Tender Option Bonds and the Transmission of Monetary Policy in Municipal Bond Mutual Funds

Yongqiang Chu
University of North Carolina at Charlotte

Quan Qi
Middle Tennessee State University

Huayi Tang
University of Kentucky

Current Draft: November 2024

Abstract

This paper examines the transmission of monetary policy on the municipal bond mutual fund and the municipal bond market, focusing on the role of tender option bonds (TOBs)—a common leverage mechanism used by these funds to enhance performance. We find that monetary policy significantly influences investor flows in TOB-using funds. In response to redemption pressures, these funds are forced to liquidate municipal bond holdings, leading to depressed returns for affected bonds. Our findings demonstrate a channel through which monetary policy affects municipal bond markets and suggest that financial stability considerations should be explicitly integrated into the monetary policy framework.

Keywords: Mutual fund, municipal bonds fragility, tender option bonds, monetary policy
JEL classification: G14, G18, G23, G28

We thank Leonce Bargeron, Taylor Begley, Igor Cunha, Kristine Hankins, Russell Jame, David Sovich, and Michael Varley for their helpful comments. We thank brownbag participants at the University of Kentucky. Contact information: Yongqiang Chu, University of North Carolina at Charlotte, Belk College of Business, Email: ychu3@uncc.edu. Quan Qi, Middle Tennessee State University, Jones College of Business, Department of Economics and Finance, Email: qqi@mtsu.edu. Huayi Tang, John Maze Stewart Department of Finance & Quantitative Methods, Gatton College of Business and Economics, University of Kentucky. Email: huayi.tang@uky.edu.

Tender Option Bonds and the Transmission of Monetary Policy in Municipal Bond Mutual Funds

Abstract

This paper examines the transmission of monetary policy on the municipal bond mutual fund and the municipal bond market, focusing on the role of tender option bonds (TOBs)—a common leverage mechanism used by these funds to enhance performance. We find that monetary policy significantly influences investor flows in TOB-using funds. In response to redemption pressures, these funds are forced to liquidate municipal bond holdings, leading to depressed returns for affected bonds. Our findings demonstrate the channels through which monetary policy affects municipal bond markets and suggest that financial stability considerations should be explicitly integrated into the monetary policy framework.

Keywords: Mutual fund, municipal bonds fragility, tender option bonds, monetary policy
JEL classification: G14, G18, G23, G28

1 Introduction

This paper investigates the transmission of monetary policy on the municipal bond mutual fund and the municipal bond market. We examine the effect of monetary policy through the usage of tender option bonds (TOBs), a common practice by municipal bond mutual funds to leverage the fund and enhance performance. We document the significant impacts of monetary policy on investor flow and municipal bond market fragility through tender option bonds. Our results suggest that one might explicitly incorporate financial stability considerations into a monetary policy framework (Stein, 2014).

Existing research has found that monetary policy affects risk premia, capital allocations, and banking institutions. [1] This paper, however, centers on municipal bond mutual funds (municipal funds), which are non-bank financial institutions (e.g., Kuong, O'Donovan, and Zhang, 2023; Fang, 2024; Cetorelli, La Spada, and Santos, 2024) and the largest institutional owners in the $4 trillion municipal bond market. [2] Despite their importance, studies on municipal funds remain sparse, with only a few notable exceptions (Stark, Yong, and Zheng, 2006; Li, O'Hara, and Zhou, 2022; Adelino et al., 2023). This study delves into the role of TOBs within municipal funds to elucidate one transmission mechanism of monetary policy in these funds. TOBs are widely used in the industry to increase leverage and enhance performance. The process involves the municipal fund depositing a municipal bond and issuing two types of tax-exempt securities against it: the floating rate certificate (floater) and the inverse floating rate certificate (residual). The municipal fund retains the residual and sells the floater, which pays floating interest based on a short-term benchmark rate, to municipal money market funds. The municipal fund reinvests the proceeds from selling the floaters in long-term municipal bonds to capture the yield spread. Coupon payments from the underlying municipal bonds first satisfy the obligations to floater buyers, with the residual income going to the municipal fund. While selling the floater provides municipal funds with additional capital to exploit the yield spread, it also exposes them to interest rate risk from

[1] Monetary policy is shown to affect equity and credit risk premia (e.g., Dreschsler, Savov, and Schnabl, 2017; Kekre and Lenel, 2022), interest rate term structure (Ang et al. 2011; Kung 2015), bank lending (e.g., Kashyap and Stein, 1994) and bank risk-taking choices (Jiménez et al. 2014; Paligorova and Santos, 2017). Refer to the survey papers by Dreschsler, Savov, and Schnabl (2018), Kashyap and Stein (2023), and Bauer, Bernanke, and Milstein (2023).

[2] As of 2023, mutual funds hold approximately 20% of outstanding municipal bonds, representing the largest share of municipal bond holdings among institutional investors. The municipal bond market size is about 4 trillion as of Q1 2024.https://www.msrb.org/sites/default/files/Trends-in-Municipal-Securities-Ownership.pdf; https://www.sifma.org/resources/research/us-municipal-bonds-statistics/.

the floating interest rate expense. Moreover, TOB transactions allow funds to invest additional capital in long-term and illiquid municipal bonds, which further increases the interest rate risk exposure. Unexpected increases in policy rates are likely to elevate floater interest expenses and reduce the valuation of holdings for municipal funds engaged in TOBs, prompting investor outflows in search of higher returns. To meet investor redemption requests, municipal funds may be compelled to fire-sell their holdings, potentially triggering panic in the municipal bond market. As TOB users are more heavily engaged in liquidity and maturity transformation than non-users and fixed-income fund flows are more sensitive to negative returns (Goldstein, Jiang, H. and Ng, 2017), TOB users are likely more vulnerable to outflows triggered by unexpected policy rate increases compared to non-TOB users.

We construct a dataset of TOBs using money market fund SEC N-MFP filings, Electronic Municipal Market Access (EMMA), and the Municipal Securities Rulemaking Board (MRSB). We find that the TOB issuance amount is higher for low-interest years. 80% (60%) of TOBs have a gear ratio, the ratio between the issuance amounts of floaters and residuals, greater than or equal to 2 (3). The average yield of the TOB floaters (TOB yield) highly correlates with the Federal Funds rate, suggesting that TOB-using institutions exploit TOBs can incur huge interest expenses during the high-interest rate regime. We then aggregate TOB usage to the municipal fund level. The number of TOB using mutual funds decreased over time and TOB usage is gradually concentrated among big funds. Over our sample period, from 2011 to 2023, about 20% of funds engage in TOB transactions, and the average and median TOB exposure at the fund level is about 5% for the TOB users. For the whole industry, the average borrowing amount through TOBs is 50 billion.

We start our empirical analysis by conducting two preliminary tests before formally testing the hypothesis on municipal fund flows. Following Nakamura and Steinsson (2018), we proxy the monetary policy shocks (MP shocks) as the changes in interest rates in a 30-minute window surrounding scheduled Federal Reserve announcements.[3] In the first test, we examine whether the MP shocks impact TOB interest expenses and subsequently dampen fund performance. We calculate a municipal fund's TOB interest expenses as the holding-weighted TOB floater yields

[3] The identification assumption in the Nakamura and Steinsson measure is that unexpected changes in interest rates in a 30-minute window surrounding scheduled Federal Reserve announcements arise from news about monetary policy. As a robustness check, we also applied measures by Gürkayna, Sack, and Swanson (2005) and changes in two-year treasury yield (Hanson and Stein, 2015).

across all the TOBs in its portfolio.[4] The results indicate that TOB users experience increased interest expenses in response to positive MP shocks. A one-standard-deviation increase in monetary policy shock will increase TOB interest expenses by 0.067%, which corresponds to 8.5% of the mean of TOB interest expenses. Additionally, MP shocks have a more pronounced negative effect on the performance of TOB-using funds compared to non-TOB-using funds. Specifically, a one-standard-deviation increase in monetary policy shocks leads to a 5% decrease (1.29 bps decrease) in monthly returns for a fund with an average TOB exposure. This finding corroborates our assumption that positive MP shocks adversely affect fund performance by raising short-term borrowing costs and dampening the valuation of long-term municipal securities.

In the second test, we examine whether the TOB users engage in more liquidation and maturity transformation. We first verify that municipal funds display a concave flow-performance relationship, consistent with the findings in bond fund literature (e.g., Goldstein, Jiang, and Ng, 2017). We then interact the non-linear fund performance function with the TOB user indicator, we find that TOB users show an additional 50% flow-performance sensitivity. Following Chen, Goldstein, and Jiang (2010) and Goldstein, Jiang, and Ng (2017), we interpret these results as TOB users display more strategic payoff complementary, indicating that TOB-using funds engage more in liquidity and maturity transformations and will be more susceptible to fund run than non-users in response to negative returns.

Equipped with two key findings—that additional borrowing costs and liquidity transformation may reduce fund performance due to MP shocks—we further demonstrate that an unexpected increase in policy rates leads to investor withdrawals from these funds, driven by the underperformance of TOB-using funds. For a fund with average TOB exposure, a one-standard-deviation increase in monetary policy shocks will increase the outflow by 1% of the sample mean. This result is robust to various fund characteristics, fund staleness (e.g., Choi, Kronlund, and Oh 2022; Kuong, O'Donovan, and Zhang; 2023), and alternative measures of MP shocks (Gürkayna, Sack, and Swanson, 2005; Hanson and Stein, 2015). Our analysis of municipal fund flows indicates that TOB-using funds experience significantly more volatile flows compared to non-TOB users. This instability raises concerns for TOB-using funds and even the municipal bond

[4] TOB yields are reported by money market funds in their N-MFP filings at the TOB floater level. After matching residuals to their corresponding floaters, we calculate the weighted average TOB yields using all the floaters related to the residuals held by the municipal fund.

market, particularly during periods of financial stress, where declining NAVs may trigger severe strategic complementarities among fund investors, potentially leading to severe fund runs.

To test the above conjecture, we focus on the 2022-2023 monetary policy tightening cycle, examining the potential externalities and negative consequences associated with TOB usage. We assess the volatile fund flows in the municipal fund and municipal bond markets during this period. The 2022~2023 interest rate hikes provide an ideal setting for empirical analysis. During this period, the Federal Reserve increased rates eleven times to combat rampant inflation, raising the federal funds rate from 0% to 5.5%. Moreover, throughout the rate-hike period, the FOMC committee adopted a data-dependent approach, often setting the federal fund rate in ways that were unforeseen by the market.[5]

First, we show that TOB funds experienced greater outflows and worse performance during the tightening cycle. For each fund, we calculate the annual flows and returns for the year 2021 and the year 2022. We then construct a fund-year panel to compare the fund performance and investor redemption for funds with various TOB exposures after the monetary policy shock in 2022. We regress these two outcomes on the interaction of TOB exposure and a post-monetary policy shock indicator. The negative and statistically significant coefficient indicates that TOB funds perform worse and experience more substantial investor outflows than non-TOB funds during the rate-hiking period. This result reinforces our earlier findings that shareholders of TOB-using funds are more reactive to unanticipated changes in monetary policy compared to those in non-TOB funds.

We then examine whether investor withdrawals affect portfolio trading decisions of TOB-using funds. We expect that during the tightening cycle, in response to large-scale investor redemptions, TOB users are more likely to sell their municipal assets to fulfill these requests. Specifically, we run a panel regression at the bond-fund-year level by regressing the percentage holding of each bond on the interaction of fund-level TOB exposure and a post-monetary policy shock indicator. To remove bond-specific differences, we saturate our specifications with bond-year fixed effects (Khwaja and Mian, 2008). In this within-bond estimation, our results show that

[5] A notable example occurred at the June 2023 FOMC meeting. Before the announcement, Fed chair Jerome Powell had explicitly stated that the committee would not consider a 0.75-point increase in upcoming meetings. However, when the annual inflation growth surged to 9.1% in June 2022, the Fed quickly revised its stance and raised the Fed fund rate by 75 basis points. This shift is also evident in our analysis of monetary policy shocks. Using the measure from Nakamura and Steinsson (2018), we find that the average monetary policy surprise was 3% between March 2022 and December 2022, compared to just 1% over the entire sample period.

after the monetary policy shock, a one-standard-deviation increase in TOB exposure at the fund level is associated with the liquidation of approximately 3% more of the same municipal bond on average. In the cross-sectional analysis, we find that the TOB users are more likely to sell liquid bonds and the bonds that represent a smaller percentage of their holdings.

Given that the municipal bond market is highly illiquid, it is crucial to determine whether fire sales by TOB users depress bond valuations and further destabilize this market. For the last part, we examine the effect on the municipal bond market, specifically whether municipal bonds with greater exposure to the selling pressure from TOB-using funds experience larger price declines than those bonds with lower exposure. To assess the selling pressure from TOB-using funds, we calculate a bond-level fragility measure for each municipal bond, defined as the weighted average of the TOB exposure across all funds that invest in it at the end of 2021. We then classify all municipal bonds into two portfolios: the fragile portfolio (22% of the sample) and the non-fragile portfolio (78%). We calculate and plot each portfolio's average cumulative monthly returns from July 2021 to June 2023 using equal-weighted averages. The graph (Figure 6) shows that, following the Fed's initial rate hike in March 2022, the return differential between the two portfolios began to diverge, driven primarily by price declines in the fragile portfolio. The difference peaked at -2.93% in October 2022 after the Fed officials implemented multiple unexpected 0.75-point rate increases, which substantially reduced the payoff of TOB programs. Starting in November 2022, the prices of fragile bonds began to rebound more significantly, and the spread between the two portfolios eventually narrowed to near zero. This subsequent price reversal suggests that the price drop during the 2022 rate hikes was driven by temporary selling pressure from TOB-using funds rather than differences in bond fundamentals (Coval and Stafford, 2007). Next, we conduct a multivariate analysis to account for unobserved bond characteristics. Controlling for bond characteristics and bond-issuer fixed effects, we find consistent results: a one-standard-deviation increase in fragility is associated with a 16.16 bps more decline in bond returns from March 2022 to October 2022, which corresponds to 72% of the sample mean. In the later recovery period, we find the same magnitude of rebound for the fragile portfolio return.

This paper contributes several strands of literature. Our paper adds to the literature on the role of financial institutions in the transmission of monetary policy. The conventional banking lending channel posits that central banks can influence the deposit funding of commercial banks. Since retail deposits are a critical funding source for these institutions, a reduction in deposits due to monetary tightening translates into a decrease in the supply of credit to the economy (Kashyap and Stein, 1994; Drechsler, Savov, and Schnabl, 2017). However, the presence of non-banking institutions significantly dampens the impact of this lending channel. Due to their rate-insensitive funding structures, various shadow banks can continue to secure adequate funding from their shareholders during monetary tightening cycles, thereby counteracting the concurrent decline in bank deposits (Xiao, 2020; Agarwal, Hu, Roman, and Zheng, 2023; Cetorelli, La Spada, and Santos, 2023). In contrast to offsetting the effect, our findings reveal that certain shadow banking groups can amplify the impact of monetary shock. Specifically, we demonstrate that municipal funds, as key shadow banking entities in municipal bond markets, finance long-term municipal securities through short-term borrowings in TOB programs. Since the efficiency of TOB transactions is directly tied to the fluctuations in benchmark rates, an unexpected rate hike can substantially disrupt TOB-using funds, which in turn transmits these policy-induced disruptions to municipal bond markets.

Several contemporaneous papers have begun evaluating the effect of monetary policy on fixed-income mutual funds. Kuong, O'Donovan, and Zhang (2023) document that corporate bond funds with a stale NAV suffer material capital withdrawals around the FOMC announcements. The economic rationale behind the finding is that fund managers fail to incorporate the rate-hike news revealed by the FOMC meetings into portfolio valuations, resulting in a temporary overpricing of fund shares. This mispricing enables opportunistic investors to strategically redeem their overvalued shares during the same period. Fang (2024) further suggests that investor redemptions induced by monetary contractions can impact real economic activities by influencing investment behavior and capturing the structures of exposed firms. In contrast, Cetorelli, La Spada, and Santo (2023) find the opposite among leveraged loan mutual funds. Due to the floating rate nature, leveraged loans' interest payments are directly tied to the benchmark rate, which results in stable income streams and leads loan funds to experience significant investor inflows in a tightening period. Our study differs in two key ways. First, we propose a distinct economic channel through which monetary policy affects a key segment of open-end bond funds. Specifically, we focus on a unique secured borrowing transaction in which municipal funds pledge high-rated holdings as collateral and reinvest additional financing into other long-term municipal securities. Due to the mark-to-market borrowing cost and additional maturity transformation, flows of TOB-using funds display greater sensitivity to monetary policy shocks compared to their peer funds.

Second, our paper leverages the recent 2022-2023 tightening cycle to provide further evidence on how TOB usage destabilizes municipal bond markets. Following several aggressive rate increases, the TOB program malfunctioned, leading to substantial return loss for TOB-using funds, which triggered huge investor outflows. In response to these redemptions, TOB users liquidate other municipal bond assets, and this forced sale increases the fragility of municipal bond markets.

