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James R. Hines Jr.
Emily Horton

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ABSTRACT

Interest paid by U.S. state and local bonds is tax-exempt, making these bonds attractive to investors – though a tax rule limits arbitrage opportunities by restricting associated interest expense deductions. Prior to 1986, U.S. banks were not subject to the interest deduction limitation, making banks preferred holders of tax-exempt debt. U.S. banks used tax-exempt debt to reduce their tax liabilities by roughly 20% in the 1950s and 45% in the 1960s, rising to as much as 80% by the early 1980s. Despite their special exemption, and in part because of their widespread holdings, banks did not benefit from investing in tax-exempt bonds, as competition between banks reduced bond yields to the point of investor indifference. The absence of a tax benefit from arbitrage appears not only in observed bond yields, but also in banks' considerable unused potential for further tax reductions. After the Tax Reform Act of 1986 removed their special tax exemption, banks significantly reduced their holdings of tax-exempt debt, particularly among banks most severely impacted by the rule change.

James R. Hines Jr.
Department of Economics
University of Michigan
343 Lorch Hall
611 Tappan Street
Ann Arbor, MI 48109-1220
and NBER
jrhines@umich.edu

Emily Horton
Office of Tax Analysis
U.S. Department of the Treasury
1500 Pennsylvania Avenue NW
Washington, DC 20220
emily.horton@treasury.gov

1. *Introduction*

Tax-exempt bonds hold obvious appeal to investors seeking after-tax returns. While interest income is generally taxable in the United States, interest received from holding U.S. state and local bonds is exempt from federal and state taxes. As a result, individuals and businesses otherwise subject to high tax rates can avoid taxes by devoting their investment funds to state and local bonds instead of taxable alternatives. Furthermore, there is scope for purposeful tax arbitrage in borrowing money and investing the proceeds in tax-exempt debt, thereby securing interest expense deductions that reduce taxable income without triggering offsetting taxable interest income. Every taxpayer, it seems, can benefit from investing in tax-exempt bonds.

Three considerations dampen the potential returns from investing in tax-exempt bonds. The first is that tax-exempt debt offers lower pretax returns than comparable taxable investments, reflecting that demand from eager investors bids up the prices of tax-exempt bonds and thereby depresses their yields. The second consideration is that tax rules limit the interest expense deductions that taxpayers holding state and local bonds are entitled to claim. In the years prior to 1986, commercial banks were largely exempt from the interest deduction limits, making commercial banks preferred holders of tax-exempt debt. And the third consideration is that firms and individuals must be potentially taxable in order to benefit from earning tax exempt returns, since the asymmetry of the tax schedule means that taxpayers with chronic negative taxable incomes do not receive rebates from the government.

This paper examines the extent to which U.S. commercial banks benefitted from investing in state and local bonds in the years prior to 1986. The evidence indicates that commercial banks used these investments to reduce their federal tax liabilities by roughly 20% in the 1950s, 45% in the 1960s, 70% in the 1970s, and as high as 80% in the early 1980s. The 1986 tax change that applied substantial interest deduction limits to commercial banks coincided with significant reductions in bank holdings of tax-exempt debt, particularly among those banks that were most affected by the tax change. This evidence is consistent with tax-motivated financial behavior on the part of commercial banks, but also raises the question of why banks did not use tax-exempt debt to avoid even more of their taxes in the era prior to 1986.

The available evidence suggests that, despite their exemption from interest expense deduction limits, commercial banks were largely indifferent between holding tax-exempt debt and making alternative taxable investments in the years before 1986. During that era, banks held considerable quantities of tax-exempt debt, but nonetheless paid extensive federal income taxes. These extensive tax payments imply that banks had significant unused capacity to benefit from additional tax savings that were readily available by expanding their holdings of tax-exempt debt. The fact that banks used tax-exempt debt to wipe out some, but not all, of their potential tax liabilities implies that they were indifferent at the margin to the benefits of holding tax-exempt debt and the tax savings that it confers. And since the marginal benefits of holding tax-preferred investments are largely the same as the average benefits, it follows that commercial banks in aggregate did not benefit from their ability to invest in tax-exempt debt, notwithstanding their ability to do so without losing the deductibility of investment interest expense.

How can it be that commercial banks in the era prior to 1986 did not benefit from an activity – holding tax-exempt debt – in which they so actively engaged? As is so often the case with supply and demand, it is their active engagement that undermined the potential benefit. Banks competed with each other in the market to own tax-exempt bonds, and in so doing bid up bond prices and depressed yields to the point of ultimate indifference; and since the corporate income tax is flat over almost all of the relevant range, marginal indifference is almost exactly the same as total indifference. It is true that the special tax treatment of commercial banks made them preferred holders of tax-exempt debt; but there were enough banks, with enough demand, that they competed away the potential benefit of the tax preference that commercial banks enjoyed.

Prior studies have called attention to differences in the yields of tax-exempt state and local bonds and taxable Treasury securities, and noted that the magnitudes of these yields appear roughly to equalize the after-tax returns of investors subject to the corporate tax, particularly for short-maturity bonds. There can be some difficulty in interpreting these yield differences, since the absence of a centralized exchange on which bonds were traded means that available yield information constitutes rough averages. Furthermore, tax-exempt bonds differ in risk and liquidity characteristics, and differ across U.S. states, with associated possible clientele effects,

all of which could affect arbitrage possibilities. Combining quantity information, in the form of unused taxable capacities of commercial banks, with the existing approaches to analyzing price information, in the form of implied tax rates of marginal investors, offers a way to test the accuracy of the current interpretation of bond yields. As it happens, both methods point in the same direction, indicating that commercial banks were the marginal holders of tax-exempt debt – and that they benefitted little if at all from these holdings.

2. *Yields on Taxable and Tax-Exempt Debt*

The potential return to tax arbitrage using tax-exempt debt depends on the relative yields of taxable and tax-exempt bonds, or what is equivalent, the difference between after-tax borrowing rates and returns on tax-free investments. It is useful to consider the tax rate t^* at which an investor would be indifferent between investing in a tax-exempt bond and an otherwise-equivalent bond that produces taxable returns. Letting r denote the return on taxable debt, and r^* the return on tax-exempt debt, the implied tax rate t^* is defined by $r(1-t^*) = r^*$, or

$$(1) \quad t^* \equiv \frac{r - r^*}{r}.$$

Taxpayers with marginal tax rates below t^* would find tax-exempt bonds to be unattractive investments, as the higher pretax yields on taxable bonds come at little associated tax cost, whereas taxpayers with marginal tax rates above t^* obtain higher after-tax yields from tax-exempt debt than they do from taxable bonds.

A similar tax calculation emerges from an arbitrage strategy that does not entail comparing alternative investments with different yields. If a taxpayer can borrow at rate r , deduct the interest expense, and invest the proceeds in tax-exempt bonds that yield r^* , then the taxpayer earns an after-tax return of $r^* - r(1-t)$, in which t is the marginal tax rate. The value of t at which this arbitrage possibility disappears is t^* in equation (1).

2.1. *Evidence from historical data.*

Salomon Brothers (1994) provides historical information on monthly bond yields from 1950-1994. The data are available for different bond types and maturities, and have been widely used by prior studies. Since these bonds were not traded on centralized exchanges, but instead individually placed, the information that Salomon Brothers reports does not necessarily represent market averages based on transaction prices, but instead are general understandings of industry insiders. The thickness of the market for U.S. Treasury securities, and the standardized form of Treasury bonds, makes the Salomon Brothers information on Treasury yields quite reliable; but its information on the yields of other types of bonds, including municipal bonds (bonds issued by state and local governments, and paying tax-exempt interest), have some impressionistic elements. Municipal bonds differ in fine details of their coupon payments, callability, and other aspects of their effective maturities; and while in that era they were generally very safe investments, they doubtless also differed in their risk characteristics (and certainly differed in whether or not their payouts were insured by third parties). The Salomon Brothers information subsumes these differences into broad industry averages for highly-rated municipal bonds.

Figure 1 presents annualized yields of one-year Treasury bonds and one-year municipal bonds, based on simple averages of the monthly series reported in the Salomon Brothers data. Treasury bond yields are significantly higher than municipal bond yields, reflecting that the Treasury returns are taxable, whereas the municipal bond returns are not. Figure 2 presents the implied values of break-even tax rates, t^* in equation (1), for the one-year bonds with yields depicted in Figure 1, and superimposes the federal statutory corporate tax rate. It is clear that the implied t^* values lie close to, though typically a bit below, the federal statutory corporate tax rate. Since Treasury securities are virtually risk-free, whereas municipal bonds were not, it is understandable that the arbitrage relationship characterized in (1) would not hold exactly, and that the implied values of t^* would therefore fall somewhat below the effective corporate tax rates, since expected after-tax yields of municipal bonds will exceed those of Treasuries. In addition, Figure 2 omits consideration of state corporate taxes, the rates of which differed across states, were always low relative to the federal rates, and in some cases were zero.

Figures 1 and 2 present information for bonds of one-year maturity. Prior studies suggest that banks tended to specialize in holding short-term bonds, possibly reflecting their liquidity and risk properties; furthermore, any non-interest returns in the form of capital gains or losses on sales of longer-maturity municipal bonds would be fully taxable. As it happens, the comparative yields of longer-duration Treasury securities and municipal bonds, as reported by Salomon Brothers (1994) and depicted in Appendix Figure 1, are similar to those of one-year bonds. The implied t^* values for these longer-duration securities are depicted in Appendix Figure 2, and again lie below the federal statutory corporate tax rate. The somewhat larger spreads between statutory corporate tax rates and the implied tax rates for longer-duration bonds, compared to those for one-year bonds, may in part be a product of the same risk and liquidity considerations that limit their attractiveness to banks.

2.2. *Changing U.S. tax law.*

A corporation must be taxable in order to benefit from investing in municipal bonds. Corporations with losses do not pay taxes and do not receive money back from the federal government, so a corporation that every year loses money and pays no tax does not benefit from reducing its taxable income by investing in tax-exempt debt. Under current law, corporations are entitled to carry any unused losses forward, without adjustment for the time value of money, though they are not permitted to use tax loss carryforwards to reduce any year's tax liability by more than 80%. Rules governing the use of net tax losses have changed over time, in many years permitting current losses to be carried back against taxable income in prior years; but it has always been the case that almost all taxpayers would find tax-exempt interest to be most valuable in years in which they would otherwise have taxable income. Consequently, careful tax planning entails predicting a firm's tax status, and avoiding tax-exempt investments in years when a firm anticipates making tax losses.

The U.S. federal government limits the tax deductibility of interest expenses associated with borrowing used to invest in tax-exempt debt. Corporations that borrow to invest in taxable bonds can deduct their borrowing interest expenses, but those that borrow to invest in tax-exempt debt are generally denied tax deductions for the associated interest expense, on the theory that tax deductions are properly permitted only for expenses that generate taxable income. Since

corporations borrow to obtain funds that are used for many different purposes, it can be difficult, if not impossible, to discern exactly which or how much of a corporation's debts were incurred to invest in the tax-exempt bonds that it holds. Consequently, the relevant U.S. tax law denies a fraction of a corporation's interest deductions, with the denied fraction equal to the ratio of tax-exempt debt holdings to a corporation's gross assets.

The current U.S. tax treatment of interest expense deductions dates at least to 1924. At the time, U.S. commercial banks argued that they should be exempted from the rule restricting interest expense deductions, offering the justification that the business model of a commercial bank entails using entirely borrowed (or what is equivalent, deposited) funds to make investments. The IRS found this reasoning persuasive in light of Congressional intent, concluding that in the absence of a documented direct connection between external borrowing and investment in tax-exempt debt, a commercial bank should be entitled to deduct all of its interest expenses. In subsequent legislation, Congress chose not to modify the IRS rule, permitting commercial banks holding tax-exempt debt nonetheless to deduct all of their interest expenses. This regime prevailed until a 1982 law change, effective January 1, 1983, that reduced the bank exception by requiring that 15% of a bank's interest expenses be subject to the interest expense restriction.¹ This was followed by legislation in 1984, effective January 1, 1985, requiring that 20% of a bank's interest expenses be subject to the interest expense limitation. And in the Tax Reform Act of 1986, effective January 1, 1987, commercial banks lost their special exemption altogether, though the legislation included a separate provision stipulating that tax-exempt bonds of jurisdictions issuing less than \$10 million in that year were not included in calculations disallowing interest expense deductions. The Tax Reform Act of 1986 also changed individual and corporate tax rates, notably reducing the corporate statutory rate from 46% to 34%, which also affected demands for, and yields of, municipal bonds.

¹ For a bank with interest expenses of \$50 million, and 20 percent of its assets invested in tax-exempt debt, this would mean that the bank would be entitled to deduct \$48.5 million of its interest expenses against gross income in calculating its net taxable income, because deductions for 20% of 15% of its interest expense would be disallowed.

