Heterogeneous Taxes and Limited Risk Sharing: Evidence from Municipal Bonds*

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ABSTRACT

Heterogeneity in the taxation of asset returns can create ownership clienteles. Using a simple model, we demonstrate that an important consequence of tax-policy-induced ownership segmentation is to limit risk-sharing, creating regions of the aggregate demand curve for the asset that are "downward-sloping." As a result, the constraints of the ownership clientele impact the asset price response to variations in asset supply and demand, and make the asset's price more sensitive to movements in idiosyncratic risk. We test these predictions on U.S. municipal bonds, where cross-state variation in state tax privilege policies results in different levels of home-state-biased ownership of local municipal bonds. In states with high tax-induced ownership segmentation, we find greater susceptibility of municipal bond yields to demand and supply variation, heightened sensitivity of muni yields to local political uncertainty, and greater difficulties in raising capital for public projects.

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ABSTRACT

Heterogeneity in the taxation of asset returns can create ownership clienteles. Using a simple model, we demonstrate that an important consequence of tax-policy-induced ownership segmentation is to limit risk-sharing, creating regions of the aggregate demand curve for the asset that are "downward-sloping." As a result, the constraints of the ownership clientele impact the asset price response to variations in asset supply and demand, and make the asset's price more sensitive to movements in idiosyncratic risk. We test these predictions on U.S. municipal bonds, where cross-state variation in state tax privilege policies results in different levels of home-state-biased ownership of local municipal bonds. In states with high tax-induced ownership segmentation, we find greater susceptibility of municipal bond yields to demand and supply variation, heightened sensitivity of muni yields to local political uncertainty, and greater difficulties in raising capital for public projects.

1. Introduction

There is considerable evidence that portfolio choice and asset ownership decisions are significantly influenced by investors' tax rates and by tax policy (see, for example, Poterba and Samwick (2003), Dammon, Spatt, and Zhang (2004), Bergstresser and Poterba (2004), Desai and Dharmapala (2011), and Rydqvist, Spizman, and Strebulaev (2014)). Whether these taxation-induced portfolio decisions ultimately impact asset prices and valuation, however, is still an active area of investigation. For example, Graham (2003) argues that "the profession has made only modest progress documenting whether investor taxes affect asset prices," and Longstaff (2011) writes that "there is still much about the effects of taxation on investment values that is not yet fully understood". Perhaps most famously, in his Presidential Address to the American Finance Association, Miller (1977) argued that while heterogeneous taxes incentivize different clienteles to hold particular types of (tax-advantaged) debt, in equilibrium, there should be no particular consequences of these tax-induced ownership structures on debt pricing or issuance. This insight is shared by the extensive literature on capital structure – namely, that bond yields should adjust to the point of capital structure irrelevance even in a world with heterogeneous personal income tax rates.

In this paper, we draw attention to an important consequence of investor taxes that can have significant effects on asset valuation. We make the point that tax-induced ownership segmentation can have implications for risk-sharing in equilibrium, which can in turn affect asset prices and the resilience of asset prices to shocks. Put differently, the key insight of our paper is that tax policy can push particular assets into a "downward-sloping" portion of the aggregate demand curve for a security (see, for example, Shleifer (1986), and Duffie (2010)), with all of the attendant pricing and issuance implications. We show this in a simple theoretical model, and present evidence that these effects are substantial in reality using data from the U.S. municipal bond market. A more general insight that can be drawn from our analysis is that clientele effects in ownership can lead to limited risk-sharing, which in turn can affect the cost of external finance – a channel which has not been greatly emphasized in the extensive literature on this topic, which has tended to focus on issues of adverse selection and moral hazard (see, for example, Myers and Majluf (1984), and DeMarzo, Fishman, He, and Wang

(2012)).

While we view our primary contribution as empirical, we build a simple model to illustrate the economic forces that are at work. The model combines the framework of Miller (1977) with that of Merton (1987), and shows that when tax privileges for specific clienteles are high enough, they become the marginal investors for the tax-advantaged asset. In the resulting equilibrium, prices and the resilience of prices to shocks reflect the constraints of the clientele in question.

We go on to test key predictions of this simple model in the U.S. municipal bond market, which has long been an important testing ground for work on taxation and asset valuation (see, for example, Green (1993), Trzcinka (1982), Green, Hollifield, and Schurhoff (2007), and Ang, Bhansali, and Xing (2010)). An important feature of these bonds is that many of them carry state-tax-advantaged status if held by in-state residents (generally, municipal bonds also carry tax-advantaged status with regards to Federal taxes). This leads to a sizeable incentive for in-state residents to hold locally-issued bonds. We first confirm using the data on holdings of municipal bond funds that the tax privilege indeed creates a disproportionately "home-state-biased" bond ownership base. Specifically, states with high levels of tax privilege issue municipal bonds that are, on average, financed by local investors, while municipal bonds issued by states with low tax privilege are purchased and are held widely by investors from all over the country. We then go on to confirm that this tax-induced segmentation commensurately diminishes the scope for cross-state risk sharing in the municipal bond market. We find that states with high tax privileges for residents exhibit predictable variation in municipal bond yields, and greater susceptibility of bond prices to shocks to demand, and movements in bond supply. We also show that such states' bonds are far more sensitive to movements in local political risk. Finally, we show that states with greater tax-induced ownership segmentation face considerable difficulties in issuing debt at favorable terms during periods of weak demand. These results are robust to the introduction of a large set of alternative drivers of municipal bond prices and issuance.

Our work highlights a relatively neglected consequence of taxation policy, and shows they are empirically important for municipal bonds. An important question that arises here is the degree to which forward-looking state governments optimize tax policy, trading off a lower cost of debt by engineering a more "local" base against the risk-sharing issues that we identify. To be clear, our model does not endogenize state tax policy or debt supply, taking these as given at the point of our analysis. We simply solve for the optimal asset demands of investors who face different tax-policy induced incentives, and clear markets to derive expressions for equilibrium returns. However, we should point out here that an awareness of a more nuanced tradeoff along these lines is not consistent with anecdotal evidence from this market. The tax privilege offered to local investors is generally thought of by state taxation authorities and market participants as being "revenue neutral." The state faces a borrowing cost that is reduced by $r \cdot \tau$, where r is the borrowing cost that would prevail free of the tax privilege and τ is the relevant state income tax rate. At the same time, the state is thought to lose $r \cdot \tau$ in tax revenue by offering this privilege.[1]

Our results are related to several areas of the finance and economics literature. On the corporate finance side, our model shows that the composition of ownership in a firm's capital structure can have effects on the value of the firm, connecting our work to the substantial body of literature on capital structure in both theory and practice that has exploded since the seminal work of Modigliani and Miller (1958) (for a recent survey of the empirical literature, see Graham and Leary (2011)). Our model has similarities with Auerbach and King (1983), who uphold capital structure irrelevance even in a world of heterogeneous taxes, but discuss how borrowing and short-sales constraints can overturn this conclusion. We empirically demonstrate that capital market outcomes can be (through the formation of clienteles) affected by tax policy, which connects our work to a series of papers, including Graham (2003), McGrattan and Prescott (2005), and Sialm (2009), who finds a strong association between effective tax rates and firm equity valuations.

Our work also contributes to the rapidly-expanding literature on municipal bond ownership and pricing (see, for example, Fama (1977), Schultz (2013), Bergstresser and Cohen (2015), and Cohen, Cornett, Mehran, and Tehranian (2015)). In particular, the effects of tax clientele may

[1] It is worth noting here that in Miller's (1977) equilibrium, the firm has a corporate tax exemption incentive to adjust debt supply to the point at which it exhausts the available demand from investors with low marginal tax rates. However, there is no such clear-cut incentive for governments to do so, precisely because of the perception of revenue neutrality. Moreover, in our conversations with market participants, the types of costs associated with tax-induced segmentation that we identify have seemed to come as something of a surprise.

help address the muni-bond puzzle, namely that municipal bond yields, particularly at the long end, are too high relative to those of otherwise similar taxable bonds multiplied by one minus the applicable marginal tax rate (see, for example, Green (1993), Chalmers (1998), and Longstaff (2011)). Although we use the municipal bond market as a laboratory, our main findings on the effects of tax clientele on pricing are broader. In particular, we show that "downward-sloping demand" for an asset can arise as a consequence of tax policy, highlighting a new channel in an area which is a very active area of investigation. See, for example, Grossman and Miller (1988), Shleifer and Vishny (1997), Gromb and Vayanos (2002), and Greenwood, Hanson, and Liao (2015), among others.[2]

Finally, our work has links with the international finance literature on the price effects of market segmentation (see, for example Errunza and Losq (1985), French and Poterba (1991), Tesar and Werner (1995), Bekaert and Harvey (1995), Baxter and Jermann (1997), Froot and Dabora (1999), Henry (2000), Bekaert and Harvey (2000), and Bekaert, Harvey, Lundblad, and Siegel (2011)). In that literature, implicit and explicit capital barriers affecting cross-border investment generate elevated costs of capital, affect loadings on local versus global risk factors, and have impacts on correlations across global markets. It is worth noting that in the U.S. municipal bond market, there is no restriction preventing the cross-state purchase of municipal bonds, and the usual complications of currencies which bedevil international finance studies are absent. Nevertheless, the incentives created by taxation policy do appear to create a disproportionately local municipal bond ownership structure.

The organization of the paper is as follows. Section 2 outlines a simple theoretical framework relevant for our empirical work, which employs insights from both Miller's (1977) and Merton's (1987) models. Section 3 describes municipal bond funds, and the data on these funds that we employ in the study. Section 4 establishes that state taxation policy is a key determinant of bond ownership structure. Section 5 documents the empirical relationships between state tax policy, the extent of local ownership of municipal bonds, and the price effects of demand and supply shocks to municipal bonds. Section 6 concludes.

[2] Also see Gabaix, Krishnamurthy, and Vigneron (2007), Garleanu, Pedersen, and Poteshman (2009), Greenwood and Vayanos (2014), and Hanson and Sunderam (2014).

2. Theoretical Framework

To better understand the empirical relationships we identify, we present a simple model, which is adapted from both Miller (1977), and Merton (1987).

We model asset price dynamics in an economy populated by a small country/state/region which incentivizes holdings by its residents of a particular asset I. The state does so by providing tax privileges for holding asset I to its own ("inside") residents. In the spirit of Merton (1987), the only other asset in the model is the "market" M, which carries no tax privileges for insiders. In this sense, the state pays insiders to underdiversify. In addition to inside investors, we consider "global" or "market" investors, who constitute the remainder of the market, see no difference in post-tax returns between these two assets, and have significantly more capital. When the tax privilege to inside investors is sufficiently high, they become the marginal investors in the inside asset. Given reasonable parameter values, this can result in demand for the inside asset becoming price elastic, and lead to a greater response of prices to shocks to demand, movements in issuance, or episodes of idiosyncratic risk.

Given our focus on the impacts on asset prices, we do not endogenize asset supply or tax policy in our simple model, taking these as given at the point of our analysis.[3] We simply solve for the optimal asset demands of inside and global investors, and clear markets to derive expressions for equilibrium returns. We then link these expressions to our empirical results using comparative statics across key parameters from the model.

2.1. Asset Structure

There are two assets, an inside asset (I) and the market (M), with the following random returns:

$$\begin{aligned} \tilde{r}_I &= \bar{r}_I + \tilde{y} + \tilde{\varepsilon}_I, \\ \tilde{r}_M &= \bar{r}_M + \tilde{y}. \end{aligned}$$

where $E(\tilde{y}) = 0$, $\mathrm{Var}(\tilde{y}) = \sigma_y^2$, $\mathrm{E}(\tilde{\varepsilon}_I) = 0$, $\mathrm{Var}(\tilde{\varepsilon}_I) = \sigma_I^2$, and $\mathrm{Cov}(\tilde{y}, \tilde{\varepsilon}_I) = 0$. We can interpret $\tilde{y}$ as a systematic risk factor, which affects both assets identically, and $\tilde{\varepsilon}_I$ as an idiosyncratic risk

[3] We provide a brief discussion of these issues at the end of this section, when we attempt to link key parameters of the model with data on municipal bonds.

factor, which is specific to the inside asset.

Furthermore, let S_I denote the net supply of asset I, which we model as net of any price-inelastic demand which is outside the model (e.g., the demand of index funds). To focus our analysis on the objects of interest, as in Merton (1987) we assume that the market for asset M is extremely large, and $\bar{r}_M$ is largely unaffected by the choices of agents in the model.

2.2. Investors

There are two investors in the model, which we label as inside (ι) and global (g). We assume that the inside investor ι receives a *relative tax privilege* for investing in asset I. In particular, the after-tax returns that ι receives from investing in assets I and M respectively are $\tilde{r}_I$ and $(1-\tau)\tilde{r}_M$.

We also assume that the inside investor's total wealth is W^ι, which is sufficient to purchase the entire supply of the inside asset I, i.e., $W^\iota > S_I$.[4]

The global investor g faces the same tax treatment for assets I and M (without loss of generality, we set this tax rate to zero). The aggregate wealth of the global investor is denoted by W^g, where $W^g >> W^\iota$.

Both investors $j \in \{\iota, g\}$ face the same utility maximization problem, with utility functions *a la* Merton (1987):

$$\begin{aligned} &\max_{\omega^j} \ \mathrm{E}(W^j(1+\tilde{r}^j)) - \frac{\delta}{2W^j}\mathrm{Var}(W^j(1+\tilde{r}^j)) - \lambda^j\omega^j \\ \Leftrightarrow \ &\max_{\omega^j} \ \mathrm{E}(\tilde{r}^j) - \frac{\delta}{2}\mathrm{Var}(\tilde{r}^j) - \lambda^j\omega^j \end{aligned} \tag{1}$$

where $\tilde{r}^j$ denotes the return of investor $j \in \{\iota, g\}$, ω^j is the weight that each investor places on asset I. λ^j is the Lagrange multiplier that reflects the constraint that ω^j is non-negative – which is a short-sales constraint that we model as applying to all holdings, including that in the inside asset I.[5] Note that investors ι and g only differ in the after-tax returns that they

[4]Without loss of generality, we normalize the price of the asset to 1. If one were to push the interpretation slightly, and assume that the inside asset is the debt of a small country or state, this condition is equivalent to assuming that the state has positive net worth, in the sense that the total assets of state residents are sufficient to cover total state liabilities.