Finally, we contribute to the literature on how mutual funds affect the stability of fixed-income markets. Earlier research suggests that the open-end structure of bond funds facilitates liquidity transformation by allowing daily redemptions while holding illiquid fixed-income assets (Edelen, 1999; Chen, Goldstein, and Jiang, 2010; Goldstein, Jiang, and Ng, 2017). This liquidity mismatch can create a first-mover advantage, leading to amplified investor withdrawals and forcing funds to sell bond holdings at a discount (Jiang, Li, and Wang, 2017; Li, O'Hara, and Zhou, 2022; Ma Xiao, and Zeng, 2022). In the context of municipal bond funds, we observe that fund managers can perform incremental liquidity transformations via other methods. Specifically, TOB users take out loans that should be rolled over every seven days, whereas investing in illiquid municipal instruments with much longer maturities. This additional liquidity transformation, coupled with the rate-sensitive nature of TOB transactions, weakens the stability of municipal bond markets during periods of monetary tightening.

2 Institutional Background

Many municipal bond mutual funds (municipal funds), including those managed by Nuveen, Invesco, Blackrock, and Oppenheimer, use the tender option bond (TOB) program to finance their long-term municipal bond investments at a short-term rate and earn tax-exempt profits.[6] Figure 1 illustrates the mechanics of a TOB transaction. A municipal fund first deposits AAA or AA-rated municipal bonds to a special purpose trust, commonly referred to as a TOB trust. Using these bonds as collateral, the trust then issues two securities: a floating rate certificate (floater) with a principal amount representing a fraction of the underlying bonds, and an inverse floating rate certificate (residual) representing the remaining principal. The floater pays a short-

[6] On average, about 20% of the bond funds consistently use TOB. Major players in the municipal bond fund industry more often use tender option bonds, such as Naveen, Invesco, Blackrock, and Oppenheimer, and the TOB is more prevalent when the market interest is low. For example, Invesco discusses its usage of TOB and the corresponding risk in its prospectus, https://www.sec.gov/Archives/edgar/data/909466/000119312519286881/d802543dncsrs.htm

term weekly rate and is typically sold to money market funds. The municipal fund retains the residual. The ratio between the value of the floater and the residual is referred to as the gear ratio. In the example shown in Figure 1, the municipal bond fund deposits $40 million to the TOB trust, which then issues $30 million floater and $10 million inverse floater. The gear ratio is 3. The gear ratio determines the level of leverage embedded within this TOB structure.

The municipal fund then reinvests the borrowed cash into additional long-term municipal bonds. Using the TOB, the municipal fund capitalizes on the spread between the yield on municipal bonds and the short-term rate on the floaters. This reinvestment behavior can further enhance the municipal fund performance in an environment characterized by an upward-sloping yield curve, where long-term rates exceed short-term equivalents.

An essential feature of the TOB program is the liquidity offered to floater investors. Although the nominal maturity of a floater is the same as the underlying bonds, its holders, such as the money funds, has the option to tender the floater back to the TOB trust at par plus accrued interest on short notice, typically seven days. The tendering option allows floaters to meet the investment requirements of money market funds under Rule 2a-7 of the Investment Company Act of 1940. In the event of a redemption request, a remarketing agent attempts to resell the tendered floaters to secondary markets. Should the reselling process fail, the trust will have to borrow a loan from a third-party liquidity provider to purchase the tendered floaters.[7]

Municipal funds maintain control over the TOB program through their ownership of residuals. Fund managers can also terminate the TOB trust and reacquire their deposited bonds at will. In such stances, floater investors are forced to redeem their holdings at par, and the underlying bond is transferred back to the municipal fund. When the municipal fund voluntarily collapses the TOB trust, it assumes the responsibility of raising cash to repay the par value of redeemed floaters.

Municipal funds receive coupon payments from the deposited bond while incurring borrowing costs at a prevailing rate. The coupon payments are first allocated to cover the TOB trust's administrative expenses and accrued interests on floaters. The remainder goes to the residual holders, the municipal funds. The floater interest rate is adjusted weekly by the

[7] This liquidity facility is only effective in the absence of Tender Option Termination Events (TOTE). For instance, if the underlying municipal bond experiences a credit rating downgrade, loses its tax-exempt status, or defaults on its coupon payments, the liquidity providers can opt not to offer corresponding liquidity enhancements.

remarketing agent according to a benchmark index, such as the BMA Municipal Swap Index.[8] Because the principal amount of floater is fixed at inception, any fluctuation in the market value of the underlying bonds will be entirely absorbed by the value of the residual. By reinvesting the proceeds from selling floaters into long-term bonds, municipal bond funds increase their exposure to interest rate risk. These characteristics enable municipal funds to benefit from price appreciation of the underlying bond, such as during declines in market interest rates while bearing full exposure to interest rate increases.

The distinctive features of the TOB structure could expose municipal funds to significant interest rate risk. In a rising interest rate environment, the municipal funds must direct more income from the underlying bond to holders of floaters, as the floater yields are tied to reference short-term rates. For the inverse floaters, the rise in interest rates will cause both a decrease in cash flow and an increase in yield, resulting in lower valuation. Because the cash flow is also affected, the value of the inverse floater is more sensitive to interest rate changes than pure bond positions.

3 Data and Sample

This section describes our data sources, the data collection process, the definitions of key variables, and their summary statistics.

3.1 Mutual fund database

The CRSP Survivor-Bias-Free Mutual Fund Database provides comprehensive information on fund characteristics, including monthly fund returns, monthly fund flows, securities holdings, total net assets (TNA), portfolio-wide maturity, fund objective codes, and miscellaneous fund characteristics. We extract all municipal bond mutual funds (municipal funds) from the database whose first two letters of the CRSP objective code are designated as "IU". We conduct our analysis at the fund level by converting class-level variables to fund-level equivalents. Specifically, we aggregate the TNAs of all share classes within a fund (identified by *crsp_cl_grp*)

[8] An example, Municipal bond 917436YP6, UTAH HSG CORP SINGLE FAMILY MTG REV / SINGLE FAM MTG BDS E-1 CLASS I, has an interest rate 5.25%, issuance amount $15,750,000, issued on September 1, 2008, and matures on Jan 1, 2039. Against this bond, on June 19, 2008, BANC OF AMERICA SECURITIES LLC underwrite a floater 05248P2K0, VAR CTFS-BOA-SER 2008-3300, with par value $7,085,000, and a residual 05248P2L8, INVERSE CTFS-BOA-SER 2008-3300, with par value $2,360,000. The gear ratio for this TOB program is 3.002.

and calculate fund-level returns and other quantitative variables, including total net asset, fund age, fund flow, fund return, cash holding, and fund maturity, as the TNA-weighted average of class-level variables. For qualitative attributes, e.g., fund objective code, we retain the value associated with the oldest share class. We exclude ETF and index municipal funds because they rarely use TOB transactions. Our sample consists of about 500 municipal funds from January 2011 to December 2023.

3.2 Municipal bond and tender option bond (TOB)

3.2.1 TOBs: floating rate securities (floater) and inverse floating rate securities (residuals)

We obtain the TOB data and municipal bond information from SEC N-MFP filings, FISD Mergent, Electronic Municipal Market Access (EMMA), and the Municipal Securities Rulemaking Board (MRSB).

We extract a sample of TOB floaters held by U.S. money market funds from their N-MFP filings. Despite the 2014 reform requiring money market funds to identify their TOB positions, the disclosures still contain incorrect classifications. Before 2014, the information was even more incomplete as money funds simply group all TOB floaters under the broad category of variable-rate notes. To mitigate this problem, we merge money market funds' portfolio municipal bond holdings to the Mergent Municipal Bond Database using 9-digit CUSIP. Mergent provides detailed information on bond issuers, issuance yield, ratings, offering date, and maturity. By carefully reading the variable "issue description" of each matched municipal security, we obtain 10,980 tender option bonds.[9] We also retrieve additional characteristics of these TOBs from Form N-MFP, such as market value, yield, maturity date, and liquidity provider information.

We manually identify inverse floating rate securities (residuals) paired with the TOB floaters in our sample. For each TOB, we retain all municipal bonds issued by the same issuer during a 10-day window, as recorded in Mergent. We identify the residual(s) for each TOB based

[9] The keywords in the variable "issue description" of TOB floater include "floater"," putter", "solar eclipse", and "spear". We also include "var", "variable", "floating", "float", "floats", and "p floats", but as the description of floating/variable rate municipal bonds can also include these keywords, our list of 10980 floaters will include some of the non-TOB floating rate bonds. However, our next step, matching to residual, will eliminate those non-TOB bonds, as these bonds don't have residuals. We also adjust for misspellings in security descriptions, e.g., "floatier" or "floter", as misspellings are frequent.

on the "issue description" and "series" reported by Mergent.[10] Moreover, we complement and verify the Mergent sample with the information from the Electronic Municipal Market Access (EMMA) website. Specifically, EMMA directly reports information on the residual securities for every TOB under the column of "Final Scale".[11] By combining the two data sources, Mergent and EMMA, our sample consists of approximately 12,000 residuals for 9,000 floaters.[12]

We show the annual issuance of floaters in panel A of Figure 2. The issuance peaks during low-interest-rate periods and declines during high-interest-rate periods. Panel B plots the floater termination amount by year during the sample period.[13] Comparing the floater and residual termination amount, the disposition rise in the residual termination amount in 2022 suggests that more TOBs with higher gear ratios are terminated during the recent monetary policy tightening cycle.

Figure 3 plots the distribution of gear ratio, defined as the ratio between the issuance amounts of floaters and residuals. The distribution reveals that 12.5% of TOBs have gear ratios of 1 or 2, respectively; about 30% have a gear ratio of 3; about 40% have a gear ratio of 4; and about 5% have a gear ratio above 6. This reflects significant borrowing through TOBs and, as shown in Figure 4, leads to increased interest expenses for residual holders if rates rise. Figure 4 plots the average TOB yield against the Federal Funds rate. The TOB yield is highly correlated with the Federal Funds rate, although floater rates are not typically directly linked to the Federal Funds Rate.

3.2.2 Fund-level TOB measures

[10] The keywords in the variable "issue description" of TOB residual include "residual"," driver", "lunar eclipse", "lifer", 'inverse", and "rites". We also correct for misspellings. For example, from Mergent, CUSIP 05248PD69 is the floater, with the description "VAR CTFS BOA SER 2008 3033X, 2008", and CUSIP 05248PD77 is the residual, with the description "INVERSE CTFS BOA SER 08 3033X, 2008". 3033X is the series number that is unique to this floater-residual pair.

[11] An example is here, https://emma.msrb.org/IssueView/Details/D909C637CFF1C7D68111C365FE84A76D. For some residuals, the information is either missing or inaccurate in Mergent, and EMMA provides additional information verification.

[12] In a TOB, there is one floater, but it can have more than one residual. For example, in this TOB, "SER 2017-XF2475", 88033YGS4 is the floater, with issue description "FLOATERS-SER 2017-XF2475" and it has two residuals, 88033YGT2, "RESIDUALS-SER 2017-XF2475", and 88033YGU9, "RESIDUALS-SER 2017-XF2475-2". TOB floaters and residuals are typically removed from research in municipal bonds because the issuer city and county are missing and cannot be matched to other data sets.

[13] Appendix B Table B1 presents the residual termination amount.

We merge our residuals sample with mutual fund portfolio holdings from the CRSP Mutual Fund Database, resulting in around 3,300 matched securities.

We construct a fund-level measure of TOB exposure using the offering amounts of floaters and residuals at issuance. When a floater is linked to multiple residuals within the same TOB structure, we aggregate the par value of all residuals to calculate the gross residual exposure for that floater. Figure 5 plots TOB usage at the fund level. About 18% of municipal bond funds participate in TOB programs, and the percentage has been decreasing in recent years. The aggregate total net assets (TNA) of funds using TOBs increased until the recent monetary tightening cycle, suggesting that TOB positions have become increasingly concentrated in larger municipal funds.

We further develop two fund-level TOB measures, $TOB\ borrowing\ amount_{j,t}$ and $TOB\ Exposure_{j,t}$. $TOB\ borrowing\ amount_{j,t}$ is defined as:

$TOB\ borrowing\ amount_{j,t} = \sum_{i=1}^{N} \left(floater\ offering\ amount_i * residual\ percentage_{i,j,t} \right)$,

here $floater\ offering\ amount_i$ is the offering par value of the floater for TOB i. $residual\ percentage_{i,j,t}$ is the percentage of the residual of TOB i that fund j invested in period t. which captures the total redemption amount if the floater holder, e.g., a money market fund, wants to get their investment back. For each residual in a fund's portfolio in a given period, we first compute the ratio of the fund's holding amount of this residual to the residual's total issuance amount, obtaining the fund's share in this residual, $residual\ percentage_{i,j,t}$. The step accounts for on the fact that multiple participants, e.g., several municipal funds or hedge funds, may participate in one TOB transaction and hold the same residual. In our multivariate analysis, we focus on TOB exposure, $TOB\ Exposure_{j,t}$, defined as $TOB\ borrowing\ amount_{j,t}$ scaled by the TNA of the fund.

Table 1 tabulates the number of TOB-using funds and TOB exposure by year. The average percentage of TOB-using funds is about 18% by number and 28% by TNA. This suggests that TOB strategy is more common among large municipal funds. TOB usage was higher from 2011 to 2015 because, during this period, the interest rate was low. TOB usage started to decrease in 2016 and during this period, interest rates started to increase and the Volker Rule started to regulate and restrict money market funds holding of tender option bonds. We observed a sharp decline from 2022 to 2023 which could be attributed to the recent monetary policy tightening cycle. The average TOB exposure for the TOB-using fund is about 5%. This is a significant portion of holdings, considering that during the same period, the cash holding percentage for TOB-using funds is 3%. In Figure 5, we plot the two measures at the aggregated level for TOB users. In Panel A, we plot the distribution of TOB exposure and in Panel B, we plot TOB borrowing amount. For the TOB users, the mean and median TOB exposure is about 4%.

3.2.3 Bond transaction data

We use the Municipal Securities Rulemaking Board's (MSRB) municipal bond transaction database to construct bond returns. This dataset contains detailed transaction information on municipal bonds, including trade date, price, and trading volume. We filter the transaction data following the literature (e.g., Goldsmith-Pinkham et al, 2023). We remove duplicate trades and noisy transaction records that occur within the first three months after issuance and a year before maturity. We focus only on tax-exempt bonds with fixed coupon payments. We calculate daily bond prices as volume-weighted averaged prices and keep the last available price in each bond month. A monthly panel of bond returns is constructed as the change in monthly bond prices across two adjacent months. Moreover, we supplement our bond return data with various bond characteristics from Mergent, such as coupon rate, credit rating, issuance amount, and maturity date.

3.3 Monetary policy surprise

We use several measures of monetary policy surprise, with a primary focus on the measure developed by Nakamura and Steinsson (2018).[14] They estimate the high-frequency responses of interest rates at different maturities to scheduled FOMC announcements within a 30-minute window, using these rates as policy indicators. The identifying assumption is that changes in these indicators within such a narrow window are primarily driven by monetary policy news revealed during the FOMC announcements. This measure also captures the effects of forward guidance, which is particularly relevant during our sample period, when federal funds rates were at the zero lower bound (ZLB). As Swanson (2021) highlights, with fed rates near zero and largely unchanged during the ZLB period, the information content of fed rate changes was minimal. However,

[14] This measure is available and updated at https://eml.berkeley.edu/~jsteinsson/papers.html.

forward guidance, which provides insights into the expected path of future rates, exhibited sufficient time-series variation and was a key component of monetary policy during this period.

The other measures, introduced by Gürkaynak, Sack, and Swanson (2005), involve two factors derived from structural estimations to capture monetary policy surprises. The first is the "current federal funds rate target" factor, reflecting unexpected changes in the current federal funds rate target. The second is the "future path of policy" factor, capturing changes in futures rates extending up to one year, independent of changes in the current funds rate target.

We also measure monetary policy rates by two-year Treasury yields because the Fed's forward guidance policy operation horizon is roughly two years. Therefore, using the two-year rates can better capture the impact of policy announcements on both current rates and the future path of policy rates (Swanson and Williams, 2014; Hanson and Stein, 2015). Specifically, we construct monetary policy surprises as two-day changes in two-year Treasury yields around FOMC meeting dates. In particular,

$$MP\ Surpise = y_{t+1}^{2\ year} - y_{t-1}^{2\ year}$$

where $y_{t+1}^{2\ year}$ ($y_{t-1}^{2\ year}$) represents two-year Treasury yields the day after (before) the FOMC announcement day t. The rationale is that within a two-day window, any change in two-year rates comes from reactions to the FOMC's policy rate announcements. A drawback of the two-year rate is that its fluctuations may contain term premia, and the two-day window may encompass other macroeconomic news that contaminate our policy shock variable.

We convert our monetary policy surprises to the monthly level to match the frequency of mutual fund flow data. If there is a FOMC meeting in a month, monetary policy surprises for this month are equal to these two measures above, otherwise, monetary policy surprises are zero.

3.4 Summary statistics

We present the summary statistics of the variables in Table 2. Panel A presents the variables at the TOB security level. Panel B presents the variables for our panel data analysis, from January 2011 to December 2023. Panel C presents the monetary policy shock measures at the monthly frequency. Panels D, E, and F report the summary statistics for the monetary policy tightening event study. Panel D tabulates the variables at the fund-year level. Panel E tabulates the variables at the fund-bond-year level. Panel F tabulates the variables at the bond-period level. Variable definitions are in Appendix A Table A1. In Appendix B, we test which characteristics relate to TOB fund usage. We find that TOB-using funds are more likely to be older funds and funds have a larger TOB exposure during low interest environment.