3. *Banks and Tax-Exempt Debt Investments*

There is extensive prior analysis of the determinants of the breakeven tax rate τ^* , and empirical evidence of its relevance to the banking industry in the years before 1987. Miller (1977) presents an arbitrage condition similar to (1), taking τ to be the statutory corporate tax rate, thereby implicitly treating corporate entities to be marginal suppliers and investors in the market for taxable bonds. Kidwell and Koch (1983) offer evidence that the market for municipal bonds in that era was segmented by maturity, with commercial banks holding short-duration bonds and other investors holding longer-duration bonds. Other empirical studies using the Salomon Brothers data also report evidence consistent with the conclusions of section 2, in that values of τ^* implied by spreads between yields on short-duration municipal bonds and Treasury securities lie close to the corporate statutory rate,² whereas those for longer-duration securities are somewhat lower, perhaps tracking individual tax rates.³ Pirinsky and Wang (2011) call attention to a different form of market segmentation, one produced by state income taxes from which investors are exempt only on in-state bonds, and consider its implications for observed yield patterns.⁴

One of the issues that the literature wrestles with is how to account for lower values of τ^* at longer maturities, given the ability of banks to purchase long-duration bonds, and given the high marginal tax rates facing many individual investors. Green (1993) notes that clever trading strategies can reduce the tax burden on holding long-duration taxable bonds, increasing their after-tax yields and thereby increasing the implied breakeven tax rate τ^* ; and Ang, Bhansali, and Xing (2010) point out that even investors in tax-exempt debt may face taxes on capital gains associated with subsequent bond sales. Furthermore, as Piros (1987) and others note, a bank

² See, for example, Hendershott and Koch (1980), Skelton (1983b), Poterba (1986, 1989), Buser and Hess (1986), Heaton (1986), Fortune (1988), and Kochin and Parks (1988). Poterba (1989) notes that short-duration bond yield responses to news of the 1969 tax reform, which affected individual but not corporate tax rates, suggest that individual investors may have played an important role in marginal demand for short-term municipal bonds in that era.

³ See, for example, Kidwell and Koch (1983) and Poterba (1986, 1989).

⁴ Poterba and Rueben (1999, 2001) find that state fiscal institutions and conditions affect yields on tax-exempt bonds issued by state governments; and Dagostino (2019) and St. Clair (2024) offer evidence that many local governments limit their borrowing to qualify their bonds for tax-exemption and subsequent placement with local banks. Beatty and Harris (2001) point out that some states exempt interest on Treasury securities from state income taxation, which also affects implied values of τ^* for their investors. Garrett et al. (2023) analyze the effect of auction market

must have positive taxable income in order to benefit from tax-exemption, so uncertainty over a bank's tax position may diminish its demand for tax-exempt debt; and as Poterba (1986) emphasizes, what matters for current yields is anticipated future tax policy. Skelton (1983b) suggests that the regulatory environment that banks faced prior to the 1980s may account for their preference for short-term municipal debt. And since the arbitrage condition in (1) applies only to certainty-equivalent bond yields, it is also possible that risk adjustment could raise the value of τ^* , even understanding that default rates of municipal bonds were negligible in that era. Extensive subsequent analysis considers these tax, regulatory and risk considerations, drawing somewhat mixed conclusions about their power in explaining the pattern of spreads between taxable and tax-free returns at different maturities.⁵

The ability of banks to avoid taxes by earning tax-exempt income financed by investments on which they paid tax-deductible interest seemed to many observers in the pre-1986 era to make commercial banks effectively tax-exempt (e.g., Wolfman, 1981). If true, this would affect their investment and financing strategies, tax obligations, and much else; and it might also undermine tax fairness; but these concerns rely on the idea that banks actually benefitted from avoiding taxes by investing in municipal bonds. If not, then a bank is effectively fully taxable, in the sense that it values a marginal dollar of pretax income at one minus the statutory tax rate. The U.S. Congress, Joint Committee on Taxation (1987, p. 562) explains that Congress changed the rules concerning interest deductibility because “Congress was concerned that financial institutions could drastically reduce their tax liability as a result of the prior-law rules. For example, under prior law, a bank often could totally eliminate its tax liabilities by investing as little as one-third or less of its assets in tax-exempt obligations.” While it was undoubtedly true that a bank was able to use municipal debt to offset most or even all of its taxes, it is somewhat less clear what assumptions Congress was making in drawing the conclusion that this would be problematic.

structure on the degree to which tax exemptions reduce interest rates; and Garrett and Shive (2023) find that large banks appear to limit voluntarily their own holdings of tax-preferred renewable power investments.

⁵ See Trzcinka (1982), Livingston (1982), Skelton (1983a), Piros (1987), Osterberg (1990), Quigley and Rubinfeld (1991), Mankiw and Poterba (1996), Park (1997), Chalmers (1998, 2006), Slemrod and Greimel (1999), Kim et al. (2000), Erickson, Goolsbee and Maydew (2003), Wang, Wu and Zhang (2008), Kueng (2014), Ang et al. (2017), Schwert (2017), Cestau et al. (2019), and Fleckenstein and Longstaff (2023).

4. *Aggregate Tax Avoidance.*

Aggregate tax statistics provide information that can be used to estimate the extent to which U.S. banks reduced their tax obligations by investing in tax-exempt debt. A bank's taxable income (TI) can be expressed as

$$(2) \quad TI = (A - M)r - I \left(1 - \frac{\gamma M}{A} \right),$$

in which A is the bank's total assets, M is its holding of municipal bonds, r is the pretax return on taxable investments, I is interest expense, and γ is the fraction of the bank's interest expense that is subject to possible disallowance (e.g., $\gamma = 0.15$ in 1983). Let M^* denote the level of municipal bond holding at which $TI = 0$. Solving (2) for M^* produces

$$(3) \quad M^* = \frac{Ar - I}{r - \frac{\gamma I}{A}}.$$

It is meaningful to consider the muni utilization (MU) variable

$$(4) \quad MU \equiv \frac{M}{M^*} = \frac{M \left(r - \frac{\gamma I}{A} \right)}{TI + M \left(r - \frac{\gamma I}{A} \right)},$$

which is the ratio of actual holdings of municipal debt to the amount of municipal debt that would have zeroed out a bank's taxable income. From (4), if a bank has no municipal debt, then $M = 0$ and $MU = 0$; whereas if a bank holds $M = M^*$, then $TI = 0$ and $MU = 1$. Since equation (2) indicates that taxable income is linear in M , it follows that MU also indicates the extent to which a bank reduces its taxable income by holding tax-exempt debt.

Data reported by the U.S. Treasury (various), together with the Salomon Brothers data, permit calculation of MU for the aggregate banking sector for years starting in 1950. Tax return data provide information on aggregate taxable income, municipal bond interest income, interest expense deductions, and total assets of U.S. banks. Values of M can be inferred from ratios of

municipal bond interest and corresponding yields of municipal bonds reported by Salomon Brothers; and values of r can be taken to correspond to Treasury bond yields reported by Salomon Brothers. One minor complication is that while the interest expense in (4) is the total amount of interest paid, the tax data report allowable interest expense $I^A = I \left(1 - \frac{\gamma M}{A}\right)$, from which it follows that (4) implies

$$(5) \quad MU = \frac{M \left(r - \frac{\gamma I^A}{A - \gamma M} \right)}{TI + M \left(r - \frac{\gamma I^A}{A - \gamma M} \right)}.$$

Figure 3 plots annual values of MU , as defined by (5), for years between 1950 and 1994, using yields on one-year Treasury securities and municipal bonds to perform the calculations. During the 1950s, MU averaged a bit above 0.2, implying that bank holdings of municipal debt reduced their total tax payments by about one-fifth, compared to alternative scenarios in which banks would have held zero municipal debt. Aggregate MU rose over time, averaging about 45% in the 1960s, 70% in the 1970s, and even exceeding 80% briefly in the 1980s before falling precipitously after 1986. Appendix Figure 3 shows that replacing one-year yields with returns on longer-duration Treasury securities and municipal bonds changes the implied values of MU very little.

Two features of bank behavior in the era prior to 1986 are clear from Figure 3. The first is that investing in municipal bonds significantly reduced bank tax payments compared to the alternative of investing in assets generating taxable returns, and did so increasingly over time prior to 1986. Since the portion of aggregate bank assets devoted to municipal bond holdings rose modestly by comparison, the secular increase in MU primarily reflects declining profitability of other bank investments, particularly in the inflationary and slow-growth 1970s and early 1980s. Appendix Figure 4 depicts the municipal bond interest share of aggregate bank income and the fraction of aggregate bank assets invested in municipal bonds between 1950 and 1994. The disproportionate rise in the municipal bond interest share of bank income implies that other investments did poorly by comparison.

The second feature of pre-1986 behavior apparent in Figure 3 is that, despite their investments in municipal bonds, banks nonetheless paid significant federal taxes. Since aggregate *MU* levels were always below one, it follows that banks had considerable unused capacity to reduce their taxes. Municipal bonds were in ample supply; evidence presented by Cortes, Cunha, and Barbosa (2023) indicates that the U.S. banking sector consistently held 40-60% of all municipal bonds over this period.⁶ And even if bond supplies had been somehow limited, individual banks with sufficient demand could have obtained additional municipal bonds by bidding a bit above market, a process that would continue until buyers were indifferent. Banks were aware of the tax-avoidance opportunities presented by municipal bonds, and availed themselves of it; but they also limited the extent to which they were willing to direct investment funds to municipal bonds in order to reduce their tax payments.

5. *Evidence from Call Reports.*

Additional information on bank behavior is available from regulatory filings that banks make with the Federal Deposit Insurance Corporation. The historical Call Report data from 1976-2001 are compiled and published by the Federal Reserve Bank of Chicago. The analysis in this paper uses banks' end of year filings to capture annual income, expenses, and holdings. The Call Report data contain a host of profit and loss and balance sheet entries, including net income and tax liability, but unfortunately do not include entries for taxable income or cash tax payments. Furthermore, some important variables are unavailable for certain years.

The Call Report data indicate that almost all reporting banks held municipal bonds during the years between 1977 and 1994. Figure 4 depicts the fraction of U.S. commercial banks with positive municipal bond holdings, which exceeds 90 percent at the start of this period and subsequently gradually declines, remaining above 80 percent throughout. It also repeats this analysis weighting banks by their gross assets, which corresponds to the fraction of gross bank assets held by banks with positive municipal bond holdings over this period. At the start of this period this fraction is close to 100 percent, reflecting that larger banks were extremely likely to

⁶ Bank shares of total outstanding state and local bonds for 1960-1990, calculated by Fortune (1991), are somewhat lower than those reported by Cortes, Cunha, and Barbosa (2023), though the two series exhibit similar patterns.

hold municipal bonds, though the fraction declines to roughly 95 percent by the end of the time period.

Banks with chronic tax losses do not stand to benefit from investing in municipal bonds, since the absence of tax rebates implies that a taxpayer does not benefit from further reducing any negative taxable income. Over this period, however, corporations with current-year tax losses could carry the losses back up to three years, to obtain rebates of taxes previously paid on prior-year positive taxable income; and in the absence of such opportunities, could carry forward any unused tax losses for up to 17 years to offset subsequent positive taxable income. These opportunities imply that even a bank with current-year losses will typically benefit from reducing its taxable income by holding municipal bonds, though the uncertainty of the availability of carry-back and carry-forward opportunities, the absence of adjustment for the time value of money, and the potential loss of tax carryforwards in corporate reorganizations make the prospective benefits of reducing negative taxable incomes less than the current benefits of reducing positive taxable incomes. In practice, however, most banks have positive income and pay taxes most years.⁷

The Call Report data indicate that, during this era, banks allocated a significant proportion of their holdings to liquid assets in the form of municipal bonds, Treasury securities, and cash. Figure 5 presents average fractions of assets in these categories over the 1977-1983 period, before the interest expense disallowance; and the 1987-1993 period, after the interest expense disallowance; distinguishing banks by asset size. In the period before the interest expense disallowance, banks held roughly 30 percent of their assets in these liquid assets, roughly equally spread among municipal bonds, Treasury securities, and cash. In the period after the interest expense disallowance, holdings of these liquid assets fell to roughly 20 percent of total assets, and this was disproportionately driven by a reduction in municipal bond holdings. These patterns are similar between small and medium banks (those with total assets in the

⁷ Appendix Figure 5 depicts fractions of banks with positive income each year in the Call Report data. The figure presents this measure calculated two ways: first the fraction of banks reporting positive annual accounting income, and second the fraction of banks reporting making positive tax payments. The fraction of banks with positive accounting income exceeds 90% every year other than during the severe recession (and very high interest rates) of the early 1980s; whereas the fraction with positive tax payments is lower, albeit always in excess of 65%. While the Call Report data do not include income for tax purposes, the accounting income entries that serve as the basis of the Call Report data closely approximate income for tax purposes.

bottom 90% of the distribution) and large banks (those with total assets in the top 10% of the distribution).

5.1. *Muni utilization by individual banks.*

The Call Report data can be used to calculate *MU* ratios for individual banks, and can be aggregated to calculate *MU* for the banking sector as a whole. These calculations follow the method described in section 4, though use equation (4) rather than equation (5), since the Call Report data are not based on tax definitions, and therefore include all interest expenses, not merely those for which taxpayers can claim deductions. The calculations exclude banks with negative net operating income.⁸ Appendix A provides details of the measurement of taxable income and municipal bond holdings in the Call Report data. Figure 6 reports the 25th percentile, median, and 75th percentile *MU* ratios in each year. In the years prior to 1983, more than a quarter of the banking sample used municipal bonds to reduce its tax payments by at least 80%, more than half of the banking sample used investments in municipal bonds to reduce its tax payments by at least 60%, and more than three quarters of the banking sample used municipal bonds to reduce its tax payments by at least 40%. In the years surrounding the introduction of the interest expense disallowance in 1983-1986, *MU* ratios dropped significantly. In the period after the Tax Reform Act of 1986, more than half of banks used municipal bonds to reduce their tax payments by 20% or less. Taking the 1977-1982 period as a whole, the distribution of *MU* across banks, as depicted in Figure 7, exhibited significant density at zero (representing banks that paid taxes but held no municipal bonds) and one (representing banks that did not pay taxes but held municipal bonds, suggesting they had fully eliminated their tax liability by holding municipal bonds).⁹ The majority of banks fell between these two extremes, using municipal bonds to eliminate some but not all of their tax liability. *MU* ratios skewed slightly higher among larger banks than smaller banks, and large banks were somewhat more likely to fully eliminate their tax liability using municipal bonds than smaller banks.

⁸ Calculations also exclude banks that report such large negative tax liabilities that they would be expected to pay negative taxes even if they held Treasuries instead of municipal bonds, as well as banks with less than \$1 million in total assets.

⁹ The *MU* ratio is censored at one because tax liability is often censored at zero, so banks with zero taxable income cannot be distinguished from banks with negative taxable income.

Figure 8 compares aggregate *MU* calculated using the Call Report data to *MU* calculated using aggregate tax return information. While the figures coincide in 1981 and 1982, in other years the aggregate *MU* based on individual bank Call Reports is lower than the corresponding figure based on aggregate tax return information. While there are many differences between these two series, it is reasonable to expect that the aggregate *MU* calculated using individual Call Report information to be a more accurate reflection of bank behavior. Banks with negative taxable income are included in the aggregate tax return series, whether or not these banks hold any municipal bonds, whereas those with negative net operating income are excluded from aggregates constructed using the Call Report data. Importantly, however, aggregate *MU* ratios calculated using the Call Report data share the salient features of aggregate *MU* calculated using aggregate tax return data, in that they indicate that banks significantly reduced their tax liabilities by investing in municipal bonds, and that banks nonetheless had significant remaining tax liabilities that could have been avoided by even more extensive investments in municipal bonds.

The Call Report data provide detail not available in the aggregate statistics, including the state in which a bank is headquartered. States tax corporate income, albeit at low rates compared to the federal government; and state economies and financial regulatory climates differ to modest degrees. As a result, there may be tax, economic, or regulatory reasons to expect *MU* ratios to differ across states. Appendix Figures 7 and 8 present state-level mean *MU* ratios for 1977-1982, both unweighted averages across banks (Appendix Figure 7) and state average *MU* weighted by bank assets (Appendix Figure 8). While these average *MU* levels differ, the differences are notably small in magnitude. Another feature of the panel nature of the Call Report data is that it is possible to compare the evolution of *MU* ratios for individual banks over time. Appendix Table 1 is a transition matrix of banks in different *MU* quartiles in 1977 and 1982. While there is notable persistence – 36% of banks in the top quartile of *MU* ratios in 1977 are also in the top quartile in 1982 – there is also quite a bit of random scatter, with 13% of top-quartile *MU* banks in 1977 falling to the bottom quartile by 1982.

5.2. *Arbitrage potential.*

The Call Report data, as well as the aggregate corporate income tax statistics, suggest that banks had significant unused opportunities to reduce their tax liabilities by increasing

investments in tax-exempt debt in the years prior to 1983. This tax arbitrage could be conducted either by selling investments that yield taxable returns, and using the sale proceeds to purchase municipal bonds, or else by borrowing, incurring deductible interest expense, and again using the proceeds to invest in municipal bonds. The most readily available of these options would be to sell Treasury securities and purchase municipal bonds. The market for Treasury securities is unusually thick, with buyers seemingly ever ready to purchase at prevailing prices. It is instructive therefore to consider the behavior of banks that held Treasury securities, paid taxes, and chose not to avoid some of their taxes by taking on additional municipal debt.

It is useful to define a bank's arbitrage potential as the minimum of its holdings of Treasury securities and the ratio of the bank's taxable income to the prevailing return on Treasury securities. This arbitrage potential corresponds to the volume of Treasuries that the bank could sell and invest in municipal bonds, with all of the foregone taxable income from the Treasuries producing tax savings. Most banks have arbitrage potential so defined, since (as noted in Appendix Figure 4) even during the rough financial conditions of the 1980s more than two-thirds had positive taxable income; and virtually all banks hold at least some Treasuries. The top panel of Figure 9 depicts the share of banks with different amounts of arbitrage potential over time. Over the 1977-1983 period before the introduction of the interest expense disallowance, more than 30% of banks in every year had arbitrage potential of at least \$1 million. It is clear that there were many banks with large amounts of untapped potential to reduce their tax liabilities.

Banks with significant arbitrage potential also held large amounts of municipal debt. The bottom panel of Figure 9 depicts portions of aggregate municipal bond income received by banks with different levels of remaining arbitrage potential. Banks with at least \$10 million of arbitrage potential received an average of a third of all municipal bond income earned by the banking sector in each year. Banks with at least \$1 million of arbitrage potential received an average of almost two thirds of all municipal bond income earned by the banking sector in each year. These banks were clearly aware of the benefits of investing in municipal bonds, and would have been able to reduce their tax liabilities even further by shedding some of their Treasury holdings, but chose not to do so.

5.3 *Arbitrage and indifference.*

Why did banks use municipal bonds to offset some but not all of their tax liabilities? This pattern is consistent with banks being indifferent between holding taxable and tax-exempt investments, though there are other possibilities. The lower yields on municipal bonds make them unattractive investments for taxpayers with persistently zero or negative taxable income; and since the likelihood that a bank has tax losses rises with the fraction of its investments placed in municipal bonds, a bank with an uncertain year-end tax status might want to limit its exposure to municipal bonds. This dynamic may account for the holdings of some banks, but cannot explain the behavior of the large number of banks that held municipal bonds but were very far from exhausting their potential tax liabilities. These banks would instead choose investments based on anticipated risks and after-tax returns.

Another possibility is that banks were reluctant to invest too high a fraction of their assets in municipal bonds due to concerns over how bank regulators, or their own investors, would view the resulting riskiness of their investment portfolios. The evidence in Figure 5 indicates that municipal bonds represented roughly ten percent of total assets for the average bank, which while limited might conceivably have been enough to trigger portfolio concerns. Given, however, the ability of banks to diversify their municipal bond holdings across issuing jurisdictions, the rarity of municipal bond defaults in the pre-1986 period, and the similarity of municipal bond utilization ratios across U.S. states with different regulatory regimes, it seems that these risk and regulatory considerations might have had only minor impact on demand for municipal bonds. Further, Appendix Figure 9 shows that it was not uncommon for banks to hold 15 percent or more of their portfolios in municipal bonds. This suggests that the large number of banks with relatively few municipal bonds could have readily increased their holdings without coming close to having their investment portfolios as concentrated in municipal bonds as were the portfolios of other banks. If risk, regulation, and tax-exhaustion considerations were relatively unimportant considerations in the marginal investment decisions of much of the banking sector, then bank demand for municipal bonds would be driven by comparisons of expected after-tax returns.

6. *Asset substitution and bank behavior.*

Bank holdings of municipal bonds declined dramatically after the Tax Reform Act of 1986 removed the special exception that commercial banks had to the rules restricting interest expense deductions of taxpayers investing in tax-exempt bonds. This section explores the extent to which the tax change affected bank demands for municipal bonds, and any resulting effects on demands for other assets.

6.1. *Tax incentives.*

A bank's after-tax profits can be denoted

$$(6) \quad \psi \equiv [R(L) + rT - I(B) - c(L, T, M, C)](1 - \tau) - \gamma\tau I(B) \frac{M}{A} + Mr^*,$$

in which L is a bank's loans, $R(L)$ the return on its loans, T is the bank's holding of Treasuries, r the return on Treasuries, C is the bank's holding of cash (assumed to offer zero return), B is the bank's borrowing, including borrowing from depositors, $I(B)$ is the bank's total interest expense, τ is the statutory corporate tax rate, γ is the extent to which interest deductions are disallowed due to investments in tax-exempt bonds, A is total assets, M is investments in tax-exempt bonds, and r^* the yield on tax-exempt bonds. The expression $c(L, T, M, C)$ is the certainty-equivalent cost of holding loans, Treasuries, and municipal bonds, as mitigated by cash holdings. Total assets must satisfy the adding-up condition $A = L + T + M + C$.

A profit-maximizing bank chooses its borrowing and asset allocation to maximize (6) subject to

$$(7) \quad B \geq L + T + E + C.$$

The first-order conditions for interior choices of T and M to maximize (6) subject to (7) are

$$(8a) \quad r(1 - \tau) - \frac{\partial c}{\partial T}(1 - \tau) + \gamma\tau I(B) \frac{M}{A^2} = \lambda$$

$$(8b) \quad r^* - \frac{\partial c}{\partial M}(1-\tau) - \gamma\tau I(B)\left(\frac{1}{A} - \frac{M}{A^2}\right) = \lambda,$$

in which λ is the shadow value of the constraint (7). Combining (8a) and (8b) yields

$$(9) \quad r(1-\tau) + \left(\frac{\partial c}{\partial M} - \frac{\partial c}{\partial T}\right)(1-\tau) = r^* - \gamma\tau \frac{I(B)}{A}.$$

Equation (9) offers two modifications to the arbitrage condition defining t^* in equation (1). The first is that any interest expense disallowance ($\gamma \neq 0$) increases the cost of holding municipal bonds relative to Treasury securities. The second modification is that the marginal liquidity costs of holding municipal bonds $\left(\frac{\partial c}{\partial M}\right)$ may differ from the marginal liquidity costs of holding Treasuries $\left(\frac{\partial c}{\partial T}\right)$. It is natural to expect municipal bonds to have entailed greater liquidity costs than Treasuries, since municipal bonds were traded on less-liquid markets and were more apt to have unanticipated capital gains and losses. Combining equations (1) and (9),

$$(10) \quad t^* = \frac{r - r^*}{r} = \tau - \left(\frac{\partial c}{\partial M} - \frac{\partial c}{\partial T}\right) \frac{(1-\tau)}{r} - \gamma\tau \frac{I(B)}{Ar},$$

which may constitute part of the reason why the breakeven tax rates implied by historical bond yields were consistently below statutory tax rates. If municipal bonds are more expensive than Treasuries from the standpoint of interest expense deductions or liquidity, then standard measures of realized yields used to fit t^* in (1) will overstate the benefits of holding municipal bonds, and consequently somewhat overstate the levels of t^* necessary to make marginal investors indifferent between taxable and tax-exempt debt.

6.2. *Estimated tax effects.*

The 1986 tax change that increased the value of γ from 0.2 to 1.0 discouraged banks from holding municipal bonds, with effects that differed based on a bank's ratio of interest expenses to assets. It is possible to use these differences to identify the effect of price incentives

on municipal bond holdings, and any effects of municipal bond holdings on demands for other assets.

Equation (9) can be rewritten as

$$(11) \quad r^* - \left(r - \frac{\partial c}{\partial T} \right) (1 - \tau) = \gamma \tau \frac{I(B)}{A} + \frac{\partial c}{\partial M} (1 - \tau),$$

the left side of which is the return to investing in municipal bonds, net of the opportunity cost of using the same funds to invest in Treasuries. The right side of (11) is the cost of investing in municipal bonds. This cost has two components, the first of which is the value of foregone interest expense deductions. The 1986 tax change significantly impacted this cost, doing so differentially across firms based on their $I(B)/A$ ratios. Of course, firms choose their own $I(B)/A$ ratios, along with other components of (11); but there appear to be stable underlying determinants of $I(B)/A$, presumably reflecting business opportunities, strategies, and borrowing costs.¹⁰ As a result, it is possible to use observed $I(B)/A$ as a measure of the effect of a change in $\gamma\tau$ on a bank's cost of investing in municipal bonds.

Equation (11) can be expressed as

$$(12) \quad \frac{\partial c}{\partial M} - \frac{\partial c}{\partial T} = \frac{r^*}{(1 - \tau)} - r - \gamma \frac{\tau}{(1 - \tau)} \frac{I(B)}{A}.$$

The 1986 tax change tripled the size of $\gamma\tau/(1 - \tau)$, increasing it from 0.17 to 0.52, thereby making it more expensive for all banks, and particularly those with high $I(B)/A$ ratios, to invest

¹⁰ Appendix Table 2 presents cross-sectional estimates indicating that a bank's $I(B)/A$ ratio in 1984-1985 (before the Tax Reform Act of 1986) is a strong predictor of its $I(B)/A$ ratio in 1988 (after the Tax Reform Act of 1986).

in municipal bonds. Approximating the left side of (12) by $\phi_i + \frac{1}{\beta} \ln M$, with ϕ_i an idiosyncratic fixed effect for each bank i and β common across banks,¹¹ it follows that

$$(13) \quad \frac{dM}{d[\gamma\tau/(1-\tau)]} = M \left[k + \beta \frac{I(B)}{A} \right],$$

with k capturing effects of the tax change that are common for all banks.

Table 1 presents coefficients from regressions that estimate the relationship expressed in (13). The dependent variable in these regressions is the change in a bank's holding of municipal bonds between 1982 and 1988, normalized by the bank's total assets in 1982. The regressions include a control variable for the change in bank assets between 1982 and 1988, but the independent variable of interest is the interaction of municipal bond holdings in 1982, normalized by 1982 assets, and the bank's average ratio of interest expense to total assets in 1984 and 1985.¹² The regressions also include fixed effects for the state in which a bank's headquarters is located and a dummy for a bank's quintile in the distribution of total assets. The state dummies capture possible effects of regional economic conditions and state banking regulations, and the size dummies partially adjust for differences over this time period in industry conditions for banks of different sizes.

The estimated -6.974 coefficient in the first column of Table 2 indicates that higher interest expenses relative to total assets are associated with more aggressive shedding of municipal bond assets between 1982 and 1988. This pattern is entirely consistent with incentives created by federal tax changes. In the sample, the mean ratio of interest expense to total assets is 0.061; consequently, the coefficient estimate implies that a ten percent higher interest expense

¹¹ This approximation takes a bank's demand for Treasuries, cash, and other assets to be a function of its municipal bond holdings, and implies that a bank's demand for municipal bonds can be expressed as

$$M = \exp \left[\frac{\beta r^*}{(1-\tau)} - \beta r - \beta \phi_i - \gamma \frac{\tau}{(1-\tau)} \beta \frac{I(B)}{A} \right].$$

¹² Appendix Table 3 presents means and standard deviations of variables used in the regressions presented in Tables 1 and 2. The regressions use interest expenses for 1984 and 1985 because the Call Report data have incomplete coverage of interest expenses prior to 1984.

ratio, evaluated at the mean, is associated with a 4.3 percent lower municipal bond holdings by 1988.

The second column of Table 1 reports coefficients from a regression that unpacks the variable of interest by separately including its components as independent regressors. The effect of the interaction of municipal bond holdings in 1982, normalized by 1982 assets, and the bank's ratio of interest expense to total assets in 1984-1985 remains significantly negative even with normalized 1982 municipal bond holdings and the 1984-1985 interest expense ratio included as independent variables, and indeed the estimated coefficient almost doubles in magnitude – though it must be interpreted differently. Equation (13) indicates that the effect of changing the extent to which banks are exempted from limits on interest expense deductions should bear differently on banks with different interactions of normalized municipal bond holdings and interest expense ratios, and bank behavior between 1982 and 1988 appears to be consistent with this interpretation.

Banks that responded to incentives created by the 1986 tax change by reducing their municipal bond holdings should have adjusted other asset positions as a consequence. It is possible to use the second of the regressions reported in Table 1 as the first stage in an instrumental variables specification of the effect of municipal bond holdings on bank demand for cash and Treasuries. This estimation identifies how banks deployed the funds no longer invested in municipal bonds, and in the process serves as a check on the reliability of the first-stage estimates. Estimated coefficients from the second stage equations of this IV system are reported in Table 2.

Table 2 reports estimated second-stage IV coefficients from regressions that use the regression reported in the second column of Table 1 to obtain predicted values of the change in municipal bond holdings. The dependent variable in column 1 of Table 2 is the change in cash holdings between 1982 and 1988, divided by total bank assets in 1982; the dependent variable in column 2 is the change in Treasury bond holdings between 1982 and 1988, divided by total bank assets in 1982. All regressions control for the bank's percent change in total assets from 1982-

1988, state fixed effects, and bank size quintile in 1982.¹³ The estimated -0.212 coefficient in column 1 implies that a bank that reduced its municipal bond holdings by \$10 million due to the tax change as a result increased its cash holdings by \$2.12 million. The estimated -0.326 coefficient in the second column implies that the same bank increased its holding of Treasuries by \$3.26 million.

6.3. *Asset substitution.*

The evidence reported in Table 1 is entirely consistent with banks responding to changing incentives by economizing on their holdings of municipal bonds. And the evidence reported in Table 2 suggests that cash and Treasury securities are strong substitutes for municipal bonds. In the framework of the profit function specified in (6), this implies that any concerns that banks had about the liquidity costs of holding municipal bonds, which would have prompted higher accompanying cash balances, were outweighed by simple substitution. And it is entirely reasonable to expect banks to substitute Treasury securities for municipal bonds when municipals become more expensive. Notably, the estimated effects on cash and Treasury security investments of predicted changes in municipal bond holdings sum to roughly 0.5, implying that banks deploy some of their newfound financial capacity in other investments, including making new loans.

7. *Conclusion*

U.S. banks in the 1950-1994 era appear to have responded rationally to the tax incentives that they faced, holding municipal bonds despite their below-market pretax returns, and rapidly adjusting their municipal bond holdings in response to tax changes. Despite, and indeed largely because of, the eagerness of their responses to tax incentives, U.S. banks received little if any benefits from the special tax situation they enjoyed in the era prior to 1986.

¹³ Appendix Table 4 presents results from alternative IV regression specifications that do not control for bank size in 1982 (columns 1 and 4); others that linearly control for bank size in 1982 (column 2 and 5); and the main specification that controls for bank size quintiles in 1982 (columns 3 and 6). The relationship between changes in municipal bond holdings and changes in Treasury holdings stays relatively stable across specifications. The relationship between changes in municipal bond holdings and changes in cash holdings is more sensitive to controlling for bank size.

Aggregate tax return data as well as regulatory filings for individual banks point strongly in the direction of many banks being indifferent between holding investments generating taxable income and investments in municipal bonds paying tax-exempt interest. The facts that banks with more than \$10 million of unused arbitrage potential collectively received an average of a third of all municipal bond income earned by the banking sector in each year between 1976 and 1983, and that those with more than \$1 million collectively received an average of almost two-thirds, suggest that, absent other considerations, these banks were indifferent between holding Treasury securities and tax-exempt debt. Furthermore, swapping Treasuries for municipal bonds was not the only municipal bond-based arbitrage opportunity available to these and other banks. The commercial banking sector could avail itself of tax-free income opportunities at the cost of earning modest yields, and did so to the point of indifference.

Corporate tax liabilities are almost exactly linear in taxable income for most banks, from which it follows that local tax indifference also implies global indifference. Consequently, the banking system did not benefit from its ability to hold tax-exempt debt while nonetheless deducting all of its interest payments. Profit-driven competition among banks drove up the prices of municipal bonds and thereby drove down the yields. Historical evidence of corporate bond yields is quite consistent with the interpretation that commercial banks were pushed to the point of indifference, though the bond yield information is sufficiently coarse as to leave some question about its precision as a test of market efficiency. Combining the bond pricing data with information on quantities of investments held by the banking sector as a whole, and the holdings of individual banks, offers a consistent picture that provides considerably more evidence that banks were ultimately indifferent to their tax-exempt investments.

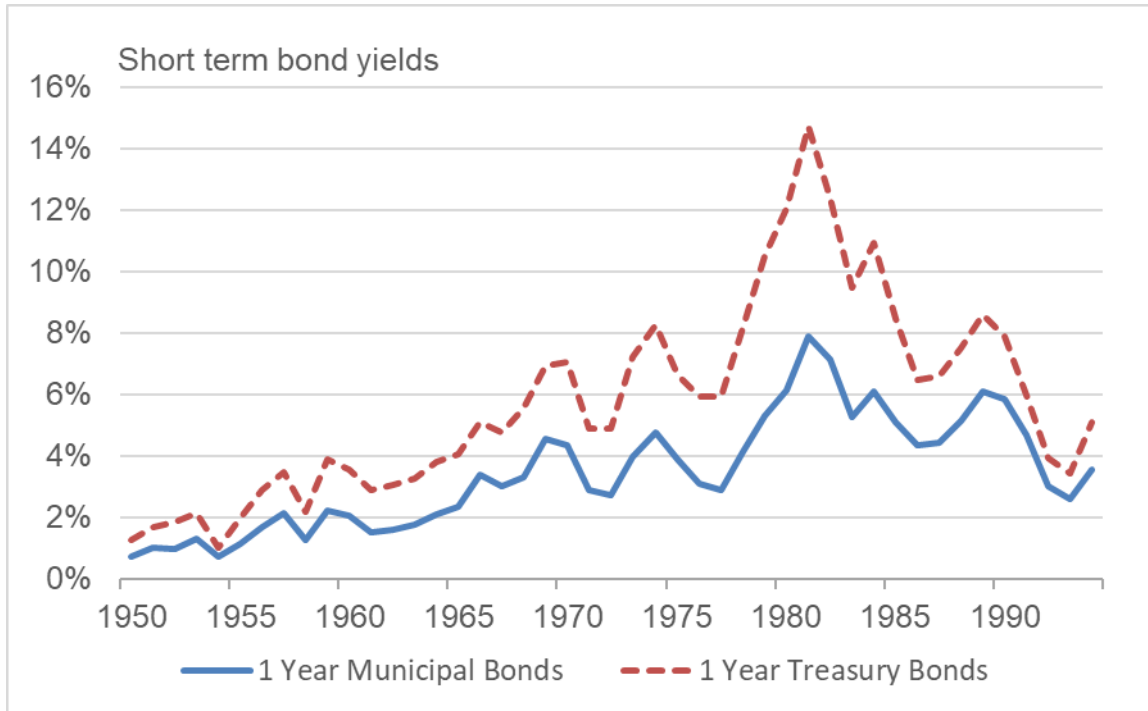
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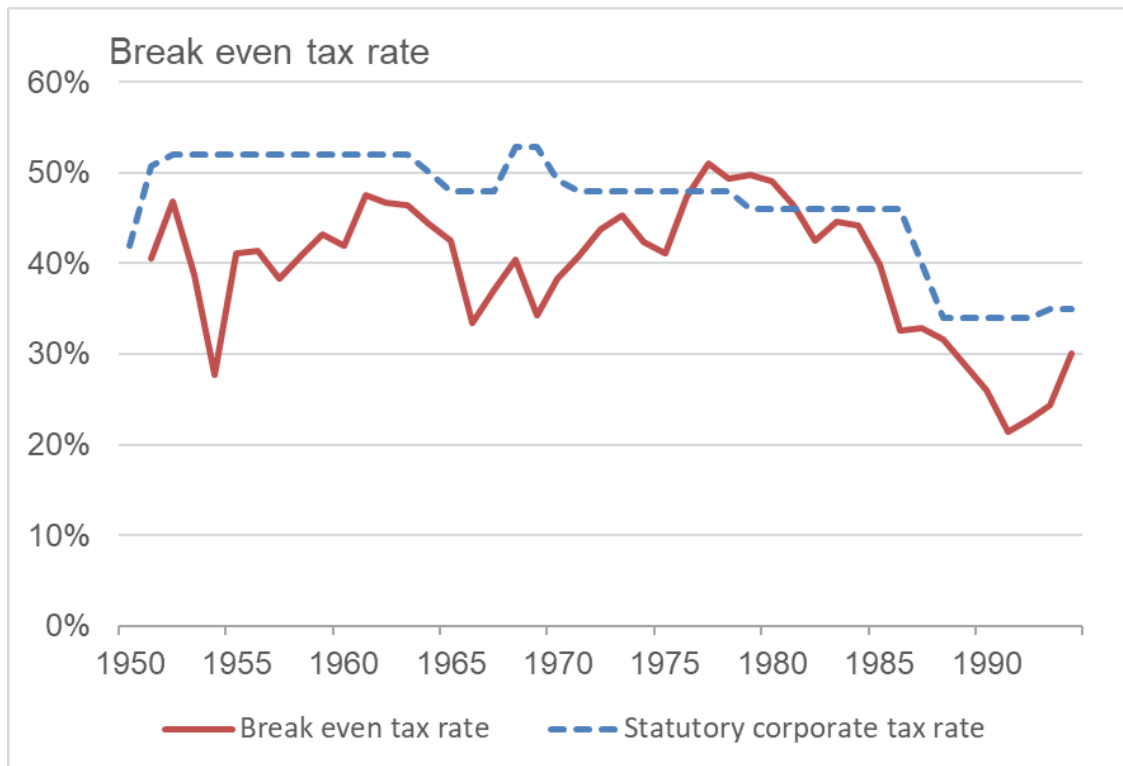
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Figure 1: Comparison Between Treasury and Municipal Bond Yields



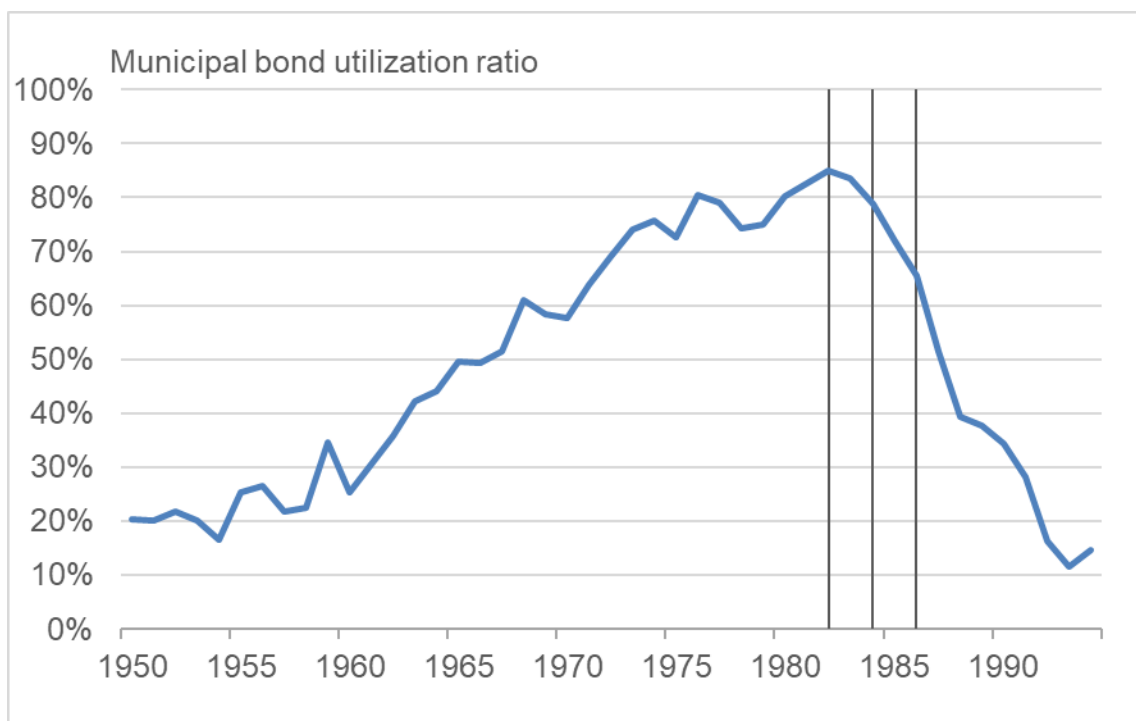
Source: Salomon Brothers, "Analytical Record of Yields and Yields Spreads," published January 1995. Annual yields are calculated from the mean of monthly yields.

**Figure 2: Tax Rate at Which Investors are Indifferent Between
Municipal Bonds and Treasury Bonds**



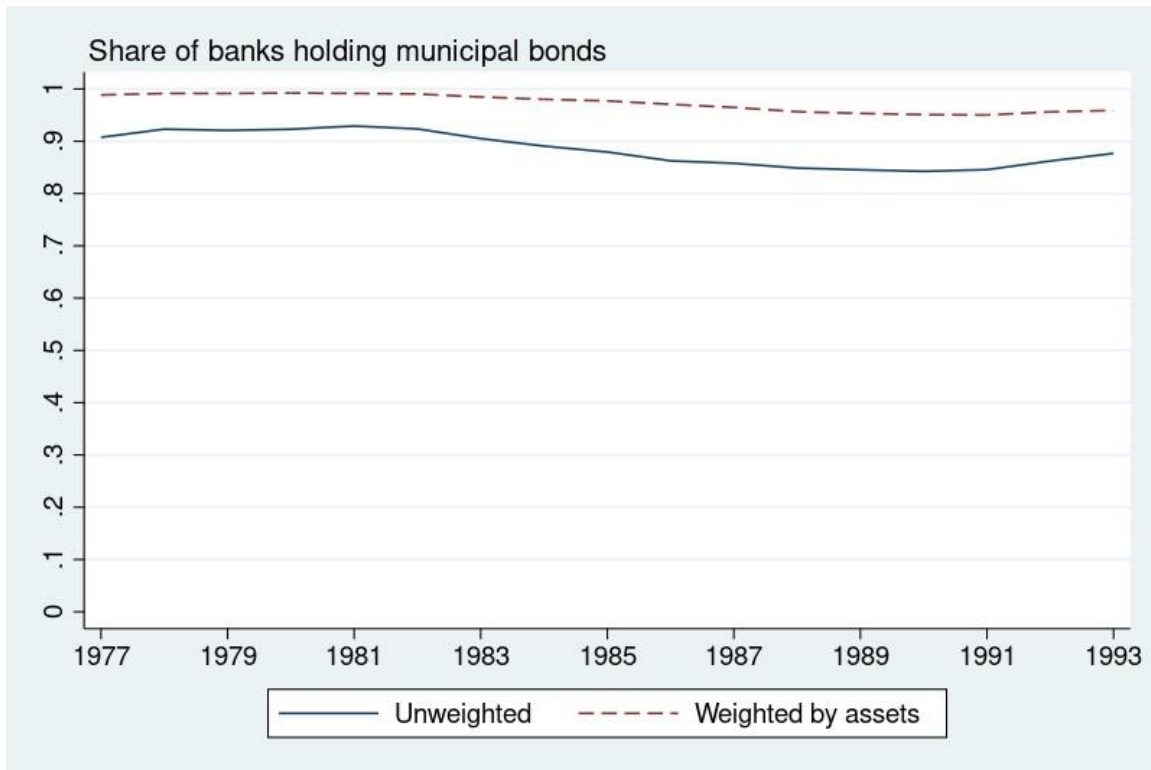
Note: Calculated from Salomon Brothers, "Analytical Record of Yields and Yield Spreads."

Figure 3: Aggregate Share of Banking Sector Tax Liability Eliminated by Holding Municipal Bonds



Note: Calculated from IRS Statistics of Income, "Corporation Complete Report" and Salomon Brothers, "Analytical Record of Yields and Yield Spreads." Muni holdings are calculated by capitalizing interest income on state and local government obligations at yield rates for 1 year municipal bonds. Vertical lines denote reductions in the tax deductibility of the interest expenses of banks holding municipal bonds.

Figure 4: Shares of Banks Holding Municipal Bonds



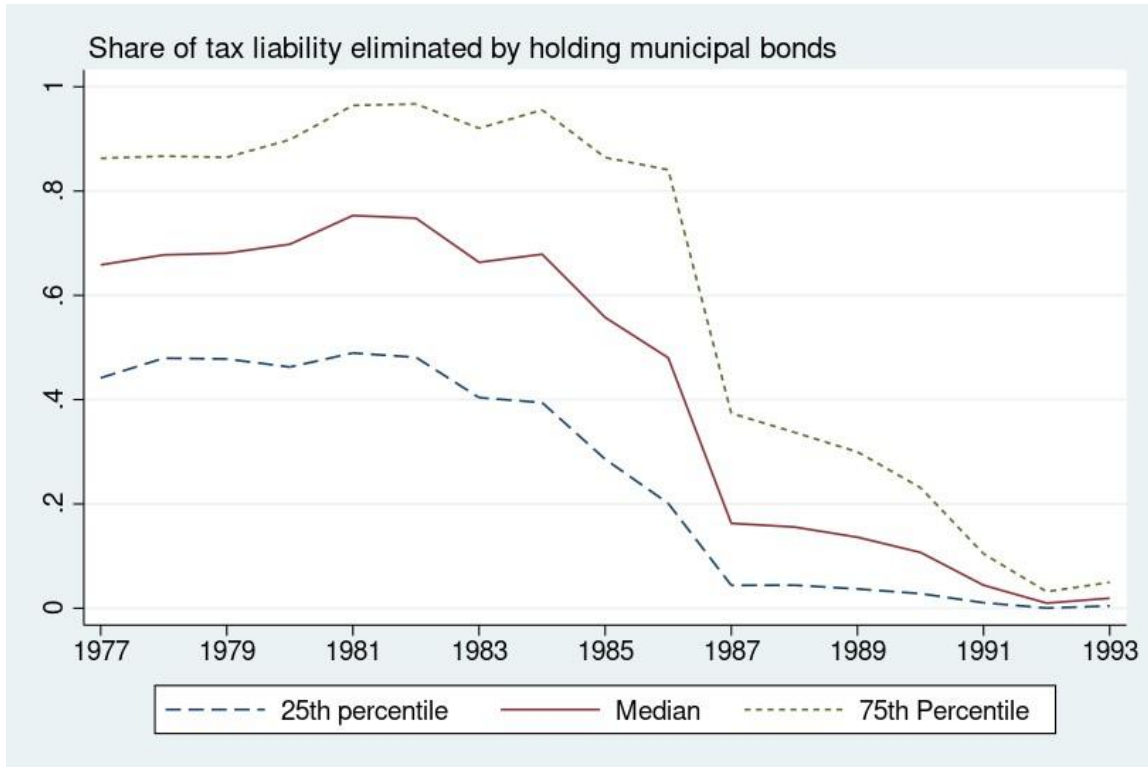
Note: The share of banks holding municipal bonds is calculated from the share of banks that report positive holdings of state and local government obligations through 1983, and positive holdings of state and local government obligations excluding leases after 1983. The unweighted series gives each bank equal weight. The weighted series weights banks by their total assets in each year.

Figure 5: Holdings of Liquid Assets, by Bank Size



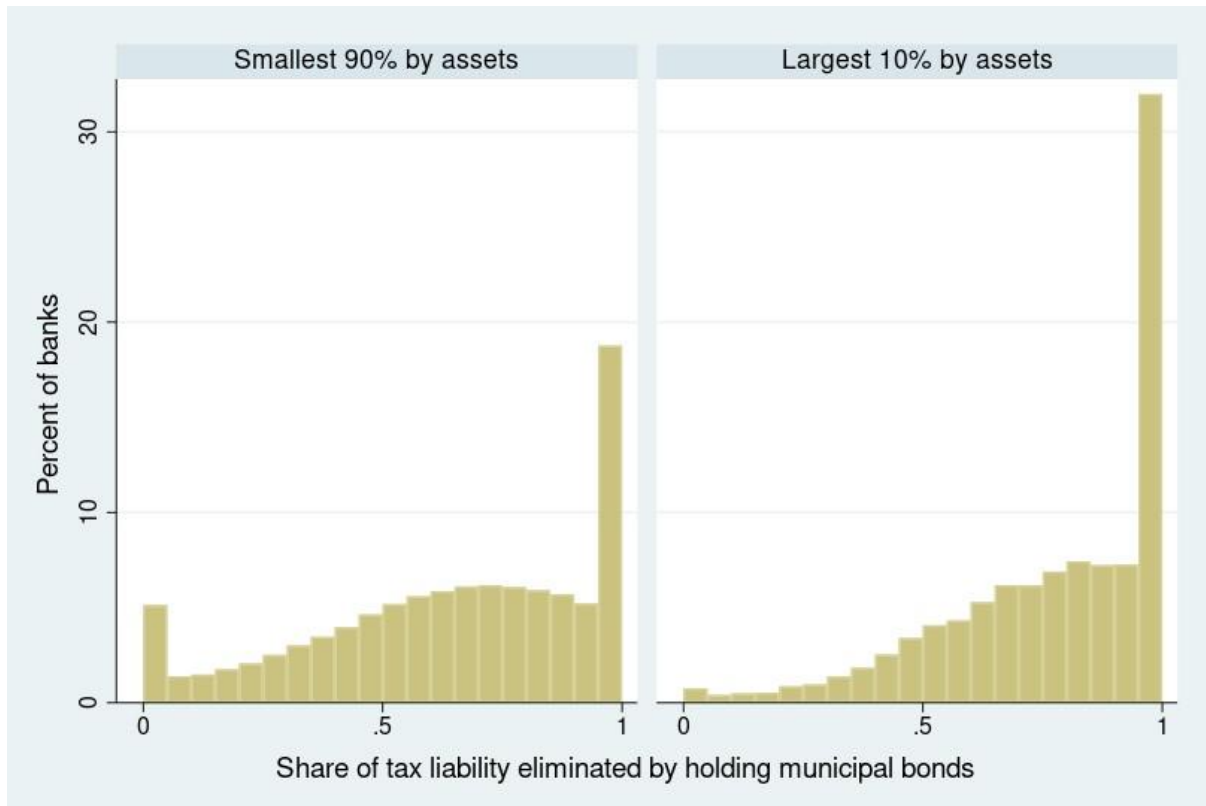
Note: Data are missing for 1984-1986 because Treasury holdings of most banks were confidential in those years. Excludes banks with less than \$1 million in total assets.

Figure 6: Distributional Features of Municipal Bond Utilization Ratios, 1977-1993



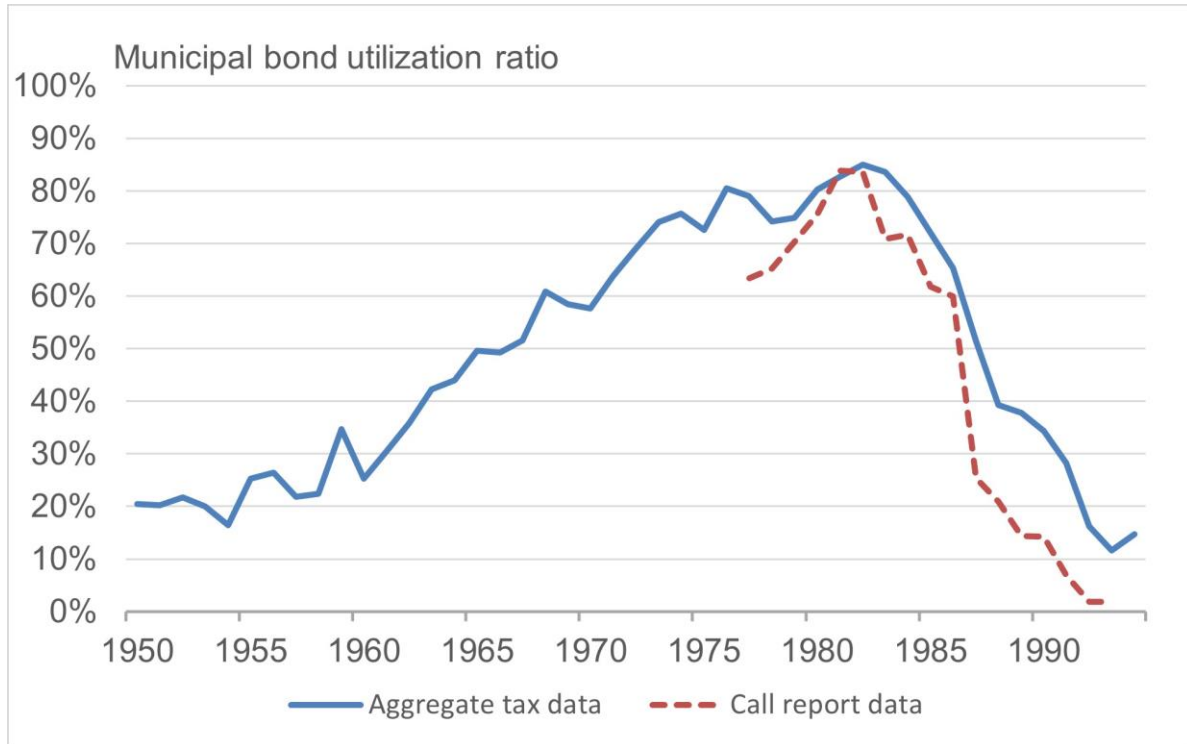
Note: Excludes banks with negative net operating income, banks with less than \$1 million in total assets, and banks that report such large negative tax liabilities that they would be expected to pay negative taxes even if they held Treasuries instead of municipal bonds.

Figure 7: Distribution of 1977-1982 Municipal Bond Utilization Ratios



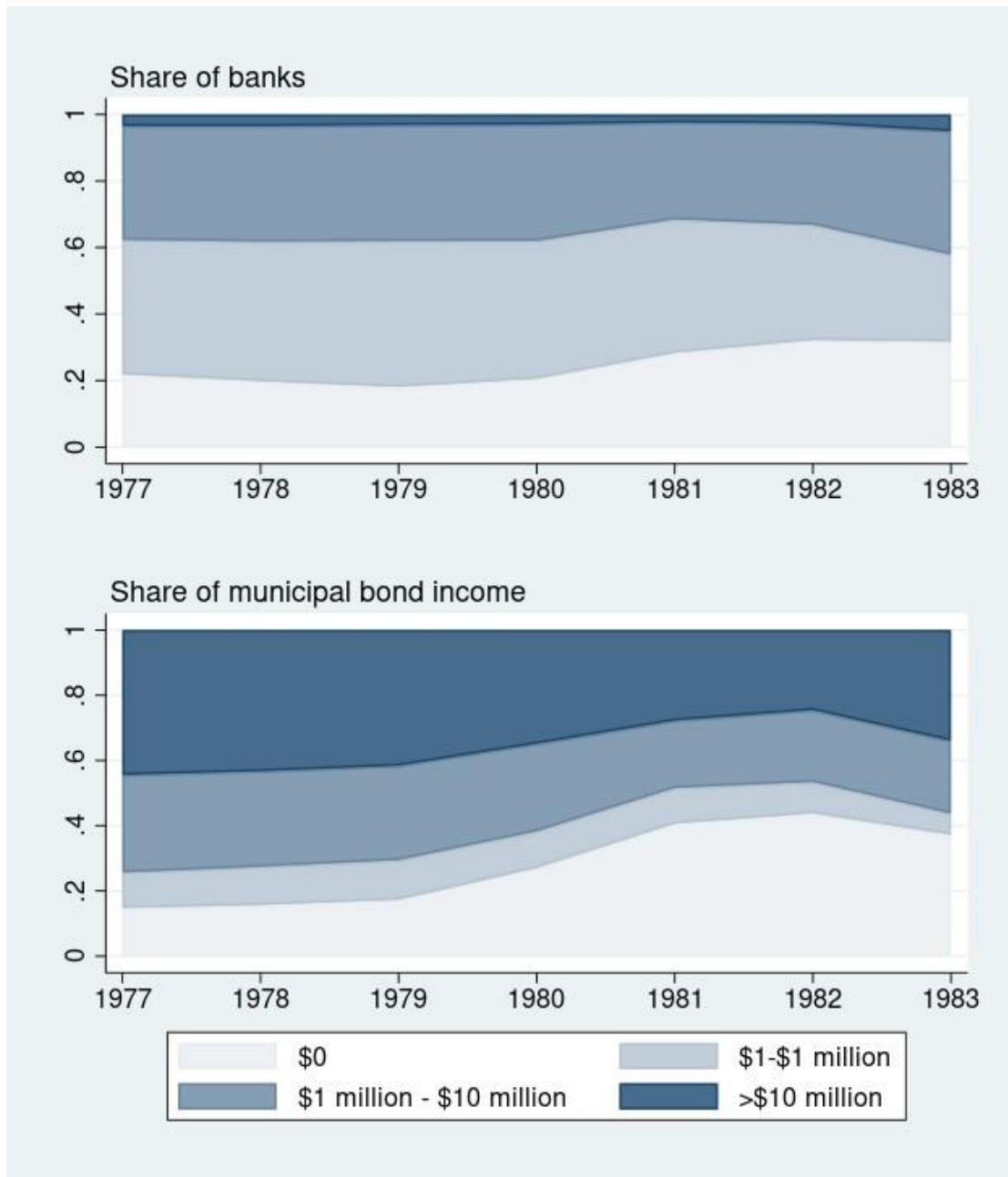
Note: The mass of banks at 100% represents banks that have no tax liability but hold municipal bonds, indicating they fully eliminated their tax liability by holding municipal bonds. Excludes banks with negative net operating income, banks with less than \$1 million in total assets, and banks that report such large negative tax liabilities that they would be expected to pay negative taxes even if they held Treasuries instead of municipal bonds.

Figure 8: Aggregate Share of Banking Sector Tax Liability Eliminated by Holding Municipal Bonds, Tax Data v. Call Report Data



Note: Both series use bond yield rates from Salomon Brothers “Analytical Record of Yields and Yield Spreads.” Aggregate tax data series is calculated from IRS Statistics of Income “Corporate Complete Report.” The Call Report data series is aggregated by taking the mean of bank-level utilization ratios, weighted by an estimate of each bank’s taxable income if it held Treasuries instead of municipal bonds.

Figure 9: Distribution of Arbitrage Potential, 1977-1983



Note: Arbitrage potential is defined as the lesser of a bank's Treasury bond holdings and the amount of Treasuries it would need to sell to reduce its tax liability to zero. Municipal bond income is assumed to be proportional to municipal bond holdings.

Table 1: Determinants of Municipal Bond Holdings, 1982-1988

Dependent Variable:	(1) Δ Munis	(2) Δ Munis
Muni ratio x interest expense ratio	-6.974 (0.201)	-13.51 (1.187)
Muni ratio		0.407 (0.0721)
Interest expense ratio		0.277 (0.130)
Δ Assets	0.0346 (0.0007)	0.0346 (0.0008)
Size quintile fixed effects	X	X
State fixed effects	X	X
Observations	11,441	11,441
R-squared	0.346	0.348

Note to Table 1: The dependent variable Δ Munis is the change in a bank's holdings of municipal bonds between 1982 and 1988, scaled by total bank assets in 1982. The interest expense ratio is the average of a bank's ratio of interest expenses to total assets in 1984 and 1985. The muni ratio is a bank's ratio of municipal bond holding to total assets in 1982. All regressions include state fixed effects and size quintile fixed effects, and control for Δ Assets, which is the change in a bank's total assets between 1982 and 1988, scaled by total bank assets in 1982. Banks are grouped into size quintiles based on total assets in 1982. All variables are winsorized at the 1st and 99th percentiles. Standard errors are in parentheses.

Table 2: Treasury and Cash Holding Responses to Changes in Municipal Bond Holdings, 1982-1988

Dependent Variable:	(1) Δ Cash	(2) Δ Treasuries
Predicted Δ Munis	-0.212 (0.0409)	-0.326 (0.0561)
Δ Assets	0.0935 (0.0019)	0.0594 (0.0030)
Size quintile fixed effects	X	X
State fixed effects	X	X
Observations	11,441	11,441

Note to Table 2: The table presents estimated coefficients from second-stage instrumental variables regressions explaining changes in bank holdings of cash and Treasuries between 1982 and 1988. The dependent variable Δ Cash is the change in cash holdings between 1982 and 1988, scaled by total bank assets in 1982. The dependent variable Δ Treasuries is the change in Treasury bond holdings between 1982 and 1988, scaled by total bank assets in 1982. The independent variable Predicted Δ Munis is the first-stage predicted change in municipal bond holdings between 1982 and 1988, divided by total bank assets in 1982; this first stage equation corresponds to Column (2) in table 2. All regressions include state fixed effects and size quintile fixed effects, and control for Δ Assets, which is the change in a bank's total assets between 1982 and 1988, scaled by total bank assets in 1982. Banks are grouped into size quintiles based on total assets in 1982. All ratios are winsorized at the 1st and 99th percentiles. Standard errors are in parentheses.

Appendix A: Measuring Bank Tax Arbitrage from Call Report Data

The Call Report Data are drawn from banks' regulatory filings. The data prior to 2001 are published by the Federal Reserve Bank of Chicago, which consolidates the data across reporting forms and over time to produce harmonized series of financial variables.¹⁴ The analysis in this paper uses the RIAD and RCFD series, which report income and assets consolidated across a banks' foreign and domestic operations, because not all key variables are reported separately for foreign and domestic operations. This paper uses year-end values of all variables, rather than quarterly or semi-annual values, to reduce noise and maximize data coverage. The sample used in this paper is commercial banks located in the 50 states and Washington, DC.

Municipal bond holdings are measured from the book value of obligations issued by states and political subdivisions in the United States. Banks can lend to municipalities using securities, loans, and leases.¹⁵ Through 1983, municipal bond holdings are measured from all holdings of state and local obligations (RCFD0900). After 1983, municipal bond holdings are measured from holdings of state and local securities (RCFD3383) and loans (RCFD2107), but leases are excluded because they cannot be observed in the data. Excluding leases should have a minimal effect on the measurement of total state and local obligations, because the vast majority of municipal debt held by banks is securities.¹⁶

A bank's taxable income is imputed by dividing its reported U.S. federal income tax expense (RIAD4780) by the statutory corporate tax rate. The bank's imputed taxable income corresponds to the amount it would need to reduce its taxable income to reduce its tax expense to zero.¹⁷ While some banks could benefit from reducing their taxable income even further and carrying tax losses backward or forward, this cannot be observed from the Call Report data.

¹⁴ These data are available at <https://www.chicagofed.org/banking/financial-institution-reports/commercial-bank-data>.

¹⁵ The analysis takes all state/local debt to be tax-exempt, even though a very small portion is not. In the period after 1986, when the data distinguished tax-exempt and taxable income from state/local securities, 97% of all income on state/local securities was tax-exempt.

¹⁶ In the period after 1985 when more detailed income data are available, income from state/local securities represented 90% of income from state/local securities, loans, and leases combined.

¹⁷ A bank's reported tax expense includes both current and deferred tax liabilities.

Figure A6 offers a check of the validity of this method of imputing taxable income from accounting income. Taxable income can be proxied from accounting income by subtracting municipal bond income (municipal bond holdings multiplied by the yield on short term municipal bonds) from net operating income (RIAD4000-RIAD4130). Figure A5 suggests that this measure of taxable income based on accounting income is highly correlated with the measure based on tax expenses. The two measures differ because tax expenses capture tax benefits such as tax credits and tax loss carryforwards that cannot be observed from accounting income, because municipal bond income cannot be perfectly proxied from municipal bond holdings, and because accounting income may include some income from foreign operations.

Appendix Table 1: Percent of Banks in Each Municipal Bond Utilization Quartile in 1982, by Utilization Quartile in 1977

1977 quartile	1982 quartile			
	1	2	3	4
1	46.35	25.50	15.08	13.07
2	17.47	30.94	29.33	22.26
3	11.22	25.53	33.34	29.90
4	13.04	20.80	30.08	36.08

Note to Appendix Table 1: The table presents a transmission matrix of bank muni utilization quartiles between 1977 and 1982, with rows defined by a bank's muni utilization quartile in 1977, and each row summing to 1.0.

Appendix Table 2: Interest Expenses before and after 1986

Dependent Variable:	(1) 1988 interest expense ratio	(2) 1988 interest expense ratio
1984-1985 interest expense ratio	0.469 (0.0053)	0.500 (0.0054)
Δ Assets		0.0007 (0.00005)
Size quintile fixed effects		X
State fixed effects		X
Observations	11,441	11,441

Note to Appendix Table 2: The dependent variable is a bank's ratio of interest expenses to total assets in 1988. The independent variable is the average of a bank's ratio of interest expenses to total assets in 1984 and 1985. The regression in the second column includes the same controls as those used in the instrumental variables regressions in Table 2: the regression includes state fixed effects and size quintile fixed effects, and controls for Δ Assets, which is the change in a bank's total assets between 1982 and 1988, scaled by total bank assets in 1982. Banks are grouped into size quintiles based on total assets in 1982. All ratios are winsorized at the 1st and 99th percentiles. Standard errors are in parentheses.

Appendix Table 3: Summary of Regression Variables

	Mean	Standard Deviation	25 th percentile	Median	75 th Percentile	N
Δ Munis	0.000	0.089	-0.052	-0.006	0.038	11,447
Δ Treasuries	0.064	0.153	-0.024	0.031	0.121	11,447
Δ Cash	0.061	0.138	-0.005	0.031	0.088	11,447
Δ Assets	0.740	1.003	0.231	0.475	0.857	11,447
Interest expense ratio	0.061	0.009	0.057	0.062	0.067	13,191
Muni ratio	0.094	0.062	0.046	0.092	0.132	14,413
$\ln(\text{Assets})$	10.40	1.19	9.62	10.30	11.00	14,416

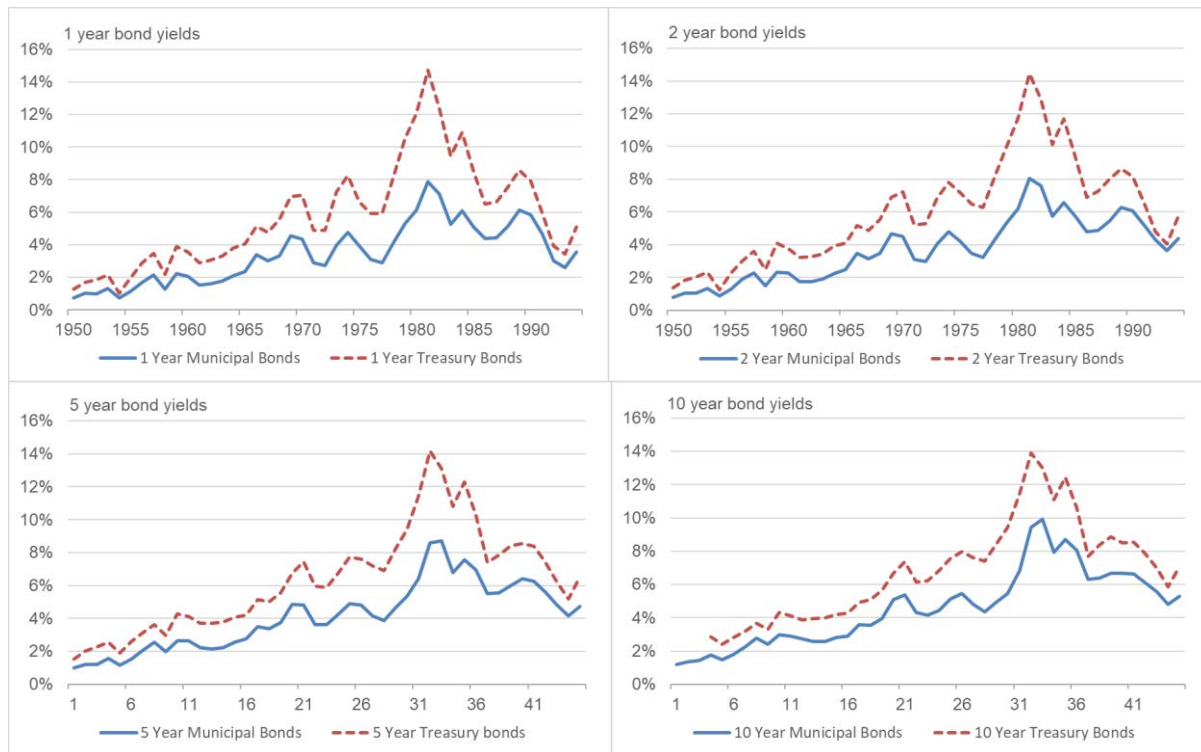
Note to Appendix Table 3: Δ Munis, Δ Treasuries, and Δ Cash represent the 1982-1988 change in the bank's municipal bond, Treasury bond, and cash holdings respectively, scaled by the bank's total assets in 1982. Δ Assets represents the percent change in the bank's total assets from 1982-1988. The interest expense ratio is the average of a bank's ratio of interest expenses to total assets in 1984 and 1985. The muni ratio is the bank's ratio of municipal bond holdings to total assets in 1982. All ratios are winsorized at the 1st and 99th percentiles.

