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What Did Policy Interventions Fix in the Municipal Bond Market – Liquidity or Credit?

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Abstract

We examine how policy interventions during the COVID pandemic impacted municipal bond market pricing. Focusing on narrow trading windows, we find that announcements of fiscal and direct monetary policy interventions reduced liquidity risk concerns but did not immediately ease credit concerns. Using rolling-window regressions, we find that policy interventions eased credit concerns for short-term bonds over time, while longer-term bond spreads show increased credit risks. The credit risk shift from short- to long-term bonds reflects policy designs that benefited short-term bonds more, as well as changing investor expectations on state and local government budgets due to the pandemic's persistence.

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 in March 2020. As governments and individuals took preventative measures, the economic outlook deteriorated rapidly and investors fled risky assets. Municipal bond yields increased sharply, potentially driven by liquidity risks associated with the tightening of broad financial conditions as well as credit concerns about issuers' ability to service their bonds.

In response, the U.S. Congress and the Federal Reserve conducted a series of swift and unprecedented policy interventions during late March and early April. The Federal Reserve accepted municipal securities as lender-of-last-resort collateral in an effort to indirectly support the municipal bond market. Congress, for its part, passed the Coronavirus Aid, Relief, and Economic Security (CARES) Act. Among other items, the bill included state and local government aid appropriations and provided funds to establish a direct lending facility that supported municipal bond issuers by making the Federal Reserve a buyer-of-last-resort.

In this paper, we focus on the following question: How did the series of policy interventions change liquidity and credit risk pricing in the municipal bond market? On one hand, liquidity strains in the broad financial markets could have aggravated investors' concerns about their ability to liquidate municipal bond portfolios, contributing to the sell-off in municipal bond markets. If so, policy interventions that supported broad financial markets, and the economy more generally, could stabilize municipal yields by easing aggregate liquidity risk concerns. On the other hand, the pandemic fundamentally changed local economic conditions, raising concerns about the ability of municipal bond issuers to service their debt. Direct aid aimed to alleviate potential revenue shortfalls at state and local governments, while the Federal Reserve's lending facility provided a way to raise new, or rollover existing, debt funding. These interventions could further stabilize the municipal bond market by easing investor credit concerns.

To separately identify the liquidity and credit risk channels, we use pre-refunded bonds as a control group to capture aggregate liquidity risks following Novy-Marx and Rauh [2012] and Schwert [2017]. For each pre-refunded bond, proceeds from issuing a new "refunded" bond are held in escrow and invested in Treasury securities. Future payments on the pre-refunded bond are fully covered by the escrow account's investment earnings. Therefore, because pre-refunded bonds are fully collateralized, their yields are affected by Treasury market movements and broad liquidity concerns, but are unlikely to be influenced by issuer-specific credit risks. In contrast, non-pre-refunded bonds are directly exposed to both issuer-specific credit risks and aggregate liquidity risks. This means that movements in pre-refunded bond yields should reflect liquidity concerns, while changes in spreads between pre-refunded and non-pre-refunded bond yields should reflect credit risks. We compare the responses of these two bond types to various policy interventions to study how the municipal bond market was impacted through the liquidity and credit risk pricing channels.

We begin by examining the immediate impact of each policy intervention on the municipal bond market. To minimize the spillovers between policy changes, we employ a high-frequency identification strategy that focuses on movements in municipal bond spreads during narrow trading windows around key policy announcements.

Specifically, we generate a sample of bonds that traded both before and after each announcement within a narrow window. With a security-level fixed effect controlling for any unobservables that are constant across the trading window, we estimate the effect of each policy announcement on municipal bond spreads against comparable maturity Treasury yields.

First, we find that policy announcements about forthcoming fiscal relief reduced municipal bond spreads quickly and significantly by lowering aggregate liquidity risk concerns. Our estimates indicate that municipal bond spreads against comparable-maturity Treasury yields declined quickly for both pre-refunded and non-pre-refunded securities following positive news about passage of the CARES Act. For instance, after a unanimous CARES Act vote in the U.S. Senate, municipal bond spreads declined more than 110 basis points, which accounted for 25 percent of the average municipal bond spread over Treasury yields at the time. Cumulatively, a series of positive news regarding the CARES Act lowered municipal spreads by more than 200 basis points. Later, the Federal Reserve's announcement of a dedicated municipal market lending facility led to a decline of close to 30 basis points in average spreads. Conversely though, we also find that policy announcements had little immediate impact on alleviating credit risk concerns in the municipal bond market. Our event studies show no additional declines in non-pre-refunded bond spreads compared to pre-refunded bonds immediately following policy announcements.

Second, we find that announcements of indirect monetary interventions had a more limited ability to stabilize municipal bond spreads, contrary to our findings on news of fiscal policy and announcements of direct monetary interventions. We consider these indirect supports to be the establishment of Federal Reserve lending facilities that extended loans to money market funds while accepting short-term municipal bonds as collateral. We find that these interventions lowered short-term municipal bond spreads but failed to stabilize longer-term spreads.

Next, we extend our analysis horizon to explore how fiscal and monetary policy interventions, as well as the pandemic, affected the liquidity and credit risk channels over longer periods. We use a rolling-window regression to compare spreads of pre-refunded and non-pre-refunded bonds daily between January and May 2020.

In the early period, we find that credit risks were an important component of the observed rise in short-term municipal bond spreads at the onset of the pandemic. From early to late March, we estimate that credit risk premia on short-term, non-pre-refunded bonds rose by more than 100 basis points. Conversely, credit risk premia remained largely unchanged for long-term, non-pre-refunded bonds during this time, despite an increase in overall spreads among these securities. The credit risk pricing difference between short- and long-term bonds reflects the immediate, as well as the perceived temporary, impact of the pandemic on local and state government budgets at the outset. Expectations at that time were that lockdown measures could contain the spread of the virus quickly. These views perpetuated a belief among investors that, despite rapidly deteriorating financial conditions, any state and local budget shortfalls due to the virus would be transitory.

Following fiscal and monetary policy interventions, we find that the design of policy interventions, combined with the persistence of the pandemic, changed the credit risk pricing dynamics in the municipal bond market. We find that credit risk premia on short-term bonds declined steadily through April, falling 70 basis points from their March peaks. It indicates that federal interventions successfully eased credit concerns for short-term, non-pre-refunded bonds. Credit risk premia on long-term, non-pre-refunded bonds, however, increased by 60 basis points between the end of March and May 2020. This steady increase likely reflected that policy interventions directly targeted the short-term municipal bond market, but did not explicitly support longer-term municipal bonds. Moreover, concerns about longer-term credit risks became more salient, as the pandemic continued to drag on and investors started to anticipate traditional recession dynamics would take hold. Indeed, we subsequently show that credit risk premia increased more substantially on long-term bonds from lower-rated issuers, highlighting that the pandemic exacerbated unchecked credit risk concerns.

By explicitly considering fiscal policy actions, our paper contributes to, and extends, a rapidly growing literature on policy interventions and financial markets during the COVID pandemic. This literature has largely focused on monetary policy interventions.[1] In comparison, we find that legislative news on the CARES Act played a pivotal role in stabilizing liquidity risks in the municipal bond market. Importantly, some of the indirect monetary interventions were announced on the same day when the CARES Act negotiations made major progress among Congressional leaders; hence, without explicitly considering fiscal policy news, estimates of

[1]For instance, prior studies have examined corporate debt markets [Boyarchenko, Kovner, and Shachar, 2020; D'Amico, Kurakula, and Lee, 2020; Falato, Goldstein, and Hortaçsu, 2021; Gilchrist, Wei, Yue, and Zakrakšek, 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], and banking stress [Acharya and Steffen, 2020; Li, Strahan, and Zhang, 2020].

the efficacy of indirect monetary interventions would be significantly biased upward. Instead, our approach allows us to better evaluate policy efficacy by combining a high-frequency identification strategy with a consideration for both fiscal and monetary policy actions.

