DO MUNICIPAL BOND INVESTORS PAY A CONVENIENCE PREMIUM TO AVOID TAXES?

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Abstract. We study the valuation of state-issued tax-exempt municipal bonds and find that there are significant convenience premia in their prices. These premia parallel those identified in Treasury markets. We find evidence that these premia are tax related. Specifically, the premia are related to measures of tax and fiscal uncertainty, forecast flows into state municipal bond funds, and are directly linked to outmigration from high-tax to low-tax states and to other measures of tax aversion such as IRA and retirement plan contributions. These results suggest that investors are willing to pay a substantial premium to avoid taxes.

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1. INTRODUCTION

One of the most important challenges in asset pricing is understanding how taxation impacts the valuation of securities. In markets where the marginal investor is subject to taxation, taxes create a wedge between the pre-tax returns from investment and the after-tax returns that investors can use for consumption. Furthermore, the deep connections between the government sector, fiscal and monetary policy, financial markets, and the macroeconomy create the potential for taxation to be a systematic risk factor impacting investment pricing and outcomes in many markets.

Investors are well aware of the corrosive effects of taxation on their wealth and actively seek to mitigate its impact. Key examples include the widespread participation by households in tax-deferred or tax-exempt investment vehicles such as IRAs, SEP-IRAs, Roth IRAs, 401(k) and 403(b) retirement savings accounts, tax-sheltered annuities, tax-advantaged 529 qualified tuition plans, and pre-tax health savings accounts (HSAs).[1] Single-state municipal bond funds that invest exclusively in the debt issued within a specific state are increasingly popular because they allow in-state resident investors to avoid both federal and state income taxation. Investors frequently use Section 1031 like-kind exchanges to defer the payment of capital gains taxes on appreciated real estate. An important recent trend in the mutual fund industry is the growth of tax-managed funds that minimize taxes by following strategies such as tax-loss harvesting, holding stocks with lower dividend yields, or avoiding the sale of stocks that would result in short-term capital gains. A highly-emphasized feature of the rapidly-growing exchange-traded fund (ETF) market is the tax efficiency of its unit creation/redemption mechanism. Wealth management and estate planning

[1]The total value of the more than 47.9 million IRAs held by U.S. households was $12.2 trillion at end of 2020. Total assets in Section 529 plans were $452.6 billion at the end of 2021. See ICI Research (2021a, 2021b).

services are standard components of the portfolio of products and strategies offered to high-net-worth clients by many investment advisors.

These market trends suggest a strong revealed preference for investment options that allow investors to avoid or defer taxes. There is an extensive literature documenting that investors often pay a substantial convenience premium for Treasury securities because of their role as safe assets. In like manner, the intense focus on limiting the negative effects of taxation on wealth raises the possibility that a similar type of convenience premium could be priced into securities that provide safety from the impact of taxation.

To explore this possibility, this paper examines whether there is evidence of a tax-related convenience premium in security prices. In doing this, we focus on the municipal bond market since it provides an ideal setting for identifying this type of premium and studying its properties. This is because municipal bonds are typically exempt from income taxation, making them particularly attractive to high-net-worth tax-averse investors. This aspect may also help explain the unique nature of this market in which most municipal bonds have historically been held directly by individual buy-and-hold investors rather than through financial intermediaries as in other fixed income markets.[2] The U.S. municipal bond market ranks among the largest fixed income markets in the world with a total notional amount of more than $4.0 trillion outstanding as of the end of 2021.[3]

The analysis is based on an extensive dataset of market prices for general obligation bonds issued by a broad cross-section of individual states, and for which the source of repayment is the state's general fund. Previous research makes clear that it is important to control for differences in credit risk and liquidity when comparing municipal bond yields to those in other fixed income

[2]Table 2 of Bergstresser (2022) indicates that as much as 56 percent of all municipal bonds were held directly by households at times during the 1990–2020 period. In contrast, only about two percent of all Treasury and corporate bonds are held directly by households.

[3]See SIFMA (2022).

markets.[4] To identify the credit risk of a state-issued general obligation bond, we use the credit default swap (CDS) spread for the state that is the actual issuer of the bond. Since the credit risk of the bond is simply the default risk of its issuer, this approach provides a clean measure of the credit component in municipal bond yields. To identify liquidity effects, we compare the credit-adjusted yields for the subset of municipal bonds in the sample that are taxable and for a matching set of Treasury bonds. The key to this novel identification approach is that taxable municipal bonds receive the same tax treatment as Treasury bonds. Thus, by holding fixed the tax treatment while also controlling for credit risk, any difference in yields provides a direct measure of the size of the liquidity component in municipal bond yields. We confirm that credit and liquidity spreads are significant components of the yields on municipal bonds, and work with the adjusted yields obtained by controlling for these credit and liquidity effects.

A simple no-arbitrage argument implies that after controlling for credit risk and liquidity effects, the yields of tax-exempt bonds with the same maturity and coupon rate should be equal across states. This follows since these bonds have identical pre-tax and post-tax cash flows. However, if tax-exempt bonds incorporate a tax-related convenience premium, these premia may be larger in high-tax states where the protection from taxation these bonds provide may be particularly prized by tax-averse investors. Accordingly, the first step in our analysis is to use pairs of matched-maturity-and-coupon tax-exempt bonds across different states to test for the presence of tax-related convenience premia. We find strong evidence that there are significant tax-related convenience premia in municipal bond prices, and that these premia are directly related to the degree of shelter from taxation these tax-exempt bonds provide. While this convenience premium technically represents a violation of the no-arbitrage condition, the differential tax treatment of coupon income from a tax-exempt bond and the interest paid by an investor borrowing a municipal bond makes an arbitrage

[4]For example, see Wang, Wu, and Zhang (2008), Ang, Bhansali, and Xing (2010, 2014), and Schwert (2017).

strategy shorting tax-exempt bonds infeasible for practical purposes.

We next use a simple model-free approach to estimate the convenience premium for each bond in the full sample. Specifically, the convenience premium is measured as the difference between the adjusted yield on a municipal bond and the tax-adjusted yield on an equivalent taxable benchmark bond. In making the adjustment to the taxable yield, we follow Schwert (2017) by applying the maximum possible combined marginal tax rate that investors may face from federal and state income taxes, as well as the 3.80 percent net investment income Medicare surtax introduced in 2013.

The results again provide strong evidence of substantial convenience premia in tax-exempt municipal bond prices. In particular, the average convenience premium is 14.87 basis points over the full sample and is highly significant from both an economic and statistical perspective. The average convenience premium taken across the entire sample period is positive for all the states in the sample, and the average convenience premium taken across all states is positive for all but two years of the sample period. These estimates of the convenience premia in tax-exempt municipal bond prices are similar in magnitude and strongly correlated with estimates of convenience premia in other fixed income markets. Furthermore, we show that these convenience premia are not simply conventional tax-related risk premia of the type described by Sialm (2009) and Longstaff (2011).

We turn next to an analysis of the properties of the estimated convenience premia. First, we find that the convenience premia in municipal bonds are linked to measures of tax and fiscal uncertainty. In particular, we regress monthly changes in the average convenience premium on changes in the tax-policy uncertainty and government-spending uncertainty indexes from Baker, Bloom, and Davis (2016). Both measures are significantly positively related to the average convenience premium. These results support the view that the premium reflects the extra value investors place on investments that allow them to avoid taxation during periods of heightened concerns about the effects of taxes.

Second, we examine the relation between the convenience premia and net flows into single-state municipal bond funds that invest only in the municipal debt issued within a specific state such as California, New York, New Jersey, etc. The intuition behind this analysis is that if investors within a state become more concerned about taxation, we may observe both an increase in demand for municipal bond funds that invest specifically in that state, as well as an increase in the convenience premium they are willing to pay for tax-sheltered investments issued in that state. Since quantities and prices are determined simultaneously in equilibrium, we use an approach that minimizes the impact of this endogeneity on the results. Specifically, we use a panel regression framework to regress the net flows into the municipal bond funds for a specific state on the lagged changes in the convenience premium for that state, and vice versa. We find that increases in the convenience premia are highly predictive of increased net flows into the municipal bond funds. These results strongly suggest that the convenience premia and the demand for municipal bond funds are driven by a common set of tax-related factors impacting tax-averse investors.

Third, we use Census Bureau data on the annual migration from the states in the sample to low-tax states as an exogenous instrument for state-level concerns about the impact of taxation. We use a panel regression approach to regress the convenience premium for each state and year on the fraction of the population of that state that migrated to one of the seven states in the United States that have no state income tax. We find that there is a significant positive relation between the rate of outmigration to low-tax states and the convenience premium. These results again suggest that the convenience premia in tax-exempt municipal bond prices reflect how motivated investors are to shield their wealth from the effects of taxation.

Fourth, we also use several specific actions taken by investors to reduce or defer federal income tax liabilities as exogenous instruments for the value they place on being able to avoid taxation on investment returns. Specifically, we examine the relation between the convenience premia for the individual states in the sample and the fraction of taxpayers in that state that contribute to an

IRA, that contribute to a tax-deferred self-employed retirement plan, that choose to itemize deductions on Form 1040, or that report charitable contributions on Schedule A. We find that the convenience premia are directly related to each of these measures of tax aversion. These results reinforce the view that the underlying source of the convenience premia in municipal bonds is tax related in nature.

Finally, we use a major exogenous shock in federal income tax policy to identify a measure of tax aversion at the individual state level. In particular, we use the decline in the total state and local tax (SALT) deduction per tax return resulting from the passage of the Tax Cuts and Jobs Act in December 2017 as an exogenous instrument for tax aversion. State income and local taxes were fully deductible prior to 2018, but the SALT deduction is now limited to a maximum of $10,000. Intuitively, investors in states most impacted by the exogenous SALT limitation may be more responsive to changes in the perceived tax-related safety of municipal bonds. We find that the cross-sectional pattern of changes in the convenience premia associated with the reduction of the top marginal federal income tax rate from 39.60 to 37.00 percent in 2018 is directly related to this instrument. These results again provide evidence of a causal connection from investors' concerns about taxation to the convenience premia observed in the prices of tax-exempt municipal bonds.

In summary, this paper makes two primary empirical contributions. First, we use two different approaches to show that there is a significant convenience premium in the prices of tax-exempt municipal bonds. In one approach, we show that the differences in the yields of matched pairs of municipal bonds with identical cash flows are not zero as a simple no-arbitrage argument would suggest, but are directly related to the relative amount of tax shelter these bonds provide investors. In the other approach, we show that the yield spread between taxable and tax-exempt bonds is significantly larger than can be explained by the difference in their tax treatment, even when we assume that taxable bonds are taxed at the maximum possible combined federal, state, and NIIT marginal tax rates. These two approaches give similar results. Second, we show that these convenience premia are tax related in nature. In particular, we show that the convenience premia are correlated with tax and fiscal uncertainty, and document that they are directly linked to various exogenous measures of investor tax aversion.

These results have several implications for financial markets. First, they demonstrate that there may be multiple types of convenience for which investors are willing to pay a premium. Previous results in the literature show that investors may be willing to pay a substantial premium for the money-like safety and liquidity convenience that Treasury securities offer. Our results suggest that investors are also willing to pay a significant premium for securities that insulate them from the impact of taxes on their wealth. Second, these results suggest that municipal bond issuers may be the beneficiaries of a form of tax-related seigniorage since they can issue tax-exempt bonds at a premium to their intrinsic fair values. In essence, the public sector can benefit by issuing bonds that protect investors from the taxes that the public sector would otherwise impose on those investors. Finally, these results raise fundamental issues about the impact of the taxation of investment returns on the cost of capital in the private sector. In particular, these results suggest that taxable yields may be higher than can be accounted for by fundamentals because of the effects of investor tax aversion in the taxable debt capital markets.

2. RELATED LITERATURE

This paper is directly related to the rapidly-growing literature on the valuation of safe assets. As discussed above, this literature documents that investors are often willing to pay an extra convenience premium for Treasury securities because of their safety and liquidity. Examples include Longstaff (2004), Krishnamurthy and Vissing-Jørgensen (2012), Nagel (2016), Du, Im, and Schreger (2018), Fleckenstein and Longstaff (2020), Lewis, Longstaff, and Petrasek (2021), Joslin, Li, and Song (2021), Christensen and Mirkov (2021), van Binsbergen, Diamond, and Grotteria (2022), and He, Nagel, and Song (2022). Fusari, Li, Liu, and Song

(2022) and He and Song (2022) present evidence of a similar convenience premium in Agency mortgage-backed securities. Theoretical models of the role that safe assets play in the markets include Krishnamurthy and Vissing-Jørgensen (2012), Gorton and Ordoñez (2013), Dang, Gorton, and Holmström (2015), Greenwood, Hanson, and Stein (2015), Nagel (2016), He, Krishnamurthy, and Milbradt (2016, 2019), Duffie (2020), Infante (2020), and Brunnermeier, Merkel, and Sannikov (2020). This paper extends this literature in a new direction by showing that investors may also be willing to pay a premium for securities with other characteristics they find attractive such as being tax-exempt.

This paper is also among the first to provide evidence of tax-related premia in the municipal bond market. The closest related paper is Longstaff (2011) who finds that there are tax-related risk premia in the pricing of swaps tied to a short-term municipal debt index. Ang, Bhansali, and Xing (2010) provide evidence of a tax-related premium in the relative pricing of above-par/below-par municipal bonds. These empirical results provide perspective on an important theoretical literature addressing the effects of tax and fiscal uncertainty on asset valuation. Sialm (2006, 2009) considers how stochastic variation in tax rates impacts the expected returns of both taxable and tax-exempt securities. Croce, Kung, Nguyen, and Schmid (2012) and Liu, Schmid, and Yaron (2021) show that tax uncertainty can have first-order effects on risk premia in financial markets and the convenience premia associated with safe assets. Babina, Jotikasthira, Lundblat, and Ramadorai (2019) show that the preferential tax treatment given to in-state resident investors may create tax-rate-related risk premia in bond pricing. Other important theoretical work showing how tax-induced clientele effects can impact asset prices include Dybvig and Ross (1986) and Dammon and Green (1987).

This paper also contributes to an extensive empirical literature focusing on the credit, liquidity, and tax-rate-related components of the spread between taxable and tax-exempt bonds. In an important recent paper, Schwert (2017) finds that after controlling for marginal tax rates, between 74 to 84 percent of the residual yield spread is explained by credit risk. In contrast, Ang, Bhansali, and

Xing (2014) find that liquidity accounts for 74 percent of the average municipal bond spread. Schaefer (1982), Litzenberger and Rolfo (1984), Jordan (1984), Green (1993), and Green and Odegaard (1997) document the effects of taxation on Treasury security pricing. Other examples of this literature include Trzcinka (1982), Arak and Guentner (1983), Skelton (1983), Yawitz, Maloney, and Ederington (1985), Ang, Peterson, and Peterson (1985), Buser and Hess (1986), Poterba (1986), Kochin and Parks (1988), Murphy (1998), Chalmers (1998), Jordan (2012), Landoni (2018), and Keung (2020).

3. TAXATION

This section provides an overview of the federal and state income taxation of tax-exempt and taxable municipal bonds, Treasury securities, and other related types of investments.[5]

3.1 Federal Income Taxation

Interest income from bond investments is generally subject to federal income taxation. Table A1 of the Internet Appendix shows that the maximum federal income tax rate was 35 percent from 2008 to 2012, 39.60 percent from 2013 to 2017, and 37.00 percent from 2018 to 2021. In addition, the Affordable Care Act (ACA) imposed an additional 3.80 percent net investment income tax (NIIT) on investment income beginning in 2013. The NIIT increased the effective maximum federal income tax rate faced by bond investors to 43.40 percent from 2013 to 2017, and to 40.80 percent from 2018 to 2021.

3.2 State Income Taxation

Interest income from bond investments is generally taxable at the state and local levels. Currently, all but seven states impose some form of tax on interest

[5]The Internet Appendix provides a more-detailed discussion of the topics summarized in this section.

income.[6] Table A1 of the Internet Appendix also shows the top marginal state tax rates for each year and each state in the sample.

Prior to the Tax Cut and Jobs Act (TCJA) of 2017, state and local income taxes were deductible from federal income taxes. To illustrate, let τ denote the top marginal federal income tax rate, and let τ_{s} denote the top marginal state tax rate. Deductibility of state and local taxes means that one dollar of pre-tax income resulted in $(1-\tau)\times(1-\tau_{\mathrm{s}})$ in after-tax income. The TCJA, however, now limits the federal income tax deduction for state and local taxes (SALT) to $10,000. The SALT limitation means that one dollar of pre-tax income above the $10,000 limit now translates into $(1-(\tau+\tau_{\mathrm{s}}))$ in after-tax income.

3.3 Taxation of Tax-Exempt Municipal Bonds

The interest income from tax-exempt bonds received by an investor is exempt from federal income taxes. In addition, interest income from tax-exempt bonds is generally not subject to state and local income taxes if the investor holds municipal bonds issued by states where the investor is considered a resident.[7] High-income households are the primary investors in tax-exempt municipal debt. Since the tax benefit due to the state and local tax-exemption accrues to individuals considered to be residents for tax purposes, the marginal investor in state-issued municipal bonds is likely a high-income in-state resident.[8]

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[6] These seven states are Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming. Indiana has an income tax but does not tax municipal interest income.

[7] Exceptions include Oklahoma, Illinois, Iowa, and Wisconsin which levy taxes on municipal bond interest income from within-state bonds.

[8] Bergstresser and Cohen (2015) find that the share of municipal bonds held by the wealthiest 0.5 percent of households grew from 24 percent to 42 percent over the 1989–2013 period. Poterba and Samwick (2001) show that the likelihood of a household holding tax-exempt debt increases with its marginal tax rate. Ang, Bhansali, and Xing (2010) argue that individual investors are the marginal pricers in the municipal bond market. Schwert (2017) assumes that the marginal tax rate impounded in tax-exempt bond yields is the state's top statutory income tax rate. Also see Longstaff (2011) and Kueng (2016).

It is important to recognize that the federal income tax treatment of tax-exempt bonds may also depend on whether an investor purchases the bond at par, at a premium, or at a discount. Consider first the case of a municipal bond purchased at par. If the investor sells the bond before maturity, any change in its value is taxable as a capital gain or loss. If held to maturity, the municipal bond purchased at par will not have any capital gain or loss at maturity. Second, when a municipal bond is purchased at a premium to par, the amortization of the premium is not considered a capital loss.[9] When a municipal bond sells at more than a de-minimis discount to par value, it may be classified as a "market discount bond." If a market discount bond is held to maturity, the entire market discount is taxable as ordinary income at the federal income tax rate.

3.4 Taxation of Taxable Municipal Bonds

Surprisingly, not all municipal bonds pay interest income that is exempt from federal income taxes. Why would a state choose to issue a taxable municipal bond instead of a tax-exempt municipal bond? The primary reason is simply that the tax-exempt status depends on the purpose for which the bond proceeds are used (as well as other requirements). In particular, if the fraction of the proceeds of a municipal bond directed to private entities exceeds certain thresholds, then the municipal bond may not be eligible for tax-exempt status even though it is a general obligation of the state, and the source of repayment is the general fund. These types of taxable municipal bonds are often referred to as private activity bonds. Examples of taxable general obligation bonds include bonds issued by the state of California primarily for funding entities conducting stem cell research or authorities developing high-speed passenger railways. Interest income from taxable municipal bonds is typically exempt from state and local income taxes for investors who are residents of the same state as the issuer.

[9]However, if the bond were sold before maturity at a price below (above) its amortized value, the investor would realize a capital gain (loss). If a bond is called, the call premium may be a capital gain (Feldstein and Fabozzi (2008)).

