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How the New Fed Municipal Bond Facility Capped Muni-Treasury Yield Spreads in the COVID-19 Recession[*]

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Abstract

For over two centuries, the municipal bond market has been a source of systemic risk, which returned early in the COVID-19 downturn when borrowing from securities markets became costly for many private and public entities, and some found it difficult to borrow at all. Indeed, just before the Fed announced its unprecedented intervention into the municipal (muni) bond market, spreads of muni over Treasury yields rose in line with the unemployment rate and appeared headed to levels not seen since the Great Depression, when real municipal gross investment plunged 35 percent below 1929 levels. To prevent a repeat, the Fed created the Municipal Liquidity Facility (MLF) to purchase newly issued, (near) investment grade state and local government bonds at normal ratings-based interest rate spreads over Treasury bonds plus a fee of 100 basis points, later reduced to 50 basis points. Despite a modest take-up, the MLF has effectively capped muni spreads at near normal levels plus the Fed fee and limited the extent to which interest rate spreads could have amplified the impact of the COVID pandemic. To establish the MLF the Fed needed Treasury indemnification against default losses. There are concerns about whether the creation of the MLF could undermine the efficiency of the bond market if the facility lasts too long and could induce moral hazard among borrowers. How the MLF will be unwound will affect these downside aspects and help answer the question whether the program's benefits exceed its costs.

Keywords: state and local governments, municipal finance, central bank policy, credit policy

JEL Codes: E40, E50, G21

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In the early weeks of the Covid-19 pandemic, U.S. state and local governments encountered difficulty in issuing bonds, as reflected in increased spreads between yields on Baa-rated municipal and 10-year Treasury bonds (henceforth, the "muni spread," shown in Figure 1). Markets became concerned about pandemic damage to the real economy (which can be proxied by the unemployment rate), impairing state budgets and raising financial risk premiums. Through the first week in April 2020, these spreads initially rose in line with the weekly, insured unemployment rate drawn from the initial claims for unemployment report (adjusted to be consistent with the more commonly used monthly unemployment report). Based on the strong positive correlation between the muni spread and the weekly unemployment rate, it appeared that spreads would have continued rising in step with the unemployment rate absent Fed intervention.

This occurred as state and local governments needed to borrow. The governments faced large retail sales tax revenue losses arising from Covid shutdowns and slower brick and mortar retail sales, coupled with likely decreases in income and property tax revenues and higher pandemic-related medical and relief spending.[1] If state and local governments could not borrow, they could have been forced into more dramatic spending cuts and layoffs than occurred.[2] Stress in the muni market goes back to the nineteenth century long before the Federal government became the dominant branch of government. Indeed, when bond market stresses—reflected in a widening of the muni-Treasury spread—occurred during the Great Depression, state and local governments slashed their investment spending and trimmed consumption spending (Figure 2).[3] As discussed in Appendix A, one lesson from the Great Depression is that distress in the municipal bond market

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[1] Clemens and Veuger (2020) estimate that the pandemic will reduce state revenues by an average of 11.5 percent, translating into about ½ percentage point of GDP. Chernick, Copeland, and Reschovsky (2020) estimate that 2020 revenue losses for 150 largest cities would range from 5.5 in a less severe scenario to 9 percent in a more severe one.

[2] Haughwout, Hyman, and Lieber (2020) note that state and local governments accounted for 8.5 percent of GDP in 2019, which was higher than the 3.8 percent of GDP from final purchases of the federal government.

[3] Figure 2 plots the yield spread between Aaa-rated muni and long-term Treasury bonds, whereas this study models the muni spread based off the average Baa-rated muni bond, whose yield series was not available before 1971.

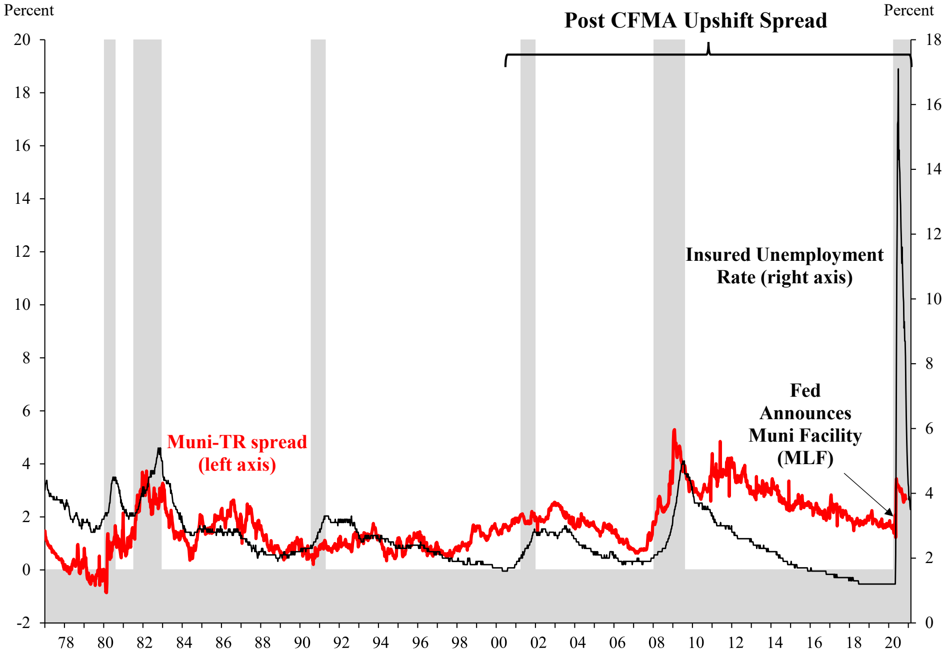

Figure 1: Spread between Baa-rated Municipal and 10 Year Treasury Bonds Yields Rises with the Unemployment Rate Until the Fed Announced its Municipal Liquidity Facility
(NBER recessions are shaded. Sources: Moody's, Federal Reserve, and authors' calculations)

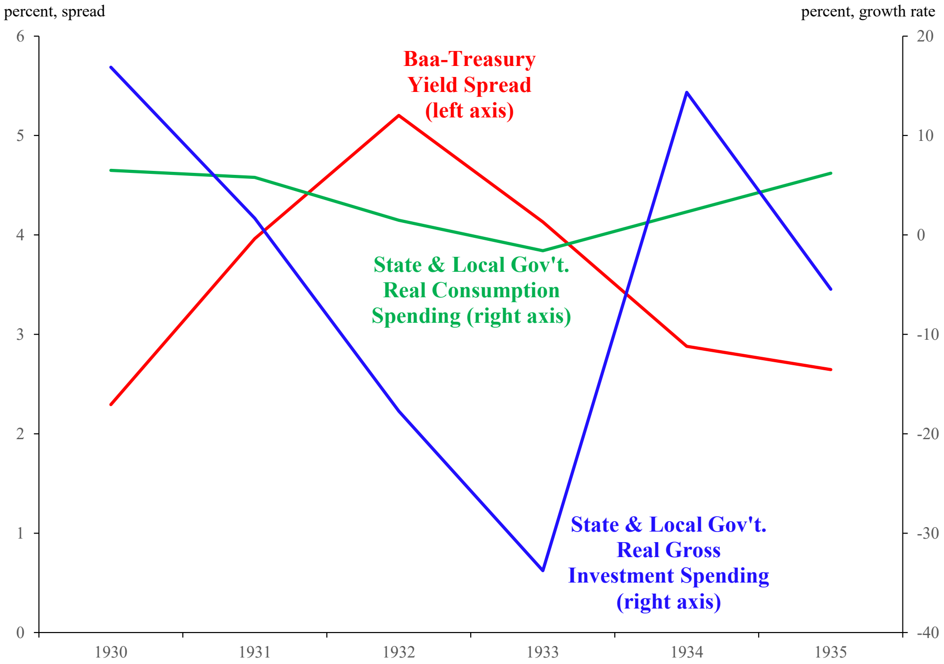

Figure 2: In the Great Depression, State & Local Governments Spending Cuts Were Mainly in Gross Investment After Default Spreads Widened
(Sources: BEA, Moody's, Federal Reserve, and authors' calculations)

induced spending cuts by state and local governments to avoid default (Wigmore, 1985), particularly those that had earlier borrowed heavily and were less constrained by statutory debt limits (Gunter and Siodla, 2018). These cuts, in turn, were viewed at the time as a major contributor to overall distress (Siodla, 2020), prompting President Hoover to lobby states and municipalities to speed up rather than reduce their planned capital expenditures (Wigmore, 1985, p. 111).

To help state and local governments avoid making even deeper spending cuts and to continue to function during the pandemic, on April 9, 2020, the Federal Reserve announced it would create the Municipal Liquidity Facility (MLF) to buy newly issued short-term debt from large municipalities. The interest rates would depend on the rating of the public entity and be priced at more normal interest rate spreads over Treasury yields for those ratings classes plus a 1 percent fee. The intent was to stop feedback from anticipated rises in unemployment from pushing muni spreads wider and preventing many municipal governments from accessing the municipal bond market. Indeed, muni spreads stopped rising in the week of the Fed announcement, well before the muni facility opened on May 26. As shown by Bordo and Duca (2020) a similar pattern occurred in the corporate bond market, where spreads over Treasury yields stopped rising when the Fed announced the creation of similar corporate bond programs (March 23), well before those facilities started buying seasoned bonds (May 12) and new issued bonds (June 29).

This study examines the impact of the announcement of the MLF on muni spreads, the Fed's first major intervention in the municipal bond market. In financial crises, the Fed has traditionally limited its interventions to providing short-term liquidity in money markets and to member banks via the discount window. Instead, the MLF is more of a credit policy or easing program designed to prevent financial frictions from amplifying the more direct macroeconomic effects of the Covid pandemic. In this sense and with the Fed intervening in debt with maturities beyond those of the money market, the MLF resembles the primary and secondary corporate credit facilities, which also had large backstop announcement effects (Bordo and Duca (2020)).

From the perspective of the Fed's price, macroeconomic, and financial stability mandates, intervention in the municipal bond market can be justified if distress in this market is widespread enough to hurt the macroeconomy or if it poses systemic risk or risk of contagion that could undermine financial stability and thereby the macroeconomy. With respect to the former, the functionality of the muni bond market matters because it provides considerable funding ($4 trillion outstanding) for capital investment and for helping municipalities address intra-year imbalances between spending and revenues. This is crucial for these governments to provide essential services.

Regarding the second justification, there have been two instances in the Fed's history when distress in the municipal bond market posed systemic risk as discussed in section 2. In four of these (including the Great Depression), there was a lack of intervention by the federal fiscal authority, an absence of a central bank or of central bank intervention, and a large wave of muni defaults that accompanied a national depression or serious downturn. Of these, in the case of the Great Depression, the Fed did not intervene, and state and local government spending fell and worsened the macro economy until the federal fiscal support was eventually provided during the New Deal. In contrast, the federal government's assumption of state debt incurred to finance the American War for Independence ended municipal distress and poor financial conditions that contributed to a weak economy in the 1780s and laid the groundwork for a recovery in the 1790s (Henning and Kessler, 2012). Given the experience in prior five cases of systemic risk from municipal distress and the national nature of the Covid pandemic, the Fed's intervention in the municipal money and bond markets in the Covid pandemic appears warranted. Systemic risk was evident when a wave of mutual fund redemptions by household investors triggered large fire sales of muni bonds by mutual funds that fueled a liquidity crisis in the muni bond market in the spring of 2020 (see Li, O'Hara, and Zhou, 2020). Their findings largely reflect the behavior of households who indirectly own about 20 percent of muni securities indirectly via mutual funds and another 45 percent via direct holdings. Thus, investor vulnerability to municipal security prices largely falls on households, with some on banks and insurers who each hold about 12 percent of total muni debt.

Our study of the municipal bond market has parallels with Wei and Yue (2020b) who discuss the impact of the Federal Reserve's Money Market Mutual Fund Liquidity Facility (MMMLF) on the ability of municipal governments to access short-term interest rate financing.[4] They show that after rising during the early pandemic, yields on variable rate deposit obligations (VRDOs, essentially floating rate, bonds that are rolled over) stopped rising when the Fed announced the creation of the MMMLF on March 18 and subsequently fell back. This was in sharp contrast to the elevated levels of VRDO yields during the global financial crisis when there was no similar Federal Reserve facility (also see Wei and Yue, 2020a).[5] These findings are consistent with those of Cipriani, Haughwout, et al. (2020) who find that municipal money market mutual fund balances fell sharply prior to the announcement of the MMMLF, which expanded the eligible collateral to include VRDOs (Cipriani, La Spada, Orchinik, and Plesset, 2020).