More directly, our paper contributes to recent work on the impacts of COVID-19 and policy interventions on the municipal bond market. In a closely related paper, Haughwout, Hyman, and Shachar [2020] focus on how issuer eligibility in the Federal Reserve's municipal lending facility affected municipal bond market spreads. Our paper complements their study but differs in the following ways. First, while they focus on the design of the Federal Reserve's direct lending facility, we study the impact of various monetary and fiscal policy announcements on municipal bond spreads. Importantly, we find that decisive fiscal policy played a crucial role in stabilizing the municipal bond market, even before the Federal Reserve's lending facility was operational. Second, we distinguish how these policies affected liquidity versus credit risk concerns primarily across bond maturity, while they focus on bond pricing differences across credit ratings. While their analysis reveals that issuer eligibility was important in lowering municipal yields, our results compliment their findings by showing that the design of policy interventions played an important role in shifting credit risk concerns from short- to longer-term bonds. In other related work, Bordo and Duca [2021] use monthly data to study the municipal bond market from a historical perspective, and find that Federal Reserve interventions were effective because they capped the growth of spreads by 5 to 8 percentage points. Li and Lu [2021] focus on how earlier mitigating policies, as well as the Federal Reserve's interventions, affected the demand for new municipal bonds. Our results differ because we distinguish how these interventions affected the credit and liquidity risk channels among actively traded, outstanding bonds. Fritsch, Bagley, and Nee [2021] investigate the impact of monetary policy interventions using Bloomberg's aggregate municipal yield curve. Our use of trade-level data allows us to uncover pricing differences driven by credit and liquidity risk concerns. Li, O'Hara, and Zhou [2021] highlight the potential fragility risks posed by mutual funds to the municipal bond market during the COVID-19 pandemic.

Our study also contributes to the literature on municipal bonds and financial conditions of state and local governments. Focusing on municipal bond transactions in 2018:Q4, Novy-Marx and Rauh [2012] estimate the effect of state pension investment losses on state bond yields and quantify a sovereign default channel in the municipal bond market. Schwert [2017] examines the pricing of municipal bonds between 1998 and 2015 and finds that credit risk accounts for a significant share of municipal bond spreads. Adelino, Cunha, and Ferreira [2017] find that municipalities' financial constraints can have a significant impact on local employment and growth. Gao, Lee, and Murphy [2019] show that different bankruptcy policies across states have significant impact on borrowing costs. 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.

Our findings have several implications for policymakers. First, our analysis shows that legislative news associated with the CARES Act played a pivotal role in stabilizing the municipal bond market. The unusually quick legislative process, as well as the massive scale of fiscal support, highlights the importance of taking and communicating decisive policy actions during a crisis. Second, we demonstrate that the presence of a dedicated lending facility from the Federal Reserve was effective at tamping down short-term credit risk concerns about state and local governments, despite limited usage of the facility by issuers. These effects are important because access to short-term municipal debt allows state and local governments to smooth spending over potentially volatile revenue collection periods, which was particularly relevant during the early days of the pandemic. A well-functioning municipal bond market is essential 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. On the other hand, after the series of policy interventions, credit risks remained a concern for longer-dated bonds. This higher cost of credit may negatively impact local capital investment and growth because debt issuance is the primary way for state and local governments to raise long-term funding [Marlowe, 2015].

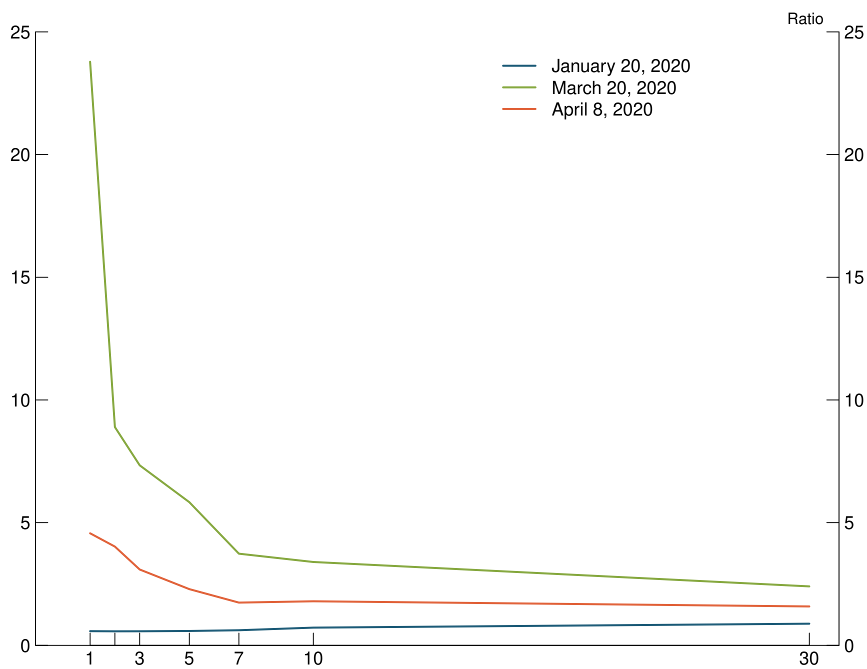
The remainder of the paper is as follows. Section 2 discusses the COVID shock and associated financial stress in the municipal bond market in March 2020, as well as unprecedented policy interventions in March and April. Section 3 provides details on our data. Section 4 evaluates the immediate impact of announcement of each policy intervention on municipal bond market through liquidity and credit risk channels. Section 5 examines how the impacts of policy interventions manifested over time. Section 6 concludes.

2 The COVID-19 Shock and Policy Interventions

After 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]), case counts rose across the nation from that date throughout February and early March. In mid-March, states began issuing quarantine and shelter-in-place orders, limiting permissible economic activities. Households also began to take precautions to avoid contracting the virus. Business revenues started to decline and unemployment increased sharply. Those developments posed a significant blow to state and local government (S&L) revenues at a time when their spending was ramping up to fight the pandemic.

Amid this economic turmoil, the COVID pandemic sparked broader concerns about financial market assets and intermediaries, as evidenced by the precipitous decline in prices of risk assets across the system. Municipal securities were not spared. Demand to hold municipal securities fell as investors rushed to cash assets. At the peak of the crisis, municipal bond market yields were extremely elevated, particularly for bonds with short remaining maturities. As shown in Figure 1, yields on one-year municipal bonds rose dramatically, reaching 25 times comparable maturity Treasury yields in mid-March. Yields on longer-dated bonds also increased, peaking at three times comparable maturity Treasury yields. These moves represent significant increases in municipal yields. Just prior to the onset of the pandemic, municipal security yields were slightly *lower* than Treasury yields across all maturities. Moreover, the acute stress in shorter maturity bonds, which led to an inversion of the municipal bond yield curve, was in-line with expectations of higher spending and lower revenue for S&Ls as well as the perceived temporary nature of the pandemic at the time.

Figure 1: Municipal Bond Yield to Treasury Yield Ratios



Note: The horizontal axis shows security maturity in months.
Source: Bloomberg.

In response to the rapid deterioration of economic conditions and widespread stress in financial markets, the U.S. Congress and the Federal Reserve undertook unprecedented policy actions in late March and early April 2020. These fiscal and monetary actions, however, were not taken simultaneously, but instead occurred in several stages that increasingly ratcheted up market support.[2]

Policy interventions began with the Federal Reserve's rollout of a series of liq-

[2]Appendix A provides a more detailed summary of Federal Reserve actions aimed at municipal bonds.

uidity facilities that were designed in a similar way to those used during the Global Financial Crisis in 2007-2008. Through these programs, the Federal Reserve extended short-term loans to financial intermediaries by accepting high quality collateral. As the crisis intensified, the type and maturity of accepted collateral were broadened. On March 20, the Federal Reserve expanded the eligible collateral for the Money Market Liquidity Facility (MMLF), which was established just days earlier to lend against certain short-term securities held by money market funds, to include highly rated, short-term municipal debt. On March 23, eligible collateral at the MMLF was further expanded to include variable rate demand notes, a decision again aimed at the municipal bond market.[3]

Despite the rocky negotiations, fiscal policy support arrived days later when the CARES Act passed both Congressional chambers during the last week of March. On March 23, negotiations were deadlocked when Senate Democrats blocked a key procedural motion, leading to a downward spiral in financial market conditions. Following late-night negotiations, however, 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 Industrial Average 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 25 and, on March 27, the bill was passed by a near-unanimous vote in the House before being signed into law by President Trump.

[3] 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.

