Pushing Bonds Over the Edge:

Investor Demand and Municipal Bond Liquidity*

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July 2023

Abstract

We examine how large changes in investor composition affect secondary asset markets by exploiting a discontinuous threshold in the tax treatment of municipal bonds. As bonds approach the threshold, institutional traders dispose of the bonds at significant risk of falling below the threshold in anticipation of higher future transactions costs. This pattern is similar across all major institutional investors and driven by the inability of mutual funds to trade below the threshold. Once bonds cross the threshold, trading activity declines and trading costs increase significantly for small, medium, and large trades. Contractionary monetary policy amplifies these dynamics and speeds up the path to illiquidity in the market.

Keywords: Monetary Policy, Municipal Bonds, Institutional Investors, Asset Liquidity

*The views stated herein are those of the authors and are not necessarily the views of the Federal Reserve Bank of Chicago, the Federal Reserve Board, or the Federal Reserve System. We thank Gene Amromin, Luca Benzoni, Celso Brunetti, Andrew Chen, Sergey Chernenko, Stefania D'Amico, Vincent Grégoire, Kinda Hachem, Nick Hirschey, John Krainer, Mattia Landoni, Dan Li, Asaf Manela, Ralf Meisenzahl, Borghan Narajabad, Piotr Orłowski, Ander Perez-Orive, Andres Schneider, Stéphane Verani, and seminar participants at HEC Montreal and the Federal Reserve Board for helpful comments. We thank Andrew Souther and Radhika Patel for excellent research assistance.

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1 Introduction

Institutional investors have substantially increased their footprint in asset markets since the 1990s and now have outsized importance in asset price formation (He and Krishnamurthy, 2013; He, Kelly and Manela, 2017; Koijen and Yogo, 2019; Gabaix and Koijen, 2021; Ben-David, Franzoni, Moussawi and Sedunov, 2021; Vayanos and Vila, 2021). While larger institutional presence tends to be associated with better market quality, their investment objectives and constraints may also have adverse effects on the orderly functioning of asset markets and transactions costs. Understanding the investment incentives of institutions is therefore crucial for policymakers and market participants alike.

In this paper we shed light on the role of institutional investors in secondary market price formation and on how monetary policy may affect these dynamics in the context of the $4 trillion municipal bond market. The municipal bond market provides a natural setting to study this question because both retail traders and institutions hold large shares of outstanding bonds and there is rich heterogeneity in tax treatment. We exploit the discontinuous tax treatment of investment proceeds to generate variation in investor composition in the same bond over time. We show that the exit of institutional investors such as mutual funds, insurance companies, and closed-end funds from the secondary market leads to significantly lower market quality and higher transactions costs—an important feature of this market even in "normal" economic times. We document how investment constraints of one influential group of investors, mutual funds, can lead to asset disposition by other institutions such as insurance companies and closed-end funds in anticipation of higher future transactions costs. Finally, we show that monetary policy tightening amplifies institutional sales of bonds at risk of adverse tax treatment and speeds up the path to illiquidity in this market.

While interest payments from tax-exempt municipal bonds are typically exempt from federal and state income taxation, realized price appreciation is not. Since 1993 investors who purchase municipal bonds below a "de minimis" prices are responsible for ordinary income taxes on any

realized price appreciation.[1] This threshold is determined by the bonds' original issue price, the number of years since issuance, and the number of full remaining years to maturity. Acquiring bonds at prices below the "de minimis" threshold can easily lead to the doubling of tax liability on realized price appreciation for municipal bond investors, who are typically in the highest income tax brackets. We show that this discrete tax hike leads to selling pressure and, consequently, higher illiquidity and transactions costs in the municipal bond market. Furthermore, sales by institutions not directly affected by the tax discontinuity are an important contributor to these dynamics.

We study bond trading dynamics around the de minimis threshold using the evenly spaced partitioning estimators of Calonico, Cattaneo and Titiunik (2015) and relying on transaction-level data from 2010 through 2022. Given the well defined nature of the de minimis price for each bond, many investors, anticipating few potential buyers and low liquidity below the threshold, have incentives to dispose of bonds above the threshold. We test this idea using secondary market trading data data and show that the incidence of trading increases as bonds move from ten to five percentage points above the threshold and declines as bonds get closer to the threshold. Furthermore, conditional on trading, the average weekly volume of customer sales is stable between 10 and 5 percentage points above de minimis, but declines rapidly thereafter. The incidence of trading activity drops sharply after bonds fall below the cutoff, suggesting a reduction in secondary market activity. Conditional on trading, average total weekly par amount traded increases for small, medium, and large trades below the threshold.[2]

The increase in the frequency of large trades above the threshold points to institutional investors dominating bond sales as prices move closer to the de minimis threshold. Using data on quarterly institutional investor, we find that mutual funds, insurance companies, and closed-end funds, which collectively account for the bulk of institutional municipal bond holdings, dispose of a significant portion of their exposure to bonds approaching the threshold. The selling patterns are highly dependent on bond duration, or the sensitivity of bonds to interest rate risk. Institutions are

[1] Realized price appreciation from bonds purchased above this threshold but below par is subject to capital gains taxes.

[2] We consider "large" trades, those exceeding $100,000 in total par dollar amount, as institutional and "small" trades, those below $25,000 in total par dollar amount, as retail.

more likely to dispose of less interest rate-sensitive, low-duration, bonds in the immediate vicinity of the de minimis threshold, but sell higher-duration bonds well above the threshold. These disposition patterns minimize the risk that these investors find themselves below the de minimis threshold due to unexpected increases in interest rates. Importantly, institutional investors exhibit the same selling patterns above the de minimis threshold, in anticipation of the absence of mutual fund buyers and, consequently, higher expected transactions costs below the threshold. This is because in contrast with other institutions, mutual funds typically cannot incur ordinary income tax liabilities and are likely to avoid purchasing bonds below the threshold. Overall, these results imply that mutual funds are essential for orderly secondary market function.

We also find large increases in trading costs around the de minimis threshold using intermediation chain markups in the spirit of Li and Schürhoff (2019). The average markups of customer prices are significantly larger below than above the threshold among all trade sizes. Far above the threshold, markups among large trades are low and in line with prior literature (Green, Hollifield, and Schürhoff, 2007; Schultz, 2012; Griffin, Hirschey and Kruger, 2022). As prices approach de minimis, we document increases in markups of large transactions. This is likely driven by selling pressure induced by institutions. We also corroborate this idea by showing that the selling pressure from Feldhütter (2012), defined as the price differential between contemporaneous large and small sales transactions (see Feldhütter (2012)), increases over the same price range.

De minimis risk appears to be tightly linked to monetary policy—it increases in a rising interest rate environment as higher rates push bonds closer to or below the threshold. During a period of monetary tightening, the bonds underlying as much as a quarter of all secondary market transactions face significant probability of falling below the threshold (carry de minimis risk). Weekly increases in the federal funds rate are strongly positively correlated with contemporaneous institutional sales volume above the threshold, amplifying the path to illiquidity documented earlier. Specifically, institutional sales volume increases immediately above the threshold for the most interest rate-sensitive bonds and over a wider range of prices above the threshold for less sensitive bonds. These results are consistent with investors disposing of high-duration bonds well in advance

of rate increases, generating a limited response to contemporaneous rate hikes. Increases in policy rates over longer than weekly horizons translate to additional institutional dispositions further away from the threshold but these effects are muted relative to the contemporaneous effects.

We extend the literature studying the role of taxes in municipal bond pricing (Green, 1993; Wang, Wu and Zhang, 2008; Cestau, Hollifield, Li and Schürhoff, 2019; Ang, Bhansali and Xing, 2014) by showing that tax-induced investor segmentation is a key determinant of bond prices. The study closest to ours, Ang, Bhansali and Xing (2010), provides model-free estimates of implicit tax rates perceived by market participants by comparing yields of bonds below the de minimis threshold to those of premium-coupon bonds. The authors estimate implied ordinary income tax rates of 70-100% below the threshold, even for dealer trades. This is puzzling because ordinary income tax rates during their sample period never exceeded 40% and because intermediaries are typically not subject to ordinary income taxes.[3] Our paper sheds light on this puzzle by showing that the increase in yields is largely driven by higher transaction costs below the de minimis threshold. Conducting a similar exercise to that in Ang, Bhansali and Xing (2010), we show that markups of below-de minimis bonds is substantially higher for municipal bonds that recently lost a significant portion of their institutional investor base or that are otherwise less liquid. More broadly, our paper suggests the interaction of fiscal and monetary policy may have large unintended consequences on asset liquidity and pricing in asset markets.

We also contribute to the recent literature studying asset prices in terms of demand for directly observed asset characteristics, instead of traditional risk-based portfolio choice. Koijen and Yogo (2019) estimate an asset demand system where heterogeneous demand elasticities across investors affect price dynamics in equity markets, while Bretscher, Schmid, Sen and Sharma (2020) apply a similar demand system estimation to the corporate bond market. A central theme in this literature is the existence of significant frictions that prevent assets from being priced solely as in classical theory (Merton, 1973; Lucas, 1976). We show that institutional demand for observed asset

[3] Longstaff (2011) also estimates implied income tax rates from municipal yields and arrives at a range of 8%-55%. Their sample, however, comprises of variable rate demand obligations (VRDOs), which have significantly shorter effective maturities and different investor base than the typical municipal bond.

characteristics also has important implications for liquidity and transactions costs in the secondary market. We also document that monetary policy can amplify the impact of institutional demand on asset illiquidity and prices.

Finally, we extend the recent literature on the growing importance of mutual funds in over-the-counter markets. While some of this literature shows that mutual funds may increase the fragility of bond markets in a time of stress (Falato, Hortacsu, Li and Shin, 2021; Li, O'Hara and Zhou, 2022), other work establishes the beneficial impact of mutual funds in bond markets. For example, Adelino, Cheong, Choi and Oh (2021) shows that relationships between issuers and mutual funds improves issuers' capital acquisition prospects whenever funds face unexpected inflows. Combining their result with our findings on institutional exit implies that the ability of issuers to raise financing in a contractionary monetary policy environment may be impaired.

We also complement Chernenko and Doan (2020), Chernenko and Doan (2022), and Giannetti and Jotikasthira (2022), which show that mutual funds are central in creating and maintaining liquidity in the municipal bond market. The Municipal Securities Rulemaking Board (MSRB), one of the primary regulators of the municipal bond market, also highlights the increased importance of mutual funds for municipal bonds.[4] We find that mutual funds exit makes large swaths of the municipal bond market more expensive to transact in during episodes of contractionary monetary policy.

2 Institutional Background

While interest on tax-exempt municipal bonds in the United States is typically exempt from income taxes, realized price appreciation may, however, be subject to income taxes. This happens when investors purchase the bond in the secondary market at a discount from its face value at issuance. The Internal Revenue Service (IRS) treats any realized price appreciation in excess of a "de minimis" amount as ordinary income, while realized price appreciation less than the "de minimis" amount

[4] https://www.msrb.org/Press-Releases/MSRB-Research-Reveals-Significant-Shifts-Municipal-Securities-Ownership

as capital gains. The de minimis amount is equal to 0.25% $\times$ the complete years remaining to maturity $\times$ the bond's par value. For example, the maximum discount taxable at capital gains rates on a tax-exempt bond issued at par with 10 full years to maturity and a par value of \$100 is equal to 10 $\times$ 0.25% $\times$ \$100, or \$2.5. Therefore, a purchase price below \$97.5 means that the buyer owes ordinary income taxes if in the future she sells or redeems the bond at prices above \$97.5. This bond is typically referred to as a "market discount" bond. A purchase price above \$97.5 but below \$100 implies capital gains taxation. Finally, the proceeds from tax-exempt bonds purchased at par or at a premium to par are tax-free.[5]

The current tax regime has been in place since May 1st 1993, when the Omnibus Budget Reconciliation Act (OBRA) of 1993 repealed the exemption of realized price appreciation on municipal bonds from ordinary income taxes under Section 1276 of the Internal Revenue Code.[6] Previously, market discount municipal bonds would only trigger capital gains taxes. Repealing the exemption of municipal bond proceeds was not among the major goals or provisions of the bill and was not expected to raise substantial government revenue as it was not listed in any of the estimates of the Congressional Budget Office (CBO) or the Joint Committee on Taxation (JCT).[7] Instead, OBRA's major provisions were expected to reduce the federal deficit by an estimated \$387 billion primarily through lowering individual income tax brackets, increasing corporate income tax rates, and decreasing direct and discretionary spending.

The municipal bond market is dominated by retail investors in the highest personal income tax brackets, who thereby have strong incentives to avoid purchasing municipal bonds below the threshold. Institutional investors are holding an increasing share of municipal bonds and may also be also sensitive to the personal tax tax consequences of de minimis bonds. Mutual funds, holding the largest share of municipal bonds among institutions, invest on behalf of tax-sensitive individuals. Consequently, most municipal bond funds promise investors income free of ordinary

[5] For additional details, see https://www.fidelity.com/bin-public/060_www_fidelity_com/documents/fixed-income/deminimis-dilemma-Fidelity.pdf.

[6] https://www.congress.gov/103/statute/STATUTE-107/STATUTE-107-Pg312.pdf

[7] See https://www.cbo.gov/sites/default/files/103rd-congress-1993-1994/reports/09-1993-outlookentirerpt_0.pdf and https://www.jct.gov/CMSPages/GetFile.aspx?guid=fb4f267b-422d-40c8-b751-c7737316f28e

income taxes, which gives them strong incentives to avoid purchasing below-de minimis bonds. Insurance companies and closed end funds also significant hold significant share of municipal bonds. Those investors do not face the same constraints as mutual funds and are not directly affected by personal income tax considerations.

Other institutions may be indirectly affected by the high sensitivity of mutual funds to discontinuous jumps in ordinary income taxes. For example, institutional investors may avoid purchasing or increase dispositions of above-de minimus municipal bonds that are close to the threshold. Market volatility or interest rates increases may push these bonds below the threshold, where few mutual funds are likely to purchase municipal bonds. The absense of mutual funds below the threshold may lower municipal bond demand and increase transactions costs for other market participants given the prominent role and frequent trading of funds. Consequently, instititions may exit the market in anticipation of low liquidity and high transaction costs below the threshold.

Concerns about tax consequences of market discount bonds naturally increase with market volatility and in rising interest rate environments. For example, when interest rates were set to increase in 2006, 2013, and 2017 "de minimis fears" increased as well.[8] Inflationary pressures have recently sparked similar fears in the municipal bond market. In light of the lower sophistication of retail investors that dominate this market, both regulators and investment advisers have recently issued statements warning investors about de minimis risk.[9]

3 Data

3.1 Data Description and Summary Statistics

To gain insight into trading activity around the de minimis threshold we use secondary market pricing data on municipal bonds since 2010 provided with permission by the Municipal Securities Rulemaking Board (MSRB). For the purposes of the analysis, we limit the sample to bonds with

[8] See https://www.bondbuyer.com/news/why-de-minimis-risk-is-a-topic-again.

[9] See https://msrb.org/-/media/Files/Resources/Tax-and-Liquidity-Considerations-for-Buying-Discount-Bonds.ashx or https://www.pimco.com/en-us/resources/education/understanding-the-de-minimis-tax-rule/

fixed coupons and zero coupon bonds. As our study focuses on secondary market outcomes, we exclude trades that occur before the settlement date or within sixty days of primary offerings, as well as transactions by the underwriters of the offerings. We also exclude observations where the transaction price or amount are missing or not verified by the MSRB, the transaction price is based on multiple transactions, customers and dealers use non-transaction-based compensation, or bond yields are negative. Finally, to mitigate the effect of outliers and data errors, we trim trade prices and yields at the 0.5^{th} and the 99.5^{th} percentiles.

We obtain the universe of municipal bond issues from the Mergent Municipal Bond Securities Database (Mergent). Mergent identifies municipal issuers as well as a wide range of issuance characteristics both at the issue and the bond series level. These include offering amount, type, maturities, the presence of bond insurance, and yields. We exclude issues where the bond coupon rate or maturity do not equal to the corresponding coupon and maturity values from the EMMA data set. We also exclude all transactions that occur after the maturity date of a given bond. This results in a sample of 92,017,724 transactions by 45,428 unique issuers (in terms of the 6-digit CUSIP) since October 2010. Because most municipal bonds are illiquid, bonds that trade frequently are likely to have a disproportionate impact on our results. To mitigate such concerns we collapse the data to the week-bond CUSIP level by computing the total dollar volume, the number of trades, and the par-weighted average price per trade for each CUSIP in a given week, resulting in 25,269,697 CUSIP-weeks. Finally, we exclude the highly volatile COVID-19 pandemic period (2020w6-2021w12), which initially led to drying up of secondary market activity with this trend reversing following the multiple rounds of government stimulus (Haughwout, Hyman and Shachar, 2022; Ivanov, Zimmermann and Heinrich, 2022). Our final sample has 22,871,452 CUSIP-weeks.