[5]See Gromb and Vayanos (2010) for an excellent summary of the literature on short sales costs. This is a relatively standard arbitrage friction that we model as a constraint in our setting.

receive on asset I, relative to those on asset M, owing to the tax privilege.

Expected after-tax portfolio returns and variances of the two investors are given by the expressions:

$$E(\tilde{r}^{\iota}) = \omega^{\iota}\bar{r}_I + (1-\tau)(1-\omega^{\iota})\bar{r}_M \text{ and } E(\tilde{r}^{g}) = \omega^{g}\bar{r}_I + (1-\omega^{g})\bar{r}_M \tag{2}$$

$$\text{Var}(\tilde{r}^{\iota}) = ((1-\tau+\tau\omega^{\iota})\sigma_y)^2 + (\omega^{\iota}\sigma_I)^2 \text{ and } \text{Var}(\tilde{r}^{g}) = \sigma_y^2 + (\omega^{g}\sigma_I)^2 \tag{3}$$

Substituting (2) and (3) into (1) and differentiating (1) with respect to ω^{ι} (ω^{g}) for investors ι (g), we obtain the following first-order conditions:

$$\omega^{\iota} = \frac{\bar{r}_I - (1-\tau)\bar{r}_M - \delta\tau(1-\tau)\sigma_y^2 - \lambda_{\iota}}{\delta(\tau\sigma_y^2 + \sigma_I^2)} \quad \text{and} \quad \omega^{g} = \frac{\bar{r}_I - \bar{r}_M - \lambda_g}{\delta\sigma_I^2}. \tag{4}$$

Equation (4) shows that investors ι will compare the (variance-adjusted) tax-privilege-induced extra return on asset I, $\bar{r}_I - (1-\tau)\bar{r}_M - \delta\tau(1-\tau)\sigma_y^2$ with the incremental non-diversifiable risk $\delta(\tau\sigma_y^2 + \sigma_I^2)$ from scaling up the position in asset I.

Investors g face a similar tradeoff, but since they do not receive any tax privilege, require a higher return on asset I than on asset M per unit of idiosyncratic risk to induce them to hold the inside asset relative to inside investors. A simple comparison illustrates this better – note that $\bar{r}_M > (1-\tau)\bar{r}_M + \delta\tau(1-\tau)\sigma_y^2$. Put differently, the tax privilege for inside investors means that they will require a smaller expected return per unit of risk to invest in asset I.

2.3. Market Clearing and Equilibrium

To clear the market for asset I, $\bar{r}_I$ must solve:

$$W^{\iota}\omega^{\iota} + W^{g}\omega^{g} = S_I. \tag{5}$$

The solution to equation (5) can fall into two possible ranges, depending on parameter values.

Region 1 $(1-\tau)\bar{r}_M + \delta\tau(1-\tau)\sigma_y^2 < \bar{r}_I \leq \bar{r}_M$

In this case, investor g will not invest in asset I ($\lambda < 0$ and $\omega^{g} = 0$), and therefore investor ι takes up the entire excess supply of asset I, and bears all of the idiosyncratic risk, σ_I^2.

Market clearing yields:

$$\bar{r}_I = (1-\tau)\bar{r}_M + \delta\tau(1-\tau)\sigma_y^2 + \frac{\delta\gamma\sigma_I^2 S_I}{W^\iota}, \tag{6}$$

where $\gamma = 1 + \tau\sigma_y^2/\sigma_I^2 > 1$ is the scaling factor that captures investors ι's change in exposure to $\tilde{y}$ (relative to the market) from investing in asset I rather than M on account of the tax privilege.

Equation (6) highlights that the tradeoff that investor ι faces between the tax privilege and the additional compensation required to bear additional idiosyncratic risk is the principal force driving equilibrium returns $\bar{r}_I$ in Region 1.

Region 2 $\bar{r}_M < \bar{r}_I$

If the additional risk compensation for the inside investors dominates the return they obtain from the tax privilege, then the equilibrium expected return will meet the requirement for investors g. Both investors ι and g will hold asset I, and will share the idiosyncratic risk on the asset. Market clearing therefore dictates that:

$$\bar{r}_I = \bar{r}_M - \frac{W^\iota}{W^\iota + \gamma W^g}\left(\tau\bar{r}_M - \delta\tau(1-\tau)\sigma_y^2\right) + \frac{\delta\gamma\sigma_I^2 S_I}{W^\iota + \gamma W^g}. \tag{7}$$

Interpreting this expression a little loosely, the tax privilege now applies only to the smaller wealth-weighted fraction of investors ι: $(W^\iota/(W^\iota + \gamma W^g))$ while the idiosyncratic risk is shared across both investors $(S_I/(W^\iota + \gamma W^g))$. Since $W^g >> W^\iota$ and $\gamma > 1$, both the tax privilege and risk compensation terms become much smaller under (7) than (6). Indeed, in the limit $W^g \to \infty$, both terms drop out and $\bar{r}_I = \bar{r}_M$.

The figure below illustrates the two regions and the equilibrium that prevails in each.

Figure 1 shows that the tax privilege creates the kink in the aggregate demand curve, when we move from Region 2, where there is risk-sharing and far less price elasticity of demand, to Region 1 in which investor ι bears the entire idiosyncratic risk of asset I, and has relatively more price elastic demand. The larger the tax privilege τ, the larger is Region 1, and the more likely it is that the prevailing equilibrium will fall in that region.

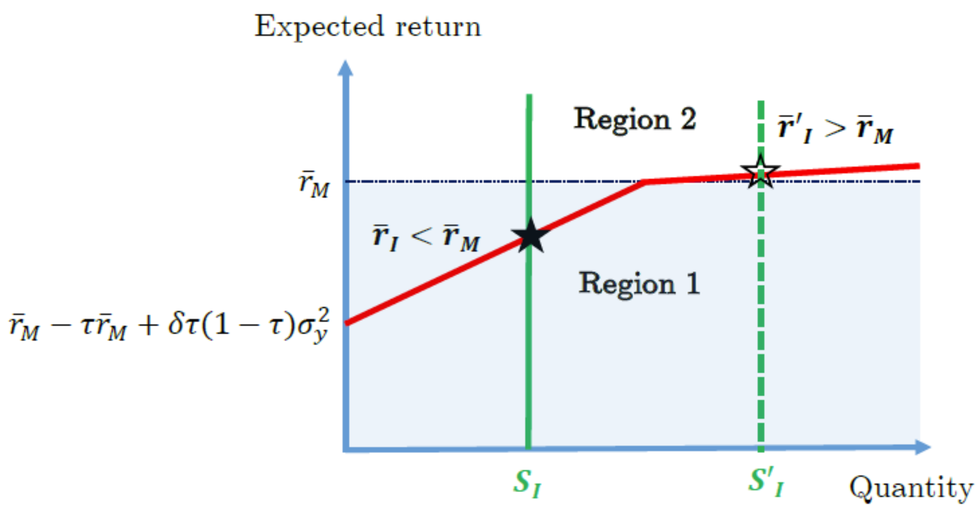

Figure 1: Equilibria with Full and Limited Risk Sharing

2.4. Comparative Statics

2.4.1. Comparative Statics in Region 1

We consider comparative statics across equilibrium returns in Region 1 as described in equation (6) to begin with, and then discuss how these predictions are affected if equilibrium falls into Region 2.

First, differentiating the expression in equation (6) for $\bar{r}_I$ with respect to σ_I^2, we get that $\frac{\partial \bar{r}_I}{\partial \sigma_I^2} = \delta S_I / W^\iota > 0$. The expression shows that the higher the idiosyncratic risk σ_I^2, the higher is the required risk compensation, resulting in a higher equilibrium expected return. We check this prediction by comparing periods of high local political risk in a state with comparatively calmer periods.

Second, differentiating $\bar{r}_I$ with respect to net supply, S_I, we get that $\frac{\partial \bar{r}_I}{\partial S_I} = \delta\gamma\sigma_I^2/W^\iota > 0$, indicating that an increase in supply increases the required risk compensation term as asset I accounts for a larger fraction of investors ι's wealth. This is easily seen on the graph as a move up the positively sloping region on the red line in Region 1.

Third, differentiating $\bar{r}_I$ in (6) with respect to δ, we obtain $\frac{\partial \bar{r}_I}{\partial \delta} = \tau(1-\tau)\sigma_y^2 + \gamma\sigma_I^2 S_I / W^\iota > 0$, indicating that any increase in the capacity of ι investors to bear risk (i.e., a decrease in risk aversion δ), will naturally also decrease the required risk compensation and hence the expected return in equilibrium.

Fourth, it is easy to show by differentiating these three partial derivatives further with respect to the ratio of available asset supply to wealth, S_I/W^ι, that all three effects increase in magnitude as the asset supply increases as a fraction of the available wealth of ι investors.

Finally, differentiating $\bar{r}_I$ in (6) with respect to τ, we obtain $\frac{\partial \bar{r}_I}{\partial \tau} = -\bar{r}_M + \delta(1-2\tau)\sigma_y^2$, which is negative with a set of reasonable parameters for the municipal bond market (see an attempt at calibration below). Thus, the higher the tax privilege τ, the further $\bar{r}_I$ is pushed below $\bar{r}_M$, making the equilibrium more likely to fall into Region 1. As we describe more fully below, this motivates our difference-in-difference empirical specifications in which we compare states with high versus low levels of tax privilege.

2.4.2. Comparative Statics in Region 2: Discussion

If the tax privilege τ is small, the equilibrium is likely to fall into Region 2. In this region, the idiosyncratic risk is fully shared across all investors.

Figure 1 shows that in this region, the aggregate demand from all investors exhibits much smaller price elasticity than in Region 1. This can easily be confirmed by the comparative statics using (7), which show that all the predictions obtained in Region 1 (from equation (6)) hold, but with substantially weaker effects.

For example, differentiating $\bar{r}_I$ in (7) with respect to net supply S_I, we obtain $0 < \delta\gamma\sigma_I^2/(W^\iota + \gamma W^g) < \delta\gamma\sigma_I^2/W^\iota$. As W^g becomes large, therefore, the effect size is vanishing. Conversely, as W^g becomes small, we move closer to the set of comparative statics described in Region 1. However, it is worth noting that in Region 2, there is little role for tax privilege – any effects are primarily driven by Merton (1987)-style frictions.[6]

2.4.3. A Simple Calibration

It is worth mentioning here that one important reason that Miller (1977) claims that heterogeneous personal taxes don't affect equilibrium prices is because he assumes that debt supply adjusts such that in equilibrium, all otherwise similar debts are priced by the same marginal

[6] Our empirical tests consider this issue by checking whether there are differential effects of idiosyncratic risk and net supply on expected municipal bond returns associated with variation in the available "global" capital (which we associate with W^g) allocated to municipal bonds. We do find evidence of such effects.

investors. Put differently, the contention is that supply will increase to the point at which all available tax privileges are exhausted, thus moving equilibrium into Region 2.

We treat S_I and τ as exogenous in our simple model, but in reality, these are quantities which are chosen by states. Our claim is that state bond supply is determined for a number of reasons (exogenous shocks affecting the state's budgetary position, for example) in addition to pure adjustment to the point of global investor indifference. Ultimately, therefore, we view it as an empirical question whether for any given state, equilibrium is in Region 1, in which the aggregate demand curve is downward-sloping, or in Region 2, in which resilience of the asset price to shocks is stronger. We attempt to shed light on this issue by calibrating selected parameters from the model to data from California and Minnesota, two states with relatively high tax privilege. Our primary goal is to ascertain whether these parameters locate equilibrium for high-privilege states in Region 1 described in the model.

We set $\bar{r}_M = 0.0472$, the average 20-year municipal bond yield in our sample, and $\sigma_y^2 = 0.0050$, the variance of annual returns on the value-weighted 20-year municipal bond portfolio. We assume that investors' coefficient of risk aversion $\delta = 3$, following a number of studies, including Das and Uppal (2004).

For California, we set the average tax privilege $\tau = 0.10$, the wealth of inside investors $W^\iota = \$MM\ 1,941,513$ (from the Internal Revenue Service's personal wealth study in 2007), and the net supply $S_I = \$MM\ 300,000$ (from the Census Bureau, also in 2007). We estimate idiosyncratic variance ($\sigma_I^2 = 0.0005$) as the variance of residuals from regressing California municipal bond returns on our measure of $\tilde{r}_M$, which is constructed as a weighted average of municipal bond returns, where the weights are proportional to the total debt outstanding per state. Using these parameters, we compute $\bar{r}_I = 0.0443 < 0.0472 = \bar{r}_M$, meaning that equilibrium comfortably falls into Region 1.

Following the same procedure for Minnesota, with $\tau = 0.08$, $W^\iota = \$MM\ 158,224$, $S_I = \$MM\ 36,000$, and $\sigma_I^2 = 0.0002$, we get $\bar{r}_I = 0.0449 < 0.0472 = \bar{r}_M$, once again putting equilibrium comfortably into Region 1. Consistent with this simple calibration, Schultz (2013) shows that relative yields on municipal bonds issued by different states are largely explained by state tax privilege.

We now turn to describing the data that we employ in our empirical analysis.

3. Municipal bond funds

This section describes our data on municipal bond funds, which we use to measure in-state versus out-of-state ownership levels. In subsequent sections of the paper, we combine these data with state- and bond-level information to test key predictions of the model.

Throughout the paper, the sample period runs from 1998 to 2014.[7] Since our analysis is largely at the level of states, we aggregate fund- and bond-level data up to the state-month or state-year level in most of our empirical work.

