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Flight to Liquidity or Safety? Recent Evidence from the Municipal Bond Market

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Abstract

We examine the impact of the COVID-19 pandemic and subsequent monetary and fiscal policy actions on municipal bond market pricing. Using high-frequency trading data, we estimate key policy events at the peak of the crisis by focusing on a sample of bonds within a very narrow window of just before and just after each event. We find that policy interventions, in particular those with explicit credit backstops, were effective in stabilizing the municipal bond market. In addition, by exploiting daily variation in traded municipal bonds and virus exposure across U.S. counties, we find that prior to the policy interventions, COVID-related credit risks were a significant component of elevated short-term bond yields. Following the interventions, however, the pricing of localized credit risks declined for short-maturity bonds, but became more notable for longer-maturity bonds. The shift in credit risk pricing reflects policy interventions being targeted on short-term bonds, as well as investors' expectation of long-lasting recessional impacts on state and local government budgets.

Keywords: municipal bonds, credit risk, fiscal and monetary policy
JEL Codes: E52, E62, G12, H74

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1 Introduction

The COVID-19 pandemic delivered a sudden blow to the U.S. economy. As governments and individuals took preventative measures, the economic outlook deteriorated and investors fled risky assets in March. Municipal bond yields increased sharply, especially for short maturity debt, and both aggregate liquidity risks and local credit risks could have contributed to the surge in yields. On one hand, investors' concerns about their ability to liquidate municipal bond portfolios in general could have contributed to the sell-offs. On the other hand, the pandemic also raised localized credit concerns about the ability of municipal bond issuers to service existing debt.

In late March and early April, the U.S. Congress, U.S. Treasury Department, and the Federal Reserve took swift and unprecedented policy interventions in response to rapid deteriorations in economic conditions and widespread financial market stress. On March 27, the Congress passed the Coronavirus Aid, Relief, and Economic Security (CARES) Act, a $2.2 trillion economic stimulus bill, which included funds to backstop Federal Reserve facilities as well as directed support to state and local governments. The Federal Reserve also took a series of extraordinary measures, conducting a number of actions specifically targeting the municipal bond market.

In this paper, we focus on two questions. First, what was the impact of the fiscal and monetary policy interventions on the municipal bond market? Second, did the increases in municipal bond yields during the pandemic reflect aggregate liquidity risks or localized credit risks? Have the policy interventions changed how investors price those risks?

To examine the policy intervention impact, we employ a high-frequency identification strategy by focusing on movements in municipal bond yields in narrow trading windows around each policy announcement and development. For each policy intervention, we generate a sample of bonds that traded both before and after the announcement within a narrow window, and estimate the effect of the policy announcement on bond yields after controlling for a CUSIP level fixed effect.

We find that news about fiscal policy interventions, as well as the monetary policy actions backstopped by the Treasury, had much more significant impact in stabilizing the municipal bond market than announcements of monetary policy that didn't have an explicit fiscal backstop. The final Congressional passage of an unprecedented fiscal bill, as well as earlier agreements on the bill among Congressional leadership, all led to significant declines in municipal bond yields. For monetary policy, however, early interventions as a lender of last resort were only moderately successful in lowering yields for short-term bonds, and didn't have a notable impact on longer-term bonds, possibly reflecting uncertainty around the passage of a more complete fiscal package during those intervention dates. On the other hand, the announcement of a dedicated credit facility for the municipal market with a Treasury backstop led to sizeable declines in municipal bond yields.

Next, in order to assess localized credit risks, we exploit daily variation in traded municipal bonds and virus exposure across U.S. counties between January and May of 2020. Our key assumption is that localized COVID case levels act as a good proxy for local credit risks of municipal governments over our sample period. To test this assumption, we follow Novy-Marx and Rauh [2012] and use pre-refunded bonds as a control group to capture aggregate liquidity risks. Pre-refunded bonds are unlikely to be affected by local credit risks, because, for each pre-refunded bond, new refunding bonds are issued with the proceeds invested in Treasury securities and held in an escrow account. The earnings from these investments cover future payments on the pre-refunded bond, thus limiting credit risk exposure to investors. We find that COVID cases at the county level didn't have any impact on pre-refunded bond yields, but had a significant impact on non-pre-refunded bonds, confirming our hypothesis that municipal bond yields reflected localized risks related to COVID cases following policy interventions.

We find that *prior to* the fiscal and monetary policy interventions, local credit risks were a significant component of elevated short-term bond yields. Counties with higher per capita COVID cases experienced more elevated yields on short-term bonds in the secondary market, compared to other counties with lower case counts in the same state. We don't find similar evidence for longer maturity bonds. This result is consistent with expectations that COVID would generate a short but significant decline in economic activity, which would strain municipal governments' budgets, followed by a quick V-shaped recovery.

Following policy interventions, however, the pricing of local credit risks shifted from short-maturity debt to longer-dated bonds. We find that in the post-intervention period, counties with higher per capita COVID cases saw yields on short-term bonds fall more against longer-maturity bonds, compared to other counties with lower case counts in the same state. Our results are in line with the fact that the joint fiscal and monetary policy actions largely targeted short-term bonds in the municipal market. The lack of explicit support for longer-dated bonds, as well as the prospect of a slower recovery, likely led investors to increase the pricing of credit risks in the longer end of the yield curve.

This paper has several implications for policy makers. First, our analysis highlights that at the peak of crisis, decisive fiscal policy, as well as monetary interventions with Treasury funding, were more effective than monetary policy actions that didn't have an explicit fiscal backstop. Second, the presence of the dedicated lending facility, despite limited usage and take up to date, is effectively holding down short-term borrowing rates by offering an explicit backstop for short-term debt. A well-functioning municipal bond market is important to the U.S. economy, as the state and local government sector accounted for 10.6 percent of U.S. GDP and 13 percent of total employment in 2019. Access to short-term municipal debt allows state and local governments to smooth spending over revenue collection periods. On the other hand, credit risks remain a concern for longer-dated bonds, which is the primary way for state and local governments to raise funding for long-term capital investments [Marlowe, 2015].[1]

The paper is closely related to many current studies on the effects of COVID-19 on financial markets and the impact of related Federal Reserve and Treasury programs. Compared to the rapidly growing literature on corporate debt and equity markets, the analysis on the municipal bond market has been largely limited to shorter analytical pieces [Bi, Marsh, Dice and Gulati, 2020; Cipriani, Haughwout, Hyman, Kovner, Spada, Lieber and Nee, 2020; Wei and Yue, 2020].[2] In a closely related paper, Haughwout, Hyman and Shachar [2020] focus on the eligibility changes in the Federal lending facility on April 27, and explore the impact of that policy change on municipal bond market. Our paper complements their study but differs in the following ways. First, we study the impact of both fiscal and monetary policy actions in late March and early April by using a high-frequency identification strategy. Second, we use COVID exposure at the county level as a proxy for local credit risks and explore how policy interventions shifted credit risk pricing along the yield curve.

Our study also contributes to the literature on municipal bonds and financial conditions of state and local governments. Schwert [2017] examines the pricing of municipal bonds between 1998 and 2015 and find that default risk accounts for 74-84 percent of municipal bond spreads. Focusing on municipal bond transactions in 2018Q4, Novy-Marx and Rauh

[1] To a lesser extent, municipal debt is held largely by households and may provide an important source of revenue or a backstop to income losses for some.

[2] Prior studies have examined corporate debt markets [Boyarchenko, Kovner and Shachar, 2020; D'Amico, Kurakula and Lee, 2020; Gilchrist, Wei, Yue and Zakrajšek, 2020; Haddad, Moreira and Muir, 2020; Karger, Lester, Lindsey, Liu, Weill and Zúñiga, 2020; Nozawa and Qiu, 2020; O'Hara and Zhou, 2020], equity markets [Baker, Bloom, Davis, Kost, Sammon and Viratyosin, 2020; Ding, Levine, Lin and Xie, 2020], banking stress [Acharya and Steffen, 2020; Li, Strahan and Zhang, 2020], and the Paycheck Protection Program [Bartik, Cullen, Glaeser, Luca, Stanton and Sunderam, 2020; Granja, Makridis, Yannelis and Zwick, 2020].

[2012] estimate the effect of state pension investment losses on state bond yields to quantify a sovereign default channel in the municipal bond market. Adelino, Cunha and Ferreira [2017] find that municipalities' financial constraints can have a significant impact on local employment and growth. In addition, our paper is related to the broad literature on the pricing of municipal bonds, see Harris and Piwowar [2006] and Green, Hollifield and Schürhoff [2006] among others. Following this line of work, we use transaction-level data to study the pricing of municipal bonds during the COVID-19 pandemic.

The remainder of the paper is as follows. Section 2 provides a short overview of the U.S. municipal bond market. Section 3 discusses the COVID shock and associated financial stress in the municipal bond market since early March. Section 4 provides details on our data, and section 5 evaluates the impact of Federal Reserve programs aimed at the municipal bond market in late March and early April. Section 6 examines the pricing of COVID risks in the market, both prior to and after the Federal Reserve intervention. Section 7 concludes.

2 The U.S. Municipal Bond Market

The municipal bond market is the primary way for state and local government units – such as counties, municipalities, and school districts – to raise funds. The public purpose and size of the municipal securities market underscores its importance in the U.S. economy.

Municipal bonds generally finance long-term capital projects. Even though state and local governments can issue short-term notes to bridge the gap between the time when expenses occur and when revenues become available, the majority of municipal bonds are sold to finance long-term capital projects rather than funding government operating expenses such as employees' salaries and benefits.[3] As documented in Marlowe [2015], approximately 90 percent of state and local capital spending is financed through municipal bonds. Therefore, municipal bonds typically have long-term maturities of between 1 and 30 years. According to the Municipal Securities Rulemaking Board (MSRB), close to 70 percent of municipal bonds trading in 2019 had remaining maturities greater than 10 years.

Municipal bonds are generally broken down into two major categories: general obligation (GO) bonds and revenue bonds. GO bonds are backed by the full faith and credit of

[3] For instance, tax anticipation notes are issued in anticipation of tax receipts and are payable from those receipts. The maturities of those municipal short-term securities can vary from 3 months to 3 years, but usually mature within 12 months.

the issuers, implying that all sources of revenue will be used to service the debt. Three quarters of local government tax revenues come from property taxes, while state governments typically rely on sales and income taxes which account for close to 90 percent of their tax revenues. Revenue bonds, on the other hand, are generally issued to finance a specific revenue-generating project and secured solely by the revenues from that project. These types of bonds are usually issued for construction of facilities and plants that provide electric power, water, transportation or other government provided services. GO bonds, which are usually considered higher quality credits than revenue bonds, represent a larger proportion of the total municipal bond market. The MSRB reported that GO bonds accounted for 68 percent of trading activity in 2019.