To shed light on the economic mechanisms behind the higher transactions costs below de minimis, we use quarter-end portfolio holdings of institutional investors from eMaxx from Thomson Reuters since the first quarter of 2010. eMaxx provides security-level data on asset holdings of a wide range of institutional investors such as US mutual funds, closed-end funds, property and casualty insurers, and life insurers. These investors account for the bulk of institutional investor

assets in the municipal bond market. Merging the holdings data with municipal bonds information from Mergent results in a sample of 546,428 different municipal bonds held by 2,142 mutual funds, 379 closed-end funds, 2,047 property & casualty insurance companies, and 1,070 life insurance companies. At the end of 2022, mutual funds held about $931 billion of outstanding municipal bonds, closed-end funds held $92 billion, property & casualty insurers held $178 billion, and life insurance companies held roughly $171 billion.

In most of our analysis, we limit the sample to customer-to-dealer sales transactions in bonds where interest is exempt from income taxes as we study the role of expected liquidity on sellers' portfolio choices. Table 1 shows that, conditional on at least one sale transaction, the size of the average transaction in a typical week is roughly $240 thousand. We define small, medium, or large trades as those below $25,000, between $25,000 and $100,000, or exceeding $100,000 in terms of transaction par value, respectively. The municipal bond market literature attributes small trades to retail investors, while large trades to institutional investors (Schultz, 2012; Cornaggia, Hund and Nguyen, 2020; Chalmers, Liu and Wang, 2021). Consistent with this idea, large trades exceed $800 thousands, while the average small trade amounts to only about $14 thousand in par value. Trading activity in terms of trades count is fairly low in a typical bond-week with only 1.29 sales transactions.[10] Such low trading activity is a distinguishing characteristic of the municipal bond market. Finally, consistent with more favorable dealer execution of institutional transactions, transaction yields are substantially lower for large than for small trades.

To understand the relation between monetary policy and municipal bond liquidity, we use Federal Funds effective rate data provided by the Board of Governors of the Federal Reserve System to create one-, four-, eight-, and twelve-week changes in the fed funds rate through November of 2022. Table 1 shows that the average fed funds rate is only 66 basis points with small and positive average rate changes as most of our sample period is characterized by low interest rates.

[10]Summing observation count across small, medium, and large trades exceeds the number of observations for combined sales volume, number of trades, and yields because a given bond-week may have trades in multiple trade sizes.

3.2 Defining the De Minimis Price Threshold

We follow IRS publication 1212 to arrive at the de minimis price for each bond.[11] The price threshold, below which bond appreciation is subject to ordinary income taxes, is a function of a bond's adjusted offering price, P_t^o, and the de minimis amount. P_t^o is computed as follows:

$$\begin{aligned} P_t^o &= P_{t-1}^o + A_t, \\ A_t &= (P_{t-1}^o \times R) - C \\ P_{t=0}^o &\equiv P^o \end{aligned} \tag{1}$$

where the bond's adjusted offering price within the first year of the offering, $P_{t=0}^o$, is simply the bond's offering price, P^o. A_t is the accretion to the adjusted offering price in year t following the offering, R is the offering yield in percent, and C is the bond's coupon in dollar terms. t is rounded up to the next full year since the offering. The de minimis price, P^d, is then defined as follows:

$$P^d = \begin{cases} 100 - \lfloor T - t \rfloor \times 0.25 & \text{if } P^o \geq 100, \\ P_t^o - \lfloor T - t \rfloor \times 0.25 & \text{if } P^o < 100 \end{cases} \tag{2}$$

where T is the bond's contractual maturity (in years) and $\lfloor T - t \rfloor$ is the number of full remaining years to maturity of the bond. This equation simply says that for par or premium coupon bonds, P^d is the difference between par value and the full remaining years to maturity multiplied by 0.25. The computation is slightly different for original issue discount (OID) bonds where we have the adjusted offering price instead of par value.

We compute the distance to the de minimis price, Δ, sequentially in terms of customer purchase, customer sales, and dealer prices because a bond's tax treatment is determined by its purchase price. We define Δ as the difference between the minimum customer purchase price and the de minimis price in a given CUSIP-week, whenever purchase prices are available. If no purchase prices are available but sale prices are, we define Δ as the difference between the minimum sale

[11] https://www.irs.gov/pub/irs-pdf/p1212.pdf

price and the de minimis price. If only dealer prices are available, we define Δ as the difference between the par-weighted average across dealer prices and the de minimis price. Table 1 shows that the average bond-week is about 10 percentage points above de minimis. Roughly a quarter of bond-weeks is close to de minimis with a distance of 4 percentage points or less.

4 Empirical Design: The Evolution of Bond Liquidity around the Cutoff

We study the evolution of municipal bond trading activity around the de minimis threshold using the evenly spaced partitioning (ES) estimators of Calonico, Cattaneo and Titiunik (2015). These estimators provide a convenient non-parametric representation of the raw data in light of the substantial variability and the large number of municipal bond transactions. The ES estimators present local means of the distribution of a given variable, x, by partitioning the data as follows:

$$p_{-,j} = x_l + j \times \frac{\bar{x} - x_l}{J_{-,n}} \quad and \quad p_{+,j} = \bar{x} + j \times \frac{x_u - \bar{x}}{J_{+,n}} \tag{3}$$

where $p_{-,j}$ and $p_{+,j}$ are the jth bin on left and the right of the cutoff, x_l and x_u are the upper and lower bounds of the support of x, $\bar{x}$ is the value of the cutoff, and $J_{-,n}$ and $J_{+,n}$ are the number of bins below and above the cutoff, respectively.

$J_{-,n}$ and $J_{+,n}$, are determined according to an integrated mean square error (IMSE) loss function that trades off bias and variability of the partitioning estimators. For example, allowing for too many bins reduces the bias of the local mean estimates but increases their variability. The ES estimator spaces the underlying data on each side of the cutoff in equal intervals and arrives at the number of bins on each side using an IMSE loss function that gives variance and bias equal weights. In robustness tests, we explore alternative approaches that account for the sparsity of the data using quantile approaches or polynomial regressions approximations of the means in each equally spaced bin, which better addresses noncontinuous outcomes. We find very similar results

in all of these cases (see Appendix Figures B.1 and B.2).

We apply the ES estimator to the weekly CUSIP data to understand the evolution of municipal trading activity around the de minimis threshold. We examine four main measures of trading activity—the incidence of trading, the number of trades, the total par value traded, and the average par value per trade—for each bond-week in the sample. In these tests we limit the sample to bonds within 10 percentage points from the de minimis threshold (expressed in percentage points of par value) as we are interested in secondary market liquidity dynamics close to the cutoff. We exclude bonds with maturities of less than one year, or over a 9,877,694 bond-weeks with 10 percentage points of the deminimis threshold.

We expect secondary-market activity in municipal bonds to decline after crossing the threshold because of the high tax sensitivity of municipal bond investors. Realized price appreciation from bonds purchased at prices below the threshold is subject to ordinary income taxes as compared to capital gains taxes for purchases above the threshold. Ordinary income is typically taxed at substantially higher rates than capital gains for most municipal bond investors. For example, over 75% of outstanding municipal bonds are held directly or indirectly in mutual funds by retail investors in the high-tax brackets of household income (Feenberg and Poterba, 1991; Poterba and Samwick, 2003; MSRB, 2020). In line with the high tax sensitivity of retail investors, municipal bond mutual funds are unlikely to purchase bonds below threshold. Many funds have formal investment objective that rule out such purchases. For example, PIMCO states that their municipal bond funds "seek high income exempt from federal taxes [...] where capital appreciation is a secondary objective" and that funds provide tax-exempt income while "preserving liquidity."[12]

Overall, falling below the de minimis threshold is likely to be associated with a reduction in investor demand and, consequently, lower secondary market activity. Such decline is likely to be more pronounced for tax-exempt than for taxable bonds as the former are typically held by tax-sensitive investors, while the latter tend to be held by less tax-sensitive clienteles such as foreign investors, pension funds, IRAs, 401(k)s, and endowments (Hernandez Barcena and Wessel, 2020).

[12] https://www.pimco.com/en-us/investments/mutual-funds/municipal-bond-fund/inst

Therefore, in most of the analysis we focus on the sub-sample of tax-exempt bonds.

Investors may anticipate the lower secondary market demand below the threshold and may preemptively sell bonds before crossing the threshold. Actively-managed institutional investors such as mutual funds are more likely to engage in such anticipatory dispositions because of shorter investment horizons and fire sales risk as compared to more buy-and-hold investors such as individuals, life insurance companies, and closed-end funds. For example, prior literature documents significant fire-sale externalities in the mutual fund industry (Coval and Stafford, 2007; Falato, Hortacsu, Li and Shin, 2021) and preemptive dispositions of holdings that are most prone to fire sales risk (Chernenko and Doan, 2020; Giannetti and Jotikasthira, 2022). Consistent with such anticipatory sales, the Bond Buyer reports that due to de minimis risk "institutional investors purchase bonds at big premiums" and that some mutual funds "have an informal protocols of bailing out and selling once a bond moves down to 103."[13] To the extent that municipal bond investors increase dispositions before the cutoff and these empirical patterns are driven by institutional investors, the dollar volume of traded bonds and trade size are likely to increase substantially before bonds hit the cutoff.

We examine the disposition activity of institutional investors as municipal bonds approach the de minimis threshold. The largest institutional holders of municipal bonds are mutual funds, commercial banks, life insurance companies, and property and casualty (P% C) insurance companies. The incentives to sell bonds approaching the de minimis threshold differ across those investors. Mututal funds and P& C insurers may be more averse to holding illiquid bonds as they face more volatile cash-flows than life insurance companies. Further, insurers' investment gains are taxed at the corporate tax rate whether they bought a bond below or above the de minimis price. We therefore expect mutual funds to be the most prominent sellers above the threshold and more muted selling behavior from buy-and-hold investors such as life insurers.

To shed light on the cost of trading, we construct complete intermediation chains following Li and Schürhoff (2019). We calculate markups for different trade sizes and estimate the following

[13] https://www.bondbuyer.com/opinion/potential-disclosure-issues-with-discount-munis

regression:

$$y_{b,w} = \sum_{i<-1}^{+10} \beta_i (Sales_{bq} \times Distance_{ibw}) + \gamma X_{b,w} + \varepsilon_{b,w} \tag{4}$$

$y_{b,w}$ is the intermediation chain markup computed as in for all complete chains. $Sales_{b,q-1}$ takes the value of one whenever institutional investors reduce their exposure to bond b in the previous quarter $q-1$ by at least 25%. $Distance_{ibw}$ takes the value of one if the price of bond b price is within interval i around the de minimis threshold ($i \in \{<-1, -1, +1, +2, ..., +10\}$) in week w, and zero otherwise. If institutional investors exit the market, we expect this to have effects on the cost of trading especially for small and medium sized trades. Dealers will have to split large lots and search for muplitple buyers if they want to sell larger positions.

Lastly, we also examine whether contractionary monetary policy amplifies bond illiquidity around the de minimis threshold. Bond prices are inversely related to interest rates, which means that contractionary monetary policy is likely to increase the fraction of bonds facing de minimis risk. To better understand the effect of monetary policy on municipal bond liquidity, we use changes in the federal funds effective rate and estimate the following specification:

$$y_{bt} = \sum_{i<-1}^{+10} \beta_i MP\ Measure_t \times Distance_{ibt} + \gamma X_{ibt} + \varepsilon_{bt} \tag{5}$$

The outcome variable of interest, y_{bt} is the total dollar volume sold by customers to dealers in bond b during week t. We examine sales volume for small, medium, and large trades separately to better understand dynamics among both institutional and retail investors. $MP\ Measure_t$ is the one-, four-, eight-, or twelve-week change in policy rates, while $Distance_{ibt}$ is an indicator variable that takes the value of one if the price of bond b is in interval i away from the de minimis threshold. i includes <-1, -1, $+1$ ..., $+10$ corresponding to the $[-10,-1)$, $[-1,0)$, $[0,+1)$ ..., $[+7,+8)$ intervals measuring distance from the de minimis threshold in percentage points, respectively. The omitted group in the regressions includes bonds in the $[+8,+10]$ interval. The matrix X_{ibt} comprises of bond, week, and *Distance* fixed effects.

5 Results

5.1 Bond Trading Activity and De Minimis Thresholds

We first examine secondary market trading activity around the de minimis threshold. Figure **??** Panel A presents the distribution of bond-weeks within ten percentage points of the de minimis threshold, showing that trading activity falls precipitously immediately after bonds cross the threshold. The incidence of trading activity immediately below the threshold is at least three to four times smaller than that immediately above and continues to decline as bonds move further below the de minimis threshold. Thus, at a first approximation secondary market liquidity declines substantially once municipal bonds approach the threshold as the municipal bond market is dominated by highly tax sensitive investors likely to minimize ordinary income taxation.

In Figure 1 Panels B and C we also consider the evolution of two additional measures of bond trading activity around the de minimis threshold conditional on the presence of trading activity—the total par value traded and trade size across the bond-weeks in our sample. We use customer-to-dealer sales transactions to construct these measures of trading activity because sellers of bonds with purchase prices above the threshold are unaffected by tax considerations. In other words, their actions are likely to be driven by expected future liquidity. The average trade size and par value traded decline as bonds approach the cutoff. The steady decline in average trade size combined with the steady decline in the number of trades suggests that institutional investors dispose of their holdings as bonds approach the threshold in anticipation of low secondary market liquidity below the threshold.

Next in Figure 2 we partition the sample into low- (Panels A, C, E) and high-duration bonds (Panels B, D, F). Low-duration (high-duration) bonds are those with duration of less than or equal to (greater than) three, which is the sample median duration. High-duration bonds have significantly higher sensitivity to interest rate changes than low-duration bonds. Consequently, we expect investors to preemptively dispose of high-duration bonds facing de minimis risk significantly earlier above the threshold than low-duration bonds.

Figure 2 Panel A shows a histogram of trading activity of bond-weeks corresponding to low-duration bonds. We find a large and more precipitous drop in trading activity at the threshold among low-duration bonds than in the full sample. Similarly, these bonds also exhibit a significant run-up in average trade size and par value traded (Panels C and E) as they approach the threshold from the right. The run-up in trading activity is consistent with the low sensitivity of low-duration bonds to interest rate changes, implying that investors have significant flexibility to divest away from these bonds close to the threshold. The increase in trade size illustrates most of the activity in the immediate vicinity of the threshold comes from institutional rather than retail investors. Finally, the minimal distribution mass below the cutoff further highlights the significant ability of investors to divest as planned and the strong preference to stay above the de minimis threshold.

Figure 2 Panels B, D, and F show that the trading patterns of high-duration bonds differ markedly from those of low-duration bonds. Specifically, trading incidence is substantially higher 5 percentage points above the threshold than immediately above the threshold. At the same time, average trade size is also larger further above the cutoff with total dollar volume remaining fairly constant, suggesting that institutions are more likely to sell high-duration bonds well above the de minimis threshold. These patterns in weekly trading activity are consistent with investors in high-duration bonds responding to de minimis risk earlier than investors in low-duration bonds. Notably, the decline in trading activity is also steeper above than below the threshold.[14]

In Figure 3 we also examine trading dynamics around the de minimis threshold for transactions of different sizes. Panels A, C, and D of Figure 3 show that while all types of investors trade less below than above the threshold, institutional investors trade markedly less than retail investors once bonds fall below the threshold. In other words, retail investors become significantly more important for price formation of bonds below the threshold. The figure also corroborates our earlier conjecture that institutional investors are responsible for the run-up in trading activity immediately above the threshold. Average trade size conditional on trading increases substantially immediately above the cutoff for large but not for small and medium trades (Panel E). In Section 6 we further

[14]Splitting the sample based on remaining maturity generates nearly identical results (see Appendix Figure B.3).

examine whether the significant institutional investor trading generates selling pressure in this segment of the market.[15]

5.2 Institutional Trading Near the Threshold

In this section, we investigate the mechanism behind the increase in institutional trading activity above the threshold. We focus on bond mutual funds, (P&C) insurers, life insurers, and closed-end funds as they hold the bulk of municipal bonds among institutions. Given the institutional holdings data are quarterly, we first compute the average distance of each bond to the de minimis threshold at the quarterly level, which we then use to track the evolution of institutional trading activity.