Our primary data on municipal bond funds are from Morningstar. For each fund, they provide data on total net assets (TNA), inflows and outflows of capital from funds, and returns, all at the monthly frequency. They also provide detailed holdings of fund assets, available with rare exceptions at the semi-annual (at worst) or monthly (at best) frequency depending on the fund and the time period.[8] Over our sample period, these data cover 983 dedicated municipal bond funds, as well as 1,341 mutual funds that hold at least one municipal bond at some point over the period. This cross-section more or less covers the universe of mutual funds holding municipal bonds.

Panel A of Figure 2 shows bars (on the left axis) from the Federal Reserve's Flow of Funds data which signify the size (bonds outstanding) of the tax-exempt longer-term municipal bond market. The market grows from just over \$1 trillion in 1998 to about \$3 trillion in 2014.[9] The figure shows that mutual funds hold between 15% and 23% of these bonds over the period, according to the Federal Reserve. Our calculation, using the Morningstar holdings data at the end of each year and Bloomberg data to identify applicable tax-exempt bonds, produces numbers that are very close to the Federal Reserve numbers, confirming that our data are reliable and representative of aggregate mutual fund ownership of municipal bonds.[10]

[7] Morningstar data cover the period from 1987 to 2014, but bond identifiers such as the bond CUSIP or ISIN, which we need to obtain bond characteristics including the state which issues the bond or the tax-exemption status of the bond, are largely missing in the earlier part of the sample. Therefore, we only use data which begin in 1998.

[8] The reporting frequency appears to improve over time. There are about 1% of fund-report date observations in which the time between consecutive report dates is greater than 6 months. In extremely rare cases where the time between consecutive report dates is greater than one year, we assume that the same fund identifiers are re-used for different funds and do not hold the previously reported positions between the two dates.

[9] These figures include only bonds with maturity at issuance longer than 1 year.

[10] In the last two quarters of 2002, over 20% of bonds in the Morningstar holding data have missing CUSIP.

Morningstar classifies municipal bond funds into three main types: (i) state funds, which are defined as funds that invest almost exclusively in bonds issued by agencies from a single state; (ii) national funds, which are defined as funds that invest in bonds issued by multiple states, and (iii) high-yield funds, which are defined as funds that invest largely in speculative-grade municipal bonds from multiple states. Of the municipal bond funds in our data, 615 are state funds, 318 are national funds, and only 50 are high-yield funds. To concentrate on the specific source of tax-induced segmentation in which we are interested, we simply drop the high-yield funds and focus on state and national funds in the remainder of our analysis. In our empirical tests, we implicitly make the assumption that the relative ownership fractions of state and national funds accurately capture the relative fractions of inside ι and global g investors. We note here that we expect any measurement error in these quantities to act in the usual fashion, biasing inferences towards zero.

Panel B of Figure 2 shows the evolution of aggregate TNA and the number of state and national funds over time. For the first part of the sample, state and national funds hold roughly the same dollar amount (shown on the left axis) of municipal bonds, ranging from just over $100 billion in 1998 to about $160 billion in 2007. In 2008-2009, however, the dollar holdings of state funds as a group appear to stagnate while those of national funds grow significantly after the financial crisis. We discuss reasons for this divergence and explore its implications for our results in more detail in Section 5.4 – indeed, this serves as a useful natural experiment in our tests. The right axis of the plot shows that numbers of state and national funds increase in the early part of the sample, reach their peak in 2003, and steadily decline thereafter. Combined with the increasing TNA held by these funds, this suggests steadily increasing asset holdings for the average fund in the sample.

Table I shows summary statistics of state and national funds. The table summarizes the panel of data in two ways, reporting the cross-sectional average and standard deviation of the time-series mean per fund, as well as the time-series average and standard deviation of the cross-sectional mean across funds in each time period. Columns 1 and 2 (for state funds) and columns 5 and 6 (for national funds) report the cross-sectional average and standard deviation of the time-series mean of each of the fund characteristics listed in the rows, and columns 3

We replace these data using the holdings in the first quarter of 2003.

and 4 (for state funds) and columns 7 and 8 (for national funds) report the time-series average and standard deviation of the cross-sectional means of the same characteristics. Overall, the averages in Columns 3 and 7 are largely similar to those in Columns 1 and 5, suggesting that the representation of sample funds is relatively similar over time. Time-series standard deviations are much smaller than cross-sectional standard deviations for virtually all fund characteristics, suggesting that much of the variation in these characteristics comes from the cross section of funds rather than time-series variation across all funds. In what follows, we therefore concentrate on describing the cross-sectional variation in time-series averages.

The table shows that state funds are, on average, far smaller than national funds both in terms of TNA ($279 million vs. $742 million) and the number of bond holdings (113 vs. 218). State and national funds have similar average monthly returns (0.3%) but cross-sectional variation in average returns across funds is more than twice as large for national funds.

Turning to inflows and outflows, over the sample period state funds experienced a net outflow while national funds experienced a net inflow, consistent with the observed divergence in the aggregate TNA held by these two groups of funds in the latter part of our sample.

In terms of holdings, state funds hold bonds issued by two states, on average, through the sample period, while national funds hold bonds issued by an average of 31 states. Each state represents 79% of the portfolio for state funds but roughly 6% of the portfolio for national funds, on average over the period.[11] Both types of funds invest most of their assets in bonds with maturity longer than 8 years, although the tilt towards longest-term bonds (greater than 15 years) is more pronounced among state funds than among national funds.

We next describe how bond holdings correlate with state-level variation in tax policy.

4. State tax rates and municipal bond holdings

A key benefit of investing in municipal bonds is that income derived from these bonds is generally exempt from federal income tax.[12] In addition, in-state residents can often claim

[11] National funds also seem to hold more cash than state funds, possibly to capture short-term market opportunities across many states, and to accommodate larger variability in fund flows.

[12] A fraction of municipal bonds are issued for purposes that are outside the realm of pure governmental functions, including some not-for-profit organizations and other "private activity" issuers. These municipal bonds are subject to the federal alternative minimum tax (AMT); however, the vast majority of municipal

exemptions from state (and sometimes local) taxation on income from municipal bonds issued by agencies in the same state. For example, consider a resident of New York. The interest income from municipal bonds issued by New York entities[13] is exempt from both federal and New York state income taxes. However, any interest income deriving from municipal bonds issued by, say, New Jersey entities is only exempt from federal income tax, while New York state income tax will still be due.

As we outline in the model this differential taxation creates different incentives for in- and out-of-state residents to hold municipal bonds of particular states. Naturally, these incentives increase with state income tax rates, as well with as the number of bonds issued by a state with such exemptions for in-state residents. The model predicts that high state income tax privileges will be associated with larger fractions of state municipal bonds held by in-state residents. This is also consistent with the work of authors such as Kidwell and Koch (1982), Kidwell and Koch (1983), and Leonard (1998).[14]

We investigate this hypothesis in detail in our sample. We first obtain data on state income tax rates from the Tax Foundation (from 2000 onwards) and the NBER Taxsim Program (prior to 2000). We use bond characteristics reported by Bloomberg to identify tax-exempt bonds issued by each state. We then sort states into terciles on the basis of the (time-series) average of state tax *privilege*, calculated from the highest state income tax rate and the applicable exemption rule for each state. Privilege is the highest state income tax rate applied to income from municipal bonds issued by other states less the highest state income tax rate applied to income from the state-issued municipal bonds.

For each state-month, we calculate the "state fund holding" (or SFH) as the ratio of the total dollar amount of state-issued tax-exempt bonds that are held by state funds, divided by the total dollar amount held by both state and national funds, and explore the relationship of

bonds are non-AMT. They can be held directly or inside a municipal bond mutual fund.

[13] Only the part of the income that does not exceed the issuance yield; see Ang, Bhansali, and Xing (2010).

[14] Note that our use of mutual funds essentially amounts to an implicit assumption that state municipal bond funds in high tax privilege states are primarily held by the residents of the state in question because of tax-benefit pass-through. In support of this assumption, we note that single state municipal bond funds are marketed to local state residents. For example, Vanguard CA Intermediate-Term Tax-Exempt Fund (VCAIX) states the following "...This low-cost municipal bond fund seeks to provide federally tax-exempt and California state tax-exempt income and typically appeals to investors in higher tax brackets who reside in California." Published information about national funds are quite different insofar as they make no mention of state taxes.

this variable to state tax privilege.[15] Additionally, as a proxy of $\frac{S_I}{W^\iota}$, we construct the total amount of the state's outstanding debt divided by the total income of state residents whose adjusted gross income is $200,000 or greater. We term this variable the "debt to high-income ratio".

Table II provides summary statistics of state tax rates, tax privilege, the debt to high-income ratio, and *SFH* for all tax-exempt bonds held by municipal bond funds, grouped by maturity. As predicted, the table shows that states in the top (bottom) privilege tercile have highest (lowest) marginal state income tax rates of 7.95% (3.23%). By construction, the differences in privilege are even more pronounced. Consistent with the hypothesis that tax privileges induce differences in ownership structure, states in the top privilege tercile also have the highest average *SFH* (shown at the bottom of the table) of 50.58%, followed by states in the middle and bottom privilege terciles at 41.88% and 15.44%, respectively. The differences in *SFH* between the top and bottom tax terciles are economically and statistically significant, with the differences being most pronounced for the longest-maturity bonds. We do not observe a clear pattern in debt to high income ratios as tax privilege changes.

The table highlights the importance of focusing on tax privilege as opposed to the "raw" state tax rate. There are some states for which the tax status for bonds issued by the state and those issued by other states are not "exempt" and "taxable," respectively. Such states offer an interesting counterpoint to the rationale for tax-induced segmentation discussed earlier, since they do not privilege in-state holders. For example, for residents in District of Columbia, income from municipal bonds issued by the District of Columbia as well as those of other states are exempt from DC income tax. The lack of a differential tax rate means that the tax-induced segmentation channel should not apply in this case. Despite a sizeable local tax rate, local municipal bond ownership is quite limited due to the fact that there is zero tax privilege present. Illinois and Wisconsin offer similar examples.

Figure 3 shows the relationship between state income tax privileges and state fund holdings for the entire cross section of states at two points in time and for two different bond maturity

[15] We do so using the most recent reported bond holdings for each fund. Since CUSIPs are missing for many bonds in the last two quarters of 2002, we replace the holdings in 2002Q3 by the most recent holdings up to that point and replace the holdings in 2002Q4 by the next reported holdings, mostly in 2003Q1. Furthermore, we include only 21 states for which the representative municipal bond yield curves are available from Bloomberg.

groups. Panel A shows that across all maturities, bonds issued by states with higher tax privilege are disproportionately held by local investors. The correlations between state tax rate and state fund holding are 0.73 and 0.79, respectively, in 2000 and 2014. Panel B confirms the robustness of this positive association at both the 10-year and 20-year maturity buckets.[16] A closer examination shows that the patterns in holdings of state and national funds are quite similar across bonds issued by the same state but vary greatly across states.

Figure 4 shows time-series variation in *SFH*. Panel A presents the average state fund holding for states in each of the three privilege terciles. For all years, the average *SFH* lines up monotonically with the average state tax privilege, i.e., it is highest for the top tax privilege states, and lowest for the bottom tax privilege states. Panel B presents *SFH* for three sample states, namely, New York, which has state tax privileges ranging from 6.85% to 8.97%, and Florida and Texas, which have zero state tax rates. Consistent with the patterns already described, we find that 45-71% of municipal bonds issued by New York entities are held by New York state funds while only about 1-5% of municipal bonds issued by Texas are held by Texas state funds. Florida, in particular, provides an interesting laboratory – while its state tax rate is zero, municipal bonds issued by other states and held by Florida residents were originally subject to an intangible property tax, which was decreased from the rate of 0.15% in 1999 to zero in 2007. The figure shows that during the period when the preferential tax treatment of bonds issued by Florida is gradually phased out, the fraction of Florida-issued bonds held by Florida state funds declines, from 57% in 1998 to less than 5% in 2014 (as the number of Florida state funds decreases from 32 to 2).

The evidence provided in this section highlights sharp differences in municipal bond holding patterns across states, which line up with the differences in tax privilege, namely the combination of state taxation rates and any exemptions offered to in- and out-of-state residents. States with high levels of tax privilege issue municipal bonds that are, on average, financed by local investors, while municipal bonds issued by states with low tax privilege are purchased and are held widely by investors from all over the country.

We now turn to testing key predictions of the model on the effects of tax-induced ownership segmentation on variation in bond yields.

[16] The 10-year (20-year) bucket contains bonds of maturities between 8- and 15-years (greater than 15-years).

5. Testing the Model's Predictions

We evaluate the municipal bond price effects engendered by idiosyncratic risk σ_I^2, which we measure using close local elections, changes in risk aversion δ, which we proxy by shocks to mutual fund flows, and variations in asset supply S_I, which we proxy by municipal bond issuance.

Our empirical approach is to measure the sensitivity of municipal bond yield spreads to variation in these proxies. The model's main prediction is that there will be heightened sensitivity of yields to movements in these variables for states with high levels of tax-induced ownership segmentation, as these are the states which are likely to fall into Region 1. We test for the differential sensitivity by measuring tax-induced ownership segmentation using "fitted" *SFH*, i.e., *SFH* multiplied by state tax privilege, and interacting this variable with the sensitivities. Finally, the model predicts that the sensitivity of prices to yields will also become stronger as $\frac{S_I}{W^\iota}$ becomes larger, and we check for this interaction in our empirical work as well, using our debt to high-income ratio proxy.