Nevertheless, the size of the debt markets directly affected by the MLF and MMMLF differ. First, the VRDO market is much smaller—about $150 billion outstanding at the end of 2018 (Securities Industry and Financial Markets Association, SIFMA)—than that of the long-term muni

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[4] From the MMMLF qualifying banks can borrow against the collateral of short-term municipal debt and variable rate deposit obligations at the primary credit rate plus 100 bps.

[5] Wei and Yue (2020a) show that yields on VRDOs rose by less than those on less liquid auction rate securities because VRDOs benefitted from liquidity backstops from banks. Nevertheless, VRDO yields rose in the GFC perhaps owing to higher liquidity risk premiums that investors demanded on non-Treasury securities. VRDO yields remained elevated for much longer in the GFC than in 2020 owing to the creation of the MMMLF, which enhanced the liquidity of VRDOs, (Wei and Yue, 2020b). The muni-Treasury bond yield spread peak lines up with the April 9 announcement of the MLF's future creation, and not on the March 18 announcement of the impending creation of the MMMLF.

bond market which was roughly 20 times the size at about $3 trillion at yearend 2018, according to the Financial Accounts of the U.S. Second, the size of the short-term muni debt market is also much smaller—about $38 billion at yearend 2018, according to the Financial Accounts of the U.S.

The remainder of the paper is organized as follows. Section 2 reviews key institutional and historical aspects of the muni bond market and the Fed's new MLF. Section 3 lays out a framework for modeling municipal bond premia, briefly presenting monthly and weekly variants of these models, and describing the data and variables. Section 4 discusses the empirical results and counterfactual simulations, and the conclusion provides a broad perspective on our findings.

2. Institutional and Historical Aspects of Muni Spreads and the Municipal Bond Facility

This section reviews institutional and tax aspects of the municipal bond market that affect muni spreads. It also provides background on pre-WWII episodes of systemic distress from muni debt and the post-WWII behavior of defaults and municipal yield spreads that is relevant for modeling spreads. Then prior experience with national interventions is discussed before providing details on the Fed's Municipal Liquidity Facility that relate to the recent behavior of muni spreads.

2.1 Institutional and Tax Aspects of Muni Bonds

There are two broad categories of municipal bonds. General obligation bonds fund current state and local government current (consumption) spending and are backed by the general taxing authority of public entities. The second feature makes such bonds less susceptible to default than so-called revenue bonds. The latter are not explicitly backed by the taxing authority of a state or local government, but rather are paid from the revenues an entity raises. Revenue bonds are often used to fund capital projects and are generally viewed as riskier than general obligation bonds.

There are important differences in the tax treatment of interest income earned on U.S. government, muni, and corporate debt. The latter is generally taxed by all three major layers of government in the U.S.—federal, state, and local entities. State and municipal governments do not tax interest earned on Treasuries and interest income on state and municipal debt is generally exempt from the federal income tax. In addition, state and local governments are largely exempt from income tax interest income on their bonds held by their citizens. As a result, the marginal federal income tax rate creates a wedge between yields on munis and Treasuries that can shift with notable federal tax changes. Accordingly, spreads between muni and Treasury rates need to be adjusted for federal tax rates unlike spreads between corporate and Treasury bond yields.

2.2 Pre-Great Depression Episodes of Systemic Risk From the Muni Bond Market

Before the New Deal, state and local governments were the primary fiscal actors in the U.S. and relative to the federal government, they played an even larger role in funding public-related infrastructure than today. State and local government debt helped fund U.S. economic development, with waves of muni issuance accompanying surges in investment in canals and railroads in the 1800s, that sometimes later led to waves of muni defaults and collapses in infrastructure investment (Studenski and Kroos, 1963).

Well before the Covid-19 pandemic and the Great Depression, there were four episodes in U.S. history when local debt posed systemic risk. The first involved debt issued by the original states to fund the American War for Independence, which created massive debt overhangs for the state governments. This had to be resolved before the fledgling U.S. Treasury could issue its own debt (Sylla, 2011). The debt overhang was resolved by the national assumption of Revolutionary War debt by the Hamilton-led Treasury in the 1790s (Perkins 1994). This was crucial to enable the Treasury to gain the credibility to issue national bonds. According to Rousseau and Sylla (2003) the creation of a national bond market was a key component of the fiscal revolution that fostered the remarkable growth of the U.S. economy in the nineteenth century., Unfortunately, this precedent may have fostered a belief that the national government would bail out the states again encouraging and magnifying a major infrastructure boom in the 1820s, 30s and 40s in canals and later railroads, largely funded by state and local debt (Sargent). Overinvestment and overleverage led to the collapse of state bond prices and the default of 10 states in the early 1840s following the panic of 1839 and a serious economic recession (Studenski and Kroos, 1963, and Temin, 1969).

The third episode of systemic risk emanating from the muni market occurred in the depression of the 1870s, with a wave of muni defaults, this time associated with the post-civil war expansion of railroads across the continent (Advisory Commission on Intergovernmental Relations, 1973, p. 11). The fourth systemic episode occurred in the protracted economic slump in the 1890s when another wave of muni defaults occurred, this time on a mix of railroad and general obligation bonds (Advisory Commission on Intergovernmental Relations, 1973, p. 11)

In contrast to the national assumption of Revolutionary War debt which resolved systemic risk in the 1790s, the other three instances of systemic risk from the muni market were not resolved by federal action and each was linked to an economic downturn, partly because the earlier excessive issuance of muni debt had funded overinvestment in economic development projects. In these respects, the three waves of muni defaults are similar to the wave of muni defaults in the Great Depression (see Appendix A).

2.3 Historical Aspects of Muni Defaults and Spreads Between WWII and Covid-19

Since the Great Depression, muni debt has continued to provide a large source of funding for public infrastructure, albeit to a lesser degree than before the growth of federal government expenditure in the New Deal (Wallis and Oates 1998). For example, the $1.65 trillion in muni debt issued between 2003 and 2012 for capital investment funded the construction of schools ($514 billion), hospitals ($288 billion), water and sewer facilities ($258 billion), roads ($178 billion), power utilities ($147 billion), and mass transit ($106 billion).[6] Thus, a general and severe systemic shock to the municipal bond market could have notable real consequences for the nation.

That said, despite the continued importance of muni debt in funding investment and a generally low overall default rate on rated municipal debt, there have been some prominent muni defaults since between WWII and the Covid-19 pandemic, but none of these isolated cases seemed to pose systemic risk. Of the seven largest municipal defaults since WWII, five involved general obligation debt: New York City's moratorium in late 1975, the bankruptcies of Orange County (December 1994), Detroit (December 2013), and Puerto Rico (July 2016),[7] and Cleveland's 1978 default on bank loans. In four cases, excess borrowing by these separate entities underappreciated by markets and officials (Detroit and New York City), increased their *individual* vulnerability to default to a major recession or prolonged economic stagnation (Cleveland, Detroit, New York City, and Puerto Rico). In the fifth case, that of Orange County, the municipality suffered a large loss on interest rate derivatives that it had issued and whose risks it did not fully appreciate. In one of the two cases involving revenue bonds, Jefferson County underappreciated the risks of relying on variable rate and short-run debt financing, whose costs rose in the GFC when the county's debt was downgraded. The remaining default, that of Washington Public Power Supply System Projects 4 and 5, involved revenue bonds of a utility rather than the debt of a city or county.

In all but one of these cases, there were substantial local but *not* national economic costs from the sudden cuts in government spending and tax increases which these municipalities imposed to restore fiscal balance.[8] In the case of New York City, there were notable cuts in police

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[6] These figures exclude refunding issues. Source: National Association of Counties (2013, p. 4).

[7] The exception is the 1983 default on bonds issued by the Washington Public Power Supply System Projects.

[8] These adjustment costs were less notable and long-lasting in relatively affluent Orange County whose bankruptcy was not a result of long-run economic decline or a downshift in future long-run economic growth.

and public health spending that were followed by large increases in crime and declines in public health—including even a mini-outbreak of tuberculosis (Freudenberg, et al., 2006). Freudenberg, et al. (2006) estimate that the economic costs to New York City were five-times the short-run budgetary savings. This case highlights the point that while metro budgets need to be sustainable in the long-run, the costs of recovering from default can entail sharp short-run, disruptive cuts in essential services which could have been avoided had pre-default spending been sustainable and the composition of spending better reflected higher value-added expenditures. Details on the factors behind these defaults and the costs of short-run adjustments are discussed in Appendix B.

Although muni default rates have been low since the 1930s relative to default rates on other publicly traded debt (Moody's, 2017),[9] the tax-adjusted spread between municipal and Treasury bond yields (*MuniTr*) is very cyclical (see Benson and Rogowski, 1978). As shown in Figure 3, the spread widens near the start of recessions and throughout most of them, and sometimes peaks after recessions before falling in the mid- and late stages of expansions, much like the unemployment rate. The combination of cyclicality and low default rates suggests that swings in—and temporary shocks to—liquidity and risk aversion are major drivers of the spread. Consistent with this view, this study later shows that the five largest U.S. municipal defaults coincided with temporary, modest rises in average muni spreads that did not persist for long.

2.4 Notable National Interventions in State and Local Debt Before the Covid-19 Pandemic

Despite the ostensible near-term success of the Federal Reserve interventions involving muni debt markets, the U.S. experience with federal bailouts of state governments suggests that such interventions could induce moral hazard for borrowing states. In his Nobel Prize lecture, Sargent

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[9] As Appleson, Haughwout, and Parsons (2012) stress default rates are notably higher for unrated (which are sizable in volume) than for rated muni bonds. The yield spreads that are modeled in this study are based on yields for publicly rated bonds which are available for a much longer time series sample that those on unrated (and less traded) bonds.

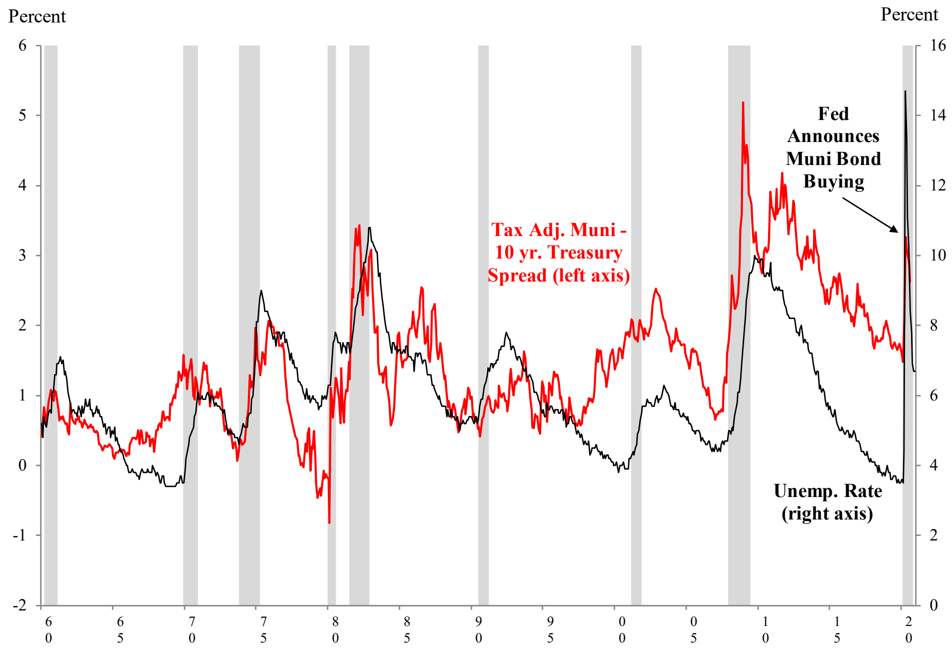

Figure 3: Since 1960, the Municipal-Treasury Bond Yield Spread Moves with the Unemployment Rate Until the Fed Announced its Municipal Bond Facility
(NBER recessions are shaded. Sources: Moody's, Federal Reserve, and authors' calculations)

(2012) reviewed the impact of the U.S. federal government's assumption of state debt that largely emanated from financing the American War for Independence, which is arguably a national rather than a state obligation. Sargent emphasizes how this assumption was feasible considering the nation's then future prospects for rapid growth that could fund the debt, as well as efforts of Hamilton and others to keep the U.S. federal debt on a sustainable downward trajectory.