Figure 4 shows the typical (median) total dollar value of net purchases of municipal securities across mutual funds, life insurance companies, P&C insurers, and closed-end funds. Panel A indicates that mutual funds are large net sellers of municipal bonds above the threshold and that net selling peaks 4-5 percentage points above the threshold, reaching nearly $500 billion quarterly. This result matches closely the empirical patterns from Figure 1. Once bonds fall below the threshold, net purchases of mutual funds stay close to zero. Panel B shows that P&C insurers exhibit roughly the same trading patterns but the magnitudes are roughly half as large as those among mutual funds.

The trading activity of mutual funds and P&C insurers stand in stark contrast with the activity of life insurance companies, shown in Panel C. While life insurers also increase total dollar dispositions of municipal bonds immediately above the de minimis threshold, such net flows are negligible. The muted activity of life insurers is consistent with these institutions following buy-and-hold investment strategies. Overall, these results corroborate the idea that institutions anticipate less liquid markets below the threshold, where investment objectives to minimize income taxes reduces the number of potential buyers. The last panel depicts closed-end funds. While those funds resemble the mutual fund trading behavior, the magnitudes differ. Closed-end funds' selling is orders of magnitudes smaller than selling by mutual funds. This is simply the consequence of closed-end

[15] Appendix Table B.1 further describes trading activity around the de minimis threshold for each trade type.

funds holding lower share of outstanding municipal bonds.

Figure 5 shows that the timing of net selling by funds and insurance companies depends on bond duration. Low-duration bonds have duration in the first quartile of the duration distribution, below 2.9, and high-duration bonds have duration in the top three quartiles. Panel A indicates that instituional investors substantially increase net selling of low-duration bonds as these bonds approach the threshold. The large institutional outflows within one percentage point above the threshold comes entirely from short-duration bonds. In contrast, investors dispose of bonds with longer duration well above the threshold (Panels B and D). For example, within the subset of high-duration bonds institutional outflows are largest in magnitude 3-6 percentage points above the de minimis threshold and decreases closer or further away from the cutoff. Outflows drop to nearly zero immediately above the cutoff, lending further support to the idea that mutual funds dispose of interest-rate sensitive bonds well above the cutoff in a planned manner.

Figure B.5 in the Appendix sheds further light on how the the timing of mutual fund trading activity depends on bond duration by splitting funds into "short-term" (Panel (a)), "intermediate term" (Panel (b)), and "long-term" (Panel (c)) according to their stated investment objective.[16]

We also examine whether the mutual fund sector fully exits their positions in bonds carrying de minimis risk. The exit of mutual funds is likely to exacerbate municipal bond illiquidity as mutual funds hold the largest share of municipal bonds among institutional investors.[17] Mutual funds also tend to be more active on the secondary market than most other institutions such as banks, insurance companies, or foreign investors. We find that conditional on mutual funds becoming net seller of a given bond between quarters t and $t-1$, they dispose of the entire position over 75 percent of the time. While our data do not allow us to provide detail on the types of institutions purchasing bonds at de minimis risk, the widespread disposition of such bonds positions by mutual funds is likely to have adverse effects on future bond liquidity.

[16]The sample for this analysis accounts for about a quarter of the full sample in Figure 4 because a fund's name does not always reveal its duration objective.

[17]As of the second quarter of 2022 mutual funds held $819 billion of outstanding municipal bonds, or roughly 20 percent of total outstanding amount, the second most significant investor in these bonds after households. See Table L.212 in the Financial Accounts of the United States, https://www.federalreserve.gov/releases/z1/20220909/z1.pdf.

Figure 6 provides further evidence of mutual funds completely exiting and avoiding bonds that are about to fall below the threshold. The figure follows bonds that are held by mutual funds at time t and drop below the threshold one year ahead at $t+4$. The figure plots how many funds hold such a bond at time t and at time $t+4$. Most bonds are held by 1 or 2 funds, with some issuances held by up to 10 funds. Yet 80% of all bonds that are held by funds and fall below the de minimis threshold are not held by any fund in the quarter the bond falls below the threshold. Most of the selling occurs one quarter prior, which is not shown in the graph.

6 The de minimis threshold, liquidity, and the cost of trading

In this section, we examine trading costs around the de minimis threshold and potential selling pressure coming from institutional investors.

Markups. We first explore how differences in trading costs between institutional and retail investors shape prices around the de minimis threshold. As institutional investors exit the market, dealers may be unable to sell large positions. This difficulty may be reflected in the cost of trading for the remaining investors, mainly retail investors. To understand such trading costs, we calculate markups using the algorithm proposed in Li and Schürhoff (2019). To the extent that the liquidity deterioration below the threshold is priced by all market participants, we expect an increase in markups for all trades, retail and institutional. Figure 7 lends support to our hypothesis that liquidity is at the heart of the dynamics around the de minimis price. While markups for retail trades are generally higher than institutional markups, markups across all trade types increase significantly once bond prices cross the threshold. Irrespective of trade size, trading costs increase threefold for all investors. And while retail investors do consistently face higher trading costs than institutional investors, their costs increase significantly as institutional investors leave the market. Further, these results also shed some light onto the large variation in markups in the municipal bond market documented by Griffin, Hirschey and Kruger (2022).

Table 2 provides more direct evidence that institutional investors' disposition increases trading

costs. Table 2 shows the results of estimating Equation 4. We estimate separate regressions for small (columns (1) and (2)), mid-sized (columns (3) and (4)), and large trades (columns (5) and (6)), and also differentiate between all bonds (columns (1), (3), and (5)) and high-duration bonds (columns (2), (4), and (6)). Figure 7 shows that trading costs increase unconditionally as bonds cross the threshold. The estimates show whether there is an additional increase in trading costs for bonds, where institutional investors collectively reduce their exposure by at least 25% in the previous quarter. Our results indicate that institutional sales translate to large increases in transactions costs for small and mid-sized trades below the threshold by 10 to 17 basis points. Furthermore, the runup in markups starts earlier over the price distribution for mid-sized trades at 10–16 basis points higher trading costs with two percentage points above the threshold.

By contrast, our tests do not detect an increase in markups among the largest (institutional) trades (columns 5 and 6). As previously shown, trading frequency for large trades declines substantially below the threshold, so potential buyers of large positions in that price region may exert higher bargaining power and obtain better execution pricing. Figure B.6 in the appendix also shows that trading large positions below the threshold may be more difficult. The figure depicts the percentage of sales for which we can identify complete intermediation chains declines steeply for large trades below the threshold. Furthermore, large trades face higher markups of between 3 and 7 basis points five-six percentage points above the de minimis threshold, which is consistent with the substantial institutional selling we document earlier driving up transactions costs. This higher institutional activity, however, may have slight positive spillover effects for small and mid-sized trades as these trades simultaneously have lower markups of between 4 to 7 basis points. Finally, the virtually identical results between the full sample and high-duration bonds suggests that our results are driven by high-duration bonds.

Selling pressure. In section 5 we show that liquidity below the de minimis threshold drops precipitously in terms of both trading incidence and volume. We utilize the selling pressure measure proposed by Feldhütter (2012) to shed additional light on the liquidity dynamics around the cutoff. This measure is equal to the difference in customer sale prices between large and small

trades in the same bond and during the same week. In the municipal bond market this price difference is typically large and positive because institutional investors receive favorable pricing relative to retail investors. A decrease in the price difference is indicative of selling pressure as the execution prices of institutional investors worsen. Figure 8 shows that the high institutional trading above the cutoff is associated with lower price differentials than below the cutoff. As bonds approach the threshold, trade execution progressivly worsens for institutional investors. In other words, the probability of selling pressure and fire sales is substantially larger right above the threshold, which is consistent with the selling activity by mutual funds that we document earlier.

Turnover and markups. Finally, we investigate how an alternative measure of liquidity, turnover, is related to the cost of trading. We follow Cestau, Green and Schürhoff (2013) and calculate quintiles of quarterly bond turnover, defined as the total quarterly trading volume of a bond divided by the bond's amount outstanding as of the previous quarter. We restrict the sample to the highest and lowest turnover quintiles and we include an interaction term between the lowest turnover quintile indicator and the indicators for distance to the threshold. If markups are unrelated to illiquidity around the threshold, we do not expect the interaction terms to be significant around the threshold. Yet Table 3 shows that markups are consistently and significantly higher for low-turnover bonds below the de minimis threshold. For all but small trades, more illiquid bonds' markups experience an additional increase in trading costs. This increase is uniform across all bonds, irrespective of their duration. In summary, these findings suggest that liquidity is not only the main driver of the trading dynamics around the de minimis threshold, but also has significant impact on trading costs.

7 Contractionary monetary policy and bond illiquidity

De minimis risk is unlikely to be stable over time and is likely to vary with market-wide factors that drive interest rate changes. Figure 10 shows that de minimis risk is highly correlated with the monetary policy cycle. Panel (a) illustrates that as interest rates increase, so does the number of

bonds traded below de minimis. Furthermore, contractionary monetary policy increases the share of bonds facing de minimis riks (at risk of falling below the threshold). Panel (b) shows that during environments with contractionary monetary policy such as most of 2022, over 25 percent of trades in a given week are executed at prices between 0 and 4 percentage points from the de minimis threshold.

While this graphical evidence is striking, it does not allow us to differentiate between anticipation and contemporaneous effects of policy rates. During our sample period, these two effects are intertwined as the Federal Reserve signalled the path of interest rates well in advance and municipal bond holders are likely to have traded on interest rate expectations. Therefore, it is important to separate these effects and examine the extent to which unexpected increases in policy rates drive de minimis risk. Understanding these dynamics is likely to have important implications for municipal bond liquidity in times of stress such as the Covid-19 crisis or the Great Recession.

To shed light on trading activity in response to monetary policy changes we first examine the evolution of bond trading activity around changes in the fed funds rate. Columns 1 and 2 of Table 4 show that weekly increases in the fed funds rate are negatively correlated with par value traded among small and medium-sized trades above the de minimis thresholds. In other words, contractionary monetary policy leads to lower sales activity among retail investors. In stark contracts with these results, column 3 shows that weekly fed fund rates strongly positively predict contemporaneous institutional sales volume above the threshold, amplifying the path to illiquidity documented earlier. Notably, this effect is four times larger in magnitude than the change in trading activity among small and mid-sized trades. Columns 4 and 5 show that institutional sales volume increases immediately above the threshold for the most interest rate-sensitive bonds and over a wider range of prices above the threshold for less sensitive bonds. The lack of response among high-duration bonds over most of the price spectrum around de minimis is consistent with investors having disposed of high-duration bonds well in advance of rate increases, generating a limited response to contemporaneous rate hikes.

In Table 5 we study how changes in policy rates over longer than weekly horizons are corre-

lated with sales activity within the subset of large trades. We find that increases in fed funds rates over four, eight, and twelve weeks translate to additional institutional sales further away from the threshold but these effects are muted relative to the contemporaneous effects (presented for the sake of comparison in column 1). For example, these longer horizon changes generate increase in institutional sales volume of between 4% and 6% only in the interval that is 2-3 percentage points above the de minimis threshold, which pales in comparison to the 9% to 12% contemporaneous increase in sales volume between 1-3 percentage points above the threshold. Finally, longer-horizon increases in the fed funds rate also further depress activity below the threshold. Institutional sales decline by about 9% among bond at least one percentage points below the threshold. There is also weaker evidence that institutional sales decline by about 6% for bonds within one percentage point below the threshold, especially for twelve-quarter changes in the fed funds rate.

8 Conclusion

Exploiting a discontinuity in the tax treatment of municipal bonds, we show that institutional investors' exit from the market leads to substantial illiquidity and illiquidity-induced spikes in secondary market transactions costs. Our results highlight the importance of institutional investor constraints and how such constraints shape asset markets. Importantly, we show that the constraints of one group of institutional investors is likely to spill over to other institutions. In our setting, the inability of mutual funds to transact below the threshold leads to the exit of all significant institutional investors in anticipation of higher future transactions costs.

We also show that this illiquidity risk increases significantly in rising interest rates environments such as the current monetary policy tightening. Interest rate hikes amplify institutional sales, both contemporaneously and over longer horizons. Overall, monetary policy speeds up the path to illiquidity and higher transactions costs in the municipal bond market.

References

Adelino, Manuel, Chiyoung Cheong, Jaewon Choi, and Ji Yeol Jimmy Oh. 2021. "Mutual fund flows and capital supply in municipal financing." Working Paper, available on SSRN at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3966774.

Ang, Andrew, Vineer Bhansali, and Yuhang Xing. 2010. "Taxes on Tax-Exempt Bonds." *Journal of Finance*, 65(2): 565–601.

Ang, Andrew, Vineer Bhansali, and Yuhang Xing. 2014. "The Muni Bond Spread: Credit, Liquidity, and Tax." *Columbia Business School Research Paper*, , (14-37).

Ben-David, Itzhak, Francesco Franzoni, Rabih Moussawi, and John Sedunov. 2021. "The granular nature of large institutional investors." *Management Science*, 67(11): 6629–6659.

Bretscher, Lorenzo, Lukas Schmid, Ishita Sen, and Varun Sharma. 2020. "Institutional corporate bond pricing." *Swiss Finance Institute Research Paper*, , (21-07).

Calonico, Sebastian, Matias D Cattaneo, and Rocio Titiunik. 2015. "Optimal Data-Driven Regression Discontinuity Plots." *Journal of the American Statistical Association*, 110(512): 1753–1769.

Cestau, Dario, Burton Hollifield, Dan Li, and Norman Schürhoff. 2019. "Municipal Bond Markets." *Annual Review of Financial Economics*, 11(1): 65–84.

Cestau, Dario, Richard C Green, and Norman Schürhoff. 2013. "Tax-subsidized underpricing: The market for build america bonds." *Journal of Monetary Economics*, 60(5): 593–608.

Chalmers, John, Yu (Steve) Liu, and Z. Jay Wang. 2021. "The difference a day makes: Timely disclosure and trading efficiency in the muni market." *Journal of Financial Economics*, 139(1): 313–335.

Chernenko, Sergey, and Viet-Dung Doan. 2020. "Forced sales and dealer choice in OTC markets." Working Paper, available on SSRN at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3750171.

Chernenko, Sergey, and Viet-Dung Doan. 2022. "Mutual fund liquidity creation." Working Paper, available on SSRN at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4019567.

Cornaggia, Kimberly, John Hund, and Giang Nguyen. 2020. "Investor attention and municipal bond returns." Working paper.

Coval, Joshua, and Erik Stafford. 2007. "Asset fire sales (and purchases) in equity markets." *Journal of Financial Economics*, 86(2): 479–512.

Falato, Antonio, Ali Hortacsu, Dan Li, and Chaehee Shin. 2021. "Fire-Sale Spillovers in Debt Markets." *The Journal of Finance*, 76(6): 3055–3102.

Feenberg, Daniel R, and James M Poterba. 1991. "Which Households Own Municipal Bonds? Evidence from Tax Returns." *National Tax Journal*, 44(4.1): 93–103.

Feldhütter, Peter. 2012. "The same bond at different prices: identifying search frictions and selling pressures." *The Review of Financial Studies*, 25(4): 1155–1206.

Gabaix, Xavier, and Ralph S.J. Koijen. 2021. "In Search of the Origins of Financial Fluctuations: The Inelastic Markets Hypothesis." *NBER Working Paper*, , (28967).

Giannetti, Mariassunta, and Chotibhak Jotikasthira. 2022. "Bond Price Fragility and the Structure of the Mutual Fund Industry." Working Paper, available on SSRN at https://papers.ssrn.com/sol3/Papers.cfm?abstract_id=3963161.

Green, Richard. 1993. "A Simple Model of the Taxable and Tax-Exempt Yield Curves." *Review of Financial Studies*, 6(2): 233–264.

Green, Richard C., Burton Hollifield, , and Norman Schürhoff. 2007. "Financial Intermediation and the Costs of Trading in an Opaque Market." *Review of Financial Studies*, 20(2): 275–314.

Griffin, John M, Nicholas Hirschey, and Samuel Kruger. 2022. "Do Municipal Bond Dealers Give their Customers' Fair and Reasonable'Pricing?" *Journal of Finance, Forthcoming*.