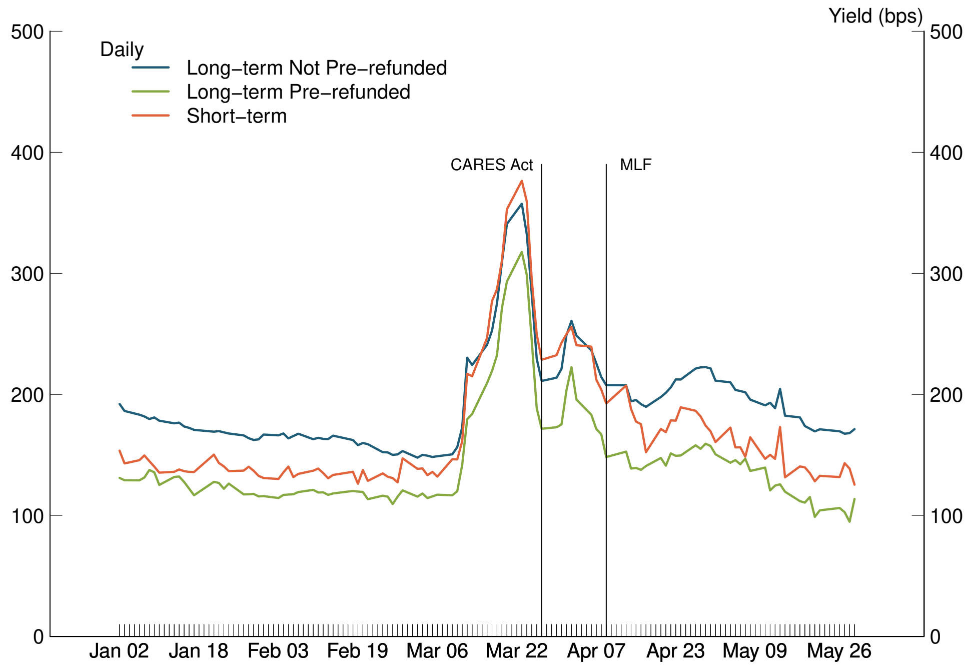
The CARES Act provided both direct and indirect support to businesses, households, and S&L governments. The bill provided an unprecedented $2.2 trillion to expand unemployment benefits and issue stimulus checks to households, extend grants and loans to small businesses, and fund COVID relief measures for S&Ls. Many of these actions helped to relieve revenue and spending pressure from S&L governments who were desperately working to contain a collapse of their local economies. The bill also appropriated funds to create backstop facilities to directly intervene in several key debt markets, including the municipal bond market. These facilities were established and operated by the Federal Reserve but were capitalized by an equity stake owned by the U.S. Treasury.

With funds appropriated from the CARES Act, the Federal Reserve Board announced the establishment of the Municipal Liquidity Facility (MLF) on April 9, providing $500 billion in loanable funds to municipal bond issuers. Under this program, the Federal Reserve could directly purchase new, short-term notes from eligible municipal bond issuers, who could then use the proceeds to support local jurisdictions under their authority.[4] By design, the MLF made the Federal Reserve a buyer-of-last-resort in the municipal market, with losses backstopped by the Treasury's equity stake. This intervention eased concerns about the ability of S&Ls to obtain short-term credit and provided a way for issuers to rollover existing debt.

Following these monetary and fiscal actions, the municipal bond market stabilized significantly, especially the short-term bond market. Figure 2 compares the trade-weighted average yields of non-pre-refunded bonds to pre-refunded bonds. All

[4]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.

Figure 2: Trade-Weighted Average Yields



Note: Chart shows average yields weighted by trade amount for non-pre-refunded municipal bonds with remaining maturity of less than 1 year and more than 1 year, as well as pre-refunded municipal bonds.
Source: Municipal Securities Rulemaking Board and authors' calculations.

pre-refunded bonds have remaining maturities longer than 1 year (green line), while non-pre-refunded bonds are split into two groups: those with remaining maturities less than 1 year (orange line), and those with remaining maturities greater than 1 year (blue line). Prior to the policy interventions, all three types of yields surged, indicating significant liquidity stress in the municipal bond market. However, increases were more pronounced for bonds with shorter remaining maturities. The passage of the CARES Act in late March led to steep declines in yields across all three types of bonds. Yields continued to normalize, particularly for shorter-dated securities, following the announcement of the Federal Reserve's MLF program in early April. Importantly, yields on short-term, non-pre-refunded bonds narrowed significantly during April and May when compared to pre-refunded bond yields. Yields on long-term, non-pre-refunded bonds remained elevated compared to pre-refunded bonds during this time. These dynamics suggest that monetary and fiscal policy interventions may have eased liquidity stress across all bond types while lowering credit risks more prominently for short-term bonds.

3 Municipal Bond Data

3.1 Overview of the Municipal Bond Market

The municipal bond market is the primary way for S&L units – 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. S&Ls can issue short-term notes to bridge the gap between the time expenses occur and revenues become available, but the majority of municipal bonds are sold to finance long-term capital projects.[5] 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.

[5] 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.

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 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 sales and income taxes account for close to 90 percent of state government tax revenues. Revenue bonds, on the other hand, are generally issued to finance a specific project and secured solely by the revenues generated from that project. 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. In addition, 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.

The interests paid on most municipal bonds are exempt from federal income taxation. Bonds issued by entities domiciled in a particular state are typically exempt from taxation by that state, too. These tax exemption features make municipal bonds especially attractive to retail investors.

3.2 Data Sources

Our analysis relies on secondary market transaction data reported to the MSRB between January 2 and May 29, 2020. The data collection records all inter-dealer and dealer-to-customer transactions on municipal GO bonds in real-time.[6] Following Novy-Marx and Rauh [2012], we focus on GO municipal bonds because they are backed by the full faith and credit of issuers. In contrast, revenue bonds are typically secured by specific revenue streams and have a more idiosyncratic risk profile that is difficult to measure. Focusing on GO bonds improves identification by allowing us to focus on the issuer's credit risk, rather than a combination of issuer and project credit risk. The raw data contain more than 1.44 million transaction records on more than 155,000 GO securities that were issued by more than 12,000 state and local government entities.

We scrub the bond trade data of potentially problematic records and outliers, following cleaning steps similar to Schwert [2017] and Green, Li, and Schürhoff [2010]. First, we drop yields that are above the 99.5 or below the 0.5 percentiles. This step removes unusual yields that might be erroneously reported while still keeping the legitimately high yields observed during the stress period peak. Second, we remove records for U.S. territories and the District of Columbia as well as trades with missing issuer state. 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, with missing trade dates, or having a value of zero for remaining maturity or principal

[6] The GO bond subsample was determined by the MSRB at our request. Transactions are reported to the MSRB with a 15 minute delay from the trade time. The data also includes a range of information about the trades and underlying bonds as described in Appendix B.

amount. We also exclude bonds issued during the pandemic to avoid selection bias.[7] After these cleaning steps, our sample includes about 1.38 million trades.

To analyze the data at a granular geographic level, we use a string parsing algorithm to determine each issuer's locality at the county level, or the state level if the issuer is a state government. The MSRB data doesn't directly provide counties associated with bond issuers; instead the locality information is embedded in the issuer name description. We rely on a string parsing algorithm detailed in Appendix C 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 example, "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 example, "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. We conduct our rolling window regressions at the county level; therefore, for bonds issued by cities, we use a county to city crosswalk provided by the USPS to assign each record with a county of issuer. 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.

We collect information on whether the bond is pre-refunded from Bloomberg. Schwert [2017] exploits within-bond changes in pre-refunded status using a long

[7]Results remain unchanged if we include bonds issued during the pandemic.

sample between January 1998 and June 2015 at monthly frequency. Because our data set covers only five months of trades, much of which is a severe stress period that hampered new debt issuance, we assume that the pre-refunded status isn't time varying. We pull pre-refunded indicators as of November 16, 2020 from Bloomberg. Details of pre-refunded bonds are discussed further in Section 4. In addition, we also match the transaction level data to ratings information from Moody's and S&P using the trade CUSIP.

Finally, we construct tax-adjusted municipal bond yields following Schwert [2017]. This adjustment accounts for the fact that most municipal bonds are exempt from taxes at the federal and state levels. To isolate the impact of policy interventions targeting municipal bonds, we use the tax-adjusted municipal spreads against Treasury yields with comparable maturities as the dependent variable in our baseline specifications. Daily Treasury yields are drawn from the Federal Reserve's H.15 release and linearly interpolated between yield curve points to match the remaining maturity on traded municipal bonds.[8]

3.3 Data Statistics

Table 1 reports summary statistics for the clean sample of daily municipal bond trades between January 2 and May 29, 2020. The average yield on securities in our sample is about 340 basis points while the average of tax-adjusted spread against comparable Treasury yields is about 242 basis points. Both these numbers reflect

[8] We have re-estimated all the results shown in the paper using the level of municipal bond yields, instead of the municipal spreads against comparable Treasury yields, as the dependent variable. These results are very close to those shown in the paper and are available upon request.

