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Abstract

The effective functioning of the municipal bond market is crucial for the provision of public services, as it is the largest capital market for state and municipal issuers. Prior research has documented tax, credit, liquidity, and segmentation effects in municipal bonds. Recent regulatory initiatives to improve transparency have made granular trade data available to researchers, rendering it a natural laboratory to study financial intermediation, asset pricing in decentralized markets, and local public finance. Trade-by-trade studies have found large trading costs, contemporaneous price dispersion and other deviations from the law-of-one- price. More research is required to understand optimal market design and the impact of post-crisis regulation, sustainability, and financial technology.

JEL Classification: G12, G14, G18, G24, G28, H21, H6, H7

Keywords: Municipal Bonds, muni-bond puzzle, Over-the-counter markets, trading cost, centrality premium, electronification, green bonds

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Municipal Bond Markets[*]

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The effective functioning of the municipal bond market is crucial for the provision of public services, as it is the largest capital market for state and municipal issuers. Prior research has documented tax, credit, liquidity, and segmentation effects in municipal bonds. Recent regulatory initiatives to improve transparency have made granular trade data available to researchers, rendering it a natural laboratory to study financial intermediation, asset pricing in decentralized markets, and local public finance. Trade-by-trade studies have found large trading costs, contemporaneous price dispersion and other deviations from the law-of-one-price. More research is required to understand optimal market design and the impact of post-crisis regulation, sustainability, and financial technology.

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Contents

In Memory of Richard C. Green.

1 Introduction

The municipal bond market is the largest and most important U.S. capital market for state and municipal finance, with about $4 trillion in market capitalization, 55 thousand issuers, 1.5 million bond issues, and 100-200 thousand new bond issued each year. Effective functioning of the market is crucial for the provision of public services.

The municipal bond market has experienced fundamental structural transformations over the past decade. It was hit hard by the financial crisis, suffered from the demise of monoline bond insurers, and faced a dry-up of liquidity, most notably in auction rate securities. Municipal bond trading is still arcane—organized as a decentralized broker-dealer market with $10-20 billion in daily volume and active inter-dealer trading, but with limited pre-trade and post-trade transparency. Post-trade transparency in the form of trade reporting has been introduced gradually over the past two decades. Electronic trading platforms providing pre-trade transparency and intensifying dealer competition have only recently been gaining in importance.

Beside its obvious economic importance, the municipal bond market has become a valuable empirical laboratory for questions in financial intermediation, market microstructure, corporation finance, and local public finance. The defining characteristic of the municipal bond market is its opacity, market fragmentation and heterogeneity and the many frictions in the market. Our goal is to describe several important findings from municipal bond market data and to point to interesting directions for future work. We do not aim to be exhaustive, but describe how several features of the municipal bond data have proven to be useful for researchers.

The municipal bond market is particularly interesting to study because tax, credit, and liquidity issues are intertwined. Long-term municipal yields are too high compared to treasury yields to be consistent with statutory tax rates—the muni-bond puzzle—and municipal credit risk premiums are too high compared to historical default rates. Efficient risk pricing requires frictionless markets, but the tax exemption naturally creates local tax clienteles and market segmentation. Illiquidity and other frictions in municipal bond trading arise as a consequence of the tax-based segmentation and fragmentation, and reinforce each other. Further studies exploiting granular trade data can shed light on the apparent mispricing of fundamental risks in the municipal bond market and guide future market reforms.

2 History of the municipal bond market

The first record of a municipal bond dates back to 1812 with a bond issued by the City of New York. Before the adoption of the Sixteenth Amendment on February 3, 1913, the interest income from municipal bonds was doubly protected from federal taxation. It was protected by a Supreme Court decision in 1895 in *Pollack v. Farmers Loan and Trust Company*[1], which ruled the federal tax on municipal bonds a non-discriminatory direct tax and so unconstitutional according to Article 1, Section 2, Clause 3 of the Constitution of the United States. It was also protected by the intergovernmental immunity doctrine dating back to 1819 [Glass III, 1946] that neither the federal governments nor the states may tax interest income from securities issued by each other. The adoption of the Sixteenth Amendment overturned the effect of a 1895 Court decision regarding the legality of non-discriminatory direct taxes and so removed one of the two formal constitutional protections of municipal bonds against federal taxation. The decision made possible the imposition of a federal income tax, which was adopted with the first federal tax code of 1913. The tax code, however, included an exemption for coupon income from municipal bonds based on the intergovernmental immunity doctrine. The tax exemption remains intact until today.

The doctrine of intergovernmental immunity has constantly evolved over the past century with successive court decisions. Powell [1945] and Glass III [1946] found that early on

[1] 157 U.S. 429 (1895), affirmed on rehearing, 158 U.S. 601 (1895).

the constitutional immunity benefited only the federal government. Eventually, reciprocal immunity became the judicial norm, but beginning in the 1930s, the Supreme Court started to reestablish federal tax supremacy. In 1987, the Supreme Court ruled in *South Carolina v. Baker* that a federal income tax on municipal bonds do not violate the intergovernmental immunity. The ruling overturned the last formal constitutional protection of municipal bonds against federal taxation, opening the door to federal taxation in the future.

The tax exemption has enabled municipal issuers to obtain funds at lower rates than similarly-rated corporate bonds. As a result, municipal bonds have become the cornerstone of financing critical infrastructure in the United States. Between 2007 and 2016, states and local governments financed around 72% of the nation's infrastructure with municipal bond issues.[2] Marlowe [2015] estimates that the tax exemption has saved state and local governments approximately $714 billion in interest expense between 2000 and 2014.

Market size and ownership structure

Today the municipal bond market is one of the largest financial markets in the U.S. based on the number of bonds outstanding and new issues. Figure 1 documents market size and the bondholders. The market has grown from less than $1.4 trillion in par value outstanding in 1996 to almost $4 trillion outstanding by 2017. With more than $350 billion issued every year between 2004 and 2016, the primary municipal market is larger than the primary markets of asset-backed securities, private equity, high-yield corporate bonds, and is more than ten times larger than venture capital and equity IPOs.

The tax exemption makes municipal bonds an attractive investment for retail investors and unattractive for tax-exempt or tax-deferred institutional investors. In contrast to other large financial markets, households are the largest holders of municipal debt. As of 2017, retail investors hold just over $1.6 trillion directly in their portfolio and another $1 trillion indirectly in bond mutual funds. The remaining $1 trillion splits about equally between banks

[2] 2017 analysis of the budget by the National Association of Counties (NACo).