Haughwout, Andrew, Benjamin Hyman, and Or Shachar. 2022. "The Option Value of Municipal Liquidity: Evidence from Federal Lending Cutoffs during COVID-19." Working Paper.

Hernandez Barcena, Lorena, and David Wessel. 2020. "Why the surge in taxable municipal bonds?" Available at: https://www.brookings.edu/blog/up-front/2020/12/21/why-the-surge-in-taxable-municipal-bonds/ (Accessed: July 10, 2022).

He, Zhiguo, and Arvind Krishnamurthy. 2013. "Intermediary asset pricing." *American Economic Review*, 103(2): 732–70.

He, Zhiguo, Bryan Kelly, and Asaf Manela. 2017. "Intermediary asset pricing: New evidence from many asset classes." *Journal of Financial Economics*, 126(1): 1–35.

Ivanov, Ivan, Tom Zimmermann, and Nathan Heinrich. 2022. "Limits of disclosure regulation in the municipal bond market." Working Paper.

Koijen, Ralph SJ, and Motohiro Yogo. 2019. "A demand system approach to asset pricing." *Journal of Political Economy*, 127(4): 1475–1515.

Li, Dan, and Norman Schürhoff. 2019. "Dealer Networks." *Journal of Finance*, 74(1): 91–144.

Li, Yi, Maureen O'Hara, and Xing (Alex) Zhou. 2022. "Mutual Fund Fragility, Dealer Liquidity Provision, and the Pricing of Municipal Bonds." Working Paper.

Longstaff, Francis A. 2011. "Municipal Debt and Marginal Tax Rates: Is There a Tax Premium in Asset Prices?" *Journal of Finance*, 66(3): 721–751.

Lucas, Robert E. 1976. "Econometric Policy Evaluation: A Critique." *Carnegie-Rochester Conference Series on Public Policy*, 1: 19–46.

Merton, Robert C. 1973. "An Intertemporal Capital Asset Pricing Model." *Econometrica*, 41(5): 867–887.

MSRB. 2020. "Trends in Municipal Bond Ownership." *MSRB*, Available at: https://www.msrb.org/msrb1/pdfs/MSRB-Brief-Trends-Bond-Ownership.pdf (Data Accessed: July 10, 2022).

Poterba, James M, and Andrew A Samwick. 2003. "Taxation and household portfolio composition: US evidence from the 1980s and 1990s." *Journal of Public Economics*, 87(1): 5–38.

Schultz, Paul. 2012. "The market for new issues of municipal bonds: The roles of transparency and limited access to retail investors." *Journal of Financial Economics*, 106(3): 492–512.

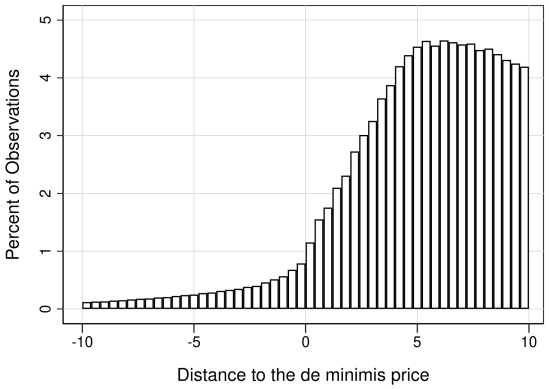
Vayanos, Dimitri, and Jean-Luc Vila. 2021. "A Preferred-Habitat Model of the Term Structure of Interest Rates." *Econometrica*, 89(1): 77–112.

Wang, Junbo, Chunchi Wu, and Frank X. Zhang. 2008. "Liquidity, default, taxes, and yields on municipal bonds." *Journal of Banking & Finance*, 32(6): 1133–1149.

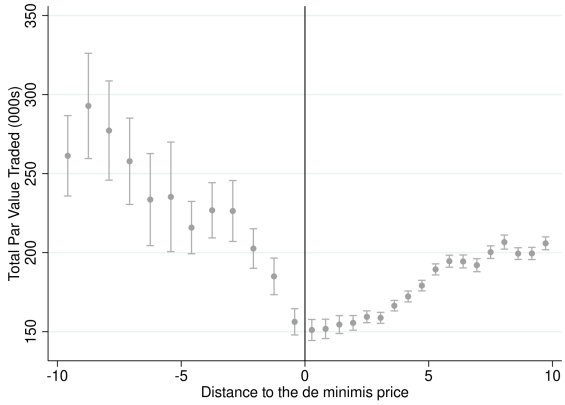
Figures

Figure 1: Secondary Market Liquidity Around the De Minimis Threshold.

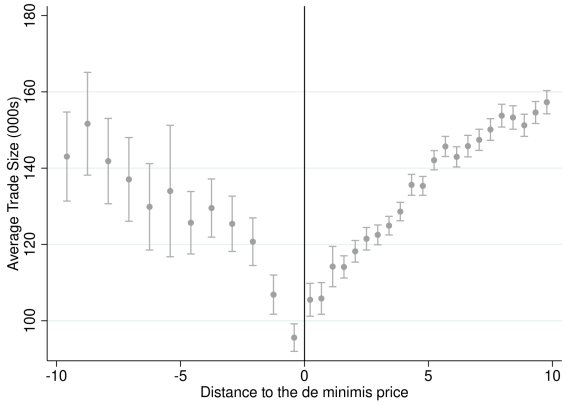
Panel A: Incidence of Trading



Panel B: Par Value Traded



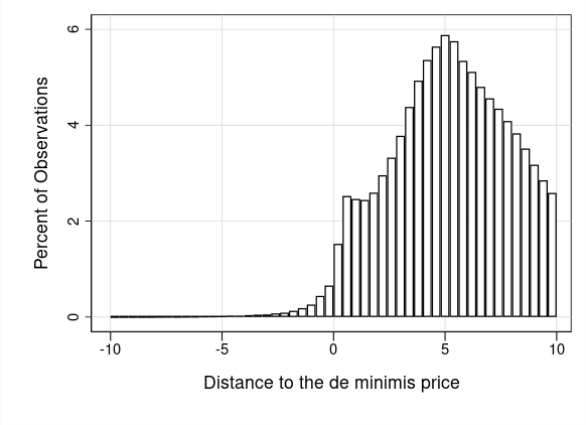
Panel C: Trade Size



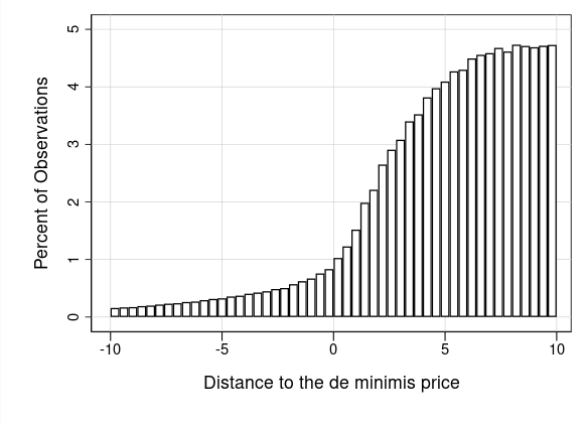
Note: Figure 1 presents the distributions of three measures of secondary municipal bond market activity around the de minimis threshold: the incidence of weekly trading activity as well as, conditional on trading, par value traded (in 000s of dollars), and the average trade size (in 000s of dollars) in a given week. We construct these measures using customer-to-dealer sales transactions. The figure presents averages and 95% confidence intervals for each bin within the [-10,10] interval around the de minimis price, where positive (negative) values indicate that the trade price is above (below) the de minimis price.

Figure 2: Secondary Market Liquidity, the De Minimis Threshold, and Bond Duration.

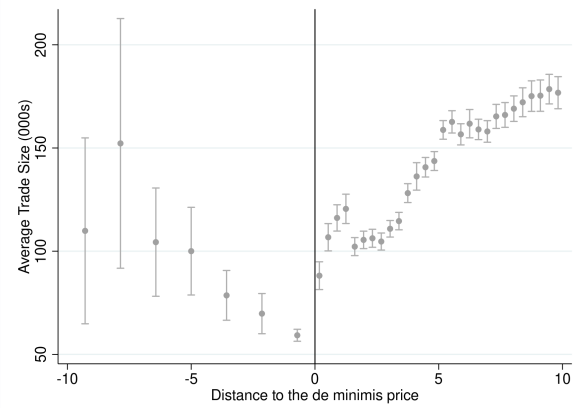
Panel A: Weekly Trades Distribution, Low Duration



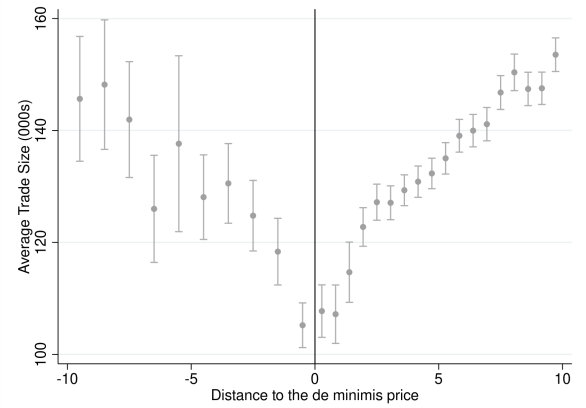
Panel B: Weekly Trades Distribution, High Duration



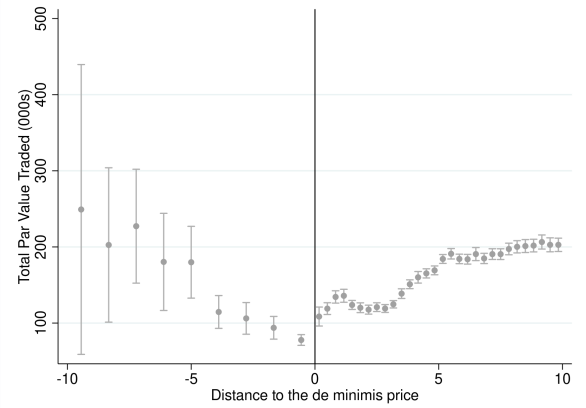
Panel C: Avg. Trade Size, Low Duration



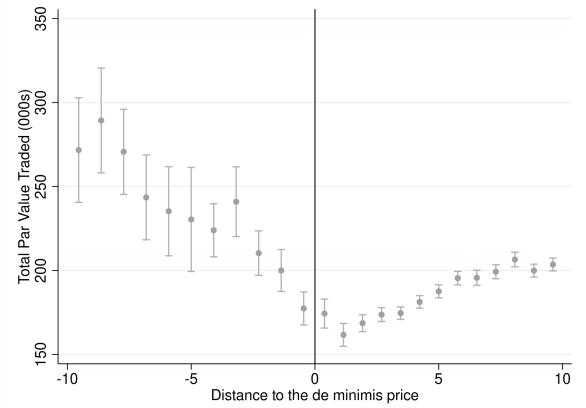
Panel D: Avg. Trade Size, High Duration



Panel E: Par Value Traded, Low Duration

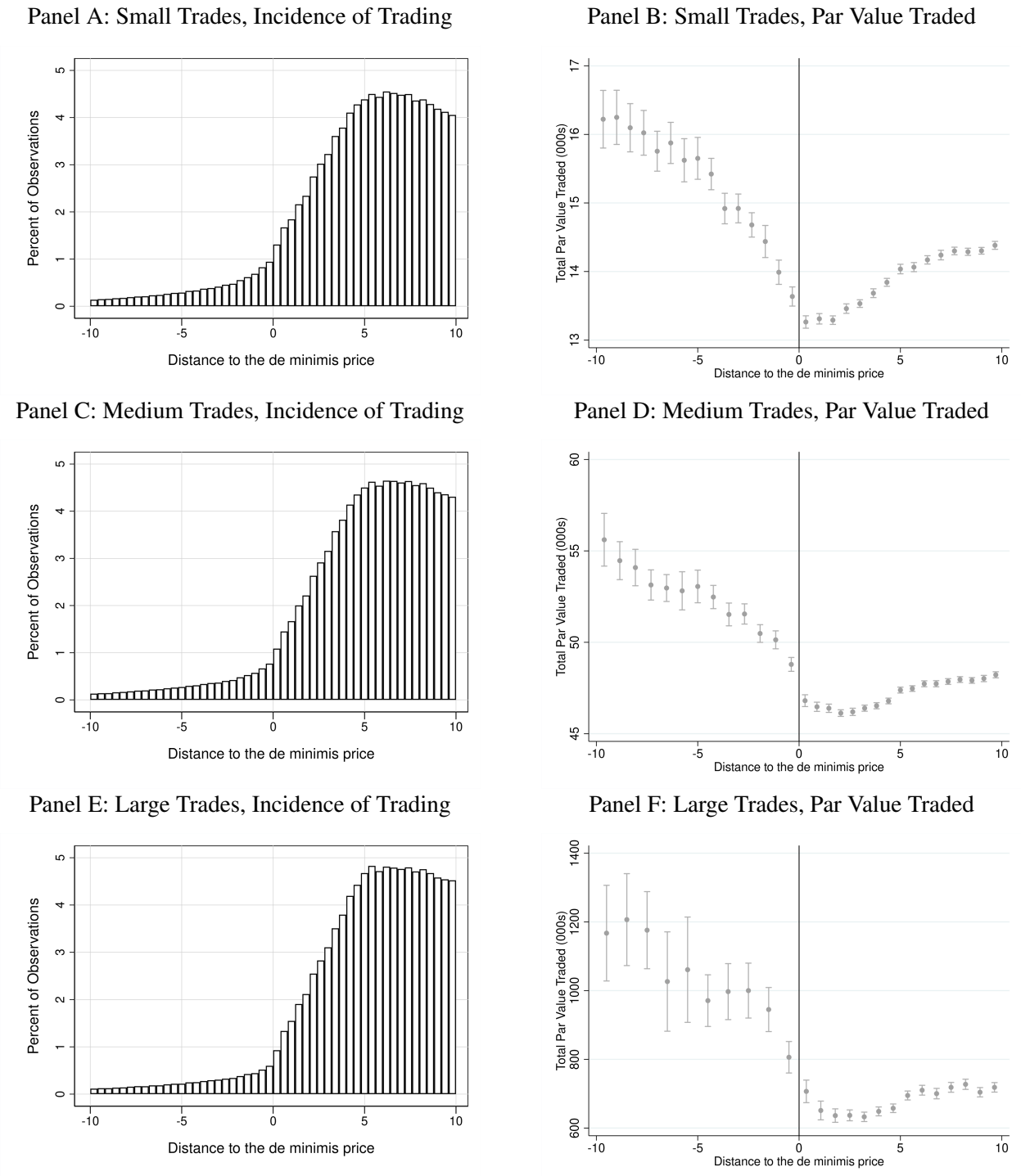


Panel F: Par Value Traded, High Duration



Note: Figure 2 presents the distributions of three measures of secondary municipal bond market activity around the de minimis threshold for both low and high duration bonds: the incidence of trading, and the averages of total par value traded (in 000s of dollars) and trade size (in 000s of dollars) in a given week. We use customer-to-dealer sales transactions to construct average total par value traded and trade size. The figure presents averages and 95% confidence intervals for each bin within the [-4,4] interval around the de minimis price, where positive (negative) values indicate that the trade price is above (below) the de minimis price. Low duration bonds are those with duration roughly ≤ 3 (the sample median duration) and long-term bonds are those with duration > 3.

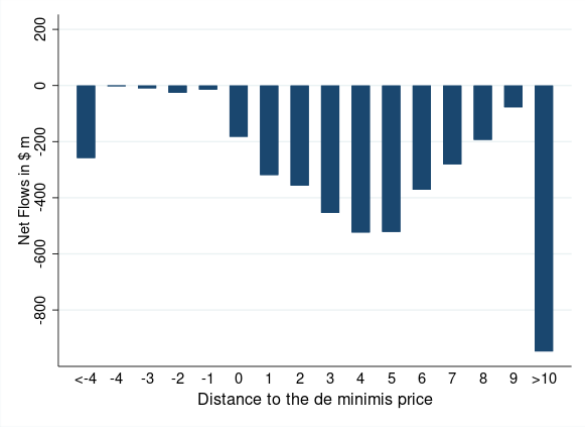
Figure 3: Trading Volume Around the De Minimis Threshold and Trade Size.