Nevertheless, Sargent argues that the precedent helped take the onus off state governments to have sustainable debt paths and in the 1820s and 1830s many had borrowed in the London bond market to fund capital improvements. The states assumed that the improvements would stimulate their economies and generate the revenue needed to service and amortize the debts. A serious economic downturn following the panic of 1839 led to disappointing tax and toll revenue, which coupled with higher interest rates, made it difficult for many states to pay. As a result, many defaulted in the early-1840s. Congress considered but did not approve a federal bailout (Sargent, 2012). The consensus in the Congress was that unlike the Revolutionary War debt, the state debt of the 1830s was not incurred in the national interest. Those defaulting states that eventually repaid later regained their ability to issue debt before the American Civil War; but those who repudiated their obligations had less if any access (English, 1996). Sargent (2012) maintains that this sobering experience ultimately induced the states to enact balanced-budget requirements in their constitutions to help restore their credibility and reputations.[10]

Moral hazard from national government bailouts of regional governments is not limited to the early U.S. experience. Bordo, Jonung and Markiewicz (2011) review the history of five countries with federal unions. In the Canada and the U.S. since the 1840s markets have generally disciplined state and local government borrowing. By contrast, Bordo, Jonung and Markiewicz (2011) stress how national government bailouts of state and local governments have prevented such market discipline in Argentina and Brazil, and how the moral hazard that such bailouts have engendered has contributed to national defaults and bouts of high inflation. Partly to avoid unduly supplanting market discipline in the future, the Federal Reserve has limited MLF purchases of state and local government debt to fund Covid-pandemic related shortfalls, limited the maturity of debt it would buy to two-years, and limited the time frame when the MLF would purchase debt.

2.5 The Fed's Municipal Bond Facility

In the early stages of the pandemic in the U.S., heightened cyclical risks as tracked by the monthly and weekly unemployment rates pushed up muni spreads by over 100 basis points. Further rises in unemployment and spreads were expected after March. To prevent additional increases in muni spreads, the Fed announced on April 9 that it would purchase up to $500 billion in revenue

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[10] These are critical for states when issuing long-term debt to fund capital projects and short-term debt to smooth out intra-year imbalances in their current spending budgets. This shift may help explain why while there were more state defaults in the nineteenth century, only one state has defaulted since the 1840s (Arkansas in 1936).

notes and other short-run debt (under 2 years in maturity) newly issued by states or cities to offset revenue losses or increased expenses related to Covid's impact.[11] The facility was limited to cities of at least 1 million residents and counties with at least 2 million residents Later, the maximum maturity was raised to three years and eligibility was expanded to include multi-state agencies. Population thresholds were subsequently lowered (250,000 for cities and 500,000 for counties) as few cities were eligible and at one point, only two entities had borrowed from the facility.

To shield the Fed from investment losses the MLF is structured as a special purpose vehicle, funded by Treasury equity stakes of up to $35 billion and up to $465 billion in debt held by the Fed. Portfolio exposure to any one entity is limited to 20% of an issuer's annual revenue. The pricing at which purchases are made was designed to prevent muni spreads from rising much further than their early April 2020 levels. Fixed spreads over Treasury yields for various issues were set at which eligible muni debt would be bought, plus a 100-basis point fee (lowered to 50 basis points on August 11, 2020). The fees and pricing were designed to make the MLF more of a backstop than a first stop source of finance for nonfederal public entities.

Muni-Treasury spreads abruptly stopped rising in the week when the Fed announced that it would set up MLF, well before the facility opened in late May and despite a rising unemployment rate. Nevertheless, MLF holdings of muni debt totaled less than $17 billion by the end of August 2020—far below the $500 billion limit on the facility's size. Instead of reflecting a balance sheet effect (as with QE), this pattern suggests a strong "backstop" effect similar to that of the Fed's corporate bond buying program on corporate spreads (Bordo and Duca, 2020.)

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[11] Governors of each state can designate a limited number of cities and counties that can borrow from the MLF.

3. Modeling the Muni-Treasury Spread

The municipal spread analyzed in this study is the tax-adjusted gap between yields on Moody's Baa-rated municipal bonds (*MuniBaa*) and the 10-year Treasury bond (*TR10*). The only other series with a long sample of relatively continuous data is the Aaa-rated muni bond, which, because its default risk is low and moves little over time, is less relevant than the Baa muni bond.

Although the Baa-rated municipal bond yield is available on a monthly basis since 1941, the longest estimated federal marginal tax rate series starts in 1960. That series—the average marginal rate from Feenberg and Coutts (1993)—is denoted as t^f:[12] Since federal income tax is levied on Treasury interest, the after-tax return on the 10-year Treasury yield equals that yield multiplied by 1 minus the t^f. In contrast, the after-tax return on munis equals the nominal municipal yield because municipal interest income is exempt from federal income tax and because state and municipal entities typically exempt interest on their bonds from taxation for local residents.[13]

$$MuniTR_t = MuniBaa - (1 - t^f)\ TR10 \qquad (1)$$

At a weekly frequency, the municipal series is available since 1975.[14]

As shown in Figure 3, this spread (*MuniTr*) widens in recessions, and tends to be coincident with business cycle peaks and troughs. The cyclical effect is nonlinear, with a stronger correlation between the spread and the square of the unemployment rate than with the level, plausibly reflecting the tail risk nature of defaults and default risk.

Before the Fed announced its new municipal bond facility, the tax-adjusted muni spread mainly reflected cyclical risks for municipal debt. Time series measures or proxies of cyclical risks

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[12] Specifically, we use their series labeled: "Same 1984 Sample for all Years."

[13] Local residents are treated as the marginal muni investors owing to the local state and municipal tax exemption.

[14] For a few missing monthly observations (owing to thin trading), we interpolate missing weekly observations and infer monthly data from weekly data. Some incorrectly entered weekly data were also corrected—see Appendix A.

are limited by data availability and endogeneity.[15] Cyclical risk is proxied by the square of the unemployment rate (UR^2), which is expected to be positively correlated with *MuniTR*.

A major shift since the late 1990s has affected that correlation. Such a shift can be tracked by either controlling for long-lasting changes in regulations, or by time trends. The latter provides little insight and coefficient estimates on time trends can suggest omitted variable bias from not controlling for other factors. With respect to the former, we found one significant upshift in the tax-adjusted muni spread after 1960. This was an upshift that we link to the Congress' December 2000 approval of the Commodity Futures Modernization Act (CFMA). As Bolton and Oehmke (2015) and Stout (2011) show, the CFMA exempts derivatives counterparties from the automatic stay in bankruptcy, enabling immediate collection from a defaulted counterparty, providing them a senior claim over most other bankruptcy claimants. The passage of CFMA was quickly followed by a surge in credit default swaps (Duca and Ling, 2020). By giving bankruptcy priority to derivatives (mainly credit default swaps), the CFMA lowered the priority of bonds and made bonds riskier (see Bolton and Oehmke 2015). CFMA can be viewed as a shift in which the use of hard-to-detect derivative positions became more acceptable for state and municipal finance authorities, while posing greater risks to bond investors.[16] We find that a shift dummy (*CFMA* =1 since December 2000 in monthly models or = 1 since December 15 in weekly models, and 0 otherwise) captures an upward level shift in the municipal-Treasury yield spread. The alternative approach—

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[15] For example, widespread central bank interventions prevent using the commercial paper bill spread (made famous by Friedman and Kuttner, 1992) for post-2007 samples or using corporate spreads for tracking risk in modeling commercial paper (Duca, 2013) or municipal-Treasury spreads after February 2020. Endogeneity concerns also raise doubts about using the yield curve as long-term Treasury yields directly affect its slope and the base off which corporate and muni spreads are measured. In addition, large holdings of long-term securities following the Fed's use of quantitative easing starting in 2008 affect the consistency of the yield curve over time. The post-2007 Fed balance sheet also limits the usefulness of the TED spread (LIBOR-short-term Treasury interest rates) as the high excess reserves used to fund Fed bond holdings limits the ability of the TED spread to track more general market risk premia.

[16] The famous 1994 bankruptcy by Orange County owed to county government losses on interest rate derivative positions, while the 2011 bankruptcy of Jefferson County, Alabama also arose from taking much interest rate risk.

included for comparison—is to include a time trend in the long-run relationship of the muni spread.

These considerations yield two specifications for econometrically modeling the equilibrium municipal-Treasury spread, one using shift variables and the other a time trend:

$$MuniTR^{*}_{t} = \alpha_0 + \alpha_1\, UR_t^2 + \alpha_2\, CFMA_t \tag{2}$$

$$MuniTR^{*}_{t} = \alpha_0 + \alpha_1\, UR_t^2 + \alpha_5 Trend_t \tag{3}$$

where each coefficient α_i has an expected positive sign. According to KPSS tests (Appendix C), *MuniTR* and *UR* are nonstationary in levels but are stationary in first differences at weekly and monthly frequencies. By construction, so is the regulatory shift variable, *CFMA*.

Accordingly, we estimate equations (2) and (3) with monthly (1960-early 2020) and weekly (1975-2020) data jointly using a cointegration approach (Johanssen's (1995)). The first difference equation of the latter includes an error-correction term (the t-1 gap between the actual and equilibrium spread), lags of first differences of the long-run variables and a vector *X* of exogenous event shocks. *X* includes impact dummies for the Covid pandemic and also dummies for unusual government policies and five prominent episodes of municipal bond distress. The former, include lags of *DCovid* (=1 only in one period, 0 otherwise) for each of the first two months and first three weeks since the onset of the Covid Pandemic (dated March 2020 and March 13, 2020 for the monthly and weekly models, respectively). In addition, we include a dummy, *DVaccine*, equal to 1 in the business weeks of November 20 and December 4, 2020 when Pfizer and Moderna announced successful stage 3 trial results for their Covid-19 vaccines. For the monthly models, this dummy equals 1 in December 2020 only.

Among the other controls are impact dummies for unusual government policy surprises, including *CredControl* (= 1 in March 1980 and 0 otherwise in the monthly models, and =1 in the week of March 7, 1980 -1 in the week of August 1, 1980, and 0 otherwise in the weekly models[17]) for the initial impact of the Carter credit controls of 1980 which triggered a jump in Treasury rates that preceded a similar rise in municipal yields. Another impact dummy is for the Fed's sudden switch to monetary targeting in 1979 announced on Saturday, October 6, 1979, which caused a one-week rise in the muni spread in the week ended Friday (October 12, 1979). This jump unwound in the next business week. The set of impact dummies for the weekly models include the time t and t-1 impact dummy, *Moneytarget*, equal to 1 for the week of October 12 and 0 otherwise. The set of monthly impact dummies does not include a similar variable as there was not a significant monthly rise in October 1979 followed by a reversal in November 1979.

The short-run variables also control for the impact of five large and generally unexpected municipal defaults. Two approaches are taken. The first includes separate dummy variables for each, including the moratorium on New York City debt payments (*DNYC* = 1 in September and October 1975 in monthly models, September 26, 1975 and October 31, 1975 in weekly models, and 0 otherwise (see Municipal Assistance Corporation for the City of New York, 1976, p. 1129, and Gramlich, 1976), and impact dummies for the bankruptcies of Cleveland (*DCleve* = 1 in January 2020 in monthly models or December 22, 1978 in weekly models, and 0 otherwise),[18] Orange County (*DOrange* = 1 in December 1994 in monthly models or December 9. 1994 in weekly models, and 0 otherwise), Jefferson County (*DJefferson* = 1 in November 2011 in monthly models or November 18, 2011 in weekly models, and 0 otherwise), and Detroit (*DDetroit* = 1 in

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[17] The Fed lifted the controls on July 24 and the week ending August 1 was the first full week of decontrol. The weekly effect for the lifting is more discernible on muni spreads (Treasury rates rose) than the monthly effect likely because averaging weekly responses into month averages spreads the effects over the months of July and August.

[18] Cleveland's default occurred after markets closed on Friday, Dec. 15, 1978, which showed up more in the monthly average for January partly because of thin trading during the holiday-heavy second half of December and because the default was on bank loans and likely had a slightly lagging effect on the muni bond market.

December 2013 in monthly models or December 6, 2013 in weekly models, and 0 otherwise).[19] The second approach combines these defaults into one series, *DMuniDef*, that sums the dummies.

Results from both approaches are very similar, with estimated coefficients on the major variables essentially the same and with estimated coefficients on the individual dummies bracketing the single point estimate using the second approach. The second approach is adopted as it is more parsimonious and better illustrates the important finding that isolated municipal defaults may temporarily affect the broader muni market, but do not really pose a systemic risk unlike a correlated shock such as the Covid-19 pandemic. Results from including five separate muni default dummies are reported in Appendix Tables A2 and A3.

Dummies were not included for two other prominent defaults, Washington Power Supply System Projects 4 and 5 (WPSS), and Puerto Rico, owing largely to difficulties with determining the timing the market response to news of these largely expected defaults. In the case of WPSS the utility stopped construction on two nuclear power plants funded by the bonds in January 1982 but did not declare bankruptcy and default until July 1983. As discussed in Appendix B, timing the market response to Puerto Rico is complicated partly because the timing of the actual default was uncertain owing to a series of court decisions about the legality of bankruptcy and partly because of uncertainty about whether the federal government might bailout the territory.

For our preferred model (eq. (2)), we estimate:

$$MuniTR_{t} = \alpha_0 + \alpha_1 UR_t^2 + \alpha_2 CFMA_t \tag{4a}$$

$$\Delta MuniTR_{t} = \beta_0 + \beta_1 EC_{t-1} + \sum^{n}_{i=1} \beta_{2i} \Delta MuniTR_{t-i} + \sum^{n}_{i=1} \beta_{3i} \Delta UR_{t-i}^2 + \sum^{n}_{i=1} \beta_{4i} \Delta CFMA_t + \Omega X_t, \tag{4b}$$

where $EC_{t-1} \equiv MuniTR_{t-1} - MuniTR^{*}_{t-1}$ (the error term from (4a)), lag lengths are chosen to

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[19] In the first week of December 2013, a court ruled that Detroit was eligible to file for bankruptcy under Chapter 9.

minimize the SIC while yielding serially uncorrelated errors, X is a vector of exogenous shock variables, Ω is a vector of coefficients for the X vector of shocks and the estimation allows for each of the variables in the long-run equation to have time trends but not a trend in the long-run relationship.

The estimated coefficient β_1 on the error-correction term is expected to be negative (so that the actual spread converges toward its equilibrium level), with the absolute magnitude implying the speed of error-correction. Note that the model implicitly imposes an almost instantaneous reaction of the municipal bond yield to the long-term Treasury yield, reflecting the Treasury yield's role as a benchmark rate. The speed of error-correction (i.e., the speed at which the spread adjusts), really indicates lags in how the perceived relative risk and degree of risk aversion for Baa-rated municipal bonds adjust in response to the business cycle and the CFMA regime shift in the bankruptcy priority and relative risk of municipal versus Treasury bonds.

Equations (4a) and (4b) comprise a baseline, long-sample model of the muni-Treasury yield spread before the Fed announced in early April 2020 that it would intervene by buying selected municipal bonds. If the Fed prevents the spread from rising past a threshold, its policy intervention breaks the normal equilibrium relationship. This is evident in Figures 1 and 3. Accordingly—and as discussed in more detail later on--for samples extending past early April 2020, we adjust the baseline equation to allow for either a level shift in the equilibrium spread or a change in the impact of the unemployment rate on the spread.

The main cyclical variable used in this study are the monthly civilian unemployment rate and the weekly, insured unemployment rate from the initial claims for unemployment report. The unadjusted weekly insured unemployment rate has not consistently moved over time with the monthly unemployment rate. As stressed by Cleary, Kwok, and Valletta (2009), the major reason is that the eligibility for—and the taxation of—UI benefits has evolved. This stems, in part, from shifts in the regional and unionized composition of employment that have affected the proclivity of the unemployed to file for benefits and count in the weekly unemployment rate series. To address this we multiply the seasonally adjusted weekly series by the centered, 12-week moving average of the ratio of the weekly unemployment rate to the monthly unemployment rate from the household survey.[20] While the adjusted and unadjusted weekly unemployment rates are each significantly related to (cointegrated with) the muni-Treasury spread and with the actual spread significantly error-correcting toward its equilibrium value, the adjusted series yields short-run residuals that are not significantly correlated, in contrast to residuals from a model of the unadjusted series. Accordingly, we use the adjusted insured unemployment rate in weekly models.

4. Empirical Results

Given the short post-Covid sample, using higher frequency weekly data has the advantage of helping identify the effects of the pandemic and Fed interventions into the municipal bond market, but this comes at the disadvantage of not spanning pre-1975 data using weekly data that are noisier than monthly data owing to thin trading at weekly frequencies.

4.1 Long-Run Estimates of Monthly and Weekly Models

Results from estimating monthly and weekly models through March and early April 2020 are reported in Tables 1 and 2, respectively. In each table, the long-run results of modeling the level of the muni spread are shown in the upper panel and short-run results for modeling the changes in the spread are reported in the lower panel. Lag lengths on the first difference terms in the short run section of each model (12 or 13 lags for monthly and weekly models) were selected to minimize the Schwartz Information Criterion among the lag lengths that yield serially

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[20] The smoothing of the adjustment parameter limits noise in the weekly series.

uncorrelated errors in the first difference model (eq. (4b)). Models 1 and 2 are estimated over a pre-Covid sample (February 1961 – March. 2020 and April 4, 1975 – March 6, 2020) for the monthly and weekly models, respectively) and respectively exclude and include the municipal shock variables in the vector *X*.

Models 3 and 4 respectively correspond to Models 1 and 2 with three differences. First, they are estimated over a sample spanning most of the Covid downturn (February 1961–December 2020 and April 4, 1975 – Dec. 25, 2020 for the monthly and weekly models). Second, they add several impact dummies. Third, Models 3 and 4 both zero out the unemployment rate channel after the Fed announced municipal bond interventions. This is done by multiplying the squared unemployment rate by one minus the dummy *MLF*, which equals 1 since April 2020 and the week of April 10 in the monthly and weekly models, respectively. Models 5 and 6 respectively correspond to Models 3 and 4 but differ in not zeroing out the unemployment rate channel after the Fed announced municipal bond interventions.

For the weekly and monthly versions of the pre-Covid Models 1 and 2 and also for Models 3 and 4 that zero out the post-Covid unemployment effects, significant and unique long-run cointegrating relationships are found among the variables in levels (we use Johansen's (1995) method), and short-run models have residuals that are not serially correlated. The long-run coefficients are significant, with the expected positive effects of unemployment and derivatives deregulation (the CFMA dummy) on the muni-Treasury spreads. Long-run coefficient estimates are similar across these four models for monthly and weekly frequencies, as can be seen from the equilibrium spreads estimated in the monthly and weekly versions of Model 3:

$$MuniTR_t = 0.192 + \underset{(0.004)}{0.022} \text{ x } UR_t^{2**} + \underset{(0.186)}{1.352}\, CFMA_t^{**} \qquad \text{(Monthly Model)} \qquad (6)$$

$$MuniTR_t = 0.110 + 0.025 \text{ x } UR_t^{2**} + 1.287\ CFMA_t^{**} \qquad \text{(Weekly Model)} \qquad (7)$$
$$\qquad\qquad (0.005) \qquad\qquad (0.236)$$

where absolute standard errors are in parentheses, * (**) denotes significant at the 95 (99) percent confidence level, the monthly model is estimated through December 2020, and the weekly model, through December 25, 2020. The estimated long-run relationships from Models 1-4 track the trends in the muni spread, shown in Figure 4 with the estimated equilibrium long-run spreads from Models 3 and 1, where the latter use pre-Covid coefficients estimates and ignores the MLF.

In contrast to the full sample Models 3 and 4, for Models 5 and 6 unique and significant cointegrating relationships could be found using shorter lags, but the short-run models had serially correlated residuals. If the lag lengths used in models 3 and 4 are applied to monthly versions of models 5 and 6—which are reported in Table 1—a unique and significant cointegrating relationship cannot be found, the error-correction term is statistically insignificant, and the model residuals are serially correlated. For the weekly versions of models 5 and 6 (Table 2), while a unique and significant cointegrating relationship can be found and the error-correction term is or is nearly statistically significant, the speeds of error correction are much slower and more importantly, the model residuals are serially correlated. This pattern of findings indicates misspecification for the models (5 and 6) that do not zero out the post-Covid impact of the unemployment rate and is consistent with the Fed's intention to prevent the deepening of the Covid Pandemic from being amplified further in the municipal market.

4.2 Short-Run Estimates of Monthly and Weekly Models

Several important patterns are apparent across the short-run models 1 to 4 shown in the lower panels of Tables 1 and 2. First, the error-correction terms are highly significant with the expected negative sign, which implies that spreads change to reduce the gap between the t-1 actual

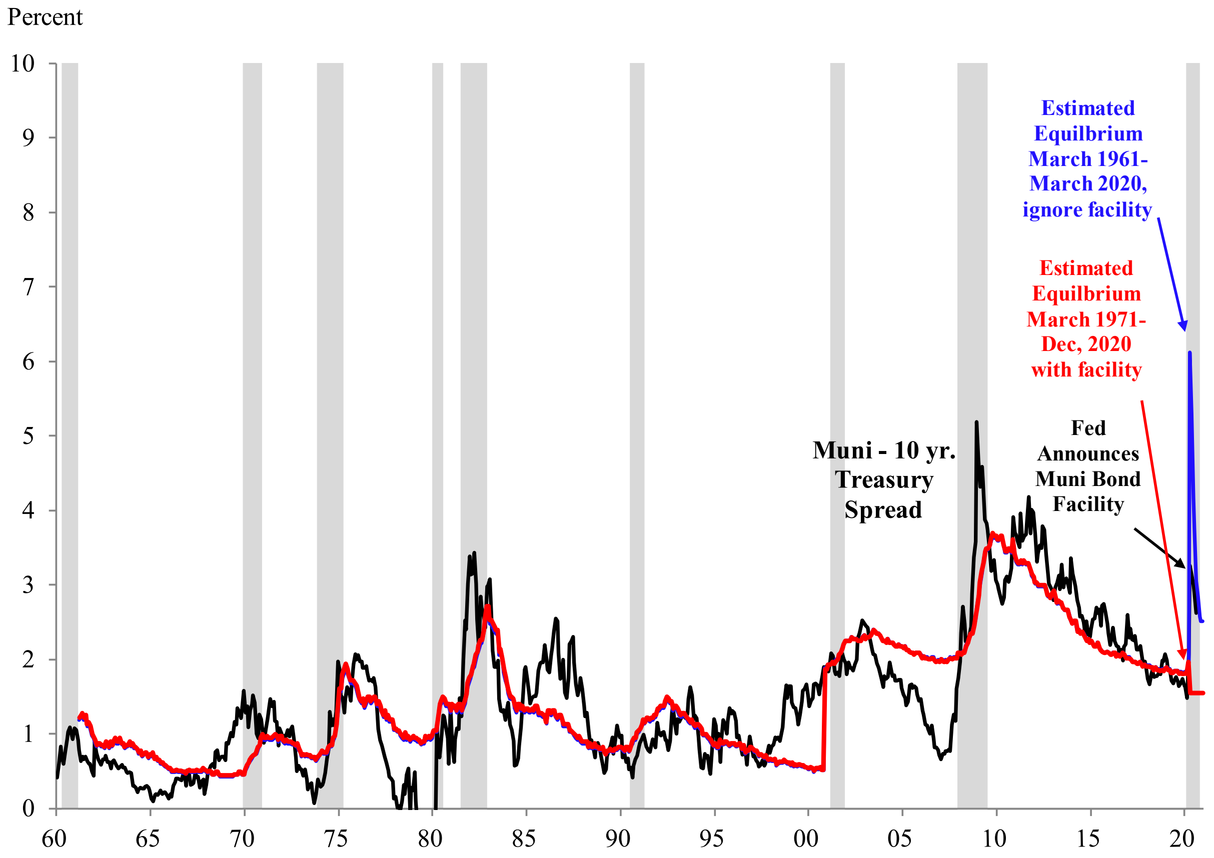

Figure 4: Equilibrium Spreads Track Actual Muni-Treasury Spreads until March 2020
(NBER recessions are shaded. Sources: BLS, NBER Macro-History Database, Moody's, Federal Reserve, and authors' calculations)

and equilibrium levels of the muni spread. The coefficients from the monthly models 1 to 4 imply a 6 to 7 percent monthly or roughly 52 to 60 percent annual speed of error-correction, while those from the weekly models 1 to 4 imply 1.8 percent weekly or roughly 60 to 61 percent annual speed of error-correction. In the corresponding full sample models (Models 3 vs. 5 and Models 4 vs. 6) that do not account for the Fed's announced muni market intervention, the error-correction coefficient is less significant and smaller, implying slower speeds of adjustment. This pattern for the short-run models of the change in the muni spread are consistent with the long-run results in that poorly specified long-run relationships (Models 5 and 6) provide less information for short-run adjustment. The corrected R-squares of the models of the change in the muni spread range from 4 to 24 percent for the monthly models and from 10 to 16 percent for the weekly models.