3.5 Taxation of Other Securities and Contracts

Interest income from Treasury bonds is exempt from state and local taxes (in all states except Tennessee) but is subject to federal income taxes. Thus, the tax treatment of Treasury notes and bonds parallels that of taxable municipal bonds.

By contrast, interest income from repo investments is subject to federal, state, and local taxes. To illustrate, recall that in a Treasury repo transaction, a "repo seller" sells a Treasury security to the "repo buyer" and, at the same time, agrees to buy back the Treasury at a pre-determined time in the future. It is important to note, however, that the repo seller retains ownership of the Treasury for tax purposes. Thus, the interest cash flows to the repo buyer are treated as interest income subject to federal, state, and local taxes. Moreover, coupon cash flows from the Treasury security accrue to the repo seller and are thus not treated as income of the repo buyer (see Choudhry (2006) and Walker (2014)).

Similar to repo investments in the cash market, interest cash flows from repo swap transactions are treated as ordinary income for income tax purposes. Specifically, the taxation of repo swaps follows the rules for plain-vanilla interest rate swaps. Thus, income from the periodic cash flows on the fixed leg of a repo swap is taxed as ordinary income and is therefore subject to federal, state, and local taxes.

While the tax treatment of CDS premium payments is currently not defined by regulation (Schwert (2017)), the Treasury proposed that CDS be included in the definition of a "Notional Principal Contract" in 2011. As a result, the tax treatment of CDS parallels that of plain-vanilla interest rate swaps, and CDS premium cash flows are interest income subject to federal, state, and local taxes.

4. THE DATA

We first describe the dataset of state-issued general obligation bond market prices constructed using the Bloomberg system ("Bloomberg") and municipal bond transactions data. We then discuss the CDS data for the states that issued the municipal bonds. Finally, we describe the Treasury bond and repo swap data.[10]

4.1 Municipal Bond Data

In this study, we focus exclusively on state-issued general obligation municipal bonds for which the source of repayment is explicitly listed as the general fund of the issuing state. Restricting the sample to these bonds has the important advantage of allowing us to identify the credit risk of the bonds directly since it is identical to that of the state issuing the bond.[11]

We collect municipal bond data manually from Bloomberg via the Bloomberg Fixed Income Search function on the terminal. We exclude bonds issued by states with either no CDS contracts traded in the market or insufficient CDS data to conduct the analysis. The resulting sample includes bonds issued by a total of 21 states. We also exclude bonds with call and put features, sinking fund provisions, and make-whole provisions. In addition, we filter out pre-refunded bonds, insured bonds, 144A securities, and municipal bonds subject to extraordinary redemption provisions. We also exclude floating-rate securities. Thus, all bonds in our dataset are fixed coupon bonds with fixed semi-annual coupon cash flows. For each municipal bond, we collect the CUSIP, the issue and maturity date, the amount issued and the price at issue, the coupon rate, coupon type and the day-count convention, the funding source of the municipal bond (the state's general fund), the tax provision (i.e., whether the bond is taxable

[10]The Internet Appendix provides full details about the data and the data sources.

[11]This need not be true for bonds issued by municipalities other than the state, or for those that are not general obligation bonds. We note that the previous literature often does not differentiate between various types of municipal bonds.

or tax-exempt), and the credit rating at issue by S&P and Moodys. Following Ang, Bhansali, and Xing (2010) and Schwert (2017), we remove municipal bonds subject to the alternative minimum tax (AMT) and municipal bonds with an original issue discount (OID).

In the next step, we supplement the bond-specific information from Bloomberg using a comprehensive historical dataset of municipal bond transaction prices from the Municipal Securities Rulemaking Board (MSRB) that covers the period from January 2005 to December 2021, which we download from the WRDS database. The MSRB requires dealers to report all municipal bond transactions, including interdealer and customer trades. Following Schwert (2017), we exclude all bond trades with less than one year to maturity from this transactions dataset.

Lastly, we collapse the municipal bond intraday transactions dataset by constructing a single "midpoint" price per day for each bond traded that day. Specifically, we follow Green, Li, and Schürhoff (2010) and Schwert (2017) and construct the daily midpoint price by calculating the average of the highest price on customer sales and the lowest price on customer purchases on each day.[12] If only interdealer transactions are observed on a given day, then the daily midpoint price is the simple average of interdealer prices. Using the daily midprice, we calculate the bond's yield to maturity using standard conventions.

4.2 Treasury Bond Data

We match each state-issued general obligation municipal bond observation with a Treasury security with the same maturity date and coupon cash flows. First, we collect daily constant-maturity Treasury (CMT) yields from January 2008 to December 2021 for maturities ranging from three months to 30 years from the webpage of the St. Louis Fed (FRED). Using the CMT term structures, we

[12]If there are only customer buys (sells) and interdealer trades, we construct the daily midpoint price by calculating the midpoint of the highest (lowest) price on customer buys (sells) and the average price of interdealer transactions.

bootstrap the Treasury bond discount function at the daily frequency using the approach described in Longstaff, Mithal, and Neis (2005) and Fleckenstein and Longstaff (2023). For each municipal bond observation, we then calculate the price of a hypothetical matched-coupon-and-maturity Treasury security simply by calculating the present value of the coupon cash flow stream of the municipal bond between the trade date and its maturity date using the Treasury discount function constructed in the previous step. Lastly, we calculate the yield to maturity of this hypothetical Treasury security using standard market conventions.

4.3 Repo Swap Data

We also match each general obligation municipal bond observation with a riskfree benchmark bond that we obtain from the term structure of fixed-for-floating interest rate swaps in which the floating leg of the swap is based on the overnight repo rate, which we refer to as a "repo swap" for brevity.[13] The intuition behind this approach is that the overnight repo rate represents a riskfree interest rate in the most fundamental sense of that term.[14]

We collect daily repo swap term structures from January 2008 to December 2021 from Bloomberg. Next, we bootstrap the riskfree discount function at the daily frequency from the term structure of repo swap rates using the methodology described in Section 4.2 above. With this riskfree discounting curve, we calculate the price of a hypothetical riskfree bond with the same cash flows and maturity date as the municipal bond simply by discounting the municipal bond's cash flows. We also calculate the yield to maturity of this matched-coupon/matched-

[13]The current repo swap market is based primarily on a specific overnight repo rate known as the Secured Overnight Financing Rate (SOFR).

[14]This is because overnight general collateral Treasury repo loans are backed by Treasury securities, perhaps the safest and most-liquid collateral in the market. Moreover, repos are overcollateralized because the pledged collateral is subject to haircuts. The finance literature has long recognized the riskfree nature of collateralized repo contracts. See Longstaff (2000), Nagel (2016), Du, Im, and Schreger (2018), Klingler and Sundaresan (2020), Infante (2020), and He, Nagel, and Song (2022).

maturity riskfree bond using standard conventions. Throughout, we refer to this bond as a "benchmark" bond.

4.4 Credit Default Swap Data

As discussed above, we are able to obtain CDS data for 21 U.S. states for the period from January 2008 to December 2021. For these states, we collect CDS term structures for tenors of one year out to ten years from S&P Capital IQ at the daily frequency. For most states, the first quotes become available starting in January 2008. We supplement the daily term structures with monthly observations of 15-year, 20-year, and 30-year CDS contracts from Bloomberg.[15] We also obtain daily end-of-day U.S. sovereign CDS mid-spreads of dollar-denominated contracts for tenors of T = 0.5, 1, 2, 3, 5, 7, 10, 15, 20, and 30 years from Markit for the period from January 2008 to December 2021.

4.5 Summary Statistics

Tables 1 and 2 present summary statistics for the yields of the tax-exempt and taxable bonds in the dataset, respectively. In addition, these tables report summary statistics for the yields of the corresponding Treasury and riskfree benchmark bonds. As shown in Table 1, the average yields of tax-exempt bonds are all positive, and the yields of the matched-coupon-and-maturity Treasury and benchmark bonds are uniformly lower than the yields of the tax-exempt bonds. Table 2 shows similar statistics for taxable bonds. It is instructive to compare the averages in Table 1 and Table 2 for the states with both tax-exempt and taxable bond issues. In particular, the average yields of taxable bonds are uniformly higher than the average yields of tax-exempt bonds of the same state. Table 3 provides summary statistics for the term structure of CDS spreads for the individual states in the sample.

[15]We calculate daily CDS spreads for the 15-year, 20-year, and 30-year tenors by adding the average monthly difference between the 10-year contract and the 15-year, 20-year, and 30-year contracts to the daily observations of the 10-year CDS.

5. CONTROLLING FOR CREDIT AND LIQUIDITY

Credit risk and bond market illiquidity can impact municipal bond yields significantly. Thus, we first need to control for the credit and liquidity spreads incorporated into municipal bond yields to identify tax-related effects accurately.[16]

5.1 Identifying the Credit Component

As discussed previously, an important advantage of focusing on state-issued general obligation municipal bonds is that the cost of protecting against default can be measured directly by the CDS spreads for the issuing state. The approach of using CDS spreads to estimate the credit-risk component in yields is now standard in the fixed income literature. Recent examples of this approach include Longstaff, Mithal, and Neis (2005), Schwert (2017), Augustin, Chernov, Schmid, and Song (2021), Fleckenstein and Longstaff (2023), and many others.

We identify the credit spread component of the municipal bond yields in the following way. First, for each municipal bond in the sample, we interpolate the CDS curve to obtain the spread for a CDS contract with the same maturity as the bond. Second, we solve for the impact of default risk on the bond's market price by computing the present value of the after-tax cost of protecting the bond against default. In doing this, we make the identifying assumption that the marginal investor in the CDS market is a corporate entity. Given this, the market price of the default risk in the bond is given by taking the sum of the present values of the CDS spread times $1 - \tau_c$, where τ_c is the maximum corporate tax rate. Third, we add the market price of the default risk to the observed market price to obtain the implied price of a riskless municipal bond. The credit spread is simply the difference between the original yield on the bond and the yield based on the implied price of the riskless municipal bond. Finally, we apply the same methodology to obtain credit-risk-adjusted Treasury bond

[16]The Internet Appendix provides full details about the methodology used to identify the credit-risk and liquidity components of municipal bonds yields.

prices.

5.2 Identifying the Liquidity Component

To identify the liquidity spread component in municipal bond yields, we introduce a novel approach that uses the subset of taxable municipal bonds in the sample. An important aspect of taxable municipal bonds is that their tax treatment is identical to that of a Treasury bond since they are subject to federal income tax, but are exempt from state taxes when held by an in-state investor. This implies that in the absence of liquidity effects, the yield on a credit-risk-adjusted taxable municipal bond should match that of a credit-risk-adjusted Treasury bond with the same coupon rate and maturity. Thus, any difference between these two credit-risk-adjusted yields should directly reflect the relative liquidity of the bonds.

To explore this, we compute the liquidity spread between the credit-risk-adjusted taxable municipal bond yield and the credit-risk-adjusted yield of the equivalent Treasury bond for every taxable municipal bond observation in the sample. Figure 1 plots the time series of the monthly averages of these spreads. As shown, the spread between these two rates is relatively stable throughout most of the sample period, typically ranging from about 40 to 60 basis points. The average value of the liquidity spread over all months is 55.59 basis points, which compares well with those reported in previous studies.[17]

In concept, we could use the average value of this spread each month as the estimate of the liquidity spread for each municipal bond in the sample that month. Rather than doing this, however, we go one step further and use these spreads to estimate a simple regression-based liquidity model that can then be applied to the individual bonds in the sample. Intuitively, this approach allows

[17] For example, taking the averages of the liquidity estimates reported in Table 4 of Wang, Wu, and Zhang (2008) results in values ranging from about 33 to 52 basis points. Table IV of Schwert (2017) reports an average liquidity spread of 30 basis points.

us to capture both the time-series and cross-sectional structure of municipal bond liquidity. Furthermore, this approach allows us to extrapolate from the subset of taxable municipal bonds to the broader set of tax-exempt bonds without assuming that the liquidity spreads for the two sets of bonds are identical.

Specifically, we estimate a panel regression in which the spreads are regressed on a vector of monthly fixed effects and several bond-specific liquidity instruments. As instruments, we include the age and maturity of the bond, the average trade size and the total trading volume for the bond for the month of the observation, and the total size of the bond issue. We also include the CDS spread of the issuer as a control for credit-related liquidity effects.[18]

Table 4 reports the results from the regression. As shown, the spreads are an increasing function of the age of the municipal bond. This highly significant result is consistent with previous evidence in the fixed income literature showing that older off-the-run bonds tend to be less liquid.[19] Similarly, the significant positive relation between the spreads and bond maturity is consistent with previous results.[20] Table 4 also shows that the average trade size and the total trading volume are negative and significant in the regression. These results are intuitive since they indicate that municipal bond liquidity improves when trading activity increases. Finally, the spreads are significantly related to issue size and the CDS spread of the issuer. Taken together, the results confirm that the spreads

[18]This approach has similarities to that used by Dick-Nielsen, Feldhütter, and Lando (2012) and others to decompose corporate bond spreads into separate credit and liquidity components. A key difference, however, is that the dependent variable in our panel regression is the difference between two credit-adjusted yields and does not include a credit component. Thus, our approach avoids the tension of having to disentangle the credit and liquidity components of the spread in a single regression.

[19]For example, see Amihud and Mendelson (1991), Kamara (1994), and Krishnamurthy (2002).

[20]Examples include Fleming (2002), Longstaff, Mithal, and Neis (2005), and Bao, Pan, and Wang (2011). Also see Chen, Lesmond, and Wei (2007) and Schestag, Schuster, and Uhrig-Homburg (2016).

reflect the liquidity effects in municipal bond yields. Given the estimated panel regression, we can model the liquidity spread for each observation in the sample by using the fitted value of the regression for that observation.

To ensure that the results are robust, we will also conduct the analysis using an alternative liquidity model. In this alternative model, we use the fact that the tax treatment of a taxable municipal bond is identical to that of a fully-taxable riskless benchmark bond from the perspective of a resident of a state that does not have a state income tax. Thus, the difference between the credit-risk-adjusted yield on a taxable municipal bond issued by one of these states and the yield on a corresponding riskless benchmark bond should again reflect the valuation impact of municipal bond illiquidity. Following an approach similar to that described above, we regress the spread between the credit-risk-adjusted yields for taxable Texas and Washington municipal bonds and the yield for equivalent benchmark bonds on the liquidity instruments.[21] We again use the fitted value from the estimated regression as the point estimate of the liquidity spread for each observation in the sample. The results obtained using this alternative liquidity model are very similar to those obtained using the first liquidity model. Accordingly, the primary results presented throughout the paper are based on the first liquidity model. The results based on the alternative liquidity model are discussed later in the robustness section.

5.3 Net Municipal Bond Yields

Given these results, we can now obtain credit-and-liquidity-adjusted yields for the tax-exempt municipal bonds in the sample by subtracting the credit and liquidity spreads from the observed market yields of these bonds. For brevity, we refer to the resulting yields simply as net yields. Table 5 presents summary statistics for the components of the original market yields and for the net yields.

[21]While other states in the sample do not have a state income tax, Texas and Washington are the only two with sufficient taxable municipal bond observations from which to estimate the panel regression.

The results in Table 5 illustrate the importance of controlling for the effects of credit and liquidity in studying the effects of taxation in the municipal bond market. In particular, Table 5 shows that the average credit spreads range from about 20 to 60 basis points across states and represent a significant component of the market yields of the bonds. Similarly, Table 5 shows that the average liquidity spreads range from about 40 to 70 basis points across states and likewise represent a substantial component of market municipal bond yields. Previous research argues that failing to control for the credit and liquidity spreads in municipal bond yields could impact inferences about the impact of taxation on investors.[22] Our results confirm the importance of taking credit and liquidity into account when comparing the yields of different types of fixed income instruments.

6. TESTING FOR CONVENIENCE PREMIA

In this section, we use two different approaches to test whether there are convenience premia in tax-exempt municipal bond prices. The first is based on matched pairs of municipal bonds. The second estimates the convenience premium for individual municipal bonds.

6.1 Cross-Sectional Estimates

In this approach, we use the cross-sectional structure of our data set to identify potential tax-related convenience premia in the pricing of tax-exempt municipal bonds. The key to this is the recognition that after controlling for differences in credit risk and bond liquidity, the prices of tax-exempt bonds with identical maturities and coupon rates should be the same across states. This follows from

[22]Examples include Trzcinka (1983), Yawitz, Maloney, and Ederington (1985), Green (1993), Chalmers (1998), Wang, Wu, and Zhang (2008), Ang, Bhansali, and Xing (2010, 2014), Longstaff (2011), Schwert (2017), and Spreen and Gerrish (2021). Several of these papers argue that credit and liquidity effects may distort estimates of marginal tax rates implied from municipal bond yields and could play a major role in resolving the "muni bond puzzle."

a standard no-arbitrage argument since these bonds have identical pre-tax and post-tax cash flows, irrespective of which state issued the bond. Thus, finding a systematic tax-related pricing difference between pairs of bonds with identical maturities and coupon rates would provide direct evidence of the existence of a convenience premium.

Accordingly, we examine whether there are systematic differences in the pricing of pairs of matched tax-exempt bonds related to the relative tax burdens of the issuing states. This makes intuitive sense since we might expect that if there were a convenience premium in tax-exempt bonds, it would likely be larger in states with higher income tax rates where investors might prize the tax shelter provided by tax-exempt bonds more highly. This perspective parallels Nagel (2016) who argues that convenience premia in Treasury markets should be directly related to the opportunity cost of holding cash as measured by the short-term riskless rate. In the context of our analysis, the opportunity cost of holding a taxable bond could be viewed as the marginal tax rate faced by the investor.

For a given day in the sample, we identify pairs of tax-exempt municipal bonds where the bonds have the same coupon rate and maturity dates within three months of each other, and where the bonds are issued by different states. Each bond is matched no more than once per day in this process. Repeating this process for each day during the sample period results in 236,583 observations of the net yields of municipal bond pairs.

We then use a panel regression framework to test whether there are tax-related convenience premia in the municipal bond prices. Specifically, we regress the (negative of the) difference in the net yields of the bonds in each pair on the difference in the maximum marginal tax rates applicable to taxable bonds for the two states represented in the pair. We include monthly fixed effects in the panel regression to control for the time-series variation in yields. Table 6 reports the regression results.

As shown, the regression provides strong evidence that the net yields of the tax-exempt bonds in the sample are directly related to the tax-related opportunity costs investors face. In particular, the coefficient on the maximum marginal tax rate variable is positive and highly significant. The positive sign of the coefficient means that the tax-exempt net yield is lower (tax-exempt bond price is higher) for states with higher marginal income tax rates. It is important to note that this relation can only be due to a convenience premium. This follows since the cash flows from a tax-exempt bond, by definition, are not subject to taxation and, therefore, are unaffected by tax rates. Thus, any relation between the net yield of a tax-exempt bond and the maximum marginal tax rate cannot arise through a valuation channel, but only through a convenience premium channel. In summary, these results allow us to draw two important conclusions. First, there are significant convenience premia in the prices of tax-exempt municipal bonds. Second, these convenience premia are directly related to the amount of tax shelter these bonds provide investors.

We also note that the convenience premia are significant in economic terms. For example, the regression coefficient for the maximum marginal tax rate variable implies that tax-exempt net yields in a state with a maximum marginal income tax rate of 10 percent are about 5.01 basis points lower than in a state with no state income tax. Taking these results one step further and extrapolating them to a combined federal and state marginal tax rate of, say, 40 percent, these results suggest that the total convenience premia could be on the order of 20 basis points. For a bond with a maturity of, say, 10 years, this could map into a price premium on the order of $1 to $2 for a tax-exempt bond with a par value of $100.

