# Financing Infrastructure with Inattentive Investors: The Case of US Municipal Governments

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**Abstract**

In the United States, building infrastructure is primarily the responsibility of municipal governments. However, prior empirical evidence suggests these governments are borrowing-constrained. This paper provides new evidence and theory that link the constraint to the dominance of retail investors in the municipal bond market, who pay less attention to new bond issues than more specialized investors, such as municipal mutual funds. Supporting this hypothesis, I find that the mutual funds disproportionately buy newly issued bonds and gradually resell them to other investors. Furthermore, a 1% inflow to the mutual fund sector increases bond issuance by county governments by 0.2% and reduces the interest rate by 0.2 basis points in the next quarter. To rationalize these observations, I develop a dynamic model featuring end investors who exhibit sluggish portfolio adjustments and invest in bonds directly or indirectly through some attentive mutual funds. By calibrating the model with the empirical estimates, I find that the elasticity of bond demand is at least one order of magnitude smaller in the short run than in the long run, suggesting that the municipal bond market is not resilient against shocks in the short run. This finding supports market interventions by the federal government in times of crisis, especially when they accompany massive outflows from municipal mutual funds.

**JEL Classification:** G12, G28, H41, H74

**Keywords:** Municipal governments, Municipal bond market, Infrastructure, Investor inattention, Intermittent rebalancing, Mutual funds.

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# 1 Introduction

Education, healthcare, road maintenance and construction, utility, and police protection are just part of the services US households receive daily from their state and local governments. Most of these services require some initial investment in infrastructure. Available estimates indicate that between 2007 and 2016, 72% of investments in the US national infrastructure were financed by the bonds issued by the municipal governments (Cestau, Hollifield, Li, and Schürhoff, 2019). Furthermore, state and local governments are in the frontline of responding to natural disasters and pandemics, which makes their timely access to credit crucial for the recovery of their local economy.

Prior empirical evidence suggests that municipal governments are credit-constrained. This is evidenced by their borrowing and expenditures being highly sensitive to their investors' lending capacity (Dagostino, 2018; Yi, 2020), their credit rating (Adelino, Cunha, and Ferreira, 2017), and the backing of their bond insurers (Agrawal and Kim, 2021). This is despite the fact that they possess statutory taxing power and their historical default rate is low.

I add to this discussion by putting forward a novel theory- supported by new empirical evidence- that sheds light on the nature of the impediment municipal governments face in their borrowing. I argue that the impediment is related to the dominance of retail investors in the municipal bond market. The household sector is the largest direct owner of municipal bonds, holding 44% of the outstanding amount. The corresponding number is 6% for the US Treasuries, and 7% for corporate and foreign bonds (See Figure A.1). Municipal bonds are attractive for retail investors, especially high net-worth ones, since the interest incomes are usually exempt from federal and state taxes. However, it drives unqualified and tax-exempt investors out of the market (e.g., pension funds and foreign investors).[1] Retail investors are typically characterized as buy-and-hold investors that might not monitor the new bond issues as closely as more specialized intermediaries, such as municipal mutual funds. This means that newly issued bonds should be initially purchased by the mutual funds and other more attentive investors, before gradually reselling the bonds to retail and other less attentive investors.

This is what Figure 1 displays about the mutual fund ownership of municipal bonds throughout their lifetime. We see that the mutual fund ownership is initially high, and the funds gradually resell the bonds to other investors. This observation is robust with respect to the choice of the bonds' initial maturity, rating, and state of origination (See Figures A.3, A.4, and A.5). Note

[1]The tax-benefit of municipal bonds pushes up their price. It lowers their expected return compared to other taxable fixed-income securities for institutional or foreign investors who do not benefit from or qualify for the tax exemption. It makes municipal bonds less attractive for those groups of investors.

that the ownership transfer happens at a slow pace, as the reselling takes more than ten years to complete on average. This is in line with the hypothesis that mutual funds monitor new bond issues more closely than an average investor in the market.[2]

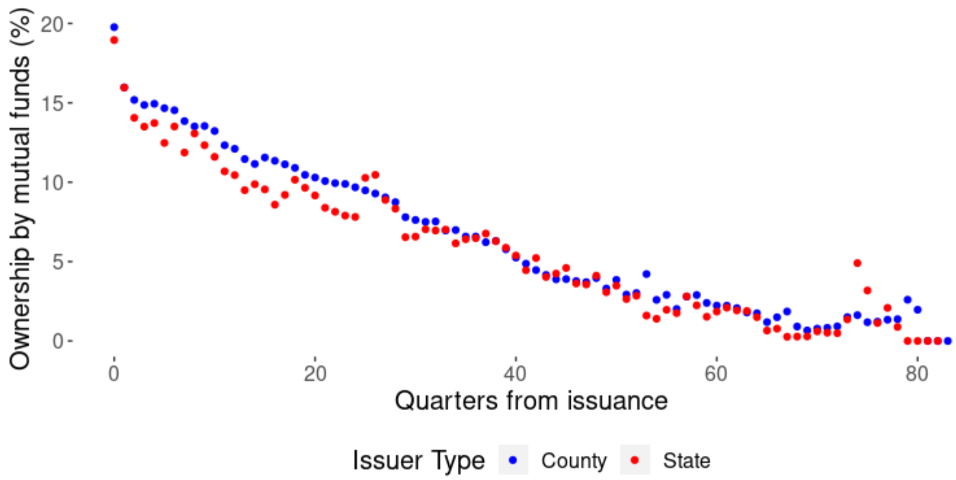



**Figure 1: Mutual funds' ownership of municipal bonds by quarters after issuance.** The figure depicts the average percentage of mutual fund ownership for each quarter after issuance for the period between 2009Q1-2021Q1, and municipal bonds that were issued in 2000 and after. The historical bond issuance data are obtained from Bloomberg for US state governments, and county governments with at least 100K population and their subsidiaries, upon availability. Mutual funds' holding data of municipal bonds are obtained from the Center for Research in Security Prices (CRSP) database.

This hypothesis implies that the debt capacity of municipal governments should depend on the capital available to mutual funds because they should initially hold a substantial portion of the issued bonds. To test this hypothesis, I estimate how capital flows in and out of mutual funds impact the timing, size, and interest rate of borrowing by municipal governments.

To obtain the estimates, I collect the historical debt issuance data of 262 largest and most frequently issuing county governments from Bloomberg. I identify their mutual fund owners from CRSP[3] between 2009 and 2019 and examine their trading behavior. The data reveal that the mutual funds respond to inflows and outflows in a predictable manner: In response to inflows, they are more likely to increase their investment in governments whose ownership has been relatively high over

[2]For corporate bonds, data suggest a similar pattern, as displayed by Figure A.6. However, the transition from mutual funds to other investors is faster for long-term bonds (about one year), while it is slower for medium-term and short-term bonds.

[3]The Center for Research in Security Prices Database

the past three years.[4]

To gauge the impact of the fund flows on the governments' borrowing behavior, I construct a measure of "flow-induced demand" for each county government in my sample, inspired by the flow-induced trade measure utilized in earlier research (e.g., Lou (2012); Li (2021)). Intuitively, the flow-induced demand is an instrument for the bond demand a municipal government faces from the mutual fund sector. In my empirical analysis, I examine how the flow-induced demand affects the timing, size, and interest rate of the bond issues by the county governments in my sample. In this estimation, the key identification assumption is that the fund flows are not correlated with the county governments' funding needs. The assumption is plausible since the bonds issued by the county governments in my sample, altogether, comprise 5.9% of the mutual funds' assets. The maximum exposure to a single county government is 0.8% on average and less than 2.1% for 90% of the observations. Moreover, the cross-section of the flows cannot be predicted by the previous fund returns and flows. Therefore, it is unlikely that the cross-section of the fund flows is connected to the funding need of the county governments. This is the exclusion restriction that I exploit in my empirical analysis.

I find that in response to a 1% point increase in the flow-induced demand for a county government's bonds, the government borrows 0.224% more in the next quarter, provided a new bond has been issued. The impact on the size of borrowing goes down over the subsequent quarters, reaching 0.088% in the fourth quarter. The evidence that the fund flows can predict the timing of the bond issues is mixed, which could reflect the procedural challenges that municipal governments encounter to receive authorization for new bond issuance. For instance, most local governments need to hold public elections and obtain supermajority approval from their residents to issue new general obligation bonds. However, once the authorization is granted, the issue size is determined in negotiations with an underwriter or an underwriting syndicate in most municipal bond issues (known as negotiated bond sales). Since the underwriters have a limited risk capacity and need to sell the bonds quickly, their perception of the bond demand becomes crucial for the issue size agreed upon.

There are some potential concerns in the estimations that I address in a set of robustness checks. A potential concern is that fund flows are part of individuals' optimal portfolio decisions, so they could be correlated with other economic variables that impact the governments' borrowing decisions. For instance, investment in mutual funds might be affected by changes in the tax rates, which affect municipal governments' revenue. I address this concern by adding state-by-year fixed effects to

[4] I define the ownership of a fund as its share in the total outstanding debt of the government that is owned by mutual funds. Section 3 provides the details.

absorb all state-level shocks at the annual level. Moreover, fluctuations in the wealth and income of the residents of a municipality could impact their investment in the mutual funds, and the tax revenue of the governments serving the municipality. I address this concern by controlling for fluctuations in the local income and house prices. It lowers the coefficient of interest from 0.224% to 0.196%. However, the effect is still significant at the 1% confidence level. Furthermore, the result is robust even after directly controlling for the recent changes in the governments' revenue, expenditure, and liability size.

Another concern is that the empirical observations are connected to the tax treatment of municipal bonds and its impact on investors' behavior. In most states, the interest incomes on municipal bonds issued in that state are exempt from state taxes for the state residents. However, the state residents would need to pay state taxes on the interest incomes earned on municipal bonds issued outside the state. Such differential tax treatments create market segmentation along the states' border lines (Schultz, 2013). This complementary hypothesis has two implications, which I test. First, most mutual funds are only active in a single state to produce tax-free income for their investors (Babina, Jotikasthira, Lundblad, and Ramadorai, 2021). It implies that the aggregate fund flows at the state level should absorb most of the fluctuations in the size of municipal borrowing. However, accounting for the state-level flows reduces the coefficient of interest from 0.224% to 0.180%, and is still significant at the 5% level. Second, the flow-induced demand should be most impactful in states with the highest degree of market segmentation, such as California or New York, where the in-state bond ownership is more concentrated due to their high top marginal tax rates. I test this hypothesis by interacting the flow-induced demand with the amount of tax-saving associated with in-state investing for the investors at the highest tax bracket. The results do not support the hypothesis, and lend further credence to the proposed mechanism in this paper.

Do the fund flows impact the borrowing interest rates as well? I find that the impact is significant, although two orders of magnitudes smaller than its impact on the borrowing quantity. It implies that in response to demand shocks, municipal governments mostly adjust the quantity of their borrowing instead of offering a higher interest rate to attract more investors. Yi (2020) also documents a similar effect on the borrowing quantities and interest rates. She finds that in response to a regulation that curtailed the lending ability of some banks to their municipal borrowers, the most affected municipalities cut their borrowing by 20% more than the least affected ones, while their yield at issuance only increased by ten basis points more than the least affected group. These observations are at odds with standard theory, as it implies that large interest rate movements should accompany large quantity adjustments.

To explain the puzzling observations, I develop a dynamic model of the municipal bond market that captures the essential elements impacting the demand and supply of the bonds. On the supply side, a representative municipal government issues bonds. The municipal government faces a convex cost of bond issuance, capturing the statutory borrowing limitations. The bonds are purchased by two groups of investors: *Direct investors*, who buy the bonds directly, and *indirect investors*, who buy the shares of some mutual funds that invest in a mix of the municipal bonds and a risk-free asset. Specifically, the mutual funds are modeled as intermediaries that could face mandates in their investments.

The key behavioral assumption of the model is that both direct and indirect investors rebalance their portfolios intermittently. It is consistent with earlier empirical observations (See, e.g., Giglio, Maggiori, Stroebel, and Utkus (2021)), and could be motivated by investor inattention. The intermittent rebalancing creates two frictions that cause the capital flows in and out of the mutual funds to affect the government's borrowing size. First, the direct investors do not immediately adjust their investment to absorb the buying or selling pressure generated by the fund flows. Second, the fund investors (the indirect investors) are slow in adjusting their allocations to "undo" the excess buying or selling induced by the investment mandates the funds face. Overall, both frictions cause the demand elasticity to be low in the short run, which is crucial to explain the large short-term quantity response I find in my empirical analysis.

Next, I calibrate the model to inform discussions about what limits the supply of infrastructure in the US. The quality of infrastructure in many US states is far from ideal: More than 30% of the residents in Alaska and Arkansas do not have access to high-speed Internet.[5] Close to 20% of the bridges in West Virginia and Rhode Island are in poor condition.[6] The water quality is low in many areas.[7] The question is what limits the financing of infrastructure projects in the US. Is the binding element the constitutional limitations that municipal governments face in their borrowing? Or, is accessing credit difficult by these governments?

The calibration results imply that in the long run, the bond supply is substantially less elastic than bond demand. Still, the demand elasticity is quite low in the short run. It is concerning regarding the depth of the market, especially when municipalities need to expand their borrowing to respond to natural disasters or other crisis events. Particularly, I find that the elasticity of bond demand for the county governments in my sample is 11.6 in the short run and 158.4 in the long run. Therefore, the demand elasticity in the short run is one order of magnitude smaller than that in the long run.

[5] Best and Worst States for Internet Coverage, Prices and Speeds, September 2021
[6] Bridge Condition by Highway System, December 2020
[7] Millions of Americans drink potentially unsafe tap water, Science 2018

Overall, the results suggest that the municipal bond market is not resilient, and its effectiveness depends on the capital available to mutual funds. Therefore, market interventions by the federal government, such as introducing emergency municipal liquidity programs (Li and Momin, 2020; Haughwout, Hyman, and Shachar, 2021), are necessary in times of crisis, especially when mutual funds experience massive outflows. This was the situation in the first few months following the outset of the COVID-19 pandemic. In fact, I find that an outflow of 5% from municipal mutual funds, which is comparable with the outflow amount in March and April 2020, reduces the bond issuance by municipal governments by 10.5 billion dollars (0.25% of the outstanding municipal debt). The estimate explains 46% of the 23 billion dollar reduction in the bond issuance in March and April 2020, compared to January and February 2020.

This paper is at the intersection of three burgeoning research areas: Public finance and municipal bond market, investor inattention, and demand-based asset pricing.

This paper adds to the growing literature of local and state government finances by putting forward novel evidence and theory that shed light on the determinants of municipal governments' borrowing capacity. Adelino, Cunha, and Ferreira (2017) and Dagostino (2018) find that credit shocks to municipal governments significantly impact their expenditure, through which they affect the local economic condition. Yi (2020) investigates the impact of a banking regulation that disrupted access to credit by the municipal governments that relied on bank lending. The previous studies chiefly examined the effect of large credit shocks on municipal borrowing. However, my empirical results indicate that even small credit shocks, such as mutual fund flows, are not promptly absorbed in the municipal bond market. Furthermore, my theoretical analysis demonstrates that the limited borrowing capacity can be explained by the sluggishness of the households' portfolio adjustments, as documented by Giglio, Maggiori, Stroebel, and Utkus (2021).

The model developed in this paper can be employed to analyze how the price and quantity of municipal bonds respond to different types of supply and demand shocks. Thus, it complements the earlier models of the municipal bond market. Myers (2019) examines the portfolio choice problem of pension funds, and how it interacts with the borrowing and default decision of the municipal government supervising the funds. Boyer (2020) presents a model of municipal bond pricing in which the bonds could have an arbitrary level of seniority compared to pension liabilities. My model complements the earlier studies by highlighting the role of mutual fund flows and investor inattention in understanding the demand for municipal bonds.

This paper also contributes to the literature of demand-based asset pricing by investigating the impact of demand shocks on the real economy, and by exploring the role of investors' infrequent rebalancing as a candidate contributing to the low demand elasticity observed for risky assets (Shleifer, 1986; Wurgler and Zhuravskaya, 2002; Koijen and Yogo, 2019; Gabaix and Koijen, 2020). Numerous studies in the literature exploit fund flows to identify demand shocks and examine their impact on asset prices (Coval and Stafford, 2007; Lou, 2012; Peng and Wang, 2019; Li, 2021). I borrow their methodology to study the effect of demand shocks on the quantity of borrowing by municipal governments.[8]

Lastly, I contribute to the literature of investor inattention by putting forward a model in which the intermediary sector creates value by paying attention to the market condition and adjusting its clients' portfolios accordingly. Abel, Eberly, and Panageas (2013) demonstrate that informational costs cause sluggishness in portfolio adjustments, a feature that appears in my model. Chien, Cole, and Lustig (2012, 2016) study a general equilibrium model in which some investors rebalance their portfolios infrequently. Moreover, in a companion paper (Azarmsa, 2021), I study an asset pricing model with heterogeneously attentive investors, and I find that the model can explain the downward term structure of the equity premium, documented by Van Binsbergen, Hueskes, Koijen, and Vrugt (2013); Van Binsbergen and Koijen (2017); Gormsen and Lazarus (2019). In an appendix, Gabaix and Koijen (2020) examine the effect of fund flows on the equilibrium prices in the presence of portfolio inertia, a feature I employ to model investor inattention. Heterogeneity in attention is also featured in Duffie (2010); however, the asset quantity is also endogenized in my model, which drastically alters the asset pricing implications.

The rest of the paper is organized as follows. Section 2 describes the data used for this study. Section 3 introduces the flow-induced demand measure, and empirically examines its impact on the size, timing, and interest rate of the bond issues for a sample of county governments and their subsidiaries. Section 4 presents a dynamic model of the municipal bond market. I use the empirical estimates in Section 3 to calibrate the model parameters and estimate the elasticities of supply and demand for municipal bonds. Section 5 concludes. Appendix A, B, and C contain the supplementary figures, proofs, and discussions respectively.

# 2 Data

## 2.1 Debt issuance data

I collected the historical debt issuance data of all state governments and county governments with a population of at least 100,000 (as of 2012) from Bloomberg, along with their subsidiaries, upon availability. For each issued bond, the data contain the 9-digit CUSIP, bond purpose, maturity

[8]Relatedly, Lou and Wang (2018) study the impact of mutual fund flows on corporate investment.

size, deal size, issuance date, maturity date, refunded date (if applicable), coupon rate, insured status, tax provision, maturity type (indicates whether the bond is callable or not), and S&P credit rating. A desirable feature of Bloomberg data is that it also lists issues from subsidiary agencies that are morally backed by the government's credit.[9]

Overall, the data contain CUSIP-level information for 157,991 bonds issued by 43 state governments and their subsidiaries,[10] and 246,870 bonds issued by 417 county governments and their subsidiaries for the period between 1950 and 2020.

The bond market is generally considered segmented across the state lines since interest incomes on municipal bonds are typically exempt from state taxes for the in-state investors, but not exempt for the out-of-state investors (Schultz, 2013). To reap the tax benefit, the majority of municipal mutual funds, both in numbers and assets under management, are only active in one state (Babina, Jotikasthira, Lundblad, and Ramadorai, 2021). Since any inflow to single-state funds should be invested within their state, it is difficult to identify the impact of fund flows on debt issuance decisions for state-level governments; they could merely reflect fluctuations in the overall bond demand of the state's residents, which is affected by numerous state-level and national-level variables, such as tax rates and interest rates.

For identification, I exploit heterogeneities across county governments, the largest sub-state governments, in their exposure to mutual funds. As we see later, mutual funds do not invest equally in all counties of their target states. Thus, the relative flows determine which counties relatively receive more demand. I will expand on the identification strategy in Section 3.

Bond issuance by county governments is sparse. The median county government in the sample issued bonds only in 7 out of the 44 quarters (15.9%) between 2009 and 2019. It points to the challenges that municipal governments face in their debt issuance. First, most municipal governments are not allowed to issue long-term bonds to fill their budget deficits when revenue is low, which drastically limits the scope of municipal bonds. Municipalities issue bonds to finance long-term projects, primarily to strengthen their local infrastructure. Second, many municipal governments have to seek voter approval to pledge their full faith and credit for a new bond issue, which are known as general obligation bonds. For instance, local governments in California are required to hold elections and obtain the approval of two-thirds of their residents.[11] However, the autho-

[9] Bloomberg System provides all bonds issued by the "credit family" of an issuer. The credit family of an issuer refers to the issuer's debt as well as the debt of its subsidiaries which it guarantees but does not have further recourse from any parent, direct or indirect, of the reference issuer.

[10] For seven states (Indiana, Kansas, Kentucky, North Dakota, Oklahoma, South Dakota, and Wyoming), the issuance data of the state government and its subsidiaries were not available.

[11] California Constitution Article XVI, sec. 18

rization rule varies across states. For instance, counties in the state of New York only need the super-majority approval from the members of their county legislature, who are allowed to delegate their authorization power to the county's chief fiscal officer (Myers and Goodfriend, 2009). An alternative for municipalities is to issue revenue bonds, for which they only pledge the revenue from the project being financed, thus the regulatory restrictions are laxer. Third, municipalities need to incur costs to hire financial and legal advisors to prepare the documentation needed for the bond sale, which could be restrictive for smaller municipalities.

Therefore, I only include governments that exhibit a frequent record of bond issuance. Particularly, I exclude governments that have issued in four years or less during my sample period of 2009 to 2019. This leaves me with 262 counties, which I henceforth refer to as the "selected counties." The selected counties are depicted in Figure 2a. Figure 2b presents their distribution across the states.

Table 1 provides the summary statistics of the issuance data for all and the selected counties. On average, a selected county government issues bonds roughly in one out of four consecutive quarters. The average amount of bonds issued in a quarter is 82.3 million dollars conditional on some issuance takes place, and $23.0 (= 27.9\% \times 82.3)$ million dollars, unconditionally. The average size of issuance in a quarter as a fraction of the total outstanding debt is 19.4%. The average (median) borrowing interest rate is 2.4% (2.3%). The majority of the bonds are long-term, as the median bond has 8.4 years to mature at its origination.

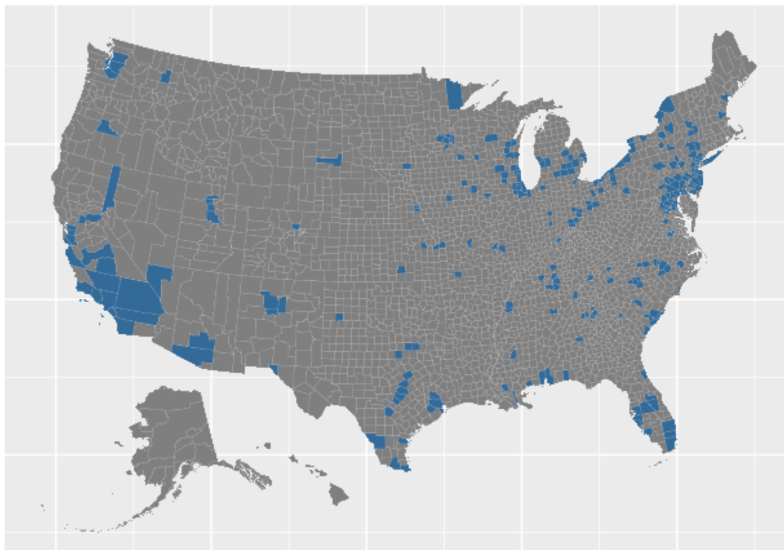
In my sample, only 7.3% of the bonds are insured. It reflects the fact that the percentage of insured municipal bonds dropped drastically after the financial crisis, due to the sharp decline in the credit rating of major municipal bond insurers.[12] Lastly, we see that more than 90% of the bonds issued by the selected county governments are exempt from federal taxes.