Like other bond markets, the municipal bond market largely functions as an over-the-counter market, where investors place their orders with dealers directly rather than through a centralized clearinghouse. Currently, the MSRB reports that more than 1,200 dealers actively participate in trades.

However, the municipal securities market differs from other fixed income markets in the following ways. First, the interest paid on most municipal bonds is exempt from taxation at the federal level and often at ithe state and local level as well. These tax exempt features make the bonds especially attractive to retail investors. As shown in Figure 1, nearly half of total municipal market debt outstanding is held by households directly and another quarter is held by money market mutual funds (MMMFs), much of it in retail money funds held by households and individuals. Second, the municipal bond market has many issuers with many small issues. The current market consists of $3.8 trillion in outstanding bonds issued by more than 50,000 individual units of government. In contrast, the corporate bond market is more than twice as large in terms of dollars outstanding, but has just over 1,000 publicly traded companies as issuers [Marlowe, 2015]. Last, the municipal market is relatively illiquid and investors tend to “buy and hold”. While municipal securities typically involve relatively frequent trading immediately following issuance, trading activities are infrequent and sporadic during the remaining life of the securities. The average daily trading volume was about $11.5 billion per day at par value in 2019, see MSRB [2020].

3 The COVID-19 Shock and Policy Interventions

The COVID-19 pandemic dramatically slowed economic activities and triggered sell-offs in financial markets. The first novel coronavirus case in the United States was reported on

January 20, 2020 [Holshue, DeBolt, Lindquist, Lofy, Wiesman, Bruce, Spitters, Ericson, Wilkerson, Tural, Diaz and Cohn, 2020]. From that date, case counts rose across the nation throughout February and early March. In mid-March, states began to issue quarantine and shelter-in-place orders, limiting permissible economic activities. Business revenues began to decline and unemployment increased sharply, representing a significant blow to state and local government revenues at a time when local government spending was ramping up to fight the pandemic. The COVID shock also sparked broad concerns about financial market assets and intermediaries, as evidenced by the precipitous decline in prices of risky assets across the financial system. Municipal securities were not spared as investors moved to cash assets and demand to hold municipal securities fell.

As local credit and aggregate liquidity risks increased, yields on municipal securities – in particular short-maturity securities – increased sharply relative to Treasury yields in March, as shown in Figure 2. Before the COVID pandemic, municipal security yields were slightly lower than Treasury yields across maturities. As cases increased nationwide, however, municipal bond yields rose, especially for short-maturity bonds. By mid-March, one-year bond yields were 25 times higher than comparable maturity Treasury yields. For longer-dated bonds, yields rose nearly three times above comparable maturity Treasury yields.

In response to rapid deteriorations in economic conditions and widespread stress in financial markets, the U.S. Congress and the Federal Reserve took swift and unprecedented policy actions in late March and early April. On March 27, the Congress passed the CARES Act, a $2.2 trillion economic stimulus bill, with a range of policy actions including funds to backstop Federal Reserve facilities as well as directly support to state and local governments.[4]

Congressional CARES Act negotiations were rocky at various stages of the discussions in late March, even though the bill ultimately passed both chambers. Negotiations were deadlocked on March 23 when Senate Democrats blocked a key procedural motion, leading to a downward spiral in financial market conditions. However, following late-night negotiations, U.S. Treasury Secretary, Steven Mnuchin, and Senate minority leader, Chuck Schumer, emerged to announce they had a deal. As a result, the Dow Jones surged more than 11 percent on March 24, its biggest one-day gain since 1933. The CARES Act was ultimately approved by the Senate during a unanimous late-night vote on March 25th. On

[4]The CARES Act also expanded unemployment benefits, provided stimulus checks to households, and appropriated grants to small businesses.

March 27, the bill was passed by a near-unanimous vote in the House and signed into law by President Trump.

The Federal Reserve also took a series of extraordinary measures in March and April, with a number of policy actions specifically targeting the municipal bond market.[5] On March 20, the Federal Reserve expanded the eligible collateral for the Money Market Mutual Fund Liquidity Facility (MMLF) to include highly rated, short-term municipal debt purchased from tax-exempt money market funds.[6] On March 23, the MMLF eligible collateral was further expanded to include variable rate demand notes, a decision again aimed at the municipal bond market.[7] Finally, following appropriation of equity funds under the CARES Act on March 27, the Federal Reserve Board announced the creation of the Municipal Liquidity Facility (MLF) on April 9. This program offered $500 billion in loanable funds to eligible municipal bond issuers. Under this program, the Federal Reserve can directly purchase new, short-term notes from eligible municipal bond issuers. Those issuers can then use the proceeds to support local jurisdictions under their authority. For example, a state could issue short-term bonds to the Federal Reserve and use those bond issuance proceeds to purchase the bonds of counties in the state.

Following these monetary and fiscal actions, municipal bond market activity stabilized significantly. Figure 2 shows that by mid-April, municipal security yields had declined across the term structure, but the decline was sharpest for shorter dated municipal securities. At the same time, tax-exempt money market fund redemptions also slowed as shown in Figure 3. Net redemptions had reached a near record level during the week ended March 20, the day of the first intervention by the Federal Reserve into the tax-exempt money fund market. Additional interventions during the following week reversed these outflows and led to a rise in net subscriptions and, since early May, flows have appeared to return to a normal level.

4 Data

We use secondary market transaction data between January 2 and May 29, 2020, which was provided by the MSRB. Following Novy-Marx and Rauh [2012], we focus on GO municipal

[5]Appendix A provides a more detailed summary of Fed actions aimed at municipal bonds.

[6]The MMLF was established on March 18, 2020, but the initial eligible assets didn't include municipal bonds.

[7]On March 23, the Federal Reserve also published an updated term sheet for the Commercial Paper Funding Facility which clarified that U.S. municipal commercial paper issuers were eligible participants.

bonds that are backed by the full faith and credit of issuers, and exclude revenue bonds secured solely by revenues from specific projects. All inter-dealer and dealer-to-customer municipal bond transactions are reported to the MSRB in real-time, with a 15 minute delay. The transaction data includes a range of information as described in Appendix B. The raw files contain more than 1.44 million transaction records on more than 155,000 securities that were issued by more than 12,000 issuers.

We clean our bond trade data by scrubbing outliers of potentially problematic records. First, we drop yields that are above the 99.5 or below the 0.5 percentiles, so as to remove unusual yields that might be erroneously reported while still keeping the legitimately high yields during the peak stress period. Second, we remove records for U.S. territories and the District of Columbia as well as trades where the issuer state is missing. Third, we drop all trades that are recorded on a weekend or on a market holiday. Finally, we remove any trades with a maturity date prior to the trade date, or missing trade dates, or having a value of zero for remaining maturity or principal amount. These data cleaning steps are similar to others used in the literature (Schwert [2017] and Green, Li and Schürhoff [2010]). Our final sample includes 1.38 million trades.

In order to analyze the data at a granular level, we determine each issuer's locality at the county level, or the state level if the issuer is a state government, by using a string parsing algorithm. The MSRB data doesn't directly provide counties associated with bond issuers; instead the locality information is embedded in the description of issuer name. As detailed in Appendix C, we rely on a string parsing algorithm to extract the locality information. First, we determine whether the issuer is a state government by looking for the state name followed immediately by "state" or "st". For instance, "New York St" is the issuer name for the New York state government. Next, we search inside the remaining strings for county and city names. For instance, "Johnson Cnty Kans" is the issuer name for Johnson county, Kansas, while "Overland Park Kans" is the issuer name for the city of Overland Park in Johnson county, Kansas. Our county list is drawn from counties reporting COVID cases as tracked by the New York Times database and counties listed in the Census Bureau's TIGER/LINE shapefiles. For cities, we use a county to city crosswalk provided by the USPS to assign the county of the issuer to each record. We identify locality information for 90 percent of issuers and match 1.27 million observations, 20 percent of which were issued by state governments and the rest by counties and cities.

Next, we pair the MSRB transaction data with several data sets on local pandemic measures.[8] The total reported COVID cases are from the *New York Times* at county level on a daily frequency, and the number of hospitals at the county level is from the Department of Homeland Security.[9] Using county population totals in 2019 from the Census Bureau, we derive per-capita measures for both Covid-19 cases and number of hospitals.

In order to capture the possible impact of the pandemic on local economies, we calculate the share of employment that was most affected by the COVID-19 shock. Following Boyarchenko et al. [2020], we calculate national employment growth from January to April at the 3-digit NAICS level using the Bureau of Labor and Statistics' Current Employment Statistics. Industries in the bottom quartile are considered the most affected. We then take these 3-digit industry codes and calculate the share employment in these affected sectors for each county as of 2019:q4 using the BLS' Quarterly Census of Employment and Wages.

4.1 Trading Counts and Frequency

Figure 4 shows trade counts from the MSRB transaction level data. Trading activity was stable in January and February, fluctuating between 10,000 and 15,000 daily trades, but increased sharply in March, peaking on March 24 with a record of 32,103 transactions. Transaction counts returned to more normal levels following the swift and unprecedented policy interventions in late March. Similarly, the number of unique traded bonds, as determined by CUSIPs, fluctuated at a stable level of around 5,000 per day in January and February, but rose in March and peaked on March 24 with a record of 11,671. The number of unique issuers, as determined by the first 6 digit in CUSIPs, was around 2,500 before March and reached the peak of 3,863 on March 24.

Less pronounced increases in the number of uniquely traded bonds and issuers, when compared to total trade counts, raise the question of whether transactions were heavily concentrated in a small set of bonds or bond issuers during the peak of the crisis. The answer is largely no, as highlighted in Figure 5. The daily trading frequencies of individual CUSIPs were largely flat during the sample period, even though the top 10th percentile of securities saw an uptick in their trading frequency from 4 to 5 at the peak of the crisis.[10]

[8] County-level data are paired using our county of issuer match. In addition, we pair state-level demographic and economic data using the issuer's state domicile provided by MSRB, and we flag CUSIPs issued by state governments.

[9] Reported dates in the *New York Times* data are as-of the end of the previous day so these can be considered lagged case counts. For periods when no cumulative cases are reported for a jurisdiction, we set the case count to zero.