Finally, as discussed above, a no-arbitrage argument implies that the net yields of tax-exempt bonds with the same coupon rate and maturity should be the same across states. Thus, finding that there is a cross-sectional relation between net yields and the maximum marginal state income tax rates raises the important issue of why this relation is not arbitraged away by investors taking long/short positions in the tax-exempt bonds issued by different states. The resolution of this is simply that shorting municipal bonds is prohibitively expensive and there is consequently no viable market for doing so. The reason for this is that if an investor borrows a tax-exempt municipal bond to implement a short sale, the investor needs to compensate the security lender for the foregone coupon income. But in contrast to the foregone tax-exempt coupon income the lender would otherwise receive, the interest paid by the borrower to the security lender is taxable. Thus, the borrower would need to gross up the interest paid by a factor of $1/(1-\tau)$ to make the lender whole. This creates a huge wedge between the actual coupons on the tax-exempt bond and the interest cost to the borrower in taking a short position. This wedge is typically so large that it makes shorting municipal bonds impractical. As a result, there is no effective mechanism to arbitrage away differences in the net yields of tax-exempt municipal bonds across states.

6.2 Individual Convenience Premium Estimates

In this approach, we use a simple model-free framework to estimate the convenience premium in individual municipal bond prices. Specifically, we compare the actual net yields for the tax-exempt bonds in the sample with a lower bound on the tax-exempt yield given by using the maximum combined federal, state, and NIIT tax rate in the mapping from taxable to tax-exempt yields. For example, imagine that the maximum possible combined federal, state, and NIIT tax rate faced by any investor was 50 percent. Assume further that the net yield for the tax-exempt bond is 1.35 percent, and the net yield of a par taxable benchmark bond with a matching maturity is 3.00 percent. Then the lower bound on what the tax-exempt net yield can be in the absence of a convenience premium is $3.00 \times (1-0.50) = 1.50$ percent. In this example, the convenience premium is simply the difference between 1.50 and the 1.35 percent net yield of the tax-exempt bond, implying a value of 15 basis points. Since this approach uses a comparison based on the maximum possible marginal tax rate, a positive value provides unambiguous evidence of the presence of a tax-related premium.[23]

[23]We note also that if the tax rate of the marginal investor is less than the

Table 7 reports the average estimated convenience premia for each state and year in the sample. As shown, there is strong evidence that the market incorporates a significant convenience premium into the spread between taxable and tax-exempt yields. In particular, the last column of the table shows that the average convenience premia taken over the entire sample period are uniformly positive for all 21 states. Almost all of these averages are highly statistically significant. Figure 2 plots these average values.

Table 7 also shows that the average convenience premium taken across all states is positive for all but two years of the sample period. In particular, the last row of the table shows that the average premia taken across all states range from about 30 to 80 basis points early in the sample, to slightly positive or negative values during the 2014–2018 period, and then back to positive values of roughly 20 basis points during the latter part of the sample period. To illustrate this time-series variation, Figure 3 plots the monthly averages of the estimated convenience premia throughout the sample period.

Finally, the average value of the convenience premia taken the entire sample is 14.87 basis points. This value is highly statistically significant and consistent with the preceding section's results. Furthermore, this value is consistent with the size of convenience premia observed in other markets.[24] These results provide strong additional evidence that there are substantial convenience premia in the prices of tax-exempt municipal bonds.

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maximum rate, then the premium estimates we obtain could underestimate the actual premium.

[24]D'Amico and King (2013) find an average on-the-run repo spread of 19.4 basis points. Nagel (2016) documents an average premium of 23.65 basis points in Treasury bill yields relative to general collateral repo rates. Fleckenstein and Longstaff (2020) find an average premium of 9.73 basis points in floating-rate Treasury notes. He and Song (2022) find an average convenience premium of 47 basis points for Agency MBS. Fleckenstein and Longstaff (2023) find that the average richness of Treasury securities is about 8 basis points.

7. THE CONVENIENCE PREMIA

In this section, we examine the time-series and cross-sectional properties of the individual convenience premia estimated in the previous section in more depth.

7.1 Relation to Other Convenience Premia

A natural first step is to explore the relation between the convenience premia in tax-exempt municipal bond prices and the convenience premia observed in other financial markets. Accordingly, we regress the monthly averages of the convenience premia for the tax-exempt bonds on a number of convenience premia proxies and estimates from other fixed-income markets. Specifically, we follow Nagel (2016) and include the spread between the three-month general-collateral Treasury repo rate and the three-month Treasury bill yield as a measure of the convenience premia for short-term Treasuries. As other proxies for the convenience premia in short-term Treasuries, we also include the three-month LIBOR-Treasury spread (TED spread) and the two-year LIBOR-based swap spread. Similarly, we follow Krishnamurthy and Vissing-Jørgensen (2012) and include the spread between AAA corporate bond yields and Treasury yields. As a measure of the convenience premia in longer-term Treasuries, we include the Fleckenstein and Longstaff (2023) measure of Treasury richness for maturities from zero to ten years. Following Longstaff (2004), we include the yield spread between ten-year Refcorp and Treasury bonds. Finally, following He and Song (2022), we include the Agency MBS spread. Table 8 reports the regression results.

As shown, the convenience premia in tax-exempt municipal bonds are strongly related to those in these other markets. In particular, there is a significant positive relation between the convenience premia for tax-exempt bonds and the swap spread, the AAA-corporate spread, the Treasury richness measure, the Refcorp spread, and the Agency MBS spreads. There is also a significant negative relation with the TED spread. The adjusted R^2 for the regression is over 70 percent. These results indicate that the convenience premium in tax-exempt bonds behave very similarly to those in Treasury and other markets. This suggests that the time variation in convenience premia across different markets may be driven by a common set of underlying factors.

7.2 Relation to Tax and Fiscal Uncertainty

If the convenience premia in tax-exempt bond prices are tax related, we might expect that they would respond to changes in the amount of uncertainty about future tax rates and fiscal conditions. To explore this, we regress the changes in the monthly averages of the convenience premia on the corresponding changes in the Baker, Bloom, and Davis (2016) measures of tax uncertainty, government-spending uncertainty, and economic uncertainty. To control for other broader types of uncertainty, we include changes in the VIX index of stock market volatility and in the MOVE index of interest rate volatility in the regression. Table 9 reports the regression results.

Table 9 shows a significant positive relation between the convenience premia and both the tax and government-spending uncertainty measures. These results are intuitive since they suggest that investors are willing to pay more for the shelter from taxes that tax-exempt municipal bonds offer during periods when investors may have greater concerns about the future tax environment.

7.3 Flows into State Municipal Bond Funds

If investors are sometimes willing to pay a larger premium for securities that provide them tax shelter, they may also simultaneously take additional steps to mitigate the effects of taxes on their wealth. To explore this, we examine the relation between changes in the premia and the net flows into state municipal bond funds. Recall that state municipal bond funds invest in the municipal debt issued within a specific state such as California. As a result, the interest earned on the fund's portfolio is exempt from both federal and state taxes for an in-state resident investor. Accordingly, the marginal investor in a state municipal bond fund is typically assumed to be a state resident.

We obtain data on the monthly net flows into state municipal bond funds for 16 of the 21 states in the sample from the Bloomberg system. Note that there are no state municipal bond funds for states such as Florida and Texas since they do not have a state income tax. For each of the 16 states with one or more state municipal bond funds, we calculate the total monthly net flow by taking the sum of the net flows over all state municipal bond funds for that state. This results in a panel of 2,339 month-state observations.

Since prices and quantities are jointly determined in equilibrium, we use an approach that attempts to mitigate the effects of endogeneity on the results. In particular, we use a panel regression framework in which we regress the net flows for a given state on the lagged changes in the average premia for that state. Similarly, we regress the change in the average premia for a state on the lagged net flows for that state. Thus, examining whether there is a predictive relation between net flows and changes in the premia, makes the results less likely to be impacted by endogeneity issues. This approach could also be viewed as a simple panel version of a standard Granger (1969) causality framework.

Table 10 reports the regression results. In Panel A, we regress the net flow on the first three lagged values of the net flow and on the first three lagged changes in the average premia. The first (second) specification excludes (includes) the contemporaneous change in the average premia. We also include state-level fixed effects in both specifications. As shown in the table, there is a strong predictive relation between the lagged changes in the average premia and subsequent net flows into state municipal bond funds. In particular, all three of the lagged changes in the average premia are positive and significant in forecasting future net flows. These results again provide evidence that the premia are tax related in nature and driven by a set of underlying factors that also motivate investors to invest in single-state municipal bond funds.

In Panel B, we regress the change in the average premia on the first three lags of the change in the average premia and on the first three lagged values of the net flow. Again, the first (second) specification excludes (includes) the contemporaneous net flow. State-level fixed effects are again included in both specifications. The regression results show that the lagged net flows have predictive power for changes in the average premia. The sign of the relation, however, is negative for the first two lags and positive for the third lag. Thus, the overall relation between net flows and future changes in premia is more complex than the unambiguously positive relation between changes in premia and future net flows. Nevertheless, these results again confirm that the premia in tax-exempt municipal bond prices are tax related in nature.

7.4 Migration

As discussed above, investors who are willing to pay a premium for tax-exempt municipal bonds may also choose to take other actions to mitigate the effects of taxation. One frequently-discussed strategy is simply moving from a high-tax state to a low-tax state. Accordingly, we use a panel regression framework to study the relation between changes in convenience premia and population outflows at an individual state level.

Specifically, we collect annual data from the U.S. Census Bureau on the percentage of the population within a state that migrated to one of the seven states without a state income tax during that year. This data is available for the 2008 to 2019 period for each of the 21 states in our sample. This results in a panel of 209 state-year observations of the year-on-year changes in the average premium and the population outflow for the corresponding period. We then regress the change in the convenience premium for a state on the outmigration percentage for that state. We include state-level fixed effects in the panel regression. Table 11 reports the regression results.

The results indicate that there is a significant positive relation between changes in the average convenience premia and population outflows to low-tax states. Since the choice to move from one state to another is unlikely to be based on the pricing of specific tax-exempt bonds, it is reasonable to view population outflows to low-tax states as an exogenous measure of investor concerns about the impact of taxation. Thus, the significant positive relation is supportive of the existence of a causal channel between investor concerns about taxation and changes in the convenience premia in tax-exempt municipal bonds.

7.5 Tax Strategies

Continuing the theme of the previous two sections, we note that investors can also take actions that serve to reduce their federal income tax liability. Examples of these types of strategies include making IRA contributions, creating tax-deferred self-employed retirement accounts, choosing to itemize deductions on IRS Form 1040, and making charitable contributions which are then reported on Schedule A of IRS Form 1040. The decision by an investor to follow one of these elective tax-minimizing strategies can again be viewed as an exogenous choice made in response to concerns about the impact of taxation.

We again use a panel regression framework to examine the relation between the convenience premia and these exogenous tax-motivated choices made by taxpayers. In particular, we collect data from the annual Internal Revenue Service Statistics of Income reports on the total number of returns by state that include an IRA contribution, self-employed retirement plan, itemized deductions, or include charitable contributions on Schedule A. We normalize these numbers as a percentage of the total number of returns for each state for the corresponding year. This results in a panel of either 240 or 250 state-year values (based on data availability) for the year-end average premia and these percentage tax-strategy measures. Since the regression is estimated in levels, we include both annual and state-level fixed effects in the regression. Because of the nontrivial correlation among some of the tax-strategy measures, we estimate the regression separately for each measure. Table 12 reports the regression results.

Table 12 shows a significant positive relation between the convenience premia and each of the tax-strategy measures. In particular, the coefficients for the IRA contribution, self-employed retirement plan, and charitable contribution measures are significant at the five-percent level, and the coefficient for the itemization measure is significant at the ten-percent level. These results again support the hypothesis of a causal link between investor concerns about taxation and the convenience premia observed in tax-exempt municipal bond prices.

7.6 The SALT Limitation Event

Finally, the passage of the Tax Cuts and Jobs Act in December 2017 and the corresponding exogenous shock to investors' ability to deduct state taxes on their federal tax returns provides us with a natural experiment to study the relation between the premia and the impact of taxation. Recall that the passage of the Act reduced the top marginal federal income tax rate from 39.60 to 37.00 percent for tax years beginning with 2018. At the same time, however, the Act limited the SALT deduction to a maximum of $10,000. Thus, the beneficial effect of the reduction in the federal income tax rate on the premia might be enhanced in the states where investors are more impacted by the SALT limitation.

To explore this, we again use the annual Internal Revenue Service Statistics of Income reports and compute the average amount of SALT deduction per income tax return by state for the 2017 and 2018 tax years. We then use the percentage change in the average SALT deduction from 2017 to 2018 as an exogenous instrument for the tax burden associated with taxable bonds or, equivalently, the relative tax-related safety provided by tax-exempt municipal bonds. We regress the change in the convenience yield by state over the six-month event window from September 2017 to March 2018 on the SALT-limitation instrument. Note that this is essentially a standard difference-in-difference regression specification. Table 13 reports the regression results.

The regression results show a significant positive cross-sectional relation between the change in the premium and the SALT-limitation instrument. In particular, this implies that the change in the premium is larger in magnitude for states where investors are more tax constrained as measured by the SALT-limitation instrument. These results again provide direct evidence that changes in the tax environment investors face lead to changes in the convenience premia they are willing to pay to obtain shelter from taxation.

8. CONVENIENCE PREMIA OR RISK PREMIA?

A convenience premium is the amount that investors are willing to pay for a security—above and beyond the cost of replicating its cash flows—because of its nonmonetary characteristics such as liquidity. Thus, a convenience premium actually represents a deviation from the law of one price rather than a conventional equilibrium risk premium. As discussed earlier, we use two approaches to examine whether there are convenience premia in municipal bond prices. In the first approach, we study the cross-sectional variation in net yields. This first approach provides unambiguous evidence of the existence of significant convenience premia in municipal bond prices.

In the second approach, we measure the convenience premium in individual bonds relative to the current maximum tax rate. In doing this, however, we implicitly assume that the current maximum tax rate applies throughout the life of a bond. Given this assumption, the estimated premium can be interpreted as a convenience premium in the usual sense. If the maximum tax rate could increase over time, however, then some portion of the estimated premium could represent a conventional risk premium compensating investors for the risk of time-varying tax rates. We note that there is a recent literature documenting the presence of tax-related risk premia in financial markets. For example, Sialm (2009) finds that there is a significant cross-sectional relation between expected stock returns and effective tax rates. Longstaff (2011) finds evidence of a countercyclical risk premium in municipal debt markets that compensates investors for the risk of time-varying tax rates.[25] In light of this possibility, it is useful to explore how much of the estimated convenience premium could plausibly be interpreted as a risk premium.

We begin by first considering the term structure of the estimated convenience premia. If these premia are actually risk premia, then we might expect that that their term structure would be a monotonic function of maturity. The intuition for

[25]See also Fleckenstein, Gandhi, and Gao (2019).

this is simply that the uncertainty in future tax rates is larger for longer horizons than for shorter horizons. This is consistent with the evidence in Longstaff (2011) about the nature of the tax-related risk premium in municipal debt markets.

To examine this, Figure 4 plots the average convenience premia by remaining time to maturity. In particular, the plots show the average convenience premium across all states for quarterly maturity ranges (1 to 1.25 years to maturity, 1.25 to 1.5 years to maturity, etc.). The top panel plots the convenience premia for the 2008 to 2012 period, when the maximum federal income tax rate was 35 percent. The middle panel plots the convenience premia for the 2013 to 2017 period, when the maximum federal tax rate (including the 3.80 percent NIIT) was 43.40 percent. The bottom panel plots the convenience premia when the maximum federal tax rate (including the NIIT) was 40.80 percent. As shown, the term structures are clearly not simple monotonic functions of maturity. In general, the term structures tend to increase initially, but then begin to decline for maturities greater than five years. Thus, the largest average values of the estimated premia tend to occur in the range of two to five years maturity. These patterns suggest that the estimated premia are unlikely to consist solely of conventional risk premia.

Another way to distinguish between convenience premia and conventional risk premia is through their implications for implied tax rates. As discussed in Sialm (2009) and Longstaff (2011), tax-related risk premia can result in implied tax rates that differ from current or expected future tax rates. What risk premia cannot do, however, is to imply tax rates that exceed 100 percent. This follows since this situation would conflict with the existence of an equivalent martingale measure. In particular, equivalence requires that events that cannot occur under the physical measure also cannot occur under the pricing measure. This means that estimated premia that imply tax rates in excess of 100 percent must include at least some convenience premium component.

To explore this, we solve for the forward tax rates implied by the difference between the net yields of tax-exempt municipal bonds and the yields of the corresponding taxable benchmark bonds. In doing this, we assume that the current maximum tax rate applies over the next year. This assumption is a modest one since tax law changes generally require a substantial lead time to implement. Given this assumption, it is then straightforward to solve for the forward tax rate applicable to the cash flows from the bond that are received after the first year.[26]

Table 14 reports the percentage of forward tax rates that exceed 100 percent. As shown, forward tax rates are frequently in excess of 100 percent. In particular, 53.26 percent of the forward rates for bonds with maturities ranging from one to two years exceed 100 percent. Similarly, 25.20 percent of the forward rates for bonds with maturities from four to five years exceed 100 percent. Thus, while we cannot rule out that some part of the premia we measure represents a conventional risk premium, we can definitely rule out the possibility that these premia are entirely due to tax-related risk premia.

9. ROBUSTNESS

9.1 Identifying Municipal Bond Liquidity

The approach we use in Section 5.1 to identify the liquidity component of municipal bond spreads begins by comparing the credit-adjusted yields on taxable municipal bonds with the credit-adjusted yields on matched Treasury securities. We use the resulting spreads to define a liquidity model that can then be applied to all of the taxable and tax-exempt municipal bonds in the sample.

In this approach, however, we implicitly assume that the liquidity of taxable and tax-exempt municipal bonds are reasonably comparable and can be captured within the same model. As a robustness check on this assumption, we collect data on a number of liquidity measures for both the taxable and tax-exempt

[26]The Internet Appendix discusses the approach used to calculate implied forward tax rates in detail.

municipal bonds in the sample. Table A3 of the Internet Appendix summarizes the data.

As shown, the liquidity measures for the taxable and tax-exempt municipal bonds are very comparable. In particular, the average number of trades per month is very similar for the two categories of bonds. The average trade size is also on the same order of magnitude for the two categories. Furthermore, the bid-ask spreads for the two categories of bonds are very similar. These summary statistics support the assumption that the liquidity of taxable and tax-exempt bonds can be viewed as reasonably comparable.

9.2 The Alternative Liquidity Model

To examine the robustness of the results to the liquidity model used, we repeat all of the analysis using the alternative liquidity model described in Section 5.2. The Internet Appendix presents alternative versions of Tables 5 through 13 based on the alternative liquidity model. These tables are titled Table 5 - Liquidity Model 2, Table 6 - Liquidity Model 2, etc.

As shown, the results are very similar to those based on the primary liquidity model. For example, Table 5 - Liquidity Model 2 shows that the average liquidity component of the tax-exempt municipal bond yields is 54.2 basis points, which is only slightly different from the value of 57.8 shown in Table 5. Similarly, Table 7 - Liquidity Model 2 shows that the average premium obtained using the alternative liquidity model is 11.29 basis points, which is close to the average value of 14.87 reported in Table 7. The other empirical results in the alternative tables are all very similar to those reported in the primary analysis.

9.3 Alternative Marginal Tax Rate Assumptions

It is also important to consider the robustness of the results relative to the assumptions made about marginal tax rates. For example, we assume in Section 5.1 that the marginal investor in the CDS market is a corporate entity and use the maximum marginal corporate tax rate in computing the after-tax cost of insuring municipal bonds against default risk. An important implication of using the maximum tax rate, however, is that it results in conservative estimates of the convenience premium. In particular, using a lower marginal tax rate (or no marginal tax rate at all) would lead to larger estimates of the credit spread in municipal bond yields which, in turn, would result in higher estimates of the convenience premia. Thus, relaxing this assumption would only strengthen the case that there are significant convenience premia in tax-exempt municipal bond prices.

Similarly, in defining the maximum possible marginal tax rate in Section 6.2, we make two assumptions. First, we assume that the marginal investor in the municipal bond market is subject to the 3.80 percent NIIT Medicare surtax imposed by the Affordable Care Act for tax years beginning in 2013. Second, we assume that the marginal investor is also subject to the SALT limitation on the deductibility of state income taxes imposed by the TCJA for tax years beginning in 2018. The effect of relaxing these assumptions, however, would be to reduce the maximum possible marginal tax rate used in the analysis, which, in turn, would increase the estimated convenience premium. Thus, relaxing these assumptions would again strengthen the results in the paper. In summary, by making the most conservative assumptions about marginal tax rates, our approach ensures that inferences about the existence of convenience premia are robust.

10. CONCLUSION

Motivated by the strong revealed preference by investors for investment options that allow them to avoid taxation, we study whether market participants pay a premium for tax-exempt municipal bonds because of the tax convenience they offer. Using an extensive dataset of state-issued municipal bonds and controlling for credit risk and liquidity effects, we find a significant convenience premium in the prices of tax-exempt municipal bonds. This convenience premium is on the order of 15 basis points on average and is strongly related to the convenience premia observed in other fixed-income markets.

We show that these convenience premia are tax related in nature. In particular, we find that the convenience premia are strongly related to measures of tax and government spending uncertainty. Changes in the convenience premia have strong forecasting ability for subsequent flows into single-state municipal bond funds. We also find that changes in convenience premia are related to migration patterns from high-tax to low-tax states. Furthermore, the convenience premia are related to other types of actions that investors take to mitigate the impact of federal taxation on their portfolios, such as making IRA contributions, creating self-employed tax-deferred retirement plans, or claiming charitable contributions on Schedule A of IRS Form 1040. Finally, we use the passage of the Tax Cuts and Jobs Act in December 2017 and the associated limitation on the SALT deduction to identify an exogenous instrument for investor tax aversion. We find that this instrument is directly related to the cross-sectional impact of the reduction in federal tax rates on the convenience premia. These results all provide strong evidence that the convenience premia incorporated in the prices of tax-exempt municipal bonds are driven by investor concerns about taxation.

Three important implications emerge from this analysis. First, previous results show that investors often pay a premium for the safety and liquidity that Treasury securities provide. These results suggest that investors may also be willing to pay a premium for other types of convenience that some securities offer, such as freedom from taxation. Second, our results suggest that some municipal bond issuers may benefit from a form of seigniorage by issuing bonds that protect investors from the taxes that those issuers would otherwise levy. Third, these results also imply that corporate bond issuers may incur higher costs of debt capital by being unable to offer tax-protected debt to investors.

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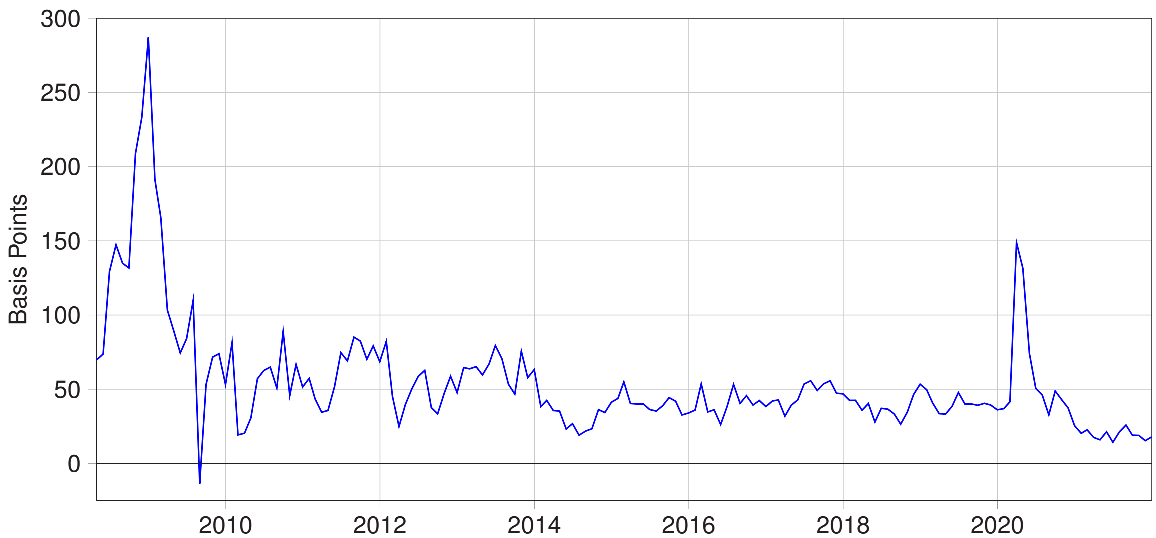

Figure 1. This graph shows the spread between the credit-adjusted yield of taxable municipal bonds and the credit-adjusted yield for matched-maturity Treasury securities.

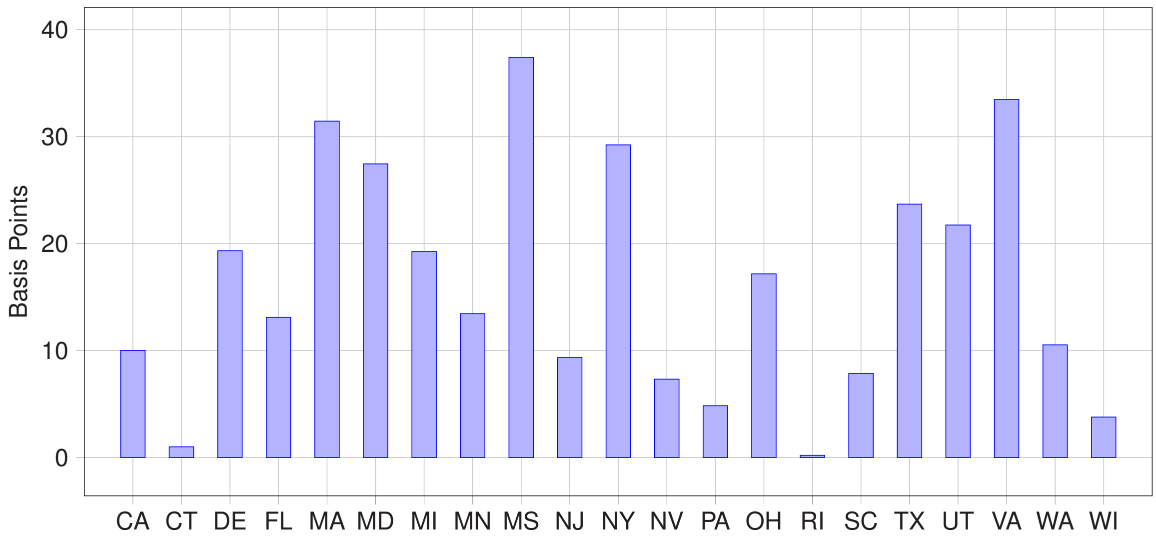

Figure 2. This graph shows the average convenience premium for the indicated states.

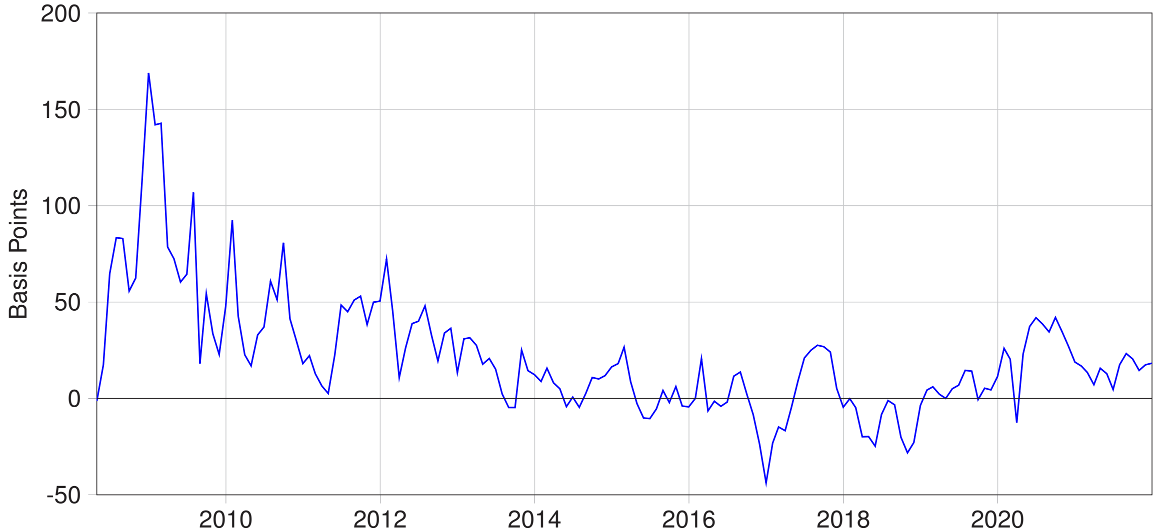

Figure 3. This graph shows the average convenience premium by month. The average is taken over all observations for all states each month.

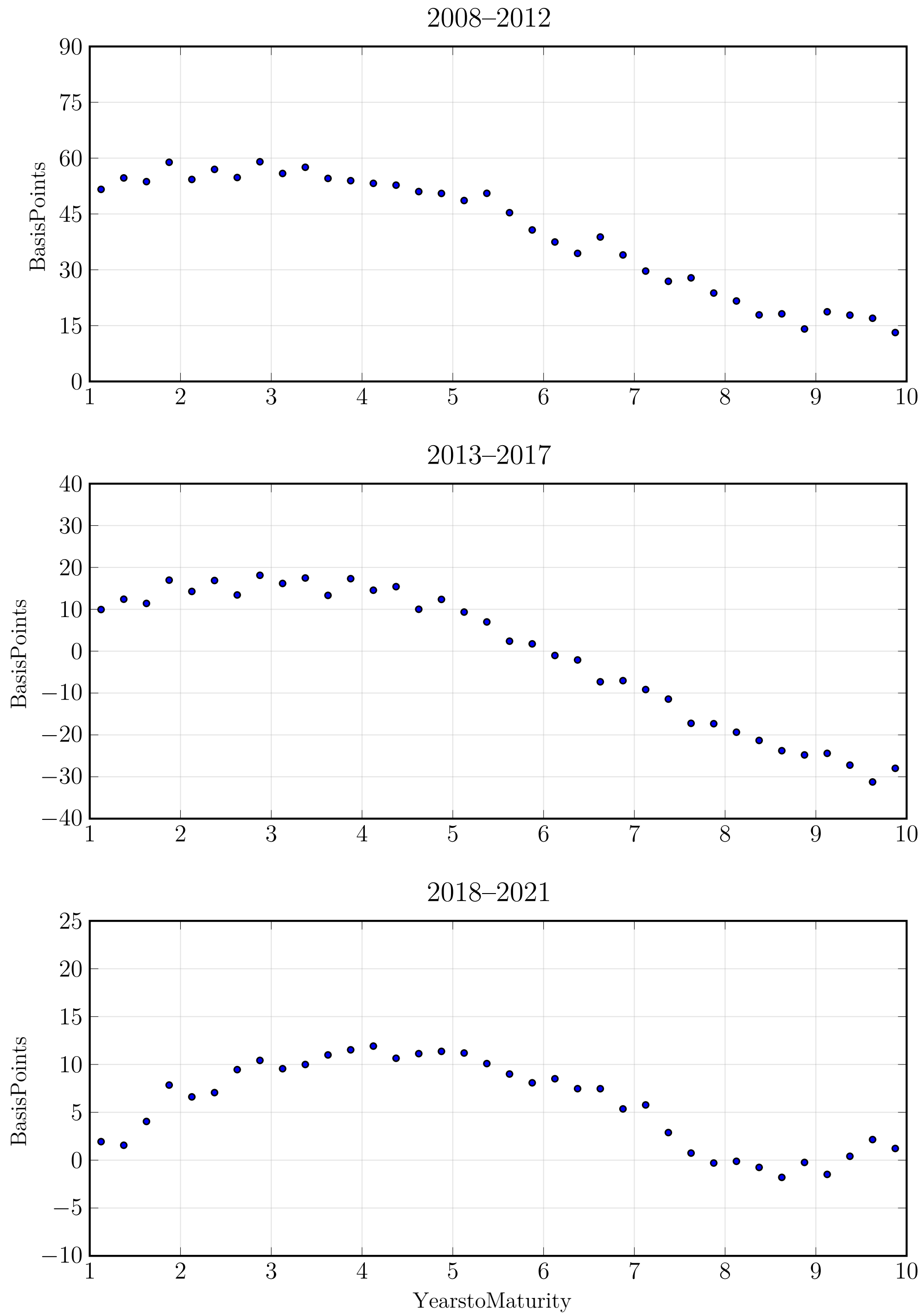

Figure 4. These plots show the average convenience premium across all states for quarterly maturity ranges. The top, middle, and lower panels plot the convenience premia for the 2008–2012, 2013–2017, and 2018–2021 periods, respectively.

Table 1

Summary Statistics for Tax-Exempt State-Issued Municipal Bond Yields. This table reports summary statistics for the yields of tax-exempt municipal bonds issued by the indicated states. Mean, Min, Median, and Max denote the average, minimum, median, and maximum yields, respectively. We match each municipal bond observation with an observation for a Treasury security with the same coupon rate and maturity as the municipal bond. Similarly, we match each municipal bond observation with an observation for a hypothetical par benchmark bond computed from the term structure of repo swap rates with the same maturity as the municipal bond. Trsy and Bench denote the average yields for these matched Treasury security and benchmark bond observations. N denotes the number of observations. Yields are expressed as a percentage. The sample is from April 1, 2008 to December 30, 2021.

	State-Issued Tax-Exempt Bonds						
State	Mean	Min	Med	Max	Trsy	Bench	N
California	1.644	0.041	1.512	7.480	1.497	1.380	133,102
Connecticut	1.658	0.044	1.625	5.191	1.450	1.311	47,128
Delaware	1.364	0.045	1.277	4.985	1.454	1.316	11,873
Florida	1.473	0.101	1.415	6.189	1.449	1.311	26,219
Maryland	1.358	0.041	1.253	5.100	1.442	1.330	44,530
Massachusetts	1.533	0.054	1.409	5.534	1.498	1.377	60,368
Michigan	1.764	0.141	1.684	5.396	1.559	1.456	5,352
Minnesota	1.301	0.054	1.224	4.857	1.339	1.208	30,305
Mississippi	1.632	0.043	1.562	5.145	1.540	1.431	6,987
Nevada	1.613	0.110	1.593	4.870	1.458	1.330	9,209
New Jersey	1.802	0.183	1.713	6.353	1.472	1.367	13,130
New York	1.453	0.084	1.320	5.797	1.334	1.256	10,645
Ohio	1.532	0.031	1.474	5.342	1.464	1.344	59,062
Pennsylvania	1.523	0.057	1.468	5.016	1.386	1.245	35,005
Rhode Island	1.514	0.061	1.453	5.799	1.422	1.280	4,187
South Carolina	1.352	0.072	1.322	4.988	1.448	1.292	6,924
Texas	1.522	0.061	1.450	5.865	1.465	1.354	27,872
Utah	1.039	0.046	0.902	3.886	1.027	0.904	7,546
Virginia	1.300	0.040	1.206	4.326	1.387	1.274	6,148
Washington	1.417	0.049	1.389	5.291	1.395	1.252	48,743
Wisconsin	1.441	0.069	1.415	4.743	1.436	1.296	26,797

Table 2

Summary Statistics for Taxable State-Issued Municipal Bond Yields. This table reports summary statistics for the yields of taxable municipal bonds issued by the indicated states. Mean, Min, Median, and Max denote the average, minimum, median, and maximum yields, respectively. We match each municipal bond observation with an observation for a Treasury security with the same coupon rate and maturity as the municipal bond. Similarly, we match each municipal bond observation with an observation for a hypothetical par benchmark bond computed from the term structure of repo swap rates with the same maturity as the municipal bond. Trsy and Bench denote the average yields for these matched Treasury security and benchmark bond observations. N denotes the number of observations. Yields are expressed as a percentage. The sample is from April 1, 2008 to December 30, 2021.

	State-Issued Taxable Bonds						
	Mean	Min	Med	Max	Trsy	Bench	N
California	1.909	0.185	1.850	8.725	1.333	1.173	3,580
Connecticut	2.362	0.207	2.398	5.109	1.561	1.371	4,393
Maryland	1.476	0.261	1.435	3.294	1.266	1.169	203
Massachusetts	1.836	0.249	1.857	3.354	1.485	1.326	250
Michigan	2.339	0.349	2.088	6.626	1.279	1.215	207
Minnesota	1.500	0.247	1.472	3.397	1.100	0.947	168
Mississippi	2.265	0.210	1.951	7.069	1.364	1.300	910
New Jersey	1.730	0.429	1.623	5.482	0.872	0.845	212
New York	2.518	0.294	2.459	6.146	1.734	1.629	899
Ohio	2.338	0.638	1.934	6.076	1.327	1.262	162
Rhode Island	2.509	0.441	2.424	4.849	1.679	1.523	277
Texas	1.976	0.171	2.036	4.863	1.481	1.301	2,139
Washington	1.809	0.137	1.726	4.037	1.268	1.141	633

Table 3

Summary Statistics for State Credit Default Swap Spreads. This table reports the average CDS spreads for the indicated states and maturities. The CDS spreads are expressed as basis points. The average CDS spreads are simple averages of the month-end values for the period from April 2008 to December 2021. First Month denotes the first month for which CDS spread data is available for the indicated state.

	CDS Maturity in Years								
State	1	2	3	5	7	10	15	20	First Month
California	68.93	81.17	93.58	111.71	127.10	141.58	150.99	156.43	Apr 2008
Connecticut	41.04	59.59	72.19	94.74	110.84	132.61	141.86	147.21	May 2009
Delaware	19.36	23.85	27.00	39.38	47.58	61.19	65.46	67.93	Oct 2009
Florida	48.55	54.29	59.42	67.36	77.00	91.99	98.82	102.23	May 2008
Maryland	34.79	39.54	45.20	52.92	60.65	71.83	76.84	79.74	Jun 2008
Massachusetts	44.23	49.53	59.71	71.20	81.27	96.91	106.06	111.24	Jun 2008
Michigan	57.79	65.76	74.10	93.02	106.28	119.29	127.61	132.42	May 2008
Minnesota	17.09	23.16	30.91	42.83	54.51	63.05	70.10	73.66	Nov 2010
Mississippi	123.75	125.50	127.74	134.12	137.01	155.89	166.77	173.05	May 2008
Nevada	48.58	56.21	64.58	78.07	88.21	106.64	114.08	118.38	May 2009
New Jersey	66.52	82.60	99.39	125.22	137.42	155.93	164.88	164.73	May 2008
New York	49.39	57.43	62.78	76.90	87.24	100.74	109.83	117.10	May 2008
Ohio	45.40	54.30	63.41	72.85	82.65	95.89	103.58	107.93	May 2008
Pennsylvania	32.45	41.55	54.60	76.64	89.24	115.91	124.00	128.68	Jul 2010
Rhode Island	26.60	39.86	53.83	68.09	81.48	99.20	106.13	110.12	Jan 2010
South Carolina	16.00	20.27	25.47	37.28	49.34	62.06	66.40	68.90	Jun 2012
Texas	30.00	33.75	39.38	53.13	64.61	76.36	87.27	92.09	May 2008
Utah	27.44	29.95	32.78	37.93	48.50	58.07	62.13	64.47	Jun 2012
Virginia	33.78	36.41	39.48	44.29	51.97	61.98	66.30	68.80	May 2009
Washington	17.48	23.68	30.95	46.56	58.52	70.66	78.30	82.03	Feb 2011
Wisconsin	26.35	32.13	37.33	49.08	61.75	74.52	79.72	82.73	Nov 2010

Table 4

The Liquidity Models. This table reports the results from the regressions used to parameterize the indicated liquidity models. For Liquidity Model 1, the dependent variable in the regression is the difference between the credit-adjusted yields of a taxable state-issued bond and a Treasury security with the same coupon rate and maturity as the taxable bond. For Liquidity Model 2, the dependent variable in the regression is the difference between the credit-adjusted yields on a taxable municipal bond issued by either Texas or Washington and a benchmark par bond with the same maturity as the taxable bond. Yields are expressed in basis points. Age and Maturity are measured in years. Trade Size is the average notional value per trade for the taxable municipal bond during the month of the observation expressed in millions of dollars. Trading Volume is the total notional value of the taxable municipal bond traded during the month of observation expressed in millions of dollars. Amount Issued is the total notional amount of the taxable bond issue expressed in millions of dollars. CDS spread is the CDS spread for the issuing state as of the end of the month of observation expressed in basis points. Standard errors are based on Liang and Zeger (1986) and clustered by year. The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is from April 1, 2008 to December 30, 2021.

	Liquidity Model 1		Liquidity Model 2	
Explanatory Variable	Coeff	t-Stat	Coeff	t-Stat
Age	4.4189	8.43**	3.3449	3.58**
Maturity	5.6560	8.36**	4.3098	4.82**
Trade Size	−0.7730	−2.51**	−1.0155	−2.30**
Trading Volume	−0.0305	−3.84**	−0.5063	−2.81**
Amount Issued	−0.0047	−1.09	0.0044	2.43**
CDS Spread	−0.2742	−5.86**	−0.1511	−0.77
Monthly Fixed Effects		Yes		Yes
Adj. R^2		0.5252		0.5301
N		14,033		2,769

Table 5

Summary Statistics for the Components of Tax-Exempt State-Issued Municipal Bond Yields. This table reports summary statistics for the decomposition of the tax-exempt state-issued municipal bond yields into separate components for the indicated states. Yield denotes the average observed bond yield. Credit denotes the average value of the credit-related component of the bond yield. Liquidity denotes the average value of the liquidity-related component of the bond yield. Net yield is the average credit-and-liquidity-adjusted bond yield and is calculated by subtracting the sum of the credit and liquidity components of the yield from the observed bond yield. Yields are expressed as a percentage. N denotes the number of observations. The sample period is from April 1, 2008 to December 30, 2021.

State	Yield	Credit	Liquidity	Adj. Yield	N
California	1.644	0.506	0.539	0.599	133,102
Connecticut	1.658	0.485	0.473	0.700	47,128
Delaware	1.364	0.223	0.627	0.514	11,873
Florida	1.473	0.278	0.549	0.646	26,219
Maryland	1.358	0.275	0.645	0.438	44,530
Massachusetts	1.533	0.377	0.691	0.465	60,368
Michigan	1.764	0.476	0.672	0.616	5,352
Minnesota	1.301	0.225	0.582	0.494	30,305
Mississippi	1.632	0.658	0.542	0.431	6,987
Nevada	1.613	0.358	0.542	0.713	9,209
New Jersey	1.802	0.617	0.552	0.634	13,130
New York	1.453	0.449	0.637	0.367	10,645
Ohio	1.532	0.367	0.609	0.556	59,062
Pennsylvania	1.523	0.379	0.525	0.619	35,005
Rhode Island	1.514	0.319	0.498	0.696	4,187
South Carolina	1.352	0.196	0.555	0.601	6,924
Texas	1.522	0.277	0.666	0.579	27,872
Utah	1.039	0.242	0.523	0.274	7,546
Virginia	1.300	0.282	0.634	0.384	6,148
Washington	1.417	0.236	0.555	0.627	48,743
Wisconsin	1.441	0.252	0.543	0.646	26,797
All	1.521	0.374	0.578	0.569	621,132

Table 6

Cross-Sectional Test for Convenience Premia. This table reports the results from the regression of the difference between the net yields for pairs of coupon and maturity-matched tax-exempt bonds from different states on the difference in the top marginal tax rates for those states. The difference in the net yields is expressed in basis points. The difference in the top marginal tax rates is expressed as a percentage. Standard errors are based on Liang and Zeger (1986) and clustered by month. The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is from April 1, 2008 to December 30, 2021.

Explanatory Variable	Coeff	t-Stat
Difference in Marginal Rates	0.5006	2.52**
Monthly Fixed Effects		Yes
Adj. R^2		0.073
N		236,583

Table 7

Summary Statistics for the Convenience Premia. This table reports the annual average values of the convenience premia in the state-issued tax-exempt municipal bonds for the indicated states and years. The last column reports the averages taken across all years by state. The last row reports the averages taken across all states by year. The value in the last row and column is the value taken over all states and years. The convenience premia are expressed in basis points. The sample period is from April 1, 2008 to December 30, 2021.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean
California	62.84	26.44	9.75	−0.44	20.43	7.97	0.18	3.90	−1.76	7.86	−14.41	1.61	29.45	14.31	10.02
Connecticut	–	79.50	54.72	48.55	38.63	13.06	4.76	−1.95	−20.05	−29.80	−46.57	−13.94	−4.17	14.28	1.01
Delaware	–	52.57	46.38	41.92	39.05	23.26	14.05	9.78	−1.61	11.56	−8.15	10.65	27.55	16.03	19.34
Florida	83.01	72.44	37.40	23.55	28.99	9.63	9.70	2.86	−6.21	10.60	2.30	15.89	22.27	14.60	13.11
Maryland	102.43	117.17	57.94	54.04	53.23	31.43	17.29	6.78	1.12	13.31	−18.18	3.99	32.87	14.57	27.46
Massachusetts	107.50	100.05	58.92	45.12	47.51	28.60	18.32	13.76	1.02	14.45	−4.53	15.16	36.20	23.33	31.45
Michigan	94.27	55.89	40.02	9.01	36.12	19.98	12.48	3.42	−8.64	6.45	−13.36	7.06	26.59	12.95	19.27
Minnesota	–	–	33.07	42.67	38.81	22.86	9.59	3.74	−2.95	9.09	−16.31	2.21	25.15	10.92	13.45
Mississippi	100.09	99.43	68.20	65.55	53.56	24.14	28.01	27.63	39.82	33.72	−3.31	12.12	32.54	25.19	37.41
Nevada	–	32.17	32.29	−2.80	7.00	−0.25	−6.19	−2.63	−6.03	10.74	3.57	16.69	20.39	16.90	7.33
New Jersey	105.94	99.69	53.44	23.35	41.49	23.06	9.22	−21.99	−25.63	−24.43	−32.87	−10.22	−17.74	−7.95	9.35
New York	86.19	90.15	57.84	32.58	39.83	13.56	7.16	8.67	4.69	19.85	−13.39	8.39	20.04	12.05	29.23
Ohio	96.01	84.88	44.91	30.29	30.31	9.06	3.51	1.53	−2.71	10.25	−11.25	8.01	26.95	16.24	17.18
Pennsylvania	–	–	49.18	36.22	38.63	12.83	1.54	−8.54	−20.21	−8.10	−26.97	1.09	18.82	18.42	4.85
Rhode Island	–	–	23.64	3.27	2.98	0.83	−14.52	−14.31	−14.62	0.75	−12.19	6.44	7.23	16.65	0.21
South Carolina	–	–	–	–	37.92	18.13	5.87	3.39	−3.09	7.62	−10.12	10.39	24.05	16.29	7.86
Texas	98.11	86.81	47.45	38.15	35.14	19.22	14.29	2.42	−4.00	12.32	3.78	17.00	23.82	15.36	23.69
Utah	–	–	–	–	39.04	34.80	30.20	21.03	9.45	16.74	−9.58	10.60	28.64	13.70	21.74
Virginia	–	97.16	66.53	59.38	45.62	29.30	14.83	8.93	3.82	18.29	−2.35	19.16	26.18	17.94	33.48
Washington	–	–	–	30.69	25.84	14.37	3.49	−2.16	−9.68	10.14	2.88	16.43	24.73	12.85	10.54
Wisconsin	–	–	15.44	22.38	24.97	4.30	−1.75	−6.06	−11.06	7.95	−14.88	2.18	20.27	12.34	3.79
Mean	83.60	69.85	41.90	31.68	33.86	15.71	6.72	2.03	−5.91	4.67	−13.31	5.92	23.91	14.90	14.87

Table 8

Regression of the Convenience Premium in the Tax-Exempt Municipal Bond Market on Convenience Premium Measures from Other Markets. This table reports the results from the regression of the monthly average convenience premium in the tax-exempt municipal bond market on convenience premium measures from other markets. The monthly average is the simple average taken over all observations for all states each month. Repo Spread is the difference between the three-month general collateral repo rate and the three-month treasury bill yield. TED Spread is the difference between the three-month Treasury bill yield and the three-month U.S. Libor rate. Swap Spread is the two-year Libor-based swap spread. AAA Spread is the difference between the yield of the Bloomberg index of AAA-rated corporate bonds and the yield on ten-year Treasury notes. Treasury Richness is the Fleckenstein and Longstaff (2023) Treasury richness measure for Treasury securities with maturities less than or equal to ten years. Refcorp Spread is the difference between the yields of Refcorp and Treasury bonds with maturities less than or equal to ten years. Agency MBS Spread is the option-adjusted yield spread between Agency MBS and Treasury notes. All variables are expressed in basis points. Standard errors are based on Newey and West (1987). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is monthly from April 2008 to December 2021.

	Coeff	t-Stat
Intercept	−54.8344	−7.24**
Repo Spread	−0.1406	−1.26
TED Spread	−0.4506	−6.09**
Swap Spread	0.4000	2.34**
AAA Spread	0.1753	3.27**
Treasury Richness	0.4304	2.43**
Refcorp Spread	0.6934	7.20**
Agency MBS Spread	0.3651	3.34**
Adj. R^2		0.7006
N		165

Table 9

Regression of the Convenience Premium on Risk and Uncertainty Measures. This table reports the results from the regression of the monthly average convenience premium in the tax-exempt municipal bond market on the indicated variables. The monthly average is the simple average taken over all observations for all states each month and is measured in basis points. VIX Index is the Chicago Board Options Exchange (CBOE) Index of S&P 500 option-implied volatility. MOVE Index is the Intercontinental Exchange's U.S. Treasury volatility index. Tax Uncertainty, Gov Spending Uncertainty, and Economic Uncertainty are the Baker, Bloom, and Davis (2016) indicies of tax undercertainty, government spending uncertainty, and economic policy uncertainty, respectively. Standard errors are based on Newey and West (1987). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is monthly from April 2008 to December 2021.

	Coeff	t-Stat
Intercept	−33.0001	−4.35**
VIX Index	0.8001	1.67*
MOVE Index	0.4332	3.69**
Tax Uncertainty	0.1425	3.34**
Gov Spending Uncertainty	0.0250	2.07**
Economic Uncertainty	−0.1156	−2.45**
Adj. R^2		0.5411
N		165

Table 10

Results from the Convenience Premium and State Municipal Bond Funds Net Fund Flows Regressions. Panel A reports the results from the panel regressions of net flows into individual state municipal bond funds on the indicated lagged and contemporaneous changes in the average monthly convenience premium for the corresponding state. A state municipal bond fund is an open-ended mutual fund that invests exclusively in the tax-exempt municipal bonds of a specific state. The states in the sample for which there are state municipal bond funds are California, Connecticut, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Utah, Virginia, and Wisconsin. Panel B reports the results from the panel regressions of changes in the average monthly convenience premium for individual states on the indicated lagged and contemporaneous net flows into state municipal bond funds for the corresponding state. The convenience premium is expressed in basis points. Net fund flows are expressed in millions. Standard errors are based on White (1980). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is monthly from April 1, 2008 to December 30, 2021.

Panel A: Net Flow Regression	Coeff	t-Stat	Coeff	t-Stat
Net Flow_{t-1}	0.3985	3.13**	0.4040	3.19**
Net Flow_{t-2}	0.0167	0.15	0.0269	0.23
Net Flow_{t-3}	0.0990	1.79*	0.0923	1.64
Δ Premium_t	–	–	0.5783	5.29**
Δ Premium_{t-1}	0.3109	2.46**	0.3937	3.01**
Δ Premium_{t-2}	0.2337	2.23**	0.3099	2.94**
Δ Premium_{t-3}	0.2032	2.46**	0.3086	3.69**
State Fixed Effects		Yes		Yes
Adj. R^2		0.2416		0.2522
N		2,331		2,331
Panel B: Δ Premium Regression	Coeff	t-Stat	Coeff	t-Stat
Δ Premium_{t-1}	−0.1431	−4.19**	−0.1509	−4.41**
Δ Premium_{t-2}	−0.1317	−5.32**	−0.1375	−5.54**
Δ Premium_{t-3}	−0.1823	−7.06**	−0.1874	−7.25**
Net Flow_t	–	–	0.0250	3.86**
Net Flow_{t-1}	−0.0096	−1.75*	−0.0196	−3.02**
Net Flow_{t-1}	−0.0176	−3.24**	−0.0180	−3.00**
Net Flow_{t-1}	0.0117	2.21**	0.0092	1.60
State Fixed Effects		Yes		Yes
Adj. R^2		0.0675		0.8060
N		2,331		2,331

Table 11

Regression of Changes in the Convenience Premia on State-Level Migration Flows. This table reports the results from the panel regression of annual changes (year-end to year-end) in the convenience premium for individual states on the percentage of that state's population that moved to one of the seven states without a state income tax. The states without a state income tax are Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming. Convenience premia are expressed in basis points. Standard errors are based on White (1980). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is annual from 2008 to 2019.

	Coeff	t-Stat
Migration	95.8377	2.30**
State Fixed Effects		Yes
Adj. R^2		0.0550
N		208

Table 12

Regression of the Convenience Premium on Tax-Minimizing Strategies. This table reports the results from the regression of the year-end convenience premia for individual states on the percentage of tax returns for each state that include an IRA contribution, include a self-employed retirement plan, itemize deductions, or include charitable contributions on Schedule A. Data are from the Internal Revenue Service Statistics of Income reports. Standard errors are based on White (1980). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is annual from 2008 to 2020.

	Coef	t-Stat	Coef	t-Stat	Coef	t-Stat	Coef	t-Stat
IRA Contribution	68.0388	4.07**	–	–	–	–	–	–
Tax-Deferred Retirement	–	–	89.4155	2.20**	–	–	–	–
Charitable Contribution	–	–	–	–	1.2941	2.48**	–	–
Itemized Deductions	–	–	–	–	–	–	0.8394	1.73*
State Fixed Effects		Yes		Yes		Yes		Yes
Year Fixed Effects		Yes		Yes		Yes		Yes
Adj. R^2		0.8238		0.9166		0.9165		0.9154
N		240		250		250		250

Table 13

SALT Limitation Event Study. This table reports the results from the cross-sectional regression of the change in the convenience premium from September 2017 to March 2018 for the individual states on the percentage change in state and local tax (SALT) deduction per income tax return for that state between the 2017 and 2018 tax years. Data are from the Internal Revenue Service Statistics of Income reports. The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively.

	Coeff	t-Stat
Intercept	−37.9883	−9.33
Δ SALT Deduction	25.4430	2.06**
Adj. R^2		0.1391
N		21

Table 14

Percentage of Implied Forward Tax Rates Exceeding 100 Percent. This table reports the percentage of implied forward tax rates greater than 100 percent for the indicated maturity categories. Implied forward tax rates are calculated by solving for the forward tax rate implied by the difference between the net yield of the tax-exempt municipal bond and the yield of the corresponding taxable benchmark bond, and using the current maximum combined federal and state tax rate over the next year. Implied forward tax rates are annualized and expressed as a percentage. The column Implied Forward Tax Rate > 100 Percent presents the percentage of observations where the implied forward tax rate is greater than 100 percent for municipal bonds with remaining maturities in the indicated maturity ranges.

Maturity Range	Implied Forward Tax Rate > 100 Percent
1–2 Years	53.26
2–3 Years	44.05
3–4 Years	35.05
4–5 Years	25.20
5–6 Years	17.51
6–7 Years	10.96
7–8 Years	6.76
8–9 Years	4.64
9–10 Years	3.91

INTERNET APPENDIX

DO MUNICIPAL BOND INVESTORS PAY A CONVENIENCE PREMIUM TO AVOID TAXES?

Matthias Fleckenstein
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INTERNET APPENDIX

A.1 Taxation

This section provides an overview of the Federal and state income taxation of tax-exempt and taxable municipal bonds.

A.1.1 History of Federal Income Taxation

The Revenue Act of 1913. In July 1909, U.S. Congress passed the 16th Amendment to the Constitution, allowing it to collect income taxes. This amendment was ratified by the requisite two-thirds of the states in February 1913. In October 1913, Congress passed the Revenue Act of 1913, which laid the groundwork for the federal income tax system that prevails today. The Act established a progressive income tax system with six brackets. The first $3,000 ($4,000) of income for single-filers (married couples) was exempt. The lowest marginal income tax rate of 1% applied to all incomes up to $20,000. Thereafter, marginal rates increased by 1% at income levels of $20,000, $50,000, $75,000, $100,000, $250,000 and $500,000, respectively. The top marginal income tax rate of 7% applied to all incomes above $500,000.[1]

Federal Income Taxes from 1913 to Post World War II. The U.S. entry into World War I, prompted a change in the federal income tax code. The Revenue Act of 1916 raised the lowest marginal income tax rate from 1% to 3% and the top marginal income tax rate from 7% to 15%. The Act also established a federal estate tax and taxes on dividend income. In response to mounting wartime expenditures, Congress increased federal income taxes in 1917. The lowest and highest individual marginal income tax rate increased to 4% and 67%, respectively (the top rate applied to taxpayers with incomes above $2 million). The Revenue Act of 1918 raised the top individual tax rate from 67% to 77%, which applied to earnings in excess of $1 million (down from $2 million in 1917). The top rate was reduced to 58% in 1922, to 25% in 1925, and finally to 24% in 1929. In 1932 the top marginal federal income tax rate was again increased to 63% during the Great Depression, and it reached 94% in 1944 (on incomes over $200,000). Over the next three decades, the top federal income tax rate never dipped below 70%. The Economic Recovery Tax Act of 1981 cut the top marginal rate from 70% to 50%. The Tax Reform Act of 1986 lowered the top income tax rate to 28% for tax years beginning in 1988. During the 1990s, the

[1]The ratio of the top-to-bottom marginal income tax rate was 3.5 to 1, which is roughly the same as today's (37% to 10%).

top rate was raised again to 39.6%.[2]

Federal Income Taxes in the 21st Century. The Economic Growth and Tax Relief and Reconciliation Act of 2001 lowered the top federal income tax rate to 35% from 2003 to 2010, and the Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act of 2010 maintained the 35% top tax rate through 2012. The American Taxpayer Relief Act of 2012 increased in the top federal income tax rate to 39.6%. In addition, the Patient Protection and Affordable Care Act (ACA) added an additional 3.8% net investment income tax (NIIT) on investment income on top of the 39.6% beginning in 2013, thus resulting in a maximum federal income tax rate of 43.4%. The Tax Cut and Jobs Act (TCJA) reduced the top federal income tax rate to 37% for tax years beginning in 2018, but the 3.8% surtax from the Patient Protection and Affordable Care Act remained in place, thus resulting in a top federal income tax rate of 40.8%. Table A1 reports the maximum Federal income tax rates for all 21 states in the sample, as well as the NIIT, if applicable, for all years over the period from 2008 to 2021.

State Income Taxation in the 21st Century. Interest income from bond investments is generally taxable at the Federal, as well as at the state and local levels. As of year-end 2022, all but seven states impose some form of tax on interest income. These seven states are Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming. New Hampshire and Tennessee tax the income from interest and dividends only. The Tax Cut and Jobs Act (TCJA) of 2017 changed the total combined Federal and state and local tax burden faced by U.S. taxpayers by capping the Federal income tax deduction for state and local taxes (SALT) to a maximum of $10,000 for tax years starting in 2018. To illustrate, let τ denote the top marginal federal income tax rate, and let τ_s denote the top marginal state tax rate. Prior to the TCJA, state and local income taxes were deductible from Federal income taxes, which meant that one dollar of pre-tax income resulted in $(1 - \tau_s) \times (1 - \tau)$ in after-tax income. The TCJA limits this deductibility to $10,000 which means that one dollar of pre-tax income above $10,000 now results in $(1 - (\tau + \tau_s))$ in after-tax income. Table A1 of the Internet Appendix reports the top marginal state tax rates for each year and each state in the sample and the SALT limitation for tax years starting in 2018.

A.1.2 Taxation of Tax-Exempt Bonds

The interest paid on municipal bonds to an investor is not subject to income tax levied by the federal government. The constitutional basis for the federal exemption for municipal bonds dates back to 1895 (Supreme Court case of Pollack v.

[2]A detailed account of the history of federal taxation in the United States, see Brownlee (2004).

Farmers' Loan and Trust Company, 157 US 429 (1895), affirmed on rehearing, 158 US 601 (1895)). The Supreme Court interpreted federal taxes on municipal bonds as a nondiscriminatory direct tax which was unconstitutional according to Article I, Section 2, Clause 3 of the Constitution of the United States. The Revenue Act of 1913, which established the first federal tax code, maintained the federal income tax exemption for interest income from municipal bonds on the constitutional basis that neither the federal government nor the states may tax interest income from securities issued by the other (Glass (1946)). In 1988, however, the Supreme Court overturned the constitutional basis for the tax exemption of municipal bonds in South Carolina v. Baker (485 U.S. 505), and, as a result, the tax exemption now rests with Congress and is no longer protected by the U.S. Constitution. However, Congress has since preserved the tax exemption through legislation. The federal tax exemption on municipal bonds is codified in Internal Revenue Code (IRC) §103(a), which exempts any interest received from municipal bonds from gross investment income that is subject to federal tax.

While the interest income on municipal bonds is not subject to income tax levied by the federal government, it may be subject to state income tax if an investor holds municipal bonds issued by states where the investor is not considered to be a resident. While the practice of states exempting interest on their own bonds from state tax and taxing residents for interest on bonds issued by other states was challenged in 2006 by the Kentucky Court of Appeals, it was upheld in 2008 by the U.S. Supreme Court in Kentucky v. Davis (553 U.S. 328). There are, however, exceptions to this rule. First, as discussed in Section A.1.1 above, some states do not levy state income taxes at all. Second, Oklahoma, Illinois, Iowa, and Wisconsin levy taxes on interest income from both in- and out-of-state municipal bonds, and one state plus the District of Columbia exempt all municipal bond interest income from state taxes. Third, interest income from bonds issued by U.S. territories such as Puerto Rico and Guam is not taxable in any state. Fourth, some states follow the concept of "reciprocity in taxation." For instance, an investor in Utah is not taxed on interest income earned on municipal bonds issued by a state which levies no taxes on bonds issued by the State of Utah.

A.1.3 Taxation of Taxable Bonds

Interest income on some municipal bonds is subject to federal income taxes. In general, when the proceeds of a municipal bond issue are used to fund private businesses or trade, interest income on those bonds is subject to federal taxes, unless some specific criteria are met. More specifically, a "private activity bond" (PAB) is subject to taxes at the federal level if any of the three tests are met: the "private loan test," the "private business tests," and a special test relating to bonds issues in excess of $150 million.[3]

First, municipal bonds meet the private loan test (and are PABs) if more than the lesser of 5% of the proceeds of the bond issue or $5 million of the proceeds is loaned directly or indirectly to one or more persons who are not states or political subdivisions or instrumentalities of states or political subdivisions.

Second, municipal bonds are also treated as PABs if they meet both of the private business tests. Municipal bonds meet the "private business use test" if more than 10% of the proceeds are used (directly or indirectly) in the private trade or business of one or more nongovernmental persons. Municipal bonds meet the "private payment/security" test if either (1) the bonds are secured by any interest in property used or to be used for a private business use and such security is more than 10% of the amount of the bonds; or (2) payments are to be made (directly or indirectly) by one or more nongovernmental persons using bond-financed property and such payments have a present value that is more than 10% of the amount of the bonds.

Third, even if the private business use portion of a bond issue meets the 10% limit for a bond issue in excess of $150 million, the bonds will nonetheless be treated as PABs if the private business use and private security or payment for the bonds exceeds $15 million. Thus, for any bond issue with an issue amount of more than $150,000,000, the private business use limitation is effectively $15 million unless the state allocates the bond towards the PAB volume cap.[4] Municipal bonds issued to fund unfunded parts of public pension obligations (pension obligation bonds) are also subject to federal taxes, and the interest income on Build America Bonds, which were issued under the American Recovery and Reinvestment Act is also taxable at the federal level.

While the market for taxable municipal bonds is small relative to the tax-exempt municipal bond market, there has been an increase in the issuance of taxable municipal bonds in the post-crisis period, particularly after the TCJA of 2017. Between 1986 and 2009, taxable municipal bond issuance was relatively

[3]For a more detailed discussion on PABs, see Feldstein and Fabozzi (2008), Chapter 7, and Congressional Research Service RL31457, available at https://crsreports.congress.gov.

[4]Some PABs are eligible for federal tax exemption if they are used to fund specific "qualified" purposes such as airports, docks, or wharves. However, the IRS limits the amount of tax-exempt PABs that can be issued by each state each year ("volume cap"). The volume cap for 2021 was set such that each state could only issue up to the greater of $110 per capita or $325 million of qualified PABs (see 26 CFR 601.602).

stable between 3% and 7% of the total municipal bond market issuance. In 2020, taxable municipal bonds accounted for about 30% of total municipal debt issuance, compared to less than 10% per year in the post-crisis period (SIFMA (2021)). One reason for this increase in taxable municipal bond issuance could be the TCJA of 2017. Prior to the TCJA, a municipality with an outstanding not-yet-callable bond issue could issue a new tax-exempt bond through a process referred to as "advance refunding." Specifically, the municipality issues a new bond with a lower coupon rate and then puts the proceeds from the new debt sale into a trust which invests in Treasury securities (so-called "State and Local Government Series Treasury Securities (SLGS)") that are then used to defease the remaining coupon payments on the existing bond up to the call date as well as the call price for the bond.[5] The TCJA disallowed municipalities to advance-refund tax-exempt debt using tax-exempt debt, and thus the new debt issued in a refunding transaction is now taxable at the federal level.

A.2 The Data

This section describes how we construct a comprehensive dataset of state-issued general obligation bond market prices. Table A2 provides a description of all the data and variables used in the study, along with their definitions and corresponding sources.

A.2.1 Municipal Bond Data

We manually collect data on state-issued general obligation bonds from Bloomberg via the Bloomberg Fixed Income Search function on the terminal. Since we control for the credit risk of a state-issued general obligation bond using credit default swaps (CDS) in our analyses, we select states for which CDS are traded in the financial markets. This leads to a set of 21 states.[6]

In the Fixed Income Search menu on the Bloomberg terminal, we first select "Municipals" under asset classes, and under the "Search Fields" section, we input the issuer name, state code, and ticker corresponding to the name of the state

[5] Section 149 of the Internal Revenue Code requires that the bond being advance refunded be called at its earliest call date for the refunding bond to retain the tax-exempt status of the existing debt.

[6] California, Connecticut, Delaware, Florida, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nevada, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin.

(e.g., California). Next, we set “Muni Industry” to general obligation to restrict the search results to state-issued general obligation bonds. We exclude bonds with call and put features, sinking fund provisions, and make-whole provisions by setting the corresponding exclude-filters in the Search Fields section. In addition, we filter out insured bonds, 144A securities, and municipal bonds subject to extraordinary redemption provisions (ERP).[7] We exclude bonds that are pre-refunded and floating rate securities. Thus, all bonds in our dataset are fixed-rate coupon bonds with semi-annual coupon cash flows. For each municipal bond issue returned by running this search, we collect the CUSIP, the issue and maturity date, the amount issued and the price at issue, the coupon rate, coupon type and the day-count convention, the funding source of the municipal bond (the state’s general fund), the tax provision (i.e., whether the bond is taxable or tax-exempt), and the credit rating at issue by S&P and Moody’s. Following Ang, Bhansali, and Xing (2010) and Schwert (2017), we remove municipal bonds subject to the alternative minimum tax (AMT) and municipal bonds with original issue discount (OID) by inspecting the fields “Tax Provision” and “Coupon Type” in the search results, respectively.

In the next step, we supplement the bond-specific information from Bloomberg, using a comprehensive historical dataset of municipal bond transaction prices from the Municipal Securities Rulemaking Board (MSRB) that covers the period from January 2005 to December 2021, which we download from the Wharton Research Data Services (WRDS) database. The MSRB requires dealers to report all municipal bond transactions, including interdealer trades, and transactions with customers. This dataset includes the bond CUSIP, the date and time of the trade, the transaction price, the issue and maturity date of the bond, the coupon rate, an indicator for whether the trade was a when-issued trade, and a categorical variable indicating whether the trade is a sale to a customer, a purchase from a customer, or an interdealer trade. Following Schwert (2017), we exclude all bond trades with less than one year to maturity from this transactions dataset.

Lastly, we collapse the municipal bond intraday transactions dataset by constructing one single “midpoint” price per day for each bond that traded on that day. Specifically, we follow following Green, Li, and Schürhoff (2010) and Schwert (2017) and construct the daily midpoint price by calculating the average of the highest price on customer sales and the lowest price on customer purchases

[7]Rule 144A allows states to sell municipal bond issues directly to “qualified institutional buyers,“ as defined in SEC Rule 144A under the Securities Act of 1933. An ERP gives the issuer the right to call a bond due to an unusual one-time event. An example would be a catastrophe that destroys the project financed with the proceeds of the bond issue.

on each day.[8] If only interdealer transactions are observed on a given day, then the daily midpoint price is the simple average of interdealer prices. Using the daily midprice, we then calculate the bond's yield to maturity using standard conventions.

A.2.2 Repo Swap Data

We match each general obligation municipal bond with a riskfree benchmark bond that we obtain from the term structure of fixed-for-floating interest rate swaps in which the floating leg of the swap is based on the overnight repo rate.

Repo swaps with maturities of less than one year pay a single cash flow on the fixed leg and the floating leg at maturity. The cash flow on the floating leg is based on the geometrically compounded overnight repo rate. For longer-dated swaps, both the fixed and floating legs have annual cash flows. To illustrate, consider a one-year repo swap with a notional amount of $100 and a quoted swap rate of 1.200%. In one year (365 days), the fixed rate payer pays 1.200/360 = 1.21667 and receives the compounded overnight repo rate for 365 days (the day-count convention for repo swaps is actual/360).

We collect daily term structures of repo swap rates for the period from January 2008 to December 2021 from Bloomberg. Since (indicative and/or official) SOFR rates have only been published since 2014, we follow Fleckenstein and Longstaff (2023) and extend the repo swap dataset to January 2008 by making minor adjustments to the rates for OIS swaps which are based on the overnight fed funds rate.[9] The resulting dataset consists of daily observations of repo swap rates for 1, 3, and 6-month, and 1, 2, 3, 5, 7, 10, 15, 20, and 30-year maturities.

Next, we bootstrap the riskfree discount function at the daily frequency from the term structure of repo swap rates using the methodology described in Longstaff, Mithal, and Neis (2005) and Fleckenstein and Longstaff (2023). With this riskfree discounting curve, we then calculate the price of a hypothetical riskfree bond with the same cash flows and maturity date as the municipal bond simply by discounting the bond's cash flows. We also calculate the yield to maturity of this matched-coupon matched-maturity riskfree bond using standard conventions.

[8] If there are only customer buys (sells) and interdealer trades, we construct the daily midpoint price by calculating the midpoint of the highest (lowest) price on customer buys (sells) and the average price of interdealer transactions.

[9] For a detailed description of all the steps, see Fleckenstein and Longstaff (2023) and the accompanying Internet Appendix.

A.2.3 Credit Default Swap Data

To control for the impact of credit risk on municipal bond yields we collect CDS data for contracts referencing the debt of individual U.S. states.[10] For the period starting in January 2008, we are able to collect CDS data for the 21 states listed in Section A.3.1 above.[11] For each state, we collect daily CDS term structures with tenors of 1, 2, 3, 5, 7, 10, 15 and 20 years.

A.2.4 Fund Flows

We collect monthly net-asset values of state-specific open-end mutual funds for California, Connecticut, Delaware, Florida, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nevada, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin. To do this, we first search the Bloomberg system for all single-state open-end municipal bond funds in the U.S. that are active at the end of our sample period in December 2021. We then use the resulting set of funds and collect their monthly net asset values from the Bloomberg system. This data is furnished by the Investment Company Institute (ICI). We also collect monthly returns for the set of state-specific open-end mutual funds from the WRDS database. We then estimate monthly flows into state municipal bond funds as follows:

$$\text{Flow}_{j,t} = \text{TNA}_{j,t} - \text{TNA}_{j,t-1}\,(1 + r_{j,t})\,,$$

where $\text{TNA}_{j,t}$ is fund j's total net asset value, and $r_{j,t}$ is the monthly return of fund j at month t.

A.2.5 State Migration

We collect data on state-to-state population migration flows from the U.S. Census Bureau.[12] This dataset is a cross-tabulation of the total number of residents living in each state at year-end and the state of residence in the prior year. We then calculate for each state the number of individuals moving from the state to another state that levies no state income taxes. The states without state-level

[10] It is important to note that by using state-issued general obligation municipal bonds, we can measure the cost of protecting against default on these bonds directly via the CDS spreads for the issuing state.

[11] CDS data are not available for all 50 states.

[12] See https://www.census.gov/topics/population/migration/guidance/state-to-state-migration-flows.html.

income taxes during the 2008 to 2021 sample period are Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming.

A.2.6 Tax Return Data

We collect tax return data from the Internal Revenue Service's (IRS) statement of income (SOI) reports for each state for the 2008 to 2020 period.[13] For each state and year, we collect the total number of returns (Variable N1), the number of returns with self-employment retirement plans (Variable N03300), the number of returns with charitable contributions (Variable N19700), the number of returns with with IRA contributions (Variable N03150), and the number of returns with itemized deductions (Variable N04470). We also collect the number of returns with taxes paid (Variable N18300), and the total amount paid (Variable A18300).

A.3 Controlling for Credit and Liquidity

This section first provides some background about credit risk and defaults in municipal bond markets in the United States. We then describe the methodology used to control for credit and liquidity effects embedded in municipal bonds yields.

A.3.1 Credit Risk of Municipal Bonds

U.S. states have defaulted on their municipal debt issues in the past. In the 1830s and 1840s, several states issued debt to finance canals and railroads, and eight states and one territory ended up in default: Arkansas, Florida Territory, Illinois, Indiana, Louisiana, Maryland, Michigan, Mississippi, and Pennsylvania.[14] After the Civil War during the 1870s and 1880s, a second wave of state defaults took place where ten states defaulted: Alabama, Arkansas, Florida, Georgia, Louisiana, Minnesota, North Carolina, South Carolina, Tennessee, and Virginia. Arkansas defaulted three times, with its third and last default to date occurring in 1933 during the Great Depression. Arkansas is also the only state to default in the 20$^{\text{th}}$ century. More recently, New York City came perilously close to bankruptcy in 1975, and Puerto Rico defaulted five times between 2015 and 2016. The latter is the largest-ever default of a U.S. government to date.

[13]See https://www.irs.gov/statistics/soi-tax-stats-historic-table-2. The SOI tables are available through year-end 2020 at the time of writing.

[14]Florida Territory and Mississippi repudiated their debt completely. For a detailed account of these events, see McGrane (1935).

Since the history of state debt in the U.S. is marked by episodes of explicit defaults, it is also important to recognize that investors in defaulted state debt have little redress to settle their claims. To understand this, note first that the 11th Amendment to the U.S. Constitution guarantees that state debt is sovereign debt, and as such, there is no bankruptcy mechanism for handling state default in the U.S. Thus, just as individual investors cannot claim the assets of the federal government, investors cannot seize state property (Ang and Longstaff (2013)).[15] In fact, when some states defaulted, the partial or complete repudiation of their debts was even placed in states' constitutions, or legislation was passed prohibiting payment (Ang and Longstaff (2013)). For instance, when Florida became a U.S. state, it wiped out its debt by legislative fiat, and its legislature voted that it did not bear liability for debts incurred while Florida was still a territory (see McGrane (1935)). Bayliss (1964) reports that the first amendment to the Arkansas constitution in 1875 made it illegal to ever pay the interest or principal on the defaulted state railroad and levee bonds associated with its default in 1841. In addition, in all defaulting state cases so far, the federal government did not step in to make investors whole (Ang and Longstaff (2013)).

A.3.2 Credit-Adjustment for Municipal Bonds and Treasury Securities

The intuition behind our approach to adjust municipal bond yields for credit risk is that the combination of a municipal bond with a CDS contract protecting against the default of the issuer is essentially the same as a riskfree bond. Thus, we will control for the impact of credit risk on municipal bond yields by adjusting the observed municipal bond yields using the spreads on CDS contracts referencing the debt of the issuer.

To illustrate the approach, consider a state-issued general obligation bond with maturity T and market price P.[16] We begin by first interpolating the term structure of CDS spreads for contracts written on the issuing state of the bond. Let the linearly interpolated CDS spread for maturity T be s.

Next, we solve for the present value of the cash flows associated with entering into the CDS position. In doing so, we assume that the marginal investor in the CDS market is a corporate entity. This implies that the market price for the default risk of the bond is given by taking the sum of the present values of the CDS spread times $(1 - \tau_c)$.

[15] Local municipalities in certain states can enter Chapter 9 of the Bankruptcy Code, similar to Chapter 11 for corporations. However, this does not apply to states.

[16] The approach for adjusting Treasury securities for credit risk is completely analogous, as we discuss below.