## 2.2 Municipal bond holding by mutual funds

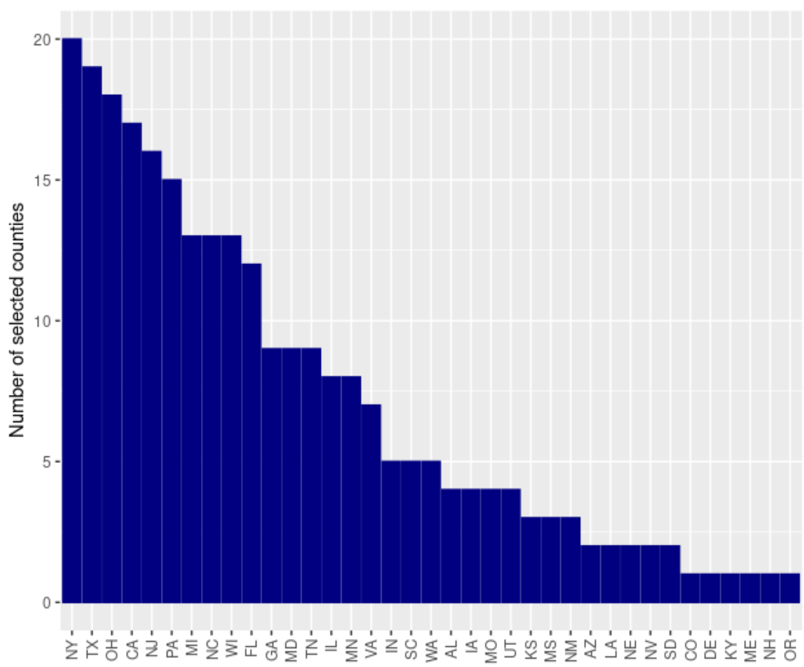
I obtain the holding data of municipal mutual funds from the Center for Research in Security Prices database (CRSP) for the years between 2000 and 2019. Since the data coverage is less comprehensive before 2009, I primarily work with the quarter-end holding data of the funds between 2009 and 2019.

Table 2 provides information about the universe of the mutual funds examined in this study. The table reveals that the funds hold small cash buffers and invest almost entirely in municipal bonds. The average share of cash and municipal bonds in the funds' portfolio are 0.9% and 98.1%,

[12] The Fundamentals of Municipal bonds, Sixth Edition, Page 86.



**(a)** Selected counties (in blue)




**(b)** Distribution of the selected counties

**Figure 2: The distribution of the selected counties.** Figure (a) displays the selected counties on a US map. Figure (b) presents the distribution of the counties across the states. The selected counties are the ones that i) had a population of at least 100,000 in 2012, ii) their issuance data are available at Bloomberg system, iii) they and their subsidiaries combined have issued debt at least in five out of the eleven years between 2009 and 2019.

| | All counties (417) (66364 bonds) | | | | | Selected counties (262) (58952 bonds) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | 10th | 50th | 90th | Mean | SD | 10th | 50th | 90th |
| Maturity size ($M) | 4.3 | 18.0 | 0.2 | 1.4 | 7.7 | 4.6 | 18.9 | 0.2 | 1.5 | 8.2 |
| Deal size ($M) | 57.1 | 113.8 | 3.3 | 23.0 | 140.7 | 59.9 | 11.6 | 3.4 | 24.6 | 150 |
| Overall issuance in a quarter ($M) | 77.0 | 143.5 | 5.0 | 30.4 | 179.4 | 82.3 | 148.3 | 5.0 | 33.7 | 194.2 |
| Overall issuance in a quarter (% of outstanding debt) | 21.0 | 30.0 | 2.8 | 13.5 | 43.4 | 19.4 | 29.6 | 2.6 | 12.6 | 38.7 |
| Outstanding debt ($M) | 426.9 | 1146.2 | 19.9 | 124.6 | 900.9 | 564.3 | 1327.4 | 37.7 | 195.0 | 1414.5 |
| Quarters with issuance (Percentage) | 8.9 (20.1%) | 6.8 (15.4%) | 2 (4.5%) | 7 (15.9%) | 18 (40.9%) | 12.3 (27.9%) | 6.3 (14.2%) | 6 (13.6%) | 11 (25%) | 21 (47.7%) |
| Yield at issuance (%) | 2.4 | 1.2 | 0.9 | 2.3 | 3.9 | 2.4 | 1.2 | 0.9 | 2.3 | 3.9 |
| Years to maturity | 9.3 | 6.2 | 2 | 8.4 | 18 | 9.3 | 6.2 | 2 | 8.4 | 18 |
| Coupon | 3.7 | 1.2 | 2 | 4 | 5 | 3.7 | 1.2 | 2 | 4 | 5 |
| Insured ($Y = 1$) | 0.077 | 0.268 | 0 | 0 | 0 | 0.073 | 0.260 | 0 | 0 | 0 |
| Federally taxable ($Y = 1$) | 0.099 | 0.299 | 0 | 0 | 0 | 0.101 | 0.301 | 0 | 0 | 1 |

**Table 1: Summary statistics of the bond issues by county governments.** This table provides the summary statistics for the county governments examined in this study for the period between 2009 and 2019. The historical data of the bond issues are obtained from Bloomberg for counties with at least 100,000 population in 2012. The data on the outstanding debt are obtained from Municipal Atlas database. I select counties with a positive bond issuance in at least five out of eleven years of the study. The summary statistics for the selected counties are presented in the right panel. Maturity size is the par value of a bond CUSIP. Deal size is the total par value of the bonds in an issue.

respectively. This observation suggests that mutual funds respond to inflows (outflows) mostly by purchasing new bonds (liquidating some of their holdings). At the end of 2019, the last year of the sample, the total value of municipal bonds held by the mutual funds was 830.9 million dollars, which almost matches the number reported in the US Financial Accounts database (831.0 million dollars). The coverage is more than 94% for the other years of the sample. The only exception is 2009, for which CRSP does not provide the overall values of municipal bond holding. The last column reports the funds' market share. We see that their market share has increased drastically over the years of the sample, indicating their increasing importance in the municipal bond market.

The mutual fund holdings dataset also provides the CUSIP of every holding, which enables me to link it to the bond issuance data. Since each share represents a fixed amount of investment at par value, one could infer the total par value of each holding from the corresponding number of shares. Moreover, the data provide the total net asset value (TNA), return, and merger information of each fund at monthly frequency, which I employ to construct a quarterly measure of flow for every fund.

Table 3 presents some information about the funds' trading behavior (Panel A), their exposure to the selected counties (Panel B), and their portfolio composition by the issuance category (Panel C). Panel A reveals that the funds, on average, make no adjustments in 88.2% of their positions over a quarter. Furthermore, they liquidate 7.1% of their positions over this period. Therefore, less than 5% of their positions are adjusted to a larger or smaller non-zero investment. It suggests that municipal funds, once they start a new position, they make none to few adjustments before the liquidation.

Panel B shows that the median fund invests at most 0.34% of its assets in a selected county government. The median exposure to the selected county governments is 4.0%. Therefore, most mutual funds have little exposure to the county governments, which makes it unlikely that households use the mutual funds to channel fundings to their county governments. This observation is important for understanding the empirical strategy, which I describe in Section 3.

Panel C presents a summary of the portfolio composition of the mutual funds. To obtain the issuer category, I link each CUSIP to its issuer with Muni Atlas dataset, which contains information about the type and sector of each bond's issuer. The dataset provides a match for 230913 out of 278666 bond CUSIPs held by the funds (82.9%). We see that bonds directly issued by state and local governments constitute only 18.5% of the funds' bond holding. The rest includes bonds issued by independent special district governments, such as school districts, and state and local governments' subsidiaries, such as enterprise funds.

| Year | # of funds | TNA ($ Million) | | Cash holding | Municipal bond holding | | | |
|---|---|---|---|---|---|---|---|---|
| | | Mean | Median | % of all assets | Total ($ Billion) | % of all assets | % of all owned by mutual funds | % of all outstanding |
| 2009 | 1799 | 262.7 | 35.5 | Not Avail. | Not Avail. | Not Avail. | Not Avail. | Not Avail. |
| 2010 | 1804 | 267.6 | 36.8 | 0.4 | 476.9 | 98.8 | 97.3 | 12.5 |
| 2011 | 1745 | 291.1 | 42.1 | 1.3 | 498.8 | 98.3 | 96.1 | 12.4 |
| 2012 | 1733 | 342.8 | 51.7 | 0.9 | 582.8 | 98.2 | 95.7 | 14.1 |
| 2013 | 1769 | 289.5 | 40.8 | 0.9 | 501.9 | 98.2 | 94.7 | 13.0 |
| 2014 | 1780 | 325.8 | 45.3 | 1.2 | 566.6 | 97.9 | 96.5 | 14.0 |
| 2015 | 1820 | 337.3 | 47.5 | 1.5 | 593.4 | 97.3 | 98.2 | 14.6 |
| 2016 | 1822 | 350.1 | 50.0 | 0.8 | 624.9 | 98.4 | 98.9 | 15.4 |
| 2017 | 1905 | 365.7 | 45.9 | 1.0 | 678.4 | 98.0 | 98.6 | 16.4 |
| 2018 | 1892 | 380.0 | 47.8 | 0.7 | 691.8 | 98.0 | 99.6 | 17.3 |
| 2019 | 1841 | 463.4 | 62.0 | 0.6 | 830.9 | 98.3 | 99.9 | 20.2 |

**Table 2: Summary statistics for municipal mutual funds.** This table provides information about the size of overall assets, cash holding, and municipal bond holding for municipal mutual funds studied between 2009 and 2019. The data are obtained from the database of the Center for Research in Security Prices (CRSP). The first column reports the number of funds studied in each year. The second and third columns provide the average and median size of the funds. The average cash holding of the funds is reported in the forth column. For 2010 and after, CRSP provides the total value of municipal bond holdings for each fund, which are the input to compute the numbers in the last four columns. In the last two columns, I compare the total value of municipal bonds held by the funds with the overall numbers provided by the financial accounts of the united states database available at the Federal Reserve board of governors website.

## 2.3 Fund flows

Following prior studies (e.g., Lou (2012)), I construct quarterly investment flows to fund $f$ at quarter $t$ based on the formula below, by using the information CRSP provides on the return, total net asset value, and merger status of each fund.

$$Flow_{f,t} = \frac{TNA_{f,t} - TNA^{adj}_{f,t-1}(1 + Ret_{f,t})}{TNA^{adj}_{f,t-1}} \tag{1}$$

| | Mean | SD | 10th | 50th | 90th |
|---|---|---|---|---|---|
| *Panel A: Trading behavior* | | | | | |
| Number of holdings at quarter-ends | 299.8 | 458.5 | 60 | 164 | 663 |
| Percentage of no trade (%) | 88.2 | 10.1 | 78.4 | 90.6 | 96.1 |
| Fraction liquidated (%) | 7.1 | 6.6 | 1.7 | 5.4 | 14.3 |
| Fraction of new holdings (%) | 8.7 | 11.9 | 1.7 | 7.1 | 16.9 |
| *Panel B: Exposure to the Selected Counties* | | | | | |
| Exposure to a selected county government (%) | 0.8 | 1.6 | 0.0 | 0.34 | 2.14 |
| Overall exposure to the selected county governments (%) | 5.9 | 7.1 | 1.4 | 4.0 | 11.7 |
| *Panel C: Portfolio Composition* | | | | | |
| State governments (%) | 7.5 | 7.6 | 0.2 | 5.5 | 17.2 |
| County governments (%) | 4.0 | 5.8 | 0.0 | 2.3 | 9.3% |
| City governments (%) | 5.8 | 4.6 | 1.1 | 4.7 | 11.7 |
| *By sector* | | | | | |
| State and local governments (%) | 18.5 | 11.6 | 6.5 | 16.2 | 33.7 |
| Utility (%) | 10.4 | 6.8 | 2.6 | 9.4 | 19.1 |
| Transportation (%) | 9.3 | 6.2 | 1.8 | 8.5 | 17.6 |
| Health (%) | 11.9 | 6.7 | 3.0 | 11.6 | 20.7 |
| Housing (%) | 4.2 | 4.6 | 0.0 | 2.9 | 10.1 |
| Education (%) | 17.2 | 10.2 | 6.3 | 15.0 | 32.0 |
| Others (%) | 28.4 | 16.6 | 9.5 | 26.1 | 48.7 |

**Table 3: Summary of trading behavior and portfolio composition of municipal funds.** This table is constructed based on the holding data obtained from CRSP, for the period between 2009 and 2019. Panel A reports some summary statistics about the trading behavior of the mutual funds in the study. Panel B provides some summary statistics on the exposure of the funds to the selected counties. In panel C, each row presents information about the distribution of the percentage of municipal bond investments allocated to each issuer group or category. The bond categorization is obtained from merging the holding data with the Municipal Atlas database.

In (1), $TNA_{f,t}$ is the total net asset value of fund $f$ at the end of quarter $t$. $TNA^{adj}_{f,t}$ accounts for the fund mergers between quarter-ends $t-1$ and $t$. Since the exact date of the mergers are not available, I assume that the target fund's assets are acquired at the first day after the date of the latest available TNA for the target fund. $Ret_{f,t}$ is the return of fund $f$ between quarter-ends $t-1$ and $t$.

# 3 Flow-induced demand and government debt issuance

In this section, I examine the impact of mutual fund flows on the borrowing behavior of the selected county governments. To this end, I follow an empirical strategy that exploits biases in the trading behavior of the mutual funds. For instance, when a fund receives outflows, it is more likely to sell from its existing positions, rather than short-selling other bonds, due to short-sale constraints. Therefore, the county governments that are exposed to the fund face a higher selling pressure compared to the unexposed governments. Such biases cause the trading behavior of the funds to be partly predictable, which we can exploit to predict which governments relatively receive more or less demand based on the observable flows. Consequently, I examine how differently the governments respond to the predicted differences in demand.

Section 3.2 verifies that the funds respond to inflows and outflows in a predictable manner. In particular, in Section 3.1, I introduce a backward-looking measure of a fund's significance for a county government's bond market, which is based on the fund's past market share in the government's outstanding bonds. Building on this finding, I introduce my main demand instrument, "Flow-induced demand," in Section 3.3. Moreover, the validity of the demand instrument is discussed. Then, I analyze how the governments respond to flow-induced demand shocks.

## 3.1 A measure of fund significance for a government

For each fund $f$, county government $c$, and quarter $t$, I define significance measure $SIG_{f,c,t}$ as

$$SIG_{f,c,t} = \max_{t-11 \le t' \le t} \quad OWN_{fct'} \tag{2}$$

,where

$$OWN_{fct} = \frac{\text{Par-value investment of } f \text{ in } c \text{ at } t}{\text{Total par-value investment of mutual funds in } c \text{ at } t} \tag{3}$$

In (3), $OWN_{f,c,t}$ is the fraction of outstanding debt of county government $c$ held by the mutual funds that is owned by fund $f$. For instance, $OWN_{f,c,t} = 1$ means that $f$ is the only mutual fund at $t$ that holds the debt of government $c$, and $OWN_{f,c,t} = 0$ implies that fund $f$ does not hold any bond of government $c$ at $t$. By construction, $\sum_{f \in \text{Funds}} OWN_{f,c,t} = 1$ for any $t$ and county government $c$. Building on this ownership variable, $SIG_{f,c,t}$ denotes the largest ownership of fund $f$ over the twelve quarters ending at $t$. Put differently, funds with large values of $SIG_{f,c,t}$ are the ones that are or were a major investor of government $c$ at some point in the past three years up to $t$. Table 4 presents the summary statistics for $OWN$ and $SIG$.

| | Mean | SD | 1th | 10th | 50th | 90th | 99th |
|---|---|---|---|---|---|---|---|
| $\text{OWN}_{f,c,t}$ (%) | 2.1 | 9.7 | 0.0 | 0.0 | 0.0 | 3.1 | 51.8 |
| $\text{SIG}_{f,c,t}$ (%) | 5.0 | 15.8 | 0.0 | 0.0 | 0.0 | 11.7 | 100.0 |

**Table 4: Summary statistics of ownership and significance variables.** $\text{OWN}_{f,c,t}$ is the share of fund $f$ at the end of quarter $t$ in the total par-value investments of the mutual funds in my sample in the bonds of county government $c$. $\text{SIG}_{f,c,t}$, as defined in (2), is the maximum value of the ownership variable for the twelve quarters ending at $t$.

### 3.2 Fund flows and trading behavior

Now, I investigate whether $SIG$ can be used to predict how a fund invests its inflows. To this end, I estimate the coefficients in the panel regression below:

$$\Delta \log Inv^{Par}_{c,f,t} = \beta_0 + \beta_1 Flow_{f,t} + \gamma_2 SIG_{c,f,t-1} + \gamma_3 Flow_{f,t} \times SIG_{c,f,t-1} + \varepsilon_{c,f,t} \tag{4}$$

In (4), $Inv^{Par}_{c,f,t}$ represents the par-value investment of fund $f$ in the bonds issued by government $c$ at the end of quarter $t$. I add \$1 to all investments to avoid infinite values for zero positions.[13] The regression results for Specification 4, along with for some benchmark cases, are provided in Table 5.

Table 5 informs how mutual funds respond to inflows and outflows. The results of specifications (1)

[13]Out of 23,916 observations of increase in investment ($\Delta Inv^{Par}_{f,c,t} > 0$), 15,586 (65%) are initiations of a new position, i.e, $Inv_{f,c,t-1} = 0$. Using the percentage change in positions as the dependent variable would eliminate most of these observations. To verify the robustness of the results, Table A.2 reports the results for different definitions of investment change with respect to a government.

| | $\Delta \log Inv^{Par}_{f,c,t}$ | | | | | |
|---|---|---|---|---|---|---|
| | Inflow Sample | | | Outflow Sample | | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $Flow_{f,t}$ | $-0.002$ | $-0.002^{*}$ | $-0.002$ | $0.524^{***}$ | $0.501^{***}$ | $0.360^{**}$ |
| | (0.001) | (0.001) | (0.001) | (0.153) | (0.154) | (0.157) |
| $\text{OWN}_{f,c,t-1}$ | | $-4.562^{***}$ | | | $-4.381^{***}$ | |
| | | (0.140) | | | (0.121) | |
| $\text{OWN}_{f,c,t-1} \times Flow_{f,t}$ | | 0.209 | | | $5.716^{***}$ | |
| | | (0.199) | | | (1.451) | |
| $\text{SIG}_{f,c,t-1}$ | | | $-0.176^{**}$ | | | $-0.286^{***}$ |
| | | | (0.069) | | | (0.073) |
| $\text{SIG}_{f,c,t-1} \times Flow_{f,t}$ | | | $0.489^{***}$ | | | $2.229^{***}$ |
| | | | (0.156) | | | (0.775) |
| Observations | 144,312 | 144,312 | 144,312 | 151,088 | 151,088 | 151,088 |
| Quarter FE | Y | Y | Y | Y | Y | Y |
| Fund FE | Y | Y | Y | Y | Y | Y |
| $R^2$ | 0.031 | 0.043 | 0.032 | 0.029 | 0.044 | 0.032 |

**Table 5:** This table reports the regression results of mutual fund trading in response to capital inflows and outflows. The dependent variable ($\Delta \log Inv_{f,c,t}$) is the change in the log of par-value investment of fund $f$ in the bonds issued by county government $c$ at the end of quarter $t$. The investments are aggregated at government level. 1$ is added to all investments to avoid infinite values for zero positions. $Flow_{f,t}$ is the quarterly flow to fund $f$ between $t-1$ and $t$, as a fraction of the merger-adjusted total net asset value at the end of quarter $t-1$. $OWN_{f,c,t}$ is the market share of fund $f$ in the total par-value investment of mutual funds in government $c$ at $t$. $SIG_{f,c,t}$ is the maximum value of $OWN_{c,f,t'}$ in the twelve quarters ending at $t$.

and (2) suggest that inflows do not result in more investment in the current positions. It is in line with the observation in Table 3 that the funds hardly expand their current positions; most of the portfolio adjustments by municipal mutual funds are in the form of liquidating an existing position or initiating a new position. In fact, regression results for specifications (2) and (5) suggest that the funds reduce their current positions regardless of the flow sign, just they do so more intensely when they receive outflows.

Specifications (3) and (6) of Table 5 demonstrate the role of past positions, captured by $SIG$, in a fund's trading. By juxtaposing specifications (2) and (3), we see that when the fund flow is sufficiently large, the funds use the inflow to invest in the bonds of governments that they used to have a larger position over the past three years. Table A.1 illustrates this point by adding a dummy of $\mathbb{I}\{SIG_{f,c,t-1} > OWN_{f,c,t-1}\}$ to Specification 4.

This trading behavior can arise for multiple reasons. For the outflows, the impact is somehow mechanical. The funds need to liquidate some of their positions to meet the withdrawals. For the inflow sample, the behavior can be explained with the presence of some informational costs. Mutual funds avoid investing in governments with a poor financial condition since they are more likely to be downgraded. Therefore, they need to perform due diligence in their investments, which is costly. The cost is lower for the governments that they have already examined their financials in their previous investments, which could lead to the pattern we see in Table 5. Another potential reason is that underwriters contact investors that are potentially interested in an issue. If a fund had repeatedly purchased the bonds of a particular government, it is more likely to be contacted by the underwriter or underwriting syndicate of a new bond issue of that government.

Overall, the main takeaway from the results of specifications (3) and (6) is that $SIG$ at $t-1$ is informative about how mutual funds respond to inflows and outflows at $t$. It is the basis of utilizing the fund flows to predict the cross-sectional changes in the demand for the bonds of the county governments. The next section details the procedure.

### 3.3 Constructing flow-induced demand

In this section, I examine whether the fund flows have an impact on the timing, size, and the interest rate of the governments' borrowing. To this end, I construct a measure of flow-induced demand (FID):

$$FID_{c,t} = \sum_{f \in \text{Funds}} \text{SIG}_{f,c,t} \times \text{Flow}_{f,t} \times \text{PSF} \tag{5}$$

In (5), $SIG_{f,c,t}$ is the maximum ownership of fund $f$ in the bond market of government $c$ over the twelve quarters ending at $t$. $Flow_{f,t}$ is the dollar flow to fund $f$ during quarter $t$, scaled by its merger-adjusted AUM at the beginning of the quarter. Lastly, $PSF$ is the point coefficient estimate under specifications (3) and (6) in Table 5. In fact, it is either 0.489 or 2.229, depending on the sign of flow, and captures how flows to fund $f$ are translated into trades (Lou, 2012). In short, $FID_{c,t}$ captures the dollar demand for the bonds of government $c$ by mutual funds at $t$, scaled by the total market value of the bonds held by the funds.[14]

$FID$ can be interpreted as a Bartik instrument that isolates an exogenous component in demand for the bonds. The exclusion restriction for the instrument's validity is that the cross-section of the fund flows is uncorrelated with the funding need of the county governments. It is a plausible assumption for three reasons. First, mutual funds tend to hold diversified portfolios in their target states. It is evidenced by Table 3, as it demonstrates that most funds hold large portfolios and do not have large exposure to any specific sector in the market or selected county government. Second, the table reveals that the bonds of the selected county governments only comprise 5.9% of the funds' assets on average. Third, Table A.3 suggests that the investors might not be perfectly strategic in their fund selection, as it shows that investors do not significantly respond to the funds' past returns. Therefore, it is unlikely that a fund's exposure to a specific county government affects the investors' capital allocation to that fund.

Figure 3 presents the average flow-induced demand for each year (left-axis), along with the total par value of the bonds issued by the selected counties for those years (right-axis). The figure reveals a comovement between these two variables. We see that the flow-induced demand is negative for most observations. It is due to the asymmetry between responses to inflows and outflows by the mutual funds, as observed in Table 5. The impact of outflows is about four times larger than the impact of inflows, which causes the asymmetry we observe in the predicted demand values.