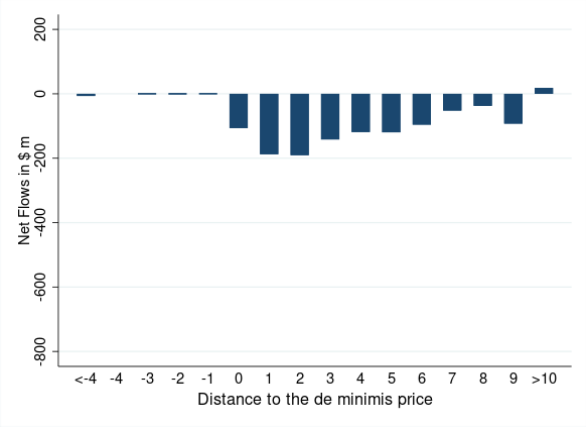
Note: Figure 3 presents the distributions of the incidence of trading activity and total par value traded around the de minimis threshold for small, medium, and large trades. We use customer-to-dealer sales transactions to construct total par value traded. We define trades as "large" whenever the underlying par value of the transaction exceeds $100,000, "small" trades whenever the par value is below $25,000, and "medium" trades whenever the par value is between $25,000 and $100,000. The three panels on the left show histograms of the incidence of trading within the [-4,4] interval, while the panels on the right present averages and 95% confidence intervals for total par value within the [-4,4] interval around the de minimis price. A positive (negative) distance from the de minimis threshold indicates that the trade price is above (below) the de minimis.

Figure 4: **Net institutional flows around the de minimis threshold**

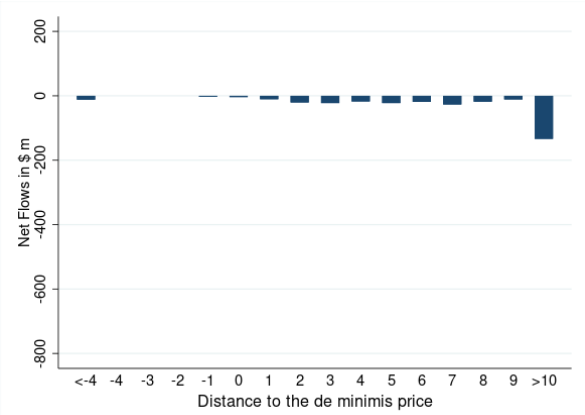
Panel A: Mutual funds



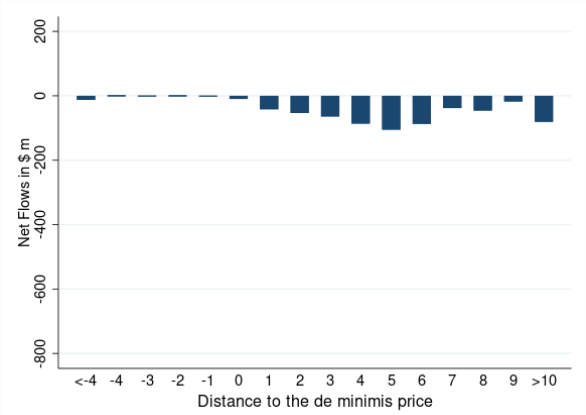
Panel B: P&C insurers



Panel C: Life insurers



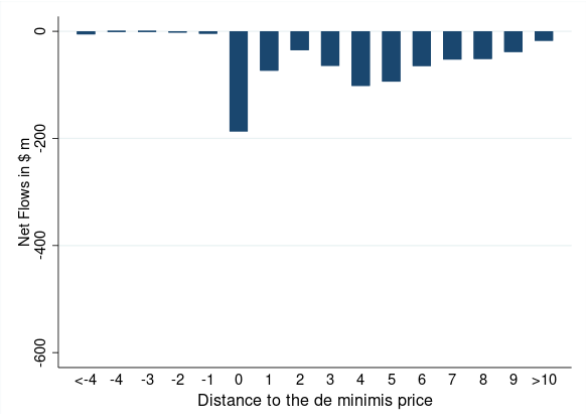
Panel D: Closed-end funds



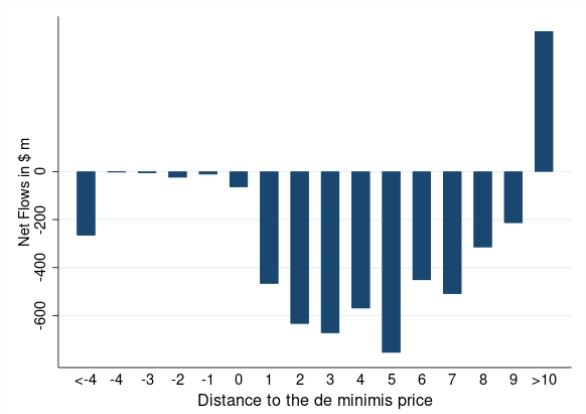
Note: Figure 4 shows the median quarterly net flows in the total par dollar amount of municipal bonds held by mutual funds, Panel (a), property & casualty insurers, Panel (b), life insurance companies, Panel (c), and closed-end funds, Panel (d), around the de minimis price. We group municipal bonds according to their average distance to the threshold in a given quarter. $< -4, -4, -3, \ldots, +9, > +10$ correspond to the < -4, $[-4, -3)$, $[-3, -2)$, …, $[+9, +10)$, $[> +10]$ intervals measuring distance from the de minimis threshold in percentage points of par value. We limit the sample to bonds that trade at least once in a given quarter.

Figure 5: **Net institutional flows around the de minimis threshold: bond duration**

Panel A: Low duration

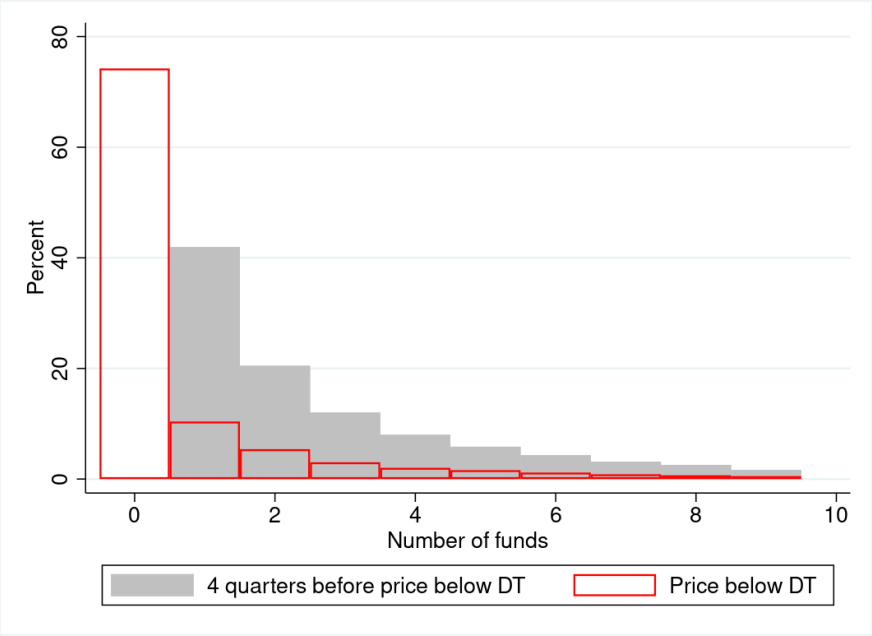


Panel B: High duration



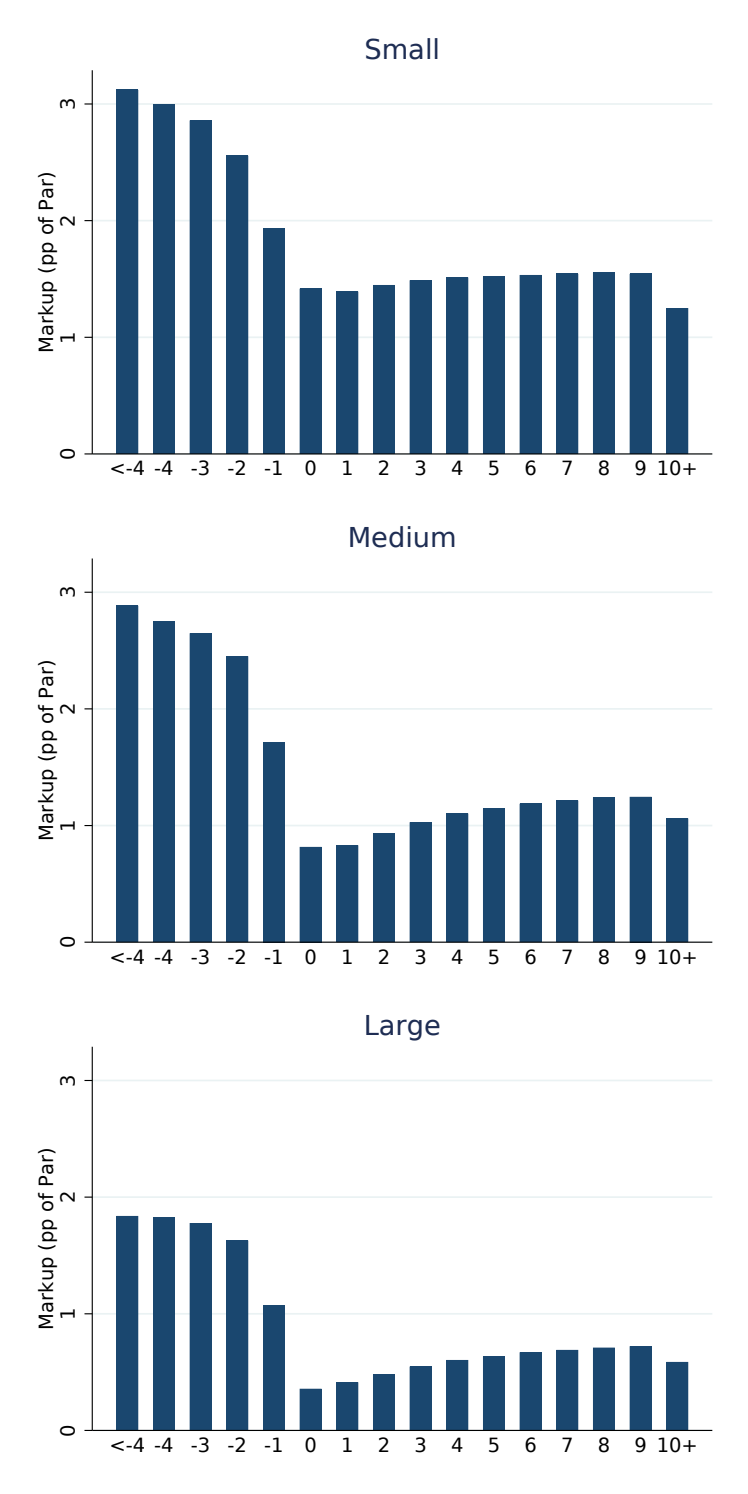
Note: Figure 4 shows the median quarterly institutional net flows in the par value of low-duration municipal bonds, Panel (a), and high-duration municipal bonds, Panel (b), around the de minimis price. Low-duration bonds have duration below the sample median, while high-duration bonds have duration above the median. We group municipal bonds according to their average distance to the threshold in a given quarter. < -4, -4, -3, …, $+9$, $> +10$ correspond to the < -4, $[-4, -3)$, $[-3, -2)$, …, $[+9, +10)$, $[> +10]$ intervals measuring distance from the de minimis threshold in percentage points of par value. We limit the sample to bonds that trade at least once in a given quarter and have available data on bond duration.

Figure 6: **Number of funds holding a bond before and after the bond crosses the DT**



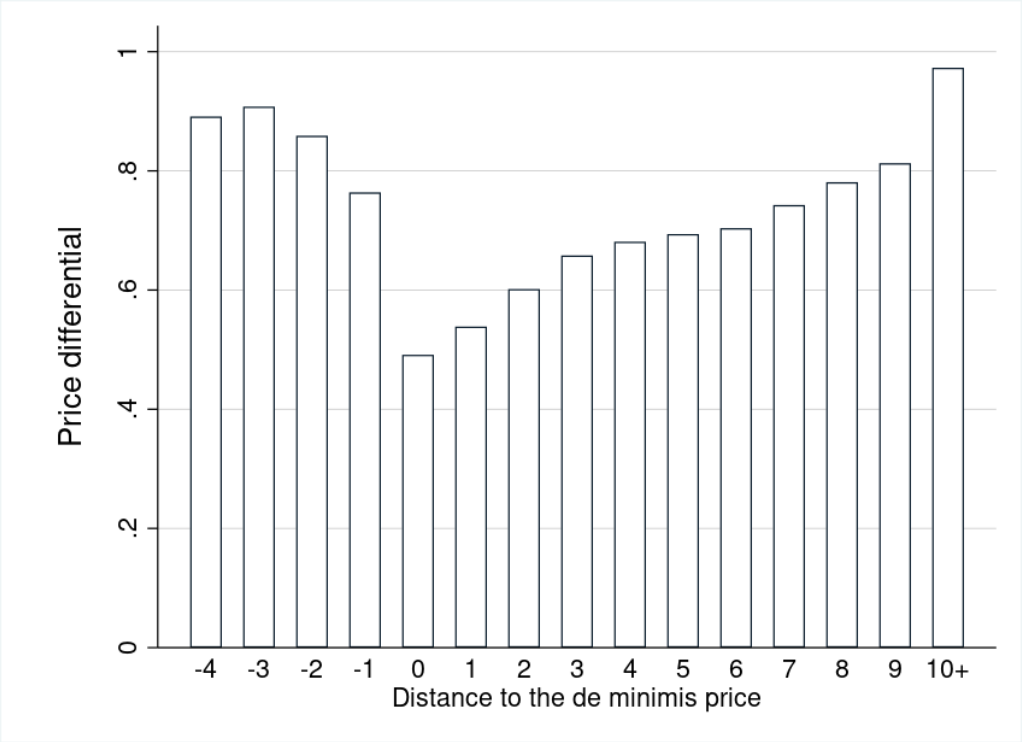
Note: Figure 6 shows the number of funds holding a municipal bond 4 quarters before and 1 quarter after a bond crosses the DT. The sample are all bonds held by mutual funds in quarter t that will cross below the DT in quarter $t+4$ and is not traded below the DT between t and $t+4$. The black histogram shows the distribution of the number of funds at time t. The red histogram shows the distribution of the number of funds holding a specific bond at time $t+4$, the first quarter the bond trades below the DT.

Figure 7: Markups around the de minimis threshold.



Note: Figure 7 presents the average markups for small, medium, and large trades around the de minimis threshold in each distance bin around the de minimis threshold. We define trades as "large" whenever the total par dollar amount of the transaction exceeds $100,000, "small" trades whenever the total par amount is below $25,000, and "medium" trades whenever the total par amount is between $25,000 and $100,000. We compute markups using the Li and Schürhoff (2019) algorithm.

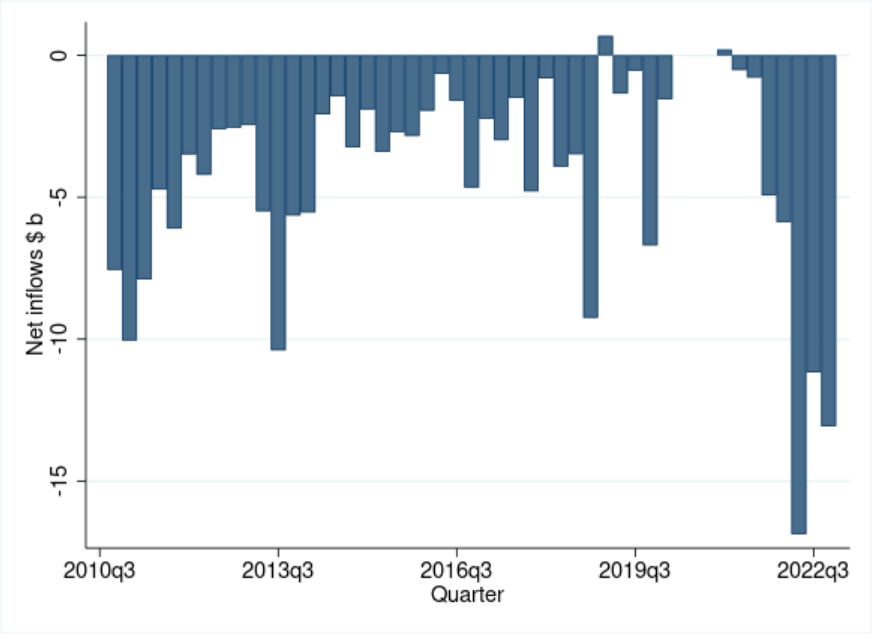
Figure 8: Selling pressure around the de minimis threshold.



Note: Figure 8 presents the average price differential between large and small sale transactions around the de minimis threshold. We define trades as "large" whenever the total par dollar amount of the transaction exceeds $100,000, "small" trades whenever the total par amount is below $25,000, and "medium" trades whenever the total par amount is between $25,000 and $100,000. We compute the price differential from average weekly customer-to-dealer sale prices across large and small trades.

Figure 9: **Net institutional flows and de minimis risk**

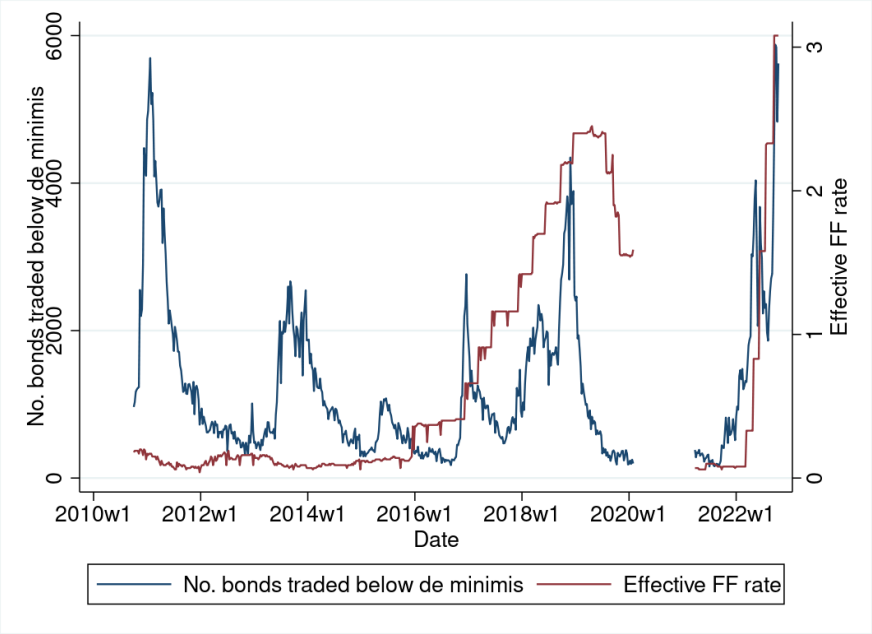
Nonbank inflows 3-8 pp above de minimis



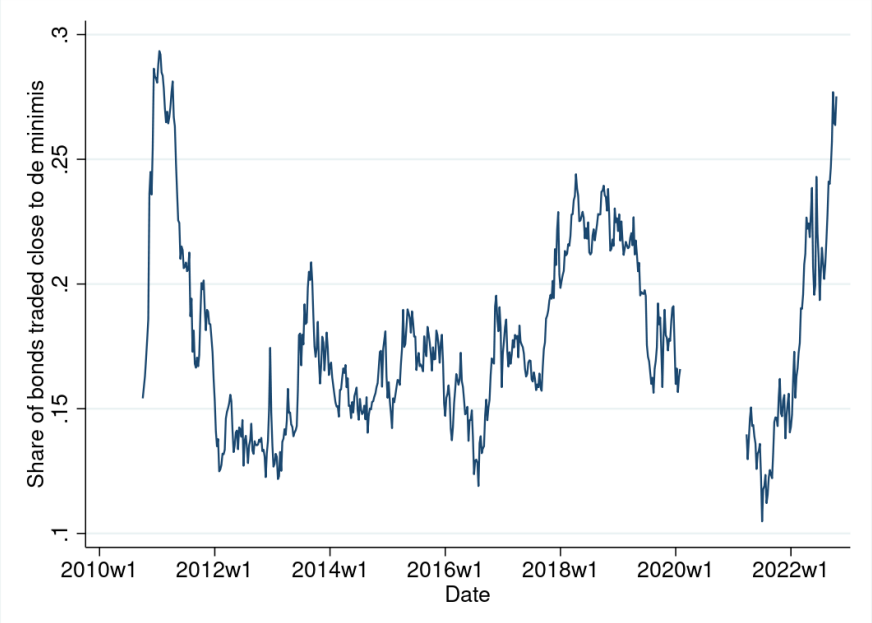
Note: Figure 9 plots the combine net inflows of institutional investors—mutual funds, insurance companies, and closed end funds—in municipal bonds over time. The sample is limited to bonds with average quarterly prices that are 3-8 pp above the de minimis threshold.

Figure 10: **De minimis risk and monetary policy**

Fed funds rate and bonds below the de minimis price



Bonds at risk



Note: Panel (a) of Figure 10 plots the number of municipal bonds that trade from zero to four percentage points below the de minimis price in a given week (the blue line) against the federal funds effective rate (the red line). Panel (b) plots the share of bonds in the secondary market that trade from zero to four percentage points above the de minimis threshold in a given week.

Tables

Table 1: Trading Characteristics

Table 1 presents summary statistics for secondary market trading characteristics of bonds in our panel. The table also compares municipal bond trading activity across small, medium, and large trades. We define trades as "large" whenever the total par dollar amount of the transaction exceeds $100,000, "small" trades whenever the total par amount is below $25,000, and "medium" trades whenever the total par amount is between $25,000 and $100,000.

	Mean	SD	Obs	25^{th}	50^{th}	75^{th}
Dollar Volume (000s)	186.29	1282.58	6,554,989	15.00	30.00	90.00
Small	14.04	13.58	2,745,038	10.00	10.00	20.00
Medium	47.66	36.74	2,969,285	25.00	40.00	50.00
Large	706.18	2630.74	1,474,266	100.00	200.00	405.00
Number of Trades	1.27	1.50	6,554,989	1.00	1.00	1.00
Small	1.18	1.54	2,745,038	1.00	1.00	1.00
Medium	1.16	0.76	2,969,285	1.00	1.00	1.00
Large	1.13	0.61	1,474,266	1.00	1.00	1.00
Yield (Percent)	2.90	1.54	6,476,643	1.62	2.78	4.05
Small	3.30	1.48	2,715,182	2.08	3.25	4.43
Medium	2.87	1.54	2,940,063	1.54	2.71	4.03
Large	2.51	1.60	1,443,351	1.12	2.20	3.74
Markup, Small	1.48	1.33	2151632	0.41	1.16	2.33
Markup, Medium	1.18	1.22	2,350,663	0.23	0.74	1.95
Markup, Large	0.76	1.03	1,125,539	0.08	0.30	1.10
Full Markup, Small	1.67	1.34	1,792,116	0.57	1.46	2.54
Full Markup, Medium	1.34	1.27	1,940,203	0.28	0.95	2.22
Full Markup, Large	0.84	1.09	944,912	0.09	0.33	1.32
FF Rate	0.66	0.84	6,554,989	0.09	0.15	1.16
ΔFF	0.01	0.09	6,554,989	0.00	0.00	0.00
Δ_4FF	0.05	0.16	6,554,989	-0.01	0.00	0.01
Δ_8FF	0.08	0.23	6,554,989	-0.01	0.00	0.04
Δ_{12}FF	0.12	0.33	6,554,989	-0.01	0.01	0.21
Low Turnover	0.20	0.40	6,121,240	0.00	0.00	0.00
Inst Sales	0.02	0.12	6,302,663	0.00	0.00	0.00
Distance to de minimis	5.02	3.52	9,871,538	3.13	5.52	7.70

Table 2: Insitutional investor sales and markups around the de minimis threshold.

Table 2 reports regression estimates of $y_{b,w} = \sum_{i<-1}^{+10} \beta_i (Sales_{bq} \times Distance_{ibw}) + \gamma X_{b,w} + \varepsilon_{b,w}$, where $y_{b,w}$ is the intermediation chain markup computed as in Li and Schürhoff (2019) for complete chains. Columns 1-2, 3-4, and 5-6 show results for small, medium, and large trades. Columns 2, 4, and 6 limit the sample to high-duration bonds. $Sales_{b,q-1}$ takes the value of one whenever the institutional sector reduces its exposure to bond b in the previous quarter $q-1$ by at least 25%. $Distance_{ibw}$ takes the value of one if the price of bond b price is within interval i around the de minimis threshold ($i \in \{<-1, -1, +1, +2, ..., +10\}$) in week w, and zero otherwise. We include bonds within 10 percentage points on either side of the threshold. All specifications include bond, week, years to maturity fixed effects as well as all $Distance_i$ indicators. Standard errors are double clustered at the week and bond level. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)
	Small		Medium		Large	
Sample	Full	High	Full	High	Full	High
Sales × Distance<-1	0.126***	0.113**	0.097**	0.100**	0.058	0.077
	(0.046)	(0.050)	(0.042)	(0.044)	(0.058)	(0.059)
Sales × Distance=-1	0.024	0.017	0.133*	0.168**	-0.016	-0.037
	(0.087)	(0.091)	(0.076)	(0.078)	(0.098)	(0.108)
Sales × Distance=+1	-0.024	-0.034	0.122**	0.156**	-0.046	-0.093
	(0.052)	(0.069)	(0.056)	(0.071)	(0.053)	(0.088)
Sales × Distance=+2	-0.001	0.052	0.051*	0.091**	-0.079***	-0.136***
	(0.043)	(0.051)	(0.030)	(0.038)	(0.027)	(0.040)
Sales × Distance=+3	-0.020	-0.018	0.005	0.010	-0.007	-0.008
	(0.034)	(0.043)	(0.028)	(0.035)	(0.021)	(0.028)
Sales × Distance=+4	0.033	0.044	-0.028	-0.029	0.026	0.039
	(0.028)	(0.035)	(0.023)	(0.030)	(0.018)	(0.028)
Sales × Distance=+5	-0.006	-0.001	-0.005	0.006	0.025*	0.042*
	(0.022)	(0.028)	(0.016)	(0.023)	(0.014)	(0.024)
Sales × Distance=+6	-0.039**	-0.042*	-0.047***	-0.072***	0.045***	0.066***
	(0.020)	(0.023)	(0.016)	(0.023)	(0.013)	(0.023)
Sales × Distance=+7	-0.028	-0.026	-0.030**	-0.037**	0.016	0.025
	(0.019)	(0.022)	(0.015)	(0.019)	(0.015)	(0.022)
Observations	959,695	818,825	906,922	686,106	355,804	221,610
R-squared	0.537	0.498	0.651	0.590	0.680	0.648
Bond FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Rem Maturity FE	Y	Y	Y	Y	Y	Y

Table 3: Quarterly turnover and markups around the de minimis threshold.

Table 3 reports regression estimates of $y_{b,w} = \sum_{i<-1}^{+10} \beta_i (Low_{bq} \times Distance_{ibw}) + \gamma X_{b,w} + \varepsilon_{b,w}$, where $y_{b,w}$ is the intermediation chain markup computed as in Li and Schürhoff (2019) for complete chains. Columns 1 and 2 show results for small trades, columns 3 and 4 for medium sized trades, and columns 5 and 6 for large trades. Columns 1, 3, and 5 use all bonds, and columns 2, 4, and 6 restrict the sample to bonds with long duration. $Low_{b,q-1}$ takes the value of one whenever a bond b is in the lowest (the first) quintile of total quarterly trading volume of bond b relative to the dollar value outstanding of bond b as of the previous quarter $q-1$. The sample consists of bonds either in the first or the fifth quintiles of prior-quarter turnover. $Distance_{ibw}$ takes the value of one if the price of bond b price is within interval i around the de minimis threshold ($i \in \{<-1, -1, +1, +2, ..., +10\}$) in week w, and zero otherwise. We include bonds within 10 percentage points on either side of the threshold. All specifications include bond, week, years to maturity fixed effects as well as all $Distance_i$ indicators. Standard errors are double clustered at the bond and week level. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)
	Small trades		Mid-sized trades		Large trades	
	Full	High	Full	High	Full	High
Low × Distance<-1	0.022	0.020	0.102***	0.100***	0.124**	0.115**
	(0.021)	(0.022)	(0.025)	(0.026)	(0.049)	(0.050)
Low × Distance=-1	0.014	0.004	0.110***	0.105**	0.042	0.008
	(0.032)	(0.034)	(0.041)	(0.043)	(0.075)	(0.081)
Low × Distance=+1	-0.008	0.006	0.057**	0.112***	0.000	-0.005
	(0.023)	(0.030)	(0.025)	(0.037)	(0.033)	(0.063)
Low × Distance=+2	-0.033*	-0.038*	-0.007	-0.016	0.007	0.010
	(0.017)	(0.020)	(0.017)	(0.023)	(0.019)	(0.030)
Low × Distance=+3	-0.014	-0.008	-0.029**	-0.045***	-0.005	-0.017
	(0.013)	(0.015)	(0.013)	(0.017)	(0.015)	(0.021)
Low × Distance=+4	-0.056***	-0.056***	-0.022**	-0.023*	-0.017	-0.028
	(0.011)	(0.012)	(0.010)	(0.013)	(0.013)	(0.018)
Low × Distance=+5	-0.058***	-0.055***	-0.058***	-0.065***	-0.005	-0.007
	(0.011)	(0.012)	(0.009)	(0.012)	(0.011)	(0.017)
Low × Distance=+6	-0.038***	-0.036***	-0.033***	-0.036***	-0.016	-0.019
	(0.010)	(0.011)	(0.009)	(0.012)	(0.010)	(0.016)
Low × Distance=+7	-0.039***	-0.037***	-0.032***	-0.031***	-0.041***	-0.061***
	(0.009)	(0.010)	(0.009)	(0.011)	(0.011)	(0.016)
Observations	655,759	558,719	642,165	486,240	266,418	174,755
R-squared	0.571	0.545	0.676	0.628	0.705	0.676
Bond FE	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y
Rem Maturity FE	Y	Y	Y	Y	Y	Y

Table 4: Trading around the de minimis threshold and contemporaneous fed funds rate changes

Table 4 reports regression estimates of Equation 5, where the outcome variable of interest is the natural logarithm of the total dollar volume of customer sales in bond b and week w. The sample is limited to small trades in columns 1, medium trades in columns 2, and large trades in columns 3 through 5. ΔFF is the weekly change in the federal funds effective rate. $Distance_{ibw}$ is an indicator variable that takes the value of one if the price of bond b price is within interval i around the de minimis threshold ($i \in \{< -1, -1, +1, +2, ..., +10\}$) in week w, and zero otherwise. We include bonds within 10 percentage points on either side of the threshold. The matrix X comprises of bond and week fixed effects as well as all $Distance_i$ indicators. The standard errors are double clustered at the bond and week level. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)
	Log(Par Value Traded)				
Trade Size	Small	Medium	Large	Large	Large
Duration	—	—	—	Low	High
ΔFF $\times$ Distance < -1	-0.034*	-0.074***	0.084	-0.120	0.101
	(0.019)	(0.023)	(0.116)	(0.216)	(0.115)
ΔFF $\times$ Distance $= -1$	-0.005	-0.022	0.130	0.194	0.072
	(0.029)	(0.026)	(0.130)	(0.165)	(0.132)
ΔFF $\times$ Distance $= +1$	-0.011	-0.056**	0.163**	0.141	0.214*
	(0.021)	(0.022)	(0.075)	(0.123)	(0.119)
ΔFF $\times$ Distance $= +2$	-0.025	-0.023	0.036	0.170	-0.015
	(0.020)	(0.017)	(0.070)	(0.106)	(0.087)
ΔFF $\times$ Distance $= +3$	-0.019	-0.031**	0.140**	0.180**	0.110*
	(0.015)	(0.015)	(0.054)	(0.091)	(0.061)
ΔFF $\times$ Distance $= +4$	-0.001	-0.053***	0.072	0.093	0.073
	(0.025)	(0.014)	(0.056)	(0.073)	(0.077)
ΔFF $\times$ Distance $= +5$	-0.038*	-0.018	0.045	0.037	0.054
	(0.020)	(0.014)	(0.038)	(0.075)	(0.069)
ΔFF $\times$ Distance $= +6$	-0.030	-0.037*	0.016	0.106	-0.041
	(0.027)	(0.019)	(0.053)	(0.067)	(0.087)
ΔFF $\times$ Distance $= +7$	-0.019	-0.023*	-0.011	-0.005	-0.025
	(0.015)	(0.014)	(0.060)	(0.082)	(0.085)
Observations	2,523,837	2,694,142	1,157,825	404,348	717,326
R-squared	0.255	0.237	0.407	0.400	0.415
Bond FE	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y