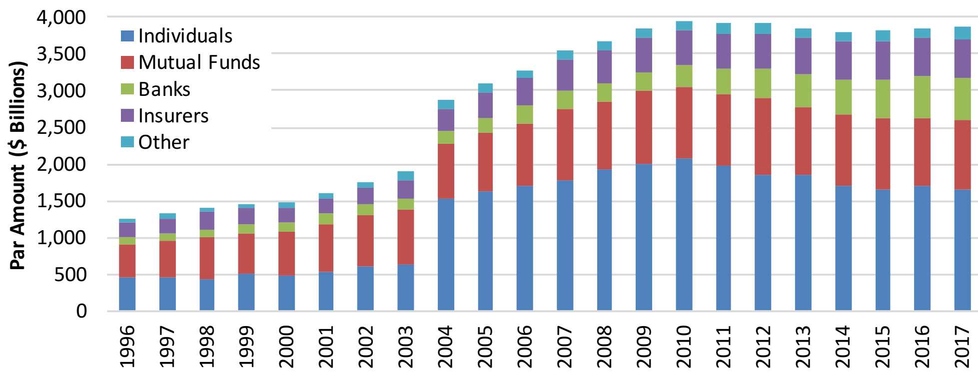

Figure 1: **Municipal bond holders.** The figure reports the holders of municipal bonds over time. The data is from the Federal flow of funds.

mostly holding tax-advantaged bank-qualified municipal debt and insurance companies.[3]

Municipal bond issuance activity has been rising steadily since the turn of the millennium. While about $210 billion of municipal bonds were issued in 1996, issuance volume rose to $450 billion in 2016. Issuance rose in 2009 and 2010 largely due to the temporary authorization of Build America Bonds (BABs) under the American Recovery and Reinvestment Act of 2009 (ARRA). The interest on BABs is taxable to investors. To make up for the extra issuance cost introduced by the taxability of bond interests, the federal government subsidizes 35% of the interest payments.

In contrast to other major financial markets in the U.S., the primary market for municipal bonds is dominated by a large number of diverse issuers, ranging from the State of California to small rural villages. According to the Census Bureau's 2012 Census of Governments, there approximately 90,056 independent local government units. Local independent governments include 3,031 counties, 15,519 municipalities such as cities, towns, and villages (including townships and boroughs in some states), 16,360 townships, 12,880 independent school districts, and 38,266 special districts of 24 different types. In addition, several non-independent federal, state, and local agencies not counted in the Census of Governments and other non-for-profit private entities are authorized to issue municipal bonds. Each government unit has

[3]The statistics of holders of U.S. municipal securities are from the *Financial Accounts of the United States-Z.1* at https://www.federalreserve.gov/releases/z1/current/.

substantial powers to decide on its budget. The power to issue bonds and allocate resources to pay the debt, however, depend on state law. Between 2004 and 2014, 25,224 government units and 7,067 subordinated governments and non-for-profit entities made a total of 168,209 bond issues, where typically, each new issued included a number of separate bonds.

3 Tax issues and the muni-bond puzzle

Muni yield curves are generally steeper than treasury yield curves. The tax exempt yield curve tends to diverge from the after-tax treasury yield curve at longer maturities. One of the most long-standing puzzles, the muni-bond puzzle, is that computing an implicit tax rate from the yield difference between taxable bonds and municipal bonds gives reasonable tax rates at short maturities but unreasonably large tax rates at long maturities.

Green [1993] argues that the muni-bond puzzle is explained by the asymmetry in the tax treatment of interest income and interest expenses from municipal bonds. Because of the asymmetry, taxable investors cannot arbitrage between coupon-bearing taxables held in isolation and tax-advantaged portfolios of taxable bonds generating the same pre-tax cash flows. Taxable investors will not be marginal between tax-exempt munis and coupon-bearing taxables. Green [1993] derives the relation between tax-exempt and taxable yields, and his model can explain a considerable portion of the anomalous behavior of the tax-exempt yield curve relative to the treasury yield curve. However, the resulting long-term tax-exempt yields still appear too high in relation to predicted ones—other factors such as credit and liquidity risk may also play a role in explaining the muni-bond puzzle.

Chalmers [1998] uses the identification provided by a legal exception to the tax-arbitrage rules to reject the hypothesis that credit spreads increasing with maturity can explain the steeper muni yield curve. When municipal issuers pre-refund an outstanding issue before the call date, they are allowed to invest the proceeds of the new tax-exempt issue in Treasury securities until the call date. At the call date, the proceeds from the sale of the Treasury securities are used to call the pre-refunded issue. Once an issue is pre-refunded, it inherits the credit risk of the federal government because Treasury securities are used to secure the debt service. Chalmers [1998] finds that the yield curve using pre-refunded bonds is still steeper than the Treasury yield curve.

Longstaff [2011] argues that tax risk may explain part of the muni-bond puzzle. He estimates an affine model for the term structure of municipal swap rates, finding a negative tax risk premium. This finding means that investors require lower yields for holding securities that are more sensitive to tax rate changes. Assuming that the sensitivity increases with maturity, everything else equal, tax-exempt and taxable yields will converge for longer maturities.

Wang et al. [2008] suggest that liquidity premiums may play an important role in explaining the muni-bond puzzle. They extend the Green [1993] model to account for default risk and add a sensitivity of tax-exempt yields to market liquidity shocks. They find that tax-exempt longer maturities are more sensitive to market liquidity shocks and, therefore, require higher liquidity premiums, explaining the muni-bond puzzle. However, the term in their equation that measures the sensitivity to liquidity shocks does not come from a structural model.

Based on Green's argument that backing out the implicit tax rate from the yield difference between tax-exempt and taxable bonds is erroneous, several studies attempt to estimate the implicit tax rate in alternative ways. Ang et al. [2010] provide direct model-free estimates of the implicit tax rate. The authors use the heterogeneity in the tax treatment of capital gains from secondary market trading to identify tax effects in the cross-section of municipal bond yields. They find that market discount bonds, which carry income tax liabilities, trade at yields around 25 basis points higher than comparable municipal bonds not subject to any taxes. The high yields on market discount bonds translate to implicit income tax rates between 70% and 100%, which are several times higher than the maximum statutory tax rates during the sample period. The authors argue that the estimated tax rates are higher than what can be inferred from corporate and Treasury securities prices because retail investors, the largest clientele of municipal bonds, have extreme sensitivity (or aversion) to tax payments.

Using prices tax-exempt variable rate demand obligations (VRDOs) and the municipal swaps, Longstaff [2011] estimates implicit tax rates between 8% and 55.3% from 2001 to 2009. The average tax rate is 38% and thus closer to statutory rates during the time period. While the estimatation method is not model-free, model misspecification is unlikely to explain the difference in implied tax rate from Ang et al. [2010]. One possible explanation is market segmentation: investors trading the VRDOs and municipal swaps studied in Longstaff [2011] are different from investors trading the long-term municipal bonds studied in Ang et al. [2010].

Another line of research explores distortions generated by various tax policies in the municipal market. Cestau et al. [2013] studies unintended consequences of the Build America Bond (BAB) program of 2009 to 2010. BABs are taxable to the holder, but the Treasury rebates 35% of the coupon to the issuer. They show that BABs are more underpriced initially than traditional municipals, particularly for interdealer trades. There is also a substitution from underwriter fees toward more underpricing, suggesting a strategic response by the underwriter and the issuer to the tax subsidy. Landoni [forthcoming] shows that the tax exemption distorts the issuance prices of tax-exempt bonds. Original issue premium (OIP) bonds are the norm in the tax-exempt municipal bond market, but rare in the taxable market. The tax subsidy helps explain this disparity. Unlike bonds issued at par or discount, the price of OIP bonds can fall and yet remain above par. Secondary market buyers of tax-exempt OIP bonds receive relatively more tax-exempt coupon and less taxable market discount.

Municipal bonds have experienced numerous and heterogeneous tax treatment changes since the 1987 Supreme Court decision. These changes make the municipal bond market an excellent laboratory to keep studying the interaction of taxes and asset prices.

4 Credit risk in municipal bonds

Municipal bond defaults have been rare historically, especially at state and territory levels. Yet, credit risk premiums embedded in municipal bond yields have been estimated to be large.

A short history of municipal bond defaults

Johnson and Young [2011], Liu et al. [2013], and Ang and Longstaff [2013] assert that eight states and the territory of Florida defaulted in the 1830s and 1840s. A second wave of state defaults took place during the Reconstruction period following the Civil War. Ten states defaulted during the 1870s and 1880s. Arkansas is the only state that has defaulted three times, and the only state to default in the twentieth century in 1933. Puerto Rico defaulted five times between 2015 and 2016, in what became to be the largest ever defaults of a U.S. government.

Liu et al. [2013] provide a recap of local government defaults. In response to the first wave of state defaults in the 1800s, municipal borrowing shifted from state to local governments. In the 1870s, local debt levels reached unsustainable levels leading to the first wave of local government defaults. A second wave of local government defaults took place during the Great Depression. Florida and North Carolina registered the highest numbers of municipal defaults. During this period, negotiations between defaulted municipalities and creditors proved costly and inefficient, leading to the enactment of Chapter 9 of the Bankruptcy code in 1937 in order to assist defaulted municipalities with their negotiations.

De Angelis and Tian [2013] note that Chapter 9 has rarely been used by municipals. Until 2009, there were fewer than 600 Chapter 9 cases, and only 61 petitions since 2010. Only a small fraction of them, 17%, is attributed to general purpose governments such as counties and municipalities. Chapter 9 petition rates slightly increased immediately following the Great Recession, with the rates recently returning to normal levels.

Bankruptcy does not imply default, and vice versa. Notable examples include the default of Cleveland, OH, in 1978, where the city defaulted on its debt but did not file for bankruptcy protection, and the bankruptcy case of Orange County, CA, in 1994, where the county did not interrupt debt service.

A 2017 Moody's report, entitled "U.S. Municipal Bond Defaults and Recoveries, 1970-2016," shows that Moody's-rated municipal securities have lower cumulative default rates and higher recovery rates than rated global corporate securities. Between 1970 and 2016, the 10-year cumulative default rates were 0.15% for rated municipal bonds and 10.29% for rated global corporates.[4] The majority of the defaults were in the housing sector—44%, and the health-care sector—22%. Defaults by general purpose local governments accounted for a small fraction, 13%, of the total. Most of the general purpose defaults took place after the Great Recession.

There are no centralized public records for defaults of unrated municipal bonds, yet around 36% of all new issues or about 9% of the total outstanding municipal securities are unrated. Unrated munis have several times the default rates of rated munis. According to Moody's, there were 71 rated defaults between 1970 and 2011, while a report by economists at the Federal Reserve Bank of New York counted a total of 2,521 defaults, including rated and unrated bond issues, during that period.[5].

The two largest defaults by general purpose local governments occurred in 2008 when the County of Jefferson defaulted on its $3.32 billion obligations, and in 2013, when the City of Detroit defaulted on its $2 billion obligations. Detroit's default speaks to the importance of determining a municipal bond's security. Two of the three types of non-performing bonds were backed by the city's 'full faith and credit' and the third type had recourse to all the available revenues of the city. The bonds had quite different recovery rates.

[4]Default rates are measured at the issuer-bond type level. Issuers may have multiple bond types outstanding.

[5]The authors constructed a more comprehensive database of municipal defaults by merging data from the three major rating agencies with unrated default data from Mergent and S&P Capital IQ. https://ritholtz.com/2012/08/the-untold-story-of-municipal-bond-defaults/.

Statutory security of municipal bonds

The Detroit case highlights that not all GO bonds are created equal. The pledge of the full faith and credit and the obligation to pay from all available revenues have traditionally been the distinguishing features separating general obligations from revenue bonds. The Detroit case shows the need to rethink how to classify municipal bonds' statutory security. Recovery rates for unlimited general obligations, limited general obligations, and certificates of participation backed by the general funds of the city were 73%, 42% and 12%, respectively (Moody's 2017). The large difference in recovery rates motivated Cestau et al. [2018] to construct a new and more accurate classification of the statutory security of general obligation bonds and revenue bonds.

Cestau et al. [2018] study the security structures backing long-term bonds, lease rentals, and certificates of participation issued by independent school districts across states. Any contract that creates a long-term financial obligation, bonded or not, has recourse to all the available funds of the issuer. The issuer may be required by statutory law to augment the obligation by pledging its full faith and credit. Pledging full faith and credit means that the issuer can be compelled by means of a writ of mandamus to raise property taxes and fees to support its obligations. In Detroit's case, the bonds with the lowest recovery rate lacked the additional pledge. Alternatively, the issuer may limit the recourse to its general funds to different degrees. It may fully restrict the recourse, or it may partially restrict it to certain funds or revenues. In the case of lease rentals or certificates of participation, the issuer may include termination clauses in the contractual obligations that secure these financings. The lease rentals in Detroit's default did not include such termination clauses.

In addition to or in lieu of the general revenues pledge, the issuer may specifically pledge ad valorem property taxes. The specific pledge of ad valorem taxes can be limited or unlimited. If unlimited, the issuer may be compelled to raise property taxes to the extent necessary to pay its obligations in full without regard to constitutional tax limits. The pledged revenues may come from levies with different usage restrictions. They may come from debt levies solely for paying debt, special levies for special purposes, capital levies for capital expenses, or the general levy. Sometimes debt levies produce an offsetting reduction in the general levy. The usage restriction played a decisive role in Detroit's default. The bonds with the highest recovery rate were backed by an unlimited and exclusive debt levy. Rather than claiming a tax raise, the plaintiffs' claim was that the city was "unlawfully diverting" the debt levy to other purposes. In addition to or in lieu of the general revenues pledge and the specific ad valorem pledge, the issuer may specifically pledge other revenues such as sales taxes, federal aid, state aid, special assessments, property tax abatements, and incremental tax receipts.

Every obligation with recourse to the general revenues of the school district or backed by an unlimited pledge of property taxes is a general obligation. The rest are revenue bonds. Table 1 lists the security structures and compares them to the general obligation-revenue bond classification (GO-RV) reported in the SDC platinum database. Sometimes the SDC classification diverges substantially from the classification in Cestau et al. [2018]. The heterogeneity in the security features of general obligation bonds is striking. Detroit's default indicates that these security features have substantial effects on recovery rates. They probably also have deterrent effects on default rates. These security features of local bond issues are also a source of exogenous variation for empirical identification, since they are provided by state law.

Still, none of these security features represent ironclad payment guarantees. Because of the lack of case law, it is impossible to predict how judges will balance the rights of bondholders and taxpayers. Underneath the security structures, the tax burden will be a determining factor in the judge's decision [Cestau, 2018].

Municipal credit risk premium

A puzzling feature of municipal yields is that default risk tends to be low, yet yield spreads are high. Municipal default has a high price of risk. Schwert [2017] applies several empirical

Table 1: **Security Structures:** The table compares the security structures of long term financings of school districts in the U.S. since 1985 to the SDC GO-RV classification. Types of obligations: bonds (Bd) and lease rentals/certificates of participation (Cp). Types of recourse to general revenues: full faith and credit (FF), unrestricted (GF), restricted (CF), fully restricted (RV), termination clause (AP). Limits to the ad valorem pledge: unlimited (Ultd) and limited (Ltd). Types of ad valorem levies: for debt service (Dadval), for special purposes (Sadval), for capital expenses (Cadval), for general expenses (Gadval). Other pledged revenues: sales taxes (Sales), federal aid (Fedaid), state aid (Staid), special assessments (Asmt), property tax abatements (Abat).

General Obligations:	GO	RV	Cadval Ultd Dadval FF Bd	18	0
Ultd Dadval FF Bd	17,082	35	Abat Ultd Dadval FF Bd	5	0
Ultd Gadval FF Bd	7,931	9	GF Cp	95	933
Ultd Dadval RV Bd	3,676	16	Ultd Dadval GF Cp	96	397
Ultd Dadval GF Bd	3,647	21	FF Cp	40	202
Ltd Gadval FF Bd	1,982	39	Ltd Dadval GF Cp	66	147
Staid Ultd Dadval FF Bd	1,479	13	Ltd Gadval FF Cp	46	31
Ltd Dadval FF Bd	1,132	3	Ultd Dadval FF Cp	61	10
FF Bd	375	70	Ultd Gadval FF Cp	1	13
Sales Ultd Dadval FF Bd	333	0	**Revenue Bonds:**		
Ultd Cadval GF Bd	215	5	Ltd Sadval RV Bd	1,207	31
Ultd Dadval off FF Bd	169	0	Sales RV Bd	153	502
Sales Ultd Dadval GF Bd	74	0	Asmt RV Bd	32	407
Staid Ltd Dadval GF Bd	64	1	Ltd Cadval RV Bd	266	13
GF Bd	22	25	Ltd Gadval RV Bd	7	15
Ltd Dadval GF Bd	43	0	Fedaid RV Bd	0	10
Ltd Sadval FF Bd	59	4	AP Cp	46	2,722
CF GF Bd	19	2	CF Cp	0	27

methods to decompose municipal yields into tax, liquidity, and credit components. The methods include using municipal swap rates as in Longstaff [2011], using a sample of pre-refunded bonds, and liquidity measures used in corporate bond modeling [Dick-Nielsen et al., 2012]. Schwert [2017] estimates that between 74% and 84% of the average yield spread is related to the price of municipal default risk. The results point out the importance of default risk pricing in the municipal bond market.

The measurement approach in Schwert [2017] does not consider how default pricing might interact with bond liquidity changes through equilibrium effects as in theoretical models such He and Milbradt [2014] or Cheng and Milbradt [2012], or the lack of dealer competition documented in Schultz [2013]. Adelino et al. [2017] document that credit rating upgrades have an economically important impact on reducing municipal bond yields and increasing issue volume in new issues. Cornaggia et al. [2017] document that upgrades reduce secondary market yields by about 19-33%. These findings highlight the interaction of credit, information flow, and ratings in municipal bond markets.

It is an open question if the high price of municipal credit risk is a consequence of high systematic risk, or a consequence of local retail investors at the margin who can not diversify idiosyncratic municipal risk due to market segmentation. The municipal bond market indeed appears segmented along state lines due to the asymmetric tax treatment of in-state and out-of-state bonds. Babina et al. [2016] show that these tax asymmetries limit risk sharing and make tax-exempt yields more sensitive to supply shocks and political uncertainty. Schultz [2013] shows that the tax-based limits to arbitrage across state borders explain systematic yield differences between bonds from different states. Tax segmentation also creates sub-markets that curb dealer competition [Li and Schürhoff, forthcoming]. It remains unclear, however, if the lack of competition in providing intermediation services leads to the high measured price of credit risk because of the lack of liquidity.

The financial market frictions have real effects, especially because municipal bonds are used to finance infrastructure. For example, Adelino et al. [2017] and Dagostino [2018] document that increases in financing costs causally impact local public finance, and they can even have large multiplier effects on the local economy. They lead to the possibility that changes in the structure of the muni markets that reduce market frictions might have large yield effects and thus real impact.

5 Municipal bond trading, illiquidity, and its effects

Liquidity in the municipal bond market is low despite the large daily trading volume, the large number of bond brokers and dealers, and the remarkably large number of securities traded. Currently, municipal bonds trading takes place in a decentralized and dealer intermediated over-the-counter (OTC) market. Trades are negotiated bilaterally between investor and broker/dealer, as opposed to a centralized limit order book like the equity market. There are over 2,000 broker-dealer firms registered with the MSRB. Among these, about 700 broker-dealer firms actively trade municipal bonds in any given month. Biais and Green [2007] document that historically, municipal bonds did not trade OTC and tended to have lower transactions costs than today, especially for retail sized orders.

Until the late 1990s, deeper looks into the sources of illiquidity and the frictions in municipal bond trading was impossible from a lack of granular transaction data. In the late 1990s, the regulatory body for the municipal bond market, the Municipal Securities Rulemaking Board (MSRB), imposed regulation forcing broker-dealers to collect and report transaction data. The granular MSRB data has allowed academics to study municipal bond trading and its effects.

Search and matching are the primary frictions when trading municipal bonds since they can hinder price formation and allocation efficiency [Duffie et al., 2005]. Professionals consider the municipal bond market a buyer's market in which identifying investors willing to buy is the dealers' most crucial task [Schultz, 2012]. The resulting illiquidity for sellers and the scope for dealer market power in the intermediation process have been major concerns for investors, academics, and regulators.

Liquidity and how it has evolved after the financial crisis is a contentious topic. Many market observers argue that liquidity has declined significantly. Trading volume rose steadily in the 2000s until it spiked with the advent of the financial crisis and has since dropped. Customer buy volume has dropped from a peak of $300 billion per month in 2007 to less than $150 billion per month in 2018. Customer sell volume has changed similarly, with the difference between buy and sell volume being driven by new bond issues.

Dealer intermediation

Dealers provide liquidity is as follows. Due to the decentralized nature of trading, information about available bonds and suitable counter-parties is sparse. Locating bonds and potential buyers requires financial intermediaries with active relationships with all types of investors and with other dealers. To cope with these frictions, dealers form decentralized trading networks with other dealers. Empirically, dealers consistently trade a significant volume of bonds in the inter-dealer market. Dealer-to-dealer volume has been around $50 billion per month since early 2009, with peak of $100 billion in early 2008.

Li and Schürhoff [forthcoming] document the topology of the inter-dealer trading network. Figure 2 illustrates the network topology, The municipal bond dealer network has a core-periphery structure with about 10 to 30 highly interconnected dealers at the center and more than 2,000 peripheral broker-dealer firms that are sparsely connected. A similar market structure exists in corporate bonds [Di Maggio et al., 2015], and in ABS and MBS [Hollifield et al., 2017].

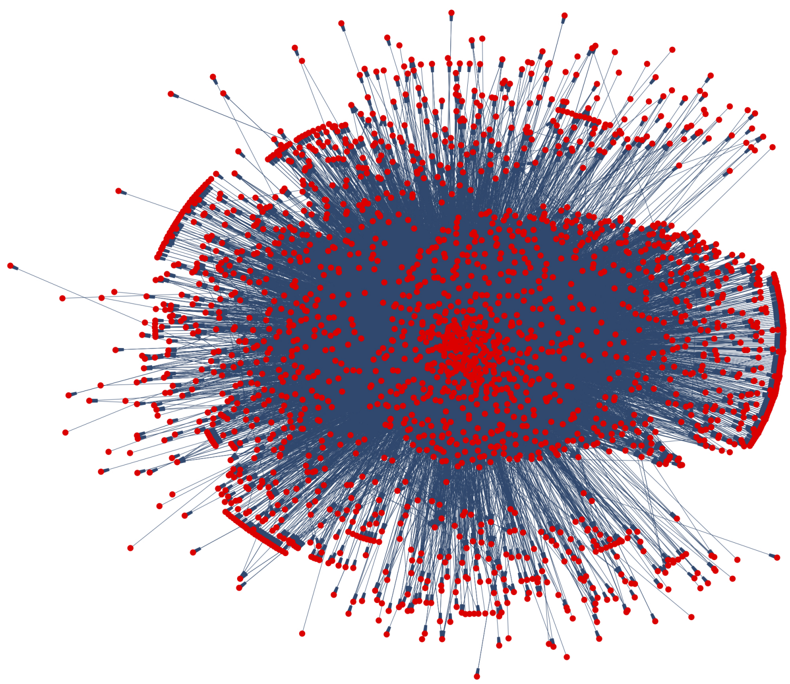

Figure 2: **Topology of the dealer network in municipal bonds.** The figure illustrates the network structure of dealers in the municipal bond market. Each node represents a dealer firm. Each arrow represents directed order flow between a pair of dealers. The plot is generated using multidimensional scaling based on the criterion that the more trade links exist between two dealers, the closer is their location on the map.

Transactions costs and the centrality premium

Harris and Piwowar [2006] and Green et al. [2007b] document trading costs in municipal bonds using the MSRB transactions data. Trading costs are substantial, with median

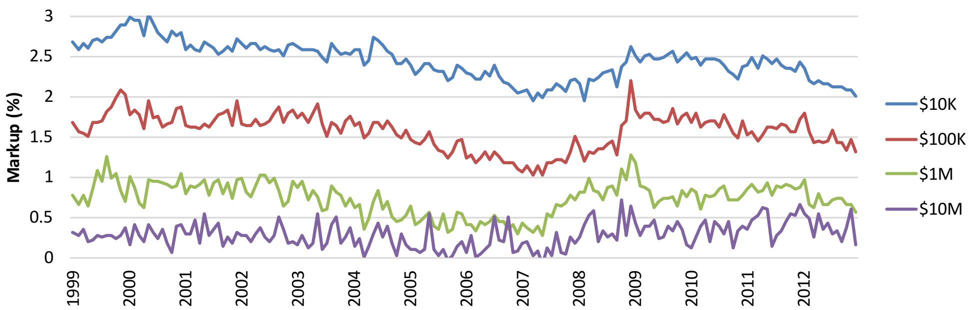

Figure 3: **Trading costs of municipal bonds by par size.** The figure reports the bonds' trading cost by par size over time. The source data is from MSRB.

markups between 1.3 and 2% of transaction value. Markups measure the cost of round-trip transactions to an investor, or the profits to a dealer from buying and disposing of the bonds. As the median yields on municipal bonds are less than 5%, transferring a bond from one investor to another involves surrendering much of a year's return to the dealer. Figure 3 documents the municipal trading costs by par size over time. Trading costs monotonically decline with trade size. A retail size of $10,000 in par value on average costs 2.5% in round-trip markups to execute, trading $100,000 costs 1.5%, $1 million between 0.5% and 1%, and larger sizes cost less than 0.5%.

These studies also find that dealers earn lower average markups on larger trades, even though dealers bear a higher risk of losses with larger trades. There is also a high level of skewness in the markups for all trade categories, and for large trades, the distribution is simultaneously more concentrated and centered at a lower level. The combination of three characteristics—lower percentage profits, higher probability of losses, and less variable profits—suggests that the largest traders transact with the dealers on more attractive terms. To rationalize these patterns, Green et al. [2007b] develop a structural model to decompose the dealer's markup on a trade into the cost of facilitating the trade and a measure of the dealer's market power. The structural model estimates produce measures of dealers' market power that strongly reject the hypothesis of no market power.

Real-time trade reporting was introduced in early 2005. Figure 3 shows that across trade sizes markups tended to shift down from the early 2000s until 2007, with the decline most pronounced after post-trade transparency. With the advent of the financial crisis, markups jumped back up, and they have been declining again since 2009.

Green et al. [2010] show that transaction prices rise faster than they fall, much like in markets for consumer goods. The authors argue that such asymmetric price adjustment benefits the dealers who tend to hold inventory. In particular, roundtrip markups on retail trades increase in rising markets but do not decrease in falling markets. Bid-ask spreads increase or decrease more when movements in fundamentals favor dealers. Yield spreads relative to Treasuries also adjust with asymmetric speed in rising and falling markets, and intraday price dispersion is asymmetric in rising and falling markets, as consumer theories based on search frictions predict.

Li and Schürhoff [forthcoming] document that the markups that municipal bond dealers charge to investors vary systematically with dealer centrality in the inter-dealer network. Central dealers in the trading network charge 0.4%-0.7% larger markups on round-trip municipal bond trades to investors than peripheral dealers. The premium that central dealers charge relative to peripheral dealers is equivalent to several months of a bond's interest income. The centrality premium is a sign that dealers do not simply compete on best execution price as stipulated by plain-vanilla Bertrand competition. Notably, central dealers offer customers more immediacy as they are more willing to commit capital by taking bonds into their inventory, rather than waiting for offsetting orders to complete riskless principal trades.

Di Maggio et al. [2015] find support for a centrality premium in the interdealer market for corporate bonds. By contrast, Hollifield et al. [2017] find evidence of a centrality discount for the largely institutional ABS/MBS market. Documenting the similarities and differences between markets is important to better understand the frictions that affect decentralized markets.

Models of trade in decentralized markets

The finding of a centrality premium for municipal bonds has spurred theoretical research on OTC markets. Neklyudov [2013] and Weller [2013] extend the Duffie et al. [2005] random search setup to allow for fast and slow dealers and a bilateral interdealer market. The model in Neklyudov [2013] shows that differences in search technologies across dealers lead to a core-periphery structure that curbs dealer competition. In a generalization of Duffie et al. [2005] to a continuum of types with short-lived relations, Hugonnier et al. [2015] show that intermediation chains can arise from valuation differences among investors. They use the empirical findings in [Li and Schürhoff, forthcoming] to calibrate their model.

A growing strand of literature models financial networks with long-lived relations, focusing on equilibrium network structures and price formation in networks, as documented empirically by Li and Schürhoff [forthcoming]. Babus [2012] and Wang [2016] predict core-periphery network structures. Their models highlight the trade-off between efficiency and stability in network topology. Chang and Zhang [2015] generate a core-periphery structure in a dynamic matching model. Sambalaibat [2015] study pricing in OTC markets when dedicated dealers differ in search-and-matching efficiency because of different network connections. Their assumption that dealers search for bonds among their own clients and connected dealers leads to the prediction that bonds flow endogenously between fast central and slow peripheral dealers.

To illustrate how search frictions impact transaction prices, what conditions are needed for a centrality premium, and how a centrality premium relates to dealer market power, we derive in the following a simple model of trade in an OTC market. The exposition follows [Li and Schürhoff, forthcoming].

Consider an OTC market in which investors buy (sell) municipal bonds from (to) dealers, and prices are set bilaterally through Nash bargaining. Investors trade because they incur liquidity shocks with a Poisson distribution, as in Vayanos and Wang [2007]. From the time of a liquidity shock a bond owner (non-owner) incurs a disutility from owning (non-owning) until the bond has been sold (bought). Investors' need for speed of execution is captured by the propensity $\kappa > 0$ with which they receive a liquidity shock. Investors' reservation value in bilateral negotiations with the dealers is $v^S = \sigma \frac{C}{r}$, given bond coupon C and discount rate r. As in Duffie et al. [2005], Neklyudov [2013], Weller [2013], and Üslü [2015], dealers randomly search for counterparties. Dealers have execution speed λ, which corresponds to the intensity with which they meet counterparties.

To determine transaction prices P^B (ask) and P^S (bid), we pin down investors' valuations. A seller values the bond at V^S, with

$$V^S = \frac{1}{1 + rdt}[\lambda dt P^S + (1 - \lambda dt)V^S] = P^S \frac{\lambda}{r + \lambda}.$$

With the value to the bond owner equal V^O, the buyer's valuation is

$$V^B = \frac{1}{1 + rdt}[\lambda dt(V^O - P^B) + (1 - \lambda dt)V^B] = (V^O - P^B)\frac{\lambda}{r + \lambda}.$$

The derivation of the owner's value function follows a similar logic and yields

$$V^O = \frac{C}{r + \kappa} + V^S \frac{\kappa}{r + \kappa}.$$

Because of the search frictions in the market, the investor values the bond less than its frictionless value, $V^O < \frac{C}{r}$.

Transaction prices P^B and P^S are set by Nash bargaining between investor and dealer. Dealer bargaining power is $w \in [0, 1]$. The dealers' value from trading is the present value of the spreads they earn in each round-trip transaction: $U^S = (B - P^S)\frac{\lambda}{r+\lambda}$ and $U^B = (P^B - A)\frac{\lambda}{r+\lambda}$, where B and A are the bid and ask prices at which the dealer can source the bonds in the interdealer market. Transaction prices equal the bargaining power-weighted average reservation values of the two parties:

$$P^S = wv^S \frac{r+\lambda}{\lambda} + (1-w)B$$

and

$$P^B = wV^O + (1-w)A.$$

The expressions shows that, so long as the dealers earn profits, $w > 0$, there exists a speed, or centrality premium and a tradeoff between execution speed and cost. Central dealers that are faster at matching buyers with sellers charge larger ask prices and pay lower bid prices than peripheral dealers. As a result, execution costs and speed are inversely related and execution costs rise with the centrality of the dealer intermediating the trade—a centrality premium. The participation constraints deliver a second result. Investor and dealer will trade only when $U^{B/S} \geq 0$, which requires a minimum execution speed $\lambda \geq r\frac{v^S}{A-v^S}$. Several of the empirical findings in [Li and Schürhoff, forthcoming] are consistent with this theoretical model.

6 The primary market for municipal bonds

The primary market for municipal bonds inherits many of the frictions in the secondary market. It is also a largely unexplored laboratory for studying book building and auctions as many new securities come to market each year. Several issuance methods are actively used in the municipal bond market, including negotiated sales and competitive sales, which are the muni counterparts to book building and auctions. Private placements represent less than 4% of the total issuance. Muni auctions are different from auctions for corporate securities, as underwriters place bids and the winning bidder is allocated the whole issue.

The same trend towards book building in global corporate markets [Jagannathan et al., 2015] is also in the muni market. Approximately 80% of bond volume is sold via negotiation.

There are several theories explaining the popularity of book building. It has been theorized that book building implements the optimal mechanism to extract private information from investors [Benveniste and Spindt, 1989, Benveniste and Wilhelm, 1990, Spatt and Srivastava, 1991]; it increases coverage [Ritter and Welch, 2002, Loughran and Ritter, 2004]; it improves analyst recommendations [Degeorge et al., 2007]; and that the underwriters' discretion reduces "flipping"[Neupane et al., 2017]. None of these theories seem to explain the popularity of negotiated sales in the muni market. Analyst coverage is not relevant, underwriters have allocation discretion in either case, and pre-play information plays a minor role since the average amount of pre-issuance orders is just about 40% of par value.

In several states the law forces some issuers to use public auctions. Cestau et al. [2018] compare the offering yields between legally constrained and legally unconstrained school districts. On average, the offering yields of constrained issuers are 0.42 percentage points lower than the offering yields of unconstrained issuers. This means that issuers that can choose prefer negotiated sales even if it is not the most cost-effective method. The evidence from the municipal bond market suggests that there are other strong reasons behind the popularity of book building that have not been studied in the existing literature.

Underpricing and price dispersion

Green et al. [2007a] document that municipal bonds are underpriced when issued, but unlike equities, the average price rises slowly over several days. Newly issued municipal bonds have high levels of price dispersion and the average price rises because the mix of trade sizes changes over time. The reoffering price is the price at which investors can place orders during the initial order period and it is the official issue price that gets certified to the tax authority. While large trades occur close to the reoffering price, small trades occur between the reoffering price to as much as 5% above the reoffering price. Schultz [2012] documents that price dispersion in the days after issuance declines dramatically after the introduction of 15-minute trade reporting by the MSRB in 2005. However, markups remain high and increasing in the days after issuance.

Garrett et al. [2017] show that tax advantages and dealer competition in municipal bond auctions are interlinked and causally affect state and local governments' borrowing costs. They argue that strategic participation and bidding in municipal bond auctions is a friction that generates excessive borrowing costs. Their estimates show that increasing the tax advantage by 3 basis points lowers borrowing costs by 9-10%. The rationale for the greater-than-unity pass-through is imperfect competition among the bidding investment banks. Using a structural auction model to evaluate the efficiency of reform proposals, they argue that additional tax advantages would cost a fraction of the reduction in municipal borrowing costs.

Demise of monoline bond insurers

The municipal bond market was hit hard by the financial crisis. It suffered from the demise of monoline bond insurers[6] that played an important role for new issuances of lower rated or unrated municipalities. Before the financial crisis, monoline bond insurers enhanced about half of newly issued municipal debt by volume. Early research has asked whether insurance creates value to municipal issuers. Cole and Officer [1981] and Kidwell et al. [1987] find that insurance provides a net benefit, due to taxes [Nanda and Singh, 2004], signaling [Thakor, 1982], and disclosure [Gore et al., 2004].

The financial distress of the monoline insurers was the result of a foray into structured products, most notably asset-backed securities, credit default swaps, and collateralized debt obligations. Municipal bond insurance resulted in zero-loss underwriting due to the low municipal default risk and, despite very high leverage ratios of 100 to 200, the monoline insurers were rated AAA. AAA ratings were crucial for the business models of monolines, as they are essentially lending their AAA ratings to municipal issuers at a fee, allowing the wrapped municipal bonds to be purchased by investors who were not most equipped to do

[6] Monoline refers to a 1989 ruling by the New York State Insurance Board that restricts insurers of financial products from writing other types of insurance, such as property and casualty, life, and health.

credit analysis on small and idiocyncratic municipal issuers. However, by 2007, monolines insured over \$800 billion of structured products, compared to \$1.3 trillion of municipal securities. Expanding into structured products jeopardized the zero-loss model and led to a sequence of downgrades and, ultimately, their demise.

Bergstresser et al. [2010] document a yield inversion phenomenon during the financial crisis. They show that as the credit quality of the bond insurers fell, yields on insured bonds started to exceed yields on equivalent uninsured issues. They link the spike in yields to a drop in liquidity of insured compared to uninsured municipal bonds. Wilkoff [2013] challenges the Bergstresser et al. [2010] findings and documents a stable gross insurance benefit of eight basis points.

Collapse of auction rate securities market

The auction rate securities (ARS) market was the municipal market's second victim of the financial crisis. Variable rate demand notes (VRDNs) and ARS allow municipalities to issue long-term debt but pay short-term interest rates. The effective maturity transformation is particularly attractive to municipal bond issuers because of the generally steeper yield curve for municipal bonds [Green, 1993] and the limitations on municipalities in issuing short-term debt.

VRDNs are long-term debt securities issued by municipal issuers for which investors have the option to tender at par at any time, generally on a seven day's notice, giving them characteristics of a short-term instrument. The interest rates on the VRDNs are reset on a regular basis by re-marketing agents based on prevailing market conditions. Municipal money-market funds constitute one major type of investors for VRDNs. Auction rate securities (ARS) are also variable-rate securities with long-term maturity, typically issued by municipalities or student loan authorities, but with rates reset through auctions. Despite the apparent similarities between a VRDN and an ARS, there are several differences. ARS investors may exit their positions as long as they submit "sell" orders into the auction and the auction clears. The lack of explicit tender option makes ARS ineligible for municipal money market funds to invest in. Most of the investors of ARS were corporate treasuries or high net worth individuals.

ARS and VRDN were relatively low cost prior to the financial crisis.[7] At their peaks in late 2007, the market for VRDNs were roughly $250 billion and the market for ARS were about $330 billion in size, with roughly half of those issued by municipalities. While auction managers were not legally obliged to ensure auction success, auction failures were rare in the two decades since ARS were first invented. Since auctions almost always cleared, ARS looked very similar to VRDN from an investor's point of view and their rates tracked each other closely until mid-2007. The 2007 financial crisis had a profound impact on the short-term municipal bond market. ARS auctions suddenly failed en mass in February 2008, exposing the fragility of their liquidity. Issuance of new ARS came to a grinding halt after the fall out and never came back.

Two papers examine the collapse of the ARS market and came to different conclusions. McConnell and Saretto [2010] focus on the cross-sectional differences across ARS in their likelihood of auction failure and concludes that investors rationally declined to bid on bonds with low maximum interest rates—interest rates investors earn when auctions fails, and the market functioned as intended. The ARS auction failed as a result of an increase in broader concern about municipalities' credit risk, and there were no evidence of "spillover" or "contagion" from the subprime mortgage crisis. Han and Li [2010] study the role of a key type of financial intermediary in this market, auction managers, both before and during the crisis, and came to sharply divergent conclusion about why the ARS market suddenly failed. Using trade-by-trade data from the MSRB, the paper documents that even years before the onset of the financial crisis, many ARS auctions would have failed if the auction managers did not act as buyers of last resort. Dealers who are auction managers systematically bought

[7] In the case of VRDN, issuers pay banks a modest fee in exchange of their explicit guarantee of investor liquidity, in the form of either a SPA (Standby Purchase Agreement) or LOC (letter of credit). In the case of ARS, issuers pay dealer banks (typically the underwriters of the bonds) small fees to manage auctions.

bonds on auction days and sold them in the secondary market between auctions. As it became increasing difficult for auction managers to offload bonds in the secondary market and as dealer balance sheet became increasingly scarce due to to the subprime crisis, the implicit liquidity support they offered to the ARS market became fragile. By mid-February of 2008, two dynamic forces, panic by retail investors and coordination failure among broker-dealers, amplify each other, resulting in the sudden collapse of the ARS market. Within a few days, after one influential dealer stopped supporting their auctions, and all other auction dealers decided to let their auctions fail without intervention—the market went from one equilibrium to another overnight.

7 Future directions

Bank LCR and other regulations

Basel III rules requires large banks to implement the Liquidity Coverage Ratio (LCR) which determines the liquidity requirements of those banks. To comply with LCR, banks need to hold sufficient amounts of High Quality Liquid Assets (HQLA) in their investment portfolios.

In the initial version of the U.S. version of the LCR, introduced by the Federal Reserve Board in October 2013, municipal bonds were not HQLA eligible, while high-grade corporate bonds, certain equities, conventional mortgages, federal agency securities, and U.S. and other OECD sovereign debt were. In April 2016, the Federal Reserve issued an amendment to the Federal Reserve's LCR rule, allowing a subset of municipal obligations—those meeting the definition of general obligation municipal securities and meeting certain trading liquidity criteria—to be recognized as HQLAs.[8] However, the OCC's and FDIC's LCR rules did not permit any municipal obligations to be recognized as HQLAs.

On August 22, 2018, the three Federal banking agencies jointly released an interim final rule that allow municipal bonds to be treated as level 2B high-quality liquid assets (HQLAs)

[8]https://www.federalreserve.gov/newsevents/pressreleases/bcreg20160401a.htm

so long as they are "investment grade" and "liquid and readily-marketable."[9]. The rule change greatly expanded the type of municipal bonds that are HQLA eligible. By offering more incentive for banks to hold municipal bond in either their investment portfolio or trading inventory, the new rule is expected to lower overall issuance cost for municipalities and potentially improve secondary market liquidity. Documenting such changes in issuance cost and trading liquidity and the impact of other regulation is a fruitful area of future research.

Electronic trading

The decade since the great financial crisis has witnessed a radical change in fixed income trading spurred by technology. Electronification means different things in different fixed income markets. In highly liquid fixed income futures and the Treasuries market, it typically refers to the rise of automated trading, including algorithmic and high-frequency trading. In less liquid OTC markets such as the corporate bond and municipal bond markets where bilateral search, voice-based negotiation and dealer intermediation was the norm, electrification often corresponds to trading in electronic trading venues and innovative protocols.

Adoption of electronic trading in the corporate and municipal bond markets was slow at the turn of the century. The high degree of heterogeneity across bonds and the low turnover made it difficult for electronic trading to encroach on relationship dealers who can offer immediacy to customers by parking bonds on their balance sheet.

Several factors since the financial crisis has spurred increases in the electronification of corporate and municipal bond trading—the increasing data availability brought by post-trade-transparency; buy-side investors' need to pinch pennies in a low interest rate environment; the regulatory push to document best execution and management control; the shrinkage in balance sheet capacity of large dealers all accentuate the need to enhance search and match efficiency.

[9]https://www.federalreserve.gov/newsevents/pressreleases/files/bcreg20180822a1.pdf

As of 2017, there are seven electronic trading platforms where municipals can be traded: Tradeweb, MarketAxess, MuniAxis, Bloomberg, MuniBrokers, TheMuniCenter and Clarity-BidRate.[10] The number of electronic platforms and total trading volume on these platforms still lags that of the corporate bond market. However, growth in recent years has been strong. New data from the MSRB show that from July 2016 to June 2017, an average of approximately 59 percent of trades between dealers and 29 percent of par volume traded were executed on an alternative trading system (ATS).[11]

The evolution in municipal market structure due to electronification provides fertile ground for future research. In particular, the impact of electronification on the business model and profitability of traditional broker-dealers, on the cost of trading for retail and institutional investors, and on the efficiencies of price discovery. The unique features of the municipal bond market allow researchers to investigate the limits of connectivity. Market frictions such as segmentation are unlikely to be fully resolved by efficient trading mechanisms and might even require more innovations in security design to fully overcome.

Green municipal bonds

Responsible investing has been a major trend in asset management in recent times. It incorporates environmental, social, and governance (ESG) factors into the investment process and aligns investments with the values of socially conscious investors. While responsible investing is a relatively new concept in the municipal bond market, it has potential to vastly impact the municipal bond market.

Green municipal bonds are a new category of municipal debt that qualify as responsible investments and specifically target socially conscious investors. Programs and projects funded through municipal bonds are considered "green" when they contribute to local communities in a positive way, such as renewable energy projects, infrastructure for clean drink-

[10] https://www.forbes.com/sites/investor/2017/05/16/municipal-bond-market-a-tech-tipping-point-is-here/#330640ca43b6

[11] http://www.msrb.org/News-and-Events/Press-Releases/2017/MSRB-Releases-Data-on-Inter-Dealer-Municipal-Trading.aspx

ing water and sustainable waste projects, public education facilities in under-served communities, not-for-profit hospitals and other health care facilities, affordable housing, and land conservation. The green municipal bond market has grown significantly. As of 2017, it was approximately $25 billion, with about $11 billion of that issued in 2017 alone. Among the major green asset classes it currently ranks fourth in size after corporates ($78 billion), supranational, sovereign and agency ($41 billion), and ABS/MBS ($25 billion).[12]

Little research exists on the pricing and liquidity of green bonds. Issuers may obtain better pricing from green bond offerings, as they appeal to a growing base of socially conscious investors who have formulated guidelines for investing in responsible securities. Green securities may serve issuers as a signal to their investors of their commitment to reducing carbon footprint. Based on the limited universe of green and comparable regular bonds makes a definitive conclusion difficult as this point. Malcolm et al. [2018] study the pricing and ownership of green municipal and corporate bonds. They find that green bonds are issued at a premium to other municipal bonds. This finding suggests socially responsible investors sacrifice return to hold green bonds, which is consistent with other findings in the ESG literature.

Another finding of Malcolm et al. [2018] is that the effects are stronger for externally certified bonds. The definition of green bonds is still evolving. Investor demand will likely result in the creation of widely accepted metrics. The major ratings agencies will likely introduce and standardize green bond ratings. Certification and verification processes for potential issuers are also being developed.[13] As pension funds and other tax-exempt institutions shift more of their portfolios to sustainable investments, the question arises if the tax exemption of municipal debt crowds out socially conscious investors from the green municipal bond

[12]https://www.bloomberg.com/professional/blog/blossoming-green-bond-market-growing-toward-250-billion-year/

[13]Guidance about qualifying assets and projects can be obtained from the Green Bond Principles (http://www.icmagroup.org/Regulatory-Policy-and-Market-Practice/green-bonds/green-bond-principles/) for broad green asset categories, and the Climate Bond Standards Scheme (http://www.climatebonds.net/standards) for specific standards for what qualifies within each asset category.

segment.

8 Conclusion

We survey recent empirical work using municipal bond data, including bond yields and granular trading data in the primary and secondary markets. Municipal yields depend on frictions such as taxes, default risk, details of the market structure, and regulations. There is much heterogeneity in the market across products, dealers and at the regulatory level allowing researchers to provide empirical estimates for tax rates, liquidity premiums, risk pricing, and dealer market power. It is still an open question how the frictions interact to determine pricing. Many other research opportunities exist. The municipal bond market has become an empirical laboratory for questions in financial intermediation, market microstructure, corporate finance, and local public finance.

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