4 Empirical Results on Fund Flow

4.1 Monetary policy and fund performance

We first examine how shareholders of municipal bond funds respond to monetary policy shocks. An unexpected rise in policy rates can negatively impact the performance of TOB-using funds by directly increasing short-term borrowing costs. Additionally, reinvesting in long-term municipal instruments heightens interest rate risk for TOB-involved funds, leading to significant valuation declines following positive monetary policy surprises. Given that municipal funds are open-ended and investors are sensitive to performance, we hypothesize that funds heavily using TOB programs will experience substantial investor withdrawals after a positive monetary policy shock.

Furthermore, TOB usage introduces a more nuanced risk. By funding long-term securities at short-term rates, municipal funds engage in liquidity transformation beyond their open-ended structure. Specifically, TOB users borrow short-term, rolling over these loans weekly, while investing in illiquid municipal securities with much longer maturities. When tightening monetary policy erodes the portfolio valuations of TOB-using funds, this additional liquidity mismatch can create strategic complementarities among investors, further amplifying redemptions (Goldstein, Jiang, and Ng, 2017; Li, Li, Macchiavelli, and Zhou 2021).

Before proceeding to the main analysis of fund redemptions and fund flows, we first validate the assumptions underlying our hypothesis that positive monetary policy shocks increase TOB funding costs. Specifically, we estimate the following fund-month level specification,

$$\begin{aligned} TOB\ funding\ costs_{i,t} &= \beta_1 \times NS\ policy\ shock_t + \beta_2 \times TOB\ Exposure_{i.t-1} + \gamma \times X_{i.t-1} \\ &+ \mu_{fund-objective} + \varepsilon_{i,t}, \end{aligned} \tag{1}$$

where $TOB\ funding\ costs_{i,t}$ denotes the weighted average TOB yields from all the floaters linked to the residuals held by the municipal fund, with weights based on the holding amounts reported in N-MFP filings. This measure is calculated at the fund-month level. The coefficient of interest, β, captures the sensitivity of TOB interest expenses to monetary policy shocks. A positive coefficient indicates that tighter monetary policy forces municipal funds to allocate a larger portion of their income to TOB floater interest expenses. *NS policy shock* is the monetary policy shock as defined by Nakamura and Steinsson (2018). $TOB\ Exposure_{i.t-1}$ is fund i's borrowing amount via tend option bond programs scaled by its TNA in the previous month *t-1*. We also control for various fund attributes, $X_{i.t-1}$, including the natural logarithm of TNA (*Log (TNA)*), the natural logarithm of fund age (*Log (Fund age)*), past fund returns (*12-month past return*), lagged fund flow (*Prior month flow*), fund cash holding scaled by TNA (*Cash holding*), the fraction of assets in institutional shares (*Fraction of assets in institutional shares*), and fund maturity (*Fund maturity*). All specifications include fund-objective fixed effects $\mu_{fund-objective}$ to control for time-invariant heterogeneity across fund types. Standard errors are clustered at the fund level.

The coefficient estimate in Column (1) suggests that a one-standard-deviation increase in monetary policy shock increases TOB funding costs by 0.067%, which corresponds to 8.5% (4.8%) of the mean (standard deviation) of TOB funding costs. Column (2) adds control variables and we get a similar result. The results in this panel confirm that monetary policy shock will increase TOB interest expenses for TOB users.

We then proceed to examine how monetary policy shocks affect fund performance, measured by fund return. We estimate the following specification,

$$Fund\ Return_{i,t} = \beta \times TOB\ Exposure_{i.t-1} \times NS\ policy\ shock_t + \gamma \times X_{i.t-1} + \mu_{fund-objective} + \mu_t + \varepsilon_{i,t}, \quad (2)$$

where $Fund\ Return_{i,t}$ denotes the monthly return of fund i in year-month t from CRSP Survivor-Bias-Free Mutual Fund database. $TOB\ Exposure_{i.t-1}$ represents fund i's borrowing amount via tend option bond programs scaled by its TNA in the previous month *t-1*. $NS\ policy\ shock_t$ is the policy news shock of Nakamura and Steinsson (2018). The coefficient of interest, β, measures how TOB affects the sensitivity of fund performance to monetary policy shocks. A negative coefficient would suggest that, when monetary policy tightens, municipal funds with higher TOB usage underperform relative to their peers. All specifications include fund-objective fixed effects, $\mu_{fund-objective}$, to control for time-invariant heterogeneity across fund types, and year-month fixed effects, μ_t, to control for time-varying macroeconomic factors. Standard errors are two-way clustered at the fund and year-month level.

In panel B, the coefficient estimates on *TOB exposure×NS policy shock* are negative and statistically significant. An unanticipated rise in monetary policy rates has a more significant negative impact on the returns of municipal funds with higher TOB exposure. This result confirms our hypothesis that a positive monetary policy shock impairs fund performance by increasing short-term borrowing costs. Economically, a one-standard-deviation increase in monetary policy shocks leads to a 5% decrease in monthly returns for a fund with average TOB exposure.[15]

Goldstein, Jiang, and Ng (2017) suggest that bond fund illiquidity, stemming from liquidity and maturity transformation, creates payoff complementarities. To assess whether TOBs increase liquidity and maturity transformation, we examine whether TOB users exhibit greater payoff complementarities, following the approach of Chen, Goldstein, and Jiang (2010). Specifically, we test for the differences in flow-return sensitivity between TOB users and non-TOB users by estimating the following the same specification as in Goldstein, Jiang, and Ng (2017):

$$\begin{aligned} Fund\ Flow_{i,t} = {} & \alpha + \beta_1 \times Past\ Return_{t-12\to t-1} + \beta_2 \times I(Past\ Return_{t-12\to t-1} < 0) \\ & + \beta_3 \times Past\ Return_{t-12\to t-1} \times I(Past\ Return_{t-12\to t-1} < 0) \\ & + \gamma \times X_{i.t-1} + \mu_{fund-objective} + \mu_t + \varepsilon_{i,t}, \end{aligned} \tag{3}$$

$Fund\ Flow_{i,t}$ denotes monthly percent change in the TNA of fund i in year-month t. $Fund\ Flow_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1}(1+Fund\ Return_{i,t})}{TNA_{i,t-1}}$, where $Fund\ Return_{i,t}$ is the monthly return. $Past\ Return_{t-12\to t-1}$ is fund i's return, adjusted by the mean return of funds with the same objective code over the past year. We also control for various fund attributes, $X_{i.t-1}$, fund-objective fixed effect, and year-month fixed effects.

In column (1) of Table 4, we confirm that municipal funds exhibit a concave flow-performance relationship, similar to that documented for corporate bond funds, with flows being

[15] One-standard-deviation increase in NS shock is 0.0197, 0.0197*0.845(the average TOB exposure)*(-0.776)=-1.29 bps; the monthly fund return is 24.6bps, 1.29 bps corresponds 5% of sample mean.

significantly more sensitive to negative returns. In column (2), we introduce a TOB-user indicator to the specification, where *I (TOB user)* equals one for municipal funds using TOBs. We then interact this indicator with the non-linear performance function. The results in column (2) show that TOB-using funds exhibit a more concave flow-performance relationship compared to non-TOB users, which indicates that investor redemptions are more responsive to poor performance in TOB-using funds. The economic significance is substantial: flow-performance sensitivity is approximately 50% higher for TOB-using funds.

4.2 Monetary policy and fund flows

After corroborating the two key assumptions, we examine how TOB affects the sensitivity of fund flows with respect to monetary policy shocks:

$$Fund\ Flow_{i,t} = \beta \times TOB\ Exposure_{i.t-1} \times MP\ Surprise_t + \gamma \times X_{i.t-1} + \mu_{fund} + \mu_t + \varepsilon_{i,t}, \quad (4)$$

where $Fund\ Flow_{i,t}$ denotes monthly percent change in the TNA of the fund i in year-month t. All other variables follow the same definition as in Equations (1)-(3). The coefficient of interest, β, measures how TOB affects the sensitivity of fund flows to monetary policy shocks.

We present the results in Table 5. Panel A uses the *NS policy shock* as the measure of monetary policy shocks. Column (1) shows that investors in TOB-using funds react negatively to monetary policy shocks, supporting our hypothesis that an unexpected increase in policy rates erodes the performance of TOB-using funds, prompting investors to withdraw. The additional liquidity transformation inherent in TOB programs amplifies this reaction, worsening the run on the funds. Economically, for a fund with average TOB exposure, a one-standard-deviation increase in monetary policy shocks leads to outflows equivalent to 0.95% of the mean monthly fund flow.

In Column (2), we address an alternative explanation that our findings may be driven by the staleness of municipal funds' net asset values (NAV) (Kuong, O'Donovan, and Zhang, 2023). Choi, Kronlund, and Oh (2022) show that municipal bonds are sparsely traded, which hinders accurate pricing, leading to widespread NAV staleness. This staleness creates mispricing opportunities around FOMC meetings, as municipal funds' NAVs adjust slowly to updated monetary policy information. As a result, opportunistic investors may strategically redeem shares to capitalize on the temporary overpricing, leading to fund outflows. To account for this possibility, we apply the method of Kuong, O'Donovan, and Zhang (2023) to construct a fund-level measure of pricing staleness, defined as the proportion of trading days with non-moving NAVs. By directly including the interaction between the fund staleness variable and $MP\ Surprise_t$ in the baseline specification, our main results continue to hold. This suggests that our observed finding is independent of the effects of fund staleness. Economically, the impact of TOB usage on fund flows is approximately 20 times greater than the effect of NAV staleness for the same magnitude of monetary policy shock.[16]

In Column (3), we include various fund-level controls, and the results remain robust. The coefficient estimates on control variables are mostly consistent with those reported in the previous literature. For example, the general concave flow-return relationship suggests that the liquidity mismatch inherent in municipal bonds—where illiquid bond holdings are paired with daily redeemability—creates incentives for investors to redeem ahead of others (Goldstein et al., 2017; Li, O'Hara, and Zhou, 2024). Additionally, the positive coefficient on cash holdings indicates that cash reserves play a critical role as a liquidity buffer against investor withdrawals.

In Panel B, we conduct a robustness test by replacing our primary monetary shock measure with the two factors from Gürkaynak, Sack, and Swanson (2005) (Columns (1) and (2)) and the two-day change in two-year Treasury yields around FOMC meetings. The primary findings remain qualitatively similar but with a slightly larger economic magnitude. This difference may arise because Nakamura and Steinsson (2018) estimate their MP measure in a very narrow window (30 minutes) around scheduled FOMC announcements, while the other measures use a broader window, which might capture the noise in the macroeconomic environment.

The results suggest that TOB-using funds exhibit greater instability in flows compared to non-TOB users. This instability raises concerns for both the funds and the broader market, particularly during periods of stress when declining NAVs may trigger investor outflows. This issue is especially critical for bond funds, as their illiquidity makes investors more sensitive to negative returns, and the concave flow-performance relationship can lead to severe payoff

[16] The comparison here needs to be taken with a grain of salt. The comparison uses a fund-month panel for staleness and TOB. Kuong, O'Donovan, and Zhang (2023) focus on a small window around FMOC announcement. Our paper uses a monthly sample instead.

complementarities during periods of poor performance. When this occurs, funds may be forced to liquidate holdings to meet redemptions, potentially spreading panic into asset markets. In the next section, we examine the 2022–2023 monetary policy tightening cycle to explore the possible externalities and negative consequences associated with TOB usage.

5 Event Study: 2022-2023 Monetary Tightening Cycle

The previous section shows that an unexpected rise in monetary policy rates directly increases short-term borrowing costs and reduces the value of the financed securities. The performance decline prompts return-chasing shareholders to withdraw from TOB-using funds. More critically, the maturity transformation inherent in the TOB structure amplifies strategic complementarities among investors, intensifying their reaction to poor returns during periods of monetary tightening.

In this section, we focus on a recent tightening cycle in 2022-2023 and examine how tighter monetary policy affects municipal funds that use TOB programs and its effect on the municipal bond market. The 2022-2023 interest rate hikes are particularly suitable for our analysis for two reasons. First, the surge in the benchmark rate during this period had a substantial impact on various rate-sensitive financial instruments, such as TOBs, and the institutions holding them. Between March 2022 and June 2023, the Federal Reserve raised the rates eleven times to combat inflation, increasing the federal funds rate from 0% to 5.5%. Notably, during the June-November 2022 period, the Fed implemented multiple aggressive 75-basis-point hikes to curb rising prices. These consecutive and sizable rate increases provide an ideal setting to identify nuances in the market, particularly for illiquid assets like municipal bonds.

Second, throughout the rate-hike period, the FOMC committee set the federal funds rate in a way that was unforeseen by the market. In this period, the Fed governors adjusted the benchmark rate and hiking frequency based on incoming inflation data. Given the difficulty in forecasting inflation trends, this data-dependent approach often led to unexpected changes in monetary policy. A notable example was the June 2023 FOMC meeting. Prior to the meeting, Fed Chair Jerome Powell stated that the committee would not consider a 75-basis-point increase. However, when the annual inflation growth surged to 9.1% in June 2022, the Fed quickly revised its stance, raising the federal funds rate by 75 basis points. This shift is also reflected in our analysis of monetary policy shocks. Using the measure from Nakamura and Steinsson (2018), we find that the average monetary policy surprise was 3% between March and December 2022, compared to just 1% over the entire sample period. The FOMC's data-dependent approach introduced significant surprises into the market's expectations of short-term borrowing rates.

Our analysis proceeds as follows. First, we document that TOB-using funds experienced significant investor redemptions during the 2022 monetary tightening. In response to these outflows, TOB users tended to liquidate their holdings to meet withdrawal demands. Finally, we show that these forced sales by TOB funds exerted downward price pressure on the sold securities.

5.1 Fund performance and flow

We conduct a fund-level analysis to examine how the use of TOB programs influences municipal fund flows and performance during the recent monetary tightening cycle. For each fund, we calculate fund performance in the year 2021 and 2022. We also calculate the cumulative flows over the January–December 2022 period to capture shareholders' responses to the monetary tightening. We start in January 2022, as the Federal Reserve signaled its intent to shift to a tighter monetary stance by reducing its stimulative asset purchases at the end of 2021. The analysis concludes in December 2022 to encompass all aggressive rate hikes that disrupted market expectations during this tightening cycle.

Next, we compare the performance and flow patterns of TOB-using funds with their peers who have not engaged in TOB transactions by estimating Equation (5) below. To mitigate econometric issues related to standard errors in panel datasets with short time dimensions (Bertrand, Duflo, and Mullainathan 2004; Donald and Lang 2007; Angrist and Pischke 2009; Cameron, Gelbach, and Miller 2008), we collapse our fund-month panel into one fund-level observation in 2021 and one fund-level observation in 2022. We then estimate the following regression at the fund-year level.

$$Y_{i,t} = \beta \times TOB\ Exposure_{j,2020Q4} \times Post + \gamma \times X_{j,t-1} + \mu_{fund} + \mu_t + \varepsilon_{i,j}, \quad (5)$$

where Y_i is either the annual fund flow or annual fund returns in year 2021 or 2022. The annual fund return is the sum of the monthly fund return in a given year. The annual fund flow is the sum of monthly fund flow in a given year. $TOB\ Exposure_{i,2020Q4}$ denotes a fund i's borrowing amount via TOB programs scaled by its total net assets in 2020 Q4, prior to the start of the sample period. $Post$ is an indicator variable, which equals 1 for 2022. The key variable of interest, $TOB\ Exposure_{j,2020Q4} \times Post$, captures fund performance and investor redemption with respect to TOB borrowing. We include an array of time-varying fund attributes as controls, including log (fund TNA), log (fund age), flow volatility, cash holding, the fraction of assets in institutional shares, and fund maturity. All the specifications contain fund fixed effects and year fixed effects. We cluster standard errors at the fund-objective level.[17]

Columns (1) and (2) report the results for fund returns. The coefficient on $TOB\ Exp_{i,2020Q4} \times Post$ is negative and statistically significant, which suggests that TOB funds underperformed non-users during this period, with a one-standard-deviation increase in TOB exposure decreasing fund returns by 147 bps in year 2022.[18] Columns (3) and (4) report the results of fund flow. The coefficient on $TOB\ Exp_{i,2020Q4} \times Post$ is negative and statistically significant, suggesting that TOB funds experienced greater investor outflows than non-TOB funds during the rate-hiking period. This finding corroborates our earlier result using a specific monetary policy shock, showing that shareholders of TOB users are more reactive to unanticipated changes in monetary policy. In Column (4), we include fund characteristics and the results are similar. A one-standard-deviation increase in TOB exposure leads to a higher outflow of 0.32% in 2022, corresponding to 25% of the sample mean of fund flow.[19]

Overall, the results in Table 6 demonstrate that the substantial interest rate risks embedded in the TOB structure dampen the funds' negative reactions to contractionary monetary policy. The liquidity transformation inherent in TOB programs amplifies payoff complementarities among fund shareholders, intensifying their reactions to the poor performance of TOB-using funds.

5.2 Municipal bond liquidation

After verifying that TOB funds experienced greater outflows, we investigate whether investor withdrawals, triggered by the 2022 monetary tightening, affect portfolio trading decisions

---

[17] The 2*2 DID setting can help address the serial correlation in the panel data, and we further conduct a cross-sectional regression at the fund level, regressing the percentage change in municipal bond holdings on the fund-level TOB exposure. Corresponding results are presented in Appendix B. For each fund, we calculate the cumulative return and flows over the January–December 2022 period to capture shareholders' responses to the monetary tightening.

[18] The standard deviation of TOB exposure is 0.0136493, 1.077*0.0136493 = 1.47%, which translates to ¼ of the standard deviation of fund return.