Table 5: The de minimis threshold and fed funds rate changes over longer horizons

Table 5 reports regression estimates of Equation 5, where the outcome variable of interest is the natural logarithm of the total dollar volume of customer sales in bond b and week w. The sample is limited to large trades. ΔFF variable is the one-week, four-week, eight-week, and twelve-week change in the federal funds effective rate in columns 1, 2, 3, and 4, respectively. $Distance_{ibw}$ is an indicator variable that takes the value of one if the price of bond b price is within interval i around the de minimis threshold ($i \in \{< -1, -1, +1, +2, +3, +4\}$) in week w, and zero otherwise. We include bonds within 10 percentage points on either side of the threshold. The matrix X comprises of bond and week fixed effects as well as all $Distance_i$ indicators. The standard errors are double clustered at the bond and week level. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
	Log(Par Value Traded)			
ΔFF Horizon	1 Qtr	4 Qtrs	8 Qtrs	12 Qtrs
ΔFF × Distance < -1	0.084	-0.051	-0.053	-0.064*
	(0.116)	(0.062)	(0.066)	(0.037)
ΔFF × Distance $= -1$	0.130	-0.010	-0.004	-0.035
	(0.130)	(0.081)	(0.070)	(0.045)
ΔFF × Distance $= +1$	0.163**	0.059	0.053	0.033
	(0.075)	(0.059)	(0.043)	(0.031)
ΔFF × Distance $= +2$	0.036	0.019	0.045	0.014
	(0.070)	(0.041)	(0.034)	(0.024)
ΔFF × Distance $= +3$	0.140**	0.073**	0.067**	0.035*
	(0.054)	(0.035)	(0.028)	(0.021)
ΔFF × Distance $= +4$	0.072	0.014	0.033	0.015
	(0.056)	(0.034)	(0.024)	(0.019)
ΔFF × Distance $= +5$	0.045	0.009	0.028	0.010
	(0.038)	(0.030)	(0.024)	(0.019)
ΔFF × Distance $= +6$	0.016	0.009	0.016	0.010
	(0.053)	(0.035)	(0.024)	(0.017)
ΔFF × Distance $= +7$	-0.011	0.038	0.027	0.020
	(0.060)	(0.035)	(0.025)	(0.017)
Observations	1,470,045	1,470,045	1,470,045	1,470,045
R-squared	0.401	0.401	0.401	0.401
Bond FE	Y	Y	Y	Y
Time FE	Y	Y	Y	Y

Online Appendix: Not For Publication

This appendix includes several sections of supplemental information. Appendix A contains definitions for all the variables used in the paper.

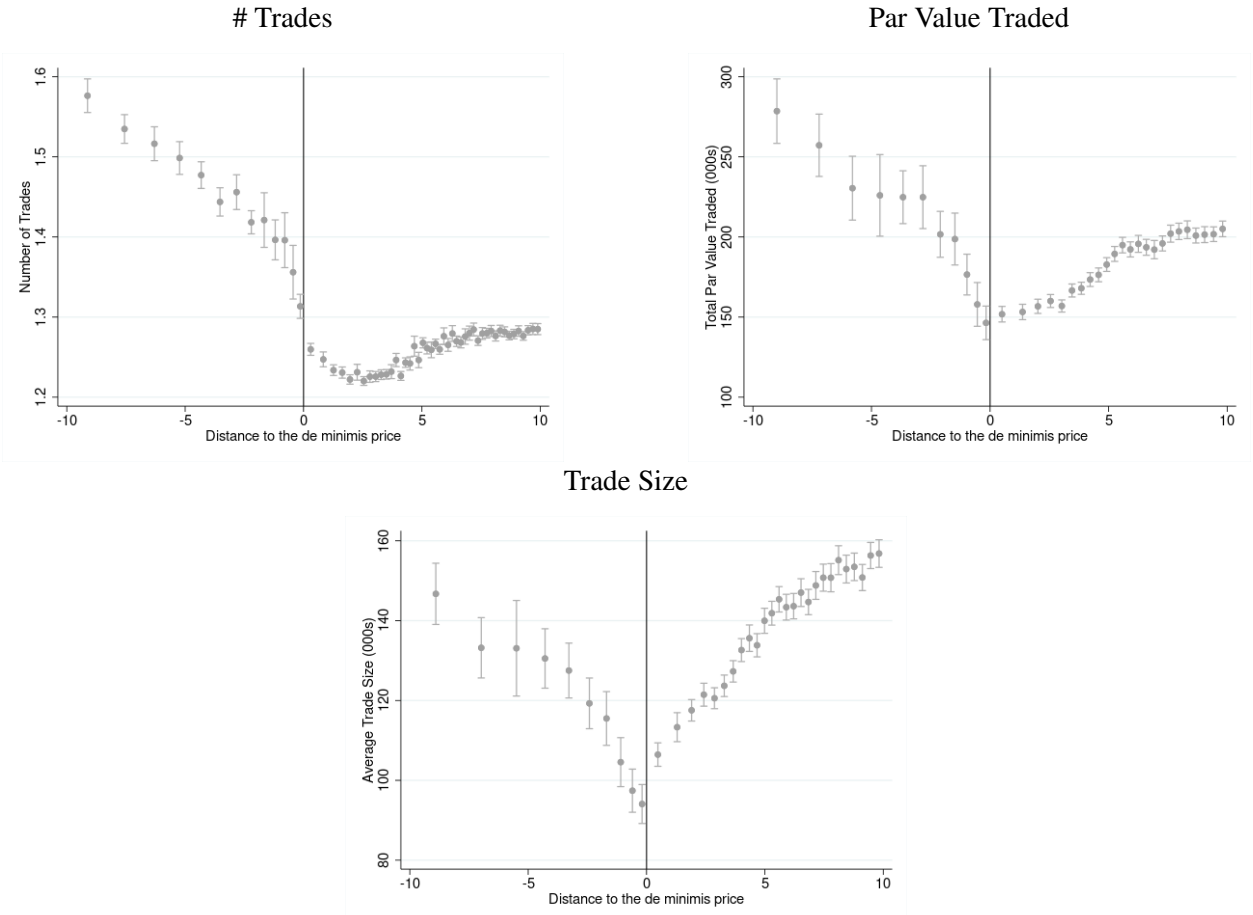
A Variable Definitions

Variable Name	Description
Log(Par Value Traded)	The natural logarithm of total dollar par value traded of customer sale transactions in a given bond-week. *Source:* MSRB
Number of trades	The total number of customer sales transaction in a given bond-week *Source:* MSRB
Trade size	The total customer purchase dollar volume divided by the number of trades in a given bond-week. We define a trade as "large" whenever the par dollar amount of the transaction exceeds $100,000, as "small" whenever the par dollar amount is below $25,000, and as "medium" whenever the par dollar amount is between $25,000 and $100,000. *Source:* MSRB
Selling pressure	The difference between average customer sale prices of large and small trades in a given bond-week. *Source:* MSRB
Markup	The difference between the average customer purchase price and the average inter-dealer price for a given bond-week. We calculate markups separately for small, medium, and large trades. *Source:* MSRB
Distance $= x$	An indicator variable that takes the value of one whenever the average price on the secondary market is in interval i from its de minimis threshold *Source:* MSRB and authors' calculations
ΔFF	The one-, four-, eight-, or twelve-week change in the federal funds effective rate. *Source:* Board of Governors of the Federal Reserve System
Sales	An indicator variable that takes the value of one whenever mutual funds, insurance companies, and closed end funds dispose of at least 25% of their position in a given municipal bond as of the previous quarter, and zero otherwise. *Source:* eMaxx
Turnover	The total dollar par value traded of a bond divided by the bond's outstanding dollar amount as of a given quarter *Source:* MSRB and Mergent
Low turnover	An indicator variable that takes the value of one whenever a bond is in the lowest quintile of turnover as of the previous quarter, and zero otherwise. *Source:* MSRB and Mergent

B Robustness Tests

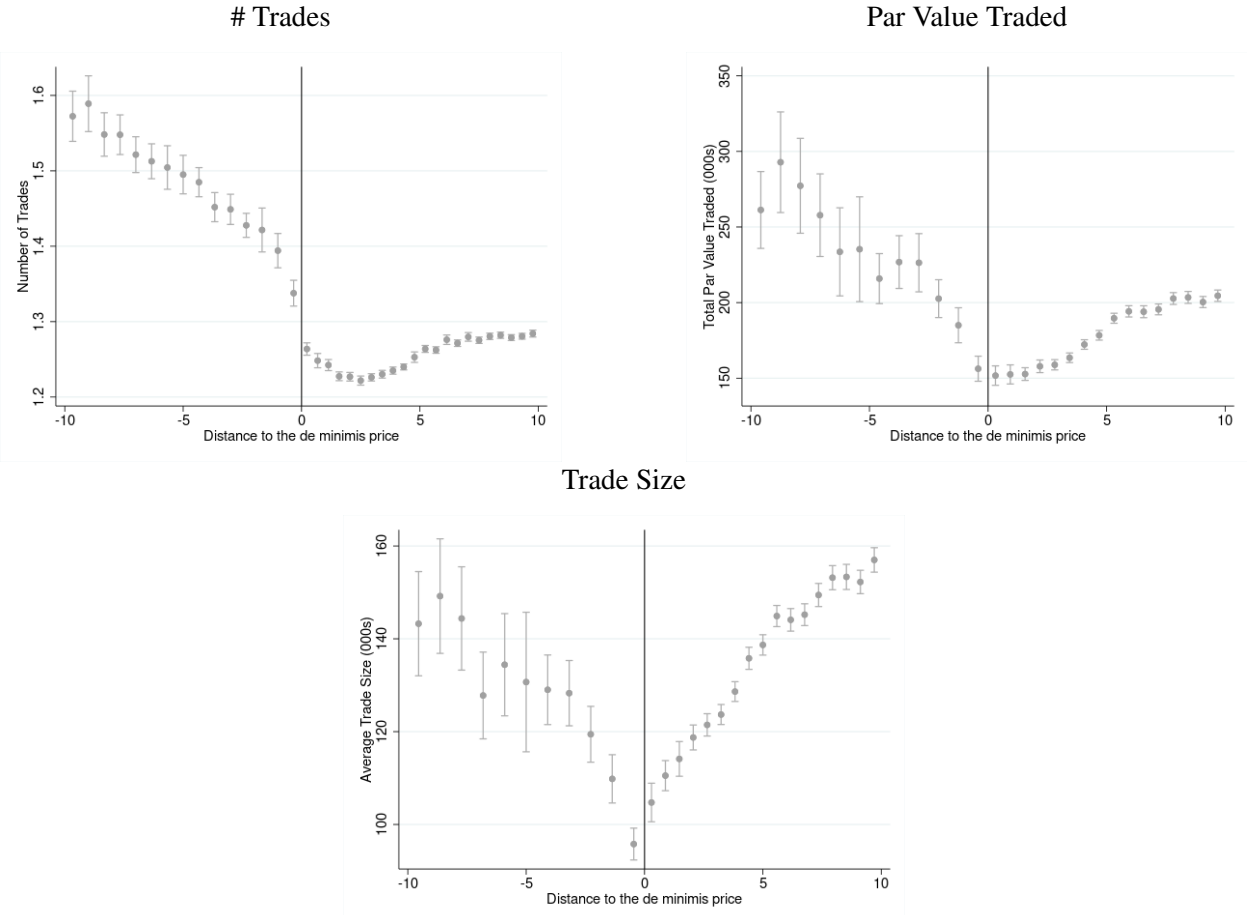
In our main tests, we apply the equally-spaced IMSE optimal estimators of Calonico, Cattaneo and Titiunik (2015) to understand the evolution of municipal trading activity around the de minimis threshold. The following two figures present robustness checks to this approach using quantile-spaced plots that account for the sparsity of the underlying data (see Figure B.1) or polynomial regressions approximations of the means in each equally spaced bin, which better address noncontinuous outcomes (see Figure B.2).

Figure B.1: Secondary Market Liquidity and the de minimis Price Threshold, Quantile Spaced Plots.



Note: Figure B.1 presents the distributions of three secondary market activity measures of municipal bonds around the de minimis threshold for tax-exempt boonds: the averages of the number of trades, total par value traded (in 000s of dollars), and trade size (in 000s of dollars) in a given week. We use customer-to-dealer sales transactions to construct these measures. The figure presents averages and 95% confidence intervals for each bin within the [-4,4] interval around the de minimis price, where positive (negative) values indicate that trade prices are above (below) the de minimis price. We construct these plots using quantile spaced plots that account for the sparsity of the underlying data.

Figure B.2: Secondary Market Liquidity and the de minimis Price Threshold, Quantile Spaced Plots.

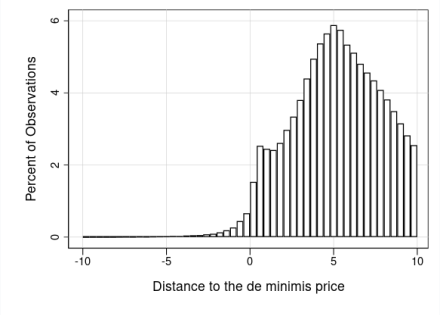


Note: Figure B.2 presents the distributions of three secondary market activity measures of municipal bonds around the de minimis threshold for tax-exempt bonds: the averages of the number of trades, total par value traded (in 000s of dollars), and trade size (in 000s of dollars) in a given week. We use customer-to-dealer sales transactions to construct these measures. The figure presents averages and 95% confidence intervals for each bin within the [-4,4] interval around the de minimis price, where positive (negative) values indicate that trade prices are above (below) the de minimis price. We construct these plots using polynomial regressions approximations of the means in each equally spaced bin, an estimator that is better equipped to handle noncontinuous outcomes of interest.

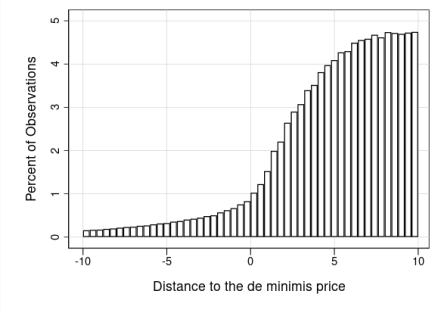
We also present sample splits across an alternative measure of bond sensitivity to interest rate risk—bond maturity. Short-term bonds typically have lower sensitivity to interest rate changes than longer-term bonds.

Figure B.3: Secondary Market Liquidity, the De Minimis Threshold, and Bond Maturity.