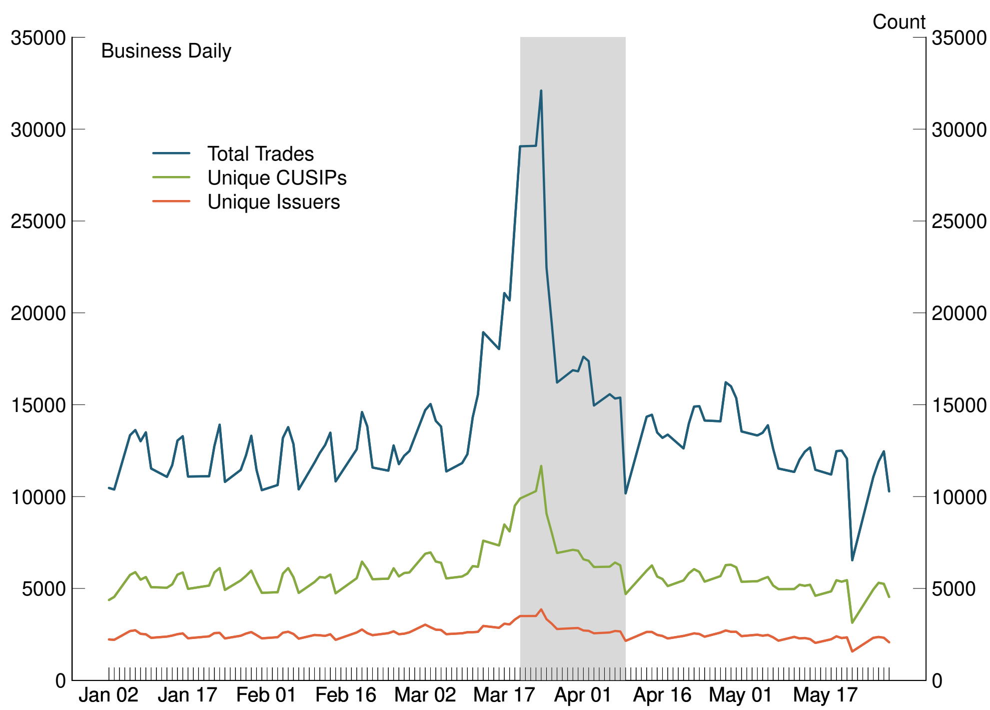
Table 1: Matched Sample Summary Stats

	Mean	Std. Dev	P25	P50	P75
Yield	339.780	157.190	216.034	313.352	423.225
Spread	241.702	170.970	112.780	216.932	335.910
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				
Ratings					
AAA	0.204				
AA	0.650				
A	0.079				
BBB	0.024				
BB	0.002				
B	0.000				
Below B	0.000				
Missing or Not Rated	0.040				
Pre-Refunded	0.047				
State Issuer	0.183				
County Issuer	0.234				
Observations	1,379,221				

Notes: Table presents summary statistics for the clean 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 observations of bonds issued by U.S. counties. Remaining observations were issued by sub-county level entities.

the severe financial stress that characterizes the majority of our sample period. The average security has a remaining maturity of just over 9 years. Although the average principal amount of an issue is rather large, at about $27 million, it reflects a few very large issues. The median principal amount of an observed trade is less than $4 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. Only 4 percent of bonds are not rated by either Moody's or S&P. Within the rated bonds, 20 percent have AAA ratings, 65 percent have AA ratings, and the remainder are rated A or below. Additionally, about 5 percent of the bonds in our sample are pre-refunded. Finally, about 20 percent of the trades were issued by states and another 20 percent were issued by county governments. The remainder were issued by municipalities, cities, or other sub-county levels of government.

Figure 3: Daily Trade Counts



Notes: Total trades are all trades reported in the MSRB transaction level data set. 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 3 shows that trading activities were unusually elevated in late March.

The figure suggests that investors were very likely to be attentive to news related to municipal bonds, and that policy interventions possibly had an immediate impact on trading activities. Specifically, trading activity was stable during January and February before increasing sharply in March. Trade volume peaked on March 24 when more than 30,000 transactions occurred. Transaction counts returned to more normal levels following the swift policy interventions in late March. In addition, bond trading across unique issuers followed a similar pattern to total trades with the number of uniquely traded issuers peaking in late March. This suggests that trading activity was broad across issuers rather than concentrated within a small set of issuers.[9]

4 Immediate Impact of Policy Interventions

As discussed in Section 2, Congress and the Federal Reserve took swift and unprecedented policy actions to address municipal bond market stress. However, each unique policy measure may have impacted municipal bonds differently. For example, the CARES Act provided direct support to the broad economy, including COVID mitigation funds for S&Ls. It also appropriated funds for the Federal Reserve to establish a lending facility that would directly purchase bonds from municipal issuers. At the same time, the Federal Reserve adopted a range of policy actions that operated through financial intermediaries, especially MMMFs, to indirectly target the municipal bond market. The effectiveness of those interventions likely varied de-

[9] Appendix D provides additional evidence that the municipal bond market was under acute stress in late March.

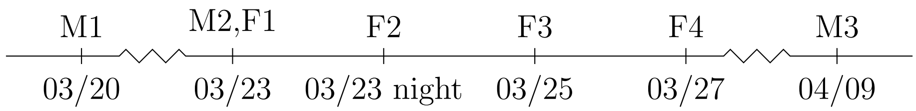
pending on how directly they intervened in the municipal market and whether they eased liquidity or credit risks.

We estimate the immediate effect of policy changes on the municipal bond market by conducting event studies within narrow trading windows around each policy announcement. Because policy developments evolved rapidly during March and April of 2020, the use of narrow windows helps minimize spillovers across news of policy events. To estimate the impact of fiscal impact, we use news of key legislative benchmarks leading up to, and including, the passage of the CARES Act. To estimate monetary policy action responses, we track Federal Reserve announcements indicating that facilities will accept or purchase municipal debt. We also estimate the effects of the announcement of the MLF, the facility operated by the Federal Reserve, and capitalized by the Treasury, to purchase newly issued, short-term municipal bonds.

Importantly, we study the channels through which each policy intervention affected the municipal bond market immediately following the announcement.[10] On one hand, liquidity strains observed in broader financial markets likely contributed to sell-offs in the municipal bond market. Thus, news about policy interventions that support the broader economy could immediately ease aggregate liquidity risks and help to stabilize municipal yields. On the other hand, the pandemic likely raised concerns about the ability of municipal bond issuers to service their existing debt. Policy interventions that directly affected the ability of S&Ls to issue and service debt would have alleviated those credit risks. Following Novy-Marx and Rauh [2012] and Schwert [2017], we use pre-refunded bonds as a control group because they are

[10]While we focus only on the immediate effects here, we estimate longer-term effects in Section 5.

Table 2: Timeline of 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 failed a procedural motion 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, and President signed into law;
M3: Federal Reserve's announcement on the MLF (announced at 8:30AM ET).

unaffected by credit risks but capture aggregate liquidity risks. Differential effects on non-pre-refunded bonds are interpreted as changes in the pricing of credit risk.

4.1 Event Studies with Narrow Trading Windows

Table 2 lays out the fiscal and monetary policy intervention timeline. The legislative activities associated with the CARES Act were largely concentrated in the last week of March. Federal Reserve actions targeting stress in the municpal bond market were carried out across the span of several weeks in late March and early April.

Using the real-time transaction data from the MSRB, we investigate each policy change within a narrow window around each policy announcement to minimize policy spillovers. We define the pre- and the post-event trades according to whether the trade occurred just prior to the announcement or after. The timing of these windows is summarized in Table 3. We estimate these effects using a sample of bonds that traded both before and after each policy announcement. 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 trades as all transactions that occurred on March 19, 2020 as well as those before 11 AM ET on March 20, 2020. The post-event trades consist of those occurring after 11 AM ET on March 20, 2020 and through the remainder of the day. We limit the analysis to bond CUSIPs that were traded in both the pre- and the post-event periods to improve identification and limit concerns about properly controlling for bond characteristics, including those that may be unobserved.

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.

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 that variable rate demand notes would be accepted as eligible collateral in the MMLF. The trading window for this event is set between March 20, the previous trading day, and March 23. One complication, however, is that on the same day, negotiations on the CARES Act were deadlocked when Democrats blocked a key procedural motion. In this case, 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. Similarly, 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. Finally, on April 9 at 8:30 AM ET, the Federal Reserve announced the establishment of the MLF program. The trading window for this event is set between April 8 and 9.

A potential concern with a narrow window event study, as we conduct here, is that the municipal market is typically illiquid, making such an approach unsuitable for studying this market. During normal times, municipal bond investors tend to hold bonds over long periods and trading activity may not react to high-frequency news. However, this was almost certainly not the case during the peak of the pandemic financial stress. Figure 3 shows elevated trading activities throughout March and April of 2020. Moreover, Li et al. [2021] highlight that the majority of municipal market trading during this period was not driven by retail investors, but rather tax-exempt mutual funds. These institutional investors are likely more attentive to policy news.[11] For these reasons, policy intervention news and announcements were likely to be quickly reflected in municipal bond yields during the unprecedented crisis.