[14] The following heuristic calculations elucidate the intuition had we defined $SIG = OWN$:

$$
\begin{aligned}
FID_{c,t} &\simeq \frac{1}{MV_{Funds,c,t-1}} \sum_{f \in \text{Fund}} MV_{f,c,t-1} \times Flow_{f,t-1} \times PSF \\
&= \frac{1}{MV_{Funds,c,t-1}} \sum_{f \in \text{Fund}} \frac{MV_{f,c,t-1}}{AUM_{f,t-1}} \times Flow^{\$}_{f,t-1} \times PSF
\end{aligned}
$$

In the first line, $MV_{Funds,c,t}$ and $MV_{f,c,t} \simeq MV_{Funds,c,t} \times OWN_{f,c,t}$ are the total market value of government $c$'s bonds held by mutual funds and fund $f$, respectively. Note that I use the approximation that all funds hold the same composition of the bonds of government $c$ so that they have the same market-to-book value. In the second line, $AUM_{f,t-1}$ is the total value of assets under the management of fund $f$, and $Flow^{\$}_{f,t}$ is the dollar flow to fund $f$. When $PSF = 1$, the demand corresponds to the case that each fund scales its portfolio uniformly across its holdings.

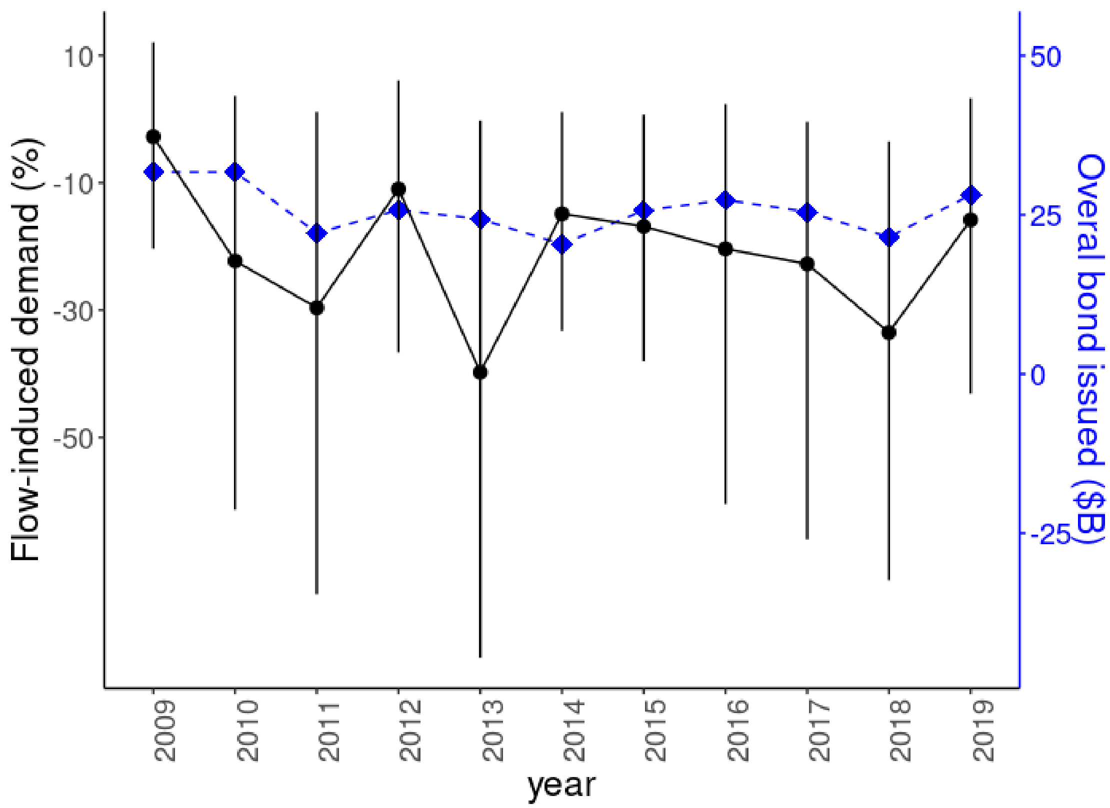



**Figure 3:** This figure presents the average value of $FID$ for each year (left-axis), along with the overall par value of bonds issued by the selected counties (dashed-line, right-axis). Flow-induced demand ($FID$) is computed based on Equation (5) for each county at every quarter. The vertical lines display the range of values between the 90th percentile and 10th percentile of $FID$ for each year.

### 3.4 Flow-induced demand and the timing of borrowing

To examine the impact of flow-induced demand on the timing of debt issuance by the selected county governments, I estimate the coefficients in Equation 6. In (6), $\text{Issue}_{c,t}$ is a dummy variable that reflects whether government $c$ issued debt at quarter $t$ :

$$Prob(\text{Issue}_{c,t+1}) = \Phi(\alpha_0 + \alpha_1 FID_{c,t} + \alpha_2 X_t) \tag{6}$$

The regression results are provided in Table 6. In Specifications (1) and (2), which do not include state-by-year fixed effect, flow-induced demand predicts the timing of issuance. Note that $FID_{c,t}$ is constructed based on time-$t$ variables. Therefore, at least in terms of timing, the fund flows lead the governments' bond issuance. However, Specification 3 suggests that the evidence that $FID$

predicts the timing is not strong, as is absorbed by the state-by-year fixed effect. It is, in fact, consistent with the long and costly nature of the process to obtain authorization for a new bond issue, especially for general obligation bonds. The procedural challenges make it difficult for many municipalities to time the market.

| | Prob($Issue_{c,t+1}$) | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| $\text{FID}_{c,t}$ | 0.128*** | 0.093** | 0.026 |
| | (0.037) | (0.037) | (0.037) |
| Observations | 8,661 | 8,661 | 8,661 |
| Type | Probit | Probit | Probit |
| County FE | Y | Y | Y |
| Season FE | N | Y | Y |
| Year-State FE | N | N | Y |
| Log Likelihood | −4,815 | −4,753 | −4,646 |

**Table 6:** This table provides the regression results inspecting the impact of flow-induced demand on the probability of bond issuance in the next quarter. The dependent variable is a dummy variable that is one if government $c$ issues bond at quarter $t+1$. A probit model is employed for the estimation. $\text{FID}_{c,t}$ is the flow-induced demand faced by government $c$ at quarter $t$, computed based on Equation 5.

Table 7 presents how the flow-induced demand affects the probability of bond issuance in the previous and subsequent quarters. It further confirms that the bond issuance does not lead $FID$. In fact, the results imply that the opposite is the case. Furthermore, there is no evidence of the governments delaying (expediting) their issuance in response to unfavorable (favorable) demand conditions. If that was the case, there should have been a negative relationship between $FID$ and probability of issuance in the subsequent quarters, which is not what Table 7 suggests.

### 3.5 Flow-induced demand and the size of borrowing

I estimate the coefficients in Specification 7 to examine the impact of flow-induced demand on the size of issuance. Issue $\text{Size}_{c,t}$ is the total par value of debt issued at quarter $t$ by government $c$. $X_t$ denotes the vector of control variables. Table 8 presents the results.

$$\log\,(\text{Issue Size})_{c,t+1} = \beta_0 + \beta_1 FID_{c,t} + \beta_2 X_t + \varepsilon^{size}_{c,t+1} \tag{7}$$

| | $Prob(Issue_{c,t+j})$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | $j=-3$ | $j=-2$ | $j=-1$ | $j=0$ | $j=1$ | $j=2$ | $j=3$ | $j=4$ |
| $\text{FID}_{c,t}$ | −0.010 | −0.050 | −0.047 | 0.065* | 0.093** | 0.103*** | 0.030 | 0.028 |
| | (0.038) | (0.038) | (0.038) | (0.037) | (0.037) | (0.038) | (0.038) | (0.038) |
| Observations | 7,973 | 8,218 | 8,465 | 8,714 | 8,661 | 8,414 | 8,169 | 7,925 |
| County FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Season FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Log Likelihood | −4,374 | −4,503 | −4,640 | −4,788 | −4,753 | −4,623 | −4,492 | −4,338 |

**Table 7:** This table provides the results of regressions that examine how the flow-induced demand impacts the probability of bond issuance in previous and subsequent quarters. $Issue_{c,t+j}$ is a dummy variable that is one if county government $c$ issues bonds at quarter $t+j$. $\text{FID}_{c,t}$ is the flow-induced demand faced by government $c$ at quarter $t$, computed based on Equation 5.

The results provide a strong evidence that $FID$ substantially impacts the size of borrowing by the county governments. In fact, it suggests that a 1% inflow to mutual funds causes the borrowing size to increase by 0.224%. It is equivalent to $0.224\% \times 19.4\% = 0.043$ percentage point increase in the size of outstanding debt, where 19.4% is the average ratio between the issue size and outstanding debt and obtained from Table 1.

Specifications (1)-(3) provide the estimation results in the presence of different sets of fixed effects. The coefficient in all specifications is stable at around 0.2%. Note that the state-by-year fixed effect absorbs all state-level shocks at annual frequency, such as changes in the tax rates, or years with natural disasters, potentially associated with a higher-than-normal supply of bonds. Specification (4) tests whether changes in the financial condition can explain the correlation between the flow-induced demand and issue size. Comparing with the baseline results of Specification (2), we see that the regression coefficient of flow-induced demand slightly increases and is significant at 1% level.

Another potential concern is that the demand for the fund shares could be correlated with the demand for the government's bonds. For instance, when the local investors receive positive wealth or credit shocks, the demand for both the bonds and fund shares might increase, following Mian and Sufi (2014); Chodorow-Reich, Nenov, and Simsek (2021). Motivated by this channel, Specification (5) controls for the changes in the local house prices and gross income in the current and previous year. The coefficient of interest decreases slightly, however it is still significant at 1% level.

What is the mechanism through which the fund flows impact the size of bond issuance? In the

| | log(Issue Size$_{c,t+1}$) | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| FID$_{c,t}$ | 0.197*** | 0.196*** | 0.224*** | 0.245*** | 0.196*** |
| | (0.060) | (0.060) | (0.068) | (0.081) | (0.075) |
| Observations | 2,590 | 2,590 | 2,590 | 2,273 | 2,119 |
| County FE | Y | Y | Y | Y | Y |
| Season FE | N | Y | Y | Y | Y |
| Year-State FE | N | N | Y | Y | Y |
| Additional Controls | N | N | N | Revenue gr. + lag<br>Expenditure gr. + lag<br>Liability gr. + lag | Income gr. + lag<br>House pr gr. + lag |
| SE-clustered | State-Year | State-Year | State-Year | State-Year | State-Year |
| $R^2$ | 0.601 | 0.601 | 0.643 | 0.656 | 0.669 |

**Table 8:** This table provides the regression results inspecting the impact of flow-induced demand on the size of debt issued by the selected county governments. The dependent variables is the logarithm of total par value of debt issued at quarter $t$ by government $c$. FID$_{c,t}$ is the flow-induced demand faced by government $c$ at quarter $t$, computed based on Equation 5. Specifications (3)-(5) include county, year-by-state, and season fixed-effects. All standard errors are clustered at state-by-year level. The controls in Specification (4) are revenue growth, expenditure growth, and liability growth of each county government, along with their lag, obtained from the Muni Atlas database. The controls in Specification (5) are the change in the overall gross income reported to IRS and house price growth, along with their lagged values, for the corresponding county.

municipal bond market, around 80% of total nominal value of municipal bonds issued are sold through negotiated sales, in which an underwriter or underwriting syndicate directly negotiates on different terms of the deal, including the issue size. Before finalizing the terms, the underwriting team surveys the market to gauge the demand for the new issue. Thus, their perception of the bond demand is crucial for the issue size since they have a limited risk capacity and need to sell their bonds quickly.

Even if the government auctions the issue to multiple underwriters, a deal type known as "competitive sale," the issuer's financial advisors potentially advise the issuing government on the issue size to help it attract more potential underwriters. Setting a large issue size when the demand is perceived to be weak deters underwriters from participating in the auction.

Table 9 examines the persistency of the impact of the fund flows on the governments' issue size. The results are visualized in Figure 4. First, the regression results confirm that there is no pre-trend for the impact of the fund flows. In other words, the governments' bond issuance does not seem to predict the fund flows. Moreover, the results suggest that $FID$ impacts the size of issuance even after four quarters. However, the magnitude of the impact is substantially smaller after one quarter. These facts are used in the calibration of the model presented in Section 4.

| | log(*Issue Size*$_{c,t+j}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $j=-3$ | $j=-2$ | $j=-1$ | $j=0$ | $j=1$ | $j=2$ | $j=3$ | $j=4$ | $j=5$ |
| FID$_{c,t}$ | 0.022 | $-0.031$ | 0.035 | 0.096$^{**}$ | 0.196$^{***}$ | 0.117$^{**}$ | 0.090$^{*}$ | 0.088$^{*}$ | 0.081 |
| | (0.037) | (0.037) | (0.045) | (0.043) | (0.060) | (0.051) | (0.050) | (0.047) | (0.049) |
| Observations | 2,381 | 2,449 | 2,520 | 2,610 | 2,590 | 2,526 | 2,446 | 2,354 | 2,273 |
| County FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Season FE | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| SE-Clustered | State-Year | State-Year | State-Year | State-Year | State-Year | State-Year | State-Year | State-Year | State-Year |

**Table 9:** This table provides the regression estimates on the impact of flow-induced demand at quarter $t$ on the size of bond issuance for quarters before and after $t$. FID$_{c,t}$ is the flow-induced demand faced by government $c$ at quarter $t$, computed based on Equation 5. All regressions include county and season fixed effects. The standard errors are clustered at state-by-year level.

**Does the tax-benefit associated with the in-state investing explain the results?**

Interest income on municipal bonds are typically exempt from state and federal taxes as long as the investment is within the state of residency. This fact creates market segmentation along the states' border lines since the tax benefit pushes up the bond prices, makes the investment unattractive for out-of-state investors. Moreover, the majority of funds operate in only one state to deliver tax-free income to their investors (Babina, Jotikasthira, Lundblad, and Ramadorai, 2021). A potential concern is that the empirical results are connected to the tax treatment of municipal bonds. In Table 10, I address this concern by testing two direct implications of the tax-induced market segmentation.

First, if the observed impact of the fund flows is related to the tax-induced market segmentation, then the fund flows should be more impactful in states with a higher degree of segmentation. The degree of market segmentation can be captured by the tax-advantage that the investors in a state receive by investing in the bonds of their residency state, rather than investing in the bonds of other states. For instance, investors in California typically do not need to pay state taxes on the interest incomes of bonds issued by California governments. However, they would need to pay state taxes, up to 13.3% of the interest income, if they hold bonds issued outside the state boundary. Since such tax benefits tend to push up the prices, it would make the bonds less appealing for investors outside the state. In the first specification of Table 10, I interact this tax-advantage for different states with $FID$. The results do not suggest that $FID$ has a stronger impact in states with a

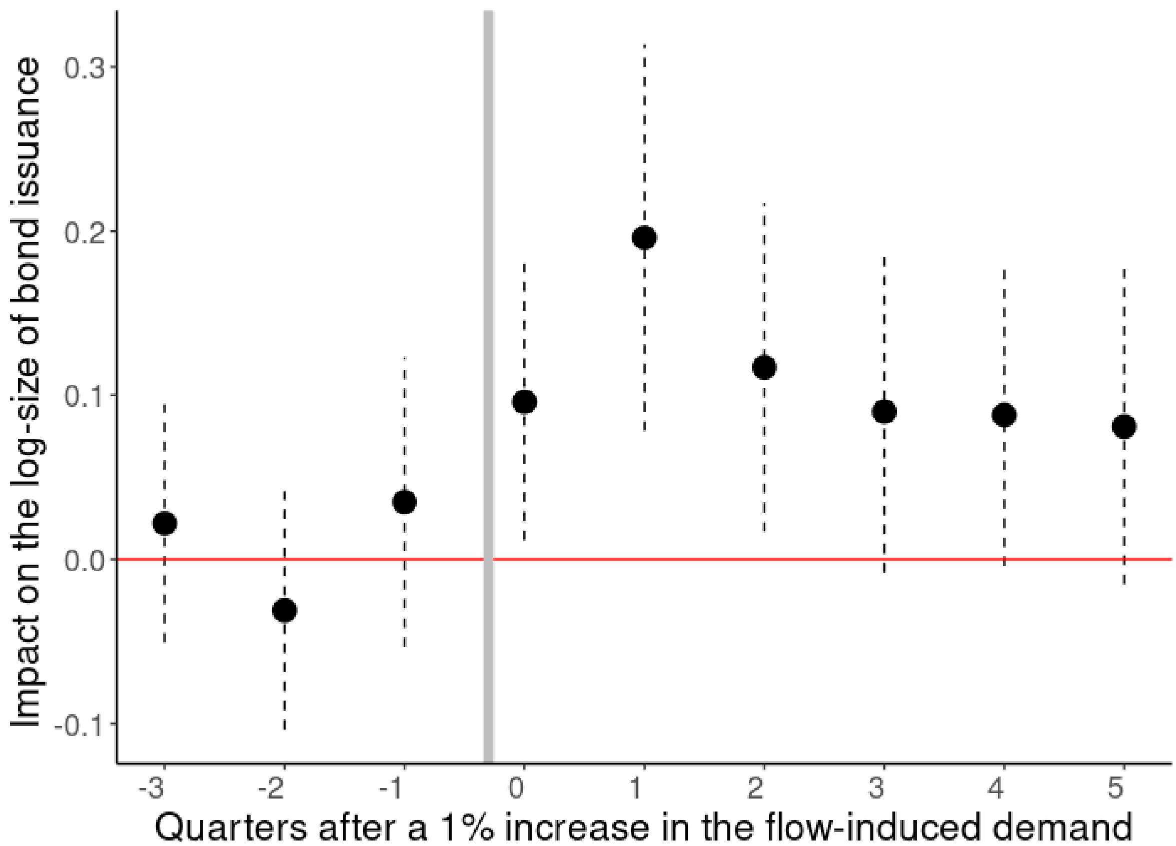



**Figure 4:** This figure displays how a 1% increase in the flow-induced demand impacts the overall size of bond issuance in the subsequent quarters. The points represent the point estimates provided in Table 9. Each point estimates is obtained by regressing the log size of bond issuance at quarter $t + j$ (log(Issue Size$_{c,t+j}$)) on $FID_{c,t}$. Quarter and county fixed effects are included, and standard errors are clustered at state-by-year level. The dashed-lines provide the confidence interval at 95% level. FID$_{c,t}$ is the flow-induced demand faced by government $c$ at quarter $t$, computed based on Equation 5.

higher degree of segmentation.

As mentioned earlier, another concern is that many funds face mandates in their investments, which forces them to invest inside their domicile state. In Specification (2) of the table, I add a state-level FID to the regression, which absorbs the demand induced by such mandates. State-level FID, in fact, is a weighted average of the fund flows, multiplied by some scaling factor, where every fund is weighted based on its significance for the municipal bond market of that state. If the market shares are persistent at the state level, then those market shares would be close to the weights used to construct the state-level $FID$. We see that the impact of the original FID is still significant at 5% level. It suggests that all governments within a state are not perfect substitutes for the funds.

| | log(Issue Size)$_{c,t+1}$ | |
|---|---|---|
| | (1) | (2) |
| FID$_{c,t}$ | 0.328$^{***}$ | 0.180$^{**}$ |
| | (0.119) | (0.088) |
| FID$_{c,t}$ $\times$ In-state tax privilege | $-0.027$ | |
| | (0.022) | |
| State-level FID$_{c,t}$ | | 0.020 |
| | | (0.019) |
| Observations | 2,542 | 2,549 |
| Type | OLS | OLS |
| County FE | Y | Y |
| Year-State FE | Y | Y |
| Season FE | Y | Y |
| SE-clustered | State-Year | State-Year |
| $R^2$ | 0.642 | 0.643 |

**Table 10:** This table provides the regression results examining the impact of tax-benefits of in-state investment on the earlier results. State-level FID$_t$ is the state-level flow-induced demand, which is computed similar to (5). "In-state tax privilege" for a state is the largest difference between the tax rate applied to the interest income of in-state and out-of-state investment for the residents of each state. FID$_{c,t}$ is the flow-induced demand faced by government $c$ at quarter $t$, computed based on Equation 5. Both regressions include county fixed effects, season fixed effects, and state-by-year fixed effects. All standard errors are clustered at state-by-year level.

### 3.6 Flow-induced demand and the borrowing rate

This section examines the impact of flow-induced demand on municipal governments' borrowing rate. Particularly, the coefficients in the following equation are estimated:

$$\begin{aligned}\text{yield-spread}_{c,t,bond} = \beta_0 + \beta_1 FID_{c,t} + \beta_2 \text{YTM} + \beta_3 \text{log-size} \\ + \beta_4 FID_{c,t} \times \text{log-size} + \beta_5 FID_{c,t} \times YTM + \gamma X_{c,t,bond} + \varepsilon_{c,t,bond}\end{aligned} \tag{8}$$

In (8), yield-spread is the tax-adjusted spread of the bond over a maturity-adjusted treasury at $t$.[15] $YTM$ denotes the bond's maturity in years, and log-size is the deal size of the bond issue. $X_{c,t,bond}$ represents a vector of bond characteristics (e.g., coupon rate, insured status, maturity type) that I control for. Quarter-rating fixed effect are also included in the regression specification. Table 11 presents the results.

The results reveal that the impact of flow-induced demand on the credit spread, while significant, is small and limited to few basis points. The coefficient estimates imply that 100 basis points increase (equivalent to one percentage point) in the flow-induced demand reduced the credit spread by 0.2 basis points. Recall from Section 3.5 that the same magnitude of change in the flow-induced demand increase the size of borrowing by 22 bps and outstanding debt by 3.2 basis points. It indicates that the impact of flow-induced demand on the debt quantity is one order of magnitude larger than its impact on the debt price.

This borrowing behavior is consistent with the earlier empirical findings. Yi (2020) examined how municipal governments responded to a regulation that reduced the lending ability of some banks to their municipal borrowers. She finds that the borrowing size of the most affected municipal governments decreased by 90% more than the least affected ones, while the relative increase in the interest rate was only 0.1% for the most affected group. Adelino, Cunha, and Ferreira (2017) and Cornaggia, Cornaggia, and Israelsen (2018) study the impact of Moody's recalibration of credit ratings in 2010 on municipal borrowing. Both studies compare the response of upgraded governments with not-upgraded ones. Their estimates indicate that the upgraded governments

[15] To compute the tax-adjusted spread, I use the equation below following Schwert (2017):

$$\text{yield-spread}_{bond_t} = \frac{\text{yield}}{(1 - \tau^{State}\mathbb{I}_{State-exempt})(1 - \tau^{Fed}\mathbb{I}_{Fed-exempt})} - r_t \tag{9}$$

The tax rates are obtained from NBER's TaxSim data set. $r_t$ in (9) is the interest rate on a maturity-matched treasury at $t$.

| | Tax-adjusted yield-spread (%) | |
|---|---|---|
| | (1) | (2) |
| $FID_{c,t}$ | $-0.002^{**}$ | $-0.002^{*}$ |
| | (0.001) | (0.001) |
| log-size | $0.026^{***}$ | $0.026^{***}$ |
| | (0.004) | (0.004) |
| YTM | $0.137^{***}$ | $0.135^{***}$ |
| | (0.001) | (0.001) |
| log-size × $FID_{c,t}$ | $0.0001^{**}$ | $0.0001^{**}$ |
| | (0.00005) | (0.00005) |
| YTM × $FID_{c,t}$ | | $-0.00005^{***}$ |
| | | (0.00001) |
| Observations | 33,705 | 33,705 |
| County FE | Y | Y |
| Coupon rate | Y | Y |
| quarter-rating FE | Y | Y |
| Insured-status dummy | Y | Y |
| Maturity-option FE | Y | Y |
| $R^2$ | 0.817 | 0.817 |

**Table 11:** This table provides the results of regression analysis pertaining to the impact of flow-induced demand on the credit spread of the bonds issued by the selected counties. The dependent variable, tax-adjusted yield spread, is constructed based on Equation 9, which adjusts for the bonds' tax-exemptions. The spread is computed relative to a maturity-matched treasury at the same month of the issuance. $FID_{c,t}$ is the flow-induced demand faced by county government $c$ at quarter $t$, derived by Equation 5. log-size is the natural logarithm of the deal size. YTM denotes the bond years-to-maturity in years. Both regressions include quarter-rating fixed effect, county fixed effect, and maturity type fixed effect, capturing whether the bond is callable or not. Other controls are the bond coupon rate and insured-status.

responded by borrowing 18% more annually. However, their interest rate only dropped by 0.2% more than the not-upgraded group.