[10] Changes in the distributions of daily trades per unique issuer are similar through the trading stress

Figure 6 compares three types of municipal market trading activities: inter-dealer transactions, bond sales from dealers to customers, and dealer bond purchases from customers. While all three types of trading activities increased in mid- and late-March, dealer bond sales and inter-dealer transactions rose more rapidly than dealer bond purchases from customers. Accordingly, dealer inventories of municipal bonds fell during the first quarter, according to the Federal Reserve's Z.1 Flow of Funds release.

4.2 Summary Statistics

Table 1 reports summary statistics for the cleaned sample of daily municipal bond trades between January 2 and May 29, 2020. The average yield on securities in our sample is about 200 basis points and the average security has a remaining maturity of just over 9 years. The average principal amount of an issue is rather large at about $27 million, but it reflects a few very large issues since the median size of the principal amount is just over $3 million. Similarly, the average traded amount in our sample is about $220,000 whereas the median traded amount is just $30,000. About 8 percent of bonds in our sample have remaining maturities under 1 year. According to Moodys, 66 percent of bonds have investment grade ratings, and nearly all of the remainder are not rated. Additionally, about 5 percent of our sample are pre-refunded bonds, which will be discussed further below. Finally, about 20 percent of the trades were issued by states and another 20 percent were issued by county governments, with the remainder issued by municipalities, cities, or other sub-county levels of government.

5 Impact of Fiscal and Monetary Policy Interventions

As discussed in Section 3, the unprecedented CARES Act that was passed by the Congress in late March not only provided direct support to households, businesses, and state and local governments, but also appropriated funds that enabled the Federal Reserve to establish liquidity facilities. During the same period, the Federal Reserve attempted to stabilize the municipal bond market via a range of policy actions, from indirect interventions through MMMFs to direct interventions supported by CARES Act funding.

In this section, we estimate the impact of both fiscal and monetary policy interventions

period (not shown in Figure 5).

Table 1: Matched Sample Summary Stats

	Mean	Std. Dev	P25	P50	P75
Yield	199.821	91.948	127.700	185.000	249.300
Maturity (years)	9.163	7.147	3.342	7.501	13.471
Principal Amount ($ Millions)	27.277	205.350	1.185	3.715	14.765
Trade Amount ($ Millions)	0.220	1.331	0.015	0.030	0.100
Indicator Variable Averages					
Maturity < 1 year	0.080				
Investment Grade	0.666				
Speculative Grade	0.005				
Not Rated	0.329				
Pre-Refunded	0.047				
State Issuer	0.183				
County Issuer	0.230				
Observations	1,379,221				

Notes: Table presents summary statistics for the full sample matched to county or state issuers. P25, P50, and P75 represent the 25th, median, and 75th percentiles respectively. The variables not reporting percentiles are indicator variables. *State issuer* denotes observations issued by one of the 50 U.S. states. *County issuer* denotes obserations of bonds issued by U.S. counties. Remaining observations were issued by sub-county level entities.

on municipal bond yields.[11] We start by dissecting the MSRB municipal bond transaction data. Next, we estimate the impact of *each* policy measure on municipal bond yields through event studies with narrow trading windows to minimize the spillovers from other policy changes.

5.1 Data Trends

At the peak of the crisis, the municipal bond market saw a rise in yields and also a shift in the distribution of remaining maturity of daily trades. In particular, the increases in yields most affected the shorter end of yield curve, suggesting that immediate liquidity and credit concerns were impacting the market.

As shown in Figure 7, the remaining maturity of traded bonds shortened on average during the peak of the crisis following a stable trading distribution across maturities in normal times. Throughout January and February, the top quartile of daily trades had a remaining maturity of 15 years, and the median level was a little below 10 years, while the bottom 10th percentile was just over 1 year. In late March, however, the top quartile saw a notable decline, reaching about 12 years at the trough prior to the fiscal and monetary policy intervention. The median maturity level of trades followed a similar pattern, but

[11] In Section E, we provide further evidence on the effectiveness of Federal Reserve interventions that specifically targeted MMMFs, including funds focused on municipal securities investments.

to a lesser degree. Notably, the remaining maturity for the bottom 10th percentile was largely unchanged throughout the period. The comparison highlights that trading activities shifted from the very long end of maturities, those above 15 years, to the range of 10 to 15 years.

Turning to yields, however, bonds with very short remaining maturities saw steeper increases in their yields than those with longer remaining maturities in late March. Figure 8 compares the trade-weighted average yields of bonds with remaining maturity less than 1 year to those of bonds with more than 1 year of remaining maturity. At the start of the year, the yield curve was upwardly sloped, as is typically the case, with longer-term bonds trading at higher yields. In March, yields rose sharply for both types of bonds, but the increase was more pronounced for bonds with shorter remaining maturities, which led to an inversion of the yield curve.

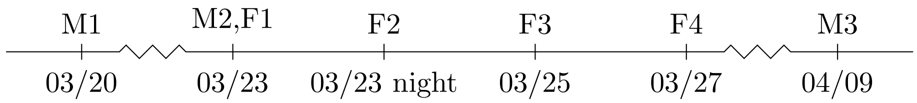
Following fiscal and monetary policy interventions in late March, bond yields declined across maturities. After the Federal Reserve announced its intention to purchase certain new issuances directly, bonds with remaining maturities less than one year saw further declines in their yields in early April and beyond, while yields for bonds with longer remaining maturities remained higher than their pre-crisis levels. The steepening yield curve for municipal bonds in May suggests that the MLF eased short-term credit concerns by providing a necessary backstop for short-dated bonds. Nevertheless, investors continued to harbor concerns about credit risks on longer dated bonds which kept yields higher than their pre-pandemic levels. These patterns suggest that fiscal and monetary policy interventions were effective at increasing secondary market bond prices across the yield curve but most effective at reducing the cost of short-term credit.

5.2 Event Studies with Narrow Trading Windows

We first estimate the immediate effect of *each* policy change. As laid out in Section 3, the legislative activities associated with the CARES Act were largely concentrated in the last week of March, while the Federal Reserve took a number of steps across the span of several weeks in late March and early April to address the stress in the municipal bond market. Table 2 lays out the timeline on fiscal and monetary policy interventions during this period.

Using the daily trading frequency of the MSRB data, we investigate each policy change within a narrow window around the announcement to minimize policy spillovers. As sum-

Table 2: Timeline on Fiscal and Monetary Policy Interventions



M1: Federal Reserve's initial inclusion of municipal bonds in the MMLF (announced at 11AM ET);
M2: Federal Reserve's inclusion of variable rate demand notes as collateral in the MMLF (announced at 8AM ET);
F1: The Senate's failed procedural motions on the CARES Act;
F2: Mnuchin and Schumer reached agreement on the CARES Act (night);
F3: The Senate passed the CARES Act (night);
F4: The House passed the CARES Act; President signs into law;
M3: Federal Reserve's announcement on the MLF (announced at 8:30AM ET).

marized in Table 3, we generate a sample of bonds that traded within a window around each policy announcement, and split this sample according to whether the trade occurred prior to the announcement or after.[12] For example, municipal bonds were first included in the MMLF on March 20, 2020, and this change was announced at 11 AM ET in a Federal Reserve press release. We define the pre-event period as trades that occured on March 19, 2020 and before 11 AM ET on March 20, 2020. The post-event period consists of trades occuring after 11 AM ET on March 20, 2020. We limit the analysis to all bond CUSIPs that were traded in both the pre- *and* post-intervention periods.

The event study window is constructed in a similar way for other policy changes. At 8 AM ET on March 23, the Federal Reserve announced the inclusion of variable rate demand notes as eligible collateral in the MMLF. The trading window is set between March 20, the previous trading day, and March 23. The complication, however, is that on the same day, CARES Act negotiations were deadlocked when Democrats blocked a key procedural motion. Our estimate would reflect the joint impact from both policy developments. On the evening of March 23, the Treasury Secretary and the Senate minority leader reached an agreement on the CARES Act, and therefore the event window is set between March 23 and 24. The event windows are set between March 25 and 26 when the Senate passed the bill, and between March 26 and 27 when the House passed the bill.[13] Finally, at 8:30 AM

[12]Summary stats for CUSIPs that are included and excluded from each event window are shown in table D in Appendix D.

[13]Timiraos and Gillers [2020] reported on March 27, 2020 that the Federal Reserve Board had hired a former Treasury official, Kent Hiteshew, to advise on municipal market issues and were considering to set up a facility specifically aimed at state and local government finance. This news article may have had some impact on the municipal bond market, but it is challenging to distinguish this event from the House passage

Table 3: Event Windows

Event	Pre-event	Post-event
MMLF Adds Muni Securities	March 19	March 20, 11:00 AM
MMLF Muni Terms Revised	March 20	March 23 8:00 AM
CARES Agreement In Principal	March 23	March 24
CARES Senate Passage	March 25	March 26
CARES House Approval; WH Signs	March 26	March 27
MLF Announcement	April 8	April 9 8:30 AM

Notes: All event windows end with the post-event sample trading day.

ET on April 9, the Federal Reserve announced the establishment of the MLF program. The trading window for this event is set between April 8 and 9.

To estimate the immediate program announcement effects, we run the regression specification defined in equation 1.

$$\ln(yield_{b,t}) = \beta_0 + \beta_1 I_t^{policy} + \beta_2 I_t^{policy} I_b^{ST} + \gamma X_{b,t} + \eta_b + \varepsilon_{b,t} \tag{1}$$

The dependent variable, $\ln(yield_{b,t})$, denotes the log of the yield on bond b traded at time t. I_t^{policy} is an indicator with a value of 1 for the period after the announcement/report and 0 before that. I_b^{ST} is an indicator with a value of 1 for securities with one year or less of remaining maturity and 0 otherwise. We also include a vector of controls, denoted $X_{b,t}$, that includes the log of the trade amount and an indicator for whether the trade was a purchase or sale to a customer by the dealer. Crucially, we include a CUSIP level fixed effect, η_b, that absorbs all time invariant security characteristics. Given that our event window covers only two trading days, the fixed effect, η_b, controls for risk at the security level as well as demand for new funding at the issuer level. The standard errors are clustered at the issuer level.

In terms of identification, this specification exploits *within* CUSIP variation, as we limit our sample to bonds that trade just before and just after the announcement. In the specification without the interaction term of $I_t^{policy} I_b^{ST}$, the coefficient of β_1 is the marginal effect of the Federal Reserve's announcement on security yields, conditional on the size of the trade, the trade type, and the time-invariant security characteristics. The

of the CARES Act.

maturity indicator, on the other hand, proxies eligibility for the MMLF program, which only accepted securities with remaining maturity of 12 months or less, and is also a proxy for the maturity eligibility criteria for the MLF which purchases issuances of two years or less. Therefore, in the specification with the interaction term, the coefficient of β_1 is the marginal effect of the announcement on longer-term security yields, while $\beta_1 + \beta_2$ is the marginal effect on short-term bond yields.

Table 4: Fiscal Policy Intervention Effects

	(1) Agreement	(2) Agreement	(3) Senate	(4) Senate	(5) House	(6) House
Intervention	-0.086***	-0.081***	-0.267***	-0.263***	-0.119***	-0.111***
	(0.003)	(0.003)	(0.006)	(0.006)	(0.006)	(0.006)
Intervention × Short-term Debt		-0.063***		-0.044*		-0.112***
		(0.017)		(0.024)		(0.039)
Observations	18,277	18,277	10,800	10,800	9,502	9,502
Adjusted R^2	0.65	0.66	0.80	0.80	0.79	0.80

Notes: Each column represents an event study where the policy indictor takes the value of 1 for bonds traded after the announcement. Agreement denotes the event of Mr. Mnuchin and Mr. Schumer reaching a deal in the evening of March 23, and the sample covers traded bonds on March 23 and 24. Senate denotes the event of the Senate passing the CARES act in the evening of March 25, and the event window covers March 25 and 26. House denotes the event of the House passing the CARES act on March 27, and the event window covers March 26 and 27. Regressions include bond characteristics as well as state issuer and trade date fixed effects. Bond characteristics include log of trade amount, and indicators for trade type, state issuers, and county issuers.
Issuer domicle state clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4 highlights that Congressional passage of the CARES Act had a significant impact in lowering municipal bond market yields. Yields on municipal securities declined following each policy development relative to their previous trading day. In addition, bonds with remaining maturities of less than one year experienced additional reductions in their yields. The passage of the CARES Act in both Congressional chambers had a more notable impact than the initial agreement reached between the Treasury Secretary and the Senator minority leader.

Turning to monetary policy, Table 5 shows that the impact from Federal Reserve's interventions varied across events. There appears to be no immediately notable or desired impact on the municipal securities market as a whole following the policy actions on the MMLF. The first column shows that following the initial inclusion of municipal securities in the MMLF on March 20, yields on municipal securities *increased*, compared to their previous trading day levels, rather than declined. However, yields on bonds with remaining maturities of less than one year were lower, as shown in the second column. The results are similar for the policy change on the following Monday, March 23, when the terms of the MMLF were expanded to include certain variable rate demand notes, as shown in columns 3 and 4. Yields continued to *increase* further across this limited sample. We also find no additional, significant benefit to short-term securities from this expansion of the facility. However, the estimate is likely to also reflect the deadlocked CARES Act negotiations in Congress. In early April, however, further monetary policy action that was backstopped by the Treasury finally turned the tides on elevated yields, as shown in the last two specifications in Table 5. The announcement of the dedicated facility on April 9 pushed yields down as shown in columns 5 and 6. The additional effect on short-maturity bond yields was negative, although the impact was not strongly statistically significant.

Table 5: Immediate Federal Reserve Municipal Bond Market Intervention Effects

	(1) MMLF	(2) MMLF	(3) MMLF Revised	(4) MMLF Revised	(5) MLF	(6) MLF
Intervention	0.063***	0.070***	0.012**	0.013***	-0.078***	-0.074***
	(0.006)	(0.006)	(0.005)	(0.005)	(0.008)	(0.007)
Intervention × Short-term Debt		-0.085***		-0.008		-0.078*
		(0.026)		(0.027)		(0.047)
Observations	15,451	15,451	15,971	15,971	5,875	5,875
Adjusted R^2	0.68	0.68	0.66	0.66	0.92	0.92

Notes: Each column represents an event study where the indictor intervention takes the value of 1 for bonds traded after the intervention announcement. The sample is the day of the announcement and the day prior. MMLF denotes the event of municipal securities being accepted by the Federal Reserve's MMLF on or after March 20, 2020 at 11 AM ET. These terms were revised at 8 AM EST on March 23. MLF denotes the event of the Federal Reserve's post Municipal Liquidity Facility announcement, and the dummy covers trades occuring on or after April 9, 2020 at 8:30 AM ET. Regressions include bond characteristics as well as state issuer and trade date fixed effects. Bond characteristics include log of trade amount, log of principal amount, and indicators for trade type, state issuers, and county issuers. Issuer domicle state clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The comparison between table 4 and 5 highlights that news of fiscal policy interventions, as well as monetary policy actions that were backstopped by the Treasury, had a more significant impact in stabilizing the municipal bond market than monetary policy announcements alone, at least among the bonds traded within the narrow window.

6 COVID-Related Credit and Liquidity Risk Pricing

In this section, we study the channels through which joint fiscal and monetary policy interventions were successful in stabilizing the municipal bond market. On one hand, liquidity strains in financial markets could have contributed to municipal bond market sell-offs, reflecting aggregate liquidity risks and a movement of investments into cash like assets. On the other hand, the COVID shock represents a fundamental change to real economic conditions, and as such was likely to increase concerns about localized credit risks for municipal bonds. It is important to understand how policy interventions reduced municipal bond yields through the aggregate liquidity risk channel and the local credit risk channel.

6.1 Pre-refunded vs. non-pre-refunded Bonds

We hypothesize that COVID exposure at a local level is a good indicator for localized credit risks affecting municipal bonds. Counties with higher COVID case counts were more likely to issue quarantine and shelter-in-place orders, slowing down economic activities in the region and undermining the local fiscal fundamentals. Although the virus was widespread during our sample period from January to May, the geographic impact was quite uneven with some areas being hit much harder than others. Importantly, the spread of COVID was exogenous to the bond issuer's fiscal fundamentals, and counties could be exposed to COVID risk to a varying degree for unanticipated and exogenous reasons.

To test this hypothesis, we follow Novy-Marx and Rauh [2012] and use pre-refunded bonds as a control group to capture aggregate liquidity risks.[14] Pre-refunding is a common strategy for refinancing municipal bonds before their callable date (Chalmers [1998]; Novy-Marx and Rauh [2012]). A bond is considered pre-refunded when new bonds, called "refunded" bonds, are issued and those proceeds are used to purchase Treasury securities which are then deposited in an escrow account. Investments in this escrow account are structured in such a way to exactly mimic the interest payments on the "pre-refunded" bond. The pre-refunded bond is considered fully collateralized in the sense that the associated principal and interest payments are paid exclusively from the income derived from the escrow account. The pre-refunded bonds can be affected by movements in the Treasury market, but are very unlikely to be influenced by local credit risks.

To examine the impact of COVID on localized credit risks, we exploit geographic variation in the spread of the virus and compare yields on pre-refunded and not pre-refunded bonds. Specifically, we use county-level differences in COVID exposures to explore whether COVID risks had differential impacts on pre-refunded and non-pre-refunded bonds, and whether policy interventions shifted those impacts. We exploit this variation by using a

[14] CUSIPs designated as pre-refunded are drawn from Bloomberg.

difference-in-difference-in-difference (DDD) estimation technique, as shown in equation 2.

$$\begin{aligned}\ln yield_{i,t} &= \alpha_{s,t} + \beta_1^c cases_{c,t} + \beta_2^{cp} cases_{c,t} \times I_t^{policy} \\ &\quad + \beta_1^n I_{i,t}^{npre} + \beta_2^{cn} cases_{c,t} \times I_{i,t}^{npre} + \beta_2^{np} I_{i,t}^{npre} \times I_t^{policy} \\ &\quad + \beta_3 cases_{c,t} \times I_{i,t}^{npre} \times I_t^{policy} + \gamma X_{i,t} + \varepsilon_{i,t} \qquad (2)\end{aligned}$$

The dependent variable is the log of the yield on municipal bond i by an issuer in county c in state s that was traded on day t. Since all pre-refunded bonds have maturity of more than 1 year, we drop non-pre-refunded bonds with maturity of shorter than 1 year to be consistent in our comparisons. $case_{c,t}$ denotes COVID cases per capita in county c on date t.[15]. We define an indicator, I_t^{policy} to split the data sample into pre- and post-policy intervention, with the indicator equaling 1 for trade dates after April 9, 2020. The cutoff date was picked to reflect that all the major policy interventions on municipal bonds in our data sample were announced on or prior to April 9. I_i^{npre} is the indicator for non-pre-refunded bonds.

Importantly, our specification includes a set of state by time fixed effects, allowing us to compare the yields on traded bonds across counties within the same state on the same day. These fixed effects pick up time-varying changes at the state level, including changes in the overall fiscal situation as the pandemic unfolds, as well as state-level changes in funding demand. Therefore, we compare counties within the same state, which allows us to include municipal bonds issued by counties within the same state that nonetheless have very different exposure to COVID. In addition, because we are comparing counties within the same state on the same day, any heightened concerns about localized spread throughout the state that affects all bonds within that state will be picked up.

In addition to fixed effects and our variables of interest, we also include a set of bond characteristics specific to the daily trade, denoted by $X_{i,t}$, which includes the log of the trade amount, the log of the bond's principal amount, the log of the remaining maturity, and indicators for whether the bond is rated investment grade or not and if the bond was issued by a county government. In some specifications, we also include county-level controls for the county's economic and health exposure risks to COVID: the share of employment that was most affected by COVID, and the number of hospitals in the county per 1000 residents. Standard errors are clustered at the state and time level using the methods of

[15]To reasonably scale parameters we use total cases per county divided by 100 residents.

Cameron, Gelbach and Miller [2011].