It is also worth highlighting that trades included in our event studies aren't systematically different from those excluded from our analysis, alleviating potential concerns on selection bias. Table E3 in Appendix E provides summary statistics for CUSIPs within each event window. As an example, close to 33,000 trades were excluded from our event study sample for the first policy change which announced

[11] In Appendix F, we follow the approach in Duygan-Bump, Parkinson, Rosengren, Suarez, and Willen [2013] and demonstrate that the Federal Reserve's intervention through the MMLF successfully reversed outflows for tax-exempt money market funds that qualified for the program.

the acceptance of municipal securities into the MMLF. These trades are excluded because that CUSIP did not trade on either the day prior to, or the day of, the policy announcement. Instead our sample for this event includes more than 14,000 trades where the underlying security traded both just before and just after the policy change announcement. The summary statistics indicate that the two groups are not systematically different. The average tax-adjusted spread on included trades was 484 basis points while the average tax-adjusted spread for excluded trades was 469 basis points. Across all samples, our inclued trades may be slightly less risky than excluded trades. Sample securities, on average, had a slightly higher investment grade share, as well as larger principal and trading amounts more typical of larger issuers. Therefore, to the extent the sample tilts towards less risky bonds, our estimates should represent a lower bound in the effectiveness of policy interventions.

4.2 Immediate Impacts of Policy Interventions

We first estimate the immediate impacts of policy intervention announcements on municipal yields using the regression specification defined in equation 1.

$$spread_{b,t} = \beta_0 + \beta_1 I_t^{Policy} + \gamma X_{b,t} + \eta_b + \varepsilon_{b,t} \quad (1)$$

The dependent variable, $spread_{b,t}$, denotes the tax-adjusted municipal bond yield spread over a comparable maturity Treasury yield for bond b traded at time t.[12] I_t^{policy} is an indicator with a value of 1 for the period after the announcement and 0 prior to

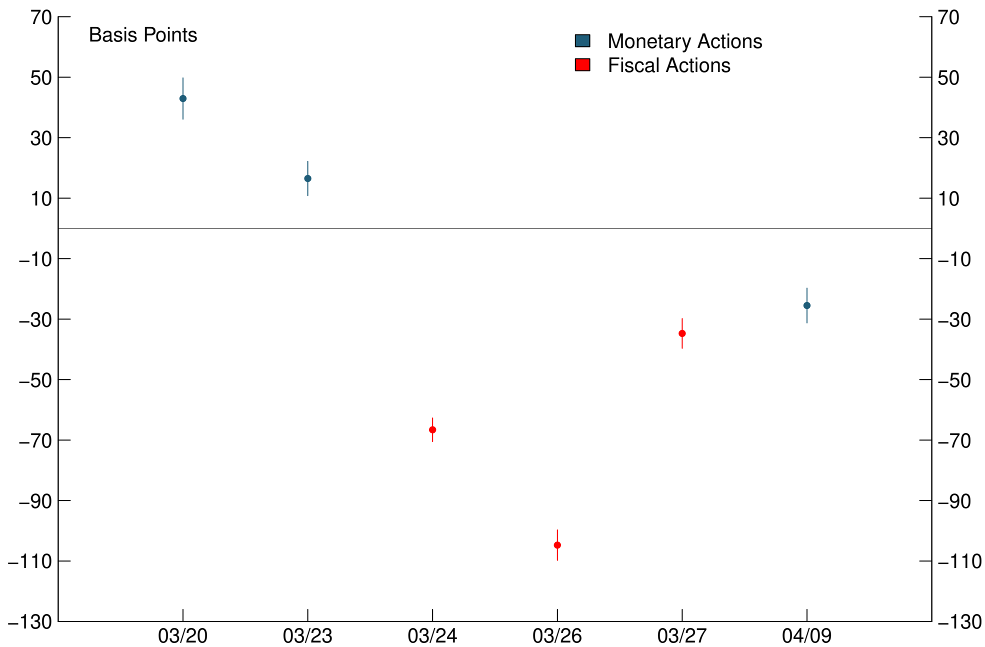
[12]The results across all specifications are qualitatively unchanged regardless we use the municipal spreads against Treasury yields or the level of municipal yields.

the announcement. The vector, $X_{b,t}$, is a set of trade specific controls that includes the log of trade amount and an indicator on whether the trade was a purchase or sale to a customer by the dealer. Standard errors are clustered at the issuer level.

Crucially, we include a CUSIP level fixed effect, η_b, that absorbs all time invariant security characteristics. By limiting our sample to securities that traded just before and just after the announcement, the fixed effect controls for time-invariant risks at the issuer and security level. For example, the fixed effect controls for demand for new funding at the issuer level, so long as demand remained constant over the two-day event window. Exploiting *within* CUSIP variation by controlling for the issuer and bond level characteristics sharpens our identification of the policy effect. The estimated coefficient β_1 is the marginal effect of the policy intervention announcement on bond spreads, conditional on the trade size and type, as well as time-invariant security characteristics.

The estimates from equation 1 are summarized by Figure 4 which shows point estimates on the average municipal bond spreads as well as 95 percent confidence intervals. The results demonstrate that Congressional passage of the CARES Act had a significant impact on stabilizing the municipal bond market. Tax-adjusted spreads of municipal securities against Treasuries declined following each policy development relative to their previous trading day as shown by the red dots. On March 24, the initial breakthrough on the fiscal stimulus package reached between Mr. Mnuchin and Mr. Schumer lowered tax-adjusted municipal spreads by more than 70 basis points. On March 26, unanimous passage of the CARES Act by the Senate led to a 110 basis point decline in spreads. The drop, which accounted for 25 percent

Figure 4: Immediate Impacts of Policy Announcements on Municipal Bond Yields



Note: The plot shows estimated coefficients from a regression of traded municipal bond spreads against Treasuries on an indicator for a monetary or fiscal policy intervention. The bond sample covers trades on the day just prior to the intervention and the day of the intervention. Control variables include CUSIP level fixed effects, log of the traded amount, and trade type.
Interventions are: 3/20 : Acceptance of certain municipal bonds into the Federal Reserve's MMLF; 3/23 : an expansion of municipal bonds accepted to the MMLF; 3/24 : Agreement between Senate and Administration leaders on the CARES Act; 3/26 : Passage of the CARES Act through the U.S. Senate; 3/27 : Passage of the CARES Act through the U.S. House and Enactment; 4/9 : Announcement of the Federal Reserve's MLF.

of the average municipal spreads against Treasuries at the time, was the largest estimated decline across all policy announcements. The final passage of the CARES Act by the House on March 27 further reduced spreads by 30 basis points. All the estimates are both statistically and economically significant. Cumulatively, the series of positive fiscal news lowered municipal spreads by more than 200 basis points, which is extraordinary given that tax-adjusted spreads averaged 400 basis points between March 19 and April 9.

Turning to monetary policy, Figure 4 shows that the MLF, the Federal Reserve's direct intervention in the municipal bond market with a credit backstop, was much more effective than earlier indirect interventions through the MMLF programs. The initial inclusion of municipal securities in the MMLF on March 20 appears to have failed to stabilize municipal spreads on average. On the following Monday, March 23, the terms of the MMLF were expanded to include certain variable rate demand notes. This policy announcement did not appear to stabilize the overall municipal bond market either. However, this estimate is likely to reflect the deadlock in the CARES Act negotiations, again highlighting the importance of fiscal policy to municipal bond investors. In contrast, the announcement of the dedicated MLF facility on April 9 lowered spreads by close to 30 basis points, a similar effect to final passage of the CARES Act in the House.

The comparison across different monetary policy responses highlights that indirect policy interventions through the MMLF program had limited immediate success in reducing municipal yields across maturities. The MMLF program worked exclusively through money market mutual funds. The Federal Reserve accepted municipal bonds as collateral in exchange for short-term loans to money market mutual funds. These programs aided the municipal bond market by providing liquidity to key municipal bond investors but without requiring the Federal Reserve to make outright purchases of municipal debt directly from issuers. As shown in Section F, the MMLF program was successful in reversing fund outflows from the money market mutual funds. However, the effectiveness of these facilities in the secondary municipal bond market appears more limited. This is likely because money market funds found the loans helpful for raising cash to meet redemption requests, but had little demand to continue investing in municipal securities, perhaps due to increased short-term credit risk. These risks were directly addressed by the announcement of the MLF, through which the Federal Reserve could directly purchase municipal bonds from issuers. The MLF announcement was accompanied by an immediate decline in municipal yields. The different impacts likely reflect that the MMLF provided a way for holders of municipal securities to liquidate their bond holdings but did not provide any assistance to S&Ls that were struggling to make debt payments. The MLF, however, provided a way for S&Ls to issue new debt, and facilitated the rollover of expiring debt, into new issues. This facility, therefore, provided critical funds to S&Ls while also supporting current debt holders.