[19] The standard deviation of TOB exposure is 0.0136493, -0.233*0.0136493 = 0.32%, which translates to ¼ of the mean fund flow.

of TOB-using funds. We hypothesize that, in response to substantial redemptions during the tightening cycle, TOB funds are more likely to liquidate municipal assets to meet these redemption demands.

To test this prediction, we conduct a difference-in-differences regression at the fund-bond-year level, regressing the municipal bond holdings on the fund-level TOB exposure. Specifically,

$$Bond\ holding_{i,j,t} = \beta \times TOB\ Exposure_{j,2021Q3} \times Post + \gamma \times X_j + \mu_{fund} + \mu_{bond-year} + \varepsilon_{i,j}, \quad (6)$$

where $Bond\ holding_{i,j,t}$ denotes the ratio of par value of bond i held by fund j to the total net asset of fund j at 2021 Q4 or 2022 Q4. This variable aims to capture a fund's trading activity in a particular bond during the 2022 monetary tightening. $Post$ equals 1 for 2022, and zero for 2021 . $TOB\ Exposure_{j,2021Q3}$ represents fund j's borrowing amount through TOB programs at the end of 2021Q3, prior to the sample period. The key variable of interest, $TOB\ Exposure_{j,2021Q3} \times Post$, captures fund j's liquidation pattern after monetary policy tightening with respect to TOB borrowing. We include the same set of fund-level time-varying controls, as in Equation (1). To mitigate the influence of bond-specific characteristics, we follow the approach of Khwaja and Mian (2008) and saturate our specifications with bond-quarter fixed effects, $\mu_{bond-year}$. This within-bond estimation focuses on municipal bonds held by multiple funds, comparing trading patterns of the same bond in the same quarter between two distinct municipal funds: one with high TOB exposure and the other with limited TOB exposure. Standard errors are clustered at the bond and fund levels.

In Column (1) of Table 7 Panel A, the coefficient estimate on $TOB\ Exposure_{j,2021} \times Post$ is negative and statistically significant at the 1% level, consistent with our hypothesis that TOB-using funds liquidate municipal securities to satisfy investor withdrawals triggered by interest rate hikes. Column (2) further demonstrates that this result persists even after controlling for fund characteristics. A one-standard-deviation increase in TOB exposure is associated with a reduction of for a particular bond holding by 0.05%. The average holding for a particular bond is 1.35%, and the 0.05% reduction corresponds to approximately 3.7% of the sample mean for a particular bond. In column (3), we conduct a robustness test using the natural log of par value of bond holdings and we find similar a result. In Appendix B, we re-estimate Equation (6) and plot the dynamic of DID estimators using eight quarters of data from 2021 Q1 to 2022 Q4. Appendix Figure B4 plots the coefficients of TOB exposure interacting with each of the quarter dummies, and there is no violation of the parallel trend before the first fed rate increase in March 2022, and the coefficients on the interaction terms are significantly negative starting from 2022 Q1.[20]

In further analysis, we study the cross-sectional pattern of fund liquidation. We triple-interact $TOB\ Exposure_{j,2021} \times Post$ with bond character indicators. For each fund quarter, we separate each of a fund's municipal bond holdings into newly issued bonds vs non-newly issued bonds, longer remaining maturity bonds vs shorter remaining maturity bonds, and smaller value bonds vs larger value bonds based on the median value. In a fund quarter, if a bond's age is below the median, *New issue* equals one, otherwise zero; *Long maturity* equals one if a bond has longer remaining maturity, otherwise zero; *Low value* equals one if a bond represents a below-median percentage of TNA, otherwise zero. Panel B tabulates the corresponding results. Column (1) shows that newly issued bonds are more heavily sold by the TOB users. This is consistent with Ma, Xiao, and Zeng (2022) that liquid bonds are more likely to be sold during stress. Column (2) shows that bonds with longer maturity are more likely to be sold by TOB using funds, and this is due to the concern that the future increase in benchmark interest rate will dampen the valuation more for long-term bonds than short-term bonds. Column (3) shows that TOB users are more likely to sell bonds that account for a smaller proportion of the TNA.[21] It is important to note that municipal bond funds often utilize various liquidity management tools to meet withdrawal demands. For example, fund managers may liquidate their most liquid securities (e.g., cash and Treasuries), borrow from other funds within the same family, or even directly deliver held securities to redeeming investors (Agarwal and Zhao, 2019; Chernenko and Sunderam, 2020; Jiang, Li, and Wang, 2021; Ma, Xiao, and Zeng, 2022; Agarwal et al., 2023). Because our sample is restricted to illiquid fixed-coupon municipal bonds, our liquidation estimate already accounts for the effects of

[20] The 2*2 DID setting can help address the serial correlation in the panel data, and we further conduct a cross-sectional regression at the fund level, regressing the percentage change in municipal bond holdings on the fund-level TOB exposure. Corresponding results are presented in Appendix B.

[21] We don't find any significant cross-sectional evidence regarding the rated (77.20% of observations) and non-rated bonds (27.80% of observations). This is because the advisor and underwriter are the same for some municipal issues and due to the conflict of interest, many good-quality bonds choose not to be rated (e.g., Peppe and Unal, 2022). We find that compared to investment-grade bonds (65.90% of observations), junk bonds (6.30% of observations) are less likely to be sold, but the evidence is not statistically significant with a p-value of 0.15. Within investment grade bonds, AAA, AA, A, and BBB each account for 3.98%, 25.01%, 22.06%, and 14.86% of observation. We don't find any pattern within the investment-grade bonds.

these liquidity management practices. Specifically, when faced with redemption requests driven by monetary tightening, TOB-using funds likely draw on their cash reserves or liquidate other liquid assets before turning to their illiquid municipal holdings.[22]

5.3 Municipal bond market fragility

The prior section demonstrates that TOB-using funds reduce their municipal bond holdings to meet investor redemptions following the 2022 Fed monetary tightening. Given the illiquid nature of the municipal bond market, which is dominated by buy-and-hold retail investors, it is essential to determine whether the sales by TOB users depress the value of the bonds sold and contribute to broader destabilization of the municipal bond market. In this subsection, we examine whether municipal bonds exposed more to the selling pressure of TOB-using funds experience a larger price decline than low-exposure bonds.

We develop a bond-level fragility measure to capture the ex-ante exposure to forced sales by TOB funds. For each municipal bond, this measure is calculated as the weighted average of $TOB\ Exposure_{j,2021Q4}$ across all the funds holding the bond. $Holding\ amount_{j,i}$ represents the par value of bond i owned by fund j as of 2021 Q4. The weight for fund j is the ratio of its holdings in bond *i* to the total outstanding balance of bond *i* at the end of 2021,

$$TOB\ fragility_i(V1) = \sum_{j=1}^{N}(weight_{j,i,2021Q4} \times TOB\ Exposure_{j,2021Q4})$$
$$= \sum_{j=1}^{N}\left(\frac{Holding\ amount_{j,i,2021Q4}}{Outstanding\ balance_{i,2021Q4}} \times TOB\ Exposure_{j,2021Q4}\right).$$

To account for the fact that some bonds held by insurance companies or individual investors might be rarely traded, we also construct a second version of TOB fragility. The weight for fund *j* is the ratio of its holdings in bond *i* to the total holding of bond *i* at the end of 2021,

[22] We obtain fund-level cash holding directly from the CRSP Mutual fund database. This measure makes it hard for us to identify whether the cash is set aside for investor redemption, or the cash comes from liquidation of municipal bonds. In the first case, TOB users could have a lower cash level than non-TOB users since they have paid more for investor redemption; in the second case, TOB users could have a higher cash level since they liquidated more of their positions for cash. The other issue with this variable is that about a quarter of the observation has a negative value, see e.g., Goldstein, Jiang, and Ng (2017).

$$TOB\ fragility_i(V2) = \sum_{j=1}^{N}(weight_{j,i,2021Q4} \times TOB\ Exposure_{j,2021Q4})$$

$$= \sum_{j=1}^{N}\left(\frac{Holding\ amount_{j,i,2021Q4}}{\sum_{j=1}^{N} Holding\ amount_{j,i,2021Q4}} \times TOB\ Exposure_{j,2021Q4}\right).$$

where $TOB\ Exposure_{j,2021Q4}$ is the TOB exposure of fund j in 2021 Q4, which holds bond i in 2021 Q4. $Holding\ amount_{j,i,2021Q4}$ represents the par value of bond i owned by fund j as of 2021 Q4.

We begin our analysis by sorting all municipal bonds into two portfolios: the fragile portfolio (22% of sample bonds) and the non-fragile portfolio (78%). The fragile portfolio includes municipal bonds with positive fragility, which may experience liquidated sales by TOB-using funds. In contrast, the non-fragile portfolio comprises bonds that should be immune to this fragility risk. We then calculate cumulative returns from July 2021 to June 2023 for each portfolio using the equal-weighted average. This univariate analysis aims to assess whether TOB-using fund selling pressure affects municipal bond price responses (proxied by cumulative returns) to the 2022 monetary tightening is influenced by the level of fragility risk associated with TOB fund selling pressure.

Figure 6 illustrates the mean cumulative returns for the two bond portfolios. Prior to the monetary policy tightening, the returns of both groups followed a similar trend. However, following the Fed's rate hike in March 2022, the return differential began to widen, primarily driven by price declines in the fragile portfolio. This pattern is consistent with that TOB users liquidated municipal assets to meet investor redemptions spurred by the monetary tightening, and the selloff exerted a negative price pressure on securities in the fragile portfolio. The difference peaked at -2.93% in October 2022, when the Fed announced several unexpected 75 basis point rate increases. Starting in November 2022, the price of fragile bonds began to rebound, and the spread between the two portfolios eventually narrowed to nearly zero. This price recovery indicates that the price decline during the 2022 rate hikes was driven by temporary selling pressure from TOB-using funds rather than by differences in bond fundamentals, consistent with Coval and Stafford (2007).

Next, we conduct a multivariate analysis to address the concern that the documented findings are driven by bond characteristics. Based on the visual evidence in Figure 6, we separate the two-year period from July 2022 to June 2023 into three periods, the pre-hike period (July 2021 to February 2022), the drop period (March 2022 to October 2022), and the rebound period (November 2022 to June 2023). We calculate the bond return in each period. We then regress these three return measures on the bond-level fragility variable and the interaction with two indicator variables to analyze the relationship between bond fragility and price movements during these periods. To be specific, we estimate Equation (7) below,

$$\begin{aligned} Bond\ return_i = {} & \beta_1 \times TOB\ fragility_i \times\ Rate\ Hike \\ & + \beta_2 \times TOB\ fragility_i \times\ Rebond + \gamma \times X_i + \mu_{issuer-period} \\ & + \mu_{bond\ type} + \mu_{use\ of\ proceeds} + \mu_{rating} + \varepsilon_i, \end{aligned} \tag{7}$$

where $Bond\ return_i$ refers to returns of bond i over the pre-hike, drop period, or rebound period. As previously defined, TOB fragility for bond *i* is the par value-weighted average of TOB exposure across all the funds that investing in it. We add a set of bond-level controls X_i measured in 2021, including bond size, coupon rate, maturity, bond age, and mutual fund ownership. All the specifications include bond-issuer-period fixed effects, bond type fixed effects, use of proceeds fixed effects, and bond-rating fixed effects. These fixed effects can remove any confounding variations at the bond-issuer level. *Rate Hike* is an indicator that equals one for either the drop period or the rebound period. *Rebound* is an indicator that equals one for the rebound period. The coefficient of interest, β_1, measures the price impact of two similar bonds issued by the same municipality but with different exposure to TOB fragility risks in the drop period relative to the pre-hike period. β_2 measures the price impact of two similar bonds issued by the same municipality but with different exposure to TOB fragility risks in the recovery period compared to drop period; $\beta_1 + \beta_2$ measures the price impact of two similar bonds issued by the same municipality but with different exposure to TOB fragility risks in the recovery period relative to pre-hike period. Standard errors are clustered at the bond-issuer level to account for potential correlations within issuers.

In Column (1) of Table 8, the negative coefficient on $TOB\ fragility_i \times\ Rate\ Hike$ indicates that the return over the price drop period (March-October 2022) are negatively correlated with TOB fragility. This relationship is consistent with the univariate analysis, indicating that municipal bonds with higher exposure to TOB-related selloffs experienced more significant price declines than those with lower exposure. The economic impact is substantial: a one-standard-deviation increase in TOB fragility results in a 16.16 bps lower return over the drop period, which corresponds to 72% of the sample mean. The coefficient on $TOB\ fragility_i \times Rebond$ is positive and significant, which corresponds to the reversal pattern in the univariate analysis of Figure 6. This finding suggests that municipal bonds with higher TOB fragility risks, after initially being impacted by rate hikes, experienced a more pronounced price rebound compared to bonds with lower exposure. Economically, a one-standard-deviation increase in TOB fragility is associated with a 16.75 bps higher return during the rebound period, which is 75% of the sample mean. Column (2) demonstrates that this result remains robust even after controlling for bond characteristics. In Columns (3) and (4), we switch to the second measure of fragility and find similar results.

6 Conclusion

This paper investigates the transmission of monetary policy to municipal bond mutual funds and the broader municipal bond market through the use of tender option bonds (TOBs), a common leveraging strategy employed to enhance fund performance. Using a fund-level monthly panel from 2011 to 2023, we find that TOB-utilizing funds exhibit TOB funding costs that correlate highly with benchmark interest rates and engage more extensively in liquidity transformation. These characteristics impair fund performance in response to positive monetary shocks. Given the concave nature of the municipal bond fund flow-performance relationship, the fund flows are particularly sensitive to negative returns. Consequently, investors' strong responsiveness to fund performance leads to volatile fund flows and increased susceptibility to fund runs even more for the TOB users. particularly for TOB users. An analysis of the 2022–2023 monetary tightening cycle shows that TOB funds faced greater outflows and engaged in fire sales of municipal bond holdings, causing negative spillovers into the broader municipal bond market. Consequently, bonds within TOB users' portfolios experienced significant negative price impacts. Our findings underscore the role of monetary policy transmission in non-bank institutions, particularly fixed-income mutual funds, and its effects on the municipal bond market, especially through TOB usage. The results also suggest that policymakers should explicitly consider financial stability when formulating monetary policy (Stein, 2014).

References

Adelino, M., Cheong, S.C., Choi, J. and Oh, J.Y.J., 2023. Mutual fund flows and the supply of capital in municipal financing . National Bureau of Economic Research Working Paper No. 30980.

Agarwal, V., Ren, H., Shen, K., and Zhao, H., 2023. Redemption in kind and mutual fund liquidity management. *Review of Financial Studies* 36: 2274-2318

Agarwal, V. and Zhao, H., 2019. Interfund lending in mutual fund families: Role in liquidity management. *Review of Financial Studies*, *32*(10), pp.4079-4115.

Ang, A., Boivin, J., Dong, S. and Loo-Kung, R., 2011. Monetary policy shifts and the term structure. *Review of Economic Studies*, *78*(2), pp.429-457.

Angrist, J.D. and Pischke, J.S., 2009. *Mostly harmless econometrics: An empiricist's companion*. Princeton University Press.

Banegas, A., Montes-Rojas, G. and Siga, L., 2016. Mutual fund flows, monetary policy and financial stability. *Monetary Policy and Financial Stability (June 16, 2016)*.

Bauer, M.D., Bernanke, B.S. and Milstein, E., 2023. Risk appetite and the risk-taking channel of monetary policy. *Journal of Economic Perspectives*, *37*(1), pp.77-100.

Bertrand, M., Duflo, E. and Mullainathan, S., 2004. How much should we trust differences-in-differences estimates? *Quarterly Journal of Economics*, *119*(1), pp.249-275.

Cameron, A.C., Gelbach, J.B. and Miller, D.L., 2008. Bootstrap-based improvements for inference with clustered errors. *Review of Economics and Statistics*, *90*(3), pp.414-427.

Cetorelli, N., La Spada, G. and Santos, J.A., 2022. *Monetary policy and the run risk of loan funds* (No. 1008). Staff Report.

Chen, Q., Goldstein, I. and Jiang, W., 2010. Payoff complementarities and financial fragility: Evidence from mutual fund outflows. *Journal of Financial Economics*, *97*(2), pp.239-262.

Chernenko, S. and Sunderam, A., 2020. Do fire sales create externalities? *Journal of Financial Economics*, *135*(3), pp.602-628.

Choi, J., Kronlund, M. and Oh, J.Y.J., 2022. Sitting bucks: Stale pricing in fixed income funds. *Journal of Financial Economics*, *145*(2), pp.296-317.

Coval, J., and Stafford, E., 2007. Asset fire sales (and purchases) in equity markets. *Journal of Financial Economics* 86:479-512.

Dannhauser, C.D. and Hoseinzade, S., 2022. The unintended consequences of corporate bond ETFs: Evidence from the taper tantrum. *Review of Financial Studies*, *35*(1), pp.51-90.

Donald, S.G. and Lang, K., 2007. Inference with difference-in-differences and other panel data. *Review of Economics and Statistics*, *89*(2), pp.221-233.

Drechsler, I., Savov, A. and Schnabl, P., 2018. A model of monetary policy and risk premia. *Journal of Finance*, *73*(1), pp.317-373.

Edelen, R.M., 1999. Investor flows and the assessed performance of open-end mutual funds. *Journal of Financial Economics*, *53*(3), pp.439-466.