As a separate exercise, we study whether the price effects that we detect feed back to the real economy, by measuring whether they impede the ability of local governments to raise funds. We also measure whether particular projects are disproportionately affected by such effects. We measure bond supply variation using state net "new" issuance, but we also consider the effects on the refunding of outstanding municipal bonds.[17] We proxy for the type of projects by splitting municipal issuance into two common types: general obligation (GO) and revenue (REV) bonds.[18]

Table III reports summary statistics by state of the key variables we use in our study. The first two columns show the best and worst representative credit ratings of each state during our sample period. The ratings data are from S&P and are for senior, unsecured GO bonds issued by the state governments. For all but one state, ratings remain AA- or better throughout our

[17] Refunding is a procedure whereby an issuer refinances outstanding bonds by issuing new bonds (perhaps to manage interests costs or remove restrictive covenants). Both current and advanced refunding are included. This refinancing motive stands in contrast to bond issuance for the purposes of raising new money for new investment projects.

[18] A GO municipal bond is backed by the taxation authority and credit of the issuing jurisdiction. In contrast, REV municipal bonds finance income-producing projects, and are secured by a specified revenue source, for example, for a local sports venue. Typically, REV bonds can be issued by any government agency or fund that is run in the manner of a business (e.g., operating revenues and expenses).

sample period. However, California's ratings are A for most of the sample period (even falling to BBB in 2003). The next three columns of Table III report the average bond yield and yield spread (over U.S. Treasuries), as well as the (annualized) 6-month bond return for the 20-year maturity bond. The yield data are from Bloomberg (Fair Value Curves), and the spreads are the differences between municipal bond yields and maturity-matched constant maturity Treasury yields from the Federal Reserve Bank of St. Louis (FRED). The average 20-year municipal bond yields differ modestly across states (4.2%-4.9%), and they are statistically different (at 13 basis points) across states in the top and bottom state tax privilege terciles. Yield spreads are generally negative, due to federal, state, and local income tax exemptions, and also differ modestly across states in the three tax privilege terciles. The average 6-month bond returns are somewhat larger than the bond yields – there is a decreasing trend in bond yields over our sample period. They do not differ materially across states.

In the next four columns of Table III, we show the variation across states along other economic and financial dimensions. On average, states in the top state tax privilege tercile have higher GDP and slightly higher Debt-to-GDP ratios, although the differences are not monotonic across the three terciles and appear to be driven by a few states. Unemployment rates across the groups are similar. Finally, monthly equity returns of firms headquartered in different states differ vastly across states, lowest in the District of Columbia (0.10%) and highest in Tennessee (1.02%), but these numbers do not appear to have any noticeable relationship with state tax privilege. Nevertheless, we control for all these variables as well as other national time-varying market conditions to absorb the effects that any of these differences may have on municipal bond prices and issuance.

Table III then reports three measures of municipal bond issuance: average net annual issuance, and average gross issuance of GO and REV bonds. Gross issuance is measured as a fraction of total debt outstanding, where we compute the numerator by simply summing all individual bonds issued in each period as reported by SDC Platinum. Net issuance is gross issuance less refunding which accounts for about half of the total issuance amount (not reported). The average net issuance to outstanding debt ratio does not vary much across states, ranging from 4.89% in Massachusetts to 9.75% in the District of Columbia. At a more disaggregated level, gross issuance is about equally split between GO and REV bonds, both with cross-state ranges from about 1.77% to 15.60%. There does not appear to be a significant difference in GO or REV issuance across tax privilege terciles, on average. We later explore whether demand shocks for state-issued bonds affect the gross issuance of GO and REV bonds differentially across levels of tax privilege and in-state ownership.

The final column reports the total number of close gubernatorial elections, defined as those in which the difference in the percentage vote between the eventual winner and loser is less than 5%. The literature (see, for example, Gao and Qi (2013)) assumes that since in such elections the outcome is hard to predict *ex-ante* (Lee (2008)), it is possible to associate the periods immediately preceding such elections as periods of heightened political risk. In our empirical tests, we view these as periods of elevated idiosyncratic risk σ_I^2.[19] The total numbers of close elections are 10, 10, and 9 for states in the top, middle, and bottom tax privilege terciles, respectively. These evenly distributed events allow us to identify whether their effects on municipal bond yields vary across states with different degrees of market segmentation.

5.1. Pricing of local political risk

Our model predicts that periods of elevated idiosyncratic risk, σ_I^2, should be associated with larger price effects in states with higher levels of tax privilege. Table IV shows panel regressions of the state-level 20-year municipal bond yield spread (over treasuries) on an indicator variable that takes a value of one in the months between state fiscal year end and a close gubernatorial election and zero otherwise.[20]

Column (1) of the table includes only an indicator for states with high state fund holdings of outstanding debt (on its own, and not yet instrumented using the tax privilege), the close election dummy, and a set of fixed effects. The negative and significant coefficient on the high state fund holding indicator shows that bond yields are lower in states disproportionately held by in-state investors. Our specifications include state fixed effects so this negative association between yield spreads and local ownership is not a time-invariant effect specific to particular states (meaning that it is not direct tax effect, as state tax privilege exhibits barely any time-

[19] See Pastor and Veronesi (2012) and Pastor and Veronesi (2013) for relevant theoretical arguments.

[20] For our main analyses, we focus on a relatively long-maturity bond yield since mutual fund holding differences are most pronounced there (see Table II); however, in subsequent analyses, we explore the implications of some important differences in fund holdings across the yield curve.

variation over our sample period). Rather, it shows when local ownership of a state's bonds is relatively high, states tend to have relatively lower yields, as in equilibrium in Region 1 in the model. Moreover, column (1) also shows that periods prior to close elections are associated with municipal bond spreads that are roughly 9 basis points on average higher, consistent with Gao and Qi (2013).

Columns (2) and (3) simply interact periods of elevated idiosyncratic risk (prior to close elections) with the high *SFH* dummy. Column (3) expands the specification in column (2) by adding a number of control variables which vary across both states and time. These control variables generally have the expected signs but are mixed in significance. State equity returns come in with a negative coefficient, indicating that spreads are lower when companies in the state are doing well. In addition, spreads are elevated when the state is more indebted, as measured by the state debt-to-GDP ratio, and spreads are higher when the state suffers high unemployment. The main result, however is that the yield sensitivity to our measure of idiosyncratic risk is substantially larger in states with high state fund ownership. This is consistent with our model, but we require an additional step, which we take in column (4). We interact the high *SFH* dummy with a dummy which takes the value of 1 for states with above-median tax privilege. This new composite indicator variable which "fits" high *SFH* with high tax privilege comes in with the expected positive sign, and is significant (at the 10% level), with a magnitude of 12 basis points.

Finally, our model predicts that the effect of tax-induced ownership segmentation should be more pronounced when the ratio of asset supply to local wealth, S_I/W^ι, is large. Column (5) therefore additionally interacts the composite indicator in column (4) with this variable. Consistent with the predictions of the model, the results show that local political risk is associated with elevated prices only in those states with high tax-induced ownership segmentation and a large ratio of asset supply to local wealth. In the remainder of the exposition, we mainly focus on discussing the results from columns (4) and (5), as the tables largely have the same structure, but provide columns (1), (2), and (3) in the tables for the interested reader.

5.2. Price effects of movements in demand

We now turn to empirically identifying the effects of movements in risk aversion δ on municipal bond yields. The model predicts that movements in local investor risk aversion should have a larger price impact in states with high tax-induced ownership segmentation. To identify such movements in risk aversion, we look for a source of information-free shocks to demand, and rely on a now vast literature on "fire sales" that begins with Shleifer and Vishny (1992). Coval and Stafford (2007) and Jotikasthira, Lundblad, and Ramadorai (2012), in particular, document sizable price effects around equity market fire sales as mutual funds experiencing extremely large inflows (outflows) tend to significantly expand (decrease) existing positions. We identify such positive (negative) demand shocks as decreases (increases) in effective risk-aversion δ.

To measure flow-induced fire sales and purchases in the municipal bond market, we adapt the *PRESSURE1* measure used in Coval and Stafford (2007). We identify flow-induced municipal bond sales (purchases) as reductions (increases) in bond positions by municipal bond funds experiencing severe outflows (inflows). We define unusual levels of flows as those below the 10th percentile ($LoFlow_{i,t} = flow_{i,t} < percentile(10)$), or above the 90th percentile ($HiFlow_{i,t} = flow_{i,t} > percentile(90)$) of mutual fund redemptions/subscriptions across all fund-months. For each state (s)-maturity group (m)-month (t), we calculate pressure from all funds i's as

$$Pressure_{s,m,t} = \frac{\sum_i \left(\max\left(0, \Delta H_{i,s,m,t}\right) | HiFlow_{i,t}\right) - \sum_i \left(\max\left(0, -\Delta H_{i,s,m,t}\right) | LoFlow_{i,t}\right)}{Outstanding\ Debt}$$

where $\Delta H_{i,s,m,t}$ is the change in fund i's holding of all bonds in maturity group m and issued by state s from time $t-1$ to t,[21] $flow_{i,t}$ is the percentage flow to fund i in period t. Unlike Coval and Stafford (2007), we replace the average volume in the denominator by outstanding municipal debt at the previous year-end.

Table V shows univariate averages of 20-year municipal bond yield spreads (third column) and returns (fourth column) across state months sorted into quintiles on the basis of *Pressure* for bonds with maturities greater than 15 years. Only state-months with non-zero values of *Pressure* are included. The table shows these effects estimated separately for states with above

[21] Ihe the case where the change in holdings can only be determined over a period greater than one month, we allocate the net change across months on the basis of flows.

(top panel) and below (bottom panel) median *SFH*.

Several key results are evident in Table V. First, flow-induced pressure on municipal bond funds is sizeable in the extremes, and similar for low and high *SFH* states. The first column of each panel shows the quintile average of the pressure variable upon which the sorting is based. For high *SFH* states, *Pressure* ranges from an inflow of 3.2% of TNA (Q1) to an average outflow of 3.0% (Q5), and from a 2.3% inflow (Q1) to a 2.7% outflow (Q5) for low *SFH* states.

Despite the fact that the range of flow-induced pressure is similar, the table shows two important differences between high and low *SFH* states. First, the difference in the yield spread (over treasuries) between periods with fire sales and extreme purchases is about 0.43%, on average for the high *SFH* states. Second, these differences subsequently reverse, resulting in municipal bond returns that are 7.10% (in annualized terms) higher following fire sales than following extreme purchases.[22] The price effects are also significant for fire sales and extreme purchases in low *SFH* states (dominated disproportionately by national funds), but the differences are not nearly as pronounced for these states as for the high *SFH* states. The bottom of the table shows that the price effects of flow shocks are significantly larger (at the 10% level) for municipal bonds issued by high *SFH* states than those issued by low *SFH* states, consistent with the model's predictions.

We note that the supposedly exogenous variation captured by fire sales and extreme purchases, particularly from state funds, could be questioned since local bond yield movements and flows from local investors may be driven by common economic conditions in the state. In Table VI, we address this concern by conducting state-month panel regressions of the 20-year municipal bond spreads on indicators for *Pressure*, alongside controls for a variety of macroeconomic and financial conditions that might directly affect bond spreads. As in Table IV, we include credit rating, state, year, and month fixed effects and, where indicated, the same controls for a variety of macroeconomic and financial conditions. We cluster standard errors by calendar month.

As described in the previous section, column (4) shows results from interacting the *Pressure* measure with a composite indicator variable that interacts the high *SFH* dummy with an

[22]Note that this magnitude is consistent with the modified duration of 20-year bonds of about 15 years (15 x 0.43% = 6.45%).

indicator variable for high tax privilege, to capture tax-induced ownership segmentation. As predicted, the coefficient of the interaction between this composite indicator and the (fire sale) pressure Q5 dummy is positive and significant, and is negative, but not precisely estimated, for extreme purchases (Q1). On balance, *Pressure* emanating from municipal bond funds (particularly selling pressure induced by fund outflows) is associated with larger municipal bond price impacts in states with high tax-induced ownership segmentation, even after controlling for other state and national conditions. Finally, our model predicts that this demand (risk aversion) effect should be more pronounced in states for which the ratio of available asset supply to local wealth, S_I/W^ι, is largest. In column (5), we explore this prediction and find strong support for it.

5.3. Price effects of supply variation

We next explore the price effects of changes in net bond supply, S_I. Table VII presents evidence on panel regressions of the 20-year municipal bond spreads on net municipal bond issuance (scaled by debt outstanding). As before, we include credit rating, state, year, and month fixed effects and, where indicated, the same controls for a variety of macroeconomic and financial conditions, and cluster standard errors by calendar month.

Before turning to column (4), it is worth noting that column (1) shows that increases in supply increase bond yields, consistent with Greenwood and Vayanos (2010), Greenwood and Vayanos (2014), and Krishnamurthy and Vissing-Jorgensen (2012), but the effect is not statistically significant when all states are collectively considered. Turning to column (4), when we interact movements in bond supply with the composite indicator variable that captures tax-induced ownership segmentation, we find that this coefficient is estimated to be positive and highly significant (at the 1% level).[23] These effects, while precisely estimated, are relatively small in magnitude – a one standard deviation increase in the net issuance ratio (0.06) only increases yields by roughly 3 basis points. Finally, column (5) shows that this issuance effect is significantly more pronounced in states for which the ratio of available asset supply to local

[23] States held more broadly by national funds can be partial substitutes, indirectly absorbing supply shocks between each other. This line of thinking is broadly consistent with the gap-filling theory of Greenwood, Hanson, and Stein (2010), whereby corporate issuers act as liquidity providers absorbing supply shocks associated with changes in the maturity structure of government debt.

wealth, S_I/W^ι, is largest, consistent with the model.

Taken together, we find that municipal bond demand and supply variation have significant impacts on local prices, but that these effects are relatively more pronounced in the states where higher levels of tax privilege act to segment the market and limit risk-sharing.

5.4. Mutual fund holdings around the financial crisis

In Figure 2 (Panel B), we observed a sharp increase in the total assets under management for national funds after the financial crisis. Prior to that moment, the total assets under management across state and national funds closely track one another. We explore this divergence more carefully in this subsection.