Since most previous studies explore the impact of large credit shocks, the new evidence provided in this section contributes to literature by suggesting that even small credit supply shocks are not easily absorbed in the municipal bond market. Furthermore, I use my empirical estimates to inform the parameters of the model presented in Section 4 to drive conclusions about the elasticity of supply and demand for municipal bonds.

## 4 A dynamic model of the municipal bond market

Empirical results in Section 3 reveal that capital flows to mutual funds substantially impact the borrowing quantity of municipal governments, especially in the short run. This result is at odds with standard theory, which implies an elastic demand for municipal bonds: when mutual funds' demand for bonds increases due to capital inflows, other market participants should promptly absorb the shock by supplying their bonds at the competitive price; thus, the impact of capital flows on the governments' borrowing quantity should be small.

The model presented here explains this puzzling empirical observation by considering two deviations from the frictionless benchmark: First, the households, the end investors of the bonds, exhibit sluggish portfolio behavior, motivated by earlier empirical evidence (See, e.g., Giglio, Maggiori, Stroebel, and Utkus (2021)). In my model, the households can invest in municipal bonds either directly or indirectly, through mutual funds. Since the directly investing households do not respond to price changes immediately, the capital flows in and out of mutual funds substantially impact the market outcomes.

The second friction is that the mutual funds do not invest optimally on behalf of their investors due to the presence of investment mandates (Gabaix and Koijen, 2020). Investment mandates further lower the short-term demand elasticity as they restrict the funds' ability to absorb flow shocks. The households' sluggish portfolio behavior intensifies the problem since the households would have undone the friction had they reoptimized their allocation to the funds frequently.

I use the empirical estimates in Section 3.3 to calibrate the model. The calibration results suggest that the bond supply elasticity by the county governments in my sample is 19, which implies that the governments increase their outstanding debt by 1.9% when the interest rate falls by ten basis points. Furthermore, the short-term demand elasticity is at one order of magnitude smaller than the long-term demand elasticity. I conclude the section by discussing in depth how the model can be deployed to gauge the impact of significant market events on the borrowing behavior of municipal governments, such as the massive outflows from municipal mutual funds in March and April 2020.

### 4.1 Setup

Time is discrete, i.e., $t = 0, 1, 2, \ldots$. The economy could represent the municipal bond market in one of the US states since most investors only invest in the bonds issued in their state of residence to maximize their tax savings. Municipal bonds are supplied by a representative municipal government. The government sets the nominal amount of outstanding debt, denoted by $Q_t$, so that maximizes its objective function:

$$P_t(\frac{Q_t}{W_t^R}) - \frac{\phi}{1+\gamma}(\frac{Q_t}{W_t^R})^{1+\gamma} \tag{10}$$

In (10), $P_t$ is the unit price of the bonds, and $W_t^R$ is the overall wealth of the residents. The government trades off the bond issuance revenue against a convex cost, capturing the statutory limitations that the government faces in expanding its debt. The convex cost could represent different tiers of municipal debt with varying levels of procedural difficulty for their issuance. For instance, cities in the State of California can issue general obligation bonds with no voting requirement up to 1.5% of the assessed value of the taxable properties in their municipality. However, they can exceed the limit up to 2.5% of that assessed value by obtaining the supermajority approval from their residents. A higher $\gamma$ corresponds to a more restrictive borrowing regulation, which causes the elasticity of bond supply to be lower. Lastly, $\phi > 0$ is a constant.

The first order condition implies that the bond supply at $t$ only depends on the residents' wealth and price at $t$:

$$q_t \equiv \frac{Q_t}{W_t^R} = \phi^{-\gamma^{-1}} P_t^{\gamma^{-1}} \tag{11}$$

This reduced-form approach in modeling the budget constraint, despite its limitations, has some realistic features, in addition to helping yield tractability. First, financial authorities in municipal governments serve for limited terms, which gives them an incentive to be relatively myopic in their borrowing behavior. In fact, Table 7 suggests that the governments do not act strategically in their bond issuance; namely, they do not postpone (expedite) their issuance when the demand is relatively weak (strong). Second, the statutory limitations hardly change over time, which could set a tighter debt limit than the discounted value of the future revenues.

Note that the government effectively optimizes the level of $Q_t/W_t^R$, the borrowing amount per one unit of the residents' wealth. It accounts for two considerations that impact the government's borrowing decisions: First, the demand for infrastructure is naturally higher when the residents are wealthier. Second, the statutory debt capacity is typically determined as a percentage of the total value of the taxable assets in the municipality, which highly correlates with the overall local wealth. I assume that the funding need of the government does not change over time. In Appendix C.1, I consider a more general model that features a time-varying need for external funding.

Suppose $D_0$ is the promised coupon payment that each unit of the bond pays at each period, and $R^F$ is the risk-free rate. Since investors compare tax-exempt municipal bonds with other taxable fixed income securities, let $D \equiv \frac{D_0}{1-\tau}$ be the coupon payment for an equivalent taxable bond, where $\tau$ is the effective tax-benefit of municipal bonds. The government defaults on a fraction of its bonds with probability $\delta$, independent across the periods. The bond return is $R^D < R^F$ if a default happens. The default risk is the only source of uncertainty in this economy, and once it happens, all investors adjust their portfolios if necessary and the government never defaults again, implying that the remaining bonds become risk-free.

The economy is populated with overlapping generations of atomistic investors. Each investor dies with probability $1 - x \in (0, 1)$ at the beginning of each period. The investors' objective is to maximize their expected log-wealth at the time of death. More formally, investor $i$ chooses its portfolio allocations, under the restrictions that are explained later, so that maximizes the following objective function, where $t + \tau^{\text{death}}$ denotes the random time of death.

$$U_t^i = \mathbb{E}_t[\log w_{t+\tau^{\text{death}}}^i] \tag{12}$$

There are two groups of investors: "direct investors" who invest in municipal bonds directly and "indirect investors" who invest in the bonds indirectly through some mutual funds. I assume no overlap between these two groups, which is consistent with the institutional feature of the market. In 2013, among the 2.4% US households with a positive investment in municipal bonds, 1.6% had indirect investments and 0.9% directly invested in municipal bonds, leading to a 0.1% overlap (equivalent with 4.2% of the municipal bond investors) (Bergstresser and Cohen, 2016). The difference in the investment approach can be explained by differences in the level of sophistication regarding municipal bond trading or level of trust to municipal fund managers. In the model, I denote the overall wealth of the direct and indirect investors by $W_t^D$ and $W_t^{ID}$, respectively. By definition, $W_t^R = W_t^D + W_t^{ID}$. Upon death, the investors are replaced by their child who inherits their investment approach (i.e., indirect or direct) and entire wealth.

The key behavioral assumption of the model is that the investors rebalance their portfolio intermittently. In every period, a fraction $1 - \lambda \in (0, 1)$ of the direct and indirect investors reoptimize their portfolio, and the rest keep the same portfolio allocation as in the previous period. As such, $\lambda$ captures the extent of sluggishness in the investors' portfolio allocations. The sluggish portfolio adjustments cause the bond demand to be less elastic in the short-run, which is crucial to explain the large short-term quantity response observed in Figure 4.

Let $\alpha_t^D$ and $\alpha_t^{ID}$ be the average wealth fraction that the direct and indirect investors allocate to the municipal bonds and the mutual funds, respectively. Therefore, the portfolio dynamics for these investors can be specified as below:

$$\alpha_t^J = \lambda \alpha_{t-1}^J + (1 - \lambda)\alpha_t^{J-Reb} \quad J \in \{D, ID\} \tag{13}$$

,where $\alpha_t^{J-Reb}$ denotes the optimal portfolio allocation for the rebalancing investors at period $t$, cognizant of the fact that they will hold the same portfolio until their next rebalancing time.

The mutual funds invest fraction $\alpha^F(R_t)$ of their assets in municipal bonds, where $R_t \equiv \frac{P_{t+1}+D}{P_t}$ is the one-period return conditional on no default happening at $t + 1$. Furthermore, $\alpha^F(R_t)$ is an increasing function with a bounded second derivative. Note that $R_t$ is a sufficient statistic to describe the bond return since the return is binary, and it is either $R_t$ with probability $1 - \delta$ or $R^D$ with probability $\delta$. The indirect investors only have access to the risk-free asset other than the mutual funds. Therefore, they effectively allocate fraction $\alpha_t^{ID}\alpha^F(R_t)$ of their wealth to municipal bonds.

Lemma 1 provides the optimal portfolios for the direct and indirect investors that rebalance at $t$, provided the government does not default by $t$.

**Lemma 1.** *Let $\{R_t\}_{t=0}^{\infty}$ be the sequence of the bond return prior to the government's default. Therefore, the optimal allocation of the rebalancing investors at t, $\alpha_t^{D-Reb}$ and $\alpha_t^{ID-Reb}$, are the solutions to the following maximization problems:*

$$\alpha_t^{D-Reb} = \arg\max_{\alpha} \quad \frac{\delta}{1-\nu}\log\{R^F + \alpha(R^D - R^F)\} + (1-\delta)\sum_{s=0}^{\infty}\nu^s \log\{R^F + \alpha(R_{t+s} - R^F)\} \tag{14}$$

$$\alpha_t^{ID-Reb} = \arg\max_{\alpha} \quad \delta\sum_{s=0}^{\infty}\nu^s \log\{R^F + \alpha\alpha^F(R_{t+s})(R^D - R^F)\} + (1-\delta)\sum_{s=0}^{\infty}\nu^s \log\{R^F + \alpha\alpha^F(R_{t+s})(R_{t+s} - R^F)\} \tag{15}$$

*,where* $\nu = x\lambda(1-\delta)$.

In (14) and (15), we see that the optimal portfolios depend on all the future returns since the investors are uncertain about their next reoptimization time. The demand sensitivity with respect to the future returns is captured by $\nu$, which is increasing in the inattention parameter $\lambda$. In the extreme case that the investors reblanace their portfolio in every period, i.e., $\lambda = 0$, the optimal portfolios only depend on $R_t$, that is they become myopic in their portfolio decisions. More specifically, the optimal portfolios are $\alpha^*(R_t)$ and $\frac{\alpha^*(R_t)}{\alpha^F(R_t)}$ in this extreme case, where:

$$\alpha^*(R_t) = \arg\max_{\alpha} \quad (1-\delta)\log\{R^F + \alpha(R_t - R^F)\} + \delta\log\{R^F + \alpha(R^D - R^F)\} \tag{16}$$

Unlike the investors, the mutual funds are responsive to changes in the bond price. In fact, they can implement the optimal exposure to municipal bonds for their investors when $\alpha^F(R_t) = \alpha^*(R_t)$. In this case, the indirect investors achieve their optimal portfolio allocation by perfectly delegating their investment decisions to the funds, i.e., $\alpha_t^{ID} = 1$. It means that even though the indirect investors never change their allocation to the funds, their exposure to municipal bonds is always optimal. However, when $\alpha^F(R_t) \neq \alpha^*(R_t)$, possibly due to agency frictions (He and Krishnamurthy, 2013) or investment mandates (Gabaix and Koijen, 2020), the funds might over-react or under-react to changes in the bond price, and their investors are slow in adjusting their capital allocation and undoing the misallocation caused by the funds' suboptimal behavior.

In fact, municipal mutual funds typically face mandates in their portfolio allocations. For instance, Vanguard high-yield tax-exempt municipal bond fund has to invest at least 80% of its assets in investment-grade municipal bonds.[16] As reported by Table 2, the municipal funds invest their funds almost entirely in municipal bonds and hold little cash buffers. This feature is reflected in my calibration exercise in Section 4.3.

Lastly, I let the mutual funds receive investments from sources other than the investors inside the economy. For instance, an investor in Texas might invest in a California fund, i.e., a municipal mutual fund that invests in the bonds issued by California governments, possibly to diversify its bond portfolio nationally. That would increase the investment in California bonds, and reduce the investment in Texas bonds. Let $F_t^{Out}$ be the net amount of such investments.

Figure 5 depicts the structure of the bond market. Equation 17 provides the market clearing condition:

$$\begin{gathered}\alpha_t^F(R_t)W_t^F + \alpha_t^D W_t^D = P_t Q_t \\ W_t^F = F_t^{Out} + \alpha_t^{ID} W_t^{ID}\end{gathered} \tag{17}$$

## 4.2 The impact of fund flows on the bond price and quantity

In practice, mutual funds receive three types of inflows (similarly, outflows): The first type is that mutual fund investors might add to their investments in mutual funds. The second type is that some investors who used to invest directly in municipal bonds decide to have some indirect investment through mutual funds. The third type is that some investors living outside the economy (here, state) decide to increase their investment in municipal bonds by allocating more funding to the mutual funds active in that state.

Flows originated from different sources have different implications for the market outcomes. The first flow type has a temporary impact on the market outcomes since the indirect investors eventually reoptimize and fix their collective excess allocations (withdrawals). The second flow type has no first-order impact on the market outcomes; because, on average, both direct and indirect investors allocate the same fraction of their wealth to the bonds, which is their unconditionally optimal portfolio share of municipal bonds. Therefore, only the third type of fund flows has a permanent effect on the equilibrium quantity and prices.

Note that the model considers the mutual funds homogeneous, which is not the case in the data. The capital flows across the funds could also have a temporary or permanent impact on the governments' outstanding debt. For instance, if the familiarity bias in mutual funds' investments is persistent, the

[16] See more information about the fund here.

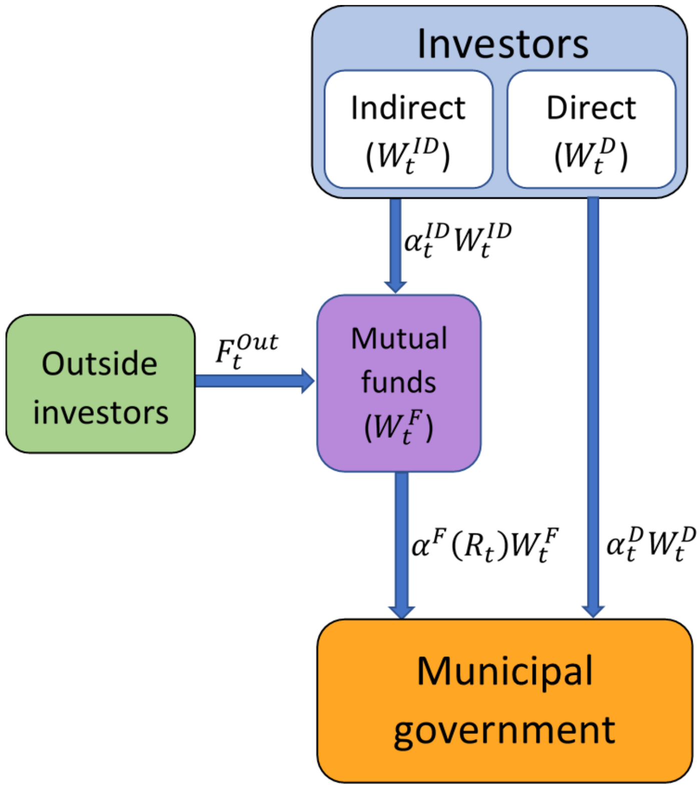



**Figure 5:** Visual representation of the market structure. The values next to each arrow presents the capital flows from one sector to another.

capital flows have a lasting effect. Since my empirical strategy mostly exploits such heterogeneities across the funds, I interpret the flows as the third type in my analysis, unless otherwise stated.

In particular, suppose initially (at $t = 0-$) $F_{0-}^{Out} = 0$, namely the bonds are only held by the investors residing in the economy. At $t = 0$, the mutual funds receive inflow $f_0 W_0^{ID}$ from investors outside the economy. In my empirical analysis, I examine the impact of a 1% inflow to the funds, which corresponds to $f_0 = 0.01$.

Section 4.2.1 examines the impact of the inflow on the steady-state price and quantity of the bonds, and reveals that the portfolio sluggishness parameter $\lambda$ has no impact on the steady-state outcomes. In Section 4.2.2, I log-linearize the model around its steady-state and investigate the dynamic implications of the permanent inflow. I find that the short-term responses indeed depend on $\lambda$. In Section 4.3, I calibrate the model with the empirical estimates obtained in Section 3.

#### 4.2.1 Long-run effects of a permanent inflow

At steady state, both $Q_t$ and $W_t^R \equiv W_t^D + W_t^{ID}$ increase at the same rate. Therefore, their ratio, $q_t \equiv \frac{Q_t}{W_t^R}$, and the bond unit price ($P_t$) are constant. Let $q_{0-}$ and $P_{0-}$ be those constants before the inflow. Therefore, the return on the bond before the inflow is $R_{0-} = \frac{D+P_{0-}}{P_{0-}}$. Prior to the inflow, the bond return is i.i.d across the periods, implying that the portfolio allocation decision for any number of inactive periods coincides with that for a single period. Therefore,

$$\alpha_{0-}^D = \alpha^*(R_{0-}), \qquad \alpha_{0-}^{ID} = \frac{\alpha^*(R_{0-})}{\alpha^F(R_{0-})}. \tag{18}$$

Since $F_{0-}^{Out} = 0$, the market clearing for the bond at $t = 0-$ implies:

$$\alpha^*(R_{0-})W_0^R = Q_{0-}P_{0-} = \phi^{-\gamma^{-1}} {P_{0-}}^{1+\gamma^{-1}} W_0^R \tag{19}$$

$$\Rightarrow \alpha^*(\frac{D+P_{0-}}{P_{0-}}) = \phi^{-\gamma^{-1}} {P_{0-}}^{1+\gamma^{-1}}. \tag{20}$$

After the inflow at $t = 0$, the total wealth available to mutual funds increases by $f_0 W_0^F$. Particularly, assume $F_t^{Out} = f_0 \alpha_t^{ID} W_t^{ID}$, implying that the outside investors allocate funds proportional to the indirect investors. By combining the market clearing condition with the bond supply equation (11), we can obtain the following market clearing condition for $t \geq 0$:

$$(1 + f_0)\alpha^F(R_t)\alpha_t^{ID} W_t^{ID} + \alpha_t^D W_t^D = P_t Q_t = \phi^{-\gamma^{-1}} P_t^{1+\gamma^{-1}} W_t^R \tag{21}$$

By repeating the same steps, we can find the new steady-state bond price, which I denote by $P_{SS}$:

$$\alpha^*(\frac{D+P_{SS}}{P_{SS}}) = \phi^{-\gamma^{-1}} {P_{SS}}^{1+\gamma^{-1}}(1 - S^F f_0) \tag{22}$$

,where $S^F \equiv \frac{W_0^{ID}}{W_0^D+W_0^{ID}}$ is the fraction of bonds held by the mutual funds. Likewise, let $S^D \equiv 1-S^F$ be the market share of the direct investors. Appendix B.2 provides the details of the derivation of (22).[17] Equation 22 implies that the rebalancing parameter $\lambda$ does not have a first-order effect on

[17] In the derivation, we see that the inflow changes the wealth of both indirect and direct investors. However, the change in the residents' overall wealth does not impact the steady-state bond price since it is perfectly absorbed by

the steady-state outcomes. Note that the measure of bond quantity used here is debt per unit of the residents' wealth. The inflow impacts the overall wealth of the residents as it pushes up the bond prices. However, the government is assumed to fully absorb the fluctuations in the overall wealth by adjusting its outstanding debt.

Suppose $\eta$ is the demand semi-elasticity with respect to the bond return. That is,

$$\eta \equiv \frac{\partial \log \alpha^*(R_t)}{\partial R_t}|_{R_t=R_{0-}}. \tag{23}$$

By dividing both sides of (22) on those of (20), we get:

$$\begin{aligned}\frac{\alpha^*(\frac{D+P_{SS}}{P_{SS}})}{\alpha^*(\frac{D+P_{0-}}{P_{0-}})} = (\frac{P_{SS}}{P_{0-}})^{1+\gamma^{-1}}(1-S^F f_0) \Rightarrow \eta dp(1-\frac{P_{SS}}{P_{0-}}) = (1+\gamma^{-1})(\frac{P_{SS}}{P_{0-}}-1) - S^F f_0 \\ \Rightarrow \frac{P_{ss}}{P_{0-}} = 1 + \frac{S^F}{\eta dp + \gamma^{-1} + 1} f_0\end{aligned} \tag{24}$$

The impact of the inflow on the steady-state value of $q_t$ can be found by combining (24) with (11):

$$\frac{q_{SS}}{q_{0-}} = (\frac{P_{SS}}{P_{0-}})^{-\gamma} \simeq 1 + \frac{\gamma^{-1} S^F}{\eta dp + \gamma^{-1} + 1} f_0 \tag{25}$$

### 4.2.2 Short-run effects of a permanent inflow

In this section, I derive the dynamics induced by the inflow in the market outcomes. In the next section, I use the derivations to calibrate the model with the elasticity estimates obtained in the empirical section.

Let the hatted variables represent the deviations from their corresponding steady-state values. That is, for variable $Y_t$ with steady-state value $Y_{SS}$, I define $\hat{y}_t = \frac{Y_t - Y_{SS}}{Y_{SS}}$. Appendix B.3 provides the details of the derivations below. The log-linearized version of the bond supply equation (11) is

$$\hat{q}_t = \gamma^{-1} \hat{p}_t. \tag{26}$$

the government, by the construction of the government's objective function 10. The wealth ratio between the two groups also has no long-term impact since all investors eventually hold the same portfolio.