Appendix Table 4: Treasury and Cash Holding Responses to Changes in Municipal Bond Holdings, Alternative Specifications

Dependent Variable:	(1) Δ Cash	(2) Δ Cash	(3) Δ Cash	(4) Δ Treasuries	(5) Δ Treasuries	(6) Δ Treasuries
Predicted Δ Munis	0.104 (0.0439)	-0.0733 (0.0413)	-0.212 (0.0409)	-0.339 (0.0594)	-0.431 (0.0576)	-0.326 (0.0561)
Δ Assets	0.0801 (0.0020)	0.0864 (0.0019)	0.0935 (0.0019)	0.0493 (0.0028)	0.0527 (0.0027)	0.0594 (0.0026)
ln(Assets)		-0.0161 (0.0008)			-0.0075 (0.0012)	
State FEs			X			X
Size quintile FEs			X			X
Observations	11,441	11,441	11,441	11,441	11,441	11,441

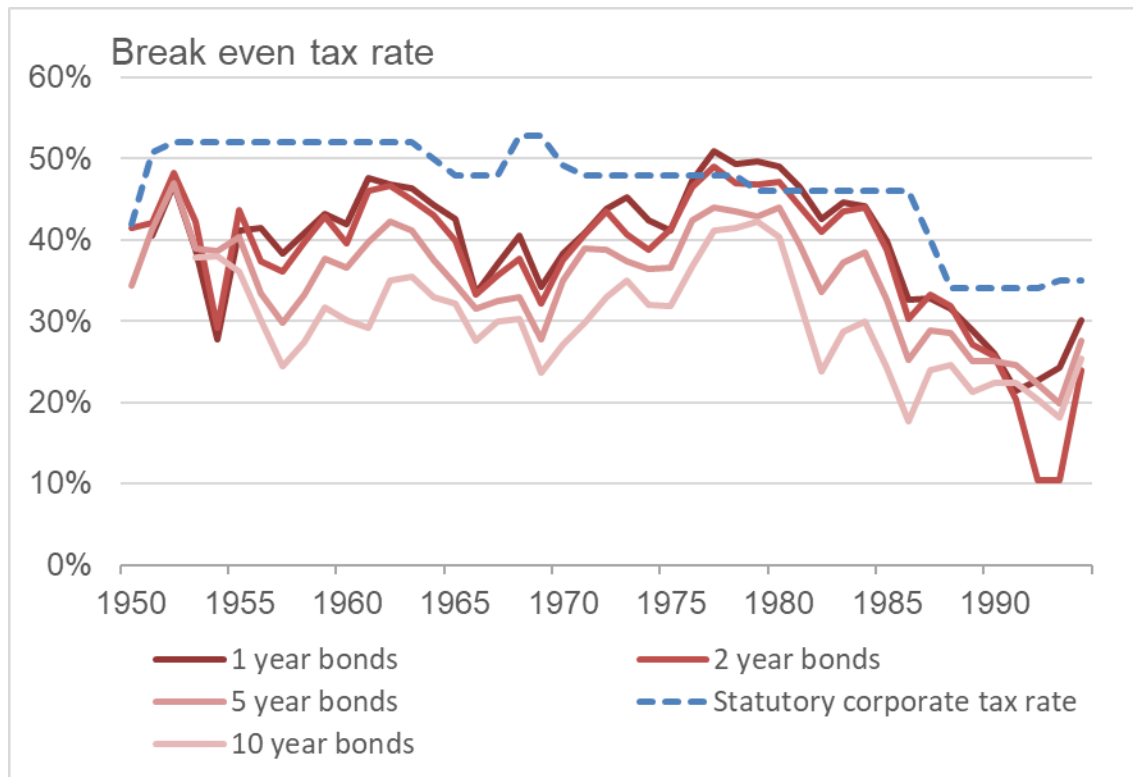
Note to Appendix Table 4: The table presents estimated coefficients from second-stage instrumental variables regressions explaining changes in bank holdings of cash and Treasuries between 1982 and 1988. The dependent variable Δ Cash is the change in cash holdings between 1982 and 1988, scaled by total bank assets in 1982. The dependent variable Δ Treasuries is the change in Treasury bond holdings between 1982 and 1988, scaled by total bank assets in 1982. The independent variable Predicted Δ Munis is the first-stage predicted change in municipal bond holdings between 1982 and 1988, scaled by total bank assets in 1982. The independent variable Δ Munis is instrumented with the bank's ratio of municipal bonds to total assets in 1982, the bank's average ratio of interest expenses to assets over 1984-1985, and the interaction of the two. The control variables are state fixed effects and size quintile fixed effects, and Δ Assets, which is the change in a bank's total assets between 1982 and 1988, scaled by total bank assets in 1982. Banks are grouped into size quintiles based on total assets in 1982. All ratios are winsorized at the 1st and 99th percentiles. Standard errors are in parentheses.

Figure A1: Comparison Between Treasury and Municipal Bond Yields, by Maturity



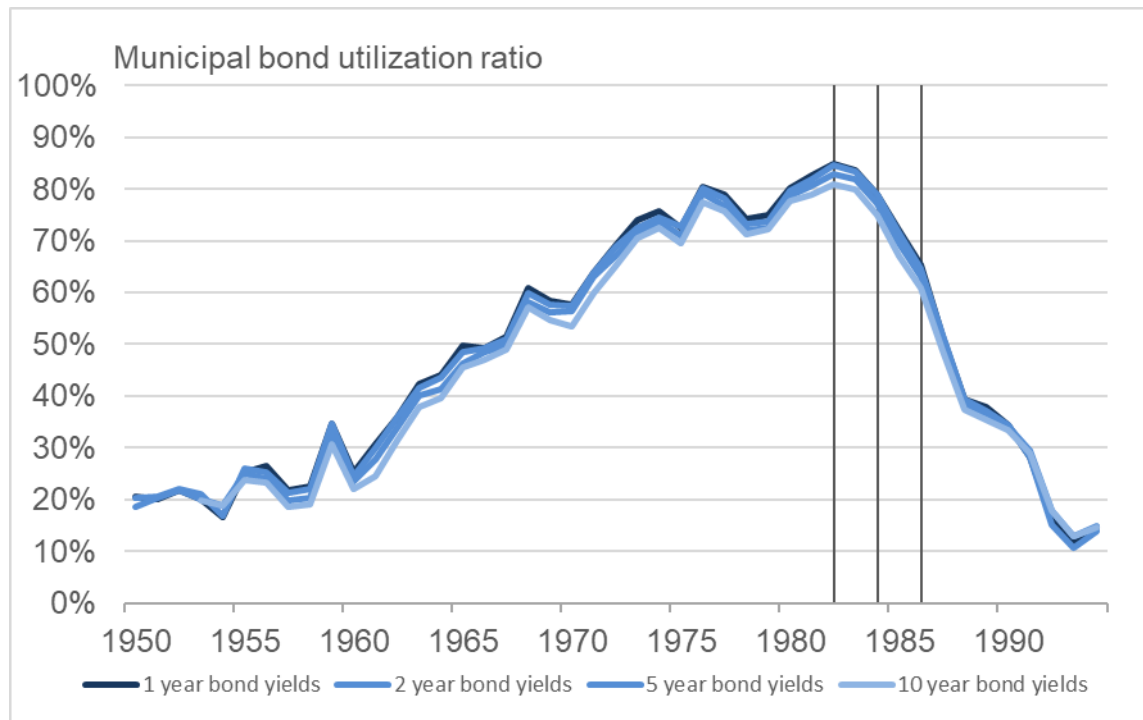
Source: Salomon Brothers, “Analytical Record of Yields and Yields Spreads,” published January 1995 and FRED series DGS10. Annual yields are calculated from the mean of monthly yields.

Figure A2: Tax Rate at Which Investors are Indifferent Between Municipal Bonds and Treasury Bonds, by Bond Maturity



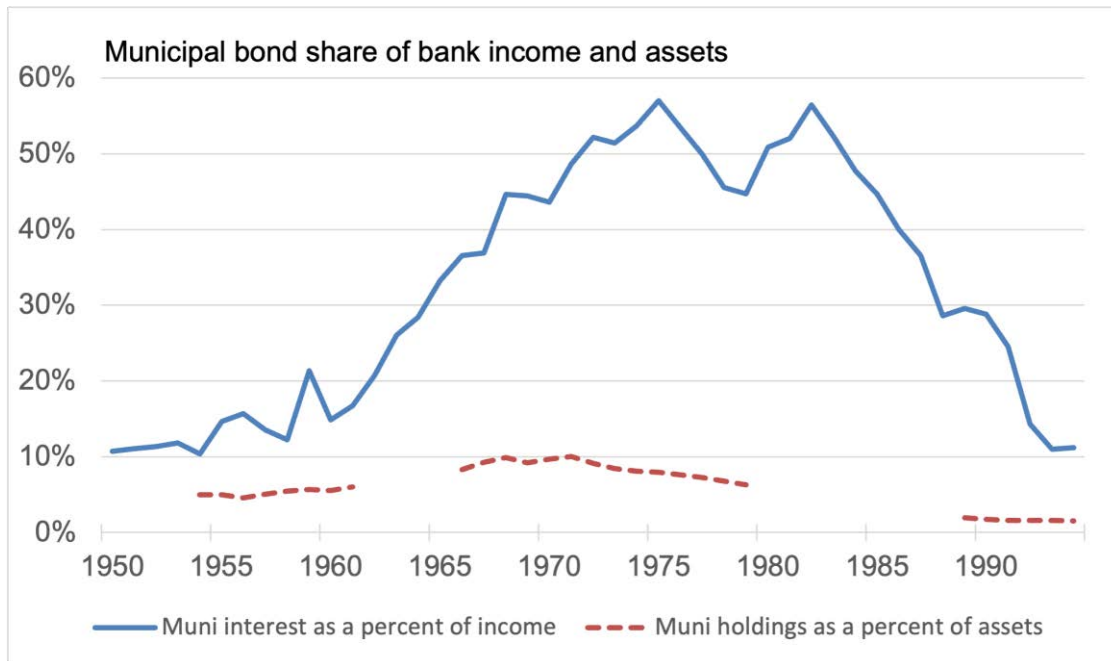
Note: Calculated from Salomon Brothers, "Analytical Record of Yields and Yield Spreads" and FRED series DGS10.

Figure A3: Aggregate Share of Banking Sector Tax Liability Eliminated by Holding Municipal Bonds of Differing Durations



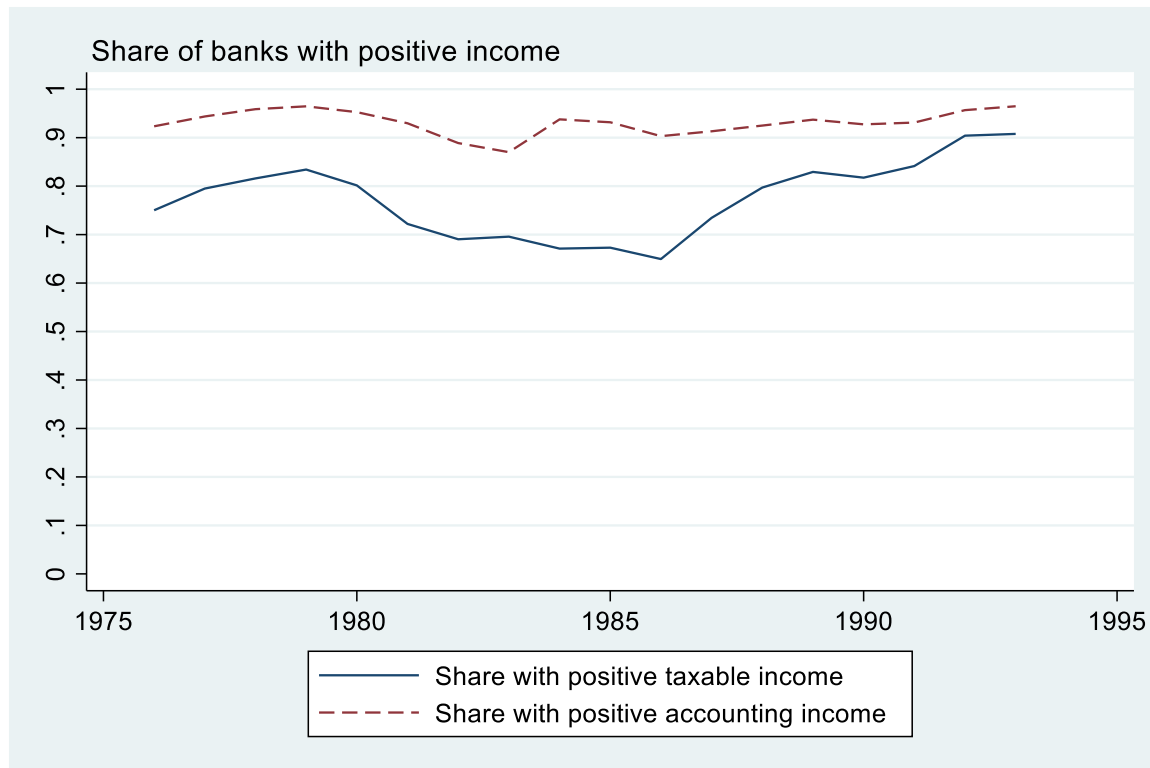
Note: Calculated from IRS Statistics of Income "Corporate Complete Report", Salomon Brothers "Analytical Record of Yields and Yield Spreads," and FRED series DGS10.