Our model predicts that price elasticities should decrease as the assets are more widely held by diversified (national) investors. To the extent that the relative holdings of in-state and national investors shift significantly after the crisis, this episode offers potentially important variation that we may be able to use to test our model further.

To examine the curious acceleration of national funds' TNA, we provide finer resolution on the evolution of TNA at short vs. long maturities in Figure 5. Specifically, Panel A (B) plots TNA of short-term (long-term) municipal bond funds. The short and long term classifications are determined by Morningstar, corresponding to an average maturity across the two groups of funds of about 1-4 and 16-20 years, respectively. This level of disaggregation shows that the sizeable increase in national funds' assets under management is largely attributable to short-term funds.

This suggests that the increase in funds allocated to short-term munis largely reflects a quasi-exogenous reallocation from traditional tax-exempt and possibly taxable money market funds to munis around and after the crisis. For example, according to the Flows of Fund reports, the amount of municipal debt held by tax-exempt money market funds declines from about \$500 billion at the end of 2007 to about \$280 billion at the end of 2014, a decrease that is of similar magnitude to the increase in TNA of national municipal bond funds. At the monthly frequency, the reallocation lines up well with the widening yield spreads between commercial paper and insured bank deposits that drives the reaching-for-yield behavior among taxable money market funds described by Kacperczyk and Schnabl (2013). That is, the desire to increase yields appears to drive investors to go down the credit quality spectrum. The extended period of almost zero interest rates, the collapse of money market funds, and the significant downgrades of most monoline bond insurers, who insure variable-rate notes and short-term municipal obligations, further fuel this reallocation.

We use this quasi-exogenous increase in national fund holdings for short-maturity bonds to test the predictions of our model further. The model predicts that the price effects associated with concentrated ownership that we detect above should be significantly smaller for short-term bond yields following the financial crisis as money pours into national municipal bond funds following the collapse of the money market. However, since state funds remain an important clientele for long-term bonds, the model predicts that this attenuation should be restricted to short-maturity munis, but not much affect sensitivities for longer maturity munis.

We examine this prediction in Table VIII. Specifically, we examine our three main regressions (yield spreads regressed on periods prior to close elections, on demand variation, and on variation in supply) for 5- and 20-year bond yields, separately. In each regression, we introduce an indicator variable that takes the value of one in all periods up to the end of 2007 and zero otherwise. We drop observations in 2008-2009 to avoid the transition period. As before, we include a host of fixed effects and control variables in each case.

Columns (1) and (4) present evidence on the price effects associated with elevated periods of idiosyncratic risks (close elections) for the short-term and long-term bonds, respectively. Our variable of interest is the four-way interaction between the close election indicator, the high *SFH* indicator, the high tax privilege indicator, and the pre-crisis dummy. Consistent with our hypothesis, we find that for short-term bonds, the heightened sensitivity of short-term municipal bond yields to local political risk for states with high tax-induced ownership segmentation are present in the pre-crisis period, but not in the post-crisis period. In contrast, these effects continue to be significant and show no real variation across the pre- and post-crisis periods for long-term municipal bonds.

Next, columns (2) and (5) present evidence on the same experiment conducted on the price effects associated with demand variation for short-term and long-term bonds, respectively. Consistent with the model's predictions, the differential price effects of demand movements in states with high tax-induced local ownership become insignificant after the crisis at short maturities but remain significant at long maturities. Finally, columns (3) and (6) present evidence on the price effects associated with supply (issuance) variation. Again, we find that the differential price effects engendered by supply movements largely disappear after the crisis for short-term bonds but remain significant throughout for long-term bonds.

In sum, the differential effects of local risk, supply and demand movements almost disappear for 5-year bonds, but remain the same for 20-year bonds after 2009. Taken together, we conclude that an exogenous reduction in concentrated ownership for short-term municipal bonds generates price effects exactly as predicted by our model.[24]

5.5. Fund raising in the face of demand shocks

We now turn to checking whether the financial frictions we identify in the model have real effects. We explore this using the distinction between GO and REV bonds. REV bonds are generally backed by cash flows which are hypothecated from specific projects, while GO bonds can be repaid through a variety of tax sources. Local investors are already highly exposed to local shocks as a result of their concentrated ownership of local municipal bonds, and REV bonds may well increase their local exposure disproportionately relative to GO bonds, given that their cashflows are even more "local". Our analysis contrasts the effects of demand shocks on the issuance of these two types of bonds in the presence of tax-induced segmentation of the ownership base.

Table IX presents evidence on panel regressions of issuance of GO (in Panel A) and REV bonds (in Panel B) across states on an above-median *SFH* dummy, Q1 and Q5 dummies on *Pressure*, and interactions of these variables. In each panel, columns (1)-(3) focus on net new issuance, whereas columns (4)-(6) focus on refunding. Panel A shows that GO net new issuance is largely unaffected by buying or selling *Pressure*, regardless of whether the state is above median in state fund holdings and tax privilege. This may partly be because net new issuance of GO bonds needs to be approved by both the state legislature and voters, making

[24] We also explore the effects of demand and supply movements on yield spreads of municipal bonds issued by Florida. Before 2007, Florida imposes intangible property tax on financial assets but exempt it for state-issued municipal bonds. In Figure 3, we show that state fund holding decreases from about 60% in 2000 to less than 5% in 2014. Consistent with the decrease in *SFH*, we find that the price effects of demand and supply, which used to be stronger for Florida than for other zero-tax states, become relatively muted after 2007.

such issuance relatively invariant to local market conditions. In contrast, columns (4)-(6) show that in periods with extremely negative *Pressure* (fire sales), states tend to issue significantly fewer GO bonds for refunding purposes. This is suggestive of market timing, particularly for states with above-median *SFH* and tax privilege.

In Panel B, columns (1)-(3) show that REV net new issuance (new money) *is* affected by flow-induced transaction pressure. However, the effect is isolated to periods with extreme positive *Pressure (*flow-driven purchases), especially in states with above-median *SFH* and tax privilege. Second, columns (4)-(6) show that states' issuance of REV bonds for refunding purposes is, like GO bonds, significantly affected by both positive and negative *Pressure*. As with GO refunding, demand shocks do seem to significantly affect issuance in REV bonds for both new projects and refunding, particularly in the states with concentrated ownership where the price effects are most pronounced.

With the exception of GO bond net issuance, the issuance effects of demand shocks are economically significant, and largest for REV bond refunding, followed by REV bond net new issuance, and smallest for GO bond refunding. For example, the estimates in column (9) of Panel B show that in states with low *SFH*, REV refunding increases by about 0.9% (annualized) of debt outstanding during periods of strong demand (Q1). Such effects increase to 3.2% (0.9% + 2.3%) in states with high *SFH*, quite substantial given that the average amount of issuance for refunding is about 7% per year.

6. Conclusion

We demonstrate using a simple model that differentials in tax rates can cause ownership segmentation of assets if the tax wedge is high enough. The key insight is that this tax policy-induced segmentation can create regions of the aggregate demand curve for the asset that are "downward-sloping," meaning that the constraints of the clientele induced to hold the asset can play a part in the resilience (or lack thereof) of asset prices to movements in supply, demand, and idiosyncratic risk.

We test and find strong support for the model's predictions in the U.S. municipal bond market. The empirical results suggest that a high level of domestic ownership of government debt induced by tax policy, may not be an unadulterated good. We find that in states with tax incentives for domestic holdings, municipal bonds are more sensitive to variations in demand, supply, and political risk. We also find that such states face greater difficulties raising finance to support capital investments.

In future research, it would be interesting to explore the effects of these financial frictions on real economic outcomes. We conduct a very preliminary analysis along these lines in this paper, exploring the variation in bond issuance under different demand conditions. Our work leads us to believe that reductions or increases in the cost of government borrowing can impact the provision of government services, and in turn, subsequent tax policy. If municipal bond holding patterns alter the terms under which local governments access capital, presumably this is in turn associated with significant degrees of variation in economic activity (such as local economic growth and employment). Put differently, our work shows that tax policy creates incentives for local investors to effectively segment the municipal bond market, and leads to price distortions. The intriguing question is whether these effects in turn generate unanticipated consequences for economic growth.

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Table I

Fund-Level Summary Statistics

This table presents summary statistics of state and national municipal bond funds. The data, including fund classifications, are from Morningstar. The sample period is from 1998 to 2014, and the observation frequencies are fund-month for total net assets (TNA), flow, and return, and fund-month or coarser, depending on each fund's reporting frequencies, for other variables. High-yield funds, representing approximately 5-10% of TNA, are excluded. Number of holdings is the number of unique bond CUSIPs held by each fund on each report date. Flows and returns are measured as a percentage of prior-month TNA, and cash holdings, average and maximum assets in a state, and assets in bonds in different maturity buckets and in general obligations vs. revenue bonds are measured as a percentage of current-month TNA. Number of states does not count U.S. territories (Puerto Rico and Guam). Average bond maturity is the value-weighted average maturity. Tests of difference in mean between state and national funds are conducted using pooled panel regressions with standard errors clustered by calendar year-month. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

	State Funds (N = 615)				National Funds (N = 318)				
	Cross-Sectional Statistics of Time-Series Mean		Time-Series Statistics of Cross-Sectional Mean		Cross-Sectional Statistics of Time-Series Mean		Time-Series Statistics of Cross-Sectional Mean		Pooled Difference (State – National)
	(1) Mean	(2) Std. Dev.	(3) Mean	(4) Std. Dev.	(5) Mean	(6) Std. Dev.	(7) Mean	(8) Std. Dev.	
TNA ($ million)	279	771	345	83	742	1,602	1,018	450	-650.805***
Number of holdings	112.75	105.96	119.91	22.71	218.28	223.14	239.84	87.72	-126.377***
Flow (%)	-0.66	2.38	-0.62	2.12	0.68	4.47	0.21	2.79	-0.718***
Return (%)	0.35	0.07	0.36	0.61	0.31	0.17	0.33	0.51	0.025*
Cash holding (%)	2.12	3.03	1.91	0.70	4.78	6.33	4.19	1.64	-2.409***
Number of states held	2.25	2.49	2.46	0.76	30.60	10.16	31.92	3.02	-29.706***
Average assets in a state (%)	79.37	28.48	78.69	5.62	6.09	13.72	5.78	1.95	72.816***
Maximum assets in a state (%)	87.35	9.52	87.57	3.02	16.86	13.54	16.34	1.19	71.247***
Average bond maturity (years)	15.36	4.64	15.55	0.99	12.91	4.58	13.35	0.90	2.250***
Assets in 1-7 year bonds (%)	15.05	16.03	14.59	3.54	26.15	20.97	24.89	5.27	-10.704***
Assets in 8-15 year bonds (%)	31.61	14.22	31.22	3.17	32.16	17.19	31.91	2.91	-0.581**
Assets in >15 year bonds (%)	42.56	23.60	43.74	4.55	31.67	21.99	33.84	3.68	9.953***
Assets in general obligations bonds (%)	19.71	12.89	18.93	1.71	22.88	12.47	22.07	1.89	-3.195***
Assets in revenue bonds (%)	69.34	13.63	70.43	3.05	66.91	14.56	68.36	2.98	1.872***

Table II

State-Level Summary Statistics on Tax Rate and State Fund Holding

This table presents summary statistics on state tax rate, privilege, and fraction of municipal bonds held by state municipal bond funds. Only 21 states, for which the Bloomberg yield curve data are available, are included. States are sorted into terciles by the (time-series) average of state tax privilege, calculated from the highest state income tax rate and the applicable exemption rule. Highest state income tax rates are from Tax Foundation (2000-2014) and NBER Taxsim program (1998-1999). Privilege is the highest state income tax rate applied to income from municipal bonds issued by other states minus the highest state income tax rate applied to income from the state-issued municipal bonds. Debt to high income ratio is the total amount of state's outstanding debt divided by total income of state residents whose adjusted gross income, as reported to Internal Revenue Service, is $200,000 or greater. For each state-month, state fund holding (SFH) is the amount of state-issued municipal bonds held by state municipal bond funds, presented as a percentage of the amount of state-issued municipal bonds held by all municipal bond funds. For each state, the mean, minimum, and maximum statistics are calculated across all available months. Tests of difference in mean between the top and bottom privilege terciles are conducted using standard errors clustered by calendar year-month. $*$, $**$, and $***$ refer to statistical significance at 10%, 5%, and 1% levels.

State	Number of State-months	Tax Status of Bonds Issued by: State	Tax Status of Bonds Issued by: Other States	State Tax (%)	Privilege (%)	Debt/ High Inc. (%)	State Fund Holding (%): All	State Fund Holding (%): 0-7 Year	State Fund Holding (%): 8-15 Year	State Fund Holding (%): 15+ Year
Top Privilege Tercile (States with Highest Average State Tax Privilege)										
CA	204	Exempt	Taxable	10.21	10.21	88.51	72.15	60.84	69.47	75.47
NJ	204	Exempt	Taxable	8.16	8.16	72.62	45.99	29.76	43.34	56.99
MN	204	Exempt	Taxable	7.99	7.99	107.85	61.31	41.29	68.27	66.33
NC	204	Exempt	Taxable	7.83	7.83	103.44	40.26	22.79	39.68	52.89
NY	204	Exempt	Taxable	7.72	7.72	109.67	61.75	39.17	56.03	71.84
SC	204	Exempt	Taxable	7.00	7.00	181.21	23.60	24.09	29.10	21.26
OH	204	Exempt	Taxable	6.72	6.72	122.49	49.01	29.53	50.30	55.83
Average				7.95	7.95	112.26	50.58	35.35	50.88	57.23

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Table II -*continued*

State	Number of State-months	Tax Status of Bonds Issued by: State	Tax Status of Bonds Issued by: Other States	State Tax (%)	Privilege (%)	Debt/ High Inc. (%)	State Fund Holding (%): All	0-7 Year	8-15 Year	15+ Year
Middle Privilege Tercile										
GA	204	Exempt	Taxable	6.00	6.00	84.80	20.27	12.56	19.29	25.63
TN	130	Exempt	Taxable	6.00	6.00	99.39	22.62	6.86	25.74	36.15
VA	204	Exempt	Taxable	5.75	5.75	82.03	56.59	35.21	61.07	63.27
MA	204	Exempt	Taxable	5.47	5.47	101.08	44.94	30.81	47.34	49.37
CT	204	Exempt	Taxable	5.39	5.39	56.43	49.91	26.38	55.82	62.57
MD	204	Exempt	Taxable	5.28	5.28	73.92	62.35	49.10	69.41	66.70
MI	204	Exempt	Taxable	4.21	4.21	139.54	36.49	22.68	35.85	42.46
Average				5.44	5.44	91.03	41.88	26.23	44.93	49.45
Bottom Privilege Tercile (States with Lowest Average State Tax Privilege)										
PA	204	Exempt	Taxable	2.97	2.97	137.87	55.35	31.83	57.89	63.49
DC	204	Exempt	Exempt	9.04	0.00	94.73	9.24	2.95	9.07	12.39
IL	204	Varies	Taxable	3.47	0.00	103.02	0.61	0.44	0.64	0.71
WI	204	Varies	Taxable	7.10	0.00	131.82	4.26	1.42	4.87	5.92
FL	204	Exempt	Taxable	0.00	0.00	85.11	35.83	24.16	33.99	42.06
TX	204	Exempt	Taxable	0.00	0.00	102.09	2.10	2.81	2.26	1.80
WA	204	Exempt	Taxable	0.00	0.00	119.81	0.69	0.47	0.81	1.02
Average				3.23	0.42	110.64	15.44	9.15	15.65	18.20
Top - Bottom				4.72***	7.52***	1.62*	35.14***	26.20***	35.24***	39.03***

Table III

State-Level Summary Statistics on Bond Yields and Other Macro Variables

This table presents summary statistics on municipal bond yields and other relevant state-level macroeconomic variables. Only 21 states, for which the Bloomberg yield curve data are available, are included. States are sorted into terciles by the (time-series) average of state tax privilege, calculated from the highest state income tax rate and the applicable exemption rule. Credit ratings are from S&P. Municipal bond yields are from Bloomberg's fair value curve, estimated to fit general obligations bonds' transaction prices from the Municipal Securities Rulemaking Board (MSRB). Spread is the difference between bond yield and constant maturity Treasury yields from FRED. Return is annualized 6-month return, calculated by revaluing the bond using the prevailing yield curve six months from the current date and adding the coupon income. Equity return is monthly return on value-weighted portfolio of firms headquartered in each state. Yields, spreads, returns, and equity returns are reported as averages of monthly data. State GDP ($ billion) and unemployment rates are from Bureau of Labor Statistics. State outstanding debt data are from Census Bureau. Net issuance and gross issuance of general obligation (GO) and revenue (RV) bonds are calculated as annualized monthly sums of individual bond issuance from SDC Platinum. All macroeconomic variables, except issuance, are reported as averages of annual data. For each state, number of close elections is the number of gubernatorial elections during the period from 1998 to 2014, in which the vote difference between the winner and loser is 5% or less. The election data are from Wikipedia. Tests of difference in mean between the top and bottom privilege terciles are conducted using standard errors clustered by calendar year or calendar year-month, depending on observation frequency. ∗, ∗∗, and ∗∗∗ refer to statistical significance at 10%, 5%, and 1% levels.

	Credit Rating		20-Yr	20-Yr	20-Yr		Debt/	Unemp.	Equity	Net Iss./	GO Iss./	REV Iss./	No. of
State	Worst	Best	Yield (%)	Spread (%)	Return (%)	GDP ($ Bil.)	GDP (%)	Rate (%)	Return (%)	Debt (%)	Debt (%)	Debt (%)	Close Elec.
Top Privilege Tercile (States with Highest Average State Tax Privilege)													
CA	BBB	AA-	4.90	0.29	6.70	1,762	16.57	7.24	1.01	7.15	6.06	7.87	2
NJ	AA-	AA+	4.57	-0.04	6.41	446	16.47	5.79	0.68	6.67	6.52	8.41	0
MN	AAA	AAA	4.48	-0.12	6.94	244	15.24	4.65	0.88	7.57	8.87	5.67	4
NC	AAA	AAA	4.45	-0.15	6.90	367	11.35	6.31	0.68	7.68	4.74	6.29	1
NY	AA	AA	4.61	0.00	7.00	1,054	23.08	6.06	0.64	5.66	5.11	8.17	1
SC	AA+	AAA	4.51	-0.10	6.59	148	19.84	6.91	0.49	7.31	4.81	7.92	1
OH	AA+	AA+	4.65	0.04	6.91	467	12.81	6.10	0.64	6.74	7.88	6.71	1
Average			4.60	-0.01	6.78	641	16.48	6.15	0.71	6.97	6.28	7.29	

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Table III -*continued*

State	Credit Rating Worst	Credit Rating Best	20-Yr Yield (%)	20-Yr Spread (%)	20-Yr Return (%)	GDP ($ Bil.)	Debt/ GDP (%)	Unemp. Rate (%)	Equity Return (%)	Net Iss./ Debt (%)	GO Iss./ Debt (%)	REV Iss./ Debt (%)	No. of Close Elec.
Middle Privilege Tercile													
GA	AAA	AAA	4.51	-0.10	6.78	376	11.01	6.13	0.79	8.47	5.25	8.06	1
TN	AA	AA+	4.22	0.21	6.94	257	12.85	6.91	1.02	5.74	4.94	5.45	1
VA	AAA	AAA	4.44	-0.17	6.90	361	13.00	4.19	0.51	7.69	4.56	7.29	0
MA	AA-	AA	4.59	-0.02	6.98	355	21.63	5.14	0.76	4.89	6.97	5.89	3
CT	AA	AA	4.55	-0.06	6.80	207	15.62	5.03	0.94	6.89	8.71	4.60	1
MD	AAA	AAA	4.44	-0.16	6.87	267	12.55	4.76	0.80	6.99	7.26	6.13	2
MI	AA-	AAA	4.77	0.16	6.99	384	16.49	7.12	0.57	5.60	4.81	5.13	2
Average			4.50	-0.02	6.90	315	14.74	5.61	0.77	6.61	6.07	6.08	
Bottom Privilege Tercile (States with Lowest Average State Tax Privilege)													
PA	AA	AA	4.74	0.13	6.47	518	19.48	5.46	0.73	5.50	5.61	5.16	0
DC	AAA	AAA	4.82	0.18	6.00	87	9.09	7.15	0.10	9.75	4.74	15.60	
IL	AA-	AA	4.85	0.24	6.04	599	17.66	6.57	0.74	6.46	6.00	4.54	2
WI	AA-	AA	4.65	0.05	6.78	229	15.38	5.20	0.88	6.38	8.80	4.76	3
FL	AA+	AAA	4.68	0.07	6.83	662	17.69	5.84	0.81	6.71	1.77	10.34	2
TX	AA	AA+	4.67	0.07	6.93	1,082	15.40	5.42	0.67	8.54	8.56	6.69	0
WA	AA	AA+	4.64	0.05	6.70	313	18.00	6.65	1.00	7.21	7.14	5.83	2
Average			4.72	0.11	6.54	499	16.10	6.15	0.71	7.22	6.09	7.56	
Top - Bottom			-0.13***	-0.12***	0.24	143***	0.38***	0.11	0.01	-0.25	0.19	-0.27	

Table IV

Pricing of Local Political Risk

This table reports results from panel regressions of municipal bond yield spreads on close election dummy and its interaction with high SFH dummy. Yield spread is the difference between municipal bond yield from Bloomberg and constant maturity Treasury yield from FRED at the 20-year maturity. Close election dummy equals one for the months between state fiscal year end and a gubernatorial election, in which the vote difference between the winner and loser is 5% or less. High privilege dummy indicates states whose state income tax privilege is above the (cross-sectional) median. High debt/high income dummy indicates states whose ratio of outstanding debt to total income of state residents with adjusted gross income of $200,000 or greater is above the (cross-sectional) median. Term spread is the difference between 10-year and 2-year constant maturity Treasury yields. Market equity return is CRSP value-weighted return, including dividends. All state-level control variables are defined in Tables II and III. All models include credit rating, state, calendar year, and calendar month dummies. Standard errors, clustered by calendar year-month, are reported in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

	(1)	(2)	(3)	(4)	(5)
Main Variables					
[A] = High SFH	-0.085***	-0.086***	-0.079***		
	(0.011)	(0.011)	(0.011)		
[B] = [A] x High privilege				-0.073***	-0.076***
				(0.009)	(0.012)
Close election	0.090**	0.062	0.040	0.034	0.031
	(0.040)	(0.039)	(0.042)	(0.042)	(0.063)
[A] x Close election		0.083***	0.092**		
		(0.031)	(0.039)		
[B] x Close election				0.124*	0.028
				(0.065)	(0.068)
High debt/hi. inc. x Close election					0.013
					(0.071)
[B] x High debt/hi. inc. x Close election					0.196*
					(0.106)
Control Variables					
State net issuance/Debt			0.155	0.162	0.160
			(0.132)	(0.131)	(0.132)
State tax privilege			-0.022***	-0.018***	-0.021***
			(0.005)	(0.006)	(0.006)
Debt/High income			0.013	0.018	0.031
			(0.023)	(0.023)	(0.023)
Term spread			-0.106	-0.106	-0.107
			(0.076)	(0.076)	(0.076)
Market equity return			-0.235	-0.237	-0.235
			(0.485)	(0.485)	(0.485)
State equity return			-0.387**	-0.385**	-0.388**
			(0.174)	(0.175)	(0.175)

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Table IV -*continued*

	(1)	(2)	(3)	(4)	(5)
State debt/GDP			2.956***	3.122***	3.210***
			(0.242)	(0.294)	(0.258)
State unemployment rate			0.012***	0.010**	0.012***
			(0.003)	(0.004)	(0.003)
Credit rating dummies	YES	YES	YES	YES	YES
State dummies	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES
Observations	3,752	3,752	3,752	3,752	3,752
R-squared (total)	0.806	0.806	0.806	0.806	0.806

Table V

Price Effects of Fire Sales and Purchases – Univariate Analysis

This table presents univariate averages of municipal bond yield spreads and returns across state-months sorted into quintiles by trading pressure. For each state-month, pressure is calculated using the same formula as Pressure 1 of Coval and Stafford (2007) but replacing the average volume in the denominator by outstanding debt at the previous year-end. SFH is the amount of state-issued municipal bonds held by state municipal bond funds at the previous month-end, presented as a percentage of the amount of state-issued municipal bonds held by all municipal bond funds. Both yield spreads and returns are at the 20-year maturity. Yield spread is the difference between municipal bond yield from and constant maturity Treasury yield. Returns are annualized 6-month returns, calculated by revaluing each bond using the prevailing yield curve six months from the current month-end and adding the coupon income. Only state-months with non-zero pressures are included. Averages of all state-months in each quintile are reported separately for states with SFH above and below the (cross-sectional) median. Tests of difference in mean between quintiles 1 and 5 and difference in differences are conducted using standard errors clustered by calendar year-month. $*$, $**$, and $***$ refer to statistical significance at 10%, 5%, and 1% levels.

Pressure Quintile	Pressure (%)	SFH (%)	Spread (%)	Return (%)
States with above-median SFH				
1 (Positive)	3.22	57.95	-0.07	3.53
2	0.49	62.86	0.05	4.58
3	0.04	64.28	0.14	5.40
4	-0.39	64.45	0.23	6.25
5 (Negative)	-3.03	58.30	0.37	10.64
1 - 5			-0.43***	-7.10***
States with below-median SFH				
1 (Positive)	2.28	19.17	0.05	4.48
2	0.52	19.32	0.11	4.83
3	0.05	21.01	0.13	4.99
4	-0.39	23.60	0.23	6.11
5 (Negative)	-2.65	22.44	0.33	9.27
1 - 5			-0.28***	-4.79***
Above-median SHF (1 - 5) – Below-median *SFH* (1 - 5)			-0.15*	-2.31*
p-value			(0.06)	(0.06)

Table VI

Price Effects of Fire Sales and Purchases – Multivariate Analysis

This table reports results from panel regressions of municipal bond yield spreads on dummy variables for being in the extreme quintiles of trading pressure from municipal bond funds and their interactions with high SFH dummy. Yield spread is the difference between municipal bond yield from Bloomberg and constant maturity Treasury yield from FRED at the 20-year maturity. For each state-month, pressure is calculated using the same formula as Pressure 1 of Coval and Stafford (2007) but replacing the average volume in the denominator by outstanding debt at the previous year-end. State-months are sorted into quintiles by pressure, and pressure Q1 and Q5 dummies indicate observations that are in the top and bottom quintiles, respectively. High SFH dummy, high privilege dummy, and high debt/high income dummy are as described in Table IV. Control variables, if included, are the same as in Table IV. All models include credit rating, state, calendar year, and calendar month dummies. Standard errors, clustered by calendar year-month, are reported in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

	(1)	(2)	(3)	(4)	(5)
[A] = High SFH	-0.077***	-0.080***	-0.074***		
	(0.010)	(0.010)	(0.009)		
[B] = [A] x High privilege				-0.072***	-0.075***
				(0.009)	(0.013)
Pressure Q1	-0.033	-0.033	-0.036	-0.020	0.010
	(0.024)	(0.029)	(0.030)	(0.029)	(0.037)
Pressure Q5	0.126***	0.102**	0.097**	0.103**	0.049
	(0.044)	(0.041)	(0.045)	(0.046)	(0.044)
[A] x Pressure Q1		0.001	0.009		
		(0.033)	(0.033)		
[A] x Pressure Q5		0.073**	0.070**		
		(0.031)	(0.034)		
[B] x Pressure Q1				-0.035	-0.023
				(0.034)	(0.038)
[B] x Pressure Q5				0.060*	0.040
				(0.030)	(0.048)
High debt/hi. inc. x Pressure Q1					-0.035
					(0.040)
High debt/hi. inc. x Pressure Q5					0.049
					(0.030)
[B] x High debt/hi. inc. x Pressure Q1					0.036
					(0.069)
[B] x High debt/hi. inc. x Pressure Q5					0.081**
					(0.040)
Control variables	NO	NO	YES	YES	YES
Credit rating dummies	YES	YES	YES	YES	YES
State dummies	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES
Observations	3,944	3,944	3,944	3,944	3,944
R-squared (total)	0.817	0.817	0.821	0.821	0.821

Table VII

Price Effects of Supply

This table reports results from panel regressions of municipal bond yield spreads on net issuance and its interaction with high SFH dummy. Yield spread is the difference between municipal bond yield and constant maturity Treasury yield at the 20-year maturity. Net issuance data are annualized monthly and are from SDC Platinum (gross issuance – refunding), presented as a percentage of state outstanding debt. State outstanding debt data are from Census Bureau. High SFH dummy, high privilege dummy, and high debt/high income dummy are as described in Table IV. Control variables, if included, are the same as in Table IV. All models include credit rating, state, calendar year, and calendar month dummies. Standard errors, clustered by calendar year-month, are reported in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

	(1)	(2)	(3)	(4)	(5)
[A] = High SFH	-0.096***	-0.115***	-0.087***		
	(0.008)	(0.010)	(0.010)		
[B] = [A] x High privilege				-0.033**	-0.103***
				(0.015)	(0.009)
Net iss./debt	0.145	-0.020	0.075	0.048	-0.018
	(0.132)	(0.140)	(0.146)	(0.138)	(0.139)
[A] x Net iss./debt		0.392***	0.254**		
		(0.128)	(0.120)		
[B] x Net iss./debt				0.473***	0.404***
				(0.146)	(0.147)
High debt/hi. inc. x Net iss./debt					0.207
					(0.140)
[B] x High debt/hi. inc. x Net iss./debt					0.352*
					(0.177)
Control variables	NO	NO	YES	YES	YES
Credit rating dummies	YES	YES	YES	YES	YES
State dummies	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES
Observations	3,944	3,944	3,944	3,944	3,944
R-squared (total)	0.816	0.816	0.819	0.819	0.820

Table VIII

Price Effects Before and After Financial Crisis

This table report results for panel regressions of municipal bond yield spreads at the 5-year and 20-year maturities on net issuance, trading pressure, and close election dummy and their interactions with high SFH dummy for the periods before the crisis (1998-2007, before dummy = 1) and after the crisis (2010-2014, before dummy = 0). Yield spread is the difference between municipal bond yield from Bloomberg and constant maturity Treasury yield from FRED. Close election dummy is the same for both maturities in each state-month. Pressure is calculated separately for each maturity bucket (1-7 years for 5-year yields and 15+ years for 20-year yields), and pressure Q1 and Q5 dummies are accordingly determined. Net issuance (gross issuance – refunding) is also split into maturity bucket. High SFH dummy and high privilege dummy are as described in Table IV. Control variables are the same as in Table IV. All models include credit rating, state, calendar year, and calendar month dummies. Standard errors, clustered by calendar year-month, are reported in parentheses. *, **, and *** refer to statistical significance at 10%, 5%, and 1% levels.

	5-Year Yield Spread			20-Year Yield Spread		
	(1)	(2)	(3)	(4)	(5)	(6)
[B] = High SFH x High privilege	0.008	0.032	0.025	-0.100***	-0.091***	-0.108***
	(0.018)	(0.019)	(0.020)	(0.011)	(0.009)	(0.010)
Close election	-0.035			-0.107		
	(0.061)			(0.074)		
[B] x Close election	-0.021			0.180***		
	(0.030)			(0.066)		
Before x Close election	0.118*			0.131***		
	(0.065)			(0.050)		
[B] x Before x Close election	0.264***			-0.054		
	(0.092)			(0.068)		
Pressure Q1		-0.057			-0.050*	
		(0.038)			(0.030)	
Pressure Q5		0.078*			0.152***	
		(0.043)			(0.056)	
[B] x Pressure Q1		-0.018			-0.141***	
		(0.024)			(0.029)	
[B] x Pressure Q5		0.069			0.038	
		(0.050)			(0.027)	
Before x Pressure Q1		-0.108**			0.011	
		(0.054)			(0.041)	
Before x Pressure Q5		0.054			-0.108	
		(0.048)			(0.072)	
[B] x Before x Pressure Q1		0.016			0.117	
		(0.038)			(0.133)	
[B] x Before x Pressure Q5		0.046**			0.009	
		(0.022)			(0.025)	

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Table VIII -*continued*

	5-Year Yield Spread			20-Year Yield Spread		
	(1)	(2)	(3)	(4)	(5)	(6)
Net iss./debt	0.876*	1.082**	-1.477	0.153*	0.135	0.455**
	(0.486)	(0.515)	(1.120)	(0.092)	(0.086)	(0.215)
[B] x Net iss./debt			-2.120			0.658***
			(1.428)			(0.169)
Before x Net iss./debt			2.174*			-0.631**
			(1.230)			(0.265)
[B] x Before x Net iss./debt			4.036**			0.125
			(1.576)			(0.119)
Control variables	YES	YES	YES	YES	YES	YES
Credit rating dummies	YES	YES	YES	YES	YES	YES
State dummies	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES	YES
Observations	3,748	3,944	3,944	3,748	3,944	3,944
R-squared (total)	0.827	0.845	0.842	0.871	0.874	0.872

Table IX

Issuance Effects of Fire Sales and Purchases

This table report results from panel regressions of gross issuance of general obligation (GO, Panel A) and revenue (REV, Panel B) bonds on dummy variables for being in the extreme quintiles of trading pressure from municipal bond funds. For each state-month, issuance is the annualized sum of par values of GO or REV bonds issued within the month by all entities in the state, as reported by SDC Platinum. In columns (1)-(3) ((4)-(6)), the dependent variable is net issuance or new money (refunding issuance). For each state-month, pressure is calculated using the same formula as Pressure 1 of Coval and Stafford (2007) but replacing the average volume in the denominator by outstanding debt at the previous year-end. State-months are sorted into quintiles by pressure, and pressure Q1 and Q5 dummies indicate observations that are in the top and bottom quintiles, respectively. High SFH dummy and high privilege dummy are as described in Table IV. Control variables, if included, are the same as in Table IV. All models include credit rating, state, calendar year, and calendar month dummies. Standard errors, clustered by calendar year-month, are reported in parentheses. ∗, ∗∗, and ∗∗∗ refer to statistical significance at 10%, 5%, and 1% levels.

Panel A: Issuance of General Obligations Bonds

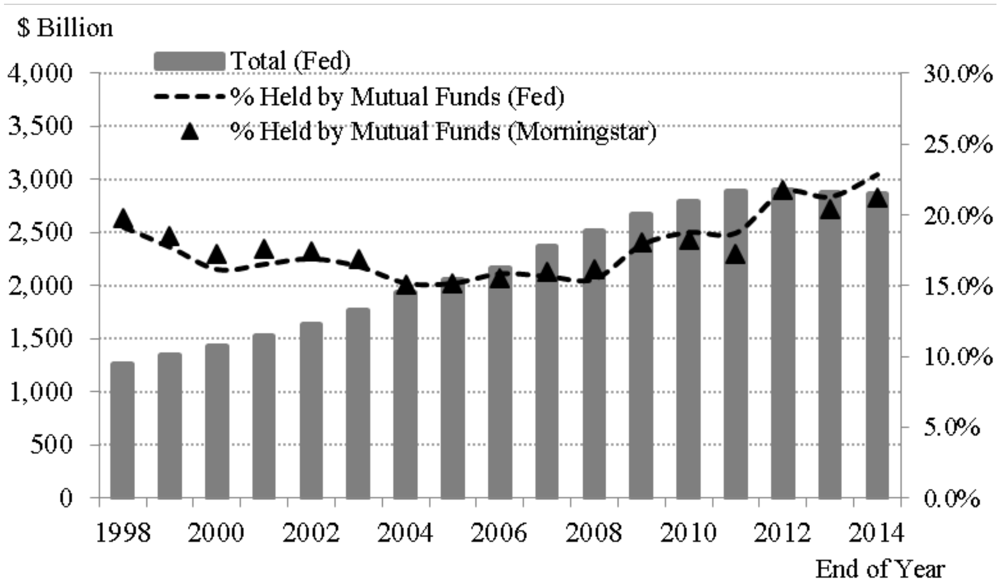
	GO Net Issuance/Debt			GO Refunding/Debt		
	(1)	(2)	(3)	(4)	(5)	(6)
[A] = High SFH	-0.002	-0.003		0.001	0.001	
	(0.004)	(0.005)		(0.003)	(0.004)	
[B] = [A] x High privilege			0.002			0.001
			(0.004)			(0.003)
Pressure Q1	0.002	0.001	0.001	0.002	0.002	0.001
	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
Pressure Q5	-0.004	-0.005	-0.004	-0.007***	-0.004*	-0.004
	(0.003)	(0.004)	(0.004)	(0.002)	(0.002)	(0.003)
[A] x Pressure Q1		0.002			-0.000	
		(0.005)			(0.003)	
[A] x Pressure Q5		0.001			-0.008**	
		(0.006)			(0.004)	
[B] x Pressure Q1			0.003			0.001
			(0.006)			(0.004)
[B] x Pressure Q5			0.000			-0.010*
			(0.005)			(0.005)
Control variables	YES	YES	YES	YES	YES	YES
Credit rating dummies	YES	YES	YES	YES	YES	YES
State dummies	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES	YES
Observations	3,949	3,949	3,949	3,949	3,949	3,949
R-squared (total)	0.183	0.183	0.183	0.071	0.071	0.071

Table IX *-continued*

Panel B: Issuance of Revenue Bonds

	REV Net Issuance/Debt			REV Refunding/Debt		
	(1)	(2)	(3)	(4)	(5)	(6)
[A] = High SFH	-0.001	-0.004		-0.002	0.000	
	(0.004)	(0.004)		(0.005)	(0.005)	
[B] = [A] x High privilege			0.003			-0.002
			(0.003)			(0.003)
Pressure Q1	0.026***	0.019***	0.020**	0.021**	0.015*	0.009*
	(0.007)	(0.005)	(0.010)	(0.010)	(0.009)	(0.005)
Pressure Q5	0.002	0.003	0.001	-0.014**	-0.001	-0.005
	(0.004)	(0.004)	(0.004)	(0.006)	(0.004)	(0.004)
[A] x Pressure Q1		0.013*			0.024*	
		(0.007)			(0.013)	
[A] x Pressure Q5		-0.002			-0.028	
		(0.005)			(0.017)	
[B] x Pressure Q1			0.015*			0.023*
			(0.008)			(0.013)
[B] x Pressure Q5			-0.003			-0.024*
			(0.005)			(0.013)
Control variables	YES	YES	YES	YES	YES	YES
Credit rating dummies	YES	YES	YES	YES	YES	YES
State dummies	YES	YES	YES	YES	YES	YES
Year dummies	YES	YES	YES	YES	YES	YES
Month dummies	YES	YES	YES	YES	YES	YES
Observations	3,949	3,949	3,949	3,949	3,949	3,949
R-squared (total)	0.122	0.123	0.123	0.081	0.082	0.081

Panel A: Aggregate Market and Value Held by Mutual Funds



Panel B: State vs. National Municipal Bond Mutual Funds

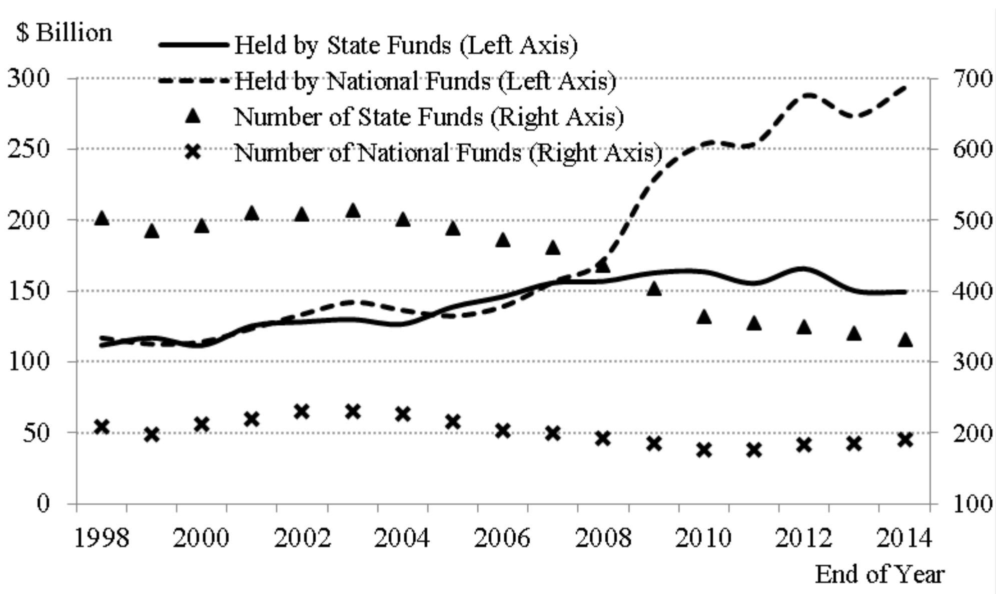
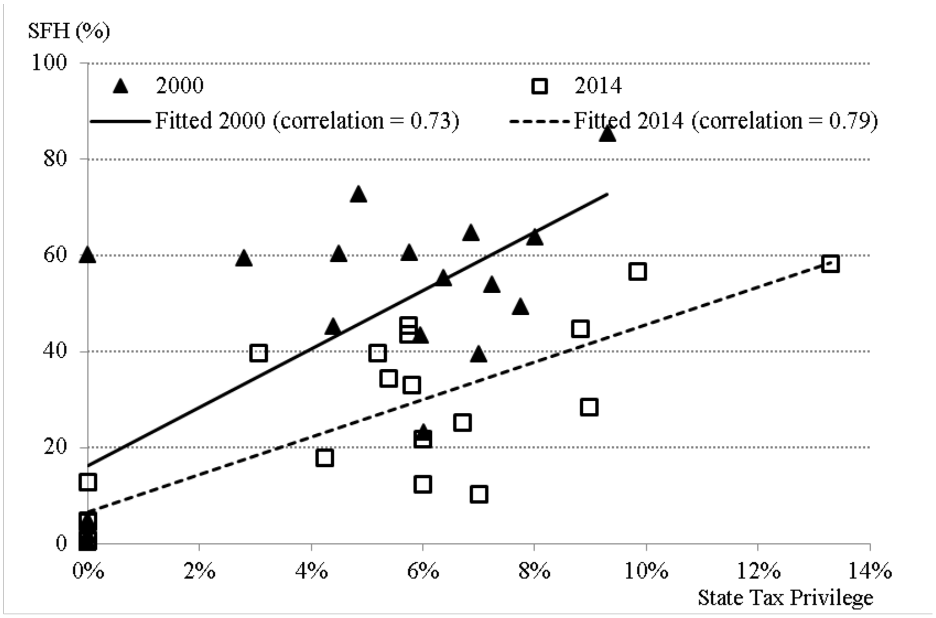


Figure 2. Tax-exempt municipal bond market and mutual funds over time. This figure presents the total outstanding amount of tax-exempt municipal bonds over the sample period from 1998 to 2014. Panel A plots the total outstanding amount and the amount held by mutual funds, as reported by the Federal Reserve, in comparison with the amount held by mutual funds, as reported by Morningstar. Only bonds with maturity 13 months or greater and only open-ended mutual funds are included. The amounts are measured in par value terms ($ billion). Panel B plots the amounts held by state vs. national municipal bond mutual funds and the numbers of these funds, as reported by Morningstar.