The inclusion of short run controls in pre-Covid models or in full sample models that account for the Fed's muni bond program is not needed to obtain serially uncorrelated residuals. Nevertheless, model fits are much higher in corresponding models that include the short-run shocks. For both weekly and monthly models, the credit control dummy is highly significant and negative as expected. In the weekly models, the lags on the Fed's surprise October 1979 policy shift are significant, picking up a temporary rise in the muni spread. Also as expected, the monthly dummy for five major muni defaults is very significant and positive, indicating that spreads rise 37 to 39 basis points on impact, with speeds of error-correction implying that their effect on the muni spread takes about 1 to 2 years to wear off. In the alternative models in the Appendix, the coefficients on separate dummies for each muni default are generally at least marginally significant and of similar size. This pattern of findings implies that isolated, unexpected municipal defaults have had short-term—but not long-term—effects on general muni spreads.[21] In comparison, the more medium-term swings in the unemployment rate and the pre-MLF behavior of muni spreads suggest that the Covid Pandemic would have had more noticeable and more medium-term effects on the levels of muni spreads absent the Fed's intervention in the muni market. Finally, the weekly dummy for the announcements of successful stage 3 trials for the Pfizer and Moderna vaccines is highly significant, indicating that each individual announcement lowered muni spreads by about 30 basis points. The combined effect of about 60 basis points is close to the roughly 50 basis point combined effect in fully specified models (3 and 4) and which is only significant in these models

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[21] One qualification is that the estimated impact of NY City's default was higher at 80 basis points versus 40 basis points for the others as the default dummy equaled 1 in two straight months for NY city's default instead of equaling 1 for only one month. Another is that the impact of NY City's default was limited because the city did not declare bankruptcy and it was effectively bailed out by NY state.

which control for the Fed intervention in the muni market.

4.3 Assessing Covid and Fed Muni Market Intervention Effects on the Muni Spread

Tthe above results and figures strongly suggest that the Fed's announced intervention into the muni bond market notably affected the muni spread by nullifying the relationship between the unemployment rate and the spread and preventing much higher municipal bond interest rates. To gauge the effects of the MLF, we use coefficients from Model 3 to trace out the equilibrium spread implied by the long-run coefficients and compare that to the equilibrium spread without shutting off the estimated impact of the unemployment effects for the monthly and weekly versions of Model 3. Using the monthly model, the resulting gap implies that had the average unemployment rate for April 2020 persisted, the equilibrium muni spread would have risen by a further 4.6 pp from its March levels, as illustrated in Figure 5. Figure 6 plots the implied effect that the announced Fed municipal bond interventions had on the equilibrium Baa-Treasury spread using the weekly model, which peaks at 7.9 percentage points in the business week ending April 24, 2020. The weekly peak effect is somewhat higher than that for the monthly model, but the implied monthly averages of the weekly effects are similar to those from the monthly model.

4.4 Possible Impact of Muni Market Intervention on State and Local Government Spending

To our knowledge, there are no available, published econometric models that can gauge the interest rate impact of the MLF on spending by state and local governments, let alone the MLF's indirect spending effects via reducing uncertainty and credit constraints facing these public entities. Nevertheless, while balance budget requirements limit most municipal debt to finance long-term capital projects, interest payments on such debt are a current expense and limit nonfederal government purchases of goods and services—especially in a deep recession. This This implies that debt service savings from lower interest costs on normal annual borrowing can cushion state and local government spending on final goods.

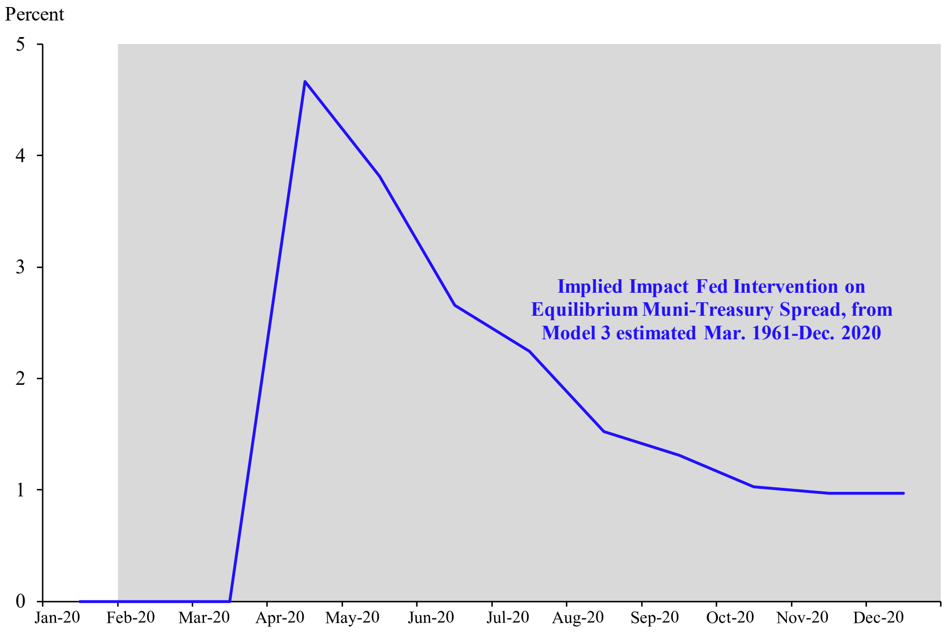

Figure 5: Monthly Model Estimates Suggest a Substantial Effect of the Announced Fed Intervention on the Municipal-Treasury Spread in 2020
(NBER recessions are shaded. Sources: Moody's, Federal Reserve, and authors' calculations)

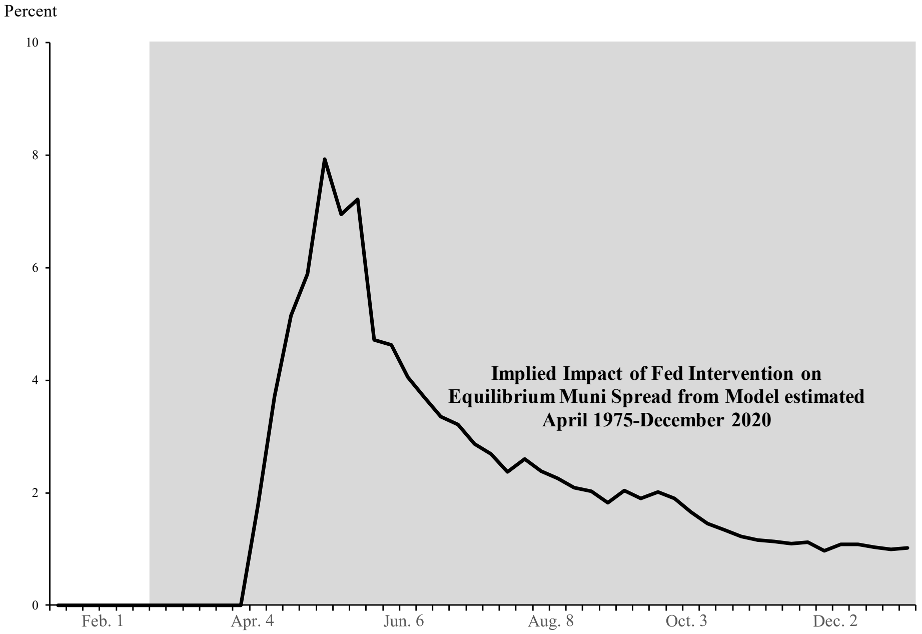

Figure 6: Weekly Model Estimates Suggest a Substantial Effect of the Announced Fed Intervention on the Municipal-Treasury Spread in 2020
(NBER recessions are shaded. Sources: Moody's, Federal Reserve, and authors' calculations)

Model estimates indicate that the announcement of the MLF lowered municipal bond yields by around 4 ½ percentage points in the second quarter of 2020, and by an average of about 3 ½ percentage points from early April to mid-September 2020. Municipal bond debt outstanding is about $3.1 trillion, with issuance of about 1/8 of that per annum or roughly $400 billion a year. This translates into $14 billion to $20 billion in annual interest rate savings or 0.075 to 0.1 percent of GDP, with the higher figure being an upper limit estimate of interest rate effects in 2020:q2, when the MLF had its peak interest rate effect. This figure does not include the effects of the MLF on increasing the short-term ability of nonfederal governments to issue tax anticipation notes to avoid sharp, near-term reductions in spending during the second and third quarters. These potential effects on state and local consumption expenditures also appear to be modest. In the first quarter of 2020, short-term muni issuance was only $670 million less than in the first quarter of 2019, while quarterly issuance since the MLF was announced exceeded year-ago quarterly levels by $1.8 and $3.5 billion in the second and third quarters, respectively. These figures may understate the overall effect of the MLF as they likely omit some long-term investment projects that would have otherwise been cancelled had the MLF not been created to help restore normal market conditions.[22]

Although the MLF was not designed to directly support investment by the nonfederal public sector, its impact as a backstop may have indirectly done so. Just before the MLF was announced, long-term muni bond issuance fell in March 2020 from its February pace and was about 30 percent below its March 2019 levels. Then, long-term issuance surged, outpacing its 2019 rates by $13.0 billion and $30.4 billion in the second and third quarters of 2020, respectively. These amounts are close to the $14 to $20 billion quarterly savings in debt service from lower

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[22] To address its budget crisis in the mid-1970s and to repay its creditors and restore access to bond financing, New York City not only cut spending on services that had contributed much to its earlier deficits, but also cut long-run infrastructure projects (see Ferretti, 1974, and Reagan, 2017) that hurt its long-run economic growth.

interest rates, though they may reflect some greater issuance induced by lower interest rates. These figures imply that the potential effect on state and local government investment expenditures could have been more notable than those on nonfederal government spending on consumption items.

Nevertheless, the impact on investment spending of the MLF may have been greater to the extent that it prevented declines in gross issuance that could have otherwise occurred. On the other hand, much of the second and third quarter issuance likely reflected refinancing of long-term debt and to that extent did not boost state and local government spending in the middle quarters of 2020.

It seems plausible that the overall effect of the MLF on state and local government spending likely bolstered those expenditures by about 0.1 percentage points through interest rate saving effects on current purchases plus a small multiple of that by preventing tighter liquidity constraints on these public entities. In sum, a plausible 0.1 to 0.3 percentage point macro effect of the MLF on state and local government purchases of final goods (coupled with a government spending multiplier of near unity) seems more modest than the 0.8 to 2 ¼ percentage point beneficial effect on GDP of the Fed's corporate facilities calculated by Bordo and Duca (2020).[23] Nevertheless, the contribution of the MLF may be understated as it could omit some infrastructure project cancellations that the creation of the MLF prevented.

5. Conclusion

In early April 2020, it was becoming more difficult for state and local governments to issue debt, evidenced in rapidly widening muni spreads and sharply lower muni issuance in March compared with both February 2020 and its year-ago pace. The Fed's April 9th announcement of a future muni bond buying program through creation of the Municipal Liquidity Facility stopped

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[23] It is difficult to assess the relative local impact of the backstop effects of these programs which are harder to pinpoint than the impact of direct lending which has been very modest so far given limited take-up by borrowers.

spreads from further rising, triggering an ebbing of spreads and a sharp revival of muni bond issuance. Analysis of a half-century of weekly and monthly municipal bond pricing indicates that the MLF kept municipal bond rates from rising nearly 5 percentage points further for April 2020 as a whole and by as much as 8 percentage points in mid-April using more granular weekly data. That these effects occurred far in advance of the opening of the MLF and given the very modest borrowing by municipal entities at the MLF together imply that the announcement of this new facility had a pronounced and rapid backstop effect. These results along with others imply that there was systemic risk in the muni bond market in the Covid-19 pandemic, that was not the case for the isolated, but prominent, muni defaults in the prior half century.

In so doing, the MLF prevented the deepening of the Covid-19 Recession from further pushing up muni rates and amplifying the downturn. From this perspective, the MLF has been very successful, much like the Money Market Municipal Liquidity Facility that helped stabilize short-term funding sources for municipal governments (Wei and Yue, 2020b). Such effects occurred well before the announcement effects of successful vaccine trials lowered spreads in November and December 2020. Nevertheless, the net effects of the MLF (and MMMLF) on state and local government purchases of final product appear to be modest in absolute terms and relative to estimates of the cushioning effects of the Fed's corporate bond programs, which are more notable.