Fang, C., 2024. *Monetary policy amplification through bond fund flows*. Working Paper, Drexel University.

Feroli, M., Kashyap, A.K., Schoenholtz, K.L. and Shin, H.S., 2014. Market tantrums and monetary policy. *Chicago Booth Research Paper*, (14-09).

Goldsmith-Pinkham, P., Gustafson, M.T., Lewis, R.C. and Schwert, M., 2023. Sea-level rise exposure and municipal bond yields. *Review of Financial Studies*, *36*(11), pp.4588-4635.

Goldstein, I., Jiang, H. and Ng, D.T., 2017. Investor flows and fragility in corporate bond funds. *Journal of Financial Economics*, *126*(3), pp.592-613.

Gürkaynak, R.S., Sack, B.P. and Swanson, E.T., 2004. Do actions speak louder than words? The response of asset prices to monetary policy actions and statements. *International Journal of Central Banking,* 1, pp 55–93.

Gürkaynak, R.S., Sack, B. and Swanson, E., 2005. The sensitivity of long-term interest rates to economic news: Evidence and implications for macroeconomic models. *American Economic Review*, *95*(1), pp.425-436.

Hanson, S.G. and Stein, J.C., 2015. Monetary policy and long-term real rates. *Journal of Financial Economics*, *115*(3), pp.429-448.

Jiménez, G., Ongena, S., Peydró, J.L. and Saurina, J., 2014. Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking? *Econometrica*, *82*(2), pp.463-505.

Jiang, H., Li, D., and Wang, A., 2021. Dynamic liquidity management by corporate bond mutual funds. *Journal of Financial and Quantitative Analysis* 56:1622-1652.

Kashyap, A.K. and Stein, J.C., 1994. Monetary policy and bank lending. In *Monetary policy* (pp. 221-261). The University of Chicago Press.

Kashyap, A.K. and Stein, J.C., 2023. Monetary policy when the central bank shapes financial-market sentiment. *Journal of Economic Perspectives*, *37*(1), pp.53-75.

Kekre, R. and Lenel, M., 2022. Monetary policy, redistribution, and risk premia. *Econometrica*, *90*(5), pp.2249-2282.

Khwaja, A.I. and Mian, A., 2008. Tracing the impact of bank liquidity shocks: Evidence from an emerging market. *American Economic Review*, *98*(4), pp.1413-1442.

Kung, H., 2015. Macroeconomic linkages between monetary policy and the term structure of interest rates. *Journal of Financial Economics*, *115*(1), pp.42-57.

Kuong, J., O'Donovan, J. and Zhang, J., 2024. Monetary Policy and Fragility in Corporate Bond Funds. 161

Li, L., Li, Y., Macchiavelli, M. and Zhou, X., 2021. Liquidity restrictions, runs, and central bank interventions: Evidence from money market funds. *The Review of Financial Studies*, *34*(11), pp.5402-5437.

Li, Y., O'Hara, M. and Zhou, X., 2024. Mutual fund fragility, dealer liquidity provision, and the pricing of municipal bonds. *Management Science*, *70*(7), pp.4802-4823.

Ma, Y., Xiao, K. and Zeng, Y., 2022. Mutual fund liquidity transformation and reverse flight to liquidity. *The Review of Financial Studies*, *35*(10), pp.4674-4711.

Nakamura, E. and Steinsson, J., 2018. High-frequency identification of monetary non-neutrality: the information effect. *Quarterly Journal of Economics*, *133*(3), pp.1283-1330.

Nakamura, E. and Steinsson, J., 2021. Monetary Economics. *NBER Reporter*, (4), pp.1-5.

Paligorova, T. and Santos, J.A., 2017. Monetary policy and bank risk-taking: Evidence from the corporate loan market. *Journal of Financial Intermediation*, *30*, pp.35-49.

Starks, L.T., Yong, L. and Zheng, L., 2006. Tax-loss selling and the January effect: evidence from municipal bond closed-end funds. *Journal of Finance*, *61*(6), pp.3049-3067.

Stein, J., 2014. *Incorporating financial stability considerations into a monetary policy framework: A speech at the international research forum on monetary policy,* Washington, DC, March 21, 2014 (No. 796). Board of Governors of the Federal Reserve System (US).

Swanson, E.T., 2021. Measuring the effects of federal reserve forward guidance and asset purchases on financial markets. *Journal of Monetary Economics*, *118*, pp.32-53.

Swanson, E.T. and Williams, J.C., 2014. Measuring the effect of the zero lower bound on medium-and longer-term interest rates. *American Economic Review*, *104*(10), pp.3154-3185.

Figure 1: The structure of a tender option bond (TOB) program.
This figure illustrates the structure of a TOB program.

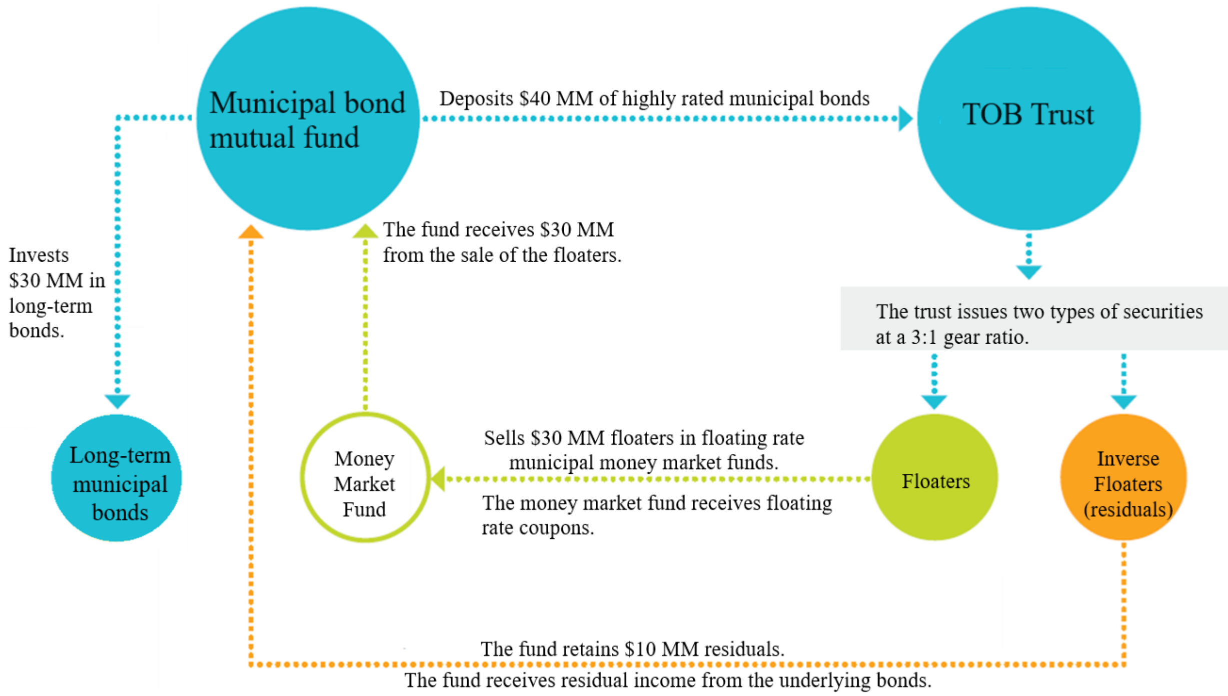
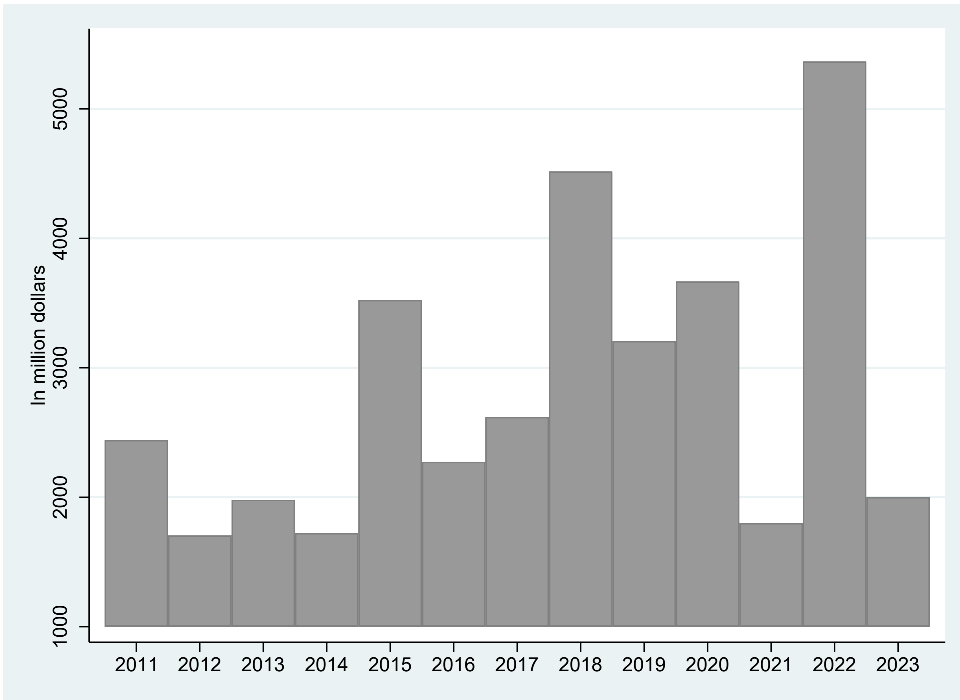


Figure 2: TOB floater issuance and termination amount
Panel A plots the aggregated floater issuance amount (in million dollars) per year. Panel B plots the residual termination amount by year.

Panel A: Floater issuance amount



Panel B: Floater termination amount

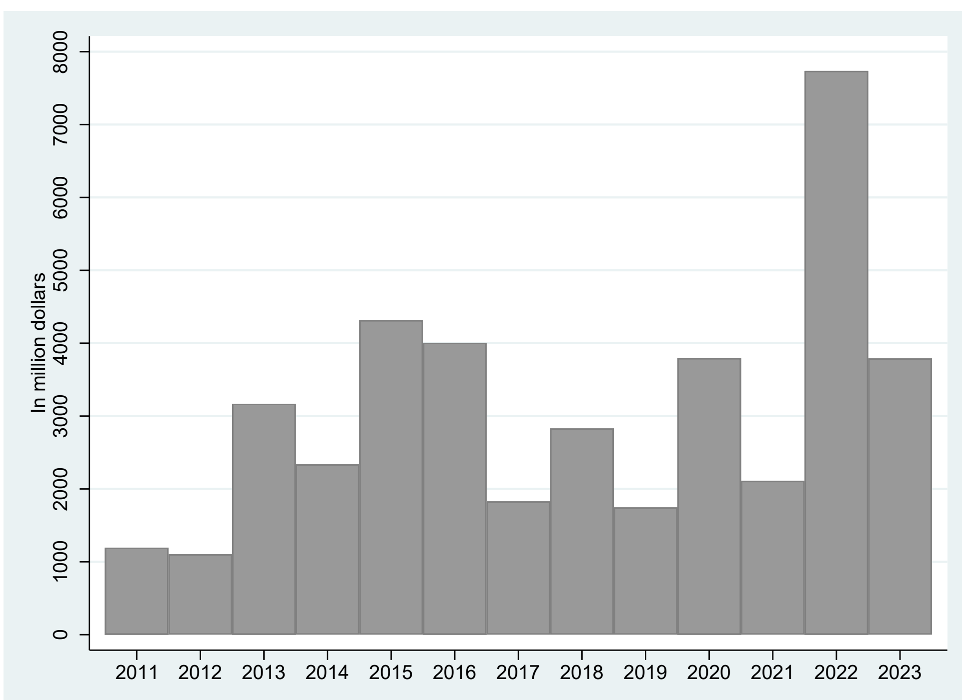


Figure 3: TOB gear ratio distribution
This figure plots the TOB gear ratio distribution at initiation from January 2011 to December 2023.

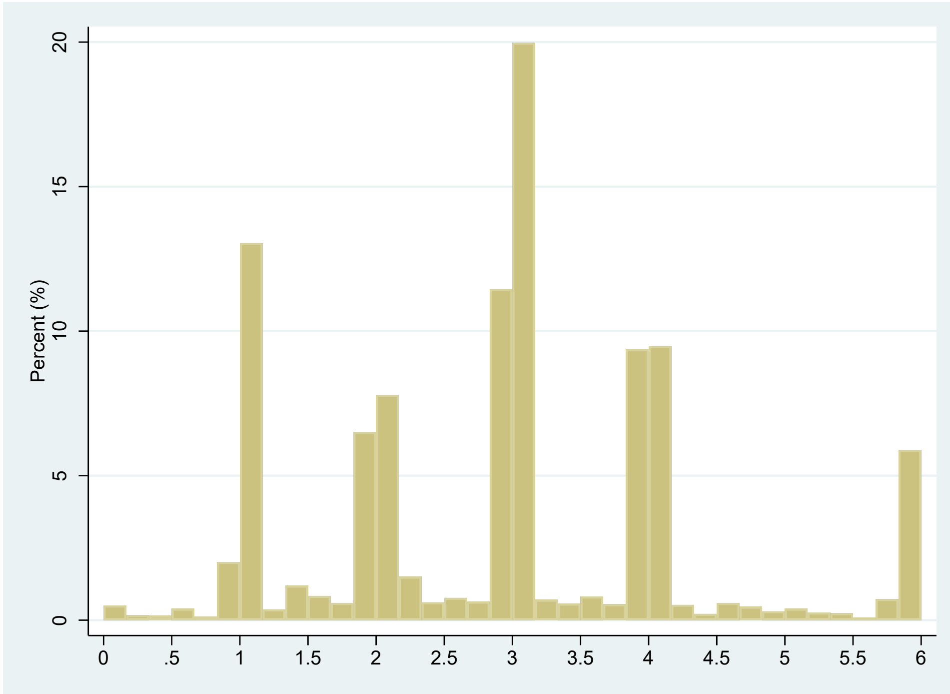


Figure 4: TOB yield and Federal Funds Rate
This figure plots the TOB yield (black dashed line) and the Federal Funds Rate (red solid line) from January 2011 to December 2023.

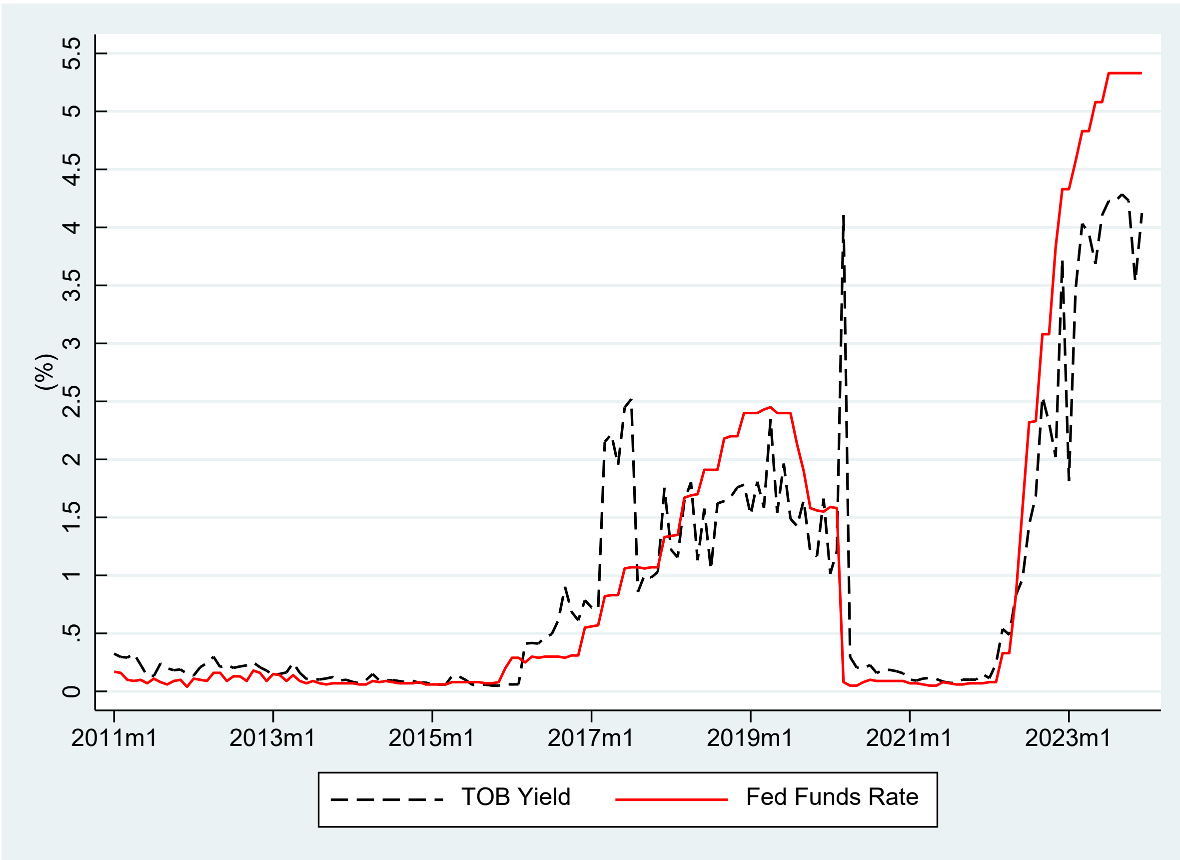
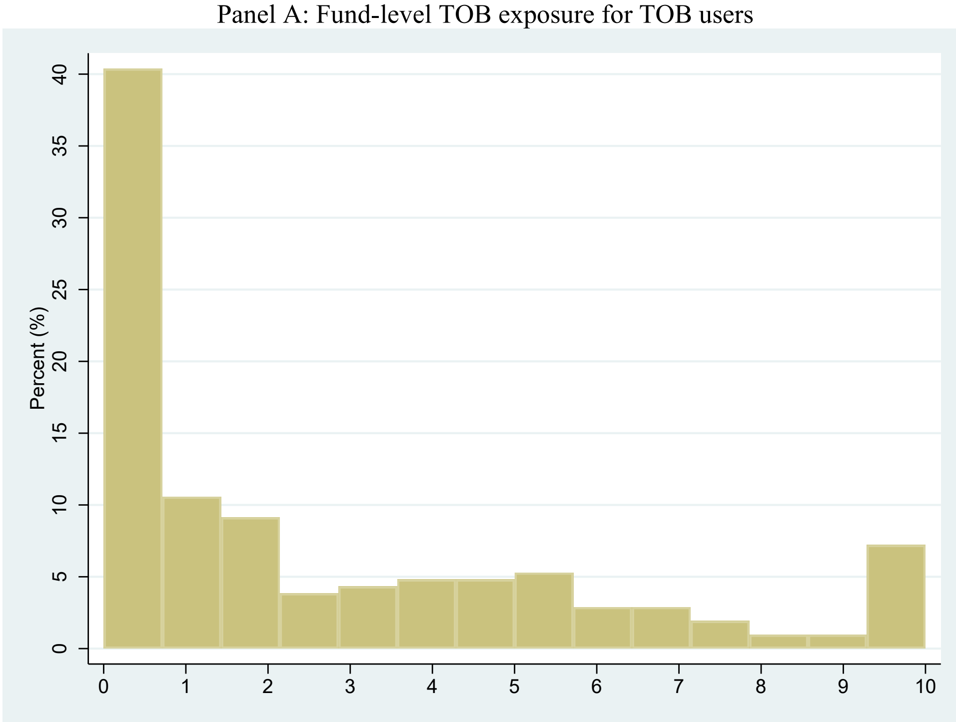


Figure 5: TOB exposure and borrowing amount for TOB users
This figure plots the TOB usage at the fund level. Panel A plots TOB exposure for TOB users. Panel B plots the percent (and the aggregate TNA amount for TOB users. Panel B plots the aggregate TOB borrowing amount (black dash line) and aggregate TNA of all municipal bond mutual funds (red solid line) from 2011 to 2023.

Panel A: Fund-level TOB exposure for TOB users



Panel B: Aggregate TOB borrowing amount

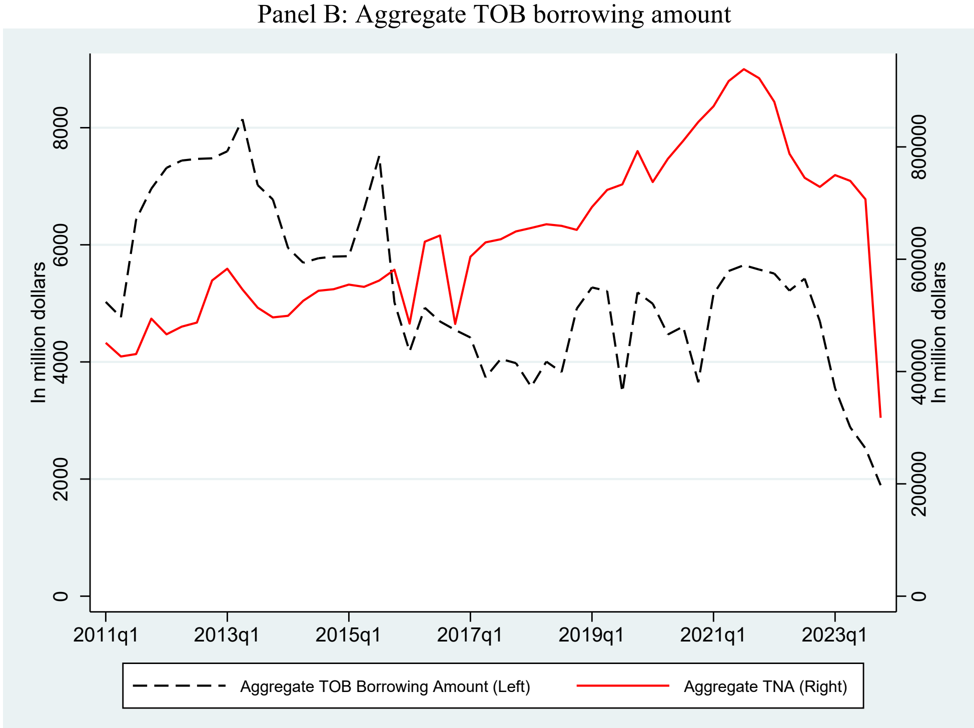


Figure 6: TOB fragility and municipal bond price impact
Figure 6 plots municipal bond returns for the pre-hike period (July 2021 to February 2022), drop period (March 2022 to October 2022), and rebound period (November 2022 to June 2023) with respect to TOB fragility. The black dashed line represents the fragile portfolio (22% of the sample) and the red solid line represents the non-fragile portfolio (78%). For each portfolio, we calculate cumulative monthly returns from July 2021 to June 2023 using equal-weighted averages.

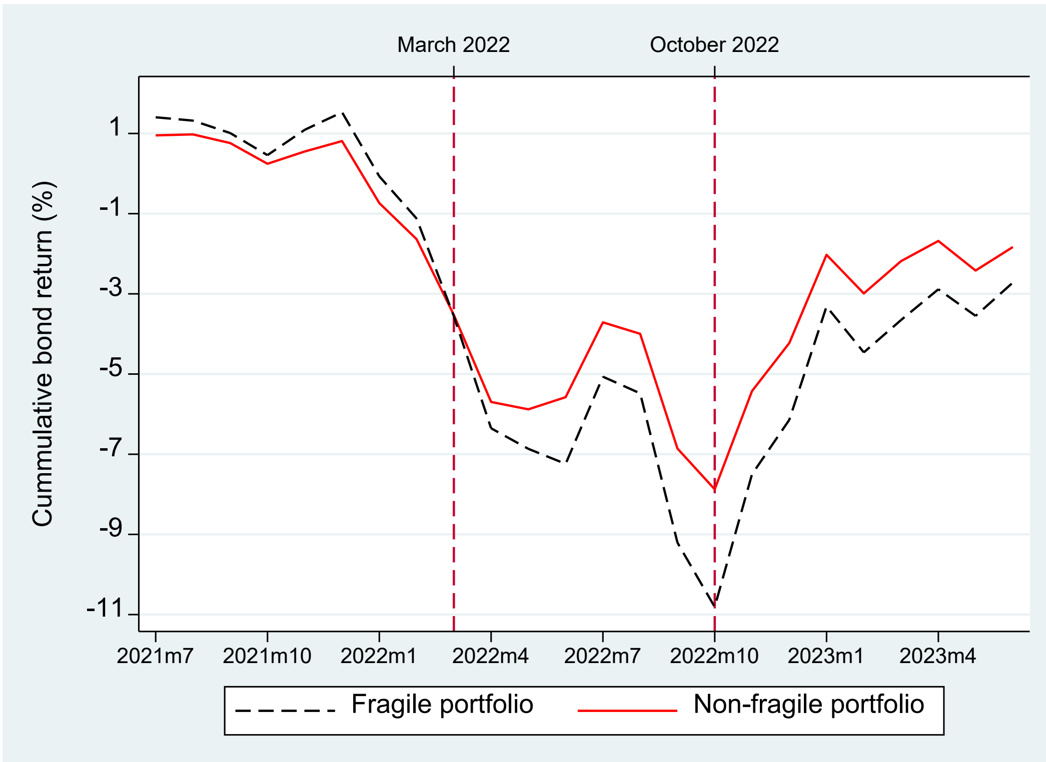


Table 1: TOB usage and TOB exposure by year

Table 1 tabulates the TOB usage by funds and the average TOB exposure at the fund level by year. *# TOB funds* stands for the number of TOB-using funds. *# funds* stands for the number of municipal bond mutual funds. *TNA (TOB funds, $mil)* stands for the total net asset of all TOB-using funds, in million dollars. *TNA (all funds, $mil)* stands for the total net asset of all municipal bond mutual funds, in million dollars. *% TOB (by # funds)* stands for the percentage of TOB using funds by number and is the ratio of *# TOB funds* divided by *# funds. % TOB (by TNA)* stands for the percentage of TOB using funds by TNA and is the ratio of *TNA (TOB funds) divided* by *TNA (all funds). TOB exposure (TOB funds)* is the average TOB exposure for TOB-using funds. *TOB exposure (all funds)* is the average TOB exposure for all municipal bond mutual funds.

Year	*# TOB funds*	*# funds*	*TNA (TOB funds, $mil)*	*TNA (all funds, $mil)*	*% TOB (by # funds)*	*% TOB (by TNA)*	*TOB exposure (TOB funds)*	*TOB exposure (all funds)*
2011	124	553	128,841.90	459,354.70	22.42%	28.05%	7.55%	1.69%
2012	110	545	156,910.40	528,815.40	20.18%	29.67%	6.76%	1.37%
2013	109	538	135,212.90	455,571.40	20.26%	29.68%	7.25%	1.46%
2014	98	539	129,761.60	513,274.60	18.18%	25.28%	6.44%	1.16%
2015	109	548	192,417.60	533,603.60	19.89%	36.06%	6.07%	1.20%
2016	104	554	177,740.10	554,443.80	18.77%	32.06%	5.10%	0.96%
2017	98	549	177,408.60	593,776.50	17.85%	29.88%	4.98%	0.89%
2018	89	539	153,397.30	598,350.70	16.51%	25.64%	5.56%	0.92%
2019	95	530	208,615.80	708,574.90	17.92%	29.44%	4.11%	0.74%
2020	88	527	208,438.50	766,019.80	16.70%	27.21%	3.61%	0.60%
2021	77	525	223,914.10	848,185.30	14.67%	26.40%	3.43%	0.50%
2022	84	521	172,974.80	646,313.00	16.12%	26.76%	4.23%	0.68%
2023	66	517	122,012.50	656,562.90	12.77%	18.58%	3.79%	0.48%

Table 2: Summary statistics for the TOB program, the panel, and the monetary policy tightening event study

This table reports summary statistics for the TOB program, the panel data from January 2011 to December 2023, and the monetary policy tightening event study. Panel A tabulates TOB security-related variables. Residual offering size ($M), Floater offering size ($M), Gear ratio, and TOB nominal maturity (year) are at the TOB security level. Floater amt outstanding ($M), Residual amt outstanding ($M), and TOB yield (%) are at the fund-security-month level. Panel B tabulates the variables used in the panel sample. Panel C tabulates monetary shock measures. Panels D, E, and F report summary statistics for the 2022~2023 monetary policy tightening cycle event study. Panel D tabulates fund-year-level summary statistics. Panel E tabulates the variables at the fund-bond-year level. Panel F tabulates the variables at the bond-period level. All variables are winsorized at 1% and 99% levels. Definitions and the data sources for all variables are included in Appendix A.

Panel A: TOB security-related variables

	Obs	Mean	SD	P25	P50	P75
Residual offering size ($M)	12,641	6.766	14.86	0.665	3.105	6.435
Floater offering size ($M)	12,641	23.29	36.73	7.500	11.58	22.50
Gear ratio	11,964	6.930	7.456	1.999	3.000	10.510
TOB nominal maturity (year)	12,641	20.88	9.865	13.76	23.15	29.06
Floater amt outstanding ($M)	358,684	16.95	20.17	6.790	10.27	18.66
Residual amt outstanding ($M)	125,958	3.990	3.981	1.500	2.700	5
TOB yield (%)	358,684	0.735	1.332	0.110	0.230	0.980

Panel B: Variables in panel data from January 2011 to December 2023

	Obs	Mean	SD	P25	P50	P75
TOB exposure (%, TOB exposure>0)	13,304	5.086	4.853	1.479	3.488	7.460
TOB exposure (%, full sample)	80,032	0.845	2.739	0	0	0
TOB funding cost (%)	12,550	0.785	1.388	0.0961	0.235	1.086
Monthly return (%)	80,058	0.246	1.405	-0.280	0.265	0.888
Monthly flow (%)	79,846	-0.00964	3.061	-1.057	-0.163	0.809
Log (TNA)	79,911	6.001	1.390	4.914	5.859	6.955
Log (Fund age)	80,086	5.456	0.726	5.328	5.707	5.903
12-month past returns (%)	79,715	0.0361	1.267	-0.551	0.00622	0.596
Cash holding (%)	80,086	1.439	2.976	0	0.770	1.980
Fraction of assets in institutional shares	79,911	0.342	0.359	0	0.203	0.636
Fund maturity (year)	79,702	14.54	5.046	10.42	15.22	18.65
Fund staleness	79,815	0.246	0.277	0.101	0.284	0.439

Panel C: Monetary policy shock

	Obs	Mean	SD	P25	P50	P75
NS	156	0.00238	0.0197	0	0	0.00629
GSS target factor	156	0.00195	0.0125	0	0	0.00389
GSS path factor	156	0.00296	0.0435	-0.000783	0	0.00967
2-year Treasury yield	156	-0.00987	0.0714	-0.0200	0	0.01000

Panel D: Fund-year-level summary statistics for 2022~2023 monetary tightening cycle event study

	Obs	Mean	SD	P25	P50	P75
Annual fund return	1,016	-0.033	0.060	-0.089	-0.004	0.016
Annual fund flow	1,016	-0.012	0.038	-0.028	-0.007	0.005
TOB exposure (%, TOB>0)	126	3.245	2.414	1.277	2.666	5.437
TOB exposure (%, full sample)	1,016	0.402	1.365	0.000	0.000	0.000
Log (TNA)	1,016	6.134	1.628	5.075	6.122	7.225
Log (Fund age)	1,016	5.529	0.730	5.239	5.826	6.016
12-month past return (%)	1,016	0.000	0.010	-0.005	-0.000	0.005
Cash holding (%)	1,016	1.663	3.201	0.000	0.865	2.195
Fraction of assets in institutional shares	1,016	0.444	0.361	0.078	0.398	0.781
Fund maturity (year)	1,016	14.556	5.056	10.696	14.746	18.765
Fund staleness	1,016	0.232	0.273	0.154	0.308	0.401

Panel E: Fund-bond-year-level summary statistics for 2022~2023 monetary tightening cycle event study

	Obs	Mean	SD	P25	P50	P75
Percentage holdings	464,842	1.358	2.848	0.001	0.240	1.242
Log value of holdings	464,842	10.541	6.192	8.294	13.629	14.626
TOB exposure (%, TOB>0)	89,696	4.901	7.379	0.844	2.494	5.779
TOB exposure (%, full sample)	464,842	0.946	3.775	0.000	0.000	0.000
Log (TNA)	464,842	7.769	1.698	6.596	7.800	8.917
Log (Fund age)	464,842	5.652	0.684	5.308	5.953	6.107
Prior month flow	464,842	-0.008	0.032	-0.022	-0.004	0.008
12-month past return	464,842	0.001	0.015	-0.006	0.000	0.007
Cash holding	464,842	1.394	2.992	0.000	0.290	1.750
Fraction of assets in institutional shares	464,842	0.456	0.357	0.038	0.464	0.774
Fund maturity	464,842	15.492	4.643	11.727	15.562	19.629
Fund staleness	464,842	0.352	0.238	0.286	0.448	0.496

Panel F: Bond-period-level summary statistics for 2022~2023 monetary tightening cycle event study

	Obs	Mean	SD	P25	P50	P75
Bond return	177,934	-0.002	0.041	-0.013	0.000	0.009
Bond fragility V1	177,934	0.001	0.004	0.000	0.000	0.000
Bond fragility V2	177,934	0.004	0.014	0.000	0.000	0.000
Log (Bond size)	177,934	2.292	1.093	1.434	2.167	3.045
Coupon	177,934	4.524	0.972	4.000	5.000	5.000
Maturity (year)	177,934	11.563	7.230	6.000	10.000	16.000
Bond age (year)	177,934	4.786	3.377	2.000	4.000	7.000
MF Ownership	177,934	0.426	0.291	0.200	0.375	0.608

Table 3: TOB funding costs and fund performance to monetary policy shock.

Panel A reports estimates for equation (1) for TOB users with the fund-month panel from January 2011 to December 2023,

$$TOB\ funding\ costs_{i,t} = \beta_1 \times NS\ policy\ shock_t + \beta_2 \times TOB\ Exposure_{i.t-1} + \gamma \times X_{i.t-1} + \mu_{fund-objective} + \varepsilon_{i,t}.$$

$TOB\ funding\ costs_{i,t}$ denotes the weighted average TOB yields from all the floaters linked to the residuals held by fund *i*; the weights are the holding amount of floaters reported in N-MFP filings. Panel B reports estimates for equation (2) for all funds using the fund-month panel from January 2011 to December 2023,

$$Fund\ Return_{i,t} = \beta \times TOB\ Exposure_{i.t-1} \times MP\ Surprise_t + \gamma \times X_{i.t-1} + \mu_{fund-objective} + \mu_t + \varepsilon_{i,t}.$$

$Fund\ Return_{i,t}$ denotes the monthly return of fund i in year-month t from CRSP Survivor-Bias-Free Mutual Fund database. Control variables and fixed effects are indicated in the panels. Definitions and the data sources for all variables are included in Appendix A. Fixed effects and heteroscedasticity-robust standard errors are indicated in the table. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: TOB funding costs to monetary policy shock

	(1)	(2)
Dependent variable	*TOB funding costs*	
NS policy shock	3.385***	2.736***
	(11.568)	(7.926)
TOB exposure		0.541
		(0.339)
Log (TNA)		-0.044
		(-0.858)
Log (Fund age)		0.428***
		(6.088)
Prior month flow		0.056
		(0.097)
12-month past return		-0.089
		(-0.032)
Cash holding		-0.019**
		(-2.034)
Fraction of assets in institutional shares		0.924***
		(4.448)
Fund maturity		0.011
		(0.737)
Fund staleness		0.277***
		(4.380)
Fund-objective FE	Yes	Yes
Clustered SE	Fund	Fund
Observations	12,550	12,488
Adjusted R-squared	0.021	0.053

Panel B: Fund performance to monetary policy shock

	(1)	(2)
Dependent variable	*Monthly return*	
*TOB exposure * NS policy shock*	-0.801***	-0.776***
	(-7.116)	(-7.187)
TOB exposure	0.009***	0.008***
	(7.047)	(6.225)
Log (TNA)		-0.000
		(-0.142)
Log (Fund age)		-0.000
		(-0.894)
Prior month flow		0.000
		(0.141)
12-month past return		0.005**
		(2.340)
Cash holding		-0.000
		(-0.335)
Fraction of assets in institutional shares		0.000
		(1.273)
Fund maturity		0.000***
		(9.529)
Fund staleness		-0.001***
		(-6.226)
Fund-objective FE	Yes	Yes
Year-month FE	Yes	Yes
Clustered SE	Fund & year-month	Fund & year-month
Observations	80,004	78,956
Adjusted R-squared	0.840	0.842

Table 4: Fund payoff complementary and liquidity transformation

This table presents the results for fund payoff complementary and liquidity transformation. Column (1) presents the estimates for equation (3),

$$Fund\ Flow_{i,t} = \alpha + \beta_1 \times Past\ Return_{t-12\to t-1} + \beta_2 \times I(Past\ Return_{t-12\to t-1} < 0) + \beta_3 \times Past\ Return_{t-12\to t-1} \times I(Past\ Return_{t-12\to t-1} < 0) + \gamma \times X_{i.t-1} + \mu_{fund-objective} + \mu_t + \varepsilon_{i,t},$$

using the fund-month panel from January 2011 to December 2023. $Fund\ Flow_{i,t}$ denotes monthly percent change in the TNA of fund i in year-month t. Columns (2) adds TOB using indicator, *I (TOB user)*, and interact with the non-linear performance function. All columns fund-objective fixed effects and year-month fixed effects. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors clustered by fund and year-month are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)
Dependent variable	*Fund flow*	
Past returns	0.114***	0.150***
	(4.629)	(4.787)
I (Past returns <0)	-0.002***	-0.002***
	(-6.231)	(-5.582)
*I (Past return <0) * Past return*	0.186***	0.142***
	(4.858)	(3.109)
*I (TOB user) * Past returns*		-0.112**
		(-2.422)
*I (TOB user) * I (Past returns <0)*		0.000
		(0.610)
*I (TOB user) * I (Past returns <0) * Past returns*		0.167**
		(2.414)
I (TOB user)		0.001
		(1.247)
Log (TNA)	0.000	0.000
	(0.942)	(0.962)
Log (Fund age)	-0.006***	-0.006***
	(-12.256)	(-12.289)
Prior month flow	0.270***	0.269***
	(15.596)	(15.618)
Cash holding	0.000***	0.000***
	(4.258)	(4.144)
Fraction of assets in institutional shares	-0.000	-0.000
	(-0.130)	(-0.192)
Fund maturity	-0.000	-0.000
	(-1.084)	(-0.871)
Fund staleness	-0.000	-0.000
	(-0.459)	(-0.444)
Fund-objective FE	Yes	Yes
Year-month FE	Yes	Yes
Clustered SE	Fund & year-month	Fund & year-month
Observations	78,895	78,895
Adjusted R-squared	0.223	0.224

Table 5: Monetary policy shock and fund flow

This table reports estimates for equation (4),

$$Fund\ flow_{i,t} = \beta \times TOB\ Exp_{i.t-1} \times MP\ Surprise_t + \gamma \times X_{i.t-1} + \mu_{fund} + \mu_t + \varepsilon_{i,t},$$

using the fund-month panel from January 2011 to December 2023. $Fund\ Flow_{i,t}$ denotes monthly percent change in the TNA of fund i in year-month t. Panel A uses NS measure and Panel B applies the two measures from Gürkayna, Sack, and Swanson (2005), the *GSS target factor* and *GSS path factor*, and changes in two-year treasury yield (Hanson and Stein, 2015), *2-year Treasury Yield,* as monetary policy shock. All columns fund fixed effects and year-month fixed effects. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors clustered by fund and year-month are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Monetary policy shock and fund flows

	(1)	(2)	(3)
Dependent variable		*Fund flow*	
*TOB exposure * NS policy shock*	-0.552***	-0.641***	-0.637***
	(-2.694)	(-2.968)	(-3.472)
TOB exposure	-0.027*	-0.026*	-0.002
	(-1.769)	(-1.711)	(-0.150)
*Fund staleness * NS policy shock*		-0.071	-0.078*
		(-1.633)	(-1.954)
Fund staleness		-0.000	-0.001
		(-0.238)	(-1.240)
Log (TNA)			-0.005***
			(-7.129)
Log (Fund age)			-0.015***
			(-9.110)
Prior month flow			0.227***
			(13.917)
12-month past return			0.219***
			(13.295)
Cash holding			0.000***
			(3.615)
Fraction of assets in institutional shares			-0.001
			(-0.400)
Fund maturity			-0.000
			(-1.540)
Fund FE	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes
Clustered SE	Fund & year-month	Fund & year-month	Fund & year-month
Observations	79,835	79,645	78,892
Adjusted R-squared	0.185	0.185	0.255

Panel B: Alternative monetary policy measures

	(1)	(2)	(3)
Dependent variable		*Fund flow*	
TOB exposure * GSS target factor	-0.297		
	(-1.278)		
TOB exposure * GSS path factor		-0.285***	
		(-3.081)	
*TOB exposure * 2-year Treasury yield*			-0.412***
			(-7.413)
TOB exposure	-0.002	-0.003	-0.003
	(-0.211)	(-0.226)	(-0.270)
Fund controls	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes
Observations	78,892	78,892	78,892
Adjusted R-squared	0.255	0.255	0.255

Table 6: Fund performance and flow during the monetary tightening cycle

This table reports the estimates for equation (5),

$$Y_i = \beta \times TOB\ Exp_{i,2020Q4} \times Post + \gamma \times X_i + \mu_{fund} + \mu_{year} + \varepsilon_i,$$

where Y_i stands for annual fund flow and return in the year 2021 and the year2022. $TOB\ Exp_{j,2020Q4}$ represents a fund i's borrowing amount through TOB programs at the end of 2020 Q4. $Post$ equals one for the year 2022 and zero for the year 2021. Columns (1) and (2) report the estimates for annual fund return. Columns (3) and (4) report the estimates for annual fund flow. All columns add fund fixed effects and year fixed effects. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors clustered by fund objectives are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent variable	*Fund return*		*Fund flow*	
*TOB exposure * Post*	-1.233***	-1.077***	-0.276**	-0.233**
	(0.121)	(0.123)	(0.124)	(0.112)
Log (TNA)		-0.077***		0.010
		(0.016)		(0.017)
Log (Fund age)		0.105***		-0.020
		(0.039)		(0.051)
Prior year flow		-0.007		0.357***
		(0.012)		(0.095)
12-month past return		-0.107		1.080***
		(0.196)		(0.337)
Cash holding		-0.000		-0.001
		(0.001)		(0.001)
Fraction of assets in institutional shares		-0.030		0.024
		(0.025)		(0.025)
Fund maturity		-0.001		-0.011
		(0.003)		(0.013)
Fund staleness		-0.033**		0.001
		(0.015)		(0.002)
Year FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Clustered SE	Fund	Fund	Fund	Fund
Observations	1,016	1,016	1,016	1,016
Adjusted R-squared	0.688	0.723	0.174	0.252

Table 7: Fund liquidation during the monetary tightening cycle

This table presents the results of municipal bond liquidation by funds during the monetary policy tightening cycle from 2021 to 2022 with respect to TOB usage. Panel A estimated estimates for Equation (6),

$$Bond\ holding_{i,j,t} = \beta \times TOB\ Exposure_{j,2021Q3} \times Post + \gamma \times X_j + \mu_{fund} + \mu_{bond-year} + \varepsilon_{i,j}.$$

In Columns (1) and (2), the dependent variable, $Bond\ holding_{i,j,t}$ is the ratio of par value of bond i to the total net asset of fund j at the end of 2021 Q4 or 2022 Q4. Column (3) uses natural log of bond i's par value as the dependent variable. $TOB\ Exp_{j,2021Q3}$ represents a fund i's borrowing amount through TOB programs at the end of 2021 Q3. $Post$ equals one for the year 2022 and zero for the year 2021. Panel B presents the cross-sectional analysis. *New issue, Long maturity,* and *Low value* are indicators that equal to one if a bond is age is below median, remaining maturity is above the median, or represents a below-median fraction of TNA for each fund-quarter. Double interactions are omitted due to the length of the table. Fund fixed effects and bond*year fixed effects are added to the model. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors with two-way clustered at bond and fund level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Fund liquidation during the monetary tightening cycle

Dependent variable	(1) *Percentage holdings*	(2) *Percentage holdings*	(3) *Log value of holdings*
*TOB exposure * Post*	-0.852***	-1.342***	-3.781***
	(0.180)	(0.445)	(1.247)
Log (TNA)		-0.329**	3.280***
		(0.153)	(0.447)
Log (Fund age)		0.141	1.136
		(0.433)	(2.050)
Prior month flow		-0.0731	3.847
		(1.067)	(3.135)
12-month past return		-1.477	5.215
		(1.560)	(4.323)
Cash holding		-0.0118***	-0.0442**
		(0.00433)	(0.0203)
Fraction of assets in institutional shares		0.279*	0.916
		(0.146)	(0.567)
Fund maturity		0.00111	-0.0950
		(0.0236)	(0.0797)
Fund staleness		0.804***	4.238***
		(0.116)	(0.576)
Bond * year FE	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes
Clustered SE	Fund & Bond	Fund & Bond	Fund & Bond
Observations	464,842	464,842	464,842
Adjusted R-squared	0.457	0.458	0.496

Panel B: Fund liquidation during the monetary tightening cycle, cross-sectional analysis

VARIABLES	(1) *Bond age*	(2) *Remaining maturity*	(3) *Bond value*
*TOB exposure * Post * New issue*	-1.584***		
	(0.426)		
*TOB exposure * Post * Long maturity*		-0.992***	
		(0.323)	
*TOB exposure * Post * Low value*			-0.665*
			(0.349)
*TOB exposure * Post*	-0.577	-0.792*	-0.774
	(0.462)	(0.448)	(0.506)
Log (TNA)	-0.311**	-0.335**	-1.141***
	(0.154)	(0.153)	(0.232)
Log (Fund age)	0.132	0.0933	-1.527**
	(0.433)	(0.420)	(0.734)
Prior month flow	-0.0978	0.0122	0.179
	(1.062)	(1.061)	(1.284)
12-month past return	-1.520	-1.661	-0.280
	(1.558)	(1.531)	(1.920)
Cash holding	-0.0116***	-0.0116***	-0.0254***
	(0.00427)	(0.00428)	(0.00609)
Fraction of assets in institutional shares	0.236	0.268*	0.212
	(0.145)	(0.144)	(0.257)
Fund maturity	0.00264	-0.000193	-0.0333
	(0.0235)	(0.0237)	(0.0312)
Fund staleness	0.810***	0.738***	0.435***
	(0.116)	(0.123)	(0.136)
R-squared	0.590	0.589	0.682
Bond * quarter FE	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes
Clustered SE	Fund & Bond	Fund & Bond	Fund & Bond
Observations	464,842	464,842	359,312
Adjusted R-squared	0.458	0.458	0.574

Table 8: Municipal bond price impact during the monetary tightening cycle

This table presents the effect of TOB exposure on municipal bond price impact during the monetary tightening cycle by estimating equation (7),

$$Bond\ return_i = \beta_1 \times TOB\ fragility_i * Rate\ Hike + \beta_2 \times TOB\ fragility_i * Rebond + \gamma \times X_i + \mu_{issuer-period} + \mu_{bond\ type} + \mu_{use\ of\ proceeds} + \mu_{rating} + \varepsilon_i.$$

$Bond\ return_i$ is the cumulative monthly returns for bond i in one of the three periods, from July 2021 to February 2022 (pre-rate hike period), from March 2022 to October 2022 (drop period), or from November 2022 to June 2023 (rebound period). $TOB\ fragility_i$ for a bond is the holding-weighted average of $TOB\ Exp_{j,2021}$ of all the funds that invest in it, scaled by the total outstanding balance (*V1*) or by the total mutual fund holdings (*V2*). *Rate Hike* is an indicator that equals one for either the drop period or the rebound period (from March 2022 to June 2023). *Rebound* is an indicator that equals one for the rebound period (November 2022 to June 2023). Fixed effects are added as indicated. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors clustered by the bond issuer are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent variable		*Bond return*		
*Bond Fragility (V1, Outstanding balance) * Rate Hike*	-0.404***	-0.418***		
	(0.065)	(0.065)		
*Bond Fragility (V1) * Rebound*	0.419***	0.415***		
	(0.103)	(0.102)		
*Bond Fragility (V2, MF holdings) * Rate Hike*			-0.280***	-0.280***
			(0.027)	(0.026)
*Bond Fragility (V2) * Rebound*			0.406***	0.401***
			(0.039)	(0.038)
Bond Fragility (V1)	0.105***	0.130***		
	(0.036)	(0.036)		
Bond Fragility (V2)			0.024*	0.046***
			(0.013)	(0.014)
Log (Bond size)		-0.003***		-0.003***
		(0.000)		(0.000)
Coupon		0.001***		0.001***
		(0.000)		(0.000)
Log(maturity)		0.007***		0.007***
		(0.000)		(0.000)
Inv(maturity)		0.049***		0.048***
		(0.002)		(0.002)
Bond age		0.001***		0.001***
		(0.000)		(0.000)
MF Ownership		0.003***		0.003***
		(0.000)		(0.000)
Issuer * period FE	Yes	Yes	Yes	Yes
Bond type FE	Yes	Yes	Yes	Yes
Use of proceeds FE	Yes	Yes	Yes	Yes
Rating FE	Yes	Yes	Yes	Yes
Clustered SE	Issuer	Issuer	Issuer	Issuer
Observations	178,047	177,923	178,627	177,934
Adjusted R-squared	0.359	0.369	0.361	0.371

Appendix A: Variable definitions

Table A1. Variable definitions

Variable Name	Definition
Gear ratio	For a specific TOB program, the gear ratio equals to the ratio between the par value of all the floaters to the total par value of all the residuals.
TOB yield	The yield of floater reported by money market funds in their N-MFP filings.
Fund-level variables	
TOB borrowing amount	*TOB borrowing amount* represents the fund i's borrowing amount via tend option bond programs.
TOB exposure	*TOB borrowing amount* scaled by its TNA in the previous month.
I (TOB user)	*I (TOB user)* is an indicator variable that equals one for TOB using municipal funds.
Monetary policy shock, NS	Monetary policy surprise measure by Nakamura and Steinsson (2018). This measure is converted to the monthly level.
Monetary policy shock, GSS target factor & GSS path factor	Two-factor monetary policy surprise measures by Gürkayna, Sack, and Swanson (2005). They are converted to the monthly level.
Monetary policy shock, 2-year Treasury yield	Monetary policy surprises measured by the two-day changes in two-year treasury yield around FOMC meeting dates. This measure is converted to the monthly level.
Fund return	It denotes the monthly return of fund i in year-month t from CRSP Survivor-Bias-Free Mutual Fund database.
TOB interest expenses	TOB yields are reported by money market funds in their N-MFP filings at the TOB floater level. After matching residuals to their corresponding floaters, we calculate the weighted average TOB yields using all the floaters related to the residuals held by the municipal fund, with weights determined by the holding amounts reported in the N-MFP filings.
Fund flow	The monthly percentage change in fund-level AUM with an adjustment of monthly fund returns, $Fund\ Flow_{i,t} = \frac{TNA_{i,t} - TNA_{i,t-1}(1+Fund\ Return_{i,t})}{TNA_{i,t-1}}$.
TNA	Fund total net assets in millions.
Fund age	Number of months since a fund's inception date.
12-month past return	Cumulative style-adjusted fund returns over the prior 3 months. The fund style is proxied by Lipper's objective code.
Cash holding	Proportion of fund assets in cash.
Fraction of assets in institutional shares	TNAs of institutional share classes scaled by fund TNA.