Panel A: All Maturities in 2000 and 2014



Panel B: 10-Year and 20-Year Maturities in 2014

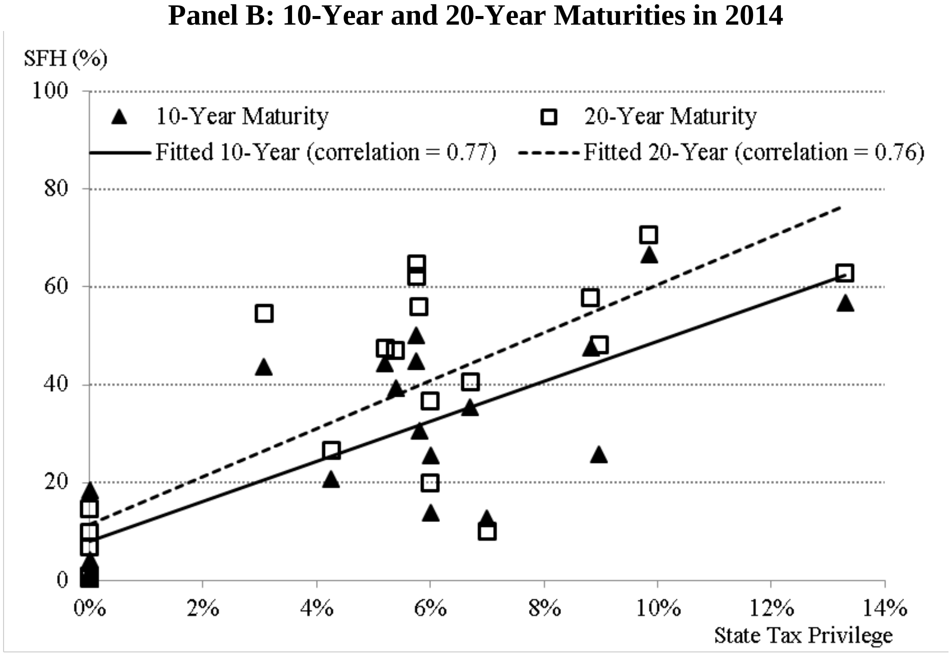
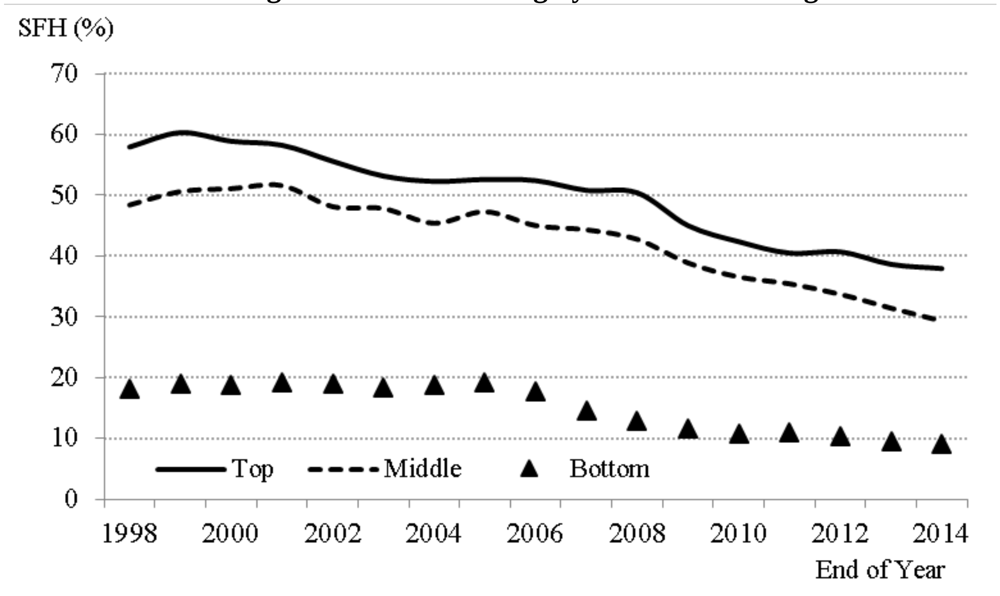


Figure 3. State tax rate and state fund holding. This figure plots state fund holding (SFH) of all municipal bonds issued by each state against state income tax privilege. For each state at each time point, privilege is the highest state income tax rate applied to income from municipal bonds issued by other states minus the highest state income tax rate applied to income from the state-issued municipal bonds. SFH is the amount of state-issued municipal bonds held by state municipal bond funds, presented as a percentage of the amount of state-issued municipal bonds held by all municipal bond funds. Panel A presents the data at the ends of 2000 (triangle) and 2014 (rectangle), and their best fitted linear lines. Panel B presents the data at the end of 2014 for bonds in the 10-year maturity bucket (triangle) and bonds in the 20-year maturity bucket (rectangle). The 10-year (20-year) maturity bucket includes maturities from 8 to 15 years (greater than 15 years). FL (prior to 2007) is excluded.

Panel A: Average State Fund Holding by State Tax Privilege Tercile



Panel A: Average State Fund Holding for Selected States

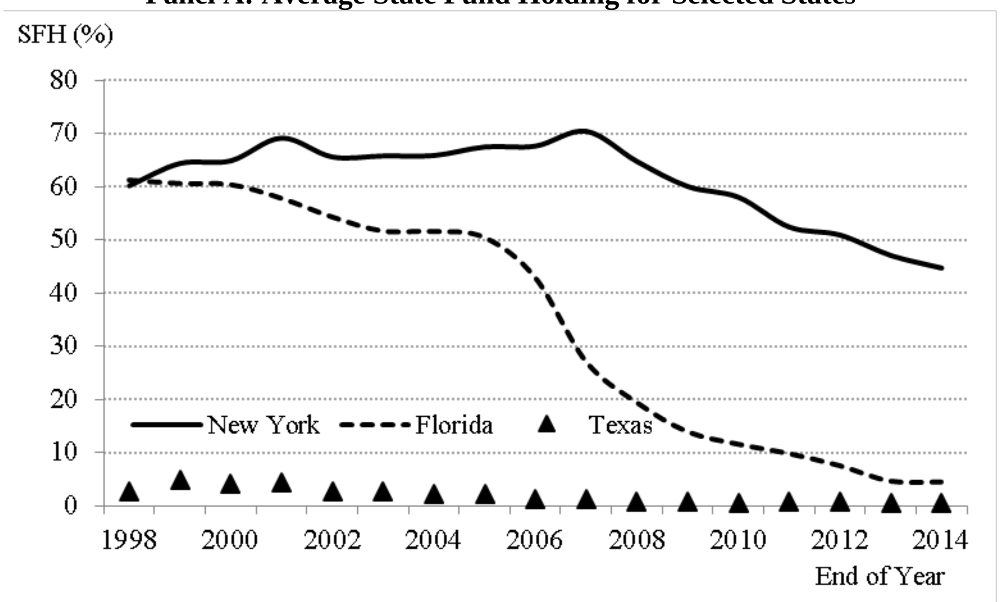
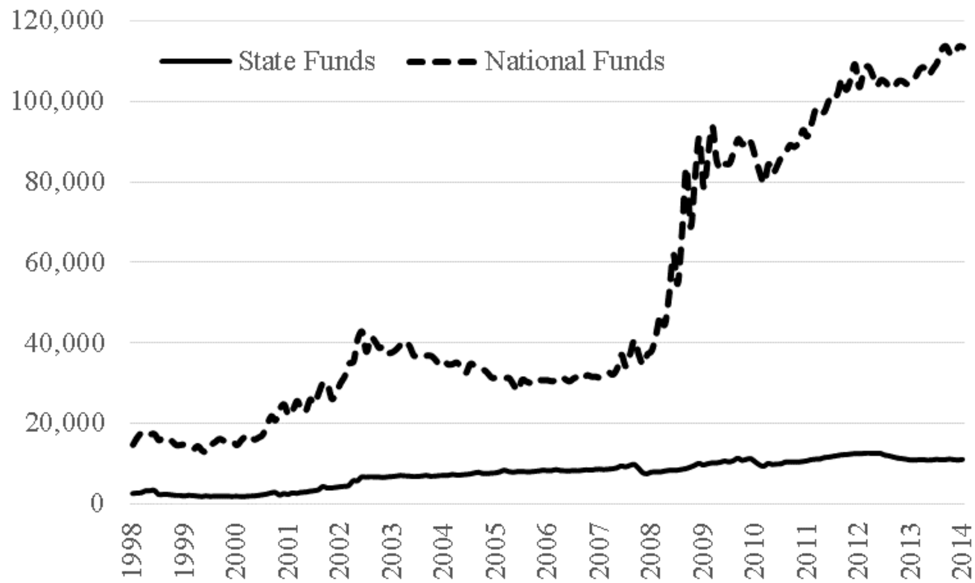


Figure 4. State fund holding for high- and low-tax states over time. This figure plots SFH for different states over time. For each state at each time point, SFH is the amount of state-issued municipal bonds held by state municipal bond funds, presented as a percentage of the amount of state-issued municipal bonds held by all municipal bond funds. Panel A presents the average SFH for three state terciles, sorted by the time-series average of highest state tax rate. The top (bottom) terciles include states with the highest (lowest) state tax rates. FL (prior to 2007) is excluded. Panel B presents the SFH for three selected states: NY, FL, and TX. Effective from 2007, FL abolished intangible property tax on financial assets, including investments in municipal bonds and bond funds.

Panel A: TNA of Short-Term Municipal Bond Funds



Panel B: TNA of Long-Term Municipal Bond Funds

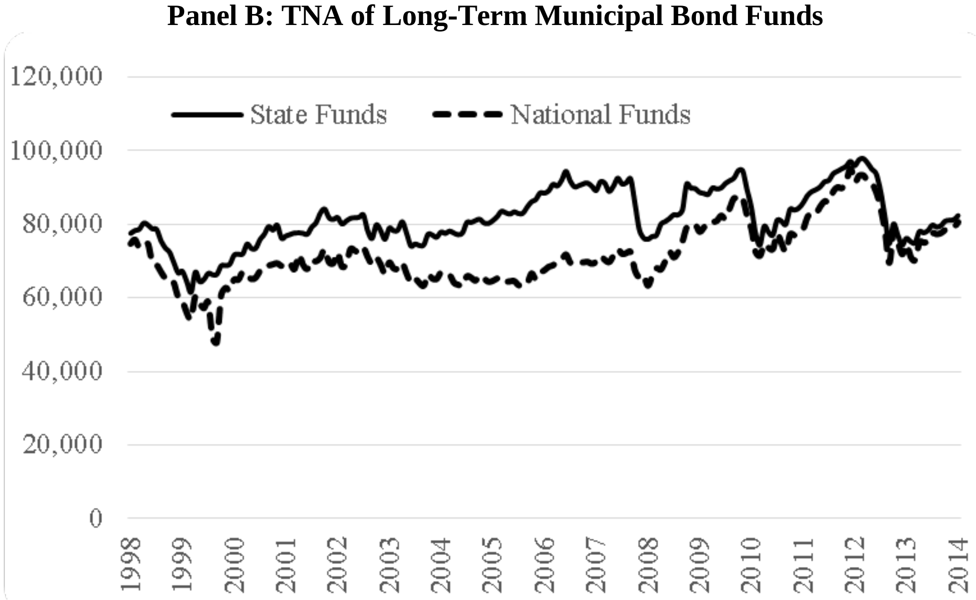


Figure 5. Total net assets of short- and long-term state and national municipal bond funds over time. This figure plots total net assets (TNA) of all short-term (Panel A) and long-term (Panel B) state and national municipal bond funds at the monthly frequency from 1/1998 to 12/2014. Fund classifications, state vs. national and short-term vs. long-term, are from Morningstar. Funds that are classified as intermediate-term and those that are not specifically classified as short-term or long-term are not included.