Table 6: Prerefunded Bonds

	(1)	(2)	(3)	(4)
Cases Per 100	0.044	0.050	0.052	0.054
	(0.042)	(0.043)	(0.040)	(0.044)
Intervention × Cases Per 100	-0.060**	-0.049	-0.064**	-0.051
	(0.027)	(0.040)	(0.030)	(0.042)
Not Prerefunded	0.221***	0.274***	0.222***	0.275***
	(0.024)	(0.024)	(0.025)	(0.025)
Not Prerefunded × Cases Per 100	-0.079	-0.084*	-0.087	-0.087*
	(0.052)	(0.045)	(0.052)	(0.046)
Intervention × Not Prerefunded	0.109***	0.131***	0.110***	0.132***
	(0.024)	(0.023)	(0.025)	(0.024)
Intervention × Not Prerefunded × Cases Per 100	0.115***	0.103***	0.119***	0.104***
	(0.033)	(0.037)	(0.035)	(0.038)
Observations	940,627	940,627	927,058	927,058
Adjusted R^2	0.39	0.60	0.39	0.60
County Controls	N	N	Y	Y
Bond Controls	N	Y	N	Y

Notes: Sample is bonds with maturity of more than 1 year traded between January 2, and May 29,2020. MLF denotes the Federal Reserve's post Municipal Liquidity Facility announcement period defined as dates on or after April 9, 2020. Regressions include bond characteristics as well as issuer state domicile by trade date fixed effects. COVID cases are measured at the county level per 100 residents. Bond characteristics include log of trade amount, log of principal amount, log of remaining maturity, and indicators for trade type. Standard errors clustered by issuer domicile state and trade date.
t statistic in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As shown in Table 6, the estimation results confirm our hypothesis that investors responded to county-level COVID cases in a way that was consistent with increased localized credit risks. While yields of pre-refunded bonds weren't affected by localized COVID exposures, non-pre-refunded bond yields did reflect those risks after the stress period and government interventions had been performed. The results are robust across different specifications with different control variables.[16]

The COVID exposure at a county level didn't have any impact on pre-refunded bond yields. In the first line, the estimate of β_1^c is statistically insignificant, implying that COVID

[16]Table E5 in Appendix E.2 provides a robustness check around the intervention date. We show that moving the policy intervention date back to March 20, the date of the MMLF actions, renders our results insignificant. This suggests that early interventions targeted a common liquidity shock and differential credit risks for untargeted segments did not materialize until after the interventions were complete.

cases at the county level didn't affect pre-refunded bonds prior to April 9. The interaction term between COVID cases and the policy dummy, β_2^{cp}, is also largely insignificant. Overall, the sum of β_1^c and β_2^{cp}, which captures the impact of COVID exposure on pre-refunded bonds following policy interventions, is close to zero and statistically insignificant. Those estimates are consistent with our hypothesis that local COVID exposure, as a good indicator for localized credit risks, didn't have a significant impact on pre-refunded bond yields.

On the other hand, local COVID cases had a significant impact on non-pre-refunded bonds, especially after the policy interventions. The third row shows that non-pre-refunded bonds have higher yields in general, reflecting their higher credit risk because they aren't secured by Treasury securities in an escrow account. The fourth row indicates that prior to April 9, COVID cases didn't have a more significant impact on non-pre-refunded bonds than pre-refunded bonds, likely reflecting the fact that liquidity risks were the dominant factor in rising yields during the stress period. The last line, however, highlights that following the policy interventions, counties with higher COVID cases saw higher yields in their non-pre-refunded bonds compared to pre-refunded bonds.

The findings on non-pre-refunded bonds may appear counterintuitive, as they suggest that policy interventions made those bonds more susceptible to COVID credit risks. However, this result largely reflects the details of the policy interventions. In particular, the policy programs targeted bonds that were short-term in nature. Thus, the non-pre-refunded bonds, which we restricted to those with longer remaining maturities, were not directly targeted by these policy programs. While the interventions were able to address liquidity provision in the market, thus lowering yields as liquidity premia declined, the post-intervention yields reflected higher credit risks on less targeted bonds. In the next section, we provide additional insight and further investigate the impact of policy intervention on short maturity yields.

6.2 Short- vs. Long-term Bonds

In this section, we further explore aggregate liquidity and local credit risks by distinguishing policy impacts on bonds with different maturities.

As the pandemic accelerated, municipal bond yields increased sharply, especially for short maturity debt. The swift policy interventions from the Treasury and the Federal Reserve helped to stabilize financial conditions broadly. More importantly, the Federal

Reserve acted as a *buyer* of last resort through the MLF facility, which is backstopped by the Treasury with funds appropriated by the CARES Act, and eased concerns about short-term credit risks in the municipal bond market.

We hypothesize that *prior to* policy interventions, local credit risks may have been a more important component for short-term debt than longer-term bonds, given the immediate impact and the perceived temporary nature of the pandemic. At the onset of the pandemic, measures such as quarantines and shelter-in-place mandates significantly lowered revenue forecasts for state and local governments, and increased the risk that municipal bond issuers would be unable to meet their obligations in the near term.

We further hypothesize that *following* the policy interventions, local credit risks eased on short-term bonds, because they could be fairly easily refinanced through government facilities, but intensified for longer-term debt. The establishment of the MLF, the joint effort by the Federal Reserve and the Treasury, provided a way for many borrowers to raise cash even if demand for new issuance was low in the private market. However, the MLF doesn't address long-run credit concerns in the municipal bond market. As the pandemic continue to drag on, these long-term credit concerns likely increased.

Specifically, we estimate the impact of credit risk associated with COVID cases on municipal bond yield using equation 3:

$$\begin{aligned}\ln yield_{i,t} \quad = \quad & \alpha_{s,t} + \beta_1^c cases_{c,t} + \beta_2^{cm} cases_{c,t} \times I_t^{policy} \\ & + \beta_1^s I_{i,t}^{ST} + \beta_2^{cs} cases_{c,t} \times I_{i,t}^{ST} \\ & + \beta_3 cases_{c,t} \times I_{i,t}^{ST} \times I_t^{policy} + \gamma X_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{3}$$

The dependent variable is the log of the yield on municipal bond i by an issuer in county c and state s that was traded on day t. $case_{c,t}$ denotes COVID cases per capita in county c on date t, and the indicator of I_t^{policy} equals 1 for trade dates after April 9, 2020. In addition, we define an indicator, $I_{i,t}^{ST}$, which takes a value of one if the bond's remaining maturity is one year or less and zero otherwise. Similar to equation 2, we control for joint state and time fixed effects, and also include bond and county controls in equation 3.

As shown in Table 7, the estimation results confirm our hypothesis that policy interventions had a greater impact on local credit risks related to short-term bonds than longer-term securities. In column 1, the coefficient on the COVID case count, β_1^c, is not statistically significant, implying that counties that have higher case counts didn't see higher yields in

Table 7: COVID Bond Pricing Effects

	(1)	(2)	(3)	(4)	(5)
Cases Per Capita	0.013	0.018	-0.076***	-0.070**	-0.069**
	(0.016)	(0.018)	(0.023)	(0.028)	(0.031)
Intervention × *Cases Per Capita*			0.091***	0.085***	0.085**
			(0.018)	(0.027)	(0.032)
Short-Term Debt		-0.105***	-0.081***	-0.082***	-0.082***
		(0.021)	(0.019)	(0.020)	(0.020)
Short-Term Debt × *Cases Per Capita*		-0.071**	0.113***	0.120***	0.119***
		(0.031)	(0.037)	(0.039)	(0.040)
Short-Term Debt × *Intervention*			-0.137***	-0.135***	-0.135***
			(0.033)	(0.033)	(0.032)
Short-Term Debt × *Intervention* × *Cases Per Capita*			-0.123***	-0.126***	-0.126***
			(0.045)	(0.044)	(0.046)
Observations	1,023,778	1,023,778	1,023,778	1,023,778	1,009,109
Adjusted R^2	0.37	0.38	0.38	0.42	0.42
Bond Controls	N	N	N	Y	Y
County Controls	N	N	N	N	Y

Notes: Sample is bonds traded between January 2, and May 29,2020. Intervention denotes period on or after April 9, 2020. Regressions include bond characteristics as well as issuer state domicile by trade date fixed effects. COVID cases are measured at the county level per 100 residents. Bond characteristics include log of trade amount, log of principal amount, log of remaining maturity, and indicators for trade type, pre-refunded bonds, and investment and speculative rated bonds according to Moodys (omitted group is not rated). Standard errors clustered by issuer domicile state and trade date.
t statistic in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

their bonds when compared to less affected counties in the same state. Column 2 makes a more subtle point as we interact the case counts with the short-term bond indicator. When compared to less affected counties in the same state, counties with higher case counts didn't see higher yields in their *long-term* bonds, as shown by the insignificant coefficient on the case count, and actually had *lower* yields on their *short-term* bonds than long-term bonds, as indicated in the negative and significant coefficient of the interaction term.

As highlighted in column 3, however, the negative relationship between case counts and short-term bond yields emerged only following the policy interventions, suggesting that the joint fiscal and monetary intervention provided significant relief on credit risks for short-term bonds. In this specification, we include the triple interaction for the post-intervention period. The coefficient of the interaction between short-term bond indicator and case counts turns positive and significant in this case. The result implies that prior to the policy interventions, counties with higher case counts had higher yields in their short-term bonds than long-term bonds when compared to less affected counties in the same state, suggesting that credit risks associated with quarantines and shelter-in-place mandates increased more significantly in the near term. Following policy interventions, however, the results flipped. The negative and statistically significant coefficient on the interaction between short-term debt and the policy indicator highlights that yields on short-term debt fell more than yields on longer term debt in the post-intervention period. Moreover, the effect of higher COVID cases was negative and statistically significant on short-term yields following policy interventions as denoted by the negative signs on the DDD estimator.

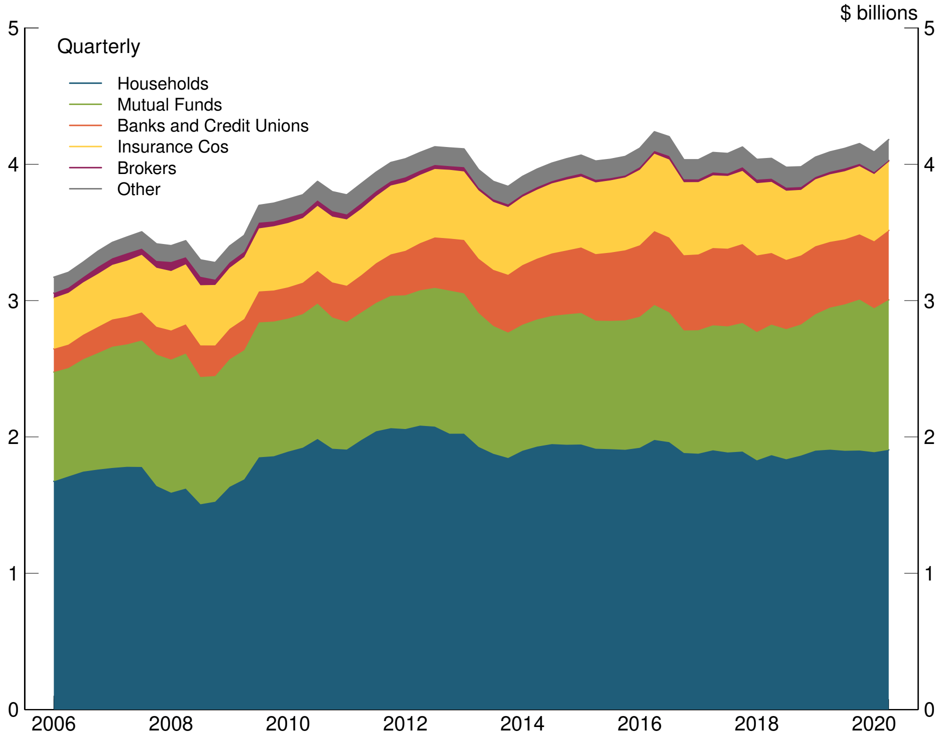
It is also notable that the marginal effect of the case counts on longer-term debt turns positive and statistically significant in the post-intervention period, as measured by the sum of two coefficients in the first two rows. This evidence is consistent with investors turning their focus to long-run credit concerns following the policy interventions, in line with not a financial panic, but a more bread-and-butter recession dynamic which was expected to follow the pandemic. The results are robust to adding bond- and county-specific controls as shown in columns 4 and 5.

7 Conclusion

In this paper, we use high-frequency identification and find that news about fiscal policy interventions, as well as the monetary policy action backstopped by the Treasury, had much more significant impact in stabilizing the municipal bond market than announcements of monetary policy that didn't have an explicit fiscal backstop.

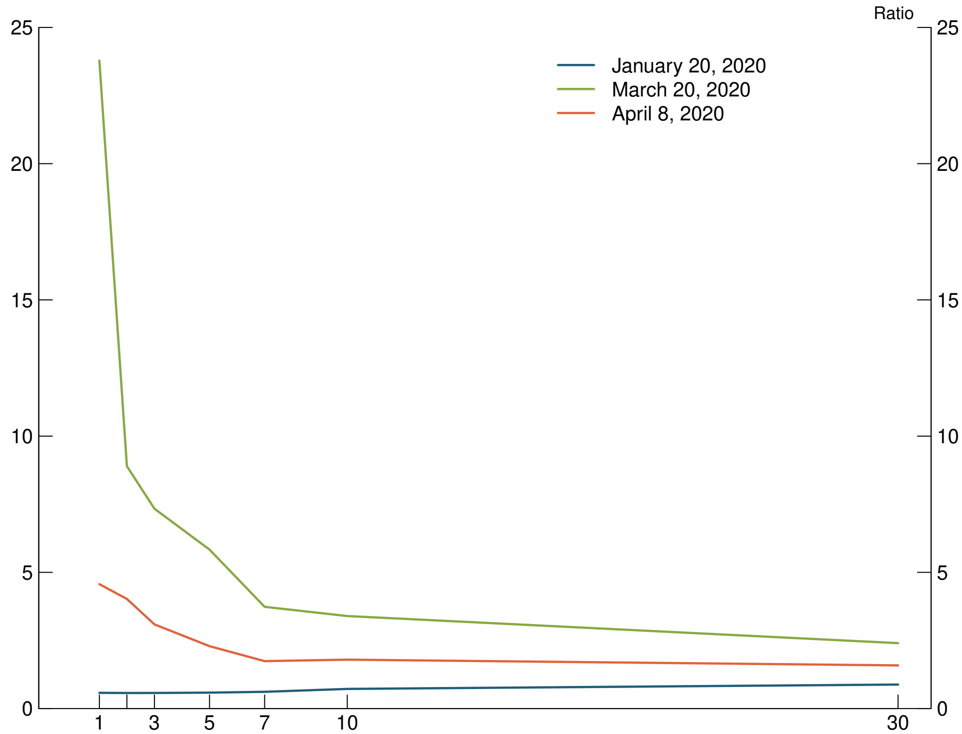
We also exploit daily variation in traded municipal bonds and virus exposure across counties to investigate the localized credit risks. Our key assumption is that COVID case levels act as a reasonable proxy for credit risks of municipal governments over our sample period. We find that prior to the fiscal and monetary policy interventions, local credit risks were a significant component of elevated short-term bond yields. Following policy interventions, however, the pricing of local credit risks shifted from short-maturity debt to longer-dated bonds.

Figure 1: Municipal Securities Holdings



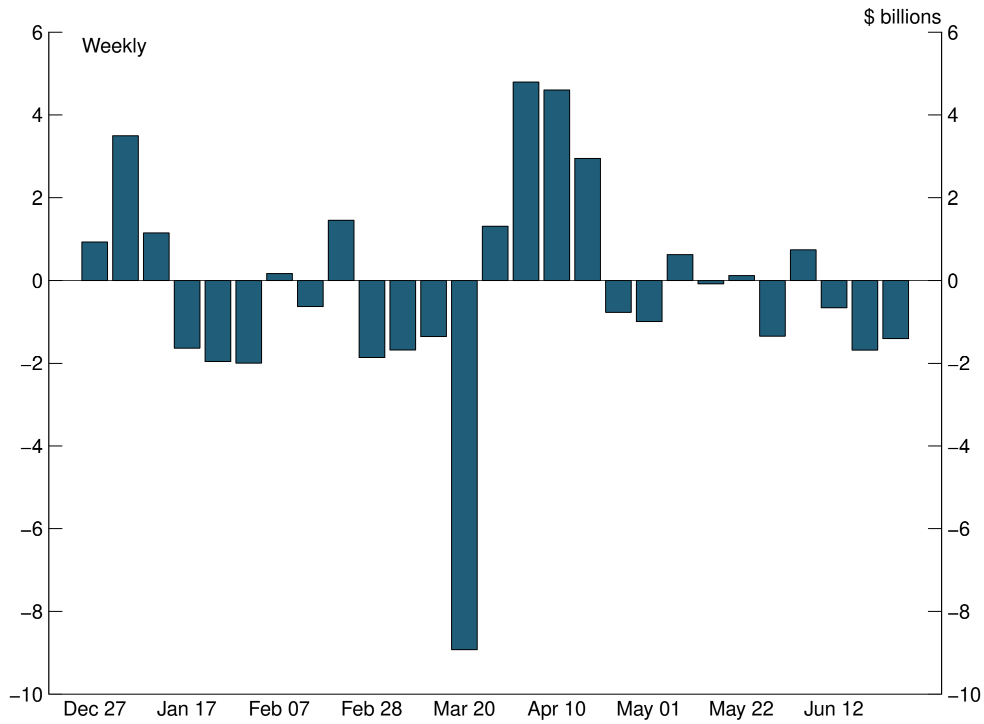
Source: Z.1 Release, Federal Reserve Board.

Figure 2: Municipal Bond Yield to Treasury Yield Ratio



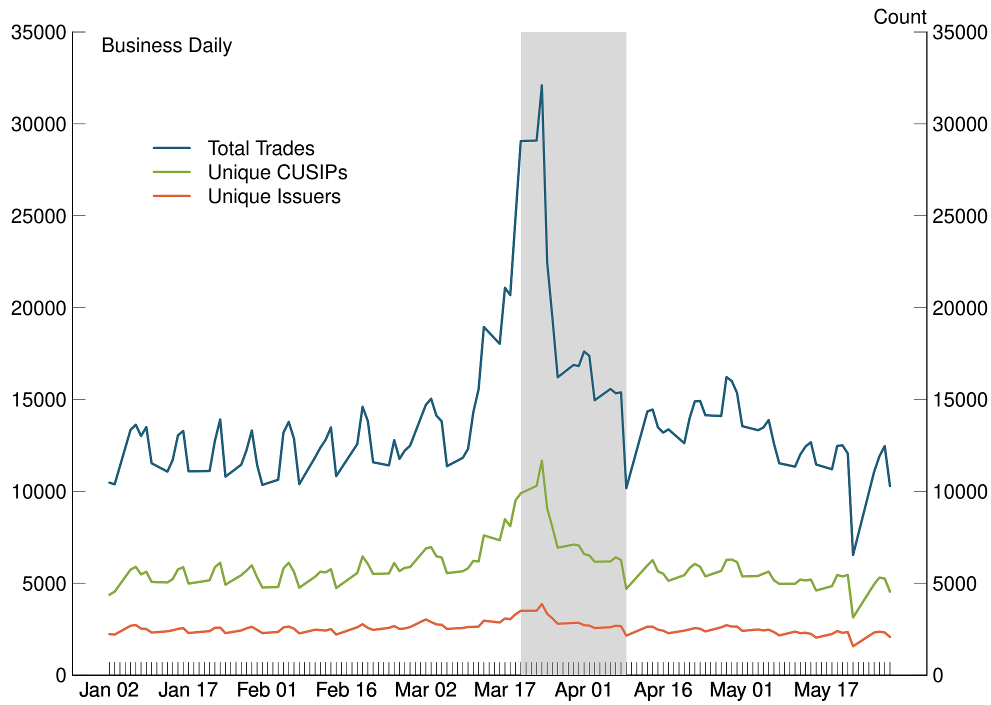
Source: Bloomberg.

Figure 3: Net Subscriptions of Tax Exempt Money Market Funds



Source: Form N-MFP, Securities and Exchange Commission.

Figure 4: Trade Count



Notes: Total trades are all trades reported in the MSRB transaction elvel dataset. Unique CUSIPs are the total number of CUSIPs traded within a single day. Unique issuers are the total number of six digit CUSIPs traded within a single day.
Source: Municipal Securities Rulemaking Board.