Figure A4: Muni Shares of Aggregate Bank Income and Assets



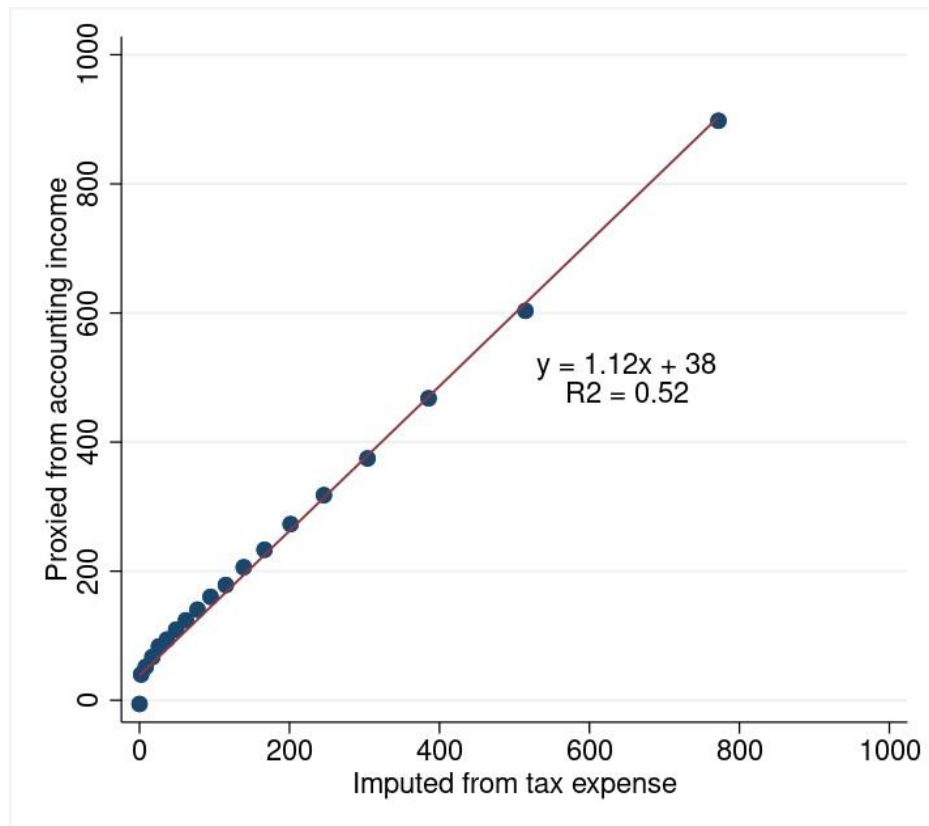
Note: The continuous blue locus is the municipal bond interest share of aggregate bank income reported on annual tax returns. The discontinuous red locus is the fraction of aggregate bank assets invested in municipal bonds, for years for which tax returns contain sufficient asset information. Data are drawn from IRS Statistics of Income, "Corporate Complete Report."

Figure A5: Share of Banks with Positive Income



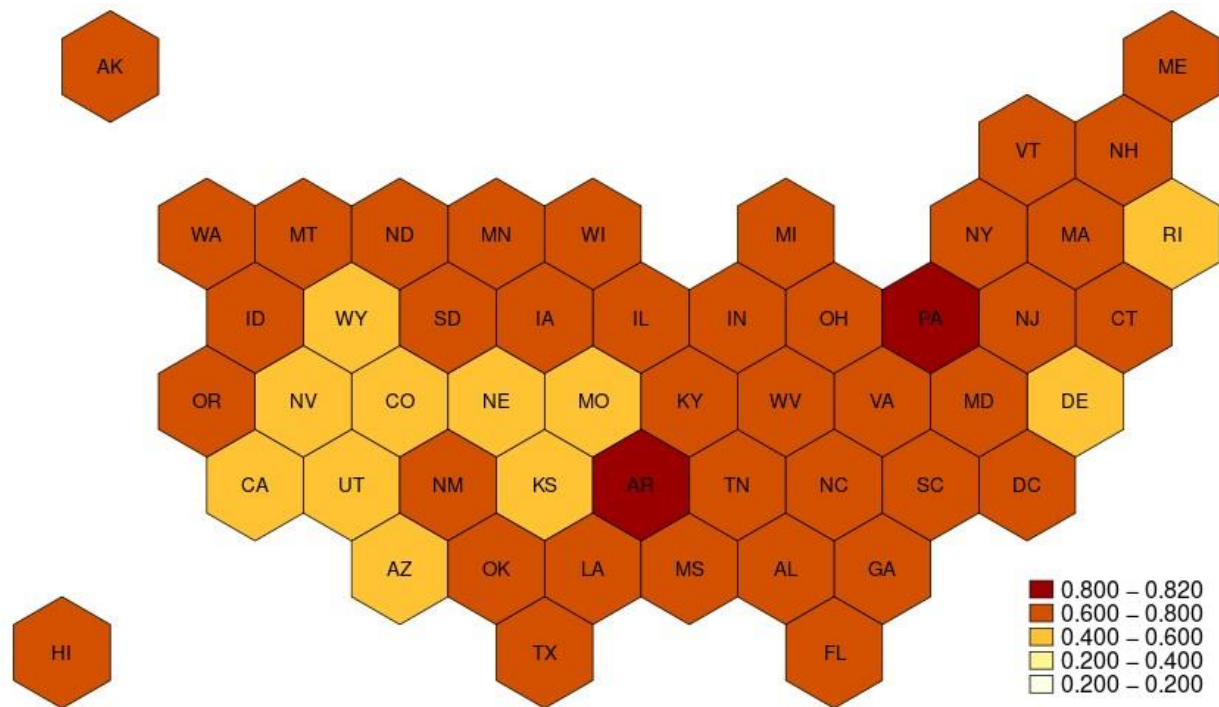
Note: The share of banks with positive taxable income is proxied by the share of banks that report positive federal income tax liability. Accounting income is net operating income (operating income less operating expenses).

Figure A6: Correlation Between Measures of Taxable Income, 1977-1982



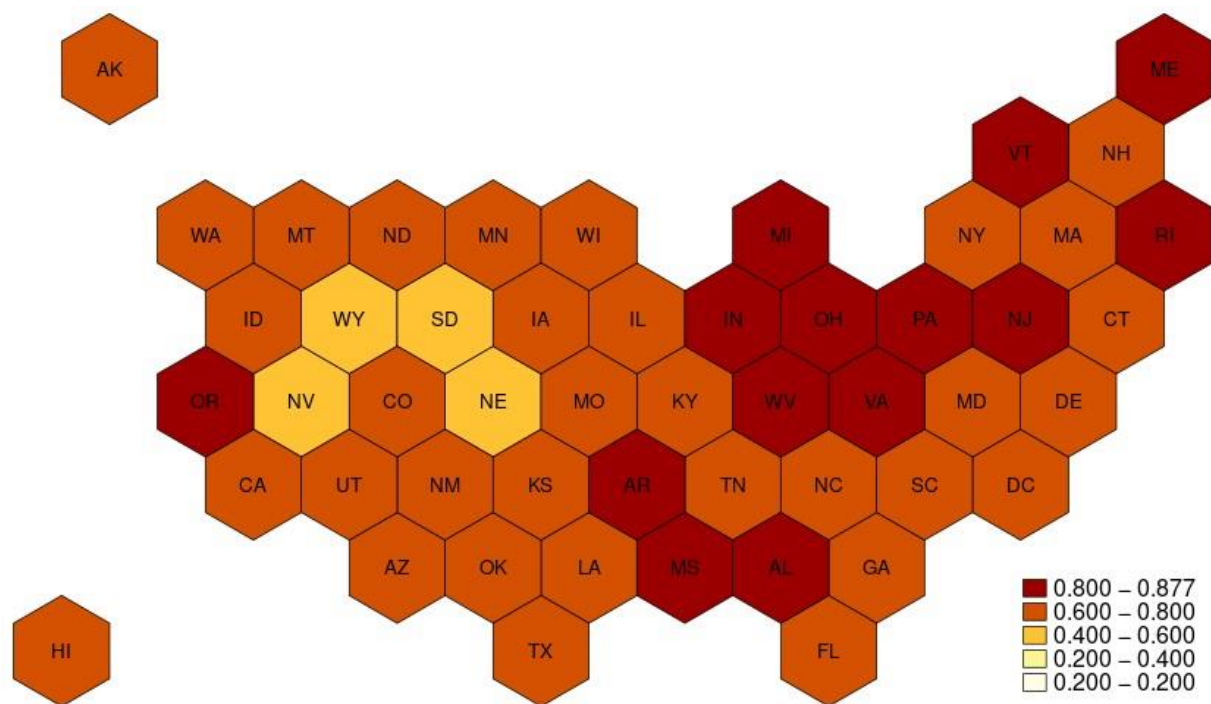
Note: Income is thousands of current dollars from 1977-1982. Taxable income proxied from accounting income is winsorized at the 1st and 99th percentiles in each year. Excludes observations with negative federal tax expense (11% of all bank-years) and observations with imputed taxable income greater than \$1 million (5% of all bank-years)

Figure A7: Average Municipal Bond Utilization Ratio, 1977-1982, by State



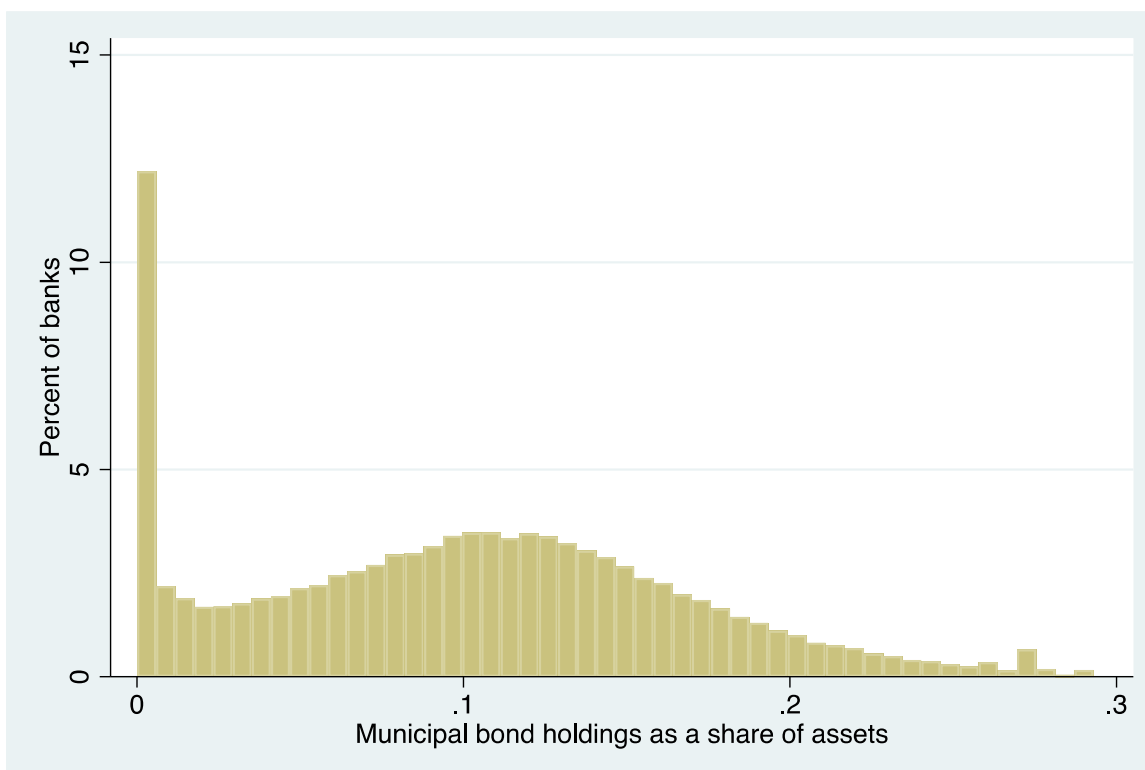
Note: State-level MU ratios are calculated from the average MU ratio for all banks headquartered in that state in all years between 1977-1982, weighting each bank equally.

Figure A8: Average Asset-Weighted Municipal Bond Utilization Ratio, 1977-1982, by State



Note: State-level MU ratios are calculated from the average MU ratio for all banks headquartered in that state in all years between 1977-1982, weighting banks by total assets in each year.

Figure A9: Distribution of Municipal Bond Holdings as a Share of Total Assets, 1976-1982



Note: Excludes banks with less than \$1 million in total assets. Ratio of municipal bond holdings to assets is winsorized at the 1st and 99th percentiles in each year.