Depending on how and when the MLF is unwound, its net effect may not be as positive as the upfront benefits many suggest for at least three reasons. First, the creation of the MLF may have lessened pressure on the Congress to provide federal fiscal relief to state and local governments. Second, the precedent set by the MLF may create moral hazard that induces municipal authorities to worry less about downside tail effects. For example, the precedent of the MLF could reduce the incentives for many states to build up "rainy day" surpluses that could be used to bolster muni spending and avoid tax hikes. And there is evidence of moral hazard in other countries; notable examples are Argentina and Brazil, where excess borrowing by state governments has been bailed out by the national government that later was forced to default (Bordo, Jonung and Markiewicz, 2011).[24] Finally, it will be important to end the MLF to restore market forces as the primary determinant of muni rates and the allocation of finance to the nonfederal public sector. Partly on this concern, the Treasury decided to terminate the MLF at yearend 2020, even though the Fed saw this as premature. Thus, the net benefit of the MLF will depend on whether it was correctly unwound and the extent of the moral hazard effects that it induces relative to the notable benefits of stopping a municipal liquidity crisis in the spring of 2020 and capping muni spreads.

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[24] On the other hand, one could point to the successful example of the U.S. federal government's assumption of the revolutionary war debt issued by states (Sargent, 2020) which was for a national purpose, and argue that in the Covid pandemic, state and local governments have de facto borne the burden of a national emergency.

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Table 1: Six Decade Sample Models of the Muni-Treasury Spread, 1961-2020

Long-Run Equilibrium: $MuniTR^{*}_{t} = \alpha_0 + \alpha_1\, UR_t^2 + \alpha_2\, CFMA_t$

Sample:	Mar. 1961-March 2020		February 1961 to December 2020			
Model No.	1	2	3^{i}	4	5	6^{i}
Constant	0.1867	0.3750	0.1915	0.3496	-1.1891	-1.6867
UR_t^2	0.0211**	0.0156**	0.0216**	0.0169**	0.0541**	0.0661**
x(1-*muni*) 3 & 4	(4.69)	(2.99)	(4.90)	(3.34)	(8.62)	(8.07)
$CFMA_t$	1.3762**	1.4472**	1.3519**	1.4081**	1.6117**	1.7024
	(7.29)	(6.67)	(7.28)	(6.67)	(6.05)	(1.56)
unique coint.	Yes**	Yes*	Yes**	Yes*	No	No
vec. # lags	12	13	12	13	13	13
trace no vec.	38.02**	33.87*	37.14**	32.43*	60.27**	48.72**
trace only 1	11.43	11.91	9.92	10.39	22.07**	21.92**

Short-Run: $\Delta MuniTR_t = \beta_0 + \beta_1 EC_{t-1} + \sum^{n}_{i=1} \beta_{2i}\Delta MuniTR_{t-i} + \sum^{n}_{i=1}\beta_{3i}\Delta UR_{t-i}^2 + \sum^{n}_{i=1}\beta_{4i}\, \Delta CFMA_t + \Omega X_t + \mu_t$

	1	2	3^{i}	4	5	6^{i}
EC_{t-1},	-0.073**	-0.059**	-0.074*	-0.059**	-0.007	0.004
	(4.26)	(3.87)	(4.33)	(3.83)	(0.71)	(0.51)
annual adjust. speed:	60%	52%	60%	52%	8%	n.a.
$\Delta MuniTR_{t-1}$	-0.004	0.023	-0.005	0.023	-0.042	-0.006
	(0.11)	(0.61)	(0.12)	(0.65)	(1.07)	(0.15)
ΔUR_{t-i}^2	0.002	0.004	0.002	0.004	-0.000	0.000
x(1-*muni*) 3 & 4	(0.43)	(1.23)	(0.50)	(1.36)	(0.05)	(0.38)
$\Delta CFMA_{t-1}$	0.037	0.037	0.043	0.046	0.054	0.055
	(0.18)	(0.20)	(0.21)	(0.25)	(0.26)	(0.29)
Constant	0.001	-0.004	-0.001	-0.006	-0.006	-0.006
	(0.15)	(0.51)	(0.13)	(0.93)	(0.00)	(0.84)
$CredControl_t$		1.880**		1.892**		2.002**
		(9.88)		(10.02)		(10.51)
$DMuniDef_t$		0.387**		0.391**		0.348**
		(4.91)		(5.01)		(4.42)
$DCovid_t$			0.557**	0.584**	0.589**	0.605**
			(2.77)	(3.16)	(2.88)	(3.22)
$DCovid_{t-1}$			1.223**	1.177**	1.232**	1.208**
			(6.00)	(6.29)	(5.99)	(6.40)
$DVaccine_t$			0.499*	0.532**	-0.089	0.328
			(2.25)	(2.66)	(0.13)	(0.46)
Adj. R^2	0.038	0.186	0.095	0.236	0.062	0.209
S.E.	0.201	0.185	0.200	0.184	0.204	0.187
VEC Auto (1)	4.01	13.81	4.81	13.53	215.67**	216.94**
VEC Auto (2)	4.09	15.60	1.74	9.65	305.39**	284.35**

VEC Auto (4)	6.37	7.80	6.93	8.20	179.93^{**}	102.56^{**}

Notes: Absolute t-statistics are in parentheses. ** (*) denoted significant at the 99% (95%) confidence level. (i) Coefficients for the UR^2 terms are multiplied by (1 – *Muni*) in models 3-4. (ii) Absolute t-statistics in parentheses. (iii) Long-run: Maximum likelihood estimates of the long-run equilibrium relationship using a two-equation system with at most one cointegrating vector. (iv) $EC_{t-1} = MuniTR_{t-1} - \alpha_0 + \alpha_1 UR_{t-1}^2 + \alpha_2 CFMA_{t-1}$. (v) First difference terms of elements in the long-run cointegrating vector. (vi) Lag lengths chosen to minimize the SIC criterion. (vii) significance of the trace and VEC Auto statistics reflects lag length.

Table 2: Four Decade Sample Weekly Models of the Muni-Treasury Spread, 1975-2020

Long-Run Equilibrium: $MuniTR^{*}_{t} = \alpha_0 + \alpha_1\, UR_t^2 + \alpha_2\, CFMA_t$

Sample:	Apr. 4, '75 - Mar. 27, '20		April 4, 1971 – Dec 25, 2020			
Model No.	1	2	3^{i}	4	5	6^{i}
Constant	0.0569	0.1072	0.1095	0.1542	-0.5468	-0.5364
UR_t^2	0.0254^{**}	0.0243^{**}	0.0248^{**}	0.0237^{**}	0.0370^{**}	0.0367^{**}
x(1-*muni*) 3 & 4	(4.86)	(4.67)	(4.79)	(4.62)	(7.70)	(7.67)
$CFMA_t$	1.2977^{**}	1.2948^{**}	1.2873^{**}	1.2859^{**}	1.4867^{**}	1.4870^{**}
	(5.49)	(5.53)	(5.45)	(5.48)	(6.73)	(6.75)
unique coint.	Yes^{**}	Yes^{*}	Yes^{**}	Yes^{*}	Yes^{**}	Yes^{**}
vec. # lags	12	12	12	12	12	12
trace no vec.	31.66^{*}	32.72^{*}	32.81^{*}	33.71^{*}	46.26^{**}	47.06^{**}
trace only 1	8.02	8.89	7.57	8.36	10.13	11.01

Short-Run: $\Delta MuniTR_t = \beta_0 + \beta_1 EC_{t-1} + \sum_{i=1}^{n} \beta_{2i}\Delta MuniTR_{t-i} + \sum_{i=1}^{n}\beta_{3i}\Delta UR_{t-i}^2 + \sum_{i=1}^{n}\beta_{4i}\,\Delta CFMA_t + \Omega X_t + \mu_t$

	1	2	3^{i}	4	5	6^{i}
EC_{t-1},	-0.018^{**}	-0.018^{**}	-0.018^{**}	-0.018^{**}	-0.010^{*}	-0.009^{*}
	(3.37)	(3.48)	(3.63)	(3.71)	(2.20)	(2.18)
annual adjust. speed:	60%	60%	61%	61%	40%	39%
$\Delta MuniTR_{t-1}$	-0.113^{**}	-0.101^{**}	-0.112^{**}	-0.100^{**}	-0.114^{**}	-0.102^{**}
	(5.36)	(4.89)	(5.37)	(4.91)	(5.46)	(5.00)
ΔUR_{t-i}^2	-0.001	-0.001	-0.001	0.001	0.001	0.001
x(1-*muni*) 3 & 4	(0.71)	(0.59)	(0.73)	(0.60)	(0.40)	(0.56)
$\Delta CFMA_{t-1}$	0.014	0.013	0.013	0.012	0.017	0.016
	(0.10)	(0.10)	(0.09)	(0.09)	(0.12)	(0.12)
Constant	0.001	-0.000	0.000	-0.001	0.001	0.000
	(0.21)	(0.04)	(0.03)	(0.22)	(0.25)	(0.00)
$CredControl_t$		0.527^{**}		0.523^{**}		0.529^{**}
		(5.44)		(5.42)		(5.46)
$MoneyTarget_t$		0.716^{**}		0.717^{**}		0.729^{**}
		(5.24)		(5.27)		(5.33)
$MoneyTarget_{t-1}$		-1.013^{**}		-1.008^{**}		-1.011^{**}
		(7.38)		(7.37)		(7.35)
$DMuniDef_t$		0.294^{**}		0.296^{**}		0.290^{**}
		(5.69)		(5.75)		(5.61)
$DCovid_t$	0.294^{*}	0.290^{*}	0.295^{*}	0.291^{*}	0.292^{*}	0.289^{*}
	(2.10)	(2.13)	(2.11)	(2.14)	(2.08)	(2.12)
$DCovid_{t-1}$	-0.803^{**}	-0.808^{**}	-0.802^{**}	-0.806^{**}	-0.808^{**}	-0.811^{**}
	(5.71)	(5.92)	(5.73)	(5.93)	(5.75)	(5.95)
$DCovid_{t-2}$	1.782^{**}	1.791^{**}	1.784^{**}	1.793^{**}	1.767^{**}	1.777^{**}
	(12.53)	(12.98)	(12.60)	(13.04)	(12.43)	(12.87)

$DCovid_{t-3}$			0.657^{**}	0.628^{**}	0.528^{**}	0.500^{**}
			(3.78)	(3.72)	(3.17)	(3.09)
$DVaccine_{t}$			0.312^{*}	0.311^{**}	0.323^{**}	0.322^{**}
			(3.15)	(3.24)	(3.24)	(3.32)
Adj. R^2	0.110	0.162	0.112	0.163	0.104	0.155
S.E.	0.140	0.136	0.139	0.135	0.140	0.136
VEC Auto (1)	6.93	3.99	3.49	3.79	92.41^{**}	90.14^{**}
VEC Auto (2)	10.89	11.57	5.58	6.42	165.15^{**}	167.21^{**}
VEC Auto (4)	9.98	7.62	9.16	8.52	74.64^{**}	18.63^{*}

Notes: Absolute t-statistics are in parentheses. ** (*) denoted significant at the 99% (95%) confidence level. (i) Coefficients for the UR^2 terms are multiplied by $(1 - Muni)$ in models 3-4. (ii) Absolute t-statistics in parentheses. (iii) Long-run: Maximum likelihood estimates of the long-run equilibrium relationship using a two-equation system with at most one cointegrating vector. (iv) $EC_{t-1} = MuniTR_{t-1} - \alpha_0 + \alpha_1 UR_{t-1}^2 + \alpha_2 CFMA_{t-1}$. (v) First difference terms of elements in the long-run cointegrating vector. (vi) Lag lengths chosen to minimize the SIC criterion. (vii) significance of the trace and VEC Auto statistics reflects lag length.

Appendix A: The Muni Bond Market in the Great Depression

This appendix reviews the main developments affecting muni spreads, volumes, and issuance in the Great Depression.[25] As noted by Wigmore (1985, pp. 110-11), before the Great Crash of 1929, muni bonds were considered very safe (all but two states had Aaa-ratings and all major cities were rated Aaa), and this segment of the overall bond market was large; indeed, the volume of existing muni bonds was nearly the size of outstanding Treasuries and was about 50 percent larger than the amount of outstanding non-railroad corporate bonds, as well as of that of utility bonds and also railroad bonds. In the few weeks immediately following the October 1929 Crash, muni yields fell reflecting their earlier, highly safe reputation.

But by yearend many cities' financial condition weakened and could not issue bonds nor could they speed up—let alone sustain—their planned capital projects for 1930 as President Hoover had requested (Wigmore (1985, p. 111). Muni spreads widened near yearend 1929. In 1930 there had been some recovery in the overall muni market despite defaults by Miami and several municipal entities in Florida. But by late 1931, a number of states and cities were once again unable to issue bonds and began cutting expenditures (Wigmore (1985, p. 290-91). Reflected in increases in muni spreads (particularly for lower rated securities), pressures on state and local budgets intensified in 1932, when many municipal governments were downgraded, had difficulty issuing bonds—some turning to bank loans as a substitute, and greatly cut spending (Wigmore, 1985, pp. 400-09).

To limit further cuts by state and local governments (whose combined expenditures were twice those of the federal government in 1932), Congress authorized the Reconstruction Finance

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[25] Aside from the wave of municipal defaults in the 1840s, there were many defaults in the slump of the 1870s when about one-quarter of municipal debt was in default. Defaults were concentrated in railroad bonds, particularly in the South and to a lesser extent, in the Midwest (Advisory Commission on Intergovernmental Relations, 1973, p. 11). According to the same source, another wave occurred in the downturn of the 1890s, which was not as large. and which included more general obligation debt and was not as concentrated in railroad debt.

Corporation (RFC) in mid-1932 to make loans to state and local governments to fund both capital projects and current spending. Nevertheless, conditions worsened in the first half of 1933 with several more state and local governments defaulting (e.g., Arkansas, Detroit, and Cook County (home to Chicago) or being unable to issue debt (particularly Southern states), and many cutting spending (especially on investment) amid further declines in revenues which amplified increases in debt service burdens. Between 1929 and 1933, 33 of the 48 states had seen their bond ratings downgraded.[26] In contrast, the federal government was much better able to debt-finance spending. Partly in response, Congress funded transfers from the Roosevelt-run federal government to fund state and local government spending and the RFC greatly expanded lending to fund construction projects, such as the Golden Gate Bridge in San Francisco and the Lincoln Tunnel in New York City (Wigmore, 1985, pp. 511-17).

Between these measures and other steps to stimulate the macroeconomy, muni market conditions improved by the end of 1933 and into 1934, which allowed some better rated state and local governments the opportunity to refinance older, higher yield bonds and helped support a rebound in real investment by state and local governments in 1934 (see Figure 2 in the main text). The rebound is particularly evident in the annual pace of bond issuance by state and local governments for funding capital projects (Table A-1), especially when deflated by the investment spending price index for state and local governments.

One lesson from the Great Depression is that distress in the municipal bond market affects the spending of more than just entities that declare default. Indeed, only one state (Arkansas) out

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[26] Sources: Table A-11 from Wigmore (1985, pp. 598-99) who derived his figures from annual Moody's Governments Manuals. The 33 downgraded states include Florida, which defaulted in 1930 losing its bond rating and erasing its debt. Of the 15 states not downgraded, 7 maintained their Aaa debt rating from 1929 to 1933 and had outstanding debt in 1933; one had no debt outstanding between 1929 and 1933 and no rating; 3 had debt outstanding but no rating in 1933, while not seeing a change in their Aaa rating between 1929 and 1932; and 5 had eliminated their debt between 1929 and 1933 and had not seen their Aaa rating in 1929 downgraded between 1929 and 1933.

of 48 defaulted between 1929 and 1933,[27] but many states had cut spending partly in response to being unable to issue municipal debt either at reasonable interest rates and several states sought federal aid to fund their spending (e.g., see Wigmore 1985, pp. 400-09). This is not to say that defaults did not directly result in spending cuts by bankrupt municipalities. There were about 4,800 state and municipal government entities that defaulted on principal or interest payments during the Great Depression (1929-37), including many cities and towns, capital and water-related improvement districts, school districts, and counties as reported by Joffe (2013, see p. 68 for a tabulation between 1920 and 1939). Nevertheless, the amount of municipal debt affected by defaults in the Great Depression ($2.5 billion cumulative, Hempel (1964) was a fraction of outstanding municipal debt and of the declines in state and local spending. This too implies that reduced or more costly access of non-defaulting state and local governments to the municipal bond market could induce lower spending.

Year	Nominal State & Local Government Bond Issuance for Capital Projects, billions	Real State & Local Government Bond Issuance for Capital Projects, $2012 billions
1928	1.33	n.a.
1929	1.42	24.90
1930	1.43	26.73
1931	1.24	25.65
1932	0.76	19.43
1933	0.48	10.82
1934	0.80	15.49
1935	0.86	17.15
1936	0.74	13.64
1937	0.73	13.22

Table A-1 State and Local Municipal Bond Issuance to Fund Capital Projects
(Sources: Wigmore (1985, Appendix Table A-27), BEA, and author's calculations)

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[27] Arkansas's default owing, in large part, to high borrowing before the Great Depression (Joffe, 2012).?

Appendix B: Major Post-WWII Defaults by Local Governments and Their Impact

This appendix provided details on the factors driving several notable defaults by local governments in the last half century and discusses the short-run costs and disruption from these governments adjusting their budgets in a sharp and sudden way.

I. Major Post-WWII Episodes of Municipal Defaults

There have been six noteworthy defaults of local governments since 1975[28], one on bank loans (Cleveland, 1978) and five on bonds: New York City (1975), Orange County (California, in 1994), Jefferson County (Louisiana in 2011), Detroit (2013), and Puerto Rico (2016). Five of these cases (Orange County being the exception) plausibly fit Winegarden's (2014, p. 6) characterization that, "Typically, those municipalities that are pushed into insolvency by an economic shock have been stagnating economically for a long time."

Although **New York City** did not declare bankruptcy and eventually paid its bond holders in full, New York City technically defaulted in 1975 when it did not make timely payments to its bond holders. The city's default stemmed from several factors (see Greenspan, MacAvoy, and Malkiel, 1975). First, the city's spending was unsustainable given its tax base whose long-run growth suffered from shifts in economic activity to lower cost metropolitan areas and higher income residents to outlying suburbs. Second, this imbalance was compounded by the city amassing increasing amounts of short-run debt to mask and fund a series of budget deficits. Third, the unsustainability of spending and borrowing practices became apparent to bond investors, who demanded higher risk premiums on the city's debt. Higher service costs, especially on short-run debt, further worsened its imbalances and the city lost access to both bond issuance and bank loans. The state of New York stepped in to provide temporary funding and put the management of the

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[28] Between the Great Depression and 1975, the only major municipal default was that by New York City's Urban Development Corporation in 1974 (see Moody's, 2017).

city's budget under the auspices of the Municipal Assistance Corporation, which mandated a series of deep cuts to city spending and some tax hikes to bring the city's budget into long-run balance.

Cleveland's default in 1978 was lesser known, partly because of its size but also because the city defaulted on bank loans rather than bonds. After the city's tax base and population was hurt by negative short- and long-run shocks to its manufacturing-oriented economy in the 1970s, Cleveland lost its ability to fund its prior spending path. In the short run, the city borrowed from local banks to fund deficits. In late 1978, its mayor and city council could not agree on selling a utility to cover some of its short-run imbalances and on spending cuts and tax increases to address its longer-run budget problems. At that point, when local banks refused to roll-over the city's maturing short-run bank loans, the city declared bankruptcy and was put under the financial supervision of the state of Ohio. The next mayor and city council agreed to spending cuts and tax increases that restored budget balance and the city emerged from bankruptcy in late 1980.

Orange County, California, declared bankruptcy after the municipality's county investment pool suffered a large loss (over $1.5 billion) on interest rate exposures that had generated enough interest income to cover 12 percent of county expenditures in 1994, above the 3 percent average for all other California counties that year (Orange County Grand Jury Report, 2013, p. 1). However, the risks entailed were not appreciated or understood by local leaders and "circumvented" the fiduciary responsibilities of the county investment pool (Orange County Grand Jury Report, 2013, p. 1). When interest rates rose quickly following the slow recovery from the moderate-sized recession of the early 1990s, Orange County suffered losses for which it was unprepared. This example highlights how financial innovations have given rise to new, less visible downside risks to holders of municipal and other bonds. While the short-run adjustment was notable, this affluent county recovered, largely because its default did not partially arise from a failure to adjust to a downshift in long-run economic prospects.

Detroit missed a scheduled debt payment in June 2013 and the next month filed to declare bankruptcy. This followed a long period of decline in the city's population and auto-oriented manufacturing base, which left it with a municipal workforce and pension liabilities more suited for its earlier, larger population. The impact of this long downtrend on the city's solvency was, according to Winegarden (2014, p. 8) exacerbated by financial mismanagement and an overhang of unfunded retiree benefits. In November 2014, Detroit emerged from bankruptcy after it was able to cut its debt load and cut pension benefits, as well as cut current spending and raise revenues.

Jefferson County, Alabama's bankruptcy stemmed, in large part, not from unfunded pensions, but rather from the debt burden of repairing and improving its sewer system to meet previously neglected federal mandates. According to Winegarden (2014, pp. 14-15), these costs were amplified by corruption and financial mismanagement. The latter included a high reliance on variable rate and short-term debt that repriced upwards when the county's debt rating was downgraded during the subprime and global financial crisis. The county filed for bankruptcy in November 2011 and emerged from it two years later when it issued new debt.

The default of the U.S. territory **Puerto Rico** in July 2016 ended a drawn-out fiscal crisis, reflecting unsustainable budgeting practices and the long-run relative decline of the territory's economy (see Yglesias, 2016). Compounding these structural ailments were the impact of two severe hurricanes that damaged the island when the local government lacked access to tax revenues and debt finance. The number of public pronouncements and warnings that predated its 2016 default also make it difficult to pinpoint discernible short-run effects on the muni market in general. As a result, it is difficult to discern any impact of Puerto Rico's default the timing of shocks and expectations to muni spreads in contrast to the more unexpected defaults of other municipalities.

II. Some Real Consequences of Financial Distress on Municipal Governments

This section reviews some evidence on the impact of sudden cuts in spending by state and local governments in response to episodes of default and acute financial distress. The focus is not on the size of the public sector which needs to be sustainable in the long-run, but rather on the cost of sudden spending cuts and tax hikes to address fiscal imbalances that may stem from poor budgeting (e.g., New York City in the mid-1970s), fiscal uncertainties from unexpected economic shocks (e.g., oil busts or the Covid-19 pandemic), or combinations of the two (e.g., Detroit, 2013).

Four noteworthy cases of post-WWII defaults of municipal governments include those of New York City (1975), Cleveland (1978), Jefferson County (2011), and Detroit (2013) whose size and structural problems has made analysis more feasible than the defaults of more well-off municipalities (Orange county) or revenue bonds issuers (e.g., Washington Public Power Supply System Projects 4 and 5). The impact on Puerto Rico is not reviewed here given its more recent occurrence and the difficulties in distinguishing between the impacts of spending cuts from those of the hurricanes and earthquakes that have hurt the island.

The social and economic costs entailed by default are considerable in several dimensions. For one, debt costs usually rise as investors demand higher risk premia and municipality bond ratings are often lowered. In cases of outright bankruptcy, municipalities can incur large legal expenses, amounting to $178 million in the case of Detroit (Reuters, 2014). These costs cut into funds available for city services and capital expenditures, such as in the case of New York City (Reagan, 2017). Second, spending cuts can impair public infrastructure as in the cases of New York (Reagan, 2017) and Jefferson County—where street repaving was even suspended (Braun, 2020). Third, cuts to social services can be dire. In the case of Jeffersion County, 1,300 public employees were fired, hospital services were cut, courthouses were closed, and even a new jail could not be staffed (Braun, 2020). As noted by Freudenberg, et al. (2006), cuts in public health spending hurt efforts to address drug addiction and even contributed to an outbreak of tuberculosis in New York City. Furthermore, there were sizable reductions in the city's police force (Corman and Mocan (2006, p. 588) of about 25 percent between 1974 and 1980, whose size negatively affects burglaries and robberies (Corman and Mocan, 2006). While many—but not all—of the spending cuts were eventually reversed, Freudenberg, et al. (2006), estimate that the economic costs ($50 billion) outweighed the short-run budgetary savings ($10 billion) of the cuts enacted.

Aside from the impact of direct cuts on municipal spending is the impact of budgetary uncertainty on how local governments perform. This issue is especially pertinent to the Covid-19 pandemic given the uncertainty about spending and revenues that the outbreak has posed for state and local governments. In a pre-Covid study, Lavertu and St. Clair (2018) find that unexpected revenue shortfalls for Ohio school districts lead to statistically significant declines in future student performance on math and reading exams, but that positive revenue surprises have much smaller effects. Plausible explanations include that when faced with revenue uncertainty, school districts preemptively reduce spending partly to build reserves to avoid more drastic and disruptive cuts, and that such precautionary cutbacks are also motivated by the incentive to head off ratings downgrades on debt or paying higher risk premiums on debt. Reminiscent of the classic adage, " be careful what you hope for," Lavertu and St. Clair (2018) ironically wrote, "More generally, we hope to see a growing body of research examining the impact of revenue uncertainty on service delivery." Clearly these public economists neither hoped for nor expected the tragedy of Covid. While the Fed's Municipal Liquidity Facility has plausibly ameliorated revenue uncertainty from the Covid-19 Pandemic, municipal revenue uncertainty unfortunately abounds and will likely impair the ability of state and local governments to limit the human cost of the pandemic.

Appendix Table A2: Six Decade Sample Models of the Muni-Treasury Spread, 1961-2020

Long-Run Equilibrium: $MuniTR^{*}_{t} = \alpha_0 + \alpha_1 UR_t^2 + \alpha_2 CFMA_t$

Sample:	Mar. 1961-March 2020		February 1961 to December 2020			
Model No.	1	2	3^{i}	4	5	6^{i}
Constant	0.1867	0.3692	0.1915	0.3429	-1.1891	-1.6229
UR_t^2	0.0211**	0.0158**	0.0216**	0.0172**	0.0541**	0.0646**
x(1-*muni*) 3 & 4	(4.69)	(3.05)	(4.90)	(3.43)	(8.62)	(8.09)
$CFMA_t$	1.3762**	1.4391**	1.3519**	1.3970**	1.6117**	1.6917
	(7.29)	(6.65)	(7.28)	(6.65)	(6.05)	(4.99)
unique coint.	Yes**	Yes*	Yes**	Yes*	No	No
vec. # lags	12	13	12	13	13	13
trace no vec.	38.02**	33.90*	37.14**	32.51*	60.27**	60.44**
trace only 1	11.43	11.76	9.92	10.23	22.07**	22.28**

Short-Run: $\Delta MuniTR_t = \beta_0 + \beta_1 EC_{t-1} + \sum^{n}_{i=1} \beta_{2i}\Delta MuniTR_{t-i} + \sum^{n}_{i=1}\beta_{3i}\Delta UR_{t-i}^2 + \sum^{n}_{i=1}\beta_{4i}\Delta CFMA_t + \Omega X_t + \mu_t$

EC_{t-1},	-0.073**	-0.060**	-0.074*	-0.060**	-0.007	0.003
	(4.26)	(3.88)	(4.33)	(3.85)	(0.71)	(0.43)
annual adjust. speed:	60%	52%	60%	52%	8%	n.a.
$\Delta MuniTR_{t-1}$	-0.004	0.022	-0.005	0.024	-0.042	-0.006
	(0.11)	(0.59)	(0.12)	(0.66)	(1.07)	(0.16)
ΔUR_{t-i}^2	0.002	0.004	0.002	0.004	-0.000	0.000
x(1-*muni*) 3 & 4	(0.43)	(1.25)	(0.50)	(1.35)	(0.05)	(0.35)
$\Delta CFMA_{t-1}$	0.037	0.037	0.043	0.045	0.054	0.055
	(0.18)	(0.20)	(0.21)	(0.24)	(0.26)	(0.29)
Constant	0.001	-0.005	-0.001	-0.007	-0.006	-0.006
	(0.15)	(0.65)	(0.13)	(0.94)	(0.00)	(0.83)
$CredControl_t$		1.880**		1.890**		1.208**
		(9.86)		(9.99)		(6.39)
$DNYC_t$		0.311*		0.327*		0.228
		(2.15)		(2.29)		(1.60)
$DClev_{t-1}$		0.360^{+}		0.347^{+}		0.385*
		(1.89)		(1.84)		(2.02)
$DOrange_t$		0.460*		0.459*		0.428*
		(2.44)		(2.46)		(2.26)
$DJefferson_{t-1}$		0.333^{+}		0.347^{+}		0.307
		(1.69)		(1.78)		(1.55)
$DDetroit_t$		0.525**		0.523**		0.489*
		(2.77)		(2.78)		(2.57)

$DCovid_t$			0.557^{**}	0.584^{**}	0.589^{**}	0.605^{**}
			(2.77)	(3.15)	(2.88)	(3.21)
$DCovid_{t-1}$			1.223^{**}	1.178^{**}	1.232^{**}	1.208^{**}
			(6.00)	(6.28)	(5.99)	(6.39)
$DVaccine_t$			0.499^{*}	0.556^{**}	-0.089	0.266
			(2.25)	(2.72)	(0.13)	(0.37)
Adj. R^2	0.038	0.182	0.095	0.233	0.062	0.206
S.E.	0.201	0.186	0.200	0.184	0.204	0.187
VEC Auto (1)	4.01	15.25	4.81	13.90	215.67^{**}	214.04^{**}
VEC Auto (2)	4.09	14.43	1.74	9.13	305.39^{**}	282.65^{**}
VEC Auto (4)	6.37	8.46	6.93	8.66	179.93^{**}	177.67^{**}

Notes: Absolute t-statistics are in parentheses. ** (*) denoted significant at the 99% (95%) confidence level. (i) Coefficients for the UR^2 terms are multiplied by (1 – *Muni*) in models 3-4. (ii) Absolute t-statistics in parentheses. (iii) Long-run: Maximum likelihood estimates of the long-run equilibrium relationship using a two-equation system with at most one cointegrating vector. (iv) $EC_{t-1} = MuniTR_{t-1} - \alpha_0 + \alpha_1 UR_{t-1}^2 + \alpha_2 CFMA_{t-1}$. (v) First difference terms of elements in the long-run cointegrating vector. (vi) Lag lengths chosen to minimize the SIC criterion. (vii) significance of the trace and VEC Auto statistics reflects lag length.

Appendix Table A3: Four Decade Sample Weekly Models of the Muni-Treasury Spread, 1975-2020

Long-Run Equilibrium: $MuniTR^{*}_t = \alpha_0 + \alpha_1 UR_t^2 + \alpha_2 CFMA_t$

Sample:	Apr. 4, '75 - Mar. 27, '20		April 4, 1971 – Dec 25, 2020			
Model No.	1	2	3^{i}	4	5	6^{i}
Constant	0.0569	0.1072	0.1095	0.1566	-0.5468	-0.5639
UR_t^2	0.0254^{**}	0.0242^{**}	0.0248^{**}	0.0237^{**}	0.0370^{**}	0.0373^{**}
x(1-*muni*) 3 & 4	(4.86)	(4.65)	(4.79)	(4.61)	(7.70)	(7.67)
$CFMA_t$	1.2977^{**}	1.2909^{**}	1.2873^{**}	1.2820^{**}	1.4867^{**}	1.4973^{**}
	(5.49)	(5.50)	(5.45)	(5.45)	(6.73)	(6.69)
unique coint.	Yes**	Yes*	Yes**	Yes*	Yes**	Yes**
vec. # lags	12	12	12	12	12	12
trace no vec.	31.66^{*}	32.93^{*}	32.81^{*}	33.97^{*}	46.26^{**}	47.32^{**}
trace only 1	8.02	9.19	7.57	8.70	10.13	11.50

Short-Run: $\Delta MuniTR_t = \beta_0 + \beta_1 EC_{t-1} + \sum^{n}_{i=1} \beta_{2i} \Delta MuniTR_{t-i} + \sum^{n}_{i=1} \beta_{3i} \Delta UR_{t-i}^2 + \sum^{n}_{i=1} \beta_{4i} \Delta CFMA_t + \Omega X_t + \mu_t$

EC_{t-1},	-0.018^{**}	-0.018^{**}	-0.018^{**}	-0.018^{**}	-0.010^{*}	-0.009^{*}
	(3.37)	(3.54)	(3.63)	(3.76)	(2.20)	(2.17)
annual adjust. speed:	60%	61%	61%	62%	31%	39%
$\Delta MuniTR_{t-1}$	-0.113^{**}	-0.100^{**}	-0.112^{**}	-0.100^{**}	-0.114^{**}	-0.102^{**}
	(5.36)	(4.86)	(5.37)	(4.89)	(5.46)	(4.99)
ΔUR_{t-i}^2	-0.001	-0.001	-0.001	0.001	0.001	0.001
x(1-*muni*) 3 & 4	(0.71)	(0.58)	(0.73)	(0.60)	(0.40)	(0.56)
$\Delta CFMA_{t-1}$	0.014	0.013	0.013	0.012	0.017	0.015
	(0.10)	(0.10)	(0.09)	(0.09)	(0.12)	(0.11)
Constant	0.001	-0.000	0.000	-0.001	0.001	0.000
	(0.21)	(0.04)	(0.03)	(0.21)	(0.25)	(0.00)
$CredControl_t$		0.527^{**}		0.523^{**}		0.530^{**}
		(5.44)		(5.42)		(5.47)
$MoneyTarget_t$		0.715^{**}		0.716^{**}		0.729^{**}
		(5.25)		(5.26)		(5.34)
$MoneyTarget_{t-1}$		-1.014^{**}		-1.009^{**}		-1.012^{**}
		(7.38)		(7.38)		(7.37)
$DNYC_t$		0.212^{**}		0.216^{**}		0.213^{**}
		(2.69)		(2.75)		(2.70)
$DClev_{t-1}$		0.296^{*}		0.295^{*}		0.301^{*}
		(2.16)		(2.16)		(2.20)
$DOrange_t$		0.289^{*}		0.289^{*}		0.283^{*}
		(2.12)		(2.12)		(2.07)

$DJefferson_{t-1}$		0.370^{**}		0.372^{**}		0.355^{*}
		(2.69)		(2.72)		(2.59)
$DDetroit_{t}$		0.465^{**}		0.466^{**}		0.452^{**}
		(3.40)		(3.43)		(3.32)
$DCovid_{t}$	0.294^{*}	0.291^{*}	0.295^{*}	0.291^{*}	0.292^{*}	0.289^{*}
	(2.10)	(2.13)	(2.11)	(2.15)	(2.08)	(2.12)
$DCovid_{t-1}$	-0.803^{**}	-0.807^{**}	-0.802^{**}	-0.806^{**}	-0.808^{**}	-0.812^{**}
	(5.71)	(5.92)	(5.73)	(5.93)	(5.75)	(5.95)
$DCovid_{t-2}$	1.782^{**}	1.792^{**}	1.784^{**}	1.794^{**}	1.767^{**}	1.777^{**}
	(12.53)	(12.98)	(12.60)	(13.04)	(12.43)	(12.87)
$DCovid_{t-3}$			0.657^{**}	0.626^{**}	0.528^{**}	0.498^{**}
			(3.78)	(3.70)	(3.17)	(3.08)
$DVaccine_{t}$			0.312^{*}	0.310^{**}	0.323^{**}	0.322^{**}
			(3.15)	(3.23)	(3.24)	(3.32)
Adj. R^2	0.110	0.161	0.112	0.163	0.104	0.155
S.E.	0.140	0.136	0.139	0.135	0.140	0.136
VEC Auto (1)	6.93	10.06	3.49	8.67	92.41^{**}	76.24^{**}
VEC Auto (2)	10.89	11.17	5.58	6.01	165.15^{**}	162.89^{**}
VEC Auto (4)	9.98	7.10	9.16	7.87	74.64^{**}	17.30^{*}

Notes: Absolute t-statistics are in parentheses. ** (*) denoted significant at the 99% (95%) confidence level. (i) Coefficients for the UR^2 terms are multiplied by (1 – *Muni*) in models 3-4. (ii) Absolute t-statistics in parentheses. (iii) Long-run: Maximum likelihood estimates of the long-run equilibrium relationship using a two-equation system with at most one cointegrating vector. (iv) $EC_{t-1} = MuniTR_{t-1} - \alpha_0 + \alpha_1 UR_{t-1}^2 + \alpha_2 CFMA_{t-1}$. (v) First difference terms of elements in the long-run cointegrating vector. (vi) Lag lengths chosen to minimize the SIC criterion. (vii) significance of the trace and VEC Auto statistics reflects lag length.

Appendix C: KPSS Stationarity Tests

(with time trend)

Monthly (January 1960 – December 2020)

	Stationarity	***(bandwidth)***		***Stationarity***	***(bandwidth)***
MuniTR	0.1626^{*}	(10.4)	Δ *MuniTR*	0.0199	(5.78)
UR	0.2378^{**}	(10.4)	Δ *UR*	0.0269	(8.65)

Weekly (January 1971 – December 25, 2020)

	Stationarity	***(bandwidth)***		***Stationarity***	***(bandwidth)***
MuniTR	0.5168^{*}	(15.6)	Δ *MuniTR*	0.0339	(13.9)
UR	0.4034^{**}	(15.9)	Δ *UR*	0.0140	(7.04)

Notes: * and ** denote 95% and 99% significance levels, respectively. Lag lengths for the KPSS stationarity tests are based on the Newey-West bandwidth selector using a Quadratic Spectral kernel for the spectral estimation method (see Hobjin, et al. 2004). The combination of a significant KPSS stationary test statistic on the level of a variable (rejecting that it is stationary) and a significant test statistic on its first difference (accepting it is stationary) is evidence against trend stationarity.