Likewise, the deviations of the bond return from its steady-state value $R_{SS} \equiv \frac{P_{SS}+D}{P_{SS}}$ can be written as follows

$$\begin{aligned} R_t &= R_{SS} + r_t, \\ r_t &= \hat{p}_{t+1} - (1+dp)\hat{p}_t, \qquad dp = \frac{D}{P_{SS}}. \end{aligned} \tag{27}$$

The share of assets that the funds and direct investors invest in municipal bonds, and the indirect investors allocate to the funds are $\alpha_t^F = \alpha_{SS}^F(1+\hat{\alpha}_t^F)$, $\alpha_t^D = \alpha_{SS}^*(1+\hat{\alpha}_t^D)$, and $\alpha_t^{ID} = \frac{\alpha_{SS}^*}{\alpha_{SS}^F}(1+\hat{\alpha}_t^{ID})$, respectively. Let $\eta^F$ be the demand semi-elasticity of the funds with respect to the returns:[18]

$$\eta^F \equiv \frac{\partial \log \alpha^F(R_t)}{\partial R_t}|_{R_t=R_{0-}}. \tag{28}$$

It directly implies that

$$\hat{\alpha}_t^F = \eta^F r_t. \tag{29}$$

The dynamics of $\hat{\alpha}_t^D$ and $\hat{\alpha}_t^{ID}$ can be obtained by log-linearizing the first-order conditions of (14) and (15):

$$\hat{\alpha}_{t+1}^D = \lambda\hat{\alpha}_t^D + (1-\lambda)(1-\nu)\eta\sum_{s=0}^{\infty}\nu^s r_{t+s} \qquad t \geq 0 \tag{30}$$

$$\hat{\alpha}_{t+1}^{ID} = \lambda\hat{\alpha}_t^D + (1-\lambda)(1-\nu)(\eta-\eta^F)\sum_{s=0}^{\infty}\nu^s r_{t+s} \qquad t \geq 0 \tag{31}$$

The initial condition is determined by the deviation of the initial portfolios from their corresponding new steady-state portfolios:

[18] Since $\alpha^F(\cdot)$ has a bounded second derivative, the difference between the demand sensitivity estimated at the initial and final steady states is small, provided the inflow $f_0$ is small. Thus, using either of these demand sensitivities has no first-order effect in the derivations.

$$
\begin{aligned}
\hat{\alpha}^{D}_{0-} &= \frac{\eta S^F dp}{\eta dp + \gamma^{-1} + 1} f_0 \\
\hat{\alpha}^{ID}_{0-} &= \frac{(\eta - \eta^F) S^F dp}{\eta dp + \gamma^{-1} + 1} f_0
\end{aligned}
\tag{32}
$$

The market clearing condition 17 can be written as below.

$$
S^F \hat{\alpha}^F_t + S^F \hat{\alpha}^{ID}_t + S^D \hat{\alpha}^D_t = \hat{p}_t + \hat{q}_t \tag{33}
$$

$\hat{\alpha}^F_t$, $\hat{\alpha}^{ID}_t$, and $\hat{\alpha}^D_t$ represent the deviations from the steady-state portfolio allocation by mutual funds, indirect investors, and direct investors, respectively. Therefore, the left-hand side in (33) presents the total deviation in the demand for bonds, divided by the residents' wealth, from its steady-state value. Likewise, the right-hand side presents the deviation of the market value of the government's outstanding debt, as a fraction of the total wealth of the residents, from its steady-state value. Thus, the condition states that the deviations in the demand and supply of the bonds should coincide at each period. By expanding and combining the equations above, we can obtain the following equation that describes the price dynamics

$$
\begin{gathered}
-S^F \eta^f \nu \hat{p}_{t+3} + \Big(\nu(1+\gamma^{-1}) + \lambda\nu S^F \eta^F + S^F \eta^F + M + (1+dp) S^F \eta^F \nu\Big)\hat{p}_{t+2} \\
-\Big((1+\lambda\nu)(1+\gamma^{-1}) + \lambda S^F \eta^F + (1+dp)(\lambda\nu S^F \eta^F + S^F \eta^F + M)\Big)\hat{p}_{t+1} \\
+\Big(\lambda(1+\gamma^{-1}) + (1+dp)\lambda S^F \eta^F\Big)\hat{p}_t = 0.
\end{gathered}
\tag{34}
$$

,where $M = (1-\lambda)(1-\nu)(\eta - S^F \eta^F)$.

**Lemma 2.** *The characteristic polynomial corresponding to dynamic process 34 has three positive roots, only one of which is smaller than one.*

Lemma 2 states that the dynamic process 34 has only one stable root, which I hereafter denote by $\kappa$. It means that the solution should have the following form

$$
\hat{p}_t = \kappa^t \hat{p}_0. \tag{35}
$$

To solve for $\hat{p}_0$, we can utilize the market clearing condition at $t = 0$ and the initial conditions provided by (32). By so doing, we obtain

$$\hat{p}_0 = \frac{\lambda(\eta - \eta^F S^F)S^F}{(1+\gamma^{-1}+dp)(1+\gamma^{-1}+(1+dp-\kappa)(\frac{M\nu}{1-\nu\kappa}+M+S^F\eta^F))} f_0. \tag{36}$$

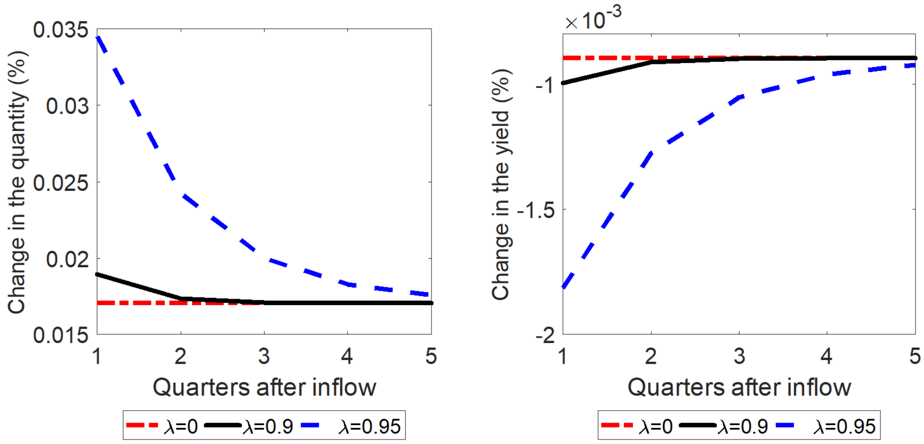
In the extreme case that the investors rebalance at every period ($\lambda = 0$), or the case that the mutual funds manage the entire wealth of the economy optimally ($S^F = 1, \eta^F = \eta$), $\hat{p}_t$ is zero, implying that the market outcomes reach their steady-state value at $t = 0$. However, Figure 4 suggests that the short-term response of the bond quantity is larger than its long-term response, which is not consistent with the implication of those extreme cases. The second $S^F$ in the numerator reflects the fact that the inflow to the market is proportional to the size of the mutual funds' market share.

Figure 6 illustrates how the portfolio sluggishness parameter $\lambda$ and the funds' semi-elasticity of demand $\eta^F$ impact the magnitude of the short-term response and speed of convergence to the new steady-state. In Panel (a), we see that as the investors rebalance less frequently, the magnitude of short-term response rises, and the convergence to the new steady-state slows down. In the extreme case of $\lambda = 0$, there is no over-shooting and the market immediately adjusts after the inflow.

The intuition is that the funds demand more bonds when they receive the inflow. However, the direct investors do not sell their bonds as much as they would were they responsive to the bond price changes. It means that either the government needs to provide more bonds, or the bond price spikes, depending on the elasticity of bond supply. The bond supply should be quite elastic to justify the large quantity movements and small price movements we see in the data. A larger $\lambda$ implies that the direct investors are slower in responding to the increased bond demand from the mutual fund sector.

Figure 6b reveals that the magnitude of the short-term responses decrease with the funds' demand semi-elasticity $\eta^F$. Note that a combination of two forces determines the overall impact of the permanent inflow on the bond demand by the mutual fund sector. First, the funds need to buy more bonds due to the inflow. However, the relationship is theoretically less than one-to-one since the funds increase their asset allocation to risk-free securities as they become relatively cheaper compared to the municipal bonds. As $\eta^F$ increases, a larger portion of the flow induced demand is offset by this substitution effect. When $\eta^F$ is close to zero, like when the funds face tight mandates, the bond demand by the mutual fund sector increases close to proportional in response to the inflow, which generates a larger spike in the bond price and quantity.

**(a)** Portfolio Sluggishness ($\lambda$)




**(b)** Mutual funds' demand sensitivity ($\eta^F$)

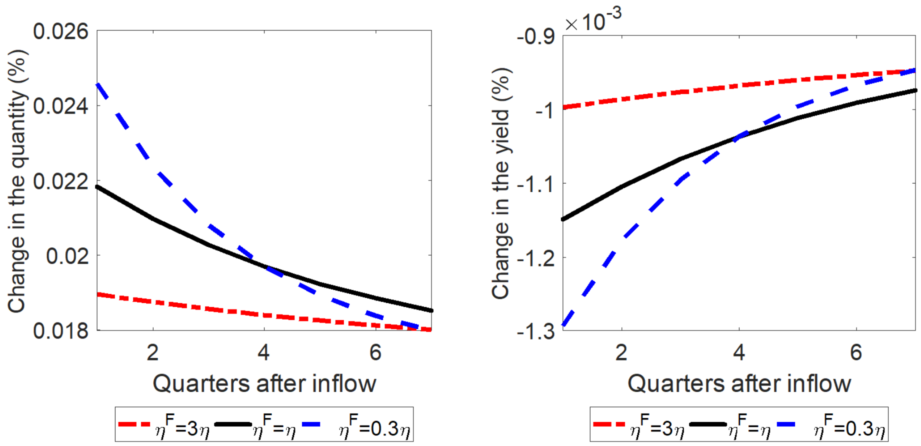



**Figure 6: The impact of a permanent inflow to the funds on the bond yield and quantity.** Panel (a) presents the results for a 1% inflow to mutual funds. Panel (b) illustrates the impact of a permanent 1% inflow to the mutual funds for different values of the funds' demand sensitivity ($\eta^F$). The parameter values reported in Table 12 are used for the illustrations, unless otherwise is stated.

## 4.3 Calibration

In the empirical section, we obtained some estimates on how capital flows to mutual funds impact the borrowing behavior of municipal governments. Particularly, Figure 4 revealed that the short-term effect of the fund flows are substantially larger than their long-term effect, and we learned that the impact on the bond quantity is about 16 times larger than the impact on the yield at issuance. With these two empirical observation, I calibrate three free parameters of the model: The bond supply elasticity ($\gamma^{-1}$), the demand semi-elasticity parameter ($\eta$), and the portfolio inertia parameter $\lambda$.[19] Table 12 provides the calibrated values for the model parameters.

| **Parameters** | Symbol | Value |
|---|---|---|
| Mutual funds' market share | $S^F$ | 0.16 |
| Dividend-price ratio (Quarterly) | $dp$ | $1.68 \times 10^{-2}$ |
| Bond supply elasticity by the municipal government | $\gamma^{-1}$ | 19 |
| Portfolio inertia | $\lambda$ | 0.924 |
| Survival rate | $x$ | 0.994 |
| Funds' demand elasticity | $\eta^F dp$ | 0 |
| Default probability | $\delta$ | $3.75 \times 10^{-5}$ |
| Long-run demand elasticity | $\eta dp$ | 158.4 |
| Short-run demand elasticity | $((1-\lambda)\eta + \lambda\eta^F S^F)dp$ | 11.6 |

**Table 12:** Parameter values used for the calibration

.

In Table 12, $S^F$ is the average market share of the mutual funds in my sample. The dividend-price ratio is equal to the average tax-adjusted quarterly coupon rate in my bond issuance data. $\gamma^{-1}$ and $\eta$ are chosen so that they match the short-term impact of fund flows, estimated in Tables 8 and 11. The long-run demand elasticity is $\eta dp$ since 1% change in the steady-state bond price causes the bond one-period return to move by $dp \times 1\%$ in the opposite direction:

$$R_{SS} - R_{0-} = \frac{D + PSS}{P_{SS}} - \frac{D + P0-}{P_{0-}} = -dp(\frac{P_{SS} - P_{0-}}{P_{0-}}) \tag{37}$$

The investors' survival rate ($x$) is selected so that they survive for 120 quarters in expectation. The default probability is chosen to match the 10-year accumulated default probability of Moody's rated municipal bonds, which is 0.15% (Cestau, Hollifield, Li, and Schürhoff, 2019). I set $\eta^F = 0$

[19] Note that $\eta$ captures the risk-tolerance of the investors, thus there is a one-to-one relationship between $\eta$ and the perceived return at default $R^D$. Therefore, I directly calibrate $\eta$.

since Table 2 suggests that the funds barely change their allocation to municipal bonds due to the tight mandates they face.

Under the calibrated parameters, the short-run demand elasticity is 12.0, which is one order of magnitude smaller than the long-run demand elasticity (171.7). This large gap between short-run and long-run demand elasticity is necessary to explain the overshooting in Figure 4, and is generated by the sluggish portfolio adjustments of the investors.

Figure 7 illustrates the dynamics implied by the model as a result of a 1% one-time and permanent inflow to mutual funds at $t = 0$ ($f_0 = 0.01$). Under the calibrated parameters, the size of outstanding debt increases by 0.038% in the first quarter and 0.017% in the long-run. These numbers match their empirical counterparts.[20] Note that even though the investors are very slow in their portfolio adjustments, the bond quantity and price converge quite quickly to their new steady state values. The intuition is that the investors who adjust earlier respond more aggressively to benefit from the temporary mispricing.

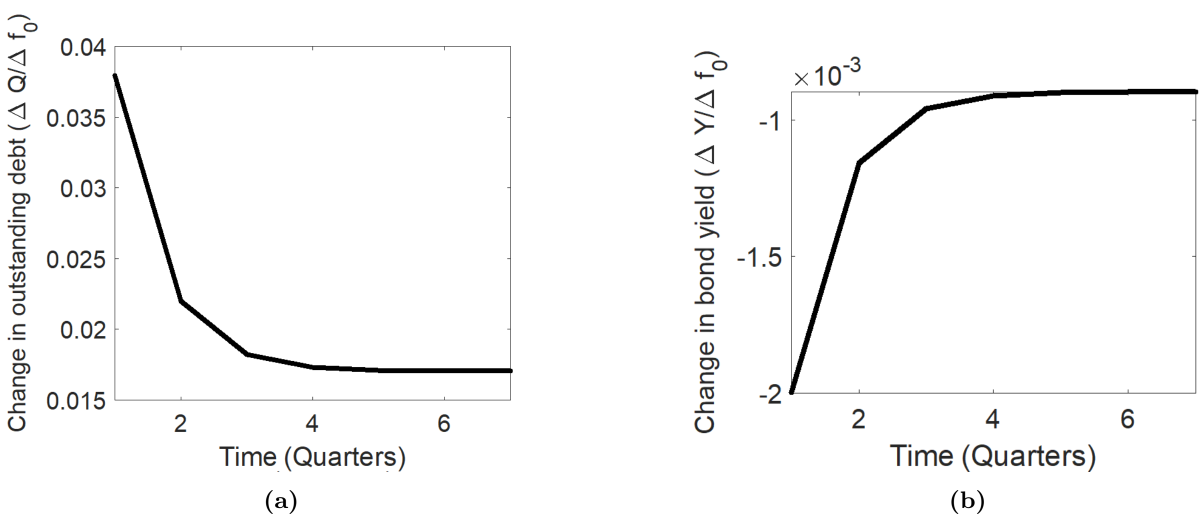



**Figure 7: Response of the bond quantity and price to a 1% inflow to mutual funds.** This figure presents the dynamic response of (a) the bond quantity, and (b) the bond yield, which is inversely related to the bond price. The parameters used to generate the figures are provided in Table 12.

How differently would the bond quantity and price respond if the demand or supply were more or

[20] To see this, note that Table 6 reveals that the size of issuance increases by 0.196% in the first quarter and 0.088% in the forth quarter after a 1% inflow. The numbers are obtained by adjusting (multiplying) them with 19.4%, the average issue size as a fraction of outstanding debt.

less elastic? The results are provided in Figure 8. In Figure 8a, we see that a substantially larger demand elasticity (ten times larger) would have produced quantity and price responses four times smaller than data. It is intuitive since more elastic demand means the market is more effective in absorbing the flows. Likewise, a substantially smaller demand elasticity generates short-term responses three time larger than the empirical estimates. Moreover, it generates dynamic responses quite slower than what data suggest. Figure 8b and 8c perform the same exercise for the bond supply elasticity and portfolio inertia.

### 4.4 Impact of the massive outflows in March and April 2020

In March and April 2020, municipal mutual funds experienced a massive outflow of about 5% of their assets. We can use the framework developed here to gauge their impact on the borrowing behavior of the municipal governments. Specifically, suppose the funds receive an uninformative outflow of $W_0^F f_0$ from their investors at $t = 0$. It means that at $t = 0$, the allocation to mutual funds by the indirect investors is:

$$\alpha_0^{ID} = \lambda \alpha_{0-}^{ID} + (1-\lambda)\hat{\alpha}_0^{ID-Reb} + f_0 \alpha_{0-}^{ID} \tag{38}$$

For simplicity, assume that there is no investment from the investors outside the economy, i.e., $F_t^{Out} = 0$. Since the outflow is temporary, the bond price and quantity should eventually converge to their steady-state values. As a result, $\hat{\alpha}_{0-}^{ID} = \hat{\alpha}_{0-}^{D} = 0$. Therefore, the initial condition in this case is

$$S^F \eta^F r_0 + S^F f_0 + M \sum_{s=0}^{\infty} \nu^s r_s = (1 + \gamma^- 1)\hat{p}_0. \tag{39}$$

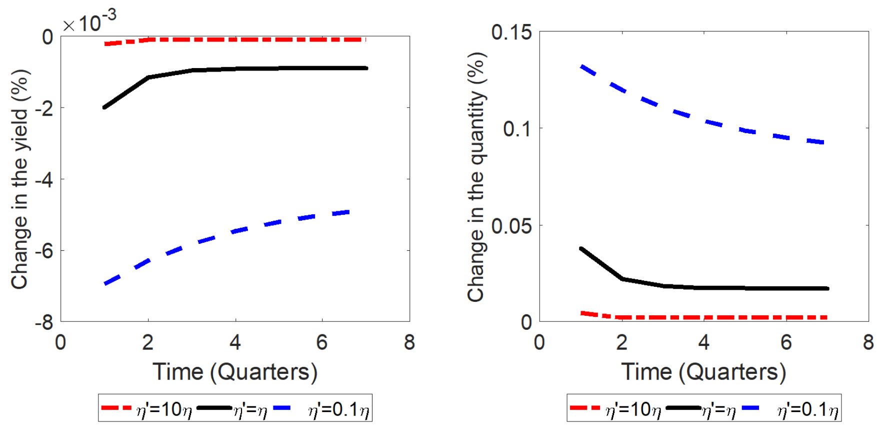
We can use the condition $\hat{p}_t = \kappa^t \hat{p}_0$ to solve for the price dynamics

$$\hat{p}_t = \frac{S^F \kappa^t}{1 + \gamma^{-1} + (1 + dp - \kappa)(\frac{M\nu}{1-\nu\kappa} + M + S^F \eta^F)} f_0. \tag{40}$$

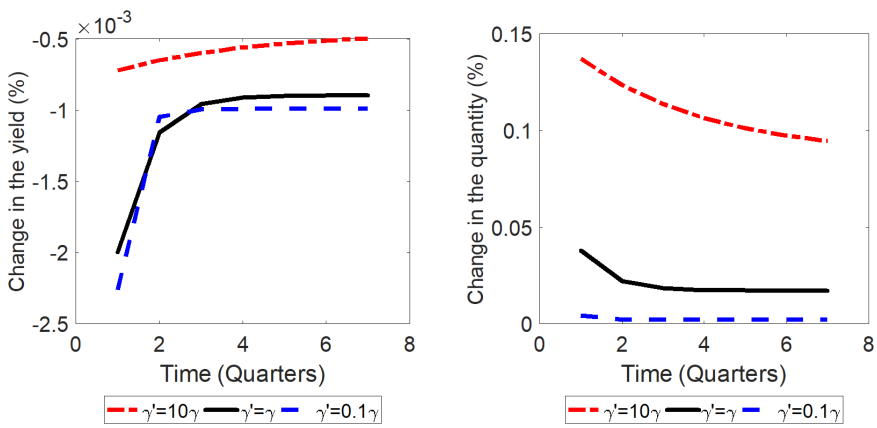
Figure 9 illustrates the price dynamics for different values of the mutual funds' demand sensitivity ($\eta^F$).

We see that the model predicts a decline in the bond issuance by 0.25% of the market size, equivalent to 10.5 billion dollars. It explains 46% of the 23 billion dollar actual decline in the bond issuance

**(a)** Changing the demand elasticity ($\eta$)




**(b)** Changing the supply elasticity ($\gamma^{-1}$)




**(c)** Changing the investor inattention parameter ($\lambda$)

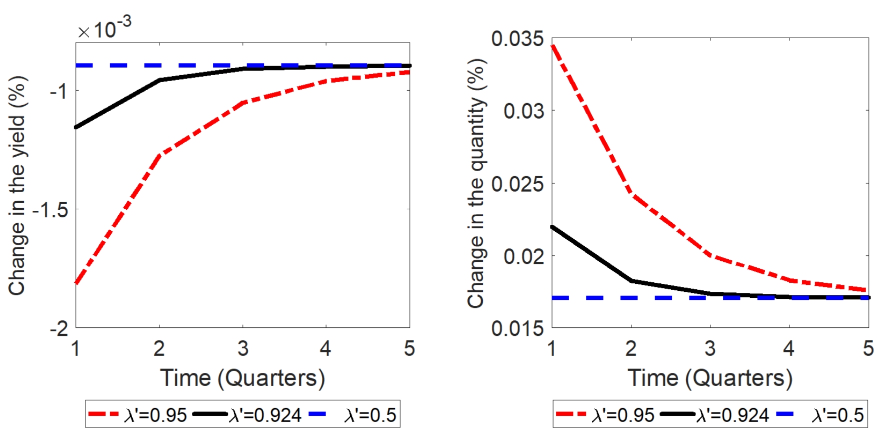





**Figure 8: The response of bond yield and quantity for various choices of parameters.** This figure presents the dynamic response of the bond yield and quantity if we were choosing substantially smaller (dashed blue lines) or larger parameters (dashed red lines) (a) for the bond demand elasticity ($\eta$), (b) bond supply elasticity ($\gamma^{-1}$), (c) household inattention parameter ($\lambda$). The black solid lines display the results under the calibration parameters. The parameters used to generate the figures are provided in Table 12.

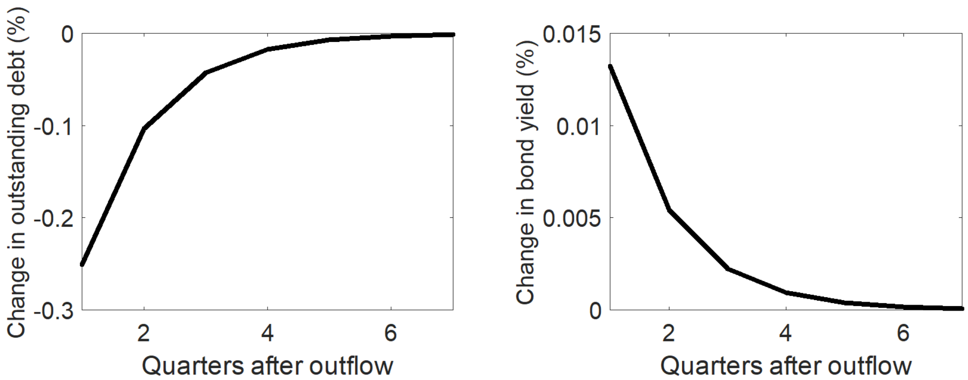



**Figure 9:** This figures displays the response of the bond quantity and yield at issuance to a 5% temporary outflow from mutual funds. The parameters in Table 12 are used for this illustration.

in March and April 2020 compared to January and February 2020.[21] Note that the it is an out-of-sample exercise since the study period ends at 2019. This result suggests that investment frictions faced by mutual funds could drastically affect the bond issuance by municipal governments during economic downturns. Therefore, federal financial assistance is particularly needed when the funds face massive outflows.

# 5 Conclusion

The municipal bond market provides the funding needed for most infrastructure projects in the US. Hence, the well-functioning of this capital market is imperative for the quality of health care services, schools, water, roads, recreational areas, and many other public services that US residents receive daily. The market effectiveness is especially crucial during economic downturns when raising tax rates is a contentious policy choice. The empirical findings in this paper indicate that the municipal bond market is not resilient in the short run, and the market effectiveness depends on the capital available to mutual funds. Therefore, market interventions by the federal government are necessary in times of crisis to ensure that municipal governments have the resources to manage the situation effectively. The federal government's support is even more needed if the crisis accompanies massive outflows from mutual funds. It was the situation in the first few months following the outset of the COVID-19 pandemic.

What makes mutual funds special for policy decisions? First, they control a large portion of the municipal bond market. As of the second quarter of 2021, they own more than 21% of the outstanding municipal debt. Second, this number chiefly reflects the ownership by "municipal" mutual

[21] The number is obtained from the Securities Industry and Financial Markets Association (SIFMA) database.

funds, which are the specialized players in the municipal bond market. It is their responsibility to pay attention to market trends and act accordingly on behalf of their clients. As the mutual funds receive more outflows, such attentive intermediaries manage a smaller portion of the market, making the market less resilient as a whole.

My study also puts forward a model of the municipal bond market that captures the key elements representing its supply and demand side. I find that the model performs quite well in predicting the impact of the massive outflows in March 2020. Thus, the model can be employed to analyze and evaluate different economic policies targeting the US infrastructure. For instance, investors are concerned about how the recently proposed infrastructure bill, which increases the federal support for infrastructure projects by about 500 billion dollars (11.6% of the overall size of the outstanding municipal debt)[22], would affect the issuance of new municipal bonds in the future. The model can provide an answer, as it is calibrated by the recent responses of municipal governments to smaller funding shocks, i.e., mutual fund flows.

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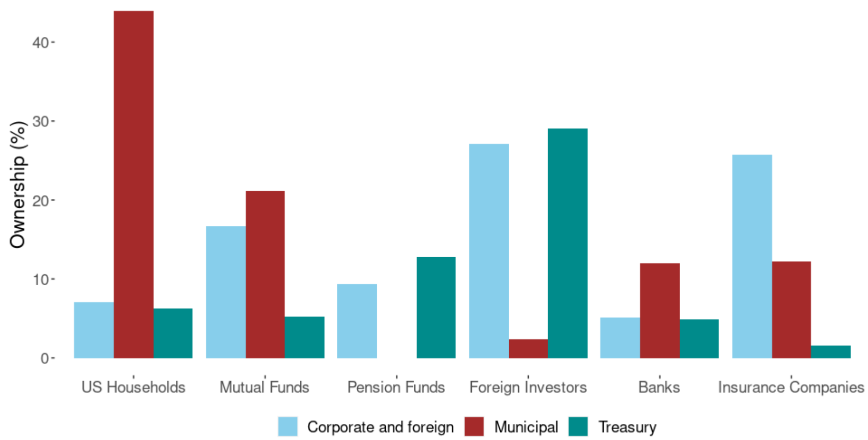
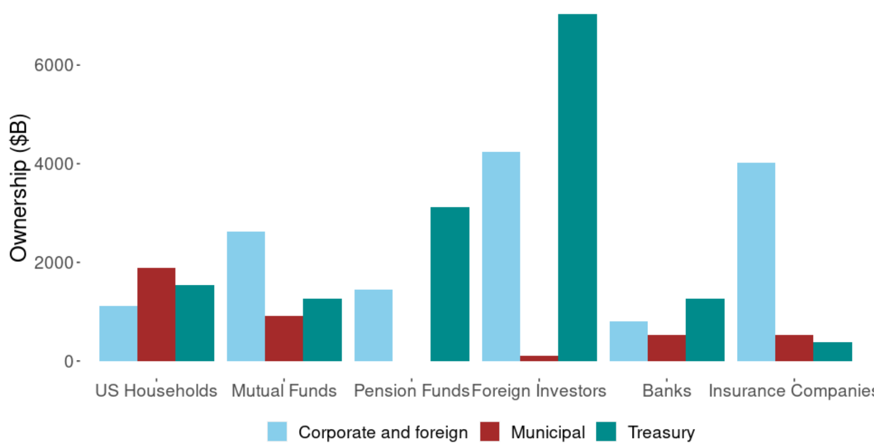
# Appendix A: Supplementary Figures and Tables



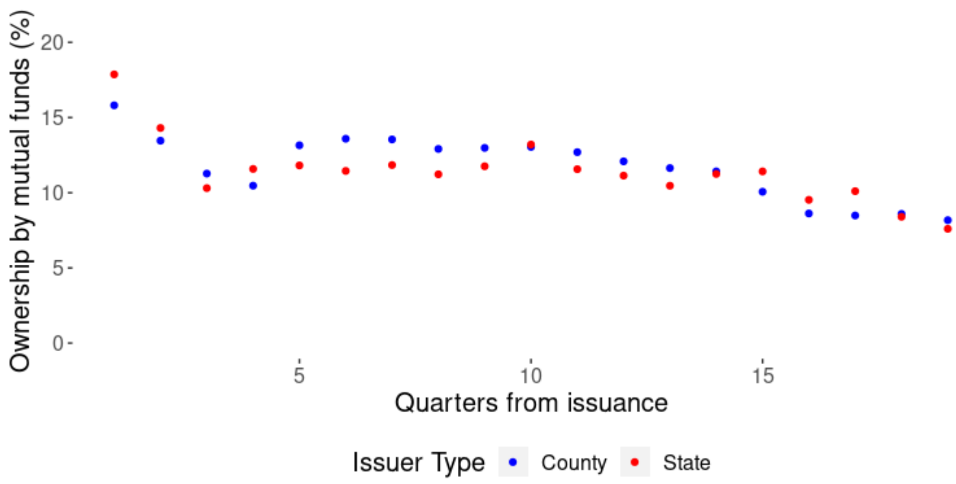

**(a)** Ownership by percentage



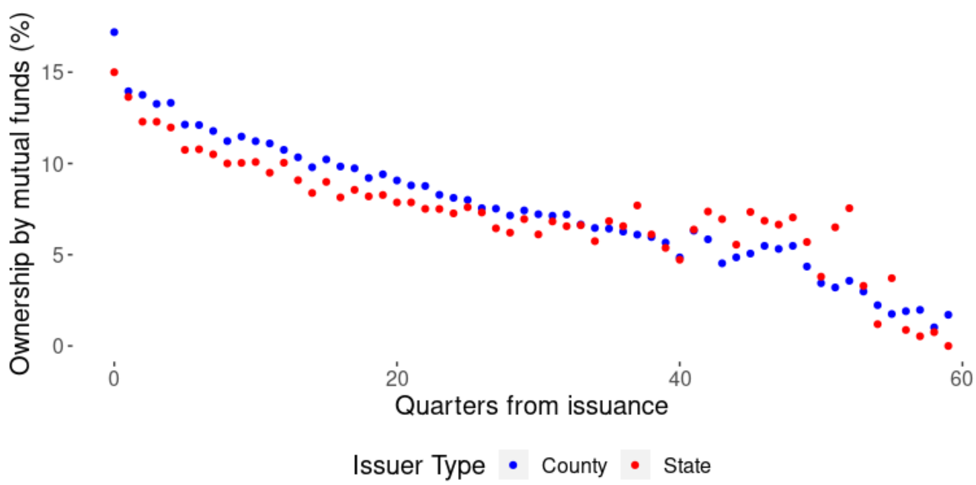

**(b)** Ownership by dollar value

**Figure A.1: Ownership of different bond categories.** Data are obtained from the US Financial Accounts database available at the Federal Reserve Board of Governors webpage. They present the ownership for the end of 2021Q1.

**(a)** Years-to-maturity of less than 5 years




**(b)** Years-to-maturity of between 5 and 15 years




**(c)** Years-to-maturity of more than 15 years

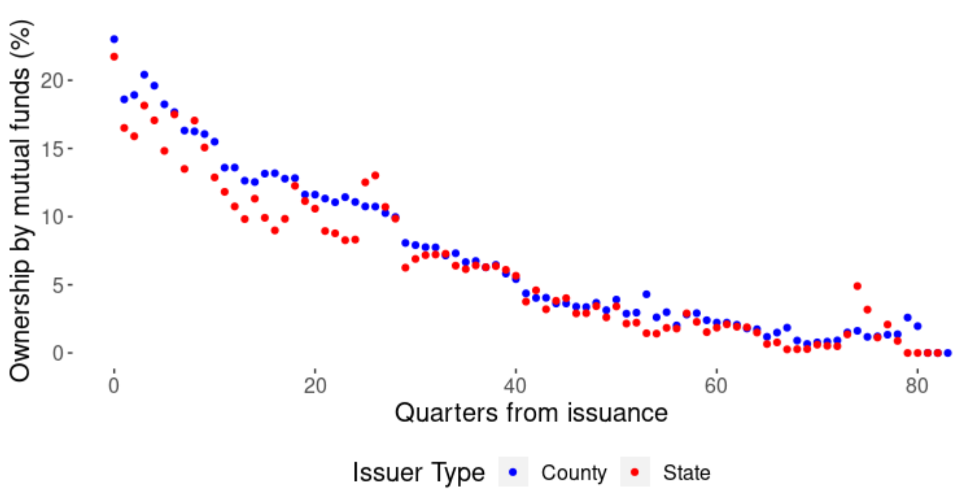
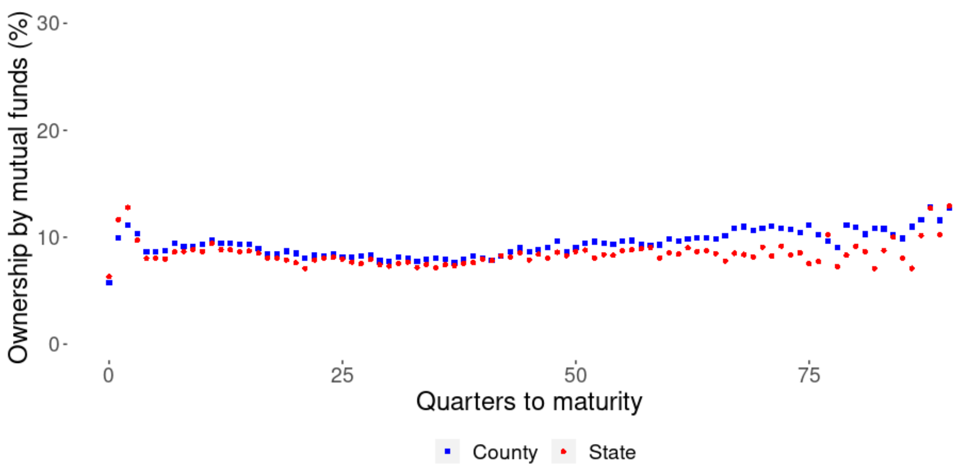



**Figure A.2: Mutual funds' municipal bond ownership by quarters after issuance for short-term, medium-term, and long-term bonds.** The figure depicts the average mutual fund ownership for each number of quarters after issuance for the period between 2009Q1-2021Q1 and municipal bonds that were issued in 2000 and after. Panel (a) provides the mutual fund ownership for bonds with maturity of less than 5 years at issuance. Likewise, Panels (b) and (c) provide the mutual fund average ownership for medium-term (5 years - 15 years) and long-term bonds (more than 15 years), respectively. The historical bond issuance data are obtained from Bloomberg for US state governments, county governments with at least 100K population, and their subsidiaries, upon availability. Mutual funds' holding data of municipal bonds are obtained from CRSP.

(a) All bonds




(b) Bonds with less than one year after issuance

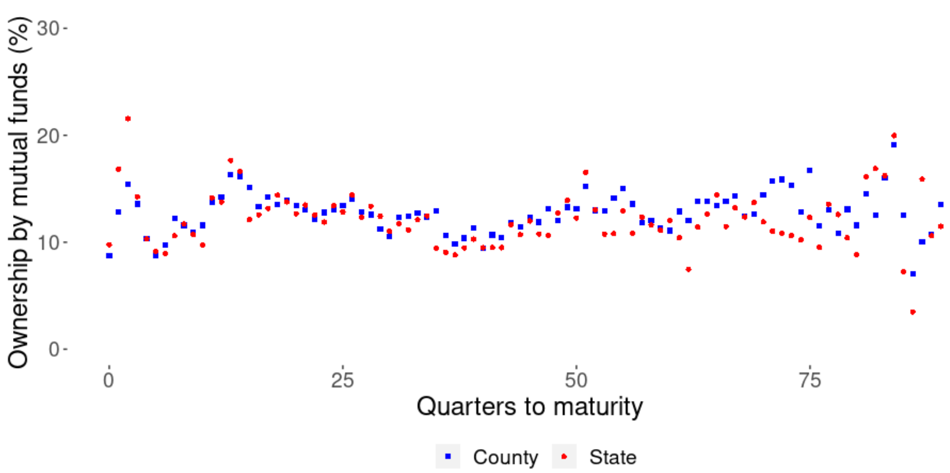
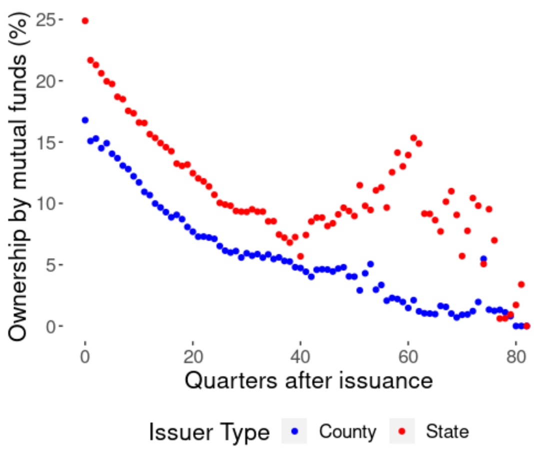
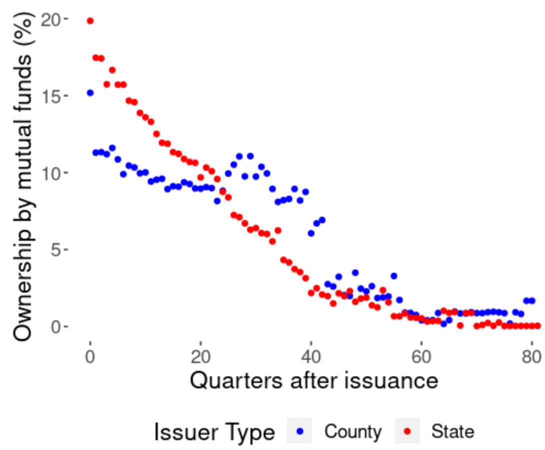



**Figure A.3: Mutual funds' municipal bond ownership by quarters to maturity.** The figure depicts the average mutual fund ownership based on the quarters to maturity for the period between 2009Q1-2021Q1 and municipal bonds that were issued in 2000 and after. Panel (a) provides the mutual fund ownership for all bonds. Panel (b) provides the mutual fund average ownership for bonds with less than one year after their issuance . The historical bond issuance data are obtained from Bloomberg for US state governments, county governments with at least 100K population, and their subsidiaries, upon availability. Mutual funds' holding data of municipal bonds are obtained from CRSP.

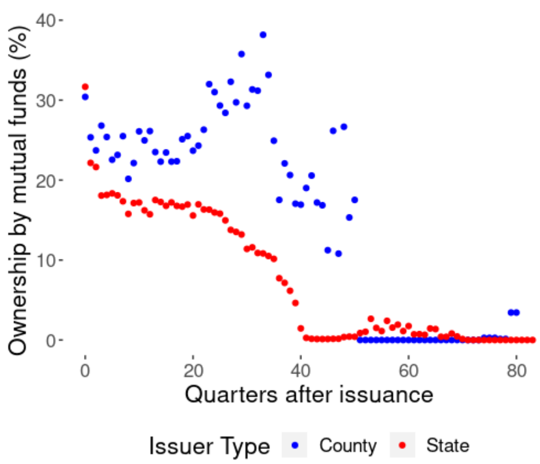
**(a)** AAA




**(b)** AA




**(c)** A




**(d)** BBB

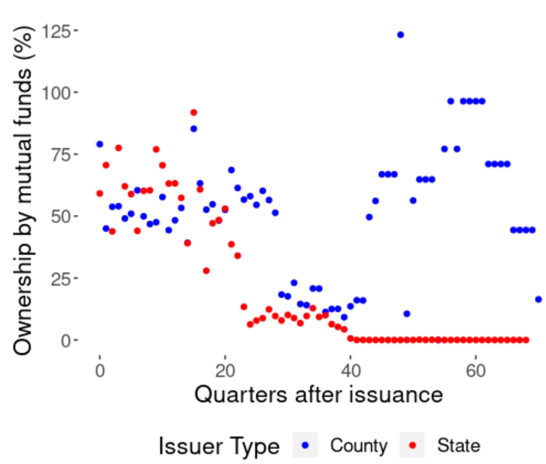



**Figure A.4: Mutual funds' municipal bond ownership by quarters after issuance for different bond ratings.** The figure depicts the average mutual fund ownership for each number of quarters after issuance for the period between 2009Q1-2021Q1 and municipal bonds that were issued in 2000 and after. The panels provide the ownership dynamics for different investment-grade credit rating categories. The historical bond issuance data are obtained from Bloomberg for US state governments, county governments with at least 100K population, and their subsidiaries, upon availability. Mutual funds' holding data of municipal bonds are obtained from CRSP.

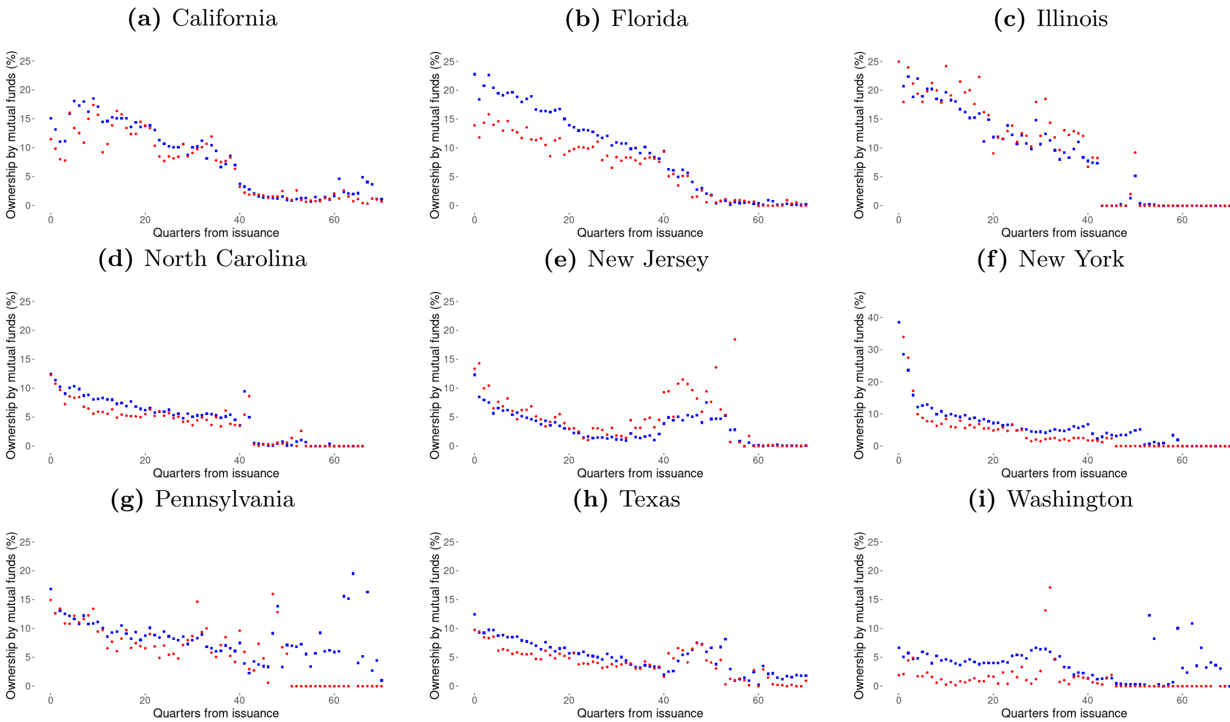
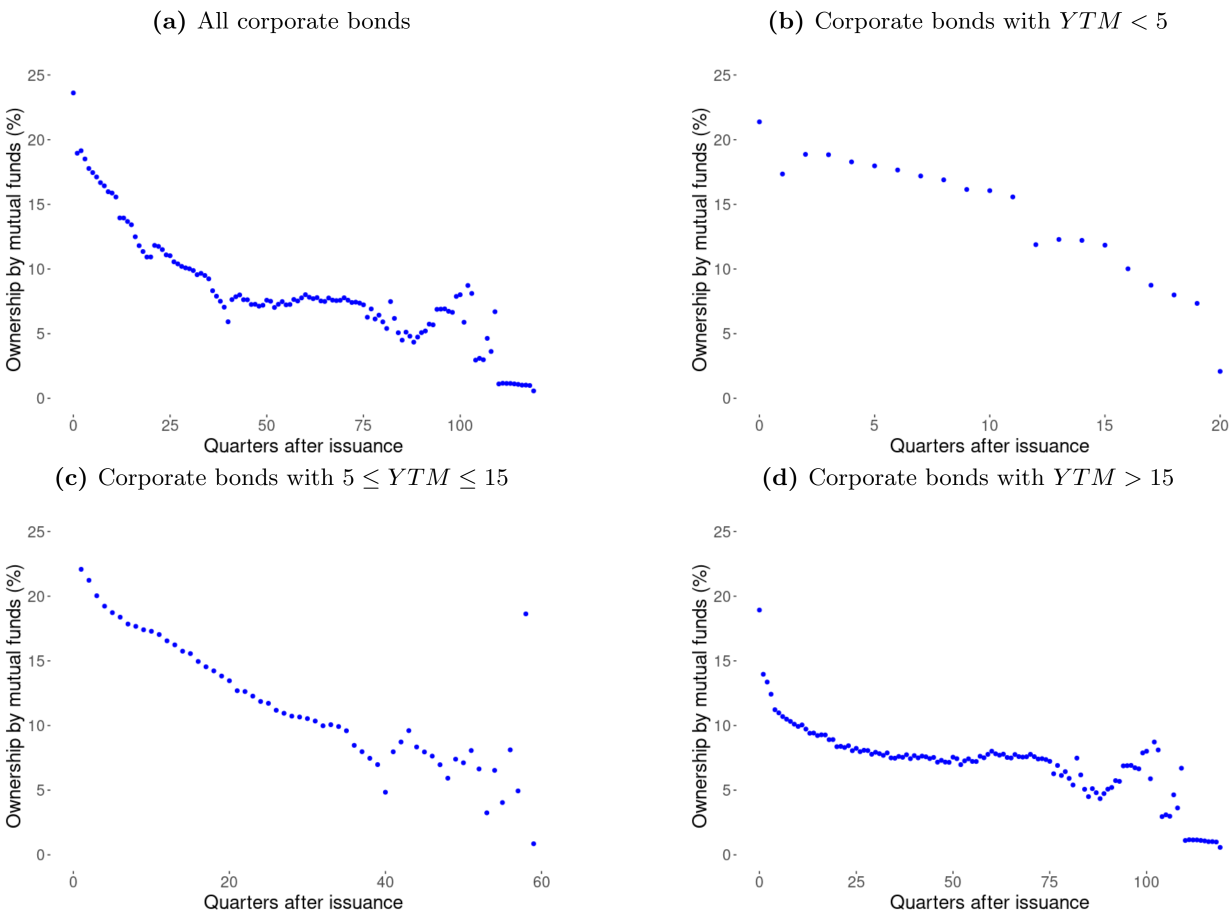



**Figure A.5: Mutual funds' municipal bond ownership by quarters after issuance for some US states.** The figure depicts the average mutual fund ownership for each number of quarters after issuance for the period between 2009Q1-2021Q1 and municipal bonds that were issued in 2000 and after. The panels provide the ownership dynamics for different states. In each panel, the blue squares represent the mutual fund ownership for bonds issued by county governments and their subsidiaries (Counties with a population of at least 100K). Red circles represent the ownership for the bonds issued by the state government and its subsidiaries. The historical bond issuance data are obtained from Bloomberg. Mutual funds' holding data of municipal bonds are obtained from CRSP.




**(a)** All corporate bonds

**(b)** Corporate bonds with $YTM < 5$

**(c)** Corporate bonds with $5 \leq YTM \leq 15$

**(d)** Corporate bonds with $YTM > 15$

**Figure A.6: Mutual funds' ownership of Corporate bonds by quarters after issuance.** The figure depicts the average mutual fund ownership for corporate bonds issued in 2000 and after for the period between 2009Q1-2021Q1. The holding data are obtained from CRSP, and covers more than 90% of the mutual funds' holding of corporate bonds, as reported by the US financial accounts. The panels provide the ownership dynamics for bonds with different years-to-maturity at origination. The historical bond issuance data are obtained from Mergent Fixed Income Securities Database (FISD).

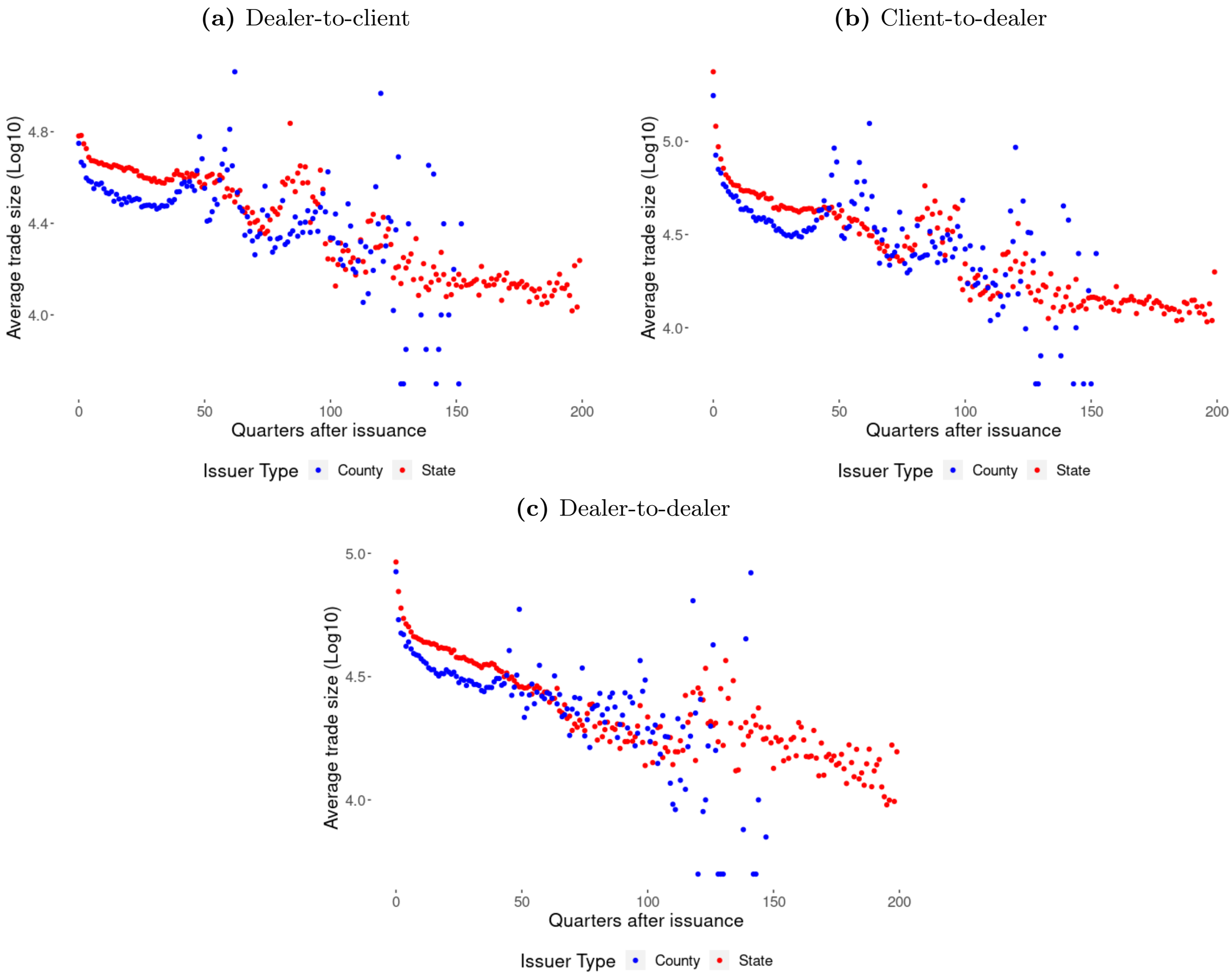



**Figure A.7: Average trade size by the number of quarters after issuance and type of transaction.** This figure displays the average log-size (logarithm in base 10) of a) dealer-to-client, b) client-to-dealer, c) dealer-to-dealer transactions of municipal bonds. In a dealer-to-client transaction, the client (an institutional or retail investor) purchases bonds from a dealer. Client-to-dealer and dealer-to-dealer transactions are defined likewise. The transaction data are obtained from MSRB database. The blue dots represents the transactions of the bonds of the selected county governments. The red dots represents the average trade size for bonds issued by state governments.

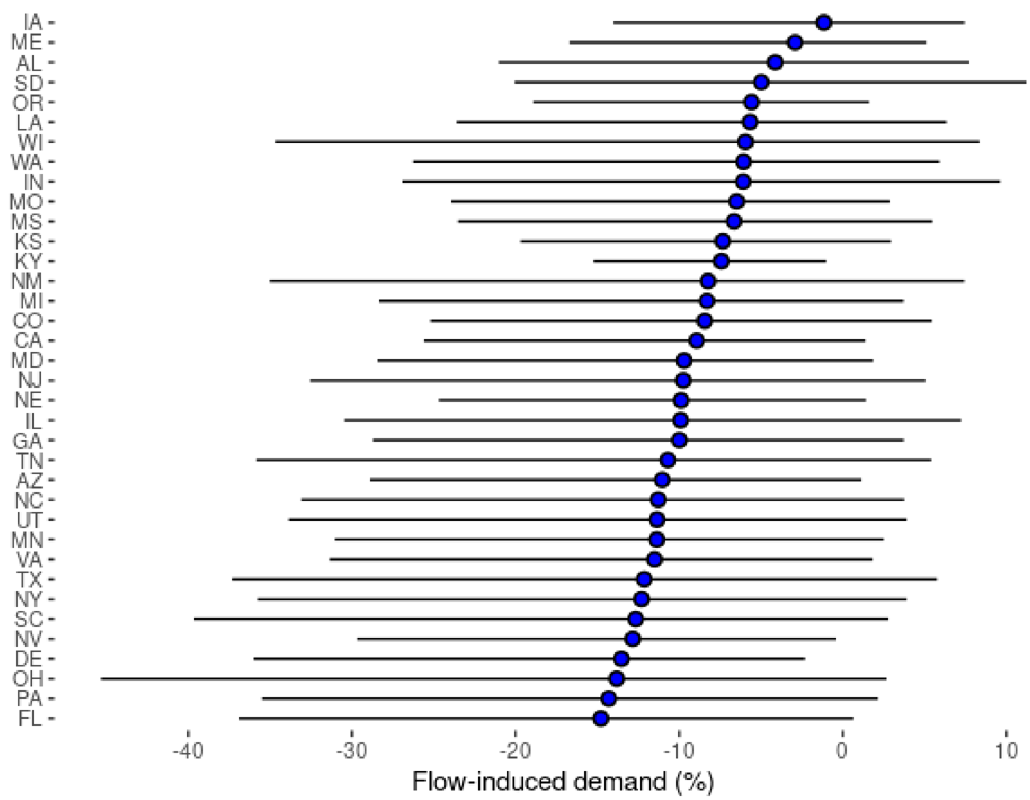



**Figure A.8:** Average and distribution of flow-induced demand for the selected counties of each state. Flow-induced demand is computed based on Equation 5 for each county at every quarter between 2009 and 2019. The filled circle presents the average value, and the horizontal line presents the range between the 10th percentile and 90th percentile observations.

| | $\Delta Inv^{Par}_{f,c,t}$ | |
|---|---|---|
| | (Inflow Sample) | (Outflow Sample) |
| $Flow_{f,t}$ | $-0.002$ | $0.002$ |
| | (0.001) | (0.190) |
| $\text{SIG}_{f,c,t-1}$ | $-1.360^{***}$ | $-1.136^{***}$ |
| | (0.073) | (0.078) |
| $\text{SIG}_{f,c,t-1} \times Flow_{f,t}$ | $-0.257$ | $1.962^{**}$ |
| | (0.195) | (0.823) |
| $\mathbb{I}\{\text{SIG}_{f,c,t-1} > \text{OWN}_{f,c,t-1}\}$ | $-0.066^{***}$ | $-0.030$ |
| | (0.025) | (0.027) |
| $\mathbb{I}\{\text{SIG}_{f,c,t-1} > \text{OWN}_{f,c,t-1}\} \times Flow_{f,t}$ | $0.278^{***}$ | $0.980^{***}$ |
| | (0.081) | (0.283) |
| Observations | 155,274 | 165,712 |
| $\text{R}^2$ | 0.035 | 0.033 |
| Quarter FE | Y | Y |
| Fund FE | Y | Y |

**Table A.1:** This table presents what the past and current investments predict about the response of a fund to inflows and outflows. The dependent variable ($\Delta \log Inv_{f,c,t}$) is the change in the log of par-value investment of fund $f$ in the bonds issued by county government $c$ at the end of quarter $t$. The investments are aggregated at government level. 1$ is added to all investments to avoid infinite values for zero positions. $Flow_{f,t}$ is the quarterly flow to fund $f$ between $t-1$ and $t$, as a fraction of the merger-adjusted total net asset value at the end of quarter $t-1$. $OWN_{f,c,t}$ is the fraction of total par-value investment of mutual funds in government $c$ at $t$ that is owned by fund $f$. $SIG_{c,f,t}$ is the maximum value of $OWN_{c,f,t'}$ in the twelve quarters ending at $t$.

| | Inflow Sample | | | Outflow Sample | | |
|---|---|---|---|---|---|---|
| | $\Delta\log(Inv^{Par}_{f,c,t}+10)$ | $\Delta\log(Inv^{Par}_{f,c,t}+10^2)$ | $\Delta\log(Inv^{Par}_{f,c,t}+10^3)$ | $\Delta\log(Inv^{Par}_{f,c,t}+10)$ | $\Delta\log(Inv^{Par}_{f,c,t}+10^2)$ | $\Delta\log(Inv^{Par}_{f,c,t}+10^3)$ |
| $Flow_{f,t}$ | $-0.001$ | $-0.001$ | $-0.001^{*}$ | $0.317^{**}$ | $0.258^{**}$ | $0.198^{**}$ |
| | (0.001) | (0.001) | (0.001) | (0.134) | (0.109) | (0.085) |
| $SIG_{f,c,t-1}$ | $-0.141^{**}$ | $-0.115^{**}$ | $-0.089^{**}$ | $-0.251^{***}$ | $-0.202^{***}$ | $-0.152^{***}$ |
| | (0.059) | (0.048) | (0.037) | (0.063) | (0.052) | (0.040) |
| $SIG_{f,c,t-1} \times Flow_{f,t}$ | $0.412^{***}$ | $0.337^{***}$ | $0.261^{***}$ | $1.838^{***}$ | $1.550^{***}$ | $1.259^{***}$ |
| | (0.132) | (0.107) | (0.082) | (0.668) | (0.545) | (0.423) |
| Observations | 155,274 | 155,274 | 155,274 | 165,712 | 165,712 | 165,712 |
| $R^2$ | 0.032 | 0.032 | 0.032 | 0.030 | 0.030 | 0.030 |
| Quarter FE | Y | Y | Y | Y | Y | Y |
| Fund FE | Y | Y | Y | Y | Y | Y |

**Table A.2:** This table presets the relationship between the fund flows and investment adjustments for different definitions of the investment change. $Flow_{f,t}$ is the quarterly flow to fund $f$ between $t-1$ and $t$, as a fraction of the merger-adjusted total net asset value at the end of quarter $t-1$. $SIG_{c,f,t}$ is the maximum ownership in the twelve quarters ending at $t$.

| | $Flow_{f,t}$ | | |
|---|---|---|---|
| | (1) | (2) | (3) |
| $Ret_{f,t-1}$ | $-0.951$ | $-1.309$ | $-0.177$ |
| | (2.518) | (2.508) | (4.149) |
| $Ret_{f,t-2}$ | 0.624 | 0.294 | $-1.261$ |
| | (2.401) | (2.349) | (4.005) |
| $Ret_{f,t-3}$ | $-1.752$ | $-1.885$ | 0.046 |
| | (2.472) | (2.401) | (4.247) |
| $Ret_{f,t-4}$ | $-1.005$ | $-1.044$ | $-2.615$ |
| | (2.472) | (2.419) | (4.142) |
| Observations | 84,887 | 84,887 | 84,887 |
| Projected $R^2$ | 0.00001 | 0.00001 | 0.00001 |
| Fund FE | N | Y | Y |
| Quarter FE | N | N | Y |

**Table A.3:** This table presents how the past performance of a fund impacts its current flow. $Flow_{f,t}$ is the flow that fund $f$ receives at quarter $t$ as a fraction of its total assets. $Ret_{f,t}$ is the fund return on its assets in quarter $t$. $Flow_{f,t}$ is the quarterly flow to fund $f$ between $t-1$ and $t$, as a fraction of the merger-adjusted total net asset value at the end of quarter $t-1$. The fund flows are constructed from the fund data available at CRSP.

| | $Flow_{f,t}$ | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| $Flow_{f,t-1}$ | $-0.0001$ | 0.001 | $-0.0002$ | 0.001 |
| | (0.002) | (0.003) | (0.002) | (0.003) |
| $Flow_{f,t-2}$ | | 0.001 | | 0.001 |
| | | (0.001) | | (0.001) |
| $Flow_{f,t-3}$ | | 0.00001 | | 0.00003 |
| | | (0.0002) | | (0.0002) |
| $Flow_{f,t-4}$ | | 0.00000 | | $-0.00000$ |
| | | (0.0001) | | (0.0001) |
| Constant | 0.414** | 0.041*** | | |
| | (0.163) | (0.011) | | |
| Observations | 77,542 | 74,285 | 77,542 | 74,285 |
| $R^2$ | 0.000 | 0.00001 | 0.001 | 0.001 |
| Quarter FE | N | N | Y | Y |

**Table A.4:** This table examines the persistency of fund flows for municipal mutual funds, between 2009Q1-2019Q4. $Flow_{f,t}$ is the quarterly flow to fund $f$ between $t-1$ and $t$, as a fraction of the merger-adjusted total net asset value at the end of quarter $t-1$. The fund flows are constructed from the fund data available at CRSP.

# Appendix B: Proofs and Mathematical derivations

## B.1 Proof of Lemma 1

I derive the optimal portfolio for the direct and indirect investors separately. Let $V_t^{D,R}(w^i)$ be the value function of a direct investor that rebalances at $t$. Likewise, $V_t^{D,NR}(w^i;\alpha^i)$ is the value function for a non-rebalancing investor with legacy portfolio share $\alpha$ in municipal bonds. Therefore, the following relationships between these two value functions hold:

$$\begin{aligned} V_t^{D,R}(w^i) = \quad & \max_{\alpha} \quad \delta \log\{R^F + \alpha(R^D - R^F)\} \\ & + (1-\delta)\Big\{(1-x)\log\{R^t + \alpha(R_t - R^F)\} + x(1-\lambda)V_{t+1}^{D,R}(w^i(R^t + \alpha(R_t - R^F))) \\ & + x\lambda V_{t+1}^{D,NR}(w^i(R^t + \alpha(R_t - R^F));\alpha)\Big\} \end{aligned} \tag{B.1}$$

$$\begin{aligned} V_t^{D,NR}(w^i;\alpha) = \quad & \delta \log\{R^F + \alpha(R^D - R^F)\} \\ & + (1-\delta)\Big\{(1-x)\log\{R^t + \alpha(R_t - R^F)\} + x(1-\lambda)V_{t+1}^{D,R}(w^i(R^t + \alpha(R_t - R^F))) \\ & + x\lambda V_{t+1}^{D,NR}(w^i(R^t + \alpha(R_t - R^F));\alpha)\Big\} \end{aligned} \tag{B.2}$$

By combining the equations above, one can guess and verify that the value functions are logarithmic in wealth, and the optimal portfolio for the rebalancing investors at $t$ can be characterized as below:

$$\alpha_t^{D-Reb} = \arg\max_{\alpha} \frac{\delta}{1-\nu}\log\{R^F + \alpha(R^D - R^F)\} + (1-\delta)\sum_{s=0}^{\infty}\nu^s \log\{R^F + \alpha(R_{t+s} - R^F)\} \tag{B.3}$$

,where $\nu = x\lambda(1-\delta)$. The only difference for the indirect investors is that by investing fraction $\alpha_t^i$ in the funds at $t$, their return is $R^F + \alpha_t^i\alpha^F(R_t)(R^D - R^F)$ if the government defaults and $R^F + \alpha_t^i\alpha^F(R_t)(R_t - R^F)$ otherwise. Since the default risk is the only source of uncertainty before the government's default, the funds' return has a perfectly predictable exposure of $\alpha^F(R_{t+s})$ to the bond return in future. That said, the optimal allocation to the funds for the indirect investors is:

$$\alpha_t^{ID-Reb} = \arg\max_{\alpha} \delta\sum_{s=0}^{\infty}\nu^s \log\{R^F + \alpha\alpha^F(R_{t+s})(R^D - R^F)\} + (1-\delta)\sum_{s=0}^{\infty}\nu^s \log\{R^F + \alpha\alpha^F(R_{t+s})(R_{t+s} - R^F)\} \tag{B.4}$$

## B.2 Derivation of Equation 22

Let $y$ be the partial impact of the inflow on the wealth ratio between the indirect and direct investors, that is

$$\lim_{t\to\infty}\frac{W_t^{ID}}{W_t^{D}}=\frac{W_0^{ID}}{W_0^{D}}(1+yf_0) \tag{B.5}$$

Moreover, let $\alpha_{SS}$ is the optimal allocation to municipal bonds in the new steady-state. Therefore, by dividing both sides of (21) by $W_t^R$ and considering the limiting case of $t\to\infty$, we get:

$$\phi^{-\gamma^{-1}}{P_{SS}}^{1+\gamma^{-1}}=\alpha_{SS}\frac{(1+f_0)(1+yf_0)\frac{W_0^{ID}}{W_0^{D}}+1}{(1+yf_0)\frac{W_0^{ID}}{W_0^{D}}+1}\simeq(1+\frac{\frac{W_0^{ID}}{W_0^{D}}}{(1+yf_0)\frac{W_0^{ID}}{W_0^{D}}}f_0)\alpha_{SS}\simeq(1+S^F f_0)\alpha_{SS} \tag{B.6}$$

In the approximations above, I use the fact that $f_0$ is small.

## B.3 Log-linearizations

### Bond return (Equation 27)

$$\begin{aligned}R_t&=\frac{D+P_{t+1}}{P_t}=\frac{D+P_{SS}(1+\hat{p}_{t+1})}{P_{SS}(1+\hat{p}_t}\\&=\frac{D}{P_{SS}}(1-\hat{p}_t)+\hat{p}_{t+1}-\hat{p}_t=R_t+\underbrace{\hat{p}_{t+1}-(1+dp)\hat{p}_t}_{r_t}\end{aligned} \tag{B.7}$$

### Portfolio allocations (Equations 30 and 31)

$$\begin{aligned}\alpha_{t+1}^D=\alpha_{SS}^*(1+\hat{\alpha}_{t+1}^D)=\lambda\alpha_{SS}^*(1+\hat{\alpha}_t^D)+(1-\lambda)\alpha_{SS}^*(1+\hat{\alpha}_t^{D-Reb})\\ \Rightarrow\hat{\alpha}_{t+1}^D=\lambda\hat{\alpha}_t^D+(1-\lambda)\hat{\alpha}_t^{D-Reb}\end{aligned} \tag{B.8}$$

Now, I show that $\hat{\alpha}_t^{D-Reb}=(1-\nu)\eta\sum_{s=0}^{\infty}\nu^s r_{t+s}$. Define $r^D=\frac{R^D}{R^F}-1$ and $\pi_t=\frac{R_t}{R^F}-1$. Therefore, the first-order condition implies:

$$\frac{\delta}{1-\nu}\frac{r^D}{1+\alpha_t^{D-Reb}r^D}+(1-\delta)\sum_{s=0}^{\infty}\nu^s\frac{\pi_{t+s}}{1+\alpha_t^{D-Reb}\pi_{t+s}}=0 \tag{B.9}$$

The equation above can be approximated around the steady-state values as below:

$$-\frac{\delta}{1-\nu}\frac{\alpha_S S^*{r^D}^2}{(1+\alpha_{SS}r^D)^2}\hat{\alpha}_t^{D-Reb}-(1-\delta)\sum_{s=0}^{\infty}\frac{\alpha\pi_{t+s}^2}{(1+\alpha\pi_{t+s})^2}\hat{\alpha}_t^{D-Reb}+(1-\delta)\sum_{s=0}^{\infty}\nu^s\Delta\pi_{t+s} \tag{B.10}$$

,where $\Delta\pi_{t+s} \equiv \frac{R_{t+s}}{R^F} - \frac{R_{SS}}{R^F} = \frac{r_{t+s}}{R^F}$. By some rearrangements, we get:

$$\hat{\alpha}_t^{D-Reb} = (1-\nu)\underbrace{\frac{(1-\delta)\frac{1}{(1+\alpha\pi_{SS})^2}}{\delta\frac{\alpha_{SS}r^{D2}}{(1+\alpha_{SS}r^D)^2} + (1-\delta)\frac{\alpha_{SS}\pi_{SS}^2}{(1+\alpha_{SS}^*\pi_{SS})^2}}}_{\eta R^F}\sum_{s=0}^{\infty}\nu^s\Delta\pi_{t+s} = (1-\nu)\eta\sum_{s=0}^{\infty}\nu^s r_{t+s} \tag{B.11}$$

The proof is similar for the case of the indirect investors.

### Initial conditions (Equation 32)

By the definition of $\eta$ in (23), we have:

$$\hat{\alpha}_{0-}^D = (\frac{\alpha_{0-}^D}{\alpha_{SS}^D} - 1) \simeq \eta(R_{0-} - R_{SS}) \simeq \eta dp(\frac{P_{SS}}{P_{0-}} - 1) = \frac{\eta S^F dp}{\eta dp + \gamma^{-1} + 1} f_0 \tag{B.12}$$

Similarly, for the indirect investors:

$$\alpha_{0-}^{ID} = \frac{\alpha_{0-}^*}{\alpha_{0-}^F} \Rightarrow \hat{\alpha}_{0-}^{ID} = \hat{\alpha}_{0-}^D - \eta^F(R_{0-} - R_{SS}) = \frac{(\eta - \eta^F)S^F dp}{\eta dp + \gamma^{-1} + 1} f_0 \tag{B.13}$$

### Market clearing (Equation 33)

As stated in (21), the market clearing condition is

$$\alpha_t^F(R_t)(1+f_0)\alpha_t^{ID}W_t^{ID} + W_t^D\alpha_t^D = P_tQ_t = P_tq_tW_t^R \tag{B.14}$$

Define $w_t^{ID} \equiv \frac{W_t^{ID}}{W_t^R}$, and $w_t^D \equiv \frac{W_t^D}{W_t^R}$. By log-linearizng (B.14) around the steady state values, we get:

$$S^F\hat{\alpha}_t^F + S^F\hat{\alpha}_t^{ID} + S^F\hat{w}_t^{ID} + S^D\hat{\alpha}_t^D + S^D\hat{w}_t^D = \hat{p}_t + \hat{q}_t \tag{B.15}$$

Note that $S^F = w_0^{ID}$ and $S^D = w_0^D$ by definition. Therefore:

$$w_t^{ID} + w_t^D = 1 \Rightarrow S^F\hat{w}_t^{ID} + S^D\hat{w}_t^D = 0 \tag{B.16}$$

The intuition for the equation above is that the government absorbs the fluctuations in the residents' wealth that are caused by the inflow. We get the provided market clearing condition by plugging this result into (B.15).