4.3 Liquidity vs. Credit Risks

We next study each policy intervention's ability to stabilize the municipal bond market by affecting either credit or liquidity pricing risks. Following Novy-Marx and Rauh [2012] and Schwert [2017], we use pre-refunded bonds as a control group to capture aggregate liquidity risks. Pre-refunding is a common strategy for refinancing municipal bonds before their callable date [Chalmers, 1998]. A bond is considered pre-refunded when new bonds, called "refunded" bonds, are issued with proceeds designated to service the existing bond. The refunded bond proceeds are used to purchase Treasury securities that are then deposited into an escrow account. The escrow account's cash flows are structured to exactly mimic the interest payments of the "pre-refunded" bond. The pre-refunded bond is considered fully collateralized because the associated principal and interest payments are paid exclusively from the income derived from the escrow account.

To explore how policy interventions affect liquidity and credit risks, we interact the policy intervention indicator with an indicator for bonds that are non-pre-refunded, denoted as I_b^{pre} in equation 2. Therefore, we compare spreads on pre-refunded and non-pre- refunded bonds to determine how policy interventions affected credit risks.

$$spread_{b,t} = \beta_0 + \beta_1 I_t^{policy} + \beta_2 I_t^{policy} I_b^{npre} + \gamma X_{b,t} + \eta_b + \varepsilon_{b,t} \quad (2)$$

Our identification crucially depends on the distinct funding schemes underlying pre-refunded and non-pre-refunded bonds. Because pre-refunded bonds are fully collateralized, they are exposed to liquidity risks associated with Treasury securities. However, the are unlikely to be affected by issuer credit risks. Non-pre-refunded bonds, on the other hand, are directly exposed to issuer credit risks, as well as liquidity risks.

As reported in Table 4, the estimated results highlight that policy intervention announcements had an immediate impact on municipal yields by lowering liquidity risks. Municipal bond market credit risks, as reflected by differential changes on non-pre-refunded bonds, were not immediately impacted. Columns (1) to (3) show that news of the passage of the CARES Act significantly reduced municipal yields by an

Table 4: Immediate Impacts of Annoucements of Policy Interventions on Muni Spreads: pre-refunded vs. non-pre-refunded bonds

	(1) Agreement	(2) Senate	(3) House	(4) MMLF	(5) MMLF Revised	(6) MLF
Intervention	-54.961***	-110.324***	-36.263***	19.836*	25.276*	-21.809**
	(6.755)	(8.052)	(7.339)	(10.637)	(13.875)	(10.126)
Intervention × *Not Prerefunded*	-12.229*	5.826	1.625	24.412**	-9.390	-3.844
	(7.129)	(8.387)	(7.532)	(10.779)	(14.303)	(10.122)
Observations	16,956	10,039	8,925	14,212	14,410	4,884
Adjusted R^2	0.69	0.81	0.79	0.69	0.67	0.92

Notes: Each column represents an event study where the indicator *Intervention* takes the value of 1 for bonds traded after the intervention announcement. The sample includes bonds traded on the day of the announcement and the day prior. Regressions include log of trade amount and indicators for trade type.
Issuer domicile state clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

average of 67 basis points.[13] The interaction term between policy intervention and the non-pre-refunded bond indicator β_2, however, is largely insignificant throughout the CARES Act negotiations and passage, meaning there were no additional declines in spreads of non-pre-refunded bonds when compared to pre-refunded bonds. Therefore, policy development announcements stabilized the municipal bond market, at least initially, by reducing liquidity risks. Credit risk concerns were not immediately eased for municipal issuers by these announcements. Columns (4) through (6) show a similar finding for monetary policy interventions. The interacted term is insignificant when the Federal Reserve announced an expansion to MMLF eligibility and when the MLF was launched. At the initial inclusion of municipal notes to the MMLF, the interaction term is even positive and significant in column (4), likely reflecting a deteriorating credit outlook at the beginning of the pandemic.

Because all pre-refunded bonds have maturity of more than 1 year, we provide a

[13] The effects ranged from 36 basis points for final passage by the House to 110 basis points when Senate passage occurred. The bill's survival was in doubt in the days leading up to Senate passage due to disagreements between party leaders. An agreement between the U.S. Treasury and Senate leadership helped drive a 55 basis point decline in spreads due to the increased probability of a fiscal support measure.

robustness check with a narrower sample by excluding all bonds with maturity less than one year. Table 5 shows that the results are unchanged in this alternative sample that includes only non-pre-refunded bonds with similar maturities as pre-refunded bonds.

Table 5: Immediate Impacts of Annoucements of Policy Interventions on Muni Spreads: pre-refunded vs. non-pre-refunded longer-term bonds

	(1) Agreement	(2) Senate	(3) House	(4) MMLF	(5) MMLF Revised	(6) MLF
Intervention	-57.721***	-112.733***	-37.980***	16.985	24.743*	-23.379**
	(6.886)	(8.089)	(7.471)	(10.824)	(13.977)	(10.339)
Intervention × Not Prerefunded	-7.710	9.229	6.981	31.374***	-7.610	-1.621
	(7.188)	(8.357)	(7.558)	(10.937)	(14.319)	(10.296)
Observations	15,401	9,071	8,242	13,037	13,371	4,580
Adjusted R^2	0.71	0.82	0.82	0.71	0.69	0.94

Notes: The samples include bonds traded on the day of the announcement and the day prior, and also excluded bonds with remaining maturity of less than 1 year. Each column represents an event study where the indicator *Intervention* takes the value of 1 for bonds traded after the intervention announcement. Regressions include log of trade amount and indicators for trade type.
Issuer domicile state clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.4 Short- vs. Long-term Bonds

The CARES Act provided pandemic relief funds to S&Ls aimed at their near-term spending needs. The Federal Reserve's interventions also targeted short-term municipal bonds. To this end, it is important to differentiate effects of these policy announcements across municipal bond maturities. Our next exercise explores the immediate impacts of policy interventions by splitting our samples into short- and long-term bonds.

As specified in equation 3, we modify our baseline specification to include an interaction term between the policy intervention indicator and a short-term debt indicator.

$$spread_{b,t} = \beta_0 + \beta_1 I_t^{policy} + \beta_2 I_t^{policy} I_b^{ST} + \gamma X_{b,t} + \eta_b + \varepsilon_{b,t} \tag{3}$$

The maturity indicator, I_b^{ST}, is a proxy for the maturity eligibility criteria for the Federal Reserve programs. It is assigned a value of 1 for securities with remaining maturities that meet the eligibility cutoff and 0 otherwise. The MMLF program only accepted securities with remaining maturity of 12 months or less, and the maturity eligibility criteria for the MLF program is two years or less.[14] We explore both 1 year and 2 year remaining maturity cutoffs in our analysis. 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.

Starting with monetary policy, Table 6 shows that Federal Reserve interventions were successful in lowering short-term bond spreads. Columns (1) and (2) show that the initial inclusion of municipal securities in the MMLF was accompanied by higher spreads on longer-term municipal bonds; but compared to those longer-term bonds, spreads of bonds with remaining maturity of less than one or two years declined by between 50 to 70 basis points. Overall, the initial intervention through the MMLF lowered spreads on bonds with remaining maturity less than one year, which were the policy target, as shown by $\beta_1 + \beta_2$. Similarly, the extended MMLF intervention also lowered short-term yields by 22 to 30 basis points when compared to longer-term bonds. The smaller impact, compared to the initial policy action, may reflect the deadlocked CARES Act negotiations in Congress on the same day. Finally, the announcement of the MLF on April 9 lowered yields for long-term bonds by about

[14]The MLF maturity eligibility was later expanded to 36 months on April 27.

23 basis points and an additional 20 to 25 basis points for short-term bonds.

Table 6: Immediate Impacts of Announcements of Federal Reserve Interventions on Muni Spreads: Short- vs. Long-term Bonds

	(1) MMLF	(2) MMLF	(3) MMLF Revised	(4) MMLF Revised	(5) MLF	(6) MLF
Intervention	48.841***	52.055***	18.623***	20.062***	-23.944***	-22.525***
	(3.441)	(3.412)	(2.666)	(2.680)	(2.667)	(2.636)
Intervention × *One Year Debt*	-72.690***		-29.628*		-26.751	
	(15.035)		(17.138)		(19.864)	
Intervention × *Two Year Debt*		-52.986***		-22.506**		-21.480**
		(8.811)		(9.851)		(9.973)
Observations	14,212	14,212	14,410	14,410	4,884	4,884
Adjusted R^2	0.69	0.69	0.67	0.67	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. Regressions include log of trade amount and indicators for trade type.
Issuer domicile state clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Turning to fiscal policy interventions, the passage of the CARES Act led to significant reductions in spreads for short-term bonds and even larger declines for long-term bonds, as shown in Table 7. The fiscal stimulus package agreement between the U.S. Treasury and Senate leadership lowered long-term bond spreads by about 60 basis points. Shorter-term bond spreads fell by about 100 basis points as shown by the estimates of $\beta_1 + \beta_2$ in column (1) and (2). The unanimous passage of the CARES Act by the Senate reduced long-term bond spreads by more than 100 basis points, and short-term spreads by an additional 25 basis points on average across specifications. Finally, the passage by the House reduced spreads for longer-term municipal bonds by more than 25 basis points and spreads on short-term bonds by an additional 40 to 60 basis points. Those estimates are statistically and economically significant.