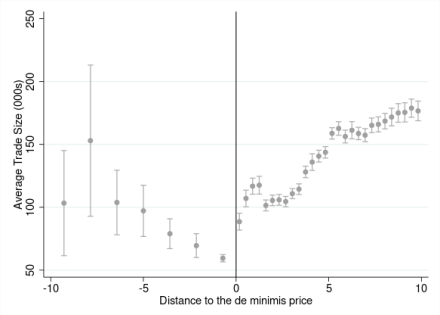
Weekly Trades Distribution, Short-term Bonds



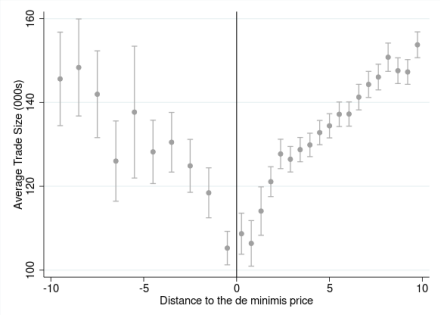
Weekly Trades Distribution, Long-term Bonds



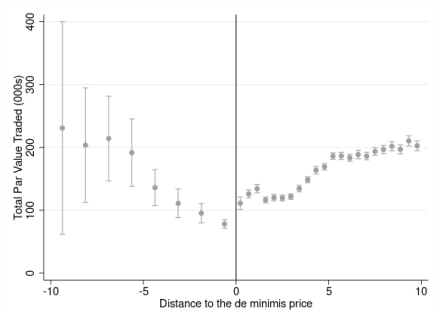
Avg. Trade Size, Short-term Bonds



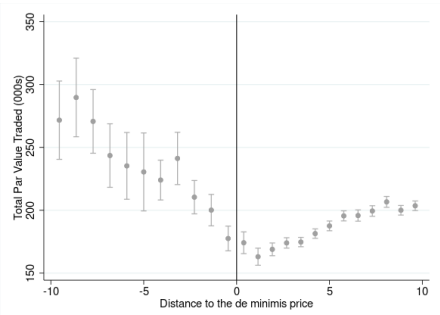
Avg. Trade Size, Long-term Bonds



Par Value Traded, Short-term Bonds



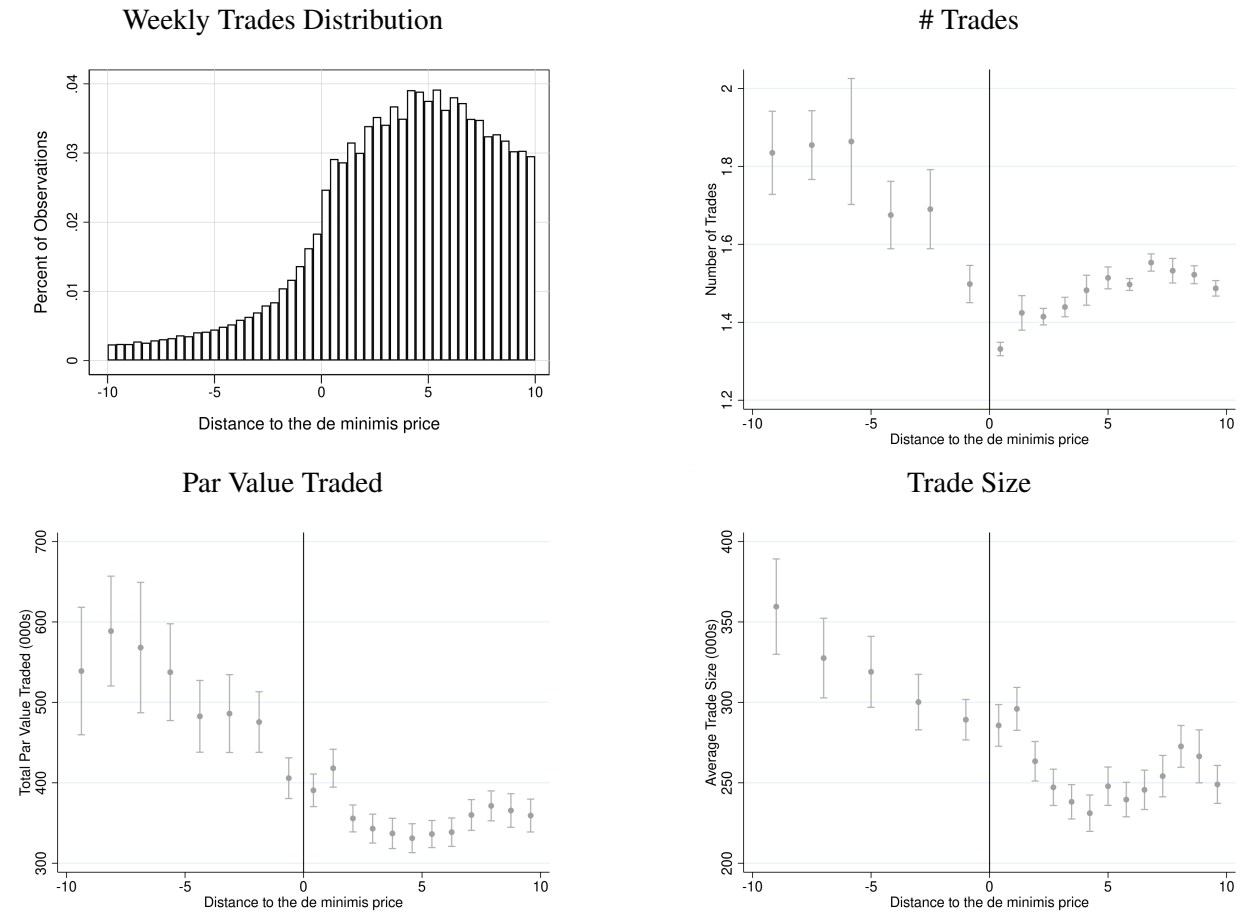
Par Value Traded, Long-term Bonds



Note: Figure B.3 presents the distributions of three measures of secondary municipal bond market activity around the de minimis threshold for short- and long-term bonds: the incidence of trading, and the averages of total par value traded (in 000s of dollars) and trade size (in 000s of dollars) in a given week. We use customer-to-dealer sales transactions to construct average total par value traded and trade size. The figure presents averages and 95% confidence intervals for each bin within the [-4,4] interval around the de minimis price, where positive (negative) values indicate that the trade price is above (below) the deminimis price. Short-term bonds are those with maturities ≤ 2 years and long-term bonds are those with maturities > 2 years.

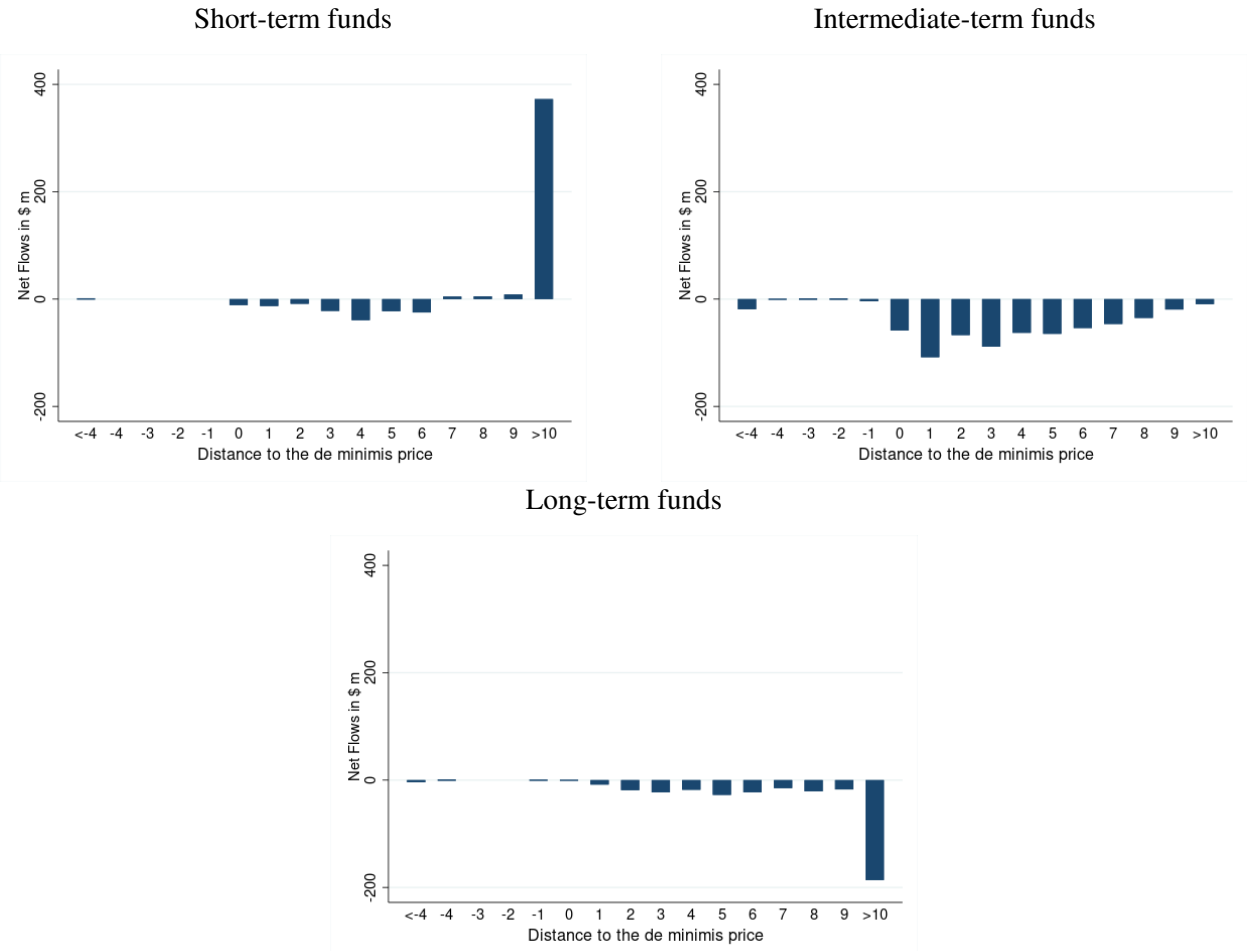
Earlier in the paper we show that investor segmentation arises because municipal bond mutual funds are sensitive to the tax treatment of price appreciation of tax-exempt municipal bonds. To the extent that taxable municipal bonds are held by less tax-sensitive investor clienteles, changes in liquidity around the de minimis threshold should be less pronounced than in the tax-exempt bonds case.

Figure B.4: Secondary Market Liquidity and the de minimis Price Threshold, Taxable Bonds.



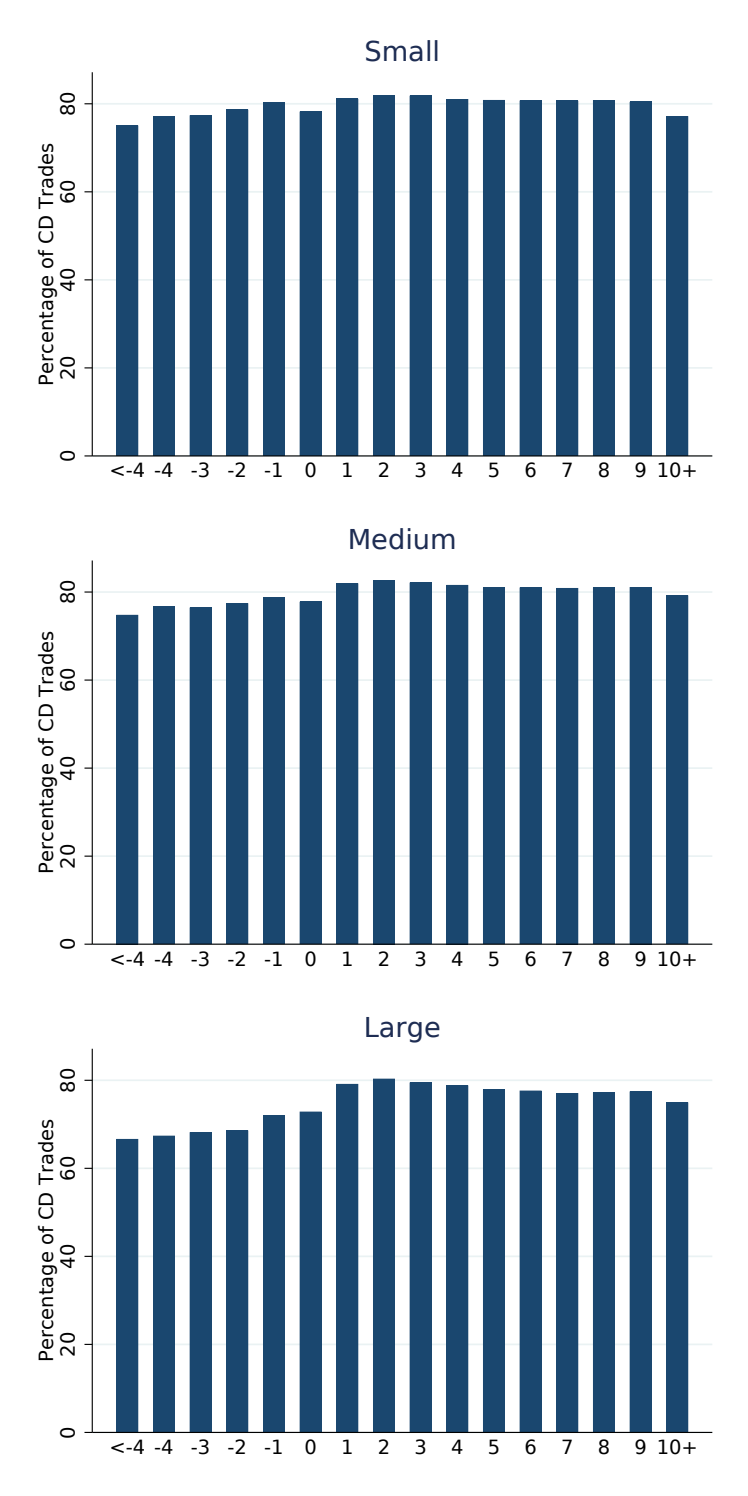
Note: Figure B.4 presents the distributions of three secondary market activity measures of municipal bonds around the de minimis threshold for taxable bonds: the incidence of trading, and the averages of total par value traded (in 000s of dollars) and trade size (in 000s of dollars) in a given week. We use customer-to-dealer sales transactions to construct average total par value traded and trade size. The figure presents averages and 95% confidence intervals for each bin within the [-4,4] interval around the deminimis price, where positive (negative) values indicate that the trade price is above (below) the deminimis price. We limit the sample to taxable bonds.

Figure B.5: Net changes of traded muni bonds around the tax threshold by different fund types.



Note: Figure B.5 shows the median quarterly net change in total par dollar amount of municipal bonds held by short-term (Panel (a)), intermediate-term (Panel (b)), and long-term mutual funds (Panel (c)) around the de minimis price. We classify mutual funds as short-, intermediate-, or long-term fund whenever a fund's name specifically mentions of such a strategy. < -4, -4, -3, ..., $+9$, $> +10$ correspond to the < -4, $[-4, -3)$, $[-3, -2)$, ..., $[+9, +10)$, $[+10, \infty]$ intervals measuring distance from the de minimis threshold in percentage points of par value. We limit the sample to bonds that trade at least once in a given quarter.

Figure B.6: Markups around the de minimis threshold.



Note: Figure 7 presents the share of sale transactions with complete chains for small, medium, and large trades around the de minimis threshold in each distance bin around the de minimis threshold. We define trades as "large" whenever the total par dollar amount of the transaction exceeds $100,000, "small" trades whenever the total par amount is below $25,000, and "medium" trades whenever the total par amount is between $25,000 and $100,000. We compute markups using the Li and Schürhoff (2019) algorithm.

Table B.1: Trading Characteristics Around the De Minimis Threshold

Table B.1 compares municipal bond trading activity below and above the de minimis threshold. The sample is limited to observations within four percentage points of the de minimis threshold, on either side of the threshold, for each bond-week observation. Rows labeled "below threshold" present summary statistics for bond-week observations that are from zero to four percentage points below the de minimis price, while bond-weeks "above threshold" refer to those from zero to four percentage points above the de minimis price (including bond-weeks at the de minimis price).

	Mean	SD	Obs	25^{th}	50^{th}	75^{th}
Dollar Volume, Small Below	14.04	13.58	2,745,038	10.00	10.00	20.00
Below threshold	14.82	16.07	253,718	10.00	10.00	20.00
Above threshold	13.96	13.30	2,491,320	10.00	10.00	20.00
Number of Trades, Small	1.18	1.54	2,745,038	1.00	1.00	1.00
Below threshold	1.29	2.57	253,718	1.00	1.00	1.00
Above threshold	1.17	1.39	2,491,320	1.00	1.00	1.00
Yield, Small	3.30	1.48	2,715,182	2.08	3.25	4.43
Below threshold	4.88	1.26	250,525	3.88	4.99	5.82
Above threshold	3.14	1.41	2,464,657	1.98	3.08	4.22
Dollar Volume, Medium	47.66	36.74	2,969,285	25.00	40.00	50.00
Below threshold	51.51	46.57	240,933	25.00	45.00	55.00
Above threshold	47.32	35.73	2,728,352	25.00	40.00	50.00
Number of Trades, Medium	1.16	0.76	2,969,285	1.00	1.00	1.00
Below threshold	1.27	1.02	240,933	1.00	1.00	1.00
Above threshold	1.15	0.73	2,728,352	1.00	1.00	1.00
Yield, Medium	2.87	1.54	2,940,063	1.54	2.71	4.03
Below threshold	4.70	1.23	238,562	3.77	4.68	5.69
Above threshold	2.71	1.46	2,701,501	1.46	2.50	3.81
Dollar Volume, Large	706.18	2630.74	1,474,266	100.00	200.00	405.00
Below threshold	984.41	4467.62	94,827	100.00	190.00	400.00
Above threshold	687.05	2453.32	1,379,439	100.00	200.00	405.00
Number of Trades, Large	1.13	0.61	1,474,266	1.00	1.00	1.00
Below threshold	1.24	0.99	94,827	1.00	1.00	1.00
Above threshold	1.12	0.58	1,379,439	1.00	1.00	1.00
Yield, Large	2.51	1.60	1,443,351	1.12	2.20	3.74
Below threshold	4.65	1.26	93,284	3.73	4.66	5.72
Above threshold	2.36	1.52	1,350,067	1.06	2.05	3.50