To illustrate, assume that the default intensity of the issuing state is a constant λ, that the loss given default is w, and that the default event is independent of interest rates.[17] The present value of the CDS protection leg is given by

$$w \int_0^T \lambda e^{-\lambda t} D(t) dt, \tag{A1}$$

where $D(t)$ denotes the time t discount function, i.e., the present value of a \$1 cash flow pre-tax to be received at time t. The present value of the CDS premium leg is given by

$$s \int_0^T e^{-\lambda t} D(t) dt. \tag{A2}$$

Setting the present value of the protection leg equal to the present value of the premium leg implies $\lambda = s/w$.[18]

Next, let $d(t)$ denote the present value of a \$1 after-tax cash flow to be received at time-t to a corporate entity with marginal tax rate τ_c. We describe how we bootstrap the $d(t)$ function from the term structure of repo swaps in Section A.3.3 below. We set τ_c equal to 35 percent for the period from 2008 to 2017 and use 21 percent for the period from 2018 to 2021.

Solving for the present value X of executing the CDS contract is now straight-forward, with X given by

$$X = s(1 - \tau_c) \int_0^T e^{-\lambda t} d(t) dt\,. \tag{A3}$$

Thus, after executing the CDS, the municipal bond is essentially equivalent to a hypothetical guaranteed municipal bond. The market price of this guaranteed bond is simply $P + X$, and its yield is easy to calculate using standard conventions. Importantly, the tax treatment of this guaranteed bond is identical to

[17]These assumptions are standard in the literature. See, e.g., Lando (1998), Duffie and Singleton (1999), and Longstaff (2013).

[18]We will use the market convention and assume $w = 0.25$. This is also consistent with the empirical evidence reported in Moody's (2021).

that of the actual municipal bond.[19] The municipal bond credit spread is simply the difference between the original yield on the municipal bond and the yield computed in the previous step.

We note that our approach to adjust Treasury securities for credit risk is completely analogous, with P and s denoting the market price of a Treasury security and the U.S. sovereign CDS spread, respectively.

A.3.3 After-Tax Discount Function

We obtain a riskfree discounting function from the term structure of repo swaps using the approach in Fleckenstein and Longstaff (2023).[20] To illustrate the approach let $D(t)$ denote the present value of a \$1 pre-tax cash flow to be received at time t. Similarly, let $d(t)$ denote the present value of a \$1 after-tax cash flow to be received at time t. To shorten the notation, we define the (semi-annual) annuity factor A_t by

$$A_t = \sum_{i=1}^{2t} d_{\frac{i}{2}} \,. \tag{A4}$$

Furthermore, let R_t denote the pre-tax repo rate, and let $c(t)$ denote the pre-tax repo swap rate for a swap expiring in t years.[21] Finally, let τ denote the marginal tax rate of the investor executing the repo swap. For example, in the case of a corporate entity, we assume that the applicable tax rate is the top marginal corporate tax rate, denoted by τ_c. The after-tax riskless rate is given by $r_t = (1 - \tau)\, R_t$.

Consider next a repo swap with maturity in T years, notional amount of \$1, and cash flows on the fixed and the floating leg occurring at times t=0.5, 1.0, 1.5, 2.0, $\ldots, T$.[22] The pre-tax cash flows on the fixed leg are $c_T/2$ for all t,

[19] Our approach also has the advantage that the coupon rate of the guaranteed bond is the same as that of the actual municipal bond. This is because we solve for the upfront cost of entering into the CDS. Thus, there are no additional cash flows resulting from the CDS.

[20] For a detailed discussion of the methodology, see Fleckenstein and Longstaff (2023) and the accompanying Internet Appendix.

[21] Following Fleckenstein and Longstaff (2023), the repo rate is the Secured Overnight Financing Rate (SOFR) for the period from 2018 to 2021, and it is the overnight fed funds rate from 2008 to 2018. For clarity of the exposition, we will simply use the term “repo rate” throughout.

[22] Without loss of generality, the cash flows on both legs of the repo swap are

and the corresponding pre-tax cash flows on the floating leg are $R_{0.5}/2$, $R_{1.0}/2$, $R_{1.5}/2$, $R_{2.5}/2$, $\ldots$, $R_T/2$. We assume that both legs are taxed at the same rate τ.[23] Thus, the after-tax cash flows on the fixed leg are $(1-\tau)\,c_T/2$ for all t, and the corresponding pre-tax cash flows on the floating leg are $(1-\tau)\,R_{0.5}/2$, $(1-\tau)\,R_{1.0}/2$, $(1-\tau)\,R_{1.5}/2$, $(1-\tau)\,R_{2.0}/2$, $\ldots$, $(1-\tau)\,R_T/2$.

Regardless of whether we consider pre-tax or after-tax cash flows, the swap has zero value at inception. Given that $r_t = (1-\tau)\,R_t$, it follows that the present value of the floating leg plus the present value of \$1 (after-tax) to be received at time T must equal \$1. This means that we can bootstrap the after-tax discount function using the standard approach. To illustrate, consider the case of a six-month swap. We obtain the six-month after-tax discount factor $d(0.5)$ by solving the expression

$$1 = (1 + (1-\tau)\,c_{0.5}/2)\ d(0.5) \tag{A5}$$

for $d(0.5)$. Simple algebra gives

$$d(0.5) = \frac{1}{1 + (1-\tau)\,c_{0.5}/2}\,. \tag{A6}$$

Next, let $T = 1.0$. Having determined $d(0.5)$, we then proceed iteratively and solve the expression

$$1 = (1-\tau)\,c_{1.0}/2\ d(0.5) + (1 + (1-\tau)\,c_{1.0}/2)\ d(1.0) \tag{A7}$$

for $d(1.0)$. Again, simple algebra gives

$$d(1.0) = \frac{1 - (1-\tau)\,c_{1.0}/2\ A_{0.5}}{(1 + (1-\tau)\,c_{0.5}/2)}, \tag{A8}$$

where we have substituted in equation (A4). By iterating over consecutive semi-annual periods, it is easy to see that the time-t after-tax discount factor is given by the expression

assumed to occur at semi-annual intervals.

[23]This assumption is consistent with the treatment of interest rate swaps as Notional Principal Contracts, see 26 CFR § 1.446-3.

$$d(T) = \frac{1 - (1 - \tau)\, c_T/2\, A_{T-0.5}}{1 + (1 - \tau)\, c_T/2}\,. \qquad (A9)$$

A.4 Implied Forward Tax Rates

In Section 8 of the paper, we solve for the forward tax rate implied by the difference between the net yield of the tax-exempt municipal bond and the yield of the corresponding taxable benchmark bond using the current maximum combined federal and state tax rate over the next year.

To illustrate the approach, suppose the net yield of a 5-year municipal bond is 1.20 percent, and the yield of the risk-free par benchmark bond (with the same maturity date as the municipal bond) is 3.00 percent. We first solve for the implied tax rate $\tilde{\tau}$ using $0.012 = (1 - \tilde{\tau}) \times 0.030$, giving $\tilde{\tau} = 0.60$.

Next, suppose the current maximum combined federal and state tax rate is 50 percent. Using this tax rate over the next year implies that the forward tax rate is given by

$$\frac{(5 \times 0.60 - 1 \times 0.50)}{5 - 1} = 0.625$$

In calculating the maximum combined federal and state tax rate, we take into account that prior to the Tax Cut and Jobs Act (TCJA) of 2017, state and local income taxes were deductible from federal income taxes (see Section 3.2 of the paper).

A.5 Robustness

As discussed in Section 5.1 of the paper, we identify the liquidity component of municipal bond spreads by comparing the credit-adjusted yields on taxable municipal bonds with the credit-adjusted yields on matched Treasury securities. In doing so, we implicitly assume that the liquidity of taxable and tax-exempt municipal bonds are reasonably comparable and can be captured within the same model. To provide some support that this assumption is a reasonable one, we collect data on several liquidity measures for both the taxable and tax-exempt municipal bonds in the sample.

Table A3 reports summary statistics for taxable and tax-exempt municipal bonds issued by the indicated states. As shown, tax-exempt and taxable bonds are fairly similar in terms of their time to maturity, trading frequency, trade size, and relative bid-ask spreads. Specifically, the average time to maturity for tax-exempt and taxable municipal bonds across all states is about 4.6 years. Across all states, tax-exempt and taxable municipal bonds trade around 9 and 11 times per month, respectively. The average relative bid-ask spreads across all states for tax-exempt and taxable municipal bonds are 0.41% and 0.50%, respectively.

In addition, to show that the results presented in the paper are robust to an alternative choice of the methodology used to liquidity-adjust municipal bond yields, we repeat all of the analysis using the alternative liquidity model ("Liquidity Model 2") described in Section 5.2. Specifically, the tables titled Table 5 – Liquidity Model 2, Table 6 – Liquidity Model 2, etc. present the results for Tables 5 through 13 in the paper based Liquidity Model 2. Similarly, Figure 2 – Liquidity Model 2 and Figure 3 – Liquidity Model 2 present the results shown in Figure 2 and Figure 3 using the alternative liquidity model.

As shown, the results are very similar to those based on the primary liquidity model. For example, Table 5 – Liquidity Model 2 shows that average liquidity component of the tax-exempt municipal bond yields is 54.2 basis points, compared to 57.8 basis points in Table 5. Similarly, Table 7 – Liquidity Model 2 shows that the average premium obtained using Liquidity Model 2 is 11.29 basis points, compared to 14.87 basis points reported in Table 7. Figure 2 – Liquidity Model 2 plots the annual average convenience premia in the state-issued tax-exempt municipal bonds for the indicated states, where the municipal bond yields are adjusted for liquidity using Liquidity Model 2. Figure 3 – Liquidity Model 2 plots the monthly averages of the estimated convenience premia throughout the sample period. As shown, the results are also very similar to those reported in Figure 2 and Figure 3 in the paper, respectively.

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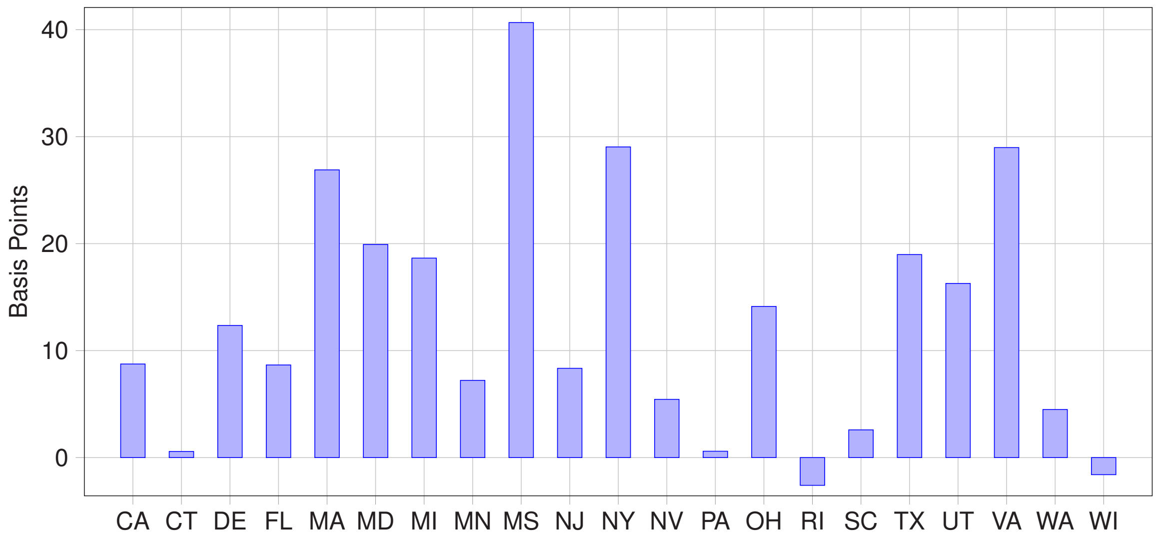

Figure 2 – Liquidity Model 2. This graph shows the average convenience premium for the indicated states.

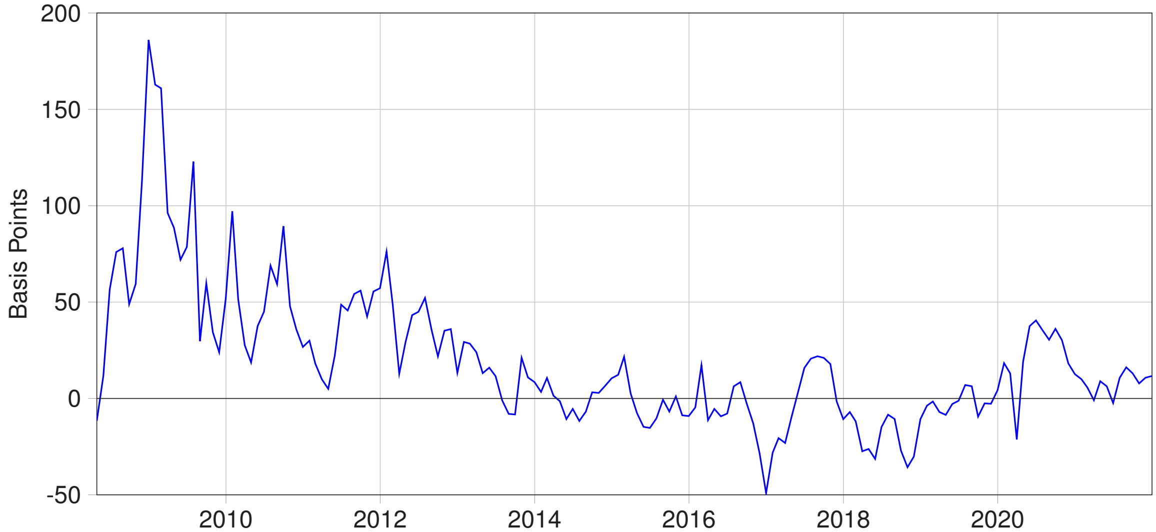

Figure 3 – Liquidity Model 2. This graph shows the average convenience premium by month. The average is taken over all observations for all states each month.

Table A1

Top Marginal Income Tax Rates. This table reports the top marginal income tax rates at the federal level and for the states shown in the column State Income Tax. The Net Investment Income Tax (NIIT) was introduced as part of the Patient Protection and Affordable Care Act (Affordable Care Act) and went into effect on January 1, 2013. SALT Limitation is the State and Local Tax limitation, introduced as part of the Tax Cuts and Jobs Act of 2017, which went into effect on January 1, 2018.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Federal Income Tax	35.00	35.00	35.00	35.00	35.00	39.60	39.60	39.60	39.60	39.60	37.00	37.00	37.00	37.00
Net Investment Income Tax	0.00	0.00	0.00	0.00	0.00	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80	3.80
SALT Limitation	No	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes
State Income Tax														
California	10.30	10.30	10.60	10.30	10.30	13.30	13.30	13.30	13.30	13.30	13.30	13.30	13.30	13.30
Connecticut	5.00	5.00	6.50	6.50	6.70	6.70	6.70	6.70	6.99	6.99	6.99	6.99	6.99	6.99
Delaware	7.20	7.20	8.20	8.20	8.00	8.00	7.85	7.85	7.85	7.85	7.85	7.85	7.85	7.85
Florida	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maryland	7.80	9.30	9.30	8.55	8.70	8.95	8.95	8.95	8.95	8.95	8.95	8.95	8.95	8.95
Massachusetts	5.30	5.30	5.30	5.30	5.25	5.25	5.20	5.15	5.10	5.10	5.10	5.05	5.00	5.00
Michigan	6.40	6.85	6.85	6.85	6.85	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65	6.65
Minnesota	7.85	7.85	7.85	7.85	7.85	7.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85	9.85
Mississippi	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Nevada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
New Jersey	8.97	8.97	10.75	8.97	9.97	9.97	9.97	9.97	9.97	9.97	9.97	11.75	11.75	11.75
New York	10.50	10.50	12.62	12.62	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70	12.70
Ohio	8.87	8.24	7.93	7.93	8.43	8.43	7.89	7.83	7.50	7.50	7.50	7.50	7.30	7.30
Pennsylvania	7.37	7.05	7.05	7.05	7.00	7.00	7.00	6.99	6.98	6.97	6.96	6.95	6.94	6.94
Rhode Island	8.00	7.00	6.50	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99	5.99
South Carolina	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Texas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Utah	5.35	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	4.95	4.95	4.95
Virginia	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75	5.75
Washington	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wisconsin	6.75	6.75	7.75	7.75	7.75	7.75	7.65	7.65	7.65	7.65	7.65	7.65	7.65	7.65

Table A2

Data Definitions and Sources. This table summarizes the datasets used in this study. Frequency shows at what intervals the data are available. Description and Source show the data source and its definition. All data are for the period from January 2008 to December 2021 unless indicated otherwise.

	Data	Frequency	Description and Source
1	Taxable and Tax-exempt Municipal Bonds	–	Data on state-issued general obligation municipal bonds for California, Connecticut, Delaware, Florida, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nevada, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin. For each bond, the data consists of the bond's CUSIP, the issue and maturity date, the amount issued and the price at issue, the coupon rate, coupon type and the day-count convention, the funding source of the municipal bond (the state's general fund), the tax provision (taxable or tax-exempt), and the credit rating at issue by S&P and Moody's. Data obtained from the Bloomberg system via the Fixed Income Search function on the terminal.
2	Taxable and Tax-exempt Municipal Bond Prices	Daily	Daily transaction prices of taxable and tax-exempt municipal bonds for taxable and tax-exempt state-issued general obligation municipal bonds for California, Connecticut, Delaware, Florida, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nevada, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin. For each transaction, the data include the CUSIP, the date and time of the trade, the transaction price, the issue and maturity date of the bond, the coupon rate, an indicator whether the trade was a when-issued trade, and a categorical variable indicating whether the trade is a sale to a customer, a purchase from a customer, or an interdealer trade. Data furnished by the the Municipal Securities Rulemaking Board (MSRB) and obtained from Wharton Research Data Services (WRDS).
3	CDS Spreads for U.S. States	Daily	Daily term structures of CDS spreads for tenors ranging from one year out to 10 years from S&P Capital IQ. Data for 15-year, 20-year, and 30-year tenors obtained from the Bloomberg system.
4	U.S. Sovereign CDS Spreads	Daily	End-of-day credit default swap mid spreads for 6-month, 1-year, 2-year, 3-year, 5-year, 7-year, 10-year, 15-year, 20-year and 30-year contracts written on U.S. Treasury debt. Data from Markit.
5	Overnight Repo Rate	Daily	End-of-day overnight general-collateral (GC) repo rate. Data retrieved from the Bloomberg system.
6	Fed Funds Rate	Daily	End-of-day effective federal funds rate. Data retrieved from the Bloomberg system.
7	SOFR Interest Rate Swaps	Daily	SOFR interest rate swap rates for tenors of 1, 3, 6, 9, 12 months, and 1, 2, 3, 5, 7, 10, 15, 20, and 30 years for the period from January 1, 2017 to December 30, 2021. SOFR swaps exchange fixed for floating SOFR cash flows based on the daily compounded SOFR rate annually for maturities over one year and have a single cash flow at maturity for tenors up to one year. Data retrieved from the Bloomberg system.

Table A2 — Continued

	Data	Frequency	Description and Source
8	OIS Interest Rate Swaps	Daily	Overnight Index Swap (OIS) rates for tenors of 1, 3, 6, 9, 12 months, and 1, 2, 3, 5, 7, 10, 15, 20, 30 years for the period from January 1, 2008 to December 30, 2021. OIS swaps exchange fixed for floating cash flows based on the daily compounded overnight Fed funds rate annually for maturities over one year, and have a single cash flow at maturity for tenors up to one year. Data retrieved from the Bloomberg system.
9	VIX Index	Monthly	The Chicago Board Options Exchange's CBOE Volatility Index of option implied volatilities. Data retrieved from the Bloomberg system.
10	MOVE Index	Monthly	The Intercontinental Exchange/Bank of America Merrill Lynch MOVE index of Treasury option implied volatilities. Data retrieved from the Bloomberg system.
11	Repo Spread	Monthly	The difference between the three-month general collateral repo rate (USRGCGC) and the the three-month Treasury bill yield (TBSM3M). Data retrieved from the Bloomberg system.
12	TED Spread	Monthly	The difference between the three-month Treasury bill rate and the three-month U.S. LIBOR rate. Data retrieved from the Bloomberg system (.TED G Index).
13	Swap Spread	Monthly	The Bloomberg 2-year swap spread index (USSP2 Index). Data retrieved from the Bloomberg system (USSP2 Index).
14	AAA Spread	Monthly	The Bloomberg AAA corporate yield spread index relative to 10-year Treasury securities. Data retrieved from the Bloomberg system (.AAA10Y G Index).
15	Treasury Richness	Monthly	The Fleckenstein and Longstaff (2022) Treasury richness measure for Treasury securities with ten years or less to maturity.
16	Refcorp Spread	Monthly	The difference between the average yield of Resolution Funding Corporation (Refcorp) strips with ten years or less to maturity and Treasury yields of the same maturity. Data retrieved from the Bloomberg system.
17	Agency MBS Spread	Monthly	The Bloomberg Agency MBS index of the option-adjusted yield spread between agency MBS and Treasury notes. Data retrieved from the Bloomberg system.
18	State Municipal Bond Funds	Monthly	Net-asset values of state-specific open-end mutual funds for for California, Connecticut, Delaware, Florida, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nevada, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin. Data furnished by the Investment Company Institute (ICI) and retrieved from the Bloomberg system.

Table A2 — Continued

	Data	Frequency	Description and Source
19	State Municipal Bond Fund Returns	Monthly	Monthly returns for state-specific open-end mutual funds for for California, Connecticut, Delaware, Florida, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nevada, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin. Data retrieved from WRDS.
20	Fiscal Uncertainty	Monthly	The Baker, Bloom & Davis U.S. Fiscal Policy Uncertainty Index. Data retrieved from the Bloomberg system.
21	Tax Uncertainty	Monthly	The Baker, Bloom & Davis U.S. Tax Policy Uncertainty Index. Data retrieved from the Bloomberg system.
22	Economic Uncertainty	Monthly	The Baker, Bloom & Davis U.S. Economic Policy Uncertainty Index. Data retrieved from the Bloomberg system.
23	State-to-State Migration Flows	Annual	Data on state to state population flows for U.S. states. Data furnished by the U.S. Census Bureau and available at https://www.census.gov/data/tables/time-series/demo/geographic-mobility/state-to-state-migration.html
24	IRS Tax Return Statistics	Annual	Annual tax return statistics from the Internal Revenue Service's (IRS) Statistics of Income. Data retrieved from https://www.irs.gov/statistics/soi-tax-stats-historic-table-2.
25	Federal Income Tax Rates	Annual	Top marignal federal income tax rate for the period from 2008 to 2021. Data from the Internal Revenue Service (IRS) Statistics of Income and available at www.irs.gov/statistics.
26	State Income Tax Rates	Annual	Top marginal income tax rates for California, Connecticut, Delaware, Florida, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Nevada, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin. Data from the Federation of Tax Administrators and available at http://www.taxadmin.org/.

Table A3

Summary Statistics for Taxable and Tax-Exempt State-Issued Municipal Bonds. This table reports summary statistics for taxable and tax-exempt municipal bonds issued by the indicated states. Maturity presents the average time to maturity in years rate of the municipal bonds for the indicated states. Trades and Trade Size denote the average monthly number of trades and the average trade size in millions per municipal bond for the indicated states, respectively. Bid-Ask presents the average monthly relative bid-ask spread, expressed as a percentage. The sample is from April 1, 2008 to December 30, 2021.

	Tax-Exempt					Taxable				
	Maturity	Trades	Trade Size	Bid-Ask	N	Maturity	Trades	Trade Size	Bid-Ask	N
California	4.84	21.16	0.34	0.63	133,102	5.28	21.29	1.98	0.54	3,580
Connecticut	4.54	11.89	0.25	0.47	47,128	5.11	11.85	0.56	0.60	4,393
Maryland	4.51	15.31	0.53	0.40	44,530	3.33	10.82	2.35	0.20	203
Massachusetts	5.03	13.93	0.24	0.45	60,368	4.64	10.34	1.67	0.25	250
Michigan	4.42	7.91	0.26	0.35	5,352	3.89	5.20	1.02	0.45	207
Minnesota	4.30	8.97	0.36	0.36	30,305	5.53	5.88	2.25	0.50	168
Mississippi	4.77	6.94	0.25	0.34	6,987	4.46	6.43	1.19	0.51	910
New Jersey	4.78	17.15	0.50	0.56	13,130	2.81	12.96	0.77	0.62	212
New York	3.96	9.61	0.22	0.45	10,645	5.54	8.20	0.20	0.68	899
Ohio	4.67	8.09	0.25	0.38	59,062	4.43	5.50	0.31	0.46	162
Rhode Island	4.49	6.41	0.22	0.24	4,187	5.52	7.60	0.22	0.84	277
Texas	4.41	7.86	0.34	0.36	27,872	5.20	6.69	0.65	0.43	2,139
Washington	4.44	9.19	0.28	0.33	48,743	4.12	5.76	0.75	0.48	633

Table 5 – Liquidity Model 2

Summary Statistics for the Components of Tax-Exempt State-Issued Municipal Bond Yields. This table reports summary statistics for the decomposition of the tax-exempt state-issued municipal bond yields into separate components for the indicated states using Liquidity Model 2. Yield denotes the average observed bond yield. Credit denotes the average value of the credit-related component of the bond yield. Liquidity denotes the average value of the liquidity-related component of the bond yield using Liquidity Model 2. Net yield is the average credit-and-liquidity-adjusted bond yield and is calculated by subtracting the sum of the credit and liquidity components of the yield from the observed bond yield. Yields are expressed as a percentage. N denotes the number of observations. The sample period is from April 1, 2008 to December 30, 2021.

State	Yield	Credit	Liquidity	Adj. Yield	N
California	1.644	0.506	0.527	0.612	133,102
Connecticut	1.658	0.485	0.468	0.704	47,128
Delaware	1.364	0.223	0.557	0.584	11,873
Florida	1.473	0.278	0.505	0.690	26,219
Maryland	1.358	0.275	0.570	0.514	44,530
Massachusetts	1.533	0.377	0.646	0.510	60,368
Michigan	1.764	0.476	0.666	0.622	5,352
Minnesota	1.301	0.225	0.520	0.556	30,305
Mississippi	1.632	0.658	0.575	0.399	6,987
Nevada	1.613	0.358	0.523	0.732	9,209
New Jersey	1.802	0.617	0.542	0.644	13,130
New York	1.453	0.449	0.635	0.369	10,645
Ohio	1.532	0.367	0.579	0.586	59,062
Pennsylvania	1.523	0.379	0.482	0.661	35,005
Rhode Island	1.514	0.319	0.470	0.724	4,187
South Carolina	1.352	0.196	0.502	0.654	6,924
Texas	1.522	0.277	0.619	0.626	27,872
Utah	1.039	0.242	0.468	0.329	7,546
Virginia	1.300	0.282	0.589	0.428	6,148
Washington	1.417	0.236	0.495	0.687	48,743
Wisconsin	1.441	0.252	0.490	0.700	26,797
All	1.521	0.374	0.542	0.605	621,132

Table 6 – Liquidity Model 2

Cross-Sectional Test for Convenience Premia. This table reports the results from the regression of the difference between the net yields for pairs of coupon and maturity-matched tax-exempt bonds from different states on the difference in the top marginal tax rates for those states. The net yields are based on using Liquidity Model 2. The difference in the net yields is expressed in basis points. The difference in the top marginal tax rates is expressed as a percentage. Standard errors are based on Liang and Zeger (1986) and clustered by month. The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is from April 1, 2008 to December 30, 2021.

Explanatory Variable	Coeff	t-Stat
Difference in Marginal Rates	0.5181	2.73**
Monthly Fixed Effects		Yes
Adj. R^2		
N		236,583

Table 7 – Liquidity Model 2

Summary Statistics for the Convenience Premia. This table reports the annual average values of the convenience premia in the state-issued tax-exempt municipal bonds for the indicated states and years where the municipal bond yields are adjusted for liquidity using Liquidity Model 2. The last column reports the averages taken across all years by state. The last row reports the averages taken across all states by year. The value in the last row and column is the value taken over all states and years. The convenience premia are expressed in basis points. The sample period is from April 1, 2008 to December 30, 2021.

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Mean
California	63.92	47.11	29.63	11.82	30.62	7.95	−5.54	0.16	−6.07	1.28	−22.81	−9.34	22.81	6.50	8.75
Connecticut	–	80.19	57.83	54.10	41.87	11.83	2.76	−1.86	−19.91	−32.42	−47.67	−16.62	−4.36	10.83	0.57
Delaware	–	46.34	41.06	38.98	35.29	16.81	5.31	0.68	−9.84	3.90	−16.05	2.02	21.08	7.47	12.35
Florida	85.01	80.61	43.97	27.91	32.10	5.23	3.79	−2.63	−11.93	5.18	−4.30	8.35	16.75	7.00	8.66
Maryland	90.92	120.06	51.77	51.39	51.59	24.21	5.59	−2.26	−6.95	3.18	−29.16	−6.13	25.78	5.64	19.92
Massachusetts	101.64	105.69	60.88	47.08	48.23	21.83	10.61	6.25	−7.18	8.59	−12.09	6.58	31.08	16.44	26.90
Michigan	97.10	74.79	53.46	15.30	36.17	14.45	5.54	−1.55	−13.29	1.43	−18.68	0.48	22.13	6.06	18.65
Minnesota	–	–	30.81	41.59	37.05	17.03	2.26	−3.83	−10.63	0.99	−24.57	−5.76	19.18	3.02	7.22
Mississippi	99.54	111.54	79.74	72.26	60.25	25.60	31.34	38.57	59.01	41.83	−11.60	3.63	27.01	18.84	40.67
Nevada	–	40.84	45.81	6.99	11.95	−0.76	−9.62	−6.20	−10.75	4.91	−2.81	9.97	16.07	12.66	5.44
New Jersey	104.20	107.91	61.67	28.65	44.34	16.94	3.42	−22.16	−20.45	−20.89	−36.75	−14.34	−37.22	−16.10	8.34
New York	86.74	104.56	70.55	36.94	42.74	7.88	0.92	2.47	−0.64	12.98	−21.22	1.48	15.77	6.67	29.04
Ohio	96.19	91.42	50.04	35.23	34.72	6.88	−0.94	−3.15	−8.36	3.24	−19.08	0.06	21.67	9.53	14.13
Pennsylvania	–	–	52.66	37.11	37.90	6.57	−6.75	−11.62	−23.37	−12.06	−32.25	−6.02	14.22	12.71	0.59
Rhode Island	–	–	30.52	9.84	6.66	−0.47	−17.62	−18.11	−18.14	−3.71	−17.32	0.18	2.89	11.06	−2.60
South Carolina	–	–	–	–	40.04	13.40	0.65	−2.52	−7.92	1.45	−17.05	4.01	19.27	10.20	2.59
Texas	95.41	90.82	45.97	37.78	34.06	13.41	4.82	−5.12	−9.79	7.27	−3.05	10.02	18.39	7.89	18.98
Utah	–	–	–	–	38.14	31.32	26.25	16.93	3.60	8.78	−19.22	3.54	21.31	6.39	16.28
Virginia	–	100.68	66.42	60.11	43.79	24.09	7.74	0.59	−4.22	10.84	−10.18	11.17	19.98	9.78	28.98
Washington	–	–	–	29.12	23.28	12.03	−4.76	−9.46	−16.93	3.09	−3.97	9.33	19.84	5.61	4.49
Wisconsin	–	–	21.41	24.61	24.80	−1.26	−8.82	−13.16	−18.31	2.65	−21.37	−4.58	14.69	5.97	−1.60
Mean	81.90	80.83	48.45	35.26	36.41	12.12	0.17	−3.02	−10.77	−1.07	−20.37	−2.11	18.47	7.85	11.29

Table 8 – Liquidity Model 2

Regression of the Convenience Premium in the Tax-Exempt Municipal Bond Market on Convenience Premium Measures from Other Markets. This table reports the results from the regression of the monthly average convenience premium in the tax-exempt municipal bond market on convenience premium measures from other markets. The convenience premium is based on Liquidity Model 2. The monthly average is the simple average taken over all observations for all states each month. Repo Spread is the difference between the three-month general collateral repo rate and the three-month treasury bill yield. TED Spread is the difference between the three-month Treasury bill yield and the three-month U.S. Libor rate. Swap Spread is the two-year Libor-based swap spread. AAA Spread is the difference between the yield of the Bloomberg index of AAA-rated corporate bonds and the yield on ten-year Treasury notes. Treasury Richness is the Fleckenstein and Longstaff (2023) Treasury richness measure for Treasury securities with maturities less than or equal to ten years. Refcorp Spread is the difference between the yields of Refcorp and Treasury bonds with maturities less than or equal to ten years. Agency MBS Spread is the option-adjusted yield spread between Agency MBS and Treasury notes. All variables are expressed in basis points. Standard errors are based on Newey and West (1987). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is monthly from April 2008 to December 2021.

	Coeff	t-Stat
Intercept	−78.0837	−9.13**
Repo Spread	−0.2016	−1.47
TED Spread	−0.5811	−7.12**
Swap Spread	0.5540	2.80**
AAA Spread	0.2683	4.07**
Treasury Richness	0.4529	2.27**
Refcorp Spread	0.8595	7.79**
Agency MBS Spread	0.3298	2.70**
Adj. R^2		0.7366
N		165

Table 9 – Liquidity Model 2

Regression of the Convenience Premium on Risk and Uncertainty Measures. This table reports the results from the regression of the monthly average convenience premium in the tax-exempt municipal bond market on the indicated variables. The convenience premia are based on Liquidity Model 2. The monthly average is the simple average taken over all observations for all states each month and is measured in basis points. VIX Index is the Chicago Board Options Exchange (CBOE) Index of S&P 500 option-implied volatility. MOVE Index is the Intercontinental Exchange's U.S. Treasury volatility index. Tax Uncertainty, Gov Spending Uncertainty, and Economic Uncertainty are the Baker, Bloom, and Davis (2016) indicies of tax undercertainty, government spending uncertainty, and economic policy uncertainty, respectively. Standard errors are based on Newey and West (1987). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is monthly from April 2008 to December 2021.

	Coeff	t-Stat
Intercept	−41.8448	−4.72**
VIX Index	0.9042	1.69*
MOVE Index	0.5109	3.91**
Tax Uncertainty	0.1774	3.75**
Gov Spending Uncertainty	0.0347	2.46**
Economic Uncertainty	−0.1576	−2.76**
Adj. R^2		0.5759
N		165

Table 10 – Liquidity Model 2

Results from the Convenience Premium and State Municipal Bond Funds Net Fund Flows Regressions. Panel A reports the results from the panel regressions of net flows into individual state municipal bond funds on the indicated lagged and contemporaneous changes in the average monthly convenience premium for the corresponding state. The premia are based on Liquidity Model 2. A state municipal bond fund is an open-ended mutual fund that invests exclusively in the tax-exempt municipal bonds of a specific state. The states in the sample for which there are state municipal bond funds are California, Connecticut, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, South Carolina, Utah, Virginia, and Wisconsin. Panel B reports the results from the panel regressions of changes in the average monthly convenience premium for individual states on the indicated lagged and contemporaneous net flows into state municipal bond funds for the corresponding state. The convenience premium is expressed in basis points. Net fund flows are expressed in millions. Standard errors are based on White (1980). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is monthly from April 1, 2008 to December 30, 2021.

Panel A: Net Flow Regression	Coeff	t-Stat	Coeff	t-Stat
Net Flow_{t-1}	0.3990	3.14**	0.4045	3.19**
Net Flow_{t-2}	0.0172	0.15	0.0266	0.23
Net Flow_{t-3}	0.0994	1.80*	0.0924	1.65*
Δ Premium_{t}	–	–	0.4729	4.39**
Δ Premium_{t-1}	0.2929	2.54**	0.3553	3.00**
Δ Premium_{t-2}	0.2194	2.34**	0.2739	2.92**
Δ Premium_{t-3}	0.1906	2.48**	0.2760	3.54**
State Fixed Effects		Yes		Yes
Adj. R^2		0.2418		0.2500
N		2,331		2,331

Panel B: Δ Premium Regression	Coeff	t-Stat	Coeff	t-Stat
Δ Premium_{t-1}	−0.1319	−3.09**	−0.1388	−3.25**
Δ Premium_{t-2}	−0.1152	−4.59**	−0.1204	−4.78**
Δ Premium_{t-3}	−0.1807	−6.93**	−0.1852	−7.08**
Net Flow_{t}	–	–	0.0237	3.63**
Net Flow_{t-1}	−0.0116	−1.97**	−0.0211	−3.04**
Net Flow_{t-1}	−0.0199	−3.16**	−0.0203	−2.96**
Net Flow_{t-1}	0.0148	2.54**	0.0124	1.97**
State Fixed Effects		Yes		Yes
Adj. R^2		0.0644		0.0744
N		2,331		2,331

Table 11 – Liquidity Model 2

Regression of Changes in the Convenience Premia on State-Level Migration Flows. This table reports the results from the panel regression of annual changes (year-end to year-end) in the convenience premium for individual states on the percentage of that state's population that moved to one of the seven states without a state income tax. The states without a state income tax are Alaska, Florida, Nevada, South Dakota, Texas, Washington, and Wyoming. Convenience premia are expressed in basis points. Convenience premia are based on Liquidity Model 2. Standard errors are based on White (1980). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is annual from 2008 to 2019.

	Coeff	t-Stat
Migration	109.7636	2.52**
State Fixed Effects		Yes
Adj. R^2		0.0404
N		208

Table 12 – Liquidity Model 2

Regression of the Convenience Premium on Tax-Minimizing Strategies. This table reports the results from the regression of the year-end convenience premia for individual states on the percentage of tax returns for each state that include an IRA contribution, include a self-employed retirement plan, itemize deductions, or include charitable contributions on Schedule A. Data are from the Internal Revenue Service Statistics of Income reports. Convenience premia are based on Liquidity Model 2. Standard errors are based on White (1980). The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively. The sample period is annual from 2008 to 2020.

	Coef	*t*-Stat	Coef	*t*-Stat	Coef	*t*-Stat	Coef	*t*-Stat
IRA Contribution	49.8064	3.24**	–	–	–	–	–	–
Tax-Deferred Retirement	–	–	79.5132	1.72**	–	–	–	–
Charitable Contribution	–	–	–	–	1.2402	2.11**	–	–
Itemized Deductions	–	–	–	–	–	–	0.7864	1.44
State Fixed Effects		Yes		Yes		Yes		Yes
Year Fixed Effects		Yes		Yes		Yes		Yes
Adj. R^2		0.8394		0.9284		0.9285		0.9276
N		240		250		250		250

Table 13 – Liquidity Model 2

SALT Limitation Event Study. This table reports the results from the cross-sectional regression of the change in the convenience premium from September 2017 to March 2018 for the individual states on the percentage change in state and local tax (SALT) deduction per income tax return for that state between the 2017 and 2018 tax years. Data are from the Internal Revenue Service Statistics of Income reports. Convenience premia are based on Liquidity Model 2. The superscripts * and ** denote significance at the ten-percent and five-percent levels, respectively.

	Coeff	t-Stat
Intercept	−37.3726	−10.37
Δ SALT Deduction	32.4645	2.47**
Adj. R^2		0.2662
N		21