." Table 1 shows that most issues (97%) include multiple bonds. Call options are relatively common, in the sense that over 5 bonds within an issue have call provisions on average. On the other hand, provisions on sinking fund or nonstandard interest rates are less common. We construct the *complexity index* of a bond by computing the average number of the latter four provisions across the bonds within the issue, and then adding a dummy indicating that the issue includes multiple bonds.

4. Motivating Evidence

This section explores the trade-off addressed by bond design: nonstandard provisions lower the default risk for the issuing government, while increasing trading frictions for investors. We argue that this trade-off is not the only driver determining bond design and is potentially distorted by underwriter's incentives. Specifically, we show that adding nonstandard provisions to a bond increases its underwriter's market share and gross profits as an intermediary in the secondary trades of the bond, illustrating the underwriter's incentive to influence bond design. Our analysis relies on an instrumental variable approach that exploits panel variation in state-level conflict-of-interest regulations targeting government officials, and the validity of this approach is discussed in Section 4.1.

4.1. **Bond Design and Revolving-door Regulations.** To identify the causal impacts of nonstandard bond provisions on market outcomes, we rely on an instrumental variable framework based on panel variation in revolving-door regulations. Revolving-door regulations may reduce the underwriter's sway over the officials who negotiate on behalf of the government at origination, thus reducing the underwriter's influence over bond design. Through this channel, these regulations may affect bond design.

Between 2010 and 2013, three states, Arkansas (2011), Indiana (2010), and Maine (2013), enacted legislation regulating post-government employment of state officials. During the same period, two states, New Mexico (2011) and Virginia (2011), expanded the set of officials subject to their existing revolving-door regulations to include local officials, in addition to state officials.[11] We construct two dummy variables capturing the scope of the revolving door legislation in place: LocalReg_i indicates there was a

[11]See Appendix B.1 for the five pieces of state legislation on regulating post-government employment.

revolving-door regulation covering local government officials when bond i was issued, while StateReg_i indicates the presence of a regulation covering state officials.

To document the impact of revolving-door regulations on bond design, we estimate the following regression model:

$$\log(s_i + 1) = \beta_1 \text{LocalReg}_i + \beta_2 \text{StateReg}_i + \gamma \mathbf{X}_i + \kappa_{c(i)} + \theta_{t(i)} + \epsilon_i, \qquad (1)$$

where $\mathbf{X}_i$ includes the face value, the maturity length, the security type (general obligation or revenue), the type of the issuing government (county, city, school districts, or other special districts), and variables representing or related to the financial health of the issuing government, such as the government's revenue-to-expenditure ratio and local unemployment rate. We denote the county where the issuing government is located by $c(i)$ and the monthly period of the issuance by $t(i)$. As for the outcome variable, s_i, we employ the complexity index, as described earlier in Section 3. Our coefficients of interest, β_1 and β_2, represent the change in the extent of bond complexity for the average bond issued after the regulation came into effect, controlling for observed bond attributes, county fixed effects, and year-month time fixed effects.

The results, displayed in Table 2, show that limiting revolving-door practices, in particular of local officials, decreases bond complexity by 6%.[12] The effect of revolving-door regulations only targeting state government officials is smaller (2% vs. 7% in Column 3), and statistical significance vanishes with more control variables (Column 4). Note that state officials are not directly involved in the bond origination negotiations, although they can indirectly influence the negotiations by, for example, state budget allocations to local governments.

This finding is consistent with the idea that revolving-door practices may reduce the degree of collusion between underwriters and government officials, as long as including nonstandard provisions in a bond benefits the underwriter, possibly at the expense of the issuing government and its taxpayers.[13] In Appendix B.3 we provide additional evidence for this mechanism by showing that the impact of these regulations intensifies with an underwriter's sway over the government officials, and with its rent from underwriting more complex bonds.

[12]This result is robust to using alternative measures of bond complexity, where we weigh each of the five components considered in the complexity index, s, differently. All components of the complexity index tends to decrease with the regulations, individually (Appendix B.2). It is also robust to controlling for linear state-specific time trend.

[13]This finding motivates our model where revolving-door regulations can, in equilibrium, affect bond design. Appendix D.1 provides a further discussion on our modelling choice, and D.2 discusses comparative statics that revolving-door regulations reduce the level of complexity in bonds.

Table 2. Do Revolving-door Regulations Affect Municipal Bond Design?

	Bond complexity index (log)			
	(1)	(2)	(3)	(4)
Local officials regulated	-0.072***	-0.064***	-0.073***	-0.064***
	(0.012)	(0.013)	(0.012)	(0.013)
State officials regulated			-0.020***	-0.010
			(0.008)	(0.010)
Bond attributes[a]	Yes	Yes	Yes	Yes
Issuer financial health attributes[b]	No	Yes	No	Yes
Year-month FE, County FE	Yes	Yes	Yes	Yes
Number of observations	13,118	13,086	13,118	13,086
R^2	0.645	0.647	0.645	0.647

Notes: This table reports OLS estimates, based on the negotiated issues of general obligation or revenue bonds with any secondary market trades originated by local governments in 2010–2013. Standard errors are adjusted for clustering at the state level, and are provided in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. *a*. Bond attributes include the logarithm of the total face value, fixed effects for the maturity length at the year level, two dummy variables on the type of assets to pay the debt (limited general obligation and revenue, relative to unlimited general obligation, respectively), and a dummy indicating whether the issue is new or refinancing. We also include dummy variables on the issuer type (city, school districts, and other special-purpose governments). *b*. Issuer attributes related to its financial health include demographic and economic variables at the county level (median household income, senior population, poverty rate, population growth rate, unemployment rate) and government finance variables (the average and standard deviation of annual government expenditures, the fraction of taxes in government revenue, and the fraction of government revenue sourced from federal and state governments.)

Below, we use changes in revolving-door regulations as instruments to explore the incentives of issuers and underwriters at origination. This approach may not be valid if state revolving-door regulations directly affect local government officials' work morale or composition, which in turn can influence investors' demand. However, Table A5 in Appendix B.4 shows that revolving-door regulations have no effects on the credit ratings of bonds issued prior to regulations (Column 1), the annual amount of bond issuance (Column 2), and the maturity length or the method of sale conditional on issuance (Columns 3–4), implying that these regulations do not affect governments' risk management or bond issuance beyond the negotiated terms. In addition, given our argument that regulations can limit underwriters' influence in bond negotiations, the design for auctioned bonds must not vary with the regulations because underwriters cannot directly affect bond design for such bonds. This is confirmed by Table A6 in Appendix B.5, which shows the OLS results based on the specification of (1) for auctioned bonds. Moreover, Appendix B.4 shows that there is no evidence of a pre-trend in bond complexity associated with revolving-door regulations (Figure A1).

4.2. **Incentives in Bond Design.** As discussed in Section 2.1, nonstandard provisions in a bond may provide the issuing government with flexibility in payments, but may result in higher trading frictions to investors, leading to an increase in interest costs to the issuer. This section provides empirical evidence on this trade-off, and then presents suggestive evidence that the underwriter's participation in the bond's intermediation market might create incentives to influence bond design.

Our analysis relies on the following model:

$$y_i = \beta_s \log(s_i + 1) + \beta_r r_i + \gamma \mathbf{X}_i + \kappa_{c(i)} + \theta_{t(i)} + \epsilon_i, \tag{2}$$

for different market outcomes y_i. To address the endogeneity of bond design we estimate a 2SLS specification that treats the complexity index, s_i, and the coupon rate, r_i, as endogenous bond attributes. We instrument these variables using the two revolving-door regulation dummy variables, interacted with county/state-level attributes inspired by the heterogeneity in the effects of revolving-door regulations as documented in Table A4. To control for different time trend depending on these county/state attributes, we include their interaction with year-month fixed effects. In addition, we control for issuer and bond characteristics, as well as county and year-month fixed effects, as in (1).

We begin studying whether the flexibility introduced by nonstandard provisions in a bond can reduce its default risk. To this end, we estimate specification (2) using as the outcome variable y_i the number of negative "credit watch" incidences during the first five years after origination, that is when the Standard & Poor's rating agency detects an event or a trend that is likely to result in lowering the credit rating. We use these negative credit events as a proxy for default risk because defaults are extremely rare in this market (Footnote 4). In our sample, on average a bond experiences 0.074 negative credit events for the first five years of its life-cycle (Table 1). Columns (1)–(2) of Table 3 show the OLS and 2SLS estimates of the model, respectively. The results in Column (2) reveal that nonstandard provisions have a substantial impact on the bond's default risk: a 1% increase in the bond complexity index lowers the number of negative credit incidences by 0.002, which corresponds to a decrease of 3% over the mean, 0.074.

Next, we look at the impact of nonstandard bond provisions on trading frictions faced by investors. We estimate (2) using as an outcome variable the bond's intermediation spread: the logarithm of the average dealer-to-investor sale price minus the logarithm of the average dealer-from-investor purchase price. Intuitively, a bond's

Table 3. Trade-off in Bond Design for Government Cost

	Number of negative rating events[c]		Intermediation spread[d]		Underwriter's Market Share[e]	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)
Complexity index (log)	0.034	-0.243**	0.009**	0.046**	0.082**	0.368**
	(0.034)	(0.091)	(0.002)	(0.018)	(0.022)	(0.181)
Coupon rate	Yes	Yes	Yes	Yes	Yes	Yes
Bond attributes[a]	Yes	Yes	Yes	Yes	Yes	Yes
Issuer financial health attributes[a]	Yes	Yes	Yes	Yes	Yes	Yes
Year-month FE, County FE	Yes	Yes	Yes	Yes	Yes	Yes
Heterogeneous time trend[b]	Yes	Yes	Yes	Yes	Yes	Yes
Number of observations	13,008	13,008	11,078	11,078	11,807	11,807
First stage F-stat	-	16.18	-	10.5	-	9.7

Notes: This table reports both OLS and 2SLS estimates, based on the negotiated issues of general obligation or revenue bonds with any secondary trades originated by local governments in 2010–2013. The instruments include dummy variables for revolving-door regulations, interacted with the Herfindahl-Hirschman index for the market of financial advisors at the state level, with the fraction of secondary transactions by individual investors at the state- and security-type level, with the length of the maturity, as well as with whether or not the state government is under divided control (executive vs. legislative or two chambers of the state legislature). Standard errors are adjusted for clustering at the state level, and are provided in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. a. These controls are identical to those in Table 2. b. We include year-month FEs interacted with the county/state-level attributes used for the instruments. *c.* The "negative rating event" refers to a "credit watch" incidence associated with a probable downgrade of the bond's credit rating during the first five years after origination, as detected by the Standard & Poors. *d.* The "intermediation spread" is the logarithm of the average dealer-to-investor sale price minus the logarithm of the average dealer-from-investor purchase price. *e.* The "market share" is defined as the ratio of the underwriter's purchases from investors to all dealers' purchases from investors within four years after origination.

intermediation spread measures the cost for an investor to participate to the bonds' trading market; this is the amount of money an investor would lose if they were to buy and immediately sell a bond. In our sample, the average intermediation spread is 0.012 or 120 basis points (Table 1). This is large, compared to the bid-ask spread of corporate bonds in 2010–2013, 30-60 basis points (Figure 13 of Mizrach (2015)).

Columns (3)–(4) of Table 3 present the OLS and 2SLS estimates. The estimated coefficient for β_s presented in Column (4) indicates that increasing the complexity index from its average value (1.46) to the 75th percentile (1.69) raises the bond's intermediation spread by 17 basis points, corresponding to a 14% increase over the average. Moreover, Columns (1)–(2) of Table A7 in Appendix C show that nonstandard provisions also reduce a bond's volume of trade. Column (5) of the same table presents the impact of revolving door regulations on the offering price, consistent with the observation that lower liquidity increases interest costs for the issuing government (Ang, Bhansali and Xing, 2014; Schwert, 2017).

A bond's underwriter tends to be a dominant player in the bond's intermediation market long after its initial sale: Table 1 shows that the underwriter's market share for a given bond is 12.2% on average. We next study if the underwriter's role as an intermediary can create incentives to distort bond design. To this end, we estimate (2) using as outcome variable the underwriter's share in the market for secondary transactions of bond i.[14,15] Columns (5)–(6) of Table 3 show the coefficient estimates using OLS and 2SLS, respectively.

Column (6) indicates that increasing the complexity index from its average value (1.46) to the 75th percentile (1.69) raises the underwriter's market share by 1.4 percentage points, corresponding to an increase of 11% compared to the average.[16] In the primary market, the underwriter has the unique advantage of learning about the investors' interests in a bond before other dealers have a chance to do so. The results suggest that this knowledge can give the underwriter a sizable edge for complex bonds, enabling it to quickly locate potential buyers and sellers and increase its market share vis-a'-vis other dealers. Note, however, that the underwriter may not necessarily benefit from raising its market share, if it coincides with a smaller market size. Columns (3)–(4) of Table A7 in Appendix C show that the underwriter's profits from intermediation also increase with bond complexity.

In summary, our results point to a potential distortion in bond design driven by the underwriter's incentives, and suggest that such a distortion affects investors and the issuing government through search frictions and cost of paying debt. Our structural analysis quantifies the extent of this distortion in bond design and its welfare implications.

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[14] Appendix A.4 describes the procedure to identify trades by an underwriter of a bond.

[15] We focus on all dealers' purchases of the bond from investors within four years after the bond's origination. The reason why we focus on purchases, not sales, is that underwriter may be a big seller to investors in the secondary market simply because it is selling its remaining inventory from the primary market. Using an alternative window does not qualitatively affect the results.

[16] This estimate is larger than the counterpart OLS estimate in Column (5) of Table 3, implying there are omitted factors that are negatively correlated with the complexity of bonds. For instance, when the underwriter has sizeable market power, the incentive for further solidifying the power by adding more nonstandard provisions might be smaller.

5. Model

This section presents our model of bond origination and trading. At origination, an underwriter and an official acting on behalf of the government negotiate over the bond's design, interest rate, and price. In exchange of the payment, the underwriter is awarded the entire face value of the debt. After origination, the dealers (including the underwriter) engage in costly search to meet investors for trading in a decentralized market. Upon meeting, dealers and investors bargain over trading price and quantities. We assume that the negotiation process both at origination and bond trades are represented by Nash bargaining.

The model reflects several key features of the municipal bonds market as highlighted in Section 4. We allow for bond design to influence investor's flow payoff, to affect search frictions in the trading market, and to provide valuable flexibility to the issuing government. This rich model is motivated by the empirical findings in Section 4.2, and enables us to unpack and quantify the mechanism through which bond complexity affects market outcomes. Moreover, the underwriter's payoff at origination depends on the profits from both initial sales and the subsequent trades as an intermediary. In view of the evidence presented in 4.2, this feature of the model allows us to study whether underwriters' incentives distort bond design, and if so, helps us to measure the extent and the welfare implications of such distortion. Finally, given the findings in Section 4.1, the model accounts for government officials' incentives to maintain a collusive relationship with the underwriter. The officials in the model may weigh in the underwriter's profits during negotiation at origination.

Our model for bond trading in the over-the-counter (OTC) market is based on Üslü (2019), which we modify in two dimensions. First, to account for the fact that bonds are traded until their maturity, we consider a finite-horizon model. Second, we assume that dealers choose their meeting rates by exerting costly efforts, as opposed to treating them as exogenously given. With this feature, we study the relationship between bond attributes and liquidity in equilibrium.

5.1. **Setup.** Consider a municipal government contemplating an issuance of a bond of size $A \in \mathbb{R}_+$, maturity $T \in \mathbb{R}_+$.[17] An underwriter and an official acting on behalf of the government negotiate over the purchase price, $F \in \mathbb{R}_+$, the expected interest rate, $r \in \mathbb{R}_+$, and the extent to which the bond contract includes various nonstandard

[17] Consistent with the evidence in Section B.4, we assume the bond amount and maturity are exogenously determined by the government's finances and the nature of the infrastructure project.

provisions, summarized by an one-dimensional index, $s \in \mathbb{R}_+$.[18] In exchange of the payment of F, the underwriter is awarded the entire bond.

We allow for rich heterogeneity across bonds and issuers. In particular, the key parameters and equilibrium objects may depend on various issuer and bond-specific attributes, in addition to (A, T, s, r), such as the overall financial solvency of the issuer and the projected revenue streams of the infrastructure project for which the bond is issued. Note that some of these attributes are not necessarily observed or easily measurable by the researcher. Thus, we assume that, although all issuer and bond attributes are known to market participants, the researcher does not observe all of them. To the extent that the underwriter and issuer factor in the unobserved attributes when designing the bond, accounting for them is important in understanding the effects of bond design on the market outcomes. We denote the exogenous attributes observed by the researcher, including (A, T), as $\mathbf{x} \in \mathcal{X} \subset \mathbb{R}^{dim(\mathbf{x})}$. The unobserved attributes related to the trading market by the multidimensional vector $\xi_M \in \mathbb{R}^{dim(\xi_M)}$ and those related to the issuing government's cost of paying the interest and the principal by $\xi_G \in \mathbb{R}$. For brevity, $\xi \equiv (\xi_M, \xi_G)$.

In the negotiations at origination, the government's bargaining power is represented by ρ_G. The outside options for the government and the underwriter, denoted as $J_G(\mathbf{x}, h)$ and $J_U(\mathbf{x}, h)$, are common knowledge. We normalize the cost of underwriting to zero.[19] The underwriter's payoff in these negotiations is the value from the initial sales and the subsequent trades of the bond, $V_U(s, r; \mathbf{x}, \xi_M)$, minus the price paid to the government:

$$V_U(s, r, \mathbf{x}, \xi_M) - F. \tag{3}$$

The issuer uses F to finance its projects, and bears the cost of paying the principal A and the interest rAT:

$$c_0(s, \mathbf{x}, \xi_G)A(1 + rT). \tag{4}$$

The coefficient $c_0(s, \mathbf{x}, \xi_G)$ represents the minimal attainable marginal cost to make the bond payments. This can be different from one and may vary with the bond

[18]Here, we abstract away from the issuing government's decision concerning the mode of sale, which is largely determined by local regulations and external factors (see Cestau et al. (2017), for example). Relatedly, we find that revolving-door regulations, while affecting bond design, do not affect the choice of sale (Table B.5). This suggests that the counterfactual policies considered in Section 8 are robust to endogenizing this decision. Moreover, we abstract away from the choice of the underwriter.

[19]As long as the cost of underwriting and the underwriter's outside option do not depend on endogenous bond attributes, (s, r), this normalization is without loss of generality because the underwriting cost does not affect negotiation at origination.

attributes for two reasons. First, movements in the cash flow of the issuing government affect the marginal cost of debt payment. As an example, the cost of making a payment is larger when the issuer has less cash available. By the same token, c_0 can also depend on the bond complexity s, since nonstandard provisions allow the issuing government to postpone or advance the future payments depending on their reserves. For example, the option of calling back (a part of) the debt allows the government to exploit an (unexpected) increase in its cash holdings as well as lower market interest rate than the bond's rate. Second, government officials may not fully internalize the cost of future payments, funded by taxpayers.

We allow for the government official to take into account the underwriter's payoff from trades. Specifically, we assume that the official's payoff is a weighted sum of the payoff of the government and the underwriter's value of the bond, with a weight representing her collusive relationship with the underwriter, denoted by $\psi \geq 0$. We allow that the weight, ψ, may vary with the presence of revolving-door regulations, denoted by a dummy variable $h \in \{0, 1\}$. The official's payoff is

$$F - c_0(s, \mathbf{x}, \xi_G)A(1 + rT) + \psi(h)V_U(s, r, \mathbf{x}, \xi_M). \tag{5}$$

This specification is guided by the empirical regularities documented in Table 2. As discussed in Appendix D.2, under this specification, the equilibrium bond design depends on ψ, thus revolving-door regulations.[20]

In the trading market, there is a large population of investors and dealers, each represented by a point in an interval with measure $m_I(\mathbf{x}) > 0$ and $m_D(\mathbf{x}) > 0$. Once the bond is issued, investors meet dealers and trade in continuous time with finite horizon $[0, T]$. Let τ denote the time remaining until the maturity of the bond, that is $\tau = T - t$. Note that in $\tau = T$ (or $t = 0$), the underwriter owns the entirety of the bond. All agents discount payoffs at rate δ.

Dealers and investors receive flow utility from holding the bond before maturity. The flow payoff of a dealer from holding $a \in \mathbb{R}$ unit of the bond before the maturity, denoted by $v_D(a, s, r, \mathbf{x}, \xi_M)$, is:

$$v_D(a, s, r, \mathbf{x}, \xi_M) = \nu_D(\mathbf{x}, \xi_M) \log(r)a - \kappa_D(\mathbf{x}, \xi_M)a^2, \tag{6}$$

[20] An alternative model would allow the official to take into account the underwriter's entire payoff, $V_U(s, r, \mathbf{x}, \xi_M) - F$, subject to a constraint on F. This constraint reflects that a particularly low bond price, F, may draw attention from watchdogs. Appendix D.1 shows that this model is observationally equivalent to our model, which is simpler and computationally more convenient.

where $\nu_D \log(r)a$ reflects the payoff from receiving the interest payments, given the coupon rate r measured in basis points and flow utility parameter $\nu_D > 0$. We assume that the flow utility is concave in r to capture the issuer's solvency problem and risk associated with a high coupon rate. We capture factors constraining dealers' ability to expand their asset holdings by $\kappa_D \geq 0$.

Similarly, investors' flow payoff from holding the bond, given the coupon rate r, depends on their taste type, $\nu \in \mathbb{R}_+$, and is specified as:

$$v_I(a, \nu, s, r, \mathbf{x}, \xi_M) = \nu \log(r)a - \kappa_I(\mathbf{x}, \xi_M)a^2. \tag{7}$$

At each instant the investor draws a new type with probability $\alpha(\mathbf{x}, \xi_M)$, from a distribution $F_{\nu|(\tau,s,\mathbf{x},\xi_M)}$. The taste type distribution can depend on bond design: some bond attributes may increase or decrease investors' average valuations of a bond, while other attributes may influence the dispersion of valuations, appealing to a niche or "mass market" (Johnson and Myatt, 2006). The payoff of holding a bonds at the end of the maturity is $\omega_I a$ for an investor and $\omega_D a$ for a dealer.[21]

Dealers meet investors and other dealers to trade. Upon meeting, the Nash bargaining weights for determining trading prices and quantities are ρ_D and $\rho(\mathbf{x}, \xi_M)$, respectively, for inter-dealer and investor trades. Note that the assumption of Nash bargaining implies that the negotiated quantity maximizes the joint gain between the two trading parties, and the price divides of the gain. The rate at which dealers meet each other, $\lambda_D(\mathbf{x}, \xi_M)$, is exogenously given and is constant across the dealers and over time. On the other hand, the rate at which a dealer meets an investor, λ, is chosen by each dealer at costly search efforts.

A dealer's cost of meeting investors at rate λ is:

$$\phi_0 \exp[-\phi_1(s, \mathbf{x}, \xi_M) \log(b)] \exp(\lambda), \tag{8}$$

which depends on two components. The first component captures pre-existing dealer-specific cost (dis)advantage: $\phi_0 \geq 0$ is a search cost type, which each dealer draws from

[21]We abstract away from directly modeling the portfolio problem that investors face. Instead, the flow utility in (7) captures the indirect utility from holding a bond when facing other assets as substitutes. To ensure that the our estimates are robust to this modeling choice, we allow investors' utility to be heterogeneous both across investors and bonds flexibly. In addition, substitution between municipal bonds is naturally limited by their tax exemption based on local residence. The main caveat, however, lies in the counterfactual analysis, which is meant to be changing the market conditions for one bond, leaving all other bonds unaffected. To consider policies impacting all bonds in the market, we should explicitly model the investors' decision to enter a bond's market, which can be estimated using standard demand estimation techniques.

a distribution that varies with bond attributes, $F_{\phi 0|(s,\mathbf{x},\xi_M)}$.[22] The second component captures how a dealer's client network impacts its search costs. We denote the size of a dealer's client network by b and measure it by the dealer's cumulative number of trades with investors for the bond.

Allowing for network effects in search (i.e., $\phi_1 > 0$) is motivated by the institutional features in Section 2.3: for a dealer it is easier to trade a bond with an investor if they have already traded it with each other before. Such an investor is familiar with the bond, while the dealer needs to spend extra time and effort to help a first-time investor of the bond figure out whether the bond suits with her needs. This implies that dealers with a larger client network might face lower costs.

Note that both F_{ϕ_0} and ϕ_1 are allowed depend on bond attributes, including the complexity index, s. For example, the more complex a bond becomes, the more difficult and time-consuming it can be for dealers, including an underwriter, to meet and communicate with an extra investor. Moreover, nonstandard provisions may change the value of a dealer's client network, by affecting the network parameter ϕ_1.

In summary, bond complexity can directly affect investor taste distribution as well as issuer costs. This feature of the model enables us to capture the idea that nonstandard provisions might cater to the risk preferences of certain investors, while providing issuers with flexibility in debt payment. In addition, we allow nonstandard provisions to affect dealers' costs of finding investors, and therefore liquidity, by affecting the initial cost type distribution and/or the strength of network effects (ϕ_1).

5.2. **Equilibrium in the Trading Market.** This section characterizes the equilibrium in the trading market for any given bond with $(s, r, \mathbf{x}, \xi)$. The dependence of primitives and equilibrium objects on $(s, r, \mathbf{x}, \xi)$ is suppressed here for ease of notation.

The state of a dealer, $u \equiv (a, b, \phi_0)$, is summarized by their inventory of the bond, a, cumulative trade with investors b, and initial search type ϕ_0. An investor's state, $y \equiv (a, \nu)$, consists of her inventory a and taste type ν. We denote the equilibrium price and quantity for a trade between two dealers of states u and u' at τ by $p_D(\tau; u, u')$ and $q_D(\tau; u, u')$; and similarly, those for a trade between a dealer of state u and an investor of state y by $p_I(\tau; u, y)$ and $q_I(\tau; u, y)$. The equilibrium distributions of dealers' and investors' state at time τ are denoted by $\Phi_D(\tau; u)$ and $\Phi_I(\tau; y)$.

[22]In estimation, the realized value of ϕ_0 is allowed to depend on the dealer's prior experience in local bond trades.

The value function of a dealer with state u at $\tau > 0$, denoted as $V(\tau; u)$, satisfies:

$$\begin{aligned}\dot{V}(\tau; u) = -\delta V(\tau; u) + v_D(a) + \lambda_D \int_{u'} \Big\{ & V\left(\tau; a + q_D(\tau; u, u'), b, \phi_0\right) - V\left(\tau, u\right) \\ & - p_D(\tau; u, u') \Big\} d\Phi_D(\tau; du') + \max_{\lambda} \left[\lambda \int_y \Big\{ V\left(\tau; a - q_I(\tau; u, y), b + 1, \phi_0\right) \right. \\ & \left. - V\left(\tau; u\right) + p_I(\tau; u, y) \Big\} d\Phi_I(\tau; dy) - \phi_0 \exp(-\phi_1 \log(b)) \exp(\lambda) \right],\end{aligned} \tag{9}$$

The first term on the right hand side of (9) captures the dealer's discounting; the second term is its flow utility; the third term is the expected change in the continuation utility associated with a trade with another dealer randomly drawn from $\Phi_D(\tau; u)$, which occurs with Poisson intensity λ_D; and the fourth term represents the expected change in the continuation utility associated with a trade with an investor. The dealer chooses meeting rate λ subject to a search cost, and the trading partner's state is drawn at random from $\Phi_I(\tau; y)$.

Based on the first order condition for λ in (9), the equilibrium meeting rate is:

$$\begin{aligned}\lambda(\tau; u) = \log \Bigg(\frac{1}{\phi_0 \exp(-\phi_1 \log(b))} \int_y \Big\{ & V\left(\tau; a - q_I(\tau; u, y), b + 1, \phi_0\right) \\ & - V\left(\tau; u\right) + p_I(\tau; u, y) \Big\} d\Phi_I(\tau; dy) \Bigg).\end{aligned} \tag{10}$$

Let $W(\tau; a, \nu) \equiv W(\tau; y)$ denote the value function of an investor with state y at $\tau > 0$:

$$\begin{aligned}\dot{W}(\tau; y) = -\delta W(\tau; y) + v_I(y) + \alpha \int & \left[W(\tau; a, \nu') - W(\tau; y) \right] f(\nu' | \tau) d\nu' \\ & + \frac{m_D}{m_I} \int_u \lambda(\tau; u) \Big\{ W(\tau; a + q_I(\tau; u, y)) - W(\tau; y) - p_I(\tau; u, y) \Big\} \Phi_D(\tau; du).\end{aligned} \tag{11}$$

The first term on the right hand side of (11) represents the investor' discounting; the second term is her flow utility; the third term is the expected change in the investor's continuation utility associated with a change in her taste type, which occurs with probability α; and the fourth term is the expected change in the continuation utility associated with a trade. The potential trading partner is randomly drawn, and the likelihood of drawing a dealer with state u is $\frac{m_D}{m_I} \lambda(\tau; u) \Phi_D(\tau; du)$. At maturity ($\tau = 0$) the agents receive the face value of their inventory. The after-tax payoff for the dealer is $V(0; u) = \omega_D a$, and for the investor $W(0; a, \nu) = \omega_I a$.

An equilibrium in the trading market consists of (i) a path for the distribution of agents' states, (ii) value functions for investors and dealers, (iii) dealer-to-investor meeting rates, and (iv) trading prices and quantities. At equilibrium, the distribution of agents' states are consistent with the transitions induced by meeting rates and trading quantities; the value functions satisfy (9)-(11) and the terminal values at maturity, given the distribution of agents' states; trading prices and quantities are the Nash bargaining outcomes; and the meeting rate is optimal given the dealers' value functions. Appendix E provides a formal definition of an equilibrium, as well as equations characterizing the equilibrium trade prices and quantities, (A.16)–(A.19).

Given the the equilibrium meeting rates and trading quantities, (A.20) and (A.21) in Appendix E provide a law of motion for the equilibrium path of the state distributions of dealers and investors. Note that such a recursive characterization of the state distribution is essential to ensure that the model is computationally tractable, since it allows us to compute the market equilibrium without simulating the model.

5.3. **Equilibrium Bond Design and Sources of Inefficiency.** Note that the underwriter's payoff from trading, $V_U(s, r, \mathbf{x}, \xi_M)$, is $V(T; A, 0, \phi_{0,U}|s, r, \mathbf{x}, \xi_M)$, where we make the dependence of the value function on the bond attributes explicit and $\phi_{0,U}$ denotes the initial search cost type of the underwriter. Under the assumption that underwriter and official negotiate over bond attributes and the price based on Nash bargaining, the solution (s^*, r^*, F^*) satisfies

$$-\frac{\partial}{\partial s} c_0(s, \mathbf{x}, \xi_G) A(1 + rT) + \{1 + \psi(h)\} \frac{\partial}{\partial s} V(T; A, 0, \phi_{0,U}|s, r, \mathbf{x}, \xi_M) = 0, \qquad (12)$$

$$-c_0(s, \mathbf{x}, \xi_G) AT + \{1 + \psi(h)\} \frac{\partial}{\partial r} V(T; A, 0, \phi_{0,U}|s, r, \mathbf{x}, \xi_M) = 0, \qquad (13)$$

$$\frac{F - c_0(s, \mathbf{x}, \xi_G) A(1 + rT) + \psi(h) V_U(s, r, \mathbf{x}, \xi_M) - J_G(\mathbf{x}, h)}{V(T; A, 0, \phi_{0,U}|s, r, \mathbf{x}, \xi_M) - F - J_U(\mathbf{x}, h)} = \frac{\rho_G}{1 - \rho_G}. \qquad (14)$$

The negotiated bond attributes, (s^*, r^*), maximize the weighted sum of the government official's payoff and the underwriter's payoff from trades, as represented by (12) and (13). The purchase price, F^*, divides the surplus of the negotiation by (14).

In the model, there are three potential channels through which the underwriter's participation to the design process might distort the prevalence of nonstandard provisions. First, these provisions affect search cost borne by all dealers and investors, as well as investor valuations. When negotiating bond design, the underwriter might fail to fully internalize these impacts of its decisions on other dealers and investors due to trading and bargaining frictions. Second, when the underwriter is active as a dealer in the trading market, strengthening the network effects can improve its competitive advantage vis-a-́vis other dealers. The underwriter's advantage comes from its exclusive right for the initial sales of the entirety of a bond, which enables it to build its client network ahead of other dealers. More nonstandard provisions can further enlarge the extent of this advantage through their impact on the network effect parameter ϕ_1. Finally, the distortions created by the two sources above can be amplified by collusion between the government official and the underwriter, which in the model is captured by ψ. Our counterfactual analysis quantifies these channels and the welfare implications of policies altering the incentives of an underwriter.

6. Estimation

This section describes what we observe in the data and the model primitives, as well as the parametric and the orthogonality assumptions. We then describe our multi-step estimation strategy.

6.1. **Model Primitives.** There are three groups of model primitives that we estimate. First we recover how search costs, investor preferences, and government costs depend on complexity (s) and exogenous bond attributes, both observed ($\mathbf{x}$) and unobserved (ξ). Namely, this include (i) the initial search cost type distribution, $F_{\phi_0|(s,\mathbf{x},\xi_M)}(\cdot|s,\mathbf{x},\xi_M)$; (ii) the search network parameter, $\phi_1(s,\mathbf{x},\xi_M)$; (iii) the investor taste type distribution, $F_{\nu|(\tau,s,\mathbf{x},\xi_M)}(\cdot|\tau,s,\mathbf{x},\xi_M)$; and (iv) the marginal cost of paying debt, $c_0(s,\mathbf{x},\xi_G)$.

Second, we estimate the parameters of the trading market that are not assumed to depend on bond design. These parameters include the dealers' utility parameters (κ_D,ν_D), the investors' cost of holding inventory κ_I and their liquidity shock α, the inter-dealer meeting rate λ_D, and the dealers' bargaining power against investors ρ. Note that, since bond design does not affect these parameters, our counterfactual analyses do not require an understanding of how these parameters vary by bond attributes. For this reason, we estimate the bond-specific realizations of these parameters: for each bond i we estimate $(\kappa_{D,i},\nu_{D,i},\kappa_{I,i},\alpha_i,\lambda_{D,i},\rho_i)$.[23]

Finally, we estimate the officials' utility weight for the underwriter, with or without revolving-door regulations: ψ_1 and ψ_0. Note that we do not estimate the bargaining parameter at origination ρ_G, and the outside options of the underwriter and

[23]More precisely, for each bond i we estimate $\kappa_{D,i}\equiv\kappa_D(\mathbf{x}_i,\xi_{i,M})$, $\nu_{D,i}\equiv\nu_D(\mathbf{x}_i,\xi_{i,M})$, $\kappa_{I,i}\equiv\kappa_I(\mathbf{x}_i,\xi_{i,M})$, $\alpha_i\equiv\alpha(\mathbf{x}_i,\xi_{i,M})$, $\lambda_{D,i}\equiv\lambda_D(\mathbf{x}_i,\xi_{i,M})$, and $\rho_i\equiv\rho(\mathbf{x}_i,\xi_{i,M})$.

the government $J_U(\mathbf{x}, h)$ and $J_G(\mathbf{x}, h)$. The main consequence is that we cannot compute the bond price F from the underwriter to the government in our counterfactual simulations.[24] Instead, we focus on the profits of the underwriter from trading bonds and the government's costs of paying the debt, as opposed to each party's payoffs.

We assume $m_I(\mathbf{x})/m_D(\mathbf{x})$ is constant for assets issued by the same state, and we set it as the highest number of trades for the bonds issued in the state within three months of the origination of a given bond, divided by the total number of dealers in that state. We also set the discount rate $\delta = 0.05$ and the inter-dealer bargaining parameter $\rho_D = 0.5$. Moreover, we set $\omega_D = 0.75$ and $\omega_I = 1$ to reflect the different tax treatment for retail investors and institutions (Section 2.1).

6.2. **Observables.** We employ data on both bond origination and transaction. First, in terms of bond origination, for each bond issue i we observe the endogenous bond attributes: the complexity index s_i defined in Section 3, which corresponds to s in the model, and the the coupon rate r_i. To capture the rich heterogeneity across bond and issuing governments, we also observe various exogenous bond attributes ($\mathbf{x}_i$), as specified in Section 4.1 (see Table 2), including the face value, the time to maturity, issuer financial, economic and demographic attributes at the time of bond i's origination, as well as month and county fixed effects. Moreover, we observe the presence of state revolving-door regulations at the time of origination, as represented by a dummy, h_i. We also observe the supply of new bonds from neighboring counties: the variable $\mathbf{z}_i$ measures the number, the amount, and the average maturity, coupon, and complexity of these bonds issued in the year of the origination.

Second, we observe all the transactions for a given bond issue until its maturity or the end period of our data, whichever is earlier. Specifically, if a j^{th} transaction on bond i is between two dealers ($d_{ij} = 0$), we observe the price p_{ij}, the quantity q_{ij}, and the time of the transaction t_{ij} with the corresponding time until the maturity, $\tau_{ij} \equiv T_i - t_{ij}$, as well as both dealers' asset holdings and past transactions (a_{ij}, a'_{ij}, b_{ij}, and b'_{ij}). If the transaction is between a dealer and an investor ($d_{ij} = 1$), we observe similar information on the transaction, except that we do not observe the investor's asset holding and past transactions.

Finally, we observe the geographical specialization of the dealer(s) involved in each transaction. Specifically, based on a dealer's transaction history during one year prior to the bond's origination, g_{ij} indicates that the dealer in the j^{th} transaction

[24]We can estimate the outside options, after setting $\rho_G = 0.5$, using the optimality condition for F, (14). This, however, requires additional functional-form assumptions given our sample size.

for bond i has experience trading bonds from the same county ($g_{ij} = 0$); or it has experience trading bonds from the same state, but not from the same county ($g_{ij} = 1$); or it has no experience trading bond from the same state ($g_{ij} = 2$).

6.3. **Identifying Assumptions.** Given our moderate sample size, we make several parametric assumptions on how search cost parameters, investor preferences, and government cost depend on bond design. Here, with a slight abuse of notation, we redefine $\xi_M \equiv \left(\xi_{\gamma_1}, \xi_{\gamma_2}, \xi_{\phi_{0,0}}, \xi_{\phi_{0,1}}, \xi_{\phi_{0,2}}, \xi_{\phi_1}\right) \in \mathbb{R}^6$, where each component represents the unobserved shock to its corresponding parameter.

First, we assume investors' taste type, ν, follows a Gamma distribution with mean $\gamma_1(s, \mathbf{x}, \xi_{\gamma_1})$ and standard deviation $\gamma_2(s, \mathbf{x}, \xi_{\gamma_2})$ for all $\tau \in [0, T]$. For $k = 1, 2$,

$$\log \gamma_k(s, \mathbf{x}, \xi_{\gamma_k}) = \theta_{\gamma_k,s} \log(s + 1) + \theta_{\gamma_k,x}\mathbf{x} + \xi_{\gamma_k}. \tag{15}$$

Second, we assume that the realization of ϕ_0 for a given dealer and a bond depends on the bond attributes and the dealer's geographical specialization, g. Since there are three types of geographical specialization, the support of $F_{\phi_0|(s,\mathbf{x},\xi_M)}$ is reduced to the three values, $\phi_{0,g}(s, \mathbf{x}, \xi_{0,g})$ for $g = 0, 1, 2$:

$$\log \phi_{0,g}(s, \mathbf{x}, \xi_{\phi_{0,g}}) = \theta_{\phi_0,s} \log(s + 1) + \theta_{\phi_0,x}\mathbf{x} + \theta_{\phi_0,g} + \xi_{\phi_{0,g}}. \tag{16}$$

The probability of each value is set by the distribution of dealers' geographic specialization. In addition, we make the following assumption on the search network parameter, ϕ_1:

$$\log \phi_1(s, \mathbf{x}, \xi_{\phi_1}) = \theta_{\phi_1,s} \log(s + 1) + \theta_{\phi_1,x}\mathbf{x} + \xi_{\phi_1}. \tag{17}$$

Lastly, since we cannot separately identify the marginal cost of financing (c_0) and the officials' weight for the underwriter (ψ), we normalize that the marginal cost of financing when nonstandard provisions are not present ($s = 0$) is one at the average $(\bar{\mathbf{x}}, \bar{\xi}_G)$, i.e., $c_0(s = 0, \bar{\mathbf{x}}, \bar{\xi}_G) = 1$. With this normalization, we assume

$$c_0(s, \mathbf{x}, \xi_G) = \theta_{c,s_1} s\mathbf{x} + \theta_{c,s_2} s^2 + \theta_{c,x}\mathbf{x} + s\xi_G. \tag{18}$$

The mean of ξ_M and ξ_G is zero, given that $\mathbf{x}$ includes a constant.

Recall that the endogenous bond attributes (s, r) depend on (ξ_M, ξ_G), which is observed by market participants but unobserved by the researcher. As discussed in Section 5.3, during the negotiations at origination the forward-looking parties anticipate each party's payoff as a function of both observed and unobserved bond/issuer attributes. This complicates identification, and to address this problem, we employ two sets of orthogonality conditions. One is that the mean of the unobserved shock to the marginal financing cost, ξ_G, is zero conditional on $\mathbf{x}$, revolving door regulations h, and bond supply from the neighboring counties $\mathbf{z}$:

$$\mathbb{E}\left(\xi_G \left| \mathbf{x}, h, \mathbf{z}\right.\right) = 0. \tag{19}$$

Indeed, bond supply from the neighboring counties may be correlated with investor demand for a bond, but we argue that it is uncorrelated with the issuer's financial cost shock. The second condition is that the unobserved bond attributes related to the trading market, ξ_M, are mean zero conditional on $(\mathbf{x}, h)$:

$$\mathbb{E}\left(\xi_M \left| \mathbf{x}, h\right.\right) = 0. \tag{20}$$

6.4. **Estimation Strategy.** We estimate the model primitives in three steps. First, we estimate the parameters of the trading market separately for each bond i, based on bond transaction data. These parameters include investor demand parameters $(\gamma_i, \kappa_{I,i}, \alpha_i)$; search cost parameters $(\phi_{0,i}, \phi_{1,i})$; dealers' utility parameters $(\nu_{D,i}, \kappa_{D,i})$; inter-dealer meeting rate $\lambda_{D,i}$; and the bargaining parameter for dealer-to-investor trades ρ_i.[25] Second, we estimate the parameters of (15)–(17), $(\theta_\gamma, \theta_{\phi_0}, \theta_{\phi_1})$, which determine how investor demand and search costs depend on the endogenous complexity as well as other observed and unobserved bond attributes. Finally, we estimate the government preference parameters, θ_c, as defined in (18), and the two parameters (ψ_0, ψ_1) that measure conflict-of-interest.

6.4.1. *Step 1: Trading Market Parameters for Each Bond.* In the first-step, we estimate the trading market parameters for each bond separately. With a slight abuse of notation we define the trading parameters to be estimated as

$$\theta_i \equiv \left\{\gamma_i, \kappa_{I,i}, \alpha_i, \phi_{0,i}, \phi_{1,i}, \nu_{D,i}, \kappa_{D,i}, \lambda_{D,i}, \rho_i\right\}.$$

To estimate the parameter $\hat{\theta}_i$ for each bond i, we first nonparametrically estimate the equilibrium distribution of dealer states, $\Phi_{D,i}$, from the observed states of dealers over time. Then, we use a nested fixed point algorithm to solve for the value functions of dealers and investors, the equilibrium meeting rate, the equilibrium trading prices and quantities, and the distributions of investors' states (Rust, 1987). Finally, we use these equilibrium objects to compute and minimize an objective function based on transaction timing, price, and quantity in the simulated and observed equilibria.

[25]To be clear, $\gamma_i \equiv \gamma(s_i, \mathbf{x}_i, \xi_{\gamma,i})$ and $\phi_{l,i} \equiv \phi_l(s_i, \mathbf{x}_i, \xi_{\phi_l,i})$ for $l \in \{0,1\}$.

We rely on an objective function that consists of three components. The first component is the squared differences between the observed and the simulated values of the average inter-dealer trading price and quantity and their covariance with the dealer's inventory. The second component is the squared differences between the observed and the simulated values of the average trading price and quantity for dealer-to-investor transactions, their variance, and their covariance with the dealer's inventory and trading network, respectively. The third component is the negative value of the log likelihood of the timing of transactions for each dealer (either with an investor or a dealer), conditional on the dealer's state. Appendix F.1 discusses identification and Appendix F.2 provides equations for the moment conditions and the likelihood function.

6.4.2. *Step 2: Trading Market Parameters as a Function of Bond Attributes.* Given our estimates of the investors' demand parameters $\hat{\gamma}_i$, and search parameters $\hat{\phi}_{0,i}$ and $\hat{\phi}_{1,i}$ for each bond i, we next estimate $(\theta_\gamma, \theta_{\phi_0}, \theta_{\phi_1})$, defined in (15)–(17), which describe how the trading market parameters depend on bond attributes.

We leverage the orthogonality condition (20) to derive the following:

$$\begin{aligned}
\mathbb{E}\Big(\log \hat{\gamma}_{k,i} - \theta_{\gamma,x}\mathbf{x}_i - \theta_{\gamma,s}s_i \Big| \mathbf{x}_i, h_i \Big) &= 0, \text{ for } k = 1,2 && (21)\\
\mathbb{E}\Big(\log \hat{\phi}_{0,k,i} - \theta_{\phi_{0,g},x}\mathbf{x}_i - \theta_{\phi_{0,g},s}s_i \Big| \mathbf{x}_i, h_i \Big) &= 0, \text{ for } k = 0,1,2, && (22)\\
\mathbb{E}\Big(\log \hat{\phi}_{1,i} - \theta_{\phi_1,x}\mathbf{x}_i - \theta_{\phi_1,s}s_i \Big| \mathbf{x}_i, h_i \Big) &= 0. && (23)
\end{aligned}$$

Given the linear specification above, we estimate the parameters by running an IV regression. As for instruments for s_i, we employ $(\mathbf{x}_i, h_i)$ as well as interactions between h_i and some of the bond attributes $\mathbf{x}_i$, following Section 4.2. Once we obtain $(\hat{\theta}_\gamma, \hat{\theta}_{\phi_0}, \hat{\theta}_{\phi_1})$, then we solve for $(\hat{\xi}_{\gamma,i}, \hat{\xi}_{\phi_0,i}, \hat{\xi}_{\phi_1,i})$ from (15)–(17) for each bond i, since all other terms in the equation are either observed or have been estimated.

6.4.3. *Step 3: Government Preferences.* The last step boils down to estimating the government preference parameters, $(\theta_c, \psi_0, \psi_1)$. Denote the derivatives of the underwriter's value from trades with respect to (s, r) by $V_{s,i}$ and $V_{r,i}$. Employing (18) for the government marginal cost of financing c_0, we derive the following moment conditions based on the optimality conditions (12)–(13) for the endogenous bond attributes

(s, r), together with (19):

$$\mathbb{E}\left(\left\{\frac{(1+\psi_{h_i})V_{s,i}}{A_i(1+r_iT_i)} - (\theta_{c,s_1}\mathbf{x}_i + 2\theta_{c,s_2}s_i)\right\}[\mathbf{x}_i, h_i, \mathbf{z}_i]\right) = 0,$$

$$\mathbb{E}\left(\frac{1}{s_i}\left\{\frac{(1+\psi_{h_i})V_{r,i}}{A_iT_i} - \left(\theta_{c,x}\mathbf{x}_i + \theta_{c,s_1}s_i\mathbf{x}_i + \theta_{c,s_2}s_i^2\right)\right\}[\mathbf{x}_i, h_i, \mathbf{z}_i]\right) = 0,$$

which we leverage to build a GMM estimator for $(\theta_c, \psi_0, \psi_1)$.

Note that the optimality conditions (12)–(13) reflect the incentives of both the issuer and the underwriter, captured by $V_{s,i}$ and $V_{r,i}$. However, the underwriter's value function is estimated in previous steps. Therefore we replace $V_{s,i}$ and $V_{r,i}$ with their respective estimates: $\frac{\partial}{\partial l}V_U(T_i; A_i, 0|s_i, r_i, \mathbf{x}_i, \hat{\xi}_{M,i}, \hat{\theta}_\gamma, \hat{\theta}_{\phi_0}, \hat{\theta}_{\phi_1})$ for $l = s, r$. Thus, this approach allows us to use the optimality conditions for (s, r) to recover the issuer preference parameters, holding fixed the underwriter's incentives concerning the bond attributes and coupon rate.

7. Estimation Results

This section describes the estimates of the key model primitives, based on the approach described in the previous section. The distribution of the first-step estimates of the bond-level trading market parameters are reported in Appendix F.3, where the model's goodness of fit is also discussed.[26] We report bootstrap standard errors based on 200 bootstrap samples where resampling is at the dealer level.

7.1. **Search Frictions and Underwriter Cost Advantage.** The bond-level estimates of the trading cost parameters reveal that search frictions in the market for municipal bonds are sizable. To see this, we consider a bond with the median values of the trading market parameter estimates from the first step $(\hat{\theta}_i)$, and simulate the model of bond trades to compute the dealers' search costs. Table 4 shows that the average dealer pays \$2,625 to find and meet investors every month. This estimate is 10% of the dealers' monthly gross profits, measured as the difference between the value of bonds sold and purchased.

Additionally, we find a dealer's knowledge of the local market is critical in lowering its search costs. Figure 1(A) shows that the initial monthly search cost for a dealer who has experience trading bonds originated from the same county $(\phi_{0,0})$ to

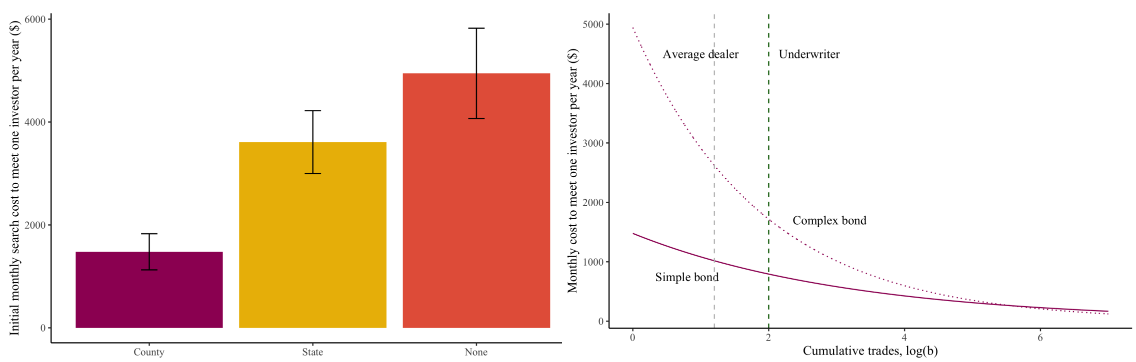
[26]The estimation is based on 927 bonds drawn from our full sample of 13,118 bonds. The estimated sample includes all bonds from the five states that introduced revolving-door regulations during the period of our study (AR, IN, ME, NM, and VA) and the counties at the borders of these states.

Table 4. Dealers' Monthly Search Cost Estimates

	Average dealer	Underwriter
Average search cost	\$2,625	\$3,045
Average search cost at $\lambda = 1$	\$1,911	\$960
Initial search cost at $\lambda = 1$, ϕ_0	\$3,216	\$3,609
Average cost advantage from client network, $\exp(-\phi_1 \log(b))$	0.50	0.34
Average meeting rate	0.19	0.23

Notes: This table presents the equilibrium search costs and meeting rates of a bond with the median values of the first-step trading market parameters, $\hat{\theta}_i$.

Figure 1. Determinants of Dealer Search Costs



(A) Geographic advantage

(B) Bond design and client network

Notes: In panel (A), each bar represents the average estimate of ϕ_0 for each type of dealers, where the type is determined by their prior history of trading bonds during one year before a given bond's origination. Panel (B) presents the estimated search cost functions of (8) at $\lambda = 1$ for two bonds with low and high levels of complexity (25^{th} and 75^{th} percentiles) and median values of other attributes, in the logarithm of the cumulative number of trades. The two dashed, vertical lines represent the logarithm of the average cumulative number of trades of the underwriter and an average dealer.

meet one investor per year is on average \$1,477, less than a third of the cost for a dealer with no experience of trading bonds from the same state ($\phi_{0,2}$).[27] This result is consistent with the local nature of municipal bond market, driven by the preferential tax treatment of owning in-state bonds.

Table 4 also presents the extent of the underwriter search advantage in equilibrium. The underwriter meets on average 0.23 investors per month, which is 20% more

[27]Given our search cost function (8), the parameter value of ϕ_0 represents the monthly search cost of meeting one investor per year ($\lambda = 1$) initially, i.e., when a dealer has not yet started trading the bond ($b = 0$).

frequent than the average dealer. This is because of the large competitive advantage in search for the underwriter. The monthly cost of maintaining the rate of meeting one investor per year is $960 for the underwriter, which is about half of the cost for other dealers on average. As a result of the higher meeting rate, the monthly average search costs are higher for the underwriter ($3,045) than an average dealer ($2,625).

The table decomposes the average search cost at $\lambda = 1$ into two parts: the initial search cost at $\lambda = 1$ (ϕ_0) and the average value of cost advantage from client network, $\exp(-\phi_1 \log(b))$. The underwriter's ϕ_0 is higher than that of an average dealer ($3,600 vs. $3,200), reflecting the underwriter's relative lack of prior experience of trading local bonds. For 72% of the bonds in our estimated sample, the underwriter has higher initial search cost than the median dealer for that bond. However, we find that the average value of $\exp(-\phi_1 \log(b))$ is 0.34 for the underwriter, 32% lower than that of an average dealer.[28] Combining these two search cost components (ϕ_0 and $\exp(-\phi_1 \log(b))$), we find that at a given rate of meeting an investor, the underwriter's cost is 21% lower than an average dealer's cost. This cost advantage, driven by the underwriter's exclusive sales at the beginning of trading, more than offsets its initial geographical disadvantage. Thus, the underwriter's dominance in a bond's trading (Table 1) is primarily driven by the economy of scale in search.

This result is consistent with the narrative that prevails in the industry (Section 2.3). Fabozzi (2008), a practitioner's manual for the municipal bond market, provides a palpable explanation: "If an institution wants to buy or sell large quantities of municipal bonds through secondary market, it typically enlists members of the dealer community who are familiar with the bonds. A dealer that was involved in the original underwriting syndicate is the logical choice because it knows which clients bought bonds at the time they were issued....Secondary market order flow tends to gravitate to that firm too, so it often has the best picture of who owns the bonds long after the issue date. Traders will call the known holders first as they start searching for buyers or sellers of those particular bonds."

7.2. **Search Frictions and Nonstandard Provisions.** The second-step estimates, $\hat{\theta}_\phi$, as specified in (16) and (17), show how bond attributes affect search costs, while

[28]The network parameter estimate, $\hat{\phi}_{1,i}$ is on average 0.436 (Table A8 in Appendix F.3), and out of 927 bonds used in the estimation, the $\hat{\phi}_{1,i}$ estimates of 82% of the bonds is statistically greater than zero at the 95% level. Note that we do not impose $\hat{\phi}_{1,i} > 0$ in our estimation procedure. Therefore, it is remarkable that a dealer's client network, built by trading the bond with investors, lowers the dealer's search costs.

Table 5. Search Cost and Investor Demand as a Function of Bond Attributes

	Search Cost		Investor Valuation	
	Initial $\log \hat{\phi}_{0,i}$ (1)	Network $\log \hat{\phi}_{1,i}$ (2)	Mean $\log \hat{\gamma}_{1,i}$ (3)	SD $\log \hat{\gamma}_{2,i}$ (4)
Complexity index (log)	3.791	1.662	-0.0851	4.599
	(2.002)	(0.543)	(0.561)	(0.956)
Bond/issuer attributes^a	Yes	Yes	Yes	Yes
Year-month FE, County FE	Yes	Yes	Yes	Yes
Heterogeneous time trend^a	Yes	Yes	Yes	Yes
Number of observations	2,753	927	927	927

Notes: This table presents the parameter estimates of (16), (17), and (15) from the IV regression of the second step of our estimation: $\theta_{\phi_0,s}$ (Column 1), $\theta_{\phi_1,s}$ (Column 2), $\theta_{\gamma_1,s}$ (Column 3), and $\theta_{\gamma_2,s}$ (Column 4). The bootstrap standard errors are in parenthesis. The instruments are dummy variables for revolving-door regulations and their interactions with the fraction of secondary transactions by individual investors at the state- and security-type level, the county-level electoral competitiveness, and the issuing government's experience originating municipal bonds. a. These controls are the same as the ones employed in Tables 3.

accounting for the endogeneity of bond design. Table 5 presents the parameter estimates related to bond complexity. We find that including more nonstandard provisions in the bond contract increases both the initial search cost and the network effect parameters. Increasing the bond complexity index in a bond contract by 1% increases ϕ_0, which measures the level of search costs, by 3.79% (Column (1)) as well as the magnitude of the network effect parameter, ϕ_1 by 1.66% (Column (2)). Given these estimates, increasing the bond complexity from its median value to the 75th percentile leads to a 43% increase in ϕ_0 and a 19% increase in ϕ_1.

Figure 1(B) visualizes these estimates by plotting an average dealer's monthly cost of meeting one investor per year as a function of its cumulative trade for a given bond, b. We consider two bonds with a small and large number of nonstandard provisions, which we call, respectively, "simple" and "complex" bonds.[29] The estimates indicate that the monthly search cost in the beginning (at $b = 0$) is lower for the simple bond, but as the dealers' trading network increases, the search costs become similar between the two bonds. This is because the decrease in the marginal search

[29] Specifically, we rely on the second-step parameter estimates (θ_{ϕ_0} and θ_{ϕ_1}) and specifications (16) and (17), to compute the search parameters associated to two bonds with the median value of the estimated unobserved search cost factors, $\hat{\xi}_{\phi_0,1}$ and $\hat{\xi}_{\phi_1,i}$ and, respectively, a complexity index of 1 (the 25^{th} percentile in our data) and 2.14 (the 75^{th} percentile).

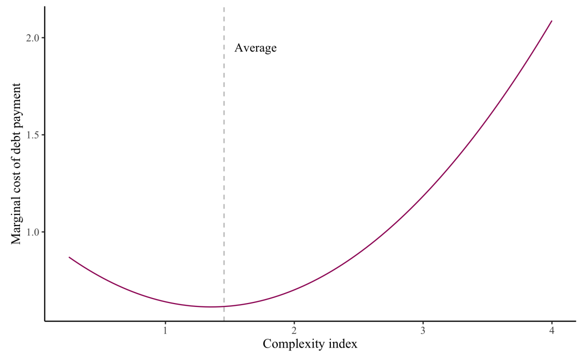
costs with respect to cumulative trade is much higher for the complex bond. These patterns illustrate that although nonstandard bond provisions increase the search costs for all dealers, they can create a cost advantage through economies of scale. The underwriter, who can quickly develop a large client network thanks to their exclusive initial sales, can take full advantage of the stronger network effect for the complex bonds. At the average number of cumulative trades for an average dealer, search costs are much higher for the complex bond than for the simple one, but such a difference is smaller at the average cumulative trade of underwriters.

7.3. **Investor Demand.** We assume that the investor taste type ν follows Gamma distribution with mean γ_1 and standard deviation γ_2, both of which depend on $(s, \mathbf{x}, \xi)$. Table 5 shows that nonstandard provisions do not substantially affect the average investors' valuation for the bond (Column 3), while substantially increasing the dispersion (Column 4). These results are consistent with the idea that bonds with these provisions are niche products that investors "either love or loathe," along the lines of Johnson and Myatt (2006) and Bar-Isaac et al. (2012). Indeed, the standard deviation of the investor valuations is much smaller for the low-complexity bond (0.003) than for the high-complexity one (0.013), implying that the fraction of investors with extreme valuations for a bond is higher as the complexity of the bond increases. These findings correspond to the idea that complex bonds tend to be favored by specific sets of investors, while simple bonds may cater to a broader range of investors.

7.4. **Government Preferences.** The government preferences are characterized by the marginal financial cost parameters θ_c, specified in (18) and the weight parameters with/without revolving regulations (ψ_1 and ψ_0). Given our θ_c estimates, we find that the marginal cost of the debt payment, c_0, for the average issuer is 0.57 (median 0.61). As discussed in Section 5, c_0 captures how the cost of paying debt payments can be affected by the issuer's cash flows. We find that local economy is an important factor in determining the government cost c_0. For example, a 1% increase in the local unemployment rate (or its growth rate), which may directly affect government cash flow through local taxes/fees and expenses for those in need, is associated with 1.26% (or 1.09%) increase in c_0.

Figure 2 displays how c_0 varies with the complexity index, where we set the value of the exogenous attributes at the median values in the sample. Consistent with the results in Table 3, we find that the marginal financial cost depends on bond

FIGURE 2. Marginal Cost of Debt Payments



Notes: The figure plots the estimated relationship between the marginal cost of debt payment, c_0, and the complexity index, evaluated at the median value of the issuing government attributes.

design, and that the number of nonstandard provisions that minimizes the marginal debt payment costs is not zero. This captures the benefit of adding these provisions, which allows the debt payment flow to be flexible with respect to the contingencies that can affect the government cash flow. This finding is consistent with our results in Column (2) of Table 3, where we show the the risk of getting downgraded is lower as the complexity index increases.

Lastly, we find evidence that conflict of interest exists, as the issuing government directly cares about the underwriter's value from trades. Our estimate of the weight parameter without revolving-door regulations, ψ_0, is sizable: 0.34. This implies that for the median unregulated issuing government the underwriter's value account for 6.7% of the government official payoff. On the other hand, our estimates reveal that the weight parameter with revolving-door regulations, ψ_1, is substantially lower, practically equal to zero.[30] These estimates explain our findings in Table 2 that revolving-door regulations reduce the number of nonstandard provisions, and suggest that these regulations are effective in reducing the incentives of the government officials to internalize interests of the underwriter.

[30]In the existing literature, Goldberg and Maggi (1999), an empirical investigation of the model of Grossman and Helpman (1994) in the context of trade protection, provide an estimate of a parameter similar to our ψ. Their counterpart parameter of our ψ is $(1-\beta)/\beta$, and its point estimate ranges from 0.014 to 0.019, depending on the specifications. Although β is precisely estimated in Goldberg and Maggi (1999), the standard error of $(1-\beta)/\beta$ is large (greater than 24 across all three specifications), so comparing these estimates with our ψ estimates is limited.

8. Counterfactual Policies

In this section, we leverage our estimated model to showcase how bond design shapes trading frictions and the government costs of paying bond obligations in the market for municipal bonds. Moreover, we examine how limiting underwriter's participation to bond design can improve market outcomes.

We consider three counterfactual scenarios. First, we study how the market would react to a mandate imposing local governments to only issue "plain vanilla bonds", by banning the use of nonstandard provisions. Next, we study the market outcomes if the use of nonstandard provisions were set to minimize the debt payment costs for the issuing government, taking into account both the policy's impact on the negotiated interest rates and the value for the government of having additional flexibility in payments. Finally, we consider a rather radical policy, where the underwriter is banned from trading the bond after six months of its origination. This last policy addresses the heart of the problem we study, the underwriter's dual role as bond designer and intermediary for trades.

In considering these scenarios, we simulate the equilibrium and welfare for a *representative bond*, which we define as a bond with the the median value of the observed bond/issuer's exogenous attributes ($\mathbf{x}_i$), the first-step estimates of the investor and dealer parameters ($\hat{\theta}_i$), and the last-step estimate of the issuer cost shock ($\hat{\xi}_G$). This bond's face value is \$6.45 million and the maturity is 7.7 years, and remarkably, it is originated when a revolving-door regulation is in place (and thus $\hat{\psi}$ is almost zero).

8.1. Standardization.

We consider a policy that imposes bond standardization by banning the use of nonstandard provisions. Under this policy, local governments can only issue "plain vanilla bonds," while the coupon rate is negotiated with the underwriter under this constraint. Column (2) of Table 6 shows that under this policy the search costs decrease. The cost of maintaining the yearly rate of meeting one investor, averaged across dealers and over time until maturity, falls by 47%. In return, the liquidity increases: the average dealer meets an investors at a rate of 0.27 per year, which is 30% higher than the baseline meeting rate. A direct implication of this higher liquidity is that the negotiated coupon rate decreases to 2.16%, which is a 23% drop from the rate under the base scenario, incorporating a lower liquidity premium necessary to sway investors weary of transaction costs at resale.

Despite this large decrease in the coupon rate, Panel (A) of Figure 3 shows that the issuer's cost, $c_0 A(1 + rT)$ increases by 35%, from the baseline of \$5.13 million for

Table 6. Effects of Counterfactual Bond Design Policies

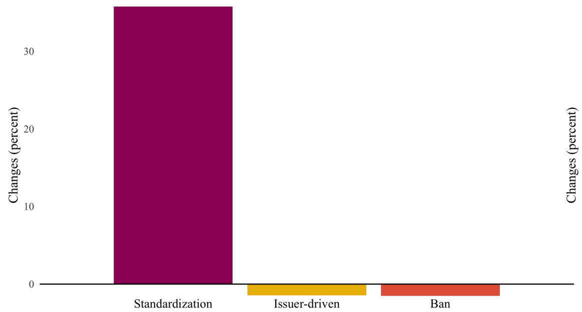
	Current	Standardization	Issuer-driven design	Intermediation ban
	(1)	(2)	(3)	(4)
Bond attributes				
Complexity index	1.41	0	1.14	1.33
		−100%	−19%	−5.7%
Interest rate (%)	2.81	2.16	2.37	2.59
		−23%	−15%	−7.8%
Search frictions (per month)				
Average cost of $\lambda = 1$ ($)	1,981	1,051	1,343	2,004
		−47%	−32%	+1.2%
Average dealer's meeting rate	0.208	0.270	0.215	0.204
		+30%	+3.4%	−1.7%
Issuer costs				
Principal and interest ($K)	8,349	7,997	8,113	8,229
		−7.8%	−6.4%	−1.4%
Marginal financial cost (c_0)	0.615	0.871	0.623	0.613
		+41%	+1.2%	−0.1%
Total issuer cost ($c_0 A(1 + rT)$, $K)	5,129	6,962	5,055	4,980
		+35%	−1.5%	−1.5%

Notes: The numbers are based on the representative bond. For each scenario, the table presents both the level and the percentage changes, relative to the current policy, regarding the equilibrium bond design (complexity and interest rate), the average monthly cost of maintaining the meeting rate of one investor per year, the monthly rate of meeting with investors, and the issuer costs. Under the scenario of "standardization", nonstandard provisions are not allowed; under the "issuer-driven design" scenario, the issuer is required to set the use of nonstandard provisions so that it minimizes its debt payment cost, anticipating its negotiation with the underwriter regarding the coupon rate; and the last scenario bans the underwriter from trading bonds after six months of the origination.

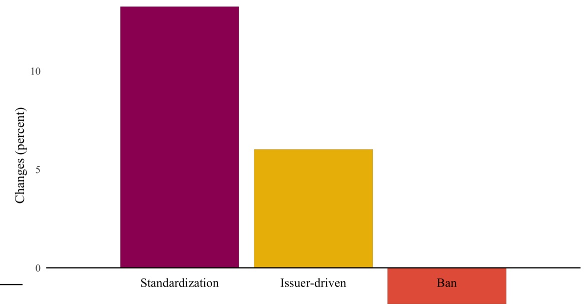
the representative bond. This is because the lower coupon rate does not full offset an increase of the marginal cost of paying the debt, c_0, from 0.615 to 0.871, an increase by 42%. This result is not surprising given our results that the marginal financing cost c_0 increases as the complexity index falls below 1 (Figure 2). This result shows such a stark, one-size-fits-all policy ignores the benefits of nonstandard provisions in providing flexibility to the issuer.

We find that investors benefit from this policy on average, despite the lower coupon rate: they appreciate liquidity and an average investor does not value non-standard features (Table 5, Column (3)). Overall, investor surplus increases by 13.3% (Panel (B) of Figure 3). Taken together, these results showcase the key trade-off that

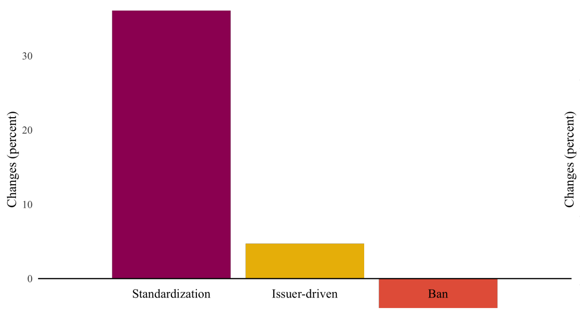
Figure 3. Welfare Implications of Counterfactual Bond Design Policies



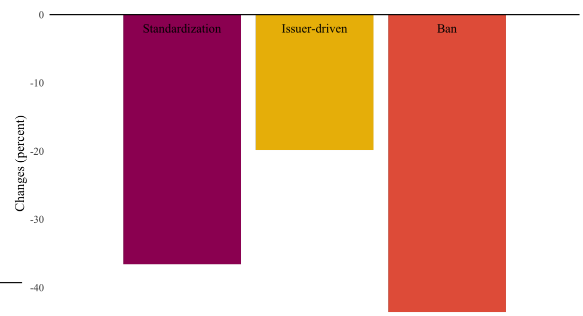
(A) Government Costs



(B) Investor Surplus



(C) Dealer Surplus



(D) Underwriter Surplus

Notes: The graphs represent the predicted percentage changes in the issuing government's cost of paying the principal and interest, the investor surplus, the underwriter's value from trading the bond, and other dealers' surplus, under each of the three counterfactual policy scenarios, relative to the baseline, for the representative bond. Each policy is described in the text and a brief summary can be found in the notes for Table 6.

bond design solves: standardized bonds are more liquid, but they are too rigid to cater to the issuer's need for flexibility.

It is also worth emphasizing the impact of the policy on financial intermediaries. First, standardization lowers the intermediation spread, consistent with the literature that search frictions benefit producers (Diamond, 1971; Ellison and Wolitzky, 2012). Second, it also dampens the underwriter's competitive advantage vis-a'-vis other dealers from exclusive initial sales. As shown in Panel (D) of Figure 3, both forces together, despite a higher meeting rate and lower baseline search costs, lower the underwriter's value from trading by 36.6%. Instead, other dealers benefit from the level playing field, and their value from trading increases by 36.1%. This finding is consistent with the results in Section 7.1, suggesting that the underwriter can leverage bond design to "raise his rival costs". For this reason, we next study two policies that explicitly limit the role of underwriters in designing a bond.

8.2. **Issuer-driven Design.** We study the market outcomes if the use of nonstandard provisions were set so as to minimize the issuer's total cost of debt payment, $c_0 A(1+rT)$, while allowing for the coupon rate to be negotiated with the underwriter. This policy offers an useful benchmark that minimizes the role of the underwriter's incentives in bond design without directly altering the trading market.

Column (3) of Table 6 indicates that the bond complexity index under this case would be 1.14, which is greater than zero but 19% smaller than the baseline value, 1.41. It is notable that the marginal financial cost c_0 is slightly higher under this scenario than the baseline scenario, reflecting the cost of rigidity in debt payment arising from a simpler bond contract. The reason that the level of complexity is not set to minimize c_0 is because the negotiated coupon rate is another important factor determining government costs. Under this scenario, the negotiated interest rate is much lower (2.37% vs. 2.81%), and the resulting total issuer cost is 1.5% lower.

In a nutshell, the outcome of this policy demonstrates that limiting the impact of the underwriter's incentives helps improving the trade-off between flexibility and liquidity. The average costs borne by dealers to meet one investor per year drops by 32% and the equilibrium meeting rate increases by 4%. This leads to a lower liquidity premium that the issuer pays in terms of interest payments, which is sufficient to offset the increase in the marginal financial cost, leading to a lower total cost for the issuer. In addition, investors benefit, on average, by 6% and so do the dealers other than the underwriter (Figure 3). The underwriter is worse off: its payoff from trading the bond in the secondary market decreases by 19.9%.

8.3. **Banning Underwriters from Intermediating Trades.** Our last counterfactual policy directly tackles the underwriter's incentive to design a bond in order to increase its profits from trading. Under this policy, the underwriter is banned from trading the bond after six months of its origination, while both nonstandard provisions and the coupon rate are negotiated at origination.

Banning the underwriter from the trading market has a theoretically ambiguous impact on market liquidity. On the one hand, as the bond becomes simpler (complexity index decreasing to 1.33 from 1.41, Column (4) of Table 6, the market for intermediating trades becomes more competitive and the search frictions faced by all dealers decrease, improving liquidity. On the other hand, banning the underwriter from the trading market implies losing information on investors learned by the underwriter during the primary market (captured in our model by the network effects parameter ϕ_1). Limiting the underwriter's ability to leverage this information in the trading market is wasteful, and can lower the average search costs and thus decrease liquidity. The latter channel explains the increase in the average cost of maintaining the meeting rate of one investor per year by 1% and the corresponding decrease in the meeting rate, despite the lower complexity index.

Overall, this policy decreases the issuer's cost of paying debt by 1.5%. This outcome is the result of two forces. First, Column (4) of Table 6 shows that the negotiated interest rate decreases to 2.59%, despite an overall decrease in liquidity. This reflects the fact that the underwriter's value from trades, now limited to six months only, is less sensitive to the coupon rate. Second, the simpler bond under this scenario leads to a lower marginal financial cost c_0.

As opposed to the "issuer-driven design" scenario discussed earlier, we find that the investor surplus drops by 1.84%. From the investors' point of view, the equilibrium bond is less appealing, as it comes with a lower coupon rate and higher search frictions. Underwriters, stripped of their market after six months of origination, lose by 43.61%. Interestingly, other dealers are also worse off by 3.97%. This is because the rent they can extract from trades is lower with the lower coupons.

9. Conclusion

This paper presents empirical evidence, along with market institutions, suggesting that the rent-seeking behavior by underwriters and government officials increases the prevalence of complex bonds. Using our estimated model, we assess market outcomes and welfare implications of a policy mandating standardized bonds. In addition, we quantify the role of the vertical integration in the municipal bond market, where underwriters also participate as an intermediary for secondary transactions.

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Online Appendix for

Search Frictions and Product Design in the Municipal Bond Market

Appendix A. Construction of Variables in the Data

This section describes how we construct the variables used in our analysis. The face value, maturity, coupon rates, and various provisions for each bond, as well as the type of assets that will pay the debt and the purpose of the funds raised by the bond, are directly from Mergent. Below, we discuss how we combine that data with the issuing government attributes at the county or state level, define the method of sale for each bond issue, summarize the underwriter and the financial advisor market at the state level, and identify which trades observed from the MSRB data belong to the underwriter(s) of a bond.

A.1. **Issuing Government Attributes.** We gather demographic and economic attributes of the residents from the American Community Survey at the county level. To merge the county-level attributes with the bond data, we obtain the county of the issuer based on the the name of the issuer for each bond and the state, both of which are provided by the Mergent database. Most issuer names indicate the county, but for those that do not, we manually search for the issuer's name online to identify its county. Some local governments serve multiple counties, in which case we randomly select one county.

The Annual Survey of State and Local Government Finances from the Census provides the local government finance information. A census is conducted every five years, and a sample of local governments is used to collect data in the intervening years. We do not always observe the finance information for every year for local governments, but we find that while the data for county governments are consistently provided over time, other local governments, especially for small ones, are not. Therefore, when necessary, we interpolate the finance information over time. In addition, for local governments other than county governments, we use the finance information aggregated over the governments of the same category (city/township, school districts, and other special-purpose governments). As for government revenues and expenditures, we use CPI-adjusted values (where the base year is 2012).

We measure the political environment that each bond issuer faces by the fraction of votes for the Democratic Presidential candidate in the most recent election at the county level, which we gather from CQ Press Voting and Elections Collection. In addition, we record whether the state government was divided, between the legislature and the governor's office, at the time of the origination of a bond, based on the state partisan composition data from the National Conference of State Legislatures.

A.2. **Method of Sale.** The Mergent database provides the method of sale for each bond issue, but when not available, we use the SDC Platinum Financial Securities data. This way, we observe the method of sale for 98% of all tax-exempt general obligation or revenue bonds issued by local governments during the period of study.

A.3. **Primary Market Conditions.** The Mergent database provides the identifiers of the underwriters and the financial advisors (if any) for each bond. Based on these identifiers, we calculate the number of available underwriters and financial advisors at the state level, and the respective Herfindahl-Hirschman index, accordingly. The underwriter identifier, along with the issuer identifier based on the first six digits of a bond's CUSIP, is used to figure out whether an underwriting firm has a history of underwriting another bond of a given issuer. Note that the identifiers for underwriters from the Mergent database do not correspond to the dealer identifiers of the trading data from the MSRB data.

A.4. **Identification of Transactions by an Underwriter.** In our analysis to study the incentives of the underwriters (Section 4.2) and to estimate our model, it is important to identify which transactions for a bond were conducted by the underwriter of the bond, as opposed to other dealers. The transaction data from the Municipal Securities Rulemaking Board (MSRB) provide anonymized dealer identifiers, so we infer whether a transaction of a bond was with its underwriter or not. Our inference procedure is based on the idea that the dealer(s) with the highest net sales given the history of secondary transactions for a given bond issue is likely to be the issue's underwriter(s). The logic behind this strategy is that the underwriter (syndicate) purchases the entirety of the issue and thus is likely to have the largest inventory. Noting that multiple financial institutions may act as an underwriter for an issue as a part of an underwriter syndicate, we look for a dealer whose net sales is the highest for each bond within an issue and when there is a tie, we choose one whose first trade of the bond as in the data precedes the other(s). This way, we designate one

TABLE A1. Distribution of Underwriters: Our Method vs. Mergent

	Issue-level		Underwriter-level	
	Ours	Mergent	Ours	Mergent
	(1)	(2)	(3)	(4)
Number of observations	13,118	12,202	375	338
5^{th} percentile	1	1	1	1
25^{th} percentile	1	1	2	2
Median	1	1	8	6
75^{th} percentile	2	1	41	35
95^{th} percentile	5	4	313	288

Notes: The first two columns of this table provide the distribution of the number of underwriters for our final sample of 13,118 issues ("Issue-level"), where we identify the underwriters based on the method described in Appendix A.4 ("Ours") or the dataset from Mergent ("Mergent". Note for 916 issues, our method is not able to identify an underwriter. The last two columns ("Underwriter-level") present the distribution of the number of issues in which an underwriter participated, based on our sample.

underwriter per bond within an issue, but there may be multiple underwriters per issue.

Column (1) of Table A1 provides order statistics regarding the distribution of the number of the underwriters that we assign based on our procedure described earlier. Because most issues include multiple bonds (i.e., are a serial issue) and we consider the highest net sellers at each of the bond given an issue as the underwriters of the issue, it is notable that our methods indicate the median number of underwriters per issue is one. This statistic corresponds to the median value based on the underwriter information in the Mergent Municipal Bond Securities Database, represented in Column (2).

Looking at our data at the underwriter level, we find the number of financial institutions that underwrote at least one of bonds in our sample, as identified by our method, is 375, which is somewhat larger than the counterpart based on the Mergent dataset, 338 ("Number of observations" for Columns (3) and (4) of Table A1). The market concentration for underwriting business is a bit higher under our method: The 95^{th} percentile underwriter under our methods is indicated to have underwritten 313 issues, while the counterpart based on the Mergent data is 288. However, overall, the two distributions seem remarkably similar.

Table A2. State Legislation on Revolving-door Lobbying (2010-2013)

State	Date	Act	Who are newly regulated?
Arkansas	April 4, 2011	H 2202	Certain state regulatory officials
Indiana	March 17, 2010	H 1001	Members of the general assembly
Maine	May 24, 2013	H 144	Members of the general assembly
New Mexico	April 7, 2011	S 432	Public officers or employees
Virginia	March 25, 2011	H 2093	Constitutional officer

Appendix B. Revolving-door Regulations

B.1. **State Legislation.** Based on the Ethics and Lobbying State Law and Legislation database by National Conference of State Legislatures, we identify the 14 enactments of state legislation regarding revolving-door practices during the period of our study, 2010-2013. Among them, five pieces of state legislation introduced revolving-door regulations to state or local government officials. Table A2 provides the list of these five pieces of legislation, which provides variation in regulations, which is important in our empirical strategy. The rest, nine pieces of legislation, is to strengthen the existing revolving-door regulations.

The enacted pieces of legislation in Arkansas, Indiana, and Maine target state officials. Those in Indiana and Maine regulate members of the state legislature. On the other hand, the legislation in Arkansas focuses on certain state officials such as the Insurance Commissioner, the Bank commissioner, and the Securities Commissioner. The other two pieces of legislation in Table A2 extend the existing revolving-door regulations to local officials. In New Mexico, the enacted legislation extended the provisions of the Governmental Conduct Act, and an important feature is to include public officers and employees of local governments. Section 10-16-8 of the State Code states, "A former public officer or employee shall not represent a person in the person's dealings with the government on a matter in which the former public officer or employee participated personally and substantially while a public officer or employee." In Virginia, H 2093, entitled "State and Local Government Conflict of Interests Act," prohibits a constitutional officer, during the one year after the termination of his public service, from acting in a representative capacity on behalf of any person or group, for compensation, on any matter before the agency of which he was an officer. This resulted in a new section, 2.2-3104.02, to the State Code. In the Section 2.2-3101 of the Code, an "officer" is defined as "any person appointed or elected to any governmental or advisory agency including local school boards, whether or not he

Table A3. Revolving-door Regulations and Individual Features of Municipal Bond Complexity

	Multiple (1)	Sinking Fund (2)	Call (3)	Irregular Payment (4)	Non-fixed Coupon (5)
Local officials regulated	-0.048***	-0.020***	-0.016	-0.020***	-0.014***
	(0.009)	(0.005)	(0.012)	(0.007)	(0.005)
State officials regulated	0.039	0.038	-0.033*	-0.030***	-0.032***
	(0.046)	(0.051)	(0.017)	(0.007)	(0.007)
Bond attributes[a]	Yes	Yes	Yes	Yes	Yes
Issuer financial health attributes[a]	Yes	Yes	Yes	Yes	Yes
Year-month FE, County FE	Yes	Yes	Yes	Yes	Yes
Number of observations	13,086	13,086	13,086	13,086	13,086
Mean of the dependent variable	0.972	0.004	0.294	0.082	0.006
R^2	0.397	0.486	0.751	0.307	0.262

Notes: This table reports OLS estimates, based on the negotiated issues of general obligation or revenue bonds with any secondary market trades originated by local governments in 2010–2013. Standard errors are adjusted for clustering at the state level, and are provided in parentheses; $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. The outcome variables represent each of the complexity features as follows: whether or not an issue consists of multiple bonds (Column (1)); the logarithm of the sum of one and the frequency of a particular bond provision (call option, sinking fund, non-standard interest payment schedule, and variable/floating interest rate) across bonds (Columns (2)–(5), respectively). *a*. See the notes in Table 2 for the details on the control variables.

receives compensation or other emolument of office." Prior to this new section to the State Code, existing provisions regulating revolving-door practices include 2.2-3104 with regards to certain state officers or employees and 30-103 regarding the members of the general assembly.

B.2. **Revolving-door Regulations and Bond Design: Further Evidence.** Table 2 shows that the bond complexity, as measured by the index described in Section 3, decreases with revolving-door regulations, especially those regulating local officials. Our complexity index is based on five different features of bond complexity and, to verify the robustness of our results, we consider alternative specifications where each of the components of the index is an outcome variable, respectively.

We present the regression results in Table A3, and find that all components decrease with the regulations. Column (1) shows that revolving-door regulations targeting local officials are associated with a 4.8% decrease in the probability that an issue includes multiple bonds, while Column (2) shows that these regulations reduce the number of provisions introducing a sinking fund. The next column presents the effects of such regulations on call option provisions, which are not statistically significant; however, regulations targeting state officials reduce call provisions. With either type of revolving-door regulations, bonds are more likely to pay interest in a non-standard schedule (Column (4)), or to use variable or floating coupon rates (Column (5)).

B.3. **Heterogeneous Effects.** We argue that revolving-door regulations increase the extent to which officials internalize the payoff of the underwriter when negotiating over bond design at origination. Appendix D.2 shows that, if the underwriter's payoff from trades is increasing in bond complexity, the equilibrium level of complexity is increasing in ψ as well as in the underwriter's rent from underwriting a complex bond. Consistent with this result, Table A4 shows that the effects of the revolving-door regulations on bond complexity vary with bond or issuers' exogenous attributes that can increase the magnitude of ψ or the underwriter's rent from complexity. This analysis serves a validation both for the model and the mechanism behind the main result presented in Table 2. The specifications used here are the same as (1), except that we include an interaction term with revolving-door regulation dummies.

First, we find that the effects of revolving-door regulations vary with the circumstances that the issuer faces in the primary market. When a government issues a bond, it can hire a financial advisor, which is the case for 52% of our sample. Column (1) of Table A4 shows that the impact of regulating local officials' post-government employment is stronger when the local market for financial advisors is more concentrated.[1] When the market for financial advisors is concentrated, local governments may be less likely to hire a financial advisor due to higher fees. In addition, higher market concentration can facilitate collusion between financial advisors and underwriters. Both channels may increase the underwriters' influence on the government officials, which is captured by the officials' weight, ψ, in the model. On a similar vein, Column (2) of Table A4 shows that the effects of revolving-door regulations are slightly muted when the local government has prior experience in issuing bonds. Such experience may help reduce the extent to which underwriters can sway the officials at negotiation, lowering the value of ψ in our model.

Another factor that may affect the officials' weight for underwriters, ψ, is the political situation that they may face in office. Column (3) of Table A4 shows that

[1]We measure the market concentration of financial advisors associated with a bond using data on the identity of the financial advisors for all municipal bonds issued in that bond's state within three calendar years prior to its issuance.

Table A4. Heterogeneous Effects of Revolving-door Regulations

	Complexity index (log)				
	(1)	(2)	(3)	(4)	(5)
Local officials regulated	-0.076***	-0.064***	-0.062***	-0.059***	-0.060***
	(0.011)	(0.013)	(0.013)	(0.012)	(0.013)
State officials regulated	0.019	-0.018*	-0.010	-0.006	-0.010
	(0.023)	(0.010)	(0.011)	(0.012)	(0.009)
Local × Financial advisor HHI[a]	-0.040***				
	(0.009)				
Local × Issuer experience[b]		0.019**			
		(0.009)			
Local × Electorally competitive[d]			-0.018**		
			(0.008)		
State × Divided government[e]				0.067**	
				(0.027)	
Local × Frac. individual investors[c]					-0.014**
					(0.006)
Bond attributes[f]	Yes	Yes	Yes	Yes	Yes
Issuer financial health attributes[f]	Yes	Yes	Yes	Yes	Yes
Year-month FE, County FE	Yes	Yes	Yes	Yes	Yes
Number of observations	13,086	13,086	13,086	13,086	13,086
R^2	0.648	0.648	0.648	0.648	0.648

Notes: This table reports OLS estimates, based on the negotiated issues of general obligation or revenue bonds with any secondary market trades originated by local governments in 2010–2013. Standard errors are adjusted for clustering at the state level, and are provided in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. For ease of interpretation, we interact a revolving-door dummy variable with the standardized value of a bond or issue attribute, by subtracting its mean and then dividing it by the standard deviation, if the attribute is a continuous variable. *a*. We calculate the Herfindahl-Hirschman index associated with a given bond using data on the identity of the financial advisors for all municipal bonds issued in the bond's state within three calendar years prior to its issuance. *b*. To measure the issuing government's experience in bond origination, we consider a dummy variable indicating whether the government issued at least one bond within the three calendar years prior to a given bond issue. *c*. We define transactions of bonds with par value less than $100,000 as individual investors'. For a given bond, we look at the fraction of such transactions among all transactions involving the bonds of the same type of security (revenue, limited or unlimited general obligation) issued by local governments in the same state during the year when the given bond was issued. *d*. A county where the issuing government of a given bond is located is considered as "electorally competitive" at issuance if the vote margin in the most recent Presidential general election outcome prior to the issuance is less than 5%. *e*. The state government is considered as "divided government" if both chambers in the state legislature are controlled by another party than the governor's. *f*. See the notes in Table 2 for the details on the control variables.

the effects of revolving-door regulations on bond design is higher in "electorally competitive" counties.[2] One explanation is that local government officials' turnover rate

[2]We label that county as "electorally competitive " if the vote share of the Republican candidate in the most recent Presidential election in a county is between 45% and 55%

in these counties can be higher than in other counties, increasing the value of post-government job opportunities and consequently the value of ψ. In addition, Column (4) in the same table shows that the effects of revolving-door regulations for state officials are dampened when the state government is divided (i.e., both chambers in the state legislature are controlled by another party than the governor's). This finding may be explained by the idea that state officials may influence local officials' dealings at bond origination, and that such influence may wane with a divided government, as scrutiny on state officials becomes stronger and thus decreasing ψ.

Finally, we argue that the rent from underwriting a complex bond increases when the the share of individual retail investors, as opposed to institutional investors, active in the trading market is larger. This, in turn, can intensify the regulations' effects on bond design, which is documented in Columns (5) and (6) of Table A4.

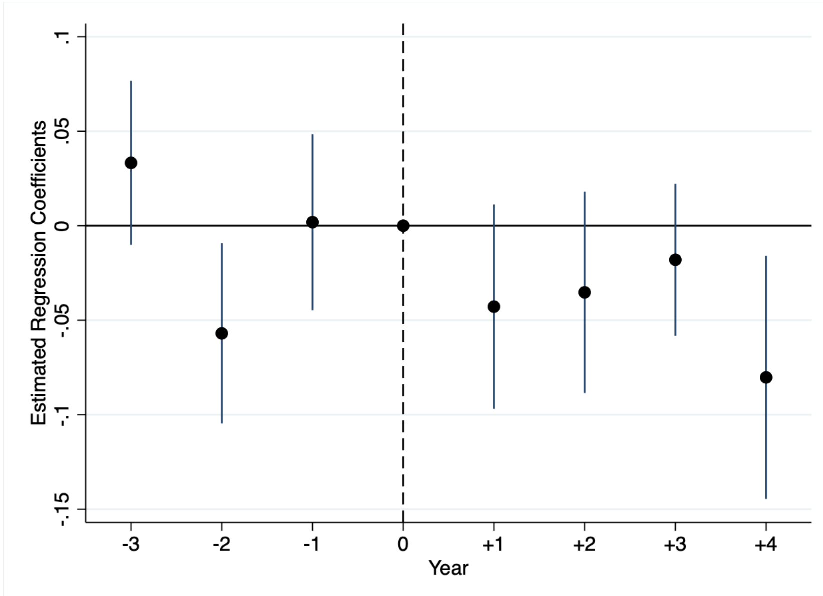
B.4. **Exogeneity Assumption as an Instrument.** Our research design relies on the across-state and over-time variation in the revolving-door regulations. We have shown that these regulations impact bond design, and use them as instruments to study the effects of bond complexity on market outcomes: credit risk, intermediation spread, and underwriter market share in and profits from secondary transactions by a dealer. For this approach to be valid, state revolving-door regulations must not affect these market outcomes directly. This section provides multiple pieces of evidence supporting this assumption. We first document that there doesn't seem to be a pre-trend in bond complexity associated with revolving-door regulations. We then show that the effects of the regulations on local governments' financial risk management or issuance behaviors are not statistically significant.

B.4.1. *Pre-trend Analysis.* Section 4.1 documents the effects of revolving-door regulations on bond design over time—before and after the regulation—controlling for county and year-month fixed effects. The specification we consider is

$$\log(s_i + 1) = \sum_{\tau_1=1}^{\tau_1=4} \beta_{\tau,1} d\tau_{1,i} + \sum_{\tau_2=1}^{\tau_2=3} \beta_{\tau,2} d\tau_{2,i} + \gamma \mathbf{X}_i + \kappa_{c(i)} + \theta_{t(i)} + \epsilon_i, \tag{A.1}$$

where $d\tau_{1,i}$ is a dummy variable indicating that the i^{th} bond issuance occurred within one to three years ($\tau = 1, 2, 3$) or beyond three years ($\tau = 4$) after a revolving-door regulation was implemented and $d\tau_{2,i}$ is similarly defined except that we count the time period prior to the regulation. Note that for this exercise, we do not distinguish

Figure A1. Effects of Revolving-door Regulations Over Time



Notes: This graph shows the regression coefficient estimates and the 95% confidence intervals for yearly time dummies before and after a revolving-door regulation was implemented. The dependent variable is the logarithm of the bond complexity index plus one. We control for various issue and issuer attributes; see the text for the specification.

regulations by their target (state vs. local officials). As for controls, we employ the same set of controls used for the specification of Column (4) of Table 2.

Figure A1 presents the coefficient estimates for $\beta_{\tau,1}$ (for Year $+1, +2, +3, +4$) and $\beta_{\tau,2}$ (for Year $-1, -2, -3$). There are two notable patterns in the coefficient estimates. First, we do not find evidence that there exists an obvious pre-trend. Second, the effects are higher and statistically significant after the regulations were in place more than three years. This may reflect that it takes time for local governments to plan on a bond issue, select an underwriter (syndicate), and negotiate over terms of issuance.

B.4.2. *Bond Management and Issuance.* Revolving-door regulations may influence the work morale or composition of government officials. In that case, the regulations may directly influence the municipal bond market. We study this possibility by looking at the direct impact of these regulations on municipal bond risk management and issuance.

To measure risk management, we look at the credit ratings of the bond that were issued prior to 2010, at the end of each year from 2010 to 2013. The ratings of a

Table A5. Revolving-door Regulations and Bond Management/Issuance

	Rating of existing bonds[b] (1)	Annual issuance amount (log)[c] (2)	Length of maturity (log)[d] (3)	Ratio of negotiation[d] (4)
Local officials regulated	-0.045	-0.322	0.151	-0.080
	(0.031)	(0.264)	(0.094)	(0.062)
State officials regulated	-0.367	0.485	-0.020	-0.027
	(0.012)	(0.455)	(0.052)	(0.026)
Bond attributes[a]	Yes	No	No	No
Issuer financial health[a]	Yes	Yes	Yes	Yes
Year FE, County FE	Yes	Yes	Yes	Yes
Number of observations	286,554	62,588	21,963	21,963
R^2	0.407	0.066	0.358	0.422

Notes: This table reports OLS estimates. Standard errors are adjusted for clustering at the state level, and are provided in parentheses; $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. a. See the notes in Table 2 for the details on the control variables. b. We use all bonds that were issued prior to 2010 by the local governments in our sample. The dependent variable is the credit rating of each bond. Note that during the four years of our study period (2010–13), we observe these bonds up to four times (depending on the maturity). c. The unit of analysis is government-year based on 15,673 governments over four years, 2010–13. The total number of observations used in the regressions are slightly less than $15,673 \times 4$ because some of the controls are not available; the results are robust to including all observations and dropping some controls. The outcome variable is the logarithm of the total money raised via municipal bonds plus one. d. We use all government-year observations with any bond issuance. The outcome variables are the logarithm of the average length of maturity among the bonds issued by the government during the given year (Column 3) and the ratio of bonds sold via negotiation, in terms of the amount of money raised (Column 4).

bond may change until it reaches its maturity, and these ratings reflect the financial health and the ability of the issuer to pay the remaining balances of a bond, which are partially determined by government officials' decisions in managing revenues and expenses. Column (1) of Table A5 shows the result of the following regression model:

$$\text{CreditRating}_{i,t} = \beta_1 \text{LocalReg}_{i,t} + \beta_2 \text{StateReg}_{i,t} + \gamma \mathbf{X}_{i,t} + \kappa_{c(i)} + \theta_t + \epsilon_{i,t}. \tag{A.2}$$

Note that the specification is different from the model presented in (1) in Section 4.1 in two dimensions. Here, a bond can be observed multiple times, and all explanatory variables, including the fixed effects, are measured at the time when a bond is observed, as opposed to when it was issued. We do not find evidence that revolving-door regulations impact the credit ratings of existing bonds, implying that their impact on government official behaviors related to the ability to pay back government debts.

We then look at local governments' bond issuance behavior in three dimensions: the amount of capital raised by municipal bonds, the average length of bond maturity, and the ratio of bonds sold via negotiation, as opposed to other methods of sale like auctions. We aggregate these variables at the government-year level and we consider the following regression model:

$$y_{j,t} = \beta_1 \text{LocalReg}_{j,t} + \beta_2 \text{StateReg}_{j,t} + \gamma \mathbf{X}_{j,t} + \kappa_{c(j)} + \theta_t + \epsilon_{j,t}, \tag{A.3}$$

where $y_{j,t}$ denotes the (aggregated) bond issuance behavior of government j during year t, and $\text{LocalReg}_{j,t}$ and $\text{StateReg}_{j,t}$ are dummies indicating that the respective regulation was in place during the entire year. The results are reported in the last three columns of Table A5, and we do not find evidence that revolving-door regulations affect local governments' bond issuance behavior.[3]

B.5. **Bond Issuance Methods: Negotiated vs. Auctioned.** Our study focuses on negotiated bonds because underwriters cannot directly influence bond design at origination for auctioned bonds. We argue that revolving-door regulations reduce conflicts of interest and limit underwriters' pushes for complex bond design in negotiations. As a way to provide additional support for this argument, we show that revolving-door regulations do not affect bond design for auctioned bonds.

To see this, we run the same specification of (1) using auctioned bonds only. Column (2) of Table A6 show that revolving-door regulations, if anything, increased complexity, which is the opposite of our findings in Section 4.1. In addition, we use all negotiated or auctioned bonds and include interaction terms between regulations and dummies for auctioned or negotiated bonds. The results, presented in Columns (3) and (4), are similar to those in Columns (1) and (2).

Appendix C. Additional Evidence for the Trade-off and Underwriter Incentives in Bond Design

To understand how bond design affects trading frictions that investors face, we measure trading frictions by the intermediation spread in Section 4.2. Alternatively, we look at the total volume of secondary trades with investors, specifically the total number of transactions in which a dealer purchased the bond from investors in the first

[3]For Column (2) of Table A5, all possible government-year combinations are used. However, for Columns (3) and (4) of the same table, given the definition of the outcome variables, we focus on government-year observations with any bond issuance. Note that among 15,673 local governments in our sample, and not all of them issue bonds annually (the average number of bonds issued by a government per year is 0.42). Thus, we acknowledge that the results reported in the latter two columns should be interpreted with a caveat that we do not correct for the sample selection. However, given our results in Column (2), the bias due to sample selection may not be important.

Table A6. Revolving-door Regulations and Design for Auctioned Bonds

	Complexity index (log)			
	Auctioned only		All	
	(1)	(2)	(3)	(4)
Local officials regulated × Auctioned	-0.013*	-0.011	-0.004	-0.0002
	(0.007)	(0.007)	(0.007)	(0.007)
State officials regulated × Auctioned		0.027***		0.064*
		(0.006)		(0.008)
Local officials regulated × Negotiated			-0.056***	-0.057***
			(0.021)	(0.020)
State officials regulated × Negotiated				-0.096*
				(0.054)
Auctioned			0.004	0.0004
			(0.009)	(0.009)
Bond attributes[a]	Yes	Yes	Yes	Yes
Issuer financial health attributes[a]	Yes	Yes	Yes	Yes
Year-month FE, County FE	Yes	Yes	Yes	Yes
Number of observations	11,172	11,172	25,717	25,717
R^2	0.777	0.777	0.647	0.649

Notes: This table reports OLS estimates, based on the general obligation or revenue bonds issued by local governments in 2010–2013. Standard errors are adjusted for clustering at the state level, and are provided in parentheses; $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. Only auctioned bonds are used in the first two columns, and all bonds are used for the other two columns. *a*. See the notes in Table 2 for the details on the control variables.

four years after origination. Note that we continue to focus on dealer purchase from investors to ensure that sales of the inventory of the underwriter from the primary market are not included. We continue to use the specification of (2) of Section 4.2, and the outcome variable is the volume of trades with investors. Columns (1)–(2) of Table A7 show the estimation results. Based on the estimates in Column (2), increasing the bond complexity index by 1% decreases trading volume by more than 1%. Taken together with the results of Column (4) of Table 3, we find that nonstandard provisions of a bond tend to lower its liquidity in the secondary market.

In addition to the underwriter's market share (Table 3), we look at the impact of bond design on the profits that underwriters earn from intermediating trades. As an incomplete, but reasonable, measure of profits, we consider the revenue associated with a bond (the value of total sales of the bond) minus the direct cost (the value of total purchases of the bond by the underwriter) within four years after origination. Borrowing an accounting terminology, we call this measure as "gross profit". We standardize the gross profit by dividing it by the total par value of the bond, so that we can measure the amount of profit from underwriting a bond of \$100. On average,

Table A7. Trade-off and Underwriter Incentives in Bond Design

	Volume of trade[c]		Gross profit[d]		Offering price (log)[e]
	OLS	2SLS	OLS	2SLS	OLS
	(1)	(2)	(3)	(4)	(5)
Complexity index (log)	-0.1872*	-1.642*	2.26**	7.69**	
	(0.1019)	(0.9561)	(0.003)	(0.035)	
Local officials regulated					0.028**
					(0.011)
State officials regulated					0.008
					(0.007)
Coupon rate	Yes	Yes	Yes	Yes	No
Bond attributes[a]	Yes	Yes	Yes	Yes	Yes
Issuer financial health attributes[a]	Yes	Yes	Yes	Yes	Yes
Year-month FE, County FE	Yes	Yes	Yes	Yes	Yes
Heterogeneous time trend[b]	Yes	Yes	Yes	Yes	No
Number of observations	13,085	13,085	11,078	11,078	13,048
First stage F-stat	-	13.631	-	10.5	

Notes: This table reports both OLS and 2SLS estimates, based on the negotiated issues of general obligation or revenue bonds with any secondary market trades originated by local governments in 2010–2013. The instruments are dummy variables for revolving-door regulations, interacted with the Herfindahl-Hirschman index for the market of financial advisors at the state level, the fraction of secondary transactions by individual investors at the state- and security-type level, the county-level electoral competitiveness, and whether or not the state government is under divided control. Standard errors are adjusted for clustering at the state level, and are provided in parentheses. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$. *a*. These controls are identical to those in Table 2. *b*. We include year-month FEs interacted with the county/state-level attributes used for the instruments. *c*. We measure the volume of trade by the total number of purchases by a dealer from an investor within the first four years after origination. *d*. The "gross profit" is defined as the value of total sales minus that of total purchases made by the underwriter within four years after origination, per a face value of $100. *e*. The "offering price" is the price received by the issuing government at origination per a face value of $100.

underwriters make $1.75 from trades per underwriting $100, and this is much larger than the corresponding average underwriting fee, $0.54 (Braun, 2015). We estimate (2) using this outcome variable.

Column (4) of Table A7 indicates the gross profits increase as the bond becomes more complex. Increasing the complexity index from its average value (1.46) to the 75th percentile (1.69) increases the underwriter's gross profit by $0.29 for every $100 of bond underwritten, which corresponds to an increase of 17% over the average. Note that the gross profits do not take into account other costs associated with dealers' activities such as searching for trading partners and opportunities. Our structural analyses can help shed light on the value of nonstandard provisions to the underwriter.

What does the lower liquidity mean for the government costs? To answer this question, we focus on the offering price associated to a bond, which is the price received by the government at origination per a face value of \$100. On average, the offering price for the bonds in our sample is \$102.7, closely related to the average interest rate 2.96% (Table 1). Since this price is negotiated by the issuing government and underwriter at origination, it can be directly affected by revolving-door regulations. Therefore, we cannot rely on our instrumental variable approach to isolate the impact of nonstandard bond provisions on offering price. Instead, we explore the combined impact of the direct effect of revolving-door regulations on offering price and their indirect effects through changes in bond attributes. We estimate a variant of the regression model specified in (1), where the outcome variable is replaced by the offering price of a bond. Our coefficients of interest, β_1 and β_2, represent the change in the offering price for the average bond issued after the regulation came into effect. The result, in Column (5) of Table A7, shows that limiting revolving-door practices, in particular of local officials, increases the offering price by 2.8%.

Appendix D. Modelling Revolving-door Regulations

The empirical findings in Section 4.1 and Appendix B.2 imply that revolving-door regulations reduces the use of nonstandard provisions in bonds. Yet, Appendix B.4 provides suggestive evidence that such regulation does not affect the investor demand or the local government behavior in managing credit risk or issuing bonds. This implies that the government cost of paying debt is not directly influenced by the regulations. To explain these findings, we propose that revolving-door regulations may affect the extent to which officials internalize the payoff of the underwriter from trades, V_U, when negotiating over bond design upon its origination.[4] Under an alternative model, the officials may internalize the net payoff of the underwriter, $V_U - F$, under constraints on bond price F. Below, we show that these two models are observationally equivalent in the sense that they both can rationalize the same equilibrium bond design. In addition, we provide comparative statics consistent with our main finding in Section 4.1 and heterogeneous effects in Appendix B.3.

[4]Specifically, our model allows that revolving-door regulations, denoted by an indicator variable h, affects the weight parameter, ψ, and that officials' payoff is the weighted sum of the government cost of paying $A(1 + rT)$ and the underwriter's payoff from trading the bond, V_U.

D.1. **Two Models.** Let us consider a simplified version of our model where bond design is one-dimensional, over s. The Nash bargaining problem is

$$\max_{(s,F)} \left[F - c(s) + \psi V_U(s)\} - J_G\right]^{\rho} \left[V_U(s) - F - J_U\right]^{1-\rho}, \tag{A.4}$$

subject to

$$P_G(s, F, \psi, J_G) \equiv F - c(s) + \psi V_U(s) - J_G \geq 0, \tag{A.5}$$

$$P_U(s, F, J_U) \equiv V_U(s) - F - J_U \geq 0. \tag{A.6}$$

The first order conditions, with respect to s and F respectively, are

$$\rho P_G^{\rho-1} P_U^{1-\rho}[-c'(s) + \psi V_U'(s)] + (1-\rho) P_G^{\rho} P_U^{-\rho} V_U'(s) = 0,$$
$$\rho P_G^{\rho-1} P_U^{1-\rho} - (1-\rho) P_G^{\rho} P_U^{-\rho} = 0,$$

where P_G and P_U denote the surpluses relative to the outside options of the officials and the underwriter as defined in (A.5)–(A.6). Rearranging them leads to

$$\frac{(1-\rho)V_U'(s)}{\rho[c'(s) - \psi V_U'(s)]} = \frac{P_U(s, F, J_U)}{P_G(s, F, \psi, J_G)} = \frac{1-\rho}{\rho}, \tag{A.7}$$

where the first equality derives from the first FOC and and the second one from the second FOC. Focusing on the equality of the two ends of (A.7), we have

$$(1 + \psi)V_U'(s) = c'(s). \tag{A.8}$$

Note ψ affects the equilibrium level of s. For example, suppose $V_U'(s)$ is decreasing in s and $c'(s)$ is increasing in s. Then a higher $\psi > 0$ leads to a more complex bond.

The alternative model where the officials internalize the underwriter's net payoff with weight ψ where the bond price F is constrained can be written as follows:

$$\max_{(s,F)} \left[F - c(s) + \psi \left\{V_U(s) - F\right\} - J_G\right]^{\rho} \left[V_U(s) - F - J_U\right]^{1-\rho}, \tag{A.9}$$

subject to

$$F \leq \bar{F}, \tag{A.10}$$

$$\tilde{P}_G(s, F, \psi, J_G) \equiv F - c(s) + \psi \left\{V_U(s) - F\right\} - J_G \geq 0, \tag{A.11}$$

$$P_U(s, F, J_U) \geq 0. \tag{A.12}$$

If the constraint on F, (A.10), is not binding, then the first order conditions with respect to (s, F) can be written as

$$\frac{(1-\rho)V_U'(s)}{\rho[c'(s)-\psi V_U'(s)]} = \frac{P_U(s,F,J_U)}{\tilde{P}_G(s,F,\psi,J_G)} = \frac{1-\rho}{\rho(1-\psi)}. \tag{A.13}$$

Rearranging terms in (A.13), we have

$$V_U'(s) = c'(s),$$

where the value of ψ does not affect the bond design.

On the other hand, suppose the constraint on F is binding so that the equilibrium F is $\bar{F}$. Then the following inequality holds

$$\frac{P_U(s,\bar{F},J_U)}{\tilde{P}_G(s,\bar{F},\psi,J_G)} \geq \frac{1-\rho}{\rho(1-\psi)}, \tag{A.14}$$

and the FOC with respect to s becomes

$$\frac{(1-\rho)V_U'(s)}{\rho[c'(s)-\psi V_U'(s)]} = \frac{P_U(s,\bar{F},J_U)}{\tilde{P}_G(s,\bar{F},\psi,J_G)}.$$

Rearranging terms in the above equation, we have

$$\left(\frac{(1-\rho)\tilde{P}_G(s,\bar{F},\psi,J_G)}{\rho P_U(s,\bar{F},J_U)} + \psi\right) V_U'(s) = c'(s). \tag{A.15}$$

Fix the underwriter's payoff from trades, $V_U(\cdot)$, outsides options J_G and J_U, the bond price upper bound $\bar{F}$, and two bargaining parameters, (ρ, ψ). In the prior model, suppose s^* satisfies (A.8) for a given cost function, $c(\cdot)$. Now consider the following alternative financial cost function, denoted by $\tilde{c}(\cdot)$:

$$\tilde{c}(s) = \frac{1}{1+\psi}\left(\frac{(1-\rho)\tilde{P}_G(s^*,\bar{F},\psi,J_G)}{\rho P_U(s^*,\bar{F},J_U)} + \psi\right) c(s).$$

If we replace $c'(s)$ with $\tilde{c}'(s)$, then s^* also satisfies (A.15). Given that we observe bond design s (but not F), our observational equivalence claim for the two above models holds. This argument can be extended if we also observe bond price.

D.2. **Comparative Statics.** Using the first model considered in the previous section, we show that the equilibrium level of bond complexity increases with the weight parameter value, ψ, if complexity increases the underwriter's payoff from trading. Using the Implicit Function Theorem, we take the derivative with respect to ψ in both sides of (A.8) to obtain

$$V_U'(s) + (1+\psi)V''(s)\frac{\partial s}{\partial \psi} = c''(s)\frac{\partial s}{\partial \psi}.$$

Rearranging terms we have

$$\{(1+\psi)V''(s) - c''(s)\}\,\frac{\partial s}{\partial \psi} = -V_U'(s).$$

Note the second order condition must hold, thus $(1+\psi)V''(s) - c''(s) < 0$. Therefore, $\frac{\partial s}{\partial \psi} > 0$ if $V_U'(s) > 0$. Put it differently, as the officials' weight for the underwriter increases, the equilibrium bond design is more complex as long as complexity benefits the underwriter's payoff from trades.

In addition, we look at the relationship between bond complexity and the size of its influence on the underwriter's payoff from trades, $V_U'(s)$. To facilitate our discussion, let us parameterize it by $V_U'(s;\alpha)$ where $\frac{\partial}{\partial \alpha}V_U'(s;\alpha) > 0$. Similarly as above, we take the derivative with respect to α in both sides of (A.8) to obtain

$$(1+\psi)\left\{V''(s)\frac{\partial s}{\partial \alpha} + \frac{\partial}{\partial \alpha}V_U'(s;\alpha)\right\} = c''(s)\frac{\partial s}{\partial \alpha}.$$

Rearranging terms we have

$$\{(1+\psi)V''(s) - c''(s)\}\,\frac{\partial s}{\partial \alpha} = -(1+\psi)\frac{\partial}{\partial \alpha}V_U'(s;\alpha).$$

Because $(1+\psi)V''(s) - c''(s) < 0$, $\frac{\partial}{\partial \alpha}V_U'(s;\alpha) > 0$ by assumption, and $\psi > 0$, we conclude that $\frac{\partial s}{\partial \alpha} > 0$, implying that as the benefit of complexity as perceived by the underwriter increases, the equilibrium bond design gets more complex.

Appendix E. Characterizing Equilibrium in the Trading Market

Given the value function of dealers and investors, as well as the optimal meeting rate that dealers choose (Section 5.2), we write the equilibrium quantity for trades with an investor, q_I, and the equilibrium quantity for inter-dealer trades, q_D:

$$q_I(\tau;u,y') = \arg\max_q \Big\{W(\tau;a'+q,\nu') - W(\tau;y) + V\left(\tau;a-q,b+1,\phi_0\right) - V\left(\tau;u\right)\Big\}, \tag{A.16}$$

$$q_D(\tau;u,u') = \arg\max_q \Big\{V(\tau;a+q,b,\phi_0) - V(\tau;u) + V\left(\tau;a'-q,b',\phi_0'\right) - V\left(\tau;u'\right)\Big\}, \tag{A.17}$$

The total—not unit—price in a transaction implements a division of the gain:

$$p_I(\tau; u, y') = \rho \max_q \Big\{ W(\tau; a' + q, \nu') - W(\tau; y') - V(\tau; a - q, b + 1, \phi_0) + V(\tau; u) \Big\}, \tag{A.18}$$

$$p_D(\tau; u, u') = (1-\rho_D) \max_q \Big\{ V(\tau; a+q, b, \phi_0) - V(\tau; u) - V(\tau; a' - q, b, \phi_0) + V(\tau; u') \Big\}. \tag{A.19}$$

Given the the equilibrium meeting rates and trading quantities, the equilibrium path of the investor state distribution satisfies:

$$\begin{aligned}
-\dot{\Phi}_I(\tau; u) &= -\alpha \Phi_I(\tau; a, \nu) \left[1 - F(\nu|\tau)\right] + \alpha \int_{-\infty}^{a} \int_{\nu}^{\infty} \Phi_I(\tau; da, d\nu') F(\nu'|\tau) \\
&- \int_{-\infty}^{\nu} \int_{-\infty}^{a} \int_{u} \lambda(\tau; u) \mathbb{I}_{\{\tilde{a} + q_I(\tau; u, \tilde{a}, \tilde{\nu}) > a\}} \Phi_D(\tau; du) \Phi_I(\tau; d\tilde{a}, d\tilde{\nu}) \\
&+ \int_{-\infty}^{\nu} \int_{a}^{\infty} \int_{u} \lambda(\tau; u) \mathbb{I}_{\{\tilde{a} + q_I(\tau; u, \tilde{a}, \tilde{\nu}) \leq a\}} \Phi_D(\tau; du) \Phi(\tau; d\tilde{a}, d\tilde{\nu}).
\end{aligned} \tag{A.20}$$

The term $-\dot{\Phi}_I(\tau; a, \nu)$ captures the net inflows of investors from $t = T - \tau$ to $t' = t + \epsilon$ for a small $\epsilon > 0$. The first two terms in the right hand side of (A.20) capture the flow of investors due to the idiosyncratic taste shock; and the last two terms are associated with trades. Specifically, the first term represents the outflow of investors who draw a new taste type greater than ν, which occurs with probability $\alpha\left[1 - F(\nu|\tau)\right]$. The second term shows the inflow of investors who draw a new taste type less than ν and have inventory less than a. The third term presents the outflow of investors whose asset holding after a trade becomes greater than a; and the fourth term reflects the inflow of investors whose post-trade inventory becomes less than a.

To define the equilibrium path of the dealer state distribution, it is useful to make a change of variable. In particular, we denote by $\varphi(b)$ the dealer's cost advantage associated with trading experience b: $\varphi(b) = \exp(-\phi_1 \log(b))$. With this notation, each dealer' state is summarized by the vector $u = (a, \varphi, \phi_0)$. Moreover, after a trade with an investor the dealers' state evolves to $\varphi(b)' = \exp(-\phi_1 \log(b + 1))$. Then the dealers' state distribution must satisfy the following law of motion:

$$
\begin{aligned}
& -\dot{\Phi}_D(\tau;u) && \text{(A.21)}\\
= & -\int_0^{\varphi}\int_{-\infty}^{a}\int_y \lambda(\tau;\tilde{u})\max\left[\mathbb{I}_{\{\tilde{a}-q_I(\tau;y,\tilde{u})>a\}},\mathbb{I}_{\{\tilde{\varphi}'>\varphi\}}\right]\Phi_I(\tau;dy)\Phi_D(\tau;d\tilde{u}) \\
+ & \int_0^{\varphi}\int_a^{\infty}\int_y \lambda(\tau;\tilde{u})\min\left[\mathbb{I}_{\{\tilde{a}-q_I(\tau;y,\tilde{u})\le a\}},\mathbb{I}_{\{\tilde{\varphi}'\le\varphi\}}\right]\Phi_I(\tau;dy)\Phi_D(\tau;d\tilde{u}) \\
+ & \int_{\varphi}^{\infty}\int_{\tilde{a}}\int_y \lambda(\tau;\tilde{u})\min\left[\mathbb{I}_{\{\tilde{a}-q_I(\tau;y,\tilde{u})\le a\}},\mathbb{I}_{\{\tilde{\varphi}'\le\varphi\}}\right]\Phi_I(\tau;dy)\Phi_D(\tau;d\tilde{u}) \\
- & \lambda_D\int_0^{\varphi}\int_{-\infty}^{a}\int_{u'} \mathbb{I}_{\{\tilde{a}+q_D(\tau;\tilde{u},u')>a\}}\Phi_D(\tau;du')\Phi_D(\tau;d\tilde{u}) \\
+ & \lambda_D\int_0^{\varphi}\int_a^{\infty}\int_{u'} \mathbb{I}_{\{\tilde{a}+q_D(\tau;\tilde{u},u')\le a\}}\Phi_D(\tau;du')\Phi_D(\tau;d\tilde{u}).
\end{aligned}
$$

The initial conditions for the investors' distribution is that investors do not hold the asset at the beginning of the trading game:

$$\Phi_I(T;a,\nu) = \mathbb{I}_{\{a\ge 0\}}F_{\nu|\tau}(\nu|T). \tag{A.22}$$

The initial condition for Φ_D requires that the underwriter, whose search cost parameter is denoted by $\phi_{0,U}$, holds all bonds in the beginning of the trades. To approximate this condition, we denote by m_U the (small) mass of the underwriter and write the initial condition:

$$\Phi_D(T;a,b,\phi_0) = \begin{cases} \mathbb{I}_{\{a\ge 0,b\ge 0\}}F_{\phi_0}(\phi_0), & \text{if } \phi_0 \ne \phi_{0,U} \\ (1-m_U)\mathbb{I}_{\{a\ge 0,b\ge 0\}}F_{\phi_0}(\phi_0) + m_U\mathbb{I}_{\{a\ge A,b\ge 0\}}F_{\phi_0}(\phi_0), & \text{if } \phi_0 = \phi_{0,U} \end{cases} \tag{A.23}$$

Now, an equilibrium in the trading market is defined as follows.

Definition E.1. *An equilibrium in the trading market is (i) a path for the distribution of investors' state, $\Phi_I(\tau;y)$, and a path for the distribution of dealers' state, $\Phi_D(\tau;u)$, (ii) value functions for investors and dealers, $W(\tau;y)$ and $V(\tau;u)$, (iii) dealer-to-investor meeting rates $\lambda(\tau;u)$, (iv) dealer-to-investor trade prices and quantities, $p_I(\tau;y,u)$ and $q_I(\tau;y,u)$ and dealer-to-dealer trade prices and quantities, $p_D(\tau;u,u')$ and $q_D(\tau;u,u')$, such that*

1. *(i) follows (A.20)–(A.21) subject to (A.22)–(A.23), given (ii)–(iv);*
2. *(ii) satisfies (9), (11), and the terminal values in Section 5, given (i);*
3. *(iii) satisfies (10), given (i)–(ii);*

4. (iv) satisfies (A.16)–(A.19), given (ii).

Appendix F. First-Step Estimation

This section discusses the identification of the trading market parameters. We then provide the moment conditions and the likelihood function used in estimating the first-step parameters for each bond, $\hat{\theta}_i$. Finally, we present the distribution of the first-step estimates across bonds and describe the model fit.

F.1. **Identification of the Trading Market Parameters.** Since our model is nonlinear, all the trading market parameters affect all the moments in our objective function. Nevertheless, it is useful to discuss how the identification of the key parameters relies on different moments in the data.

The observed timing of trades can be used to compute directly the distribution of meeting rates. Indeed, recall that the investor taste type is continuously distributed, bonds are perfectly divisible, and short-selling is allowed in our model. These assumptions ensure that when two agents meet, they can find a mutually beneficial trade with probability one. Therefore, the inter-dealer meeting frequency pins down the inter-dealer meeting rate, $\lambda_{D,i}$.

Moreover, the observed dealer-to-investor meeting rate and its covariance with dealers' client network b and prior geographic specialization g help us identify search cost parameters, $\phi_{0,i}$ and $\phi_{1,i}$. We characterize the time-varying, dealer-specific meeting rate with investors, $\lambda(\tau, a, b, g)$, in (10). The extent to which a dealer's search intensity increases as the dealer's network b expands is governed by the strength of the network effects, measured by $\phi_{1,i}$. With that, the observed baseline meeting frequency for each dealer is informative of the initial search cost parameter, $\phi_{0,i}$, as it varies by the dealer's geographic specialization g.

Next, the moments related to inter-dealer trading price and quantity help us identify dealer preference parameters, $\nu_{D,i}$ and $\kappa_{D,i}$. For example, consider two dealers with the same geographic specialization but different levels of inventory. If the marginal cost of holding inventory, $\kappa_{D,i}$, is large, the inventories of these dealers after their trade will be close to each other because the quantity traded maximizes the gains from trade. In addition, the flow value of holding the bond for a dealer, $\nu_{D,i}$, determines the price difference between inter-dealer and dealer-to-investor trades.

Identifying a bargaining parameter from bargaining outcomes is notoriously difficult.[5] We argue that in our setting, the over-time and across-dealer variation in the dealers' inventory and its correlation with trading prices is useful for identifying ρ_i. As an example, in the extreme case where the dealer's bargaining power is zero, the price would be uncorrelated with the dealer's state, after controlling for the quantity and the timing of the trade. Given this, we use the observed distribution of trading prices to identify the investor type distribution $(\gamma_{1,i}, \gamma_{2,i})$.[6] Finally, note that the exogenous passage of time, along with the fact that the model is finite-horizon, helps identification. For example, α_i shapes the overall volume of trade after the initial reallocation of assets from the underwriter to investors.

F.2. **First-Step Estimator.** We first estimate the dealer state distribution, denoted by $\hat{\Phi}_D(\tau; u)$ using a Kernel estimator. We then estimate θ_i by minimizing the weighted average of three sets of components. The first group of components relates to the joint distribution of price, quantity, and dealer inventory for transactions between dealers $(d_{ij} = 0)$. Let $p_D(\tau; u, u'|\theta)$ and $q_D(\tau; u, u'|\theta)$ denote the inter-dealer trading prices and quantities defined in (A.17) and (A.19), and let $\Phi_D(\tau; u)$ denote the distribution of dealer states $u = (a, b, g)$ defined in (A.21). The moment conditions are based on the average inter-dealer trading price and the covariance of trading price (quantity) with a dealer's inventory, over the period that we observe trades, denoted by $\bar{t}_i$, which is often less than the bond's maturity, T_i, given our data. Denoting the inventory of a dealer participating in transaction j by a_{ij}, we have the following conditions:

$$
\begin{aligned}
\mathbb{E}\left(\left[p_{ij} - \int_{T_i-\bar{t}_i}^{T_i} \int_{u'} \int_{u} p_D(\tau; u, u'|\theta_i) d\hat{\Phi}_D(\tau; du) d\hat{\Phi}_D(\tau; du') d\tau\right](1 - d_{ij})\right) &= 0, \\
\mathbb{E}\left(\left[p_{ij} a_{ij} - \int_{T_i-\bar{t}_i}^{T_i} \int_{u'} \int_{u} p_D(\tau; u, u'|\theta_i) a d\hat{\Phi}_D(\tau; du) d\hat{\Phi}_D(\tau; du') d\tau\right](1 - d_{ij})\right) &= 0, \\
\mathbb{E}\left(\left[q_{ij} a_{ij} - \int_{T_i-\bar{t}_i}^{T_i} \int_{u'} \int_{u} q_D(\tau; u, u'|\theta_i) a d\hat{\Phi}_D(\tau; du) d\hat{\Phi}_D(\tau; du') d\tau\right](1 - d_{ij})\right) &= 0,
\end{aligned}
$$

[5]See, for example, footnote 13 in Gavazza (2016).

[6]Recall we do not observe investors' inventory, while we observe dealers' inventory. This can make the identification of inventors' preferences difficult, which contrasts to the identification of dealer preferences. For example, an investor may pay a relatively low price for a bond because she has drawn a low taste type or because she has a large inventory of that bond. However, the market clearing condition introduces a constraint on the joint distribution of investors' asset holdings and tastes, which, combined with our data on all transactions on a given bond, helps us identify investor preference parameters.

The second group of components concerns the the joint distribution of price, quantity, inventory, and trading network for dealer-to-investor trades ($d_{ij} = 1$). Let $p_I(\tau; u, y|\theta)$ and $q_I(\tau; u, y|\theta)$ denote the trading prices and quantities defined in (A.16) and (A.18), and let $\Phi_I(\tau; y|\theta)$ be the distribution of investors' states $y = (\nu, a)$ defined in (A.20). We define the distribution of dealer state, conditional on meeting and trading with an investor, by $\tilde{\Phi}_D$:

$$\tilde{\Phi}_D(\tau; u|\theta) = \frac{\lambda(\tau; u|\theta)\hat{\Phi}_D(\tau; u)}{\int \lambda(\tau; u|\theta)d\hat{\Phi}_D(\tau; u)}.$$

We rely on moment conditions related to the first two moments of trading price and quantity:

$$\begin{aligned}
\mathbb{E}\left(\left[p_{ij} - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u p_I(\tau; u, y|\theta_i)d\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)d\tau\right] d_{ij}\right) &= 0, \\
\mathbb{E}\left(\left[q_{ij} - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u q_I(\tau; u, y|\theta_i)d\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)d\tau\right] d_{ij}\right) &= 0.
\end{aligned}$$

$$\begin{aligned}
\mathbb{E}\left(\left[p_{ij}^2 - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u p_I(\tau; u, y|\theta_i)^2 d\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)d\tau\right] d_{ij}\right) &= 0, \\
\mathbb{E}\left(\left[q_{ij}^2 - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u q_I(\tau; u, y|\theta_i)^2 d\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)d\tau\right] d_{ij}\right) &= 0.
\end{aligned}$$

Moreover, we match the covariance of trading prices and quantities with the dealer's inventory a and trading network b. Denoting the inventory and network of the dealer participating in trade j by (a_{ij}, b_{ij}), we present the moment conditions as follows:

$$\begin{aligned}
\mathbb{E}\left(\left[p_{ij}a_{ij} - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u p_I(\tau; u, y|\theta_i)ad\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)\right] d_{ij}\right) &= 0, \\
\mathbb{E}\left(\left[q_{ij}a_{ij} - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u q_I(\tau; u, y|\theta_i)ad\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)\right] d_{ij}\right) &= 0, \\
\mathbb{E}\left(\left[p_{ij}b_{ij} - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u p_I(\tau; u, y|\theta_i)bd\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)\right] d_{ij}\right) &= 0, \\
\mathbb{E}\left(\left[q_{ij}b_{ij} - \int_{T_i-\bar{t}_i}^{T_i}\int_y\int_u q_I(\tau; u, y|\theta_i)bd\tilde{\Phi}_D(\tau; du|\theta_i)d\Phi_I(\tau; dy|\theta_i)\right] d_{ij}\right) &= 0.
\end{aligned}$$

The last component of our objective function is the negative value of the log likelihood of timing of each observed transaction. Let $\tau_{i,-1}$ denote the time at which the most recent trade by the dealer of trade j prior to that trade, and let us denote

Table A8. The Distribution of First-Step Parameter Estimates

	Mean	SD		Mean	SD
Search cost			*Investor demand*		
$\hat{\phi}_{1,i}$	0.436	0.188	$\hat{\gamma}_{1,i}$	0.047	0.047
	(0.007)	(0.005)		(0.0006)	(0.001)
$\hat{\phi}_{0,0,i}$	838	1,759	$\hat{\gamma}_{2,i}$	0.026	0.023
	(91)	(101)		(0.0006)	(0.001)
$\hat{\phi}_{0,1,i}$	1,374	2,134	$\hat{\kappa}_{I,i}$	0.001	0.003
	(109)	(100)		(0.0002)	(0.0004)
$\hat{\phi}_{0,2,i}$	1,647	2,227	$\hat{\alpha}_i$	1.42	1.05
	(75)	(65)		(0.021)	(0.013)
Dealer preferences			*Bargaining parameter*		
$\hat{v}_D$	0.029	0.036	$\hat{\rho}_i$	0.597	0.203
	(0.0004)	(0.0002)		(0.007)	(0.003)
$\hat{\kappa}_{D,i}$	0.0006	0.002			
	(0.0001)	(0.0004)			

Notes: This table presents the mean and the standard deviation of the first-step parameter estimates, over the bonds used in the estimation. The bootstrapped standard errors are in parentheses.

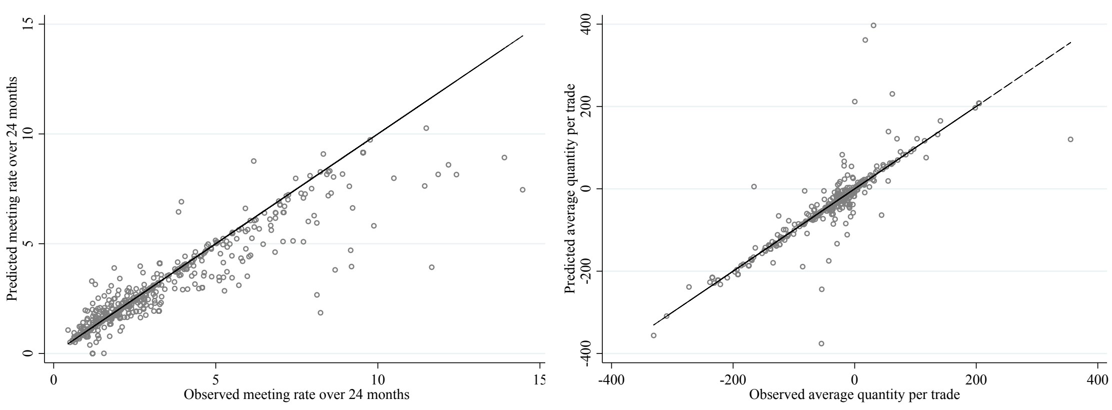
the dealer's state for trade j by $u_{ij} \equiv (a_j, b_j, g_j)$, which is observed from the data. We denote the equilibrium dealer-to-investor meeting rate at time τ_{ij}, as characterized by (10), by $\lambda(\tau_{ij}; u_{ij}|\theta_i)$, and recall that the inter-dealer meeting rate, denoted by $\lambda_{D,i}$, is a part of trading market parameters, θ_i. The log-likelihood of τ_{ij} conditional on $(\tau_{ij,-1}, u_{ij}, d_{ij})$ is

$$\begin{aligned}\log \mathcal{L}(\tau_{ij}|\tau_{ij,-1}, u_{ij}, d_{ij}, \theta_i) &= d_{ij}\left[\log\left\{\lambda(\tau_{ij}; u_{ij}|\theta_i)\right\} - \int_{\tau_{ij,-1}}^{\tau_{ij}} \lambda(s, u_{ij}|\theta_i)ds\right] \\ &+ (1-d_{ij})\left\{\log \lambda_{D,i} - (\tau_{ij} - \tau_{ij,-1})\lambda_{D,i}\right\}. \qquad \text{(A.24)}\end{aligned}$$

F.3. **First Step Estimates and Fit.** Table A8 reports the average and standard deviation of the first stage estimates across bonds, along with the bootstrapped standard errors for each statistic.

Figure A2 depicts the fit of the model in terms of the average dealers' meeting rate and trading quantity across estimated bonds. The model does a good job of fitting the data. Indeed, the average trading quantity across estimated bonds is $-69,000, and the simulated one is $-71,000. Similarly, the average meeting rate over 24 months is 3.3, and the simulated one is 3.05.

Figure A2. Goodness of fit



(a) Meeting Rate (b) Trading Quantity

Notes: In Panel (A), each dot represents the average observed and predicted meeting rates for each bond used in the estimation. In Panel (B), each dot shows the average observed and predicted trading quantities for each bond. For both graphs, the 45-degree line is presented to facilitate the comparison.