**Price dynamics (Equations 36 and 34)**

By expanding Equation 33 by using Equations 30 and 31, we get:

$$\begin{aligned} S^F \hat{\alpha}_t^F + S^F(\lambda \hat{\alpha}_{t-1}^{ID} + (1-\lambda)(1-\nu)(\eta - \eta^F)\sum_{s=0}^{\infty} \nu^s r_{t+s}) \\ + S^D(\lambda \hat{\alpha}_{t-1}^{D} + (1-\lambda)(1-\nu)\eta \sum_{s=0}^{\infty} \nu^s r_{t+s}) = \hat{p}_t + \hat{q}_t \end{aligned} \tag{B.17}$$

We can employ the market-clearing condition at $t-1$ (provided $t \geq 1$), and bond supply equation (26), to substitute for $\hat{\alpha}_{t-1}^D$, $\hat{\alpha}_{t-1}^{ID}$, and $\hat{q}_t$. Furthermore, we know that $\hat{\alpha}_t^F = \eta^F r_t$. Therefore:

$$S^F \eta^F r_t + M \sum_{s=0}^{\infty} \nu^s r_{t+s} + \lambda(1+\gamma^{-1})\hat{p}_{t-1} - \lambda S^F \eta^F r_{t-1} = (1+\gamma^{-1})\hat{p}_t \tag{B.18}$$

,where $M = (1-\lambda)(1-\nu)(\eta - S^F\eta^F)$. We can solve for $M \sum_{s=1}^{\infty} \nu^s r_{t+s}$ by writing the same equation for time $t+1$. After some rearrangements, it yields us the equation below:

$$\nu(1+\gamma^{-1})\hat{p}_{t+1} - (1+\lambda\nu)\hat{p}_t + \lambda(1+\gamma^{-1})\hat{p}_{t-1} - S^F\eta^F \nu r_{t+1} + (\lambda\nu S^F\eta^F + S^F\eta^F + M)r_t - \lambda S^F \eta^F r_{t-1} = 0 \tag{B.19}$$

Equation 34 can be obtained by using the fact that $r_t = \hat{p}_{t+1} - (1+dp)\hat{p}_t$.

## B.4 Proof of Lemma 2

Let $C(z)$ be the characteristic polynomial of system 34. $C(z)$ can be written as below:

$$C(z) = S^F\eta^F(1-\nu z)(z-\lambda)(z-1-dp) + Mz(z-1-dp) - (1+\gamma^{-1})(1-\nu z)(z-\lambda) \tag{B.20}$$

It is straightforward to check $C(z) > 0$ for $z < 0$. Furthermore, $C(1) < 0$, $C(\max\{1+dp, \nu^{-1}\}) > 0$, and $C(z)$ converges to $-\infty$ as $z$ goes to $\infty$. Therefore, $C(z)$ should have one root in each one of $(0,1)$, $(1, \max\{1+dp, \nu^{-1}\})$, and $(\max\{1+dp, \nu^{-1}\}, \infty)$. It completes the proof. In fact, one can show that the smallest root should be less than $\lambda$ as well.

## B.5 Derivation of short-run demand elasticity

In the derivation of the long-run demand elasticity, we consider the impact of a permanent price change on the steady-state bond demand. To make the short-term demand elasticity comparable, I consider the impact of the same permanent price change on the bond demand at $t = 0$. Specifically, let the bond price increase permanently by $P_{SS}\Delta p$ from its steady-state value $P_{SS}$. Therefore, the bond return falls by $dp\Delta p$ in every period. As such, the change in the bond demand at $t = 0$ is

$$
\begin{aligned}
\Delta q^{demand} =& \eta^F S^F r_0 + M \sum_{s=0}^{\infty} \nu^s r_s + \lambda(\hat{\alpha}_{0-}^D + \hat{\alpha}_{0-}^{ID}) \\
=& -(\eta^F S^F + \frac{M}{1-\nu}) dp\Delta p + \lambda(\hat{\alpha}_{0-}^D + \hat{\alpha}_{0-}^{ID}) \\
=& -((1-\lambda)\eta + \lambda\eta^F S^F) dp\Delta p + \lambda(\hat{\alpha}_{0-}^D + \hat{\alpha}_{0-}^{ID}).
\end{aligned}
\tag{B.21}
$$

When the investors frequently rebalance (i.e., $\lambda = 0$), the short-run and long-run demand elasticities coincide. Otherwise, the short-run demand elasticity is strictly smaller, provided $\eta^F = \eta$.

# Appendix C: Additional discussions

## C.1 Price and quantity dynamics with stochastic fund flows and funding need shocks

Our baseline setup only examines the impact of a one-time inflow on the market outcomes, featuring no uncertainty about the future flows or shocks to the government's funding need. This section relaxes these assumptions. Specifically, suppose the government's objective function is modified as below:

$$\max_{\{Q_t\}_{t=0}^{\infty}} \sum_{t=0}^{\infty} \beta_G^t \{(1+u_t)P_t(\frac{Q_t}{W_t^R}) - \frac{\phi}{1+\gamma}(\frac{Q_t}{W_t^R})^{1+\gamma}\} \tag{C.1}$$

$u_t$ is a supply shifter that represents fluctuations in the government's need for funding. For instance, $u_t$ is higher in times of natural disasters, which intensify the government's need for borrowing. In the baseline case, since the focus is on the impact of fund flows on the market outcomes, I assume that $\tilde{u}_t$'s are i.i.d across the periods and normally distributed with mean zero and variance $\sigma_u^2$, prior to the government's default. Once the government defaults, all investors reoptimize their portfolio, and no shock happens afterward. Furthermore, before the default, the allocation of the indirect investors to the funds follows the process below:

$$\alpha_t^{ID} = \lambda \alpha_{t-1}^{ID} + (1-\lambda)\frac{\alpha_t^*}{\alpha_t^F} + f_t \alpha_{t-1}^{ID} \tag{C.2}$$

In (C.2), $f_t$ is the random flow to mutual funds, which is i.i.d and normally distributed: $\tilde{f}_t \sim \mathcal{N}(0, \sigma_f^2)$. $\alpha_t^*$ and $\alpha_t^F$ are the optimal portfolio shares to municipal bonds for the investors and funds, respectively. In particular, suppose both investors and funds are myopic and maximize $\mathbb{E}_t v^J(R_t^J)$, $J \in \{I, F\}$, respectively, where:

$$\begin{aligned} v^J(R_t^J) &= \frac{1}{1-\zeta_J} {R_t^J}^{1-\zeta_J} \qquad J \in \{I, F\} \\ R_t^J &= R^F + \alpha(R_t - R^F) \end{aligned} \tag{C.3}$$

If the government does not default at $t+1$, the return on its bond is $R_t$, it is $R^D$ otherwise. One could show that the bond return conditional on no default is normally distributed with a constant variance. Furthermore, similar to the baseline case, the deviations of the optimal portfolios from the steady-state ones can be characterized as below:

$$\begin{aligned} \hat{\alpha}_t^* &= \eta \mathbb{E}_t[\hat{p}_{t+1}] - (1+dp)\hat{p}_t \\ \hat{\alpha}_t^F &= \eta^F \mathbb{E}_t[\hat{p}_{t+1}] - (1+dp)\hat{p}_t \end{aligned} \tag{C.4}$$

Therefore, the equations that characterize the dynamics should be modified as below:

$$\hat{q}_t = \gamma^{-1}\hat{p}_t + \gamma^{-1}u_t \tag{C.5}$$
$$S^F\hat{\alpha}_t^F + S^F\hat{\alpha}_t^{ID} + S^D\hat{\alpha}_t^D = \hat{p}_t + \hat{q}_t \tag{C.6}$$
$$\hat{\alpha}_t^F = \eta^F E_t[r_t] \tag{C.7}$$
$$\hat{\alpha}_t^D = \lambda\hat{\alpha}_{t-1}^D + (1-\lambda)\eta E_t[r_t] \tag{C.8}$$
$$\hat{\alpha}_t^{ID} = \lambda\hat{\alpha}_{t-1}^{ID} + (1-\lambda)(\eta - \eta^F)E_t[r_t] + f_t \tag{C.9}$$
$$E_t[r_t] = \mathbb{E}_t[\hat{p}_{t+1}] - (1+dp)\hat{p}_t \tag{C.10}$$

**Proposition C.1.** *The deviation of the bond price from its steady-state value is given by:*

$$\hat{p}_t = \kappa\hat{p}_{t-1} + C_1 u_t + C_t u_{t-1} + Df_t \tag{C.11}$$

$$\begin{aligned}
D &= \frac{S^F/K}{1+dp+\frac{1+\gamma^{-1}}{K}-\kappa} \\
C_2 &= \frac{\lambda\gamma^{-1}/K}{1+dp+\frac{1+\gamma^{-1}}{K}+\frac{\lambda S^F\eta^F}{K}-\kappa} \\
C_1 &= \frac{C_2-\gamma^{-1}/K}{1+dp+\frac{1+\gamma^{-1}}{K}-\kappa}
\end{aligned} \tag{C.12}$$

*Proof.* By combining equations C.5-C.10, we get:

$$\begin{aligned}
\mathbb{E}_t[\hat{p}_{t+1}] = (1+dp+\frac{1+\gamma^{-1}}{K})\hat{p}_t - (\frac{\lambda(1+\gamma^{-1})}{K} + \frac{\lambda S^F\eta^F(1+dp)}{K})\hat{p}_{t-1} + \frac{\lambda S^F\eta^F}{K}\mathbb{E}_{t-1}[\hat{p}_t] \\
-\frac{\lambda\gamma^{-1}}{K}u_{t-1} + \frac{\gamma^{-1}}{K}u_t - \frac{S^F}{K}f_t
\end{aligned} \tag{C.13}$$

One can verify that Equation C.11 satisfies (C.13).

□

Note that there is no forward-looking element in Equation C.11 since the shocks are i.i.d. This implies that current shocks do not impact the investors' belief about the future flows or the government's funding need shocks. If the shocks followed an AR(1) process, we would have an additional term capturing that element in the price formation. Moreover, note that the bond quantity can be inferred from (C.5).

In a model with fully attentive investors, the equilibrium bond price and quantity should only depend on the current and expected future perturbations. Equation C.11 reveals that is not the case here when investors exhibit sluggish portfolio behavior. It causes the previous perturbations to impact the current bond price and quantity, captured by the lag terms in Equation C.11. An implication of this observation is that a temporary shock to the government's funding need propagates over time since the demand is not resilient enough to absorb the shock immediately.

## C.2 Examination of municipal bonds' credit spread when the investors are inattentive

In this section, I present a model of bond pricing with investor inattention. The purpose of the model is to understand how the investor inattention impacts the credit spreads on municipal bonds. The model features a government that decides about its size of bond issuance, and the prices are determined endogenously. The bond is defaultable. The government faces two groups of investors: Attentive investors, who are present to invest since the time of issuance, and some inattentive investors, who learn about the new bond issue with a delay, and trade the bond dynamically afterwards. The delayed learning, in fact, is the only point of departure of the model from a full-participation benchmark, in which all investors actively participate throughout the bond's lifetime.

We see that the credit spread is larger in the presence of inattentive investors, since it results in a limited risk-sharing between inattentive and attentive investors. In fact, shortly after the issuance, when the bond is mostly held by the attentive investors, they should bear the entire default risk. As a result, they need a higher compensation for being over-exposed to the default risk of the issuing government. In particular, the model predicts that younger bonds command a higher risk-premium, since the limited risk-sharing friction is the most severe for those bonds. In fact, since the younger bonds a longer time to maturity all else equal, this prediction is consistent with the empirical observation that the term structure of credit spread is upward-sloping for municipal bonds Cestau, Hollifield, Li, and Schürhoff (2019).

## C.3 Setup

Time $(t)$ is continuous. A government issues $Q$ units of zero-coupon bonds at $t = 0$ that mature at $t = T$. Each unit of bond pays one unit of wealth at maturity. The bond is defaultable. The government defaults on the bond according to a Poisson process, with parameter $\delta > 0$. $\delta$ captures the riskiness of the government's bond; There higher $\delta$, the government is more likely to default prior to the maturity. Alternative to the government bond, risk-free assets are available with short-term return $r > 0$. The price of the government bond is denoted by $P(t)$, and solved endogenously.

The economy comprises of two types of investors: attentive and inattentive investors. Attentive investors are aware of the new issuance at $t = 0$. In contrast, inattentive investors gradually become aware of the issuance. The learning process is modeled by a Poisson process with parameter $\lambda$. Thus, by $t \geq 0$, fraction $1 - e^{-\lambda t}$ of the inattentive investors have become aware of the new issue, and continuously trade in both the government and risk-free bond market. The rest of the inattentive investors only invest in the risk-free asset prior to learning about the government bond. At $t = 0$, the overall wealth of attentive and inattentive investors are

$W_0^A$ and $W_0^{IA}$, respectively. A key implication of the gradual learning by inattentive investors is that attentive investors buy the bonds first at $t = 0$, and gradually resell the bonds to inattentive investors.[23]

Note that the model lies between two extreme well-studied cases: The classical full-participation case, in which all investors are aware of the bond since $t = 0$, and the limited-participation case (e.g., Basak and Cuoco (1998)) in which inattentive investors never learn about the bond ($\lambda \to 0$).[24]

The objective of all investors is to maximize their utility over their terminal wealth at $T$.[25] The utility function is assumed to be logarithmic for tractability reasons.

## C.4 Equilibrium price and risk-premium

An investor's optimization problem can be characterized as below for the period he is aware of the bond:

$$\delta V = \max_{\alpha} \quad V_t + (rw + \alpha w \underbrace{(\frac{dP}{P} - r)}_{\text{risk premium}})V_w + \delta \underbrace{\log((1-\alpha)e^{r(T-t)}w)}_{\text{Utility upon default}} \tag{C.14}$$

In (C.14), $V(w,t)$ denotes the investor's value function, and $V_t$ and $V_w$ represent the partial derivatives with respect to time and wealth respectively. $\alpha$ is the fraction of wealth invested in the government bonds, which is the investor's only control variable. For inattentive investors, prior to them learning about the bond, $\alpha = 0$.

**Proposition C.2.** *The value function $V(w,t)$ is logarithmic in wealth. Specifically, there exists $v(t)$ such that*

$$V(w,t) = v(t) + \log w \tag{C.15}$$

*Proof.* We can prove the proposition by guessing and verifying that the value function is in form of (C.15). It implies that $V_w = w^{-1}$ and $V_t = v'(t)$. The first-order condition for the optimal $\alpha$, denoted by $\alpha^*(t)$, is as below:

$$\frac{dP}{P} - r = \frac{\delta}{1-\alpha^*(t)} \tag{C.16}$$

By substituting (C.16) in (C.14), a dividing both sides by $\delta$, we get:

$$V(w,t) = v'(t) + r\delta^{-1} + \frac{\alpha^*(t)}{1-\alpha^*(t)} + \log(1-\alpha^*(t)) + r(T-t) + \log w \tag{C.17}$$

[23] Duffie (2010) postulates a similar prediction about asset allocation dynamics when investors are heterogeneously attentive.

[24] Note that the extreme case of $\lambda \to \infty$ does not correspond to the full-participation case, as even at the limit, only attentive investors participate at $t = 0$.

[25] It is innocuous to assume that the terminal point is the same as the bond maturity since there is no uncertainty afterwards.

It proves the conjecture about the functional form, and provides a characterization for $v(t)$.

$\square$

By applying (C.15) to (C.14), we see that all investors that are aware of the bond at $t$ invest the same fraction ($\alpha^*$) of their wealth in the government bonds, where $\alpha^*$ satisfies the following condition:

$$\mathbb{E}[\frac{dP}{P}] - r = \frac{\delta}{1-\alpha^*} - \delta \tag{C.18}$$

Note that when the bond size is small compared to the overall wealth of investors aware of the bond, $\alpha^*$ is small, implying the risk-premium is close to zero. Therefore, the model generates a risk-premium larger than the frictionless benchmark since all investors do not pay attention, leading to an imperfect risk-sharing among the investors.

Proposition C.3 provides the equilibrium price and risk-premium:

**Proposition C.3.** *Provided the government does not default on its bond by $t$, the price of the government bond is:*

$$P(t) = e^{(r+\delta)(t-T)}x(t) \tag{C.19}$$

*,where*

$$x(t) = (1 + \int_t^T \frac{\delta Q e^{-(r+\delta)T} e^{\delta s}}{W_0^A - P(0)Q + (1-e^{-\lambda s})W_0^{IA}} ds)^{-1} \tag{C.20}$$

*The implied risk-premium is:*

$$\mathbb{E}[\frac{dP}{P} - r] = \frac{\delta Q e^{-rt} P(t)}{W_0^A - P(0)Q + (1-e^{-\lambda t})W_0^{IA}} \tag{C.21}$$

*Proof.* Equation C.16 implies that attentive investors and the inattentive investors that are aware of the bond at $t$ have the same $\alpha^*$, that is they invest the same fraction of their wealth in the government bond. Define $W(t)$ as the total wealth of these two groups of investors at $t$. Therefore, $\alpha^* = \frac{QP(t)}{W(t)}$. By substituting this in (C.16), and some rearrangements, we get (Time indices are dropped for brevity, unless necessary):

$$P' - rP = \delta P(1 - \frac{QP}{W})^{-1} \tag{C.22}$$

,where $P'(t) = \frac{dP}{dt}$. One can solve the ODE and obtain the expressions provided in (C.19) and (C.20) by following the steps below:

$$
\begin{aligned}
P' - rP &= \delta P(1 - \frac{QP}{W})^{-1} \\
P' - (r+\delta)P &= \delta P^2 Q(W - PQ)^{-1} \\
P' e^{-(r+\delta)(t-T)} - (r+\delta) P e^{-(r+\delta)(t-T)} &= e^{-(r+\delta)(t-T)} \delta P^2 Q (W - PQ)^{-1}
\end{aligned} \tag{C.23}
$$

Define $y = e^{(r+\delta)(t-T)} P^{-1}$, and substitute in (C.23):

$$
y' = -\delta e^{(r+\delta)(t-T)} Q m^{-1} \tag{C.24}
$$

,where $m = W - PQ$. Note that

$$
\begin{aligned}
& dm = dW - QdP = QdP + rmdt + \lambda e^{(r-\lambda)t} W_0^{IA} dt - QdP \\
& \Rightarrow m = e^{rt}(W_0^A - P(0)Q + (1 - e^{-\lambda t}) W_0^{IA})
\end{aligned} \tag{C.25}
$$

In (C.25), I use the fact that at $t = 0$, only attentive investors participate, that is $W = W_0^A$. Now, we can solve for $y(t)$, and consequently $P(t)$, by substituting (C.25) in (C.24), integrating over $[t, T]$, and noting the fact that $y(T) = P(T)^{-1} = 1$:

$$
\begin{aligned}
y(t) &= 1 + \int_t^T \frac{\delta Q e^{-(r+\delta)T} e^{\delta s}}{W_0^A - P(0)Q + (1 - e^{-\lambda s}) W_0^{IA}} ds \\
P(t) &= e^{(r+\delta)(t-T)} y^{-1}(t) = e^{(r+\delta)(t-T)} x(t)
\end{aligned} \tag{C.26}
$$

To derive the risk-premium formula (C.21), we should note that the pricing formula is conditional on the government not defaulting on the bond. As a result the risk-premium is

$$
\begin{aligned}
\mathbb{E}[\frac{dP}{P} - r] &= \frac{dP}{P} - r - \delta \\
&= y^{-2} e^{(r+\delta)(t-T)} P^{-1} y' \\
&= \frac{\delta Q e^{-rt} P}{W_0^A - P(0)Q + (1 - e^{-\lambda t}) W_0^{IA}}
\end{aligned} \tag{C.27}
$$

□

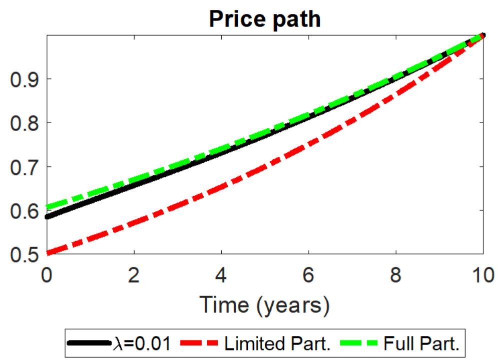
In (C.19), the first term is the bond price in a benchmark case in which the credit spread is equal to the default probability (Duffie and Singleton, 1999). The second term, $x(t)$, captures how the investor inattention impacts the bond price. $x(t)$ is close to one when the attentive capital ($W_0^A$) is large compared to the issue size ($W_0^A \gg Q$), or when the inattentive capital ($W_0^{IA}$) is large and the inattentive investors rapidly become aware of the bond after its issuance ($W_0^{IA} \gg Q, \lambda \to \infty$). In the specification of $x(t)$, $P(0)$ also appears, which can be found by combining (C.19) and (C.20).

Figure C.1a depicts the price path for the case with investor inattention, along with two extreme cases: Full participation, corresponding to a case that all investors are aware of the bond at the issuance time, and limited participation, corresponding to the case with $\lambda = 0$.[26]

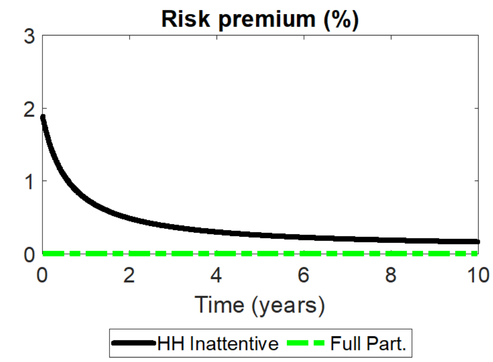
The risk-premium is provided by Equation (C.21), and its evolution is depicted in Figure C.1b, along with the two extreme cases of full and limited participation. As shown in Figure C.1b, the risk-premium goes down as more investors become aware of the bond, due to the improved risk-sharing between the attentive and inattentive investors. Interestingly, we see that the risk-premium is not simply between the values for the two extreme cases. To see the intuition, note that, in the beginning, the price reflects the fact that more investors will join the market in the future, thus the initial price is higher than the limited participation case. However, at the same time, the ownership is still concentrated, implying that the attentive investors need to allocate a larger fraction of their wealth to the bond compared to the limited participation case, thus they require a larger compensation for the default risk.

A long-standing puzzle in the literature of municipal bond markets is the large credit spreads implied by the prices, despite the low historical default rates (Cestau, Hollifield, Li, and Schürhoff, 2019; Schwert, 2017). Schultz (2013) and Li and Schürhoff (2019) suggest that the high credit spreads are attributable to the fact that municipal bond markets are segmented due to the tax advantage of in-state investors, which limits arbitrageurs' ability to inject liquidity. Relatedly, Babina, Jotikasthira, Lundblad, and Ramadorai (2021) find evidence that the demand for the bonds is more inelastic in states with small out-of-state ownership, which are mostly the states with large relative tax-advantage of in-state investors. Note that this type of market segmentation hinders risk-sharing across states. However, investor inattention limits the risk-sharing between more attentive investors, such as mutual funds, and less attentive investors within the same state.

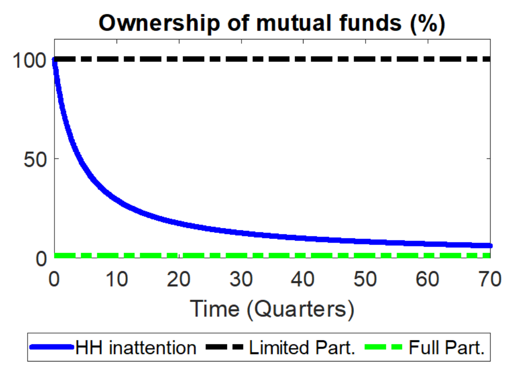
[26] Note that the mode does not converge to the full participation case when $\lambda \to \infty$ because for all values of $\lambda$, only attentive investors are aware of the bond at $t = 0$. Full participation requires all investors to be participate in the government bond market from $t = 0$ onward.




(a)




(b)




(c)

**Figure C.1: The evolution of the price, risk-premium, and ownership throughout the bond's lifetime.** In all figures, the solid black line represents the case with investor inattention. Red and green dashed liens represent the cases with limited and full participation. Figures (a), (b), and (c) respectively display the government bond price, risk premium on the bond ($\mathbb{E}[\frac{dP}{P}]-r$), and the fraction held by the attentive investors. The parameter values used are: $\lambda = 0.01$, risk-free rate (annual) $= 2\%, \delta = 3\%$, Maturity $= 10 years, Q = \$60M, W_0^A = \$90M, W_0^{IA} = \$9B$