Fund maturity	Weighted average of maturities of bond holdings.
Fund staleness	A fund-level measure of pricing staleness as the proportion of trading days with non-moving NAVs (Kuong, O'Donovan, and Zhang 2023)
Event study variables	
Annual fund return	
Cumulative fund return	
Annual fund flow	It is the percent change in the TNA of fund i between January 2022 and December 2022, with an adjustment of cumulative fund returns over the same period.
Cumulative fund flow	It is the percent change in the TNA of fund i between January 2022 and December 2022, with an adjustment of cumulative fund returns over the same period.
Bond holding	The ratio of par value of bond *i* held by fund *j* to the total net asset of fund *j* at 2021 Q4 or 2022 Q4. An alternative measure is the natural log of (1+pay value of bond *i* held by fund *j*) at 2021 Q4 or 2022 Q4.
Bond Trading	Percentage change in its par value of bond *i* in fund *j*'s portfolio from 2021 Q4 to 2022 Q4.
New Issue	*New issue* is an indicator that equals to one if a bond is age is below median for a given fund-quarter.
Long maturity	*Long maturity* is an indicator that equals to one if a bond's remaining maturity is above median for a given fund-quarter.
Low value	*Low value* is an indicator that equal to one if a bond represents a below-median fraction of TNA for a given fund-quarter.
Bond Fragility	It is the ex-ante exposure to forced sales by TOB funds. For each municipal bond, we compute this measure as the weighted average of $TOB\ Exp_{j,2021}$ of all the funds that invest in it. There are two methods to calculate the weights. In the first method, the weight for fund *j* is the ratio of holdings in bond *i* to the outstanding balance of bond *i* at the 2021 Q4, $TOB\ fragility_i = \sum_{j=1}^{N} \frac{Holding\ amount_{j,i,2021Q4} \times TOB\ Exposure_{j,2021Q4}}{Outstanding\ balance_{i,2021Q4}}$. In the second method, the weight for fund *j* is the ratio of holdings in bond *i* to the combined holding amount of each fund invested bond *i* at the 2021Q4, $TOB\ fragility_i = \sum_{j=1}^{N} \frac{Holding\ amount_{j,i,2021Q4} \times TOB\ Exposure_{j,2021Q4}}{\sum_{j=1}^{N} Holding\ amount_{j,i,2021Q4}}$. $TOB\ Exp_{j,2021Q4}$ is the TOB exposure of fund j in 2021 Q4. $Holding\ amount_{j,i}$ represents the par value of bond i owned by fund j as of 2021.

Bond returns	$$r_t = \frac{P_t + AI_t + C_t - (P_{t-1} + AI_{t-1})}{P_{t-1} + AI_{t-1}}$$ where $P_{t\ (t-1)}$ denotes the weighted average of transaction prices at day t (t-1) based on the dollar trading volume of each transaction price. $AI_{t\ (t-1)}$ is the accrued interest on day t (t-1). C_t is the semi-annual coupon payment (if any) between day t-1 and day t.
Log(bond size)	Natural log of a municipal bond offering amount.
Coupon	Municipal bond coupon rate from Mergent.
Maturity; Log(maturity); Inv(maturity)	The remaining maturity (in years) of a municipal bonds. Log(maturity) is the natural log of 1+the remaining maturity (in years). Inverse maturity is the inverse remaining maturity (in years).
Bond age	The number of years since the bond's issuance date.
MF Ownership	Percentage of a municipal bond held by mutual funds.

Appendix B: Additional figures and results

Figure B1: Residual termination amount by year
This figure plots the residual termination amount by year.

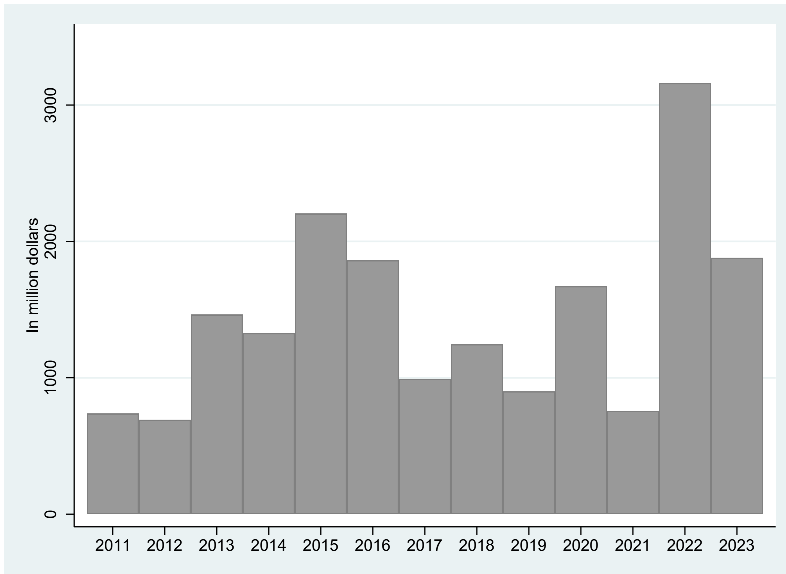


Figure B2: Fund-level TOB usage

This figure plots the aggregate TOB borrowing amount and the percentage of TOB borrowing amount to the aggregate TNA of all municipal bond mutual funds from 2011 to 2023.

Figure B3: Fund-level TOB usage and TNA for TOB users
This figure plots the percentage of TOB users and the aggregate TNA of TOB users from 2011 to 2023.

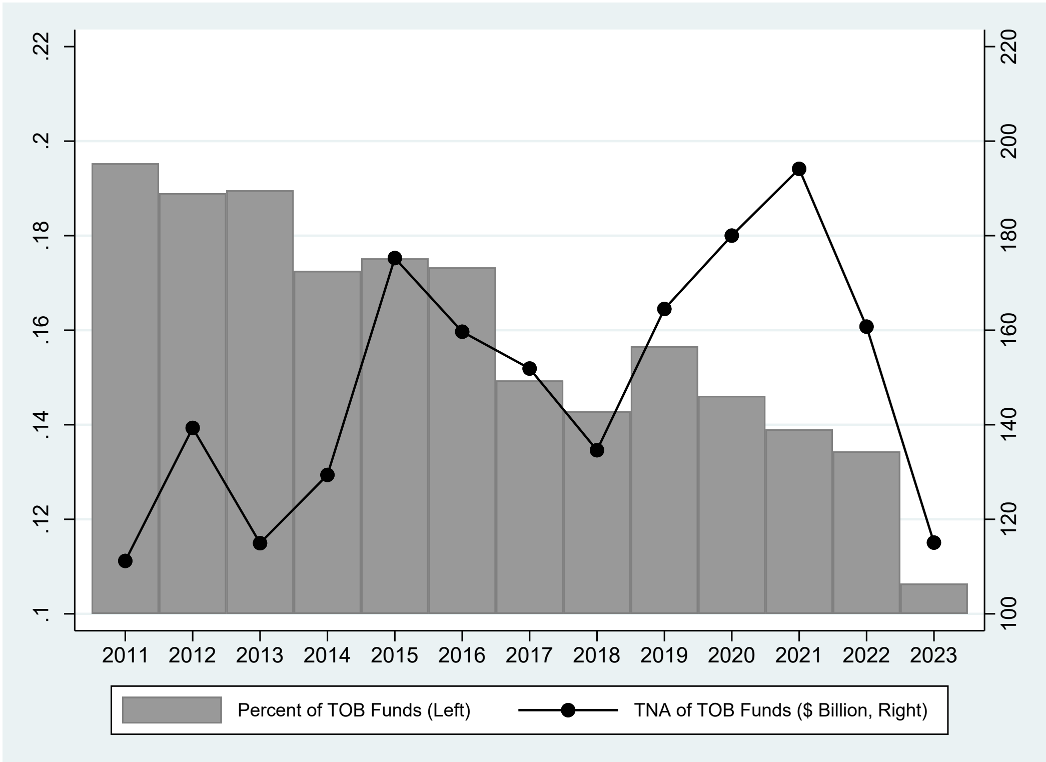


Figure B4: DID treatment effect of monetary policy tightening cycle on TOB usage

Figure B4 plots regression coefficients and two-tailed 95% confidence intervals for the treatment effect of monetary policy tightening on the municipal bond holdings with respect to TOB usage from Q1 2021 to Q4 2022. The pre-period is Q1 2021 to Q4 2022. The first Fed rate increase happened in March 2022. The specification is similar to Equation (6) estimated in Column (2) of Table 7 Panel A. The coefficient estimates on interaction terms between *TOB exposure* and quarter indicators from these regressions are plotted in this figure (Q4 2021 serves as the benchmark month, so the coefficient is zero).

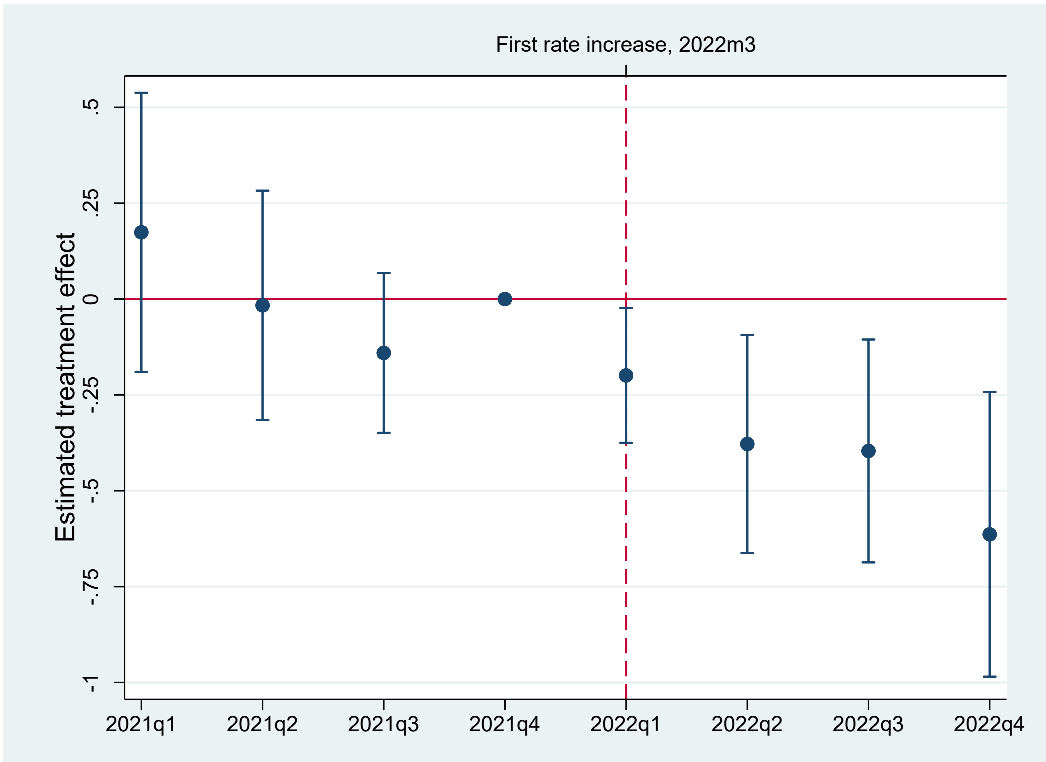


Table B1: Determinants of fund-level TOB exposure

This table reports the estimates for the equation below at the fund-quarter level,

$$TOB\ Exp_{i,t} = \beta \times X_{i,t-1} + \gamma \times Fed\ funds\ rate_t + u + \varepsilon_i,$$

where $TOB\ Exp_{i,t}$ stands for fund-level TOB exposure. $X_{i,t-1}$ represents a fund i's time-varying characteristics. $Fed\ funds\ rate_t$ is the current month's Federal funds rate. Fixed effects and clustered standard errors are indicated in each column. Definitions and the data sources for all variables are included in Appendix A. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)
	Fund-level TOB exposure	
Log (TNA)	-0.000512	0.000201
	(0.00143)	(0.00144)
Log (Fund age)	0.00276*	-0.00372***
	(0.00162)	(0.00140)
Prior month flow	-0.00674*	-0.0112***
	(0.00393)	(0.00416)
12-month past return	0.0111	0.0174
	(0.0282)	(0.0281)
Cash holding	0.000211	0.000247
	(0.000151)	(0.000151)
Fraction of assets in institutional shares	-0.00303	-0.00912***
	(0.00249)	(0.00254)
Fund maturity	0.00121***	0.00117***
	(0.000375)	(0.000374)
Fund staleness	-0.000157	-0.000714
	(0.00109)	(0.000648)
Fed funds rate		-0.000489***
		(0.000159)
Fund FE	Yes	Yes
Year quarter FE	Yes	No
Clustered SE	Fund & Year-quarter	Fund & Year-quarter
Observations	84,518	84,518
Adjusted R-squared	0.706	0.700

Table B2: Fund performance and flow during the monetary tightening cycle

This table reports the estimates for the equation below,

$$Y_i = \beta \times TOB\ Exp_{i,2021} + \gamma \times X_i + \mu_{fund-objective} + \varepsilon_i,$$

where Y_i stands for cumulative fund flow and cumulative fund return from December 2021 to December 2022. $TOB\ Exp_{j,2021}$ represents a fund i's borrowing amount through TOB programs at the end of 2021. Columns (1) and (2) report the estimates for cumulative fund flow and Columns (3) and (4) report the estimates for cumulative fund return. All columns fund-objective fixed effects. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors clustered by fund objectives are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent variable	*Cumulative Fund Flow*		*Cumulative Fund Return*	
$TOB\ exposure_{i,2021}$	-0.276***	-0.151**	-1.170**	-1.079**
	(-3.693)	(-2.139)	(-2.209)	(-2.463)
Log (TNA)		0.002***		-0.013*
		(3.880)		(-1.938)
Log (Fund age)		-0.006***		-0.078***
		(-3.265)		(-4.836)
Prior month flow		-0.109		3.814***
		(-0.854)		(3.505)
12-month past return		-0.023		0.551
		(-0.516)		(0.553)
Cash holding		0.001***		0.003
		(5.654)		(0.974)
Fraction of assets in institutional shares		-0.001		-0.124***
		(-0.387)		(-3.530)
Fund maturity		-0.003***		-0.009***
		(-4.433)		(-3.271)
Fund staleness		-0.020***		-0.002
		(-4.855)		(-0.028)
Fund-objective FE	Yes	Yes	Yes	Yes
Observations	501	492	507	498
Adjusted R-squared	0.664	0.850	-0.003	0.093

Table B3: Fund liquidation during the monetary tightening cycle-cross-sectional analysis

This table presents the results of municipal bond liquidation by funds during the monetary policy tightening cycle from December 2021 to December 2022. Columns (1) and (2) present the estimates for the equation below,

$$Bond\ Trading_{i,j} = \beta \times TOB\ Exp_{j,2021} + \gamma \times X_j + \mu_{fund-objective} + \mu_{bond} + \varepsilon_{i,j}.$$

Bond Trading is measured as the percentage par value change in bond i by fund j from 2021 Q4 to 2022 Q4. $TOB\ Exp_{j,2021}$ represents a fund j's borrowing amount through TOB programs at the end of 2021. Fund-objective fixed effects and bond fixed effects are added to the model. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors with two-way clustered at bond and fund level are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)
Dependent variable	*Bond Trading*	
TOB exposure	-1.222***	-1.239***
	(-3.566)	(-3.863)
Log (TNA)		0.040***
		(6.849)
Log (Fund age)		-0.017
		(-0.867)
Prior month flow		-0.172
		(-0.267)
12-month past return		-0.569*
		(-1.725)
Cash holding		0.006**
		(2.362)
Fraction of assets in institutional shares		-0.112***
		(-4.778)
Fund maturity		-0.009**
		(-2.511)
Fund staleness		-0.081
		(-1.164)
Bond FE	Yes	Yes
Fund-objective FE	Yes	Yes
Observations	174,333	171,590
Adjusted R-squared	0.242	0.276

Table B4: Municipal bond price impact during the monetary tightening cycle

This table presents the effect of TOB exposure on municipal bond price impact during the monetary tightening cycle by estimating the equation below,

$$Bond\ cummulative\ return_i = \beta \times TOB\ fragility_i + \gamma \times X_i + \mu_{issuer} + \mu_{rating} + \varepsilon_i.$$

In Columns (1) and (2), $Bond\ cummulative\ return_i$ is the cumulative return over the drop period, from March 2022 to October 2022. In Columns (3) and (4), $Bond\ cummulative\ return_i$ is the cumulative return over the rebound period, from November 2022-July 2023. $TOB\ fragility_i$ for a bond is the weighted average of $TOB\ Exp_{j,2021}$ of all the funds that invest in it. The weight for fund j is the ratio of holdings in bond i to the combined holding amount of each fund invested bond i at the end of 2021. Bond issuer fixed effects and bond type fixed effects are added. Definitions and the data sources for all variables are included in Appendix A. Heteroscedasticity-robust standard errors clustered by the bond issuer are reported in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	(1)	(2)	(3)	(4)
Dependent variable	*Cumulative bond returns Drop period (Mar 2022-Oct 2022)*		*Cumulative bond returns Rebound period (Nov 2022-Jul 2023)*	
Bond Fragility	-0.317***	-0.162***	0.179***	0.100***
	(-11.052)	(-6.130)	(8.709)	(5.344)
Bond Size		-0.020***		0.010***
		(-36.463)		(29.247)
Coupon		0.010***		-0.011***
		(15.142)		(-19.463)
MF Ownership		0.027***		-0.012***
		(26.638)		(-17.109)
Bond-Issuer FE	Yes	Yes	Yes	Yes
Bond-type FE	Yes	Yes	Yes	Yes
Observations	64,110	63,873	60,966	60,723
Adjusted R-squared	0.156	0.272	0.087	0.188