Figure 5: Trade Frequency at the Security Level

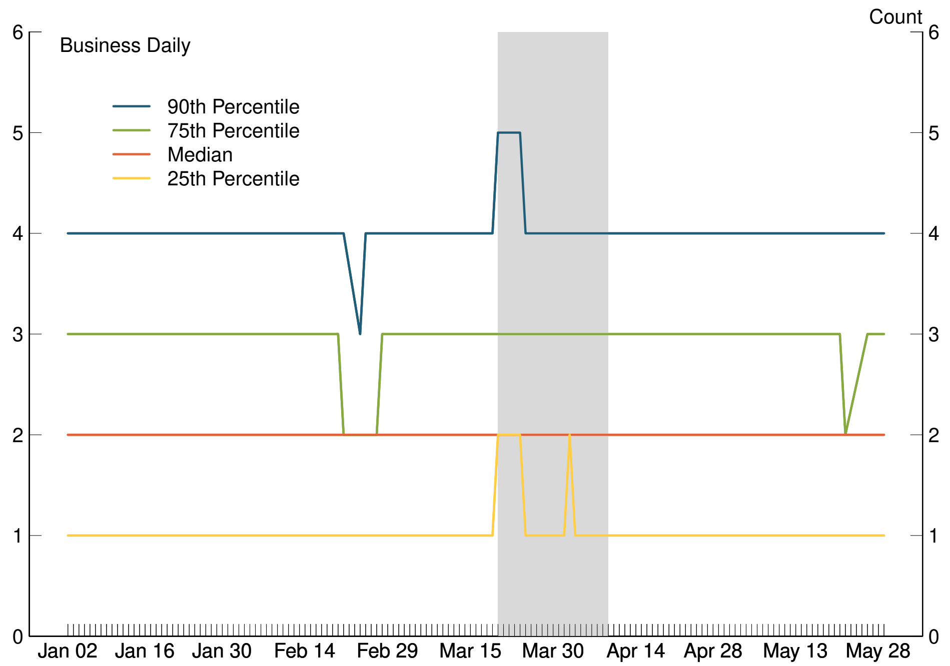
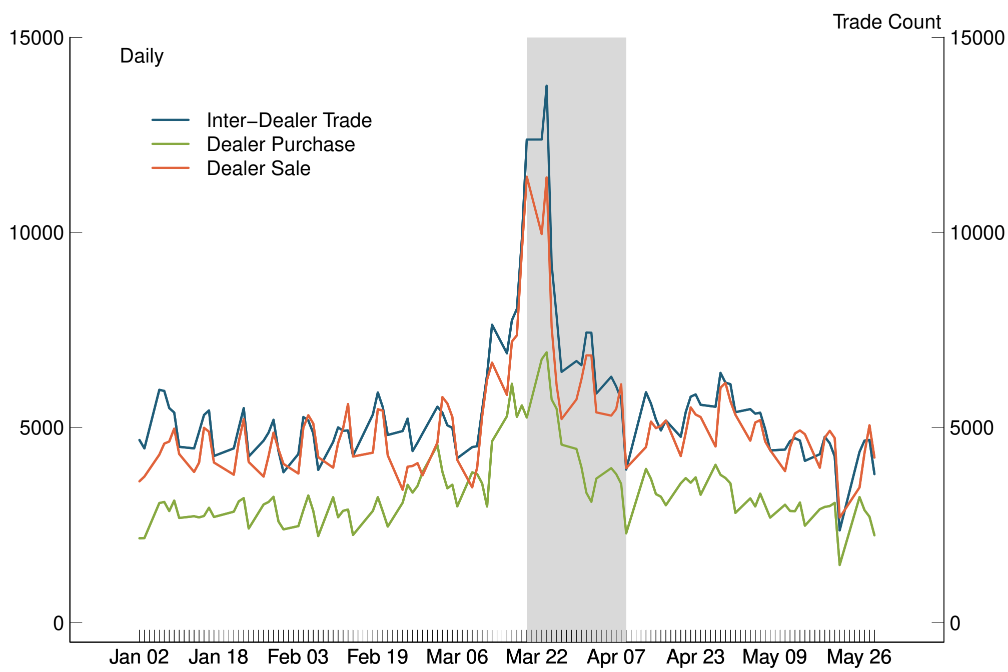


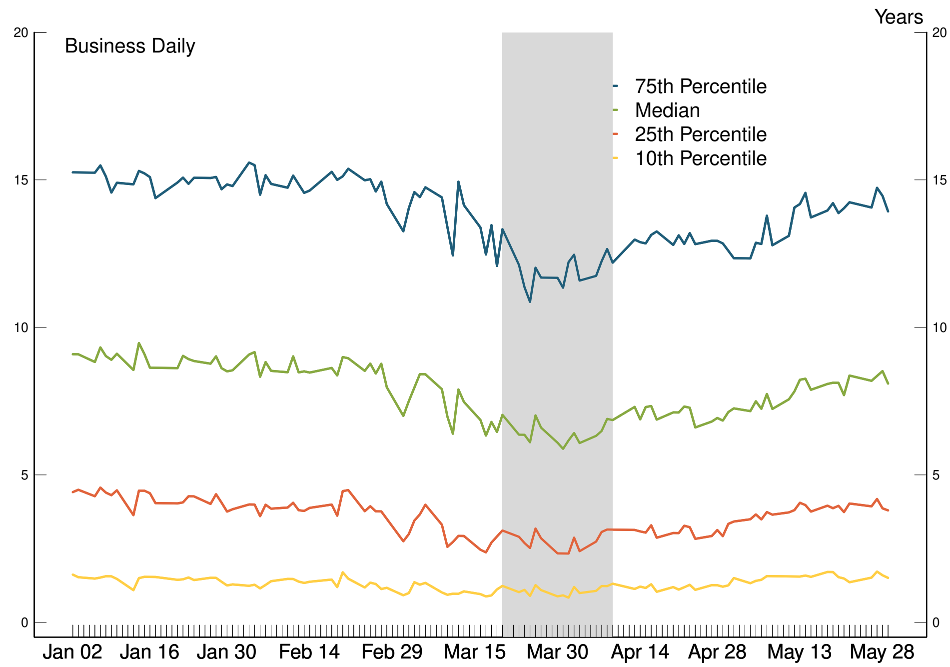
Chart shows the daily distribution of the number of times a single security, as determined by its CUSIP, is traded per day.
Source: Municipal Securities Rulemaking Board.

Figure 6: Trade Count: Purchase vs. Sale vs. Inter-dealer transaction



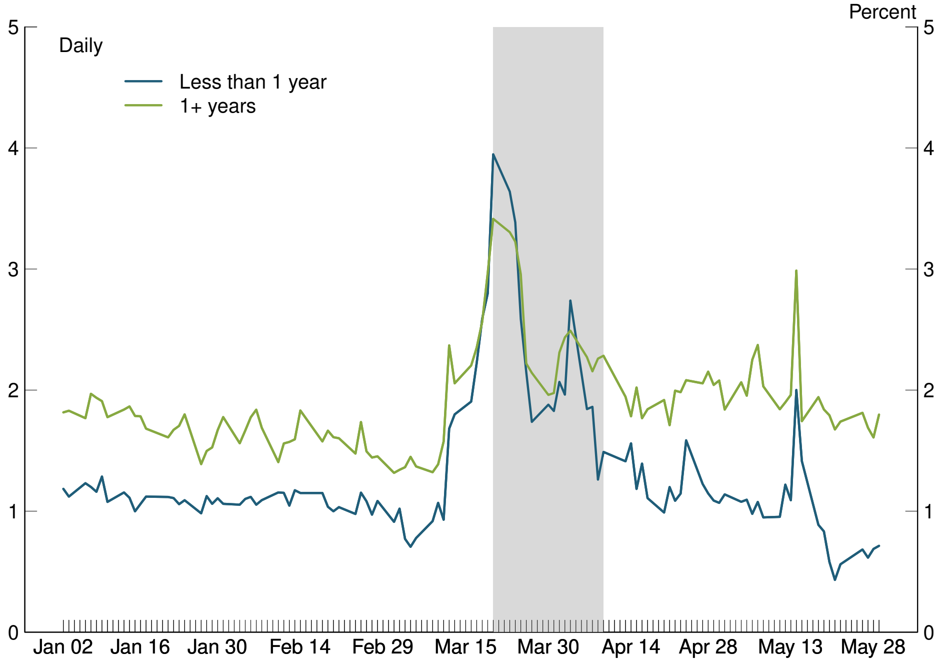
Source: Municipal Securities Rulemaking Board.

Figure 7: Remaining Maturity Distribution



Source: Municipal Securities Rulemaking Board.

Figure 8: Trade-weighted Average Yields



Notes: Chart shows average yield weighted by trade amount for securities with remaining maturity of less than 1 year and more than 1 year.
Source: Municipal Securities Rulemaking Board.

A Descriptions of Federal Reserve Programs Affecting U.S. Municipal Markets

Table A1: Dates and Descriptions of Federal Reserve Programs

Program	**Date**	**Program Action**	**Details**
MMLF	03/20	MMLF will accept highly rated municipal debt with remaining maturity not exceeding 12 months purchased from prime, single state, and other tax exempt funds as collateral from U.S. depository institutions, BHCs, and branches and agencies	Link
CPFF	03/23	CPFF will purchase highly rated 3-month U.S. dollar denominated commercial paper issued by eligible issuers, including municipalities, from CPFF dealers. Issuers must have issued new debt to non-sponsoring institutions between March 16, 2019 and March 16, 2020	Link
MMLF	03/23	MMLF will accept highly rated variable rate demand notes with features allowing holders to tender the note within 12 months	Link
MLF	04/09	MLF will purchase tax, tax and revenue, and bond anticipation notes or other short dated issues with maturity of 24 months or less issuers. Eligible issuers are states and D.C., cities with populations of more than 1 million residents, and counties with populations of 2 million residents.	Link

Notes: CCPF is the Commercial Paper Funding Facility. MMLF is the Money Market Mutual Fund Liquidity Program, MLF is the Municipal Liquidity Facility.

B MSRB Data Item Descriptions

Table B2: MSRB Transaction Data Items

Variable	Description
CUSIP	CUSIP of issue traded
Trade type	Customer purchase/sale, inter-dealer transaction
Trade date	Date trade was effected
Trade time	Time of trade execution
Dated date	Date of issuance
Settlement date	Date trade was settled
Maturity date	Maturity date of issue
Interest rate	Interest rate of issue
Yield	Yield-to-maturity
Issue description	Description of issue traded
Issuer name	Description of issuer
State	Issuer state
Seller/buyer ID	Dealer ID
Trade amount	Trade dollar amount
Principal amount	Principal dollar amount at issuance

C Determining County and State-Issuers

We determine county and state issuers using the following method:

1. We clean the issuer name provided by the MSRB by lower casing the name, dropping punctuation and special characters, and replacing abbreviations for words such as saint, mount, road, etc. We use the algorithm from Cohen, Friedrichs, Gupta, Hayes, Lee, Marsh, Mislang, Shaton and Sicilian [2018].

2. For state issuers, we look for combinations of the issuer's domiciled state as reported by the MSRB and the word "st" or "state" in the issuer name.

3. For county issuers, we search for names of counties reported in the COVID data. Most counties are followed by strings such as "cnty" or "cntys".

4. For the remaining unmatched issuers, we look for cities names reported in the USPS county-city crosswalk.

5. We allow for multiple matches in the case of jointly issued bonds. For multiple county matches, we set the county as missing. For multiple city matches, we set the county as the county of the cities if they are in the same county. Otherwise, we set the county to missing.

6. For certain cases our algorithm can't catch, such as determining between sets of cities or a single city, such as "bethel park, PA", we had assign a county after manually reviewing.

D Event Study Summary Stats

Table D3: Event Study Summary Stats

	Full Sample		MMLF		MMLF Revised		CARES Senate		CARES House		CARES Enacted		MLF	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	No Intervention	3/27-4/9	excluded	included	excluded	included	excluded	included	excluded	included	excluded	included	excluded	included
Yield	179.937	270.991	321.701	330.308	346.127	352.377	260.307	251.135	222.238	216.075	342.197	349.396	204.412	221.499
	(81.042)	(93.421)	(81.452)	(76.579)	(75.272)	(72.478)	(76.087)	(81.153)	(75.590)	(79.399)	(69.326)	(70.714)	(76.883)	(96.258)
Maturity (years)	9.460	8.102	8.094	9.724	7.878	10.379	7.703	8.056	7.821	9.093	7.721	8.543	7.964	10.128
	(7.225)	(6.757)	(6.610)	(8.028)	(6.528)	(8.165)	(6.257)	(6.654)	(6.327)	(7.232)	(6.347)	(6.973)	(6.442)	(7.910)
Maturity < 1 year	0.076	0.092	0.088	0.081	0.092	0.067	0.098	0.092	0.090	0.074	0.091	0.087	0.085	0.056
	(0.266)	(0.290)	(0.283)	(0.273)	(0.289)	(0.250)	(0.298)	(0.289)	(0.286)	(0.262)	(0.288)	(0.282)	(0.279)	(0.229)
Investment Grade	0.650	0.723	0.692	0.803	0.716	0.781	0.699	0.787	0.707	0.794	0.714	0.782	0.664	0.702
	(0.477)	(0.448)	(0.462)	(0.398)	(0.451)	(0.414)	(0.459)	(0.409)	(0.455)	(0.404)	(0.452)	(0.413)	(0.472)	(0.458)
Speculative Grade	0.005	0.002	0.002	0.000	0.001	0.001	0.003	0.004	0.003	0.003	0.002	0.001	0.003	0.004
	(0.072)	(0.049)	(0.040)	(0.018)	(0.029)	(0.030)	(0.054)	(0.060)	(0.052)	(0.059)	(0.042)	(0.025)	(0.057)	(0.065)
Not Rated	0.344	0.275	0.307	0.197	0.283	0.218	0.298	0.209	0.291	0.202	0.285	0.217	0.333	0.294
	(0.475)	(0.447)	(0.461)	(0.398)	(0.450)	(0.413)	(0.457)	(0.407)	(0.454)	(0.402)	(0.451)	(0.412)	(0.471)	(0.456)
Observations	1,078,044	301,177	35,984	15,451	39,531	15,971	29,391	10,800	24,639	9,502	40,346	18,277	18,852	5,875

Notes: Columns show mean values for bond characteristics with standard deviations in parentheses. First two columns compare bonds traded between March 23 and April 9, the dates of the monetary and fiscal interventions, and all other dates in the full sample. Columns (2) - (14) show bonds included in each event study compared to bonds trade on event study dates but excluded from our sample because they were trade on prior to or after the event but not both before and after the event within the event window.

E Robustness Checks

E.1 Money Market Mutual Fund Effects

The Federal Reserve established the MMLF to directly assist MMMFs and to stabilize the broad financial conditions. During the height of the crisis, investors quickly pulled cash from money market funds, and MMMFs needed to sell their asset holdings to generate cash in order to meet redemption requests. As security prices declined, raising cash through asset and security sales became more difficult. By establishing the MMLF, the Federal Reserve provides a backstop to money market funds by facilitating purchases of assets via commercial banks. Specifically, the Federal Reserve accepts certain high-quality assets – including certain municipal bonds that are purchased from prime and tax-exempt money market funds – as collateral from commercial banks, BHCs, and U.S. branches of foreign banks, and issues short-term loans to those banks. In this way, the Federal Reserve can provide liquidity to MMMFs and their investors.

We follow the approach in Duygan-Bump, Parkinson, Rosengren, Suarez and Willen [2013] and study how the MMLF affected the net fund inflows in MMMFs. The structure of the MMLF was much like the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF) during the Great Financial Crisis. Duygan-Bump et al. [2013] explore the effects of the AMLF program on money fund assets and find that it was effective in reducing redemptions. Similarly, we estimate how the establishment of MMLF affected fund flows into MMMFs in general, and in particular those funds with larger shares of assets eligible as MMLF collateral.

We use data from the SEC's Form N-MFP, a required filing for all MMMFs, to estimate the effects of the Federal Reserve programs on flows into money market mutual funds. The report collects monthly data on money market fund assets and security holdings, and also collects subscriptions and redemptions into individual funds at weekly frequency. Unfortunately, there is no daily information reported on N-MFP, and therefore we cannot directly measure the impact of each individual intervention from the Federal Reserve.[17]

Accordingly, we estimate the following equation,

$$y_{i,t} = \beta_0 + \beta_1 MMLF_t + \beta_2 MMLF_t \times s_i^{eligible} + \gamma X_i + \varepsilon_{i,t}. \tag{4}$$

[17] Interventions occurred on March 18 (ABCP), March 20 (single state and tax-exempt funds holdings short-term municipal debt), and March 23 (variable rate demand notes).

$y_{i,t}$ is net fund subscriptions at fund i in week t scaled by end-of-month net assets. We define the dummy indicator $MMLF_t$ which equals 1 for weeks after the week of March 23 to 27, 2020, as the Federal Reserve decided to accept variable rate demand notes on March 23, which was the last Fed announcement associated with the MMLF. The variable $s_i^{eligible}$ denotes the share of eligible asset-backed commercial paper and municipal bond debt held by the money fund at the end of February, before the COVID shock hit the financial system. The vector X_i is a set of fund characteristics measured as of the end of February. We include the fraction of assets maturing in 7 days and the share of liquid assets held, both of which are measures of fund liquidity.[18] We also include an indicator for institutional funds. As a robustness check, we estimate an equation using the average annualized 7-day yield of the fund, following Duygan-Bump et al. [2013]. Standard errors are clustered at the fund level.

Table E4: Money Market Liquidity Facility Effects

	(1)	(2)	(3)	(4)	(5)
Post MMLF Indicator × Eligible Asset Share	0.060***	0.060***	0.060***	0.060***	0.063***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)
Post MMLF Indicator	-0.721				-0.778
	(0.469)				(0.497)
Eligible Asset Share	-0.052***	-0.052***		-0.006	-0.094***
	(0.011)	(0.011)		(0.016)	(0.016)
Fraction of Assets Maturing in 7 days				0.057***	
				(0.010)	
Liquid Asset Share				-0.003	
				(0.010)	
Institutional fund indicator				-2.122***	
				(0.647)	
Average Annualized Gross 7 Day Yield					-4.844***
					(1.190)
Constant	1.228***	0.211	-0.745*	-2.370***	11.778***
	(0.393)	(0.474)	(0.386)	(0.873)	(2.503)
Week Fixed Effects	N	Y	Y	Y	N
Fund Fixed Effects	N	N	Y	N	N
Observations	3,552	3,552	3,552	3,552	3,362
Adjusted R^2	0.012	0.021	0.020	0.037	0.020

Notes: Dependent variable is weekly net subscriptions divided by end of month net assets. Post MMLF date is March 27, 2020. Standard errors clustered by fund series.
t statistic in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[18] We follow Duygan-Bump et al. [2013] and define liquid assets as the stock of Treasuries, Agency debt, and repos.

We find that the MMLF program had a significant and large effect on reversing outflows for funds that held large shares of eligible assets, even though the impact wasn't significant in general across all money market mutual funds. As shown in table E4, the indicator for the post-MMLF dummy is insignificant for all specifications. On the other hand, our estimates on the interaction term between the MMLF indicator and the eligible asset share are positive and significant, indicating that funds with large shares of eligible asset saw net subscriptions following the program announcement. Those estimates are robust across different specifications that vary with fund control variables, time and fund fixed effects, and the inclusion of average annualized 7-day yield.

E.2 Alternative Intervention Breakpoints for Credit Risk Regressions

In this Appendix section, we present a robustness check to the baseline empirical analysis on pre-refunded bonds (see Table 6). In this alternative specification, we adopt the policy intervention cutoff date of March 20, the date when the Federal Reserve announced its first policy action targeting the municipal bond market by including municipal securities in the MMLF program.

Table E5 shows that using the earlier cutoff date, all results involving COVID cases become insignificant. Given that yields spiked around this date for both pre-refunded and non-pre-refunded bonds, this finding suggests that earlier interventions were successful in reliving increases in aggregate liquidity pricing, as there was no differential impact of the MMLF intervention on non-pre-refunded bonds. Furthermore, including the additional 3 weeks of March 20 and April 9 in the post-intervention sample renders the cases effects insignificant. Therefore, we conclude that the positive and significant effects of COVID cases after the April 9 intervention, as shown in the baseline case of Table 6, arise due to the fact that these securities were not directly targeted by the program and thus there was no explicit backstop available to these securities to relieve them of elevated credit risk induced by higher local COVID exposure.

Table E5: Prerefunded Bonds

	(1)	(2)	(3)	(4)
MMLF × Not Prerefunded × Cases Per 100	0.379	0.493	0.409	0.499
	(0.489)	(0.538)	(0.517)	(0.552)
Cases Per 100	0.360	0.013	0.364	0.014
	(0.393)	(0.584)	(0.408)	(0.601)
MMLF × Cases Per 100	-0.448	-0.086	-0.448	-0.085
	(0.421)	(0.600)	(0.440)	(0.617)
Not Prerefunded	0.240***	0.287***	0.242***	0.288***
	(0.025)	(0.024)	(0.026)	(0.024)
Not Prerefunded × Cases Per 100	-0.272	-0.400	-0.304	-0.408
	(0.452)	(0.513)	(0.484)	(0.528)
MMLF × Not Prerefunded	0.008	0.033	0.007	0.033
	(0.022)	(0.023)	(0.022)	(0.023)
Observations	940,627	940,627	927,058	927,058
Adjusted R^2	0.39	0.60	0.39	0.60
County Controls	N	N	Y	Y
Bond Controls	N	Y	N	Y

Notes: Sample is bonds with maturity greater than 1 year traded between January 2, and May 29, 2020. MMLF denotes the Federal Reserve's post Money Market Mutual Fund Liquidity Facility announcement period defined as dates on or after March 20, 2020. Regressions include bond characteristics as well as issuer state domicile by trade date fixed effects. COVID cases are measured at the county level per 100 residents. Bond characteristics include log of trade amount, log of principal amount, log of remaining maturity, and indicators for trade type. Standard errors clustered by issuer domicile state and trade date. t statistic in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

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