Taken together, when focusing on a narrow trading window around policy announcements, we find that fiscal policy interventions, as well as direct monetary

Table 7: Immediate Impacts of Announcements of Fiscal Policy Interventions on Muni Spreads: Short- vs. Long-term Bonds

	(1) Agreement	(2) Agreement	(3) Senate	(4) Senate	(5) House	(6) House
Intervention	-62.810***	-58.908***	-102.144***	-100.441***	-29.576***	-27.502***
	(1.865)	(1.866)	(2.499)	(2.801)	(2.296)	(2.440)
Intervention × One Year Debt	-42.805***		-27.357**		-64.712***	
	(10.954)		(11.677)		(17.300)	
Intervention × Two Year Debt		-41.846***		-22.834***		-40.999***
		(6.498)		(6.642)		(8.521)
Observations	16,956	16,956	10,039	10,039	8,925	8,925
Adjusted R^2	0.70	0.70	0.81	0.81	0.79	0.79

Notes: Each column represents an event study where the indictor *Intervention* takes the value of 1 for bonds traded after the announcement. Regressions include log of trade amount and indicators for trade type.
Issuer domicle state clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

policy interventions with a backstop, had a significant and immediate impact in stabilizing municipal bond yields across maturities. Indirect monetary policy interventions that operate through financial intermediaries were successful in lowering spreads on short-term bonds, while their impacts on long-term bonds were limited. Importantly, we find that, at least within a narrow trading window, the policy announcements stabilized the municipal bond market by lowering liquidity risks rather than alleviating credit concerns about municipal issuers.

5 Impact of Policy Interventions Over Time

In the previous section, we estimated the immediate impact of policy announcements by focusing on a narrow window. However, it may take time for policy interventions to play out and for investors to fully price in policy changes. In this section, we estimate how the impact of fiscal and monetary policy interventions manifested over a longer period of time. A downside of our approach, though, is it does not provide an understanding of an individual policy's overall impact. Instead, we must interpret these results as the long-term, cumulative impact of policies supporting the municipal bond market.

5.1 Rolling Window Regressions

To explore the liquidity and credit risk channels over time, we compare spreads on pre-refunded and non-pre-refunded bonds using a rolling-window regression as shown in equation 4.

$$spread_{i,t}(n) = \alpha_{c,t}(n) + \beta_t(n)I^{npre}(n) + \gamma_t(n)X_{i,t}(n) + \varepsilon_{i,t}(n) \quad (4)$$

The rolling window width is n trading days. We construct a security, trading day panel using the trade data by averaging trade specific measures, such as prices and spreads, by CUSIP identifier. Because the rolling window estimates are averages, this prevents the estimation from being dominated by a very liquid security with a large number of trades on a single day. It also allows us to include security level controls that do not vary across trades in a given day. While better identification could be achieved with a CUSIP level fixed effect, as done previously, we would need to restrict the sample to securities that only traded multiple times in the same day. This could introduce selection bias into our estimates by leaving us with only the most liquid securities traded.

Using the security-trade day panel, we proceed with the daily estimation as follows. The dependent variable is the average tax-adjusted spread against comparable maturity Treasury yields on municipal bond i from an issuer in county c in state s

that was traded on day t. $I^{npre}(n)$ is the indicator for non-pre-refunded bonds. The vector, $X_{i,t}$, is a set of bond-specific controls that includes the log of the remaining maturity, the log of trade amount, the log of principal amount, and indicators for whether the security was rated as investment grade, speculative grade, or not rated. We also include the share of trades for security i that were not dealer to customer.[15] Importantly, we include a county-time fixed effect, $\alpha_{c,t}$, and therefore compare the yields on traded bonds within counties on the same day. These fixed effects pick up time-varying changes at the county level that may affect both pre-refunded and non-pre-refunded bonds.[16] Standard errors are clustered at the state level.

As with the event studies, our identification crucially depends on the distinct funding schemes underlying pre-refunded and non-pre-refunded bonds. Most notably, pre-refunded bonds do not have credit risk while non-pre-refunded bonds do. Therefore, $\beta_t(n)$ represents the average credit risk premia that investors charge on non-pre-refunded bonds over pre-refunded bonds during the rolling window, after controlling for county and bond specific characteristics.

Figure 5 shows the estimated path of $\beta_t(n)$ with a rolling window of one day.[17] As expected, the estimated credit risk premia, defined as the difference in conditional spreads between non-pre-refunded and pre-refunded bonds denoted by β_t in equation 4, are positive and significant throughout the sample. Credit risk premia were largely

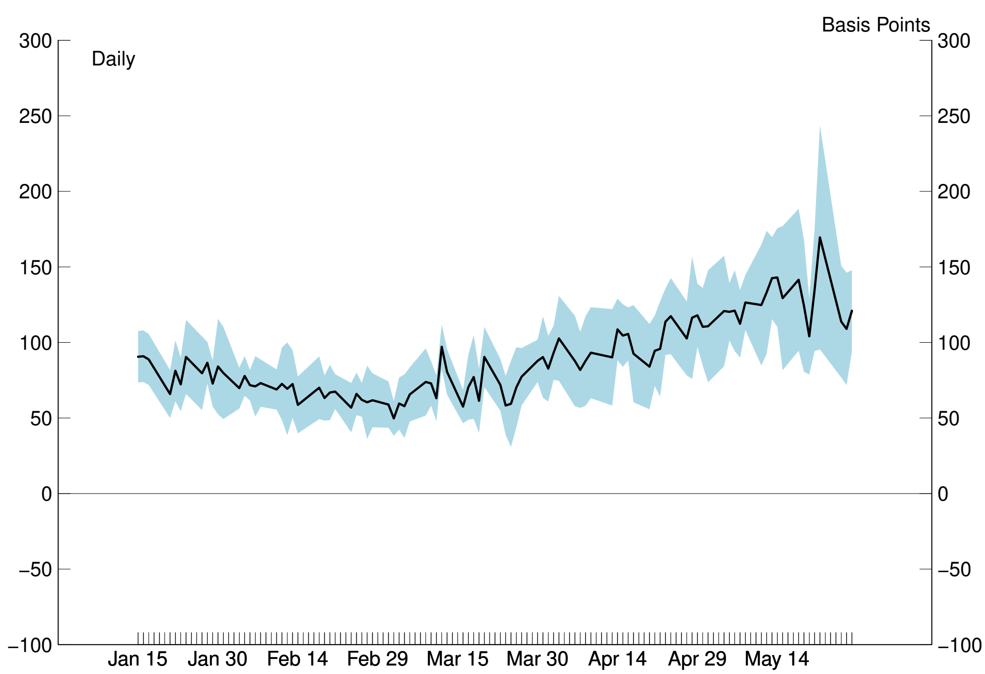
[15]Specifically, we calculate the share of all daily trades that were dealer-to-customer and customer-to-dealer. The dealer-to-dealer share is the omitted group so that shares do not sum to one.

[16]In the case of $n = 1$, the county-time fixed effect becomes a county fixed effect that controls for average effects within the county on that day. Therefore, the fixed effect controls for unobserved county characteristics that affect bond yields.

[17]Longer rolling windows generate smoother estimates, but the results are qualitatively unchanged. Additional results are available upon request.

stable from January to early April as the pandemic unfolded across the United States. These results suggest that liquidity risk was the driving factor for municipal bond yields *on average* during the early days of the pandemic because both pre-refunded and non-pre-refunded spreads increased commensurately. A surge in liquidity risk pricing would also be consistent with problems experienced in other markets during this time that also lacked significant credit risk, such as the U.S Treasury market [He, Nagel, and Song, 2022].

Figure 5: Rolling Window Regressions: Credit Risk Premia of Non Pre-Refunded Bonds



In April and throughout May, however, credit risk premia began to increase notably before reaching about 120 basis points. The late timing of the increase in average spreads seems puzzling at first glance. By pooling municipal bonds across maturities, however, Figure 5 potentially masks the distinct impacts of policy interventions on short-term and longer-term bonds. Because federal support programs largely targeted short-term municipal bonds, we expect these policies will have differential effects depending on a bond's remaining maturity. Moreover, our results likely reflect long-tem bond effects because they make up the bulk of the market. Said differently, the notable rise in credit risk premia shown in Figure 5 potentially captures an increase in credit risk premia demanded by investors on longer-term, non-pre-refunded municipal bonds following the interventions because these securities were provided less public support and left more exposed to credit risks created by the pandemic.

5.2 Liquidity and Credit Risk Across Maturities

To understand pricing differences across maturities, we split the data sample based on bond maturity. Specifically, when estimating the rolling-window regression in equation 4 (with $n = 1$), we separate the non-pre-refunded bonds into three groups: 1) short-term bonds with remaining maturity less than one year, 2) long-term, non-pre-refunded bonds with remaining maturity longer than one year, and 3) long-term, pre-refunded bonds with remaining maturity greater than one year.[18] Across these three groups, we consider two comparisons to estimate changes in credit risk premia. In the first case, we *exclude* long-term, non-pre-refunded bonds in order to

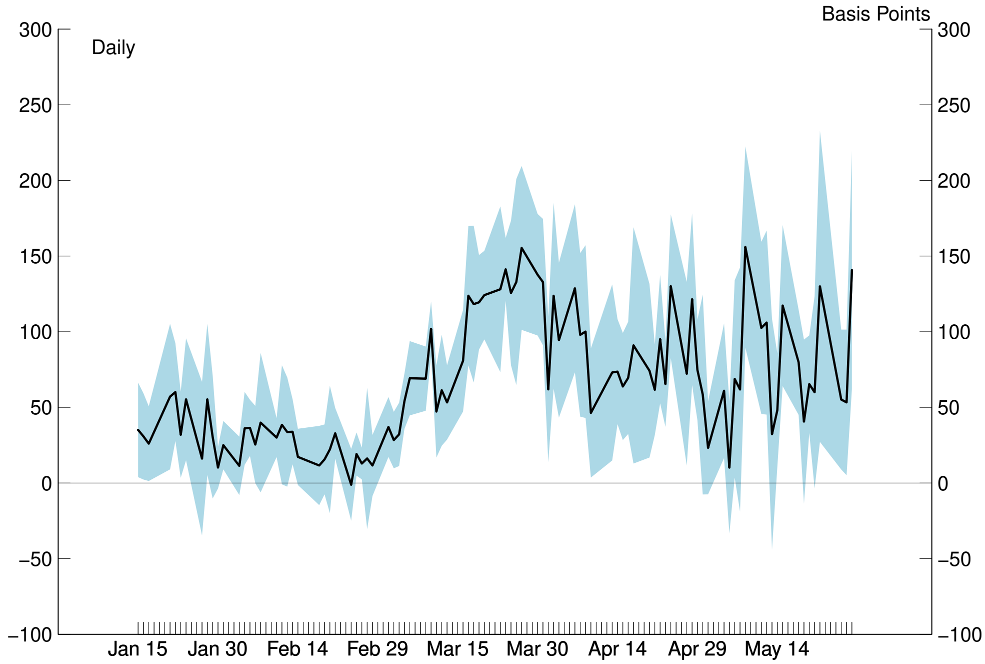
[18]Our sample does not contain any pre-refunded bonds with maturities less than one year.

compare spreads on short-term, non-pre-refunded bonds and spreads on long-term, pre-refunded bonds. In the second case, we limit the comparison between long-term, non-pre-refunded bonds and pre-refunded bonds by *excluding* short-term, non-pre-refunded bond. In both comparisons, we leverage the fact that non-pre-refunded bonds lack any credit risk premia, so that the estimated $\beta_t(n)$ reflects the credit risk premia on the non-pre-refunded group. All regressions control for remaining maturity and other bond specific fixed effects as previously discussed.

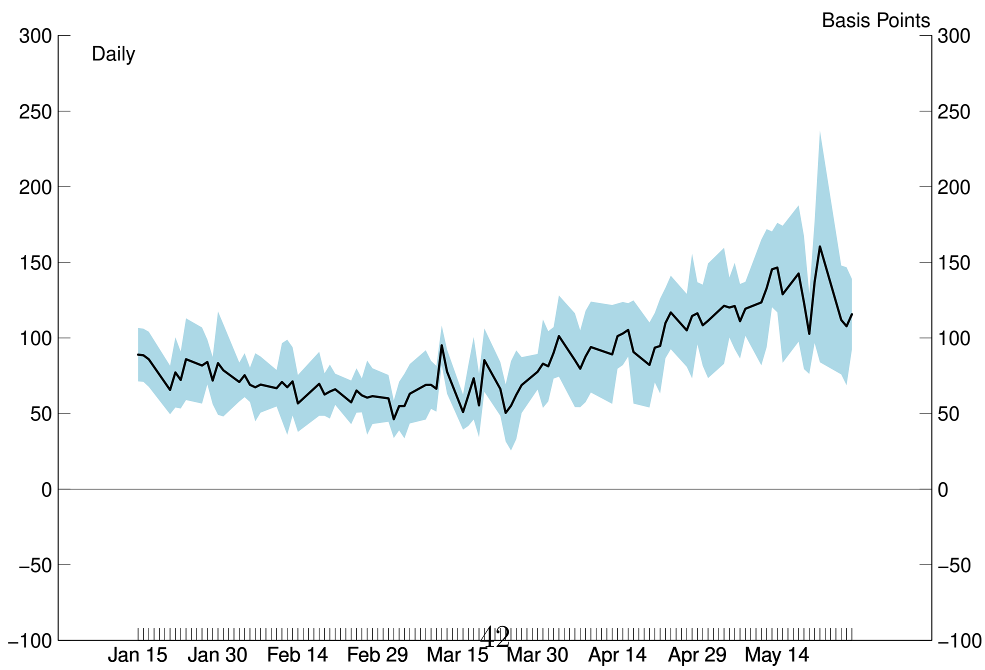
As shown in Figure 6a,the daily estimated β_t, which denotes the credit risk premia for short-term, non-pre-refunded bonds, increased sharply during the early days of the pandemic. Short-term spreads rose steadily from mid- to late-March and, at their peak, were more than 150 basis points above spreads on long-term, pre-refunded bonds. This contrasts with short-term spreads less than 50 basis points above pre-refunded spreads prior to the pandemic. The result indicates that credit risks were an important component of observed short-term debt spreads. Indeed, the immediate impact, as well as the perceived temporary nature of the pandemic in the Spring of 2020, likely contributed to the sharp rise in short-term debt spreads driven, in part, by credit concerns. 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.

Figure 6: Credit Risk Premia of Non-Pre-Refunded Bonds by Maturity

(a) Short-term Bonds



(b) Long-term Bonds



Looking out over a longer horizon, credit risk premia on short-term, non-pre-refunded bonds remained at an elevated level in late March but declined after a series of fiscal and monetary policy interventions were announced. The elevated credit risk premia during late March are consistent with the event studies in Section 4, which show that within a narrow trading window, those policy announcements had a very limited immediate impact on the pricing of credit risks. However, credit risk premia on short-term bonds declined steadily throughout April, falling by 70 basis points during the month.[19] We conclude from this result that policy interventions successfully eased credit concerns over time for short-term debt.

In contrast, Figure 6b shows that the pandemic and policy interventions had a drastically different impact on the price of credit risk for long-term, non-pre-refunded bonds. Credit risk premia were largely stable from January to early April. Estimated credit risk premia even narrowed somewhat in February, declining from 80 basis points to about 50 basis points. In March, as the pandemic picked up speed and the financial crisis peaked, spreads on long-term, non-pre-refunded bonds returned to pre-pandemic levels compared to pre-refunded bonds, though this increase is not notable. Compared to short-term, non-refunded bonds shown in Figure 6a, changes in credit risk premia for long-term bonds were small at the peak of the crisis, indicating much of the average spread increase was due to market illiquidity. In the Spring of 2020, lockdown measures were taken in the hope that the spread of the virus would be contained quickly and normal economic activities would resume quickly, which

[19] In line with a return to more normal market operations, trading activity increased somewhat following an expansion of the MLF eligibility rules. This expansion also corresponded with a noticeable, but short-lived, increase in spreads during May, likely due to the continued thawing of municipal debt markets, including a willingness to trade riskier securities.

likely insulated longer-term bonds from heightened credit risk concerns initially.

However, credit risk premia for long-term bonds increased steadily throughout April and May, reaching over 130 basis points, on average, in mid-May. These spreads are quite elevated when compared to spreads of around 70 basis points before the pandemic. The increase in credit risk premia for longer-term bonds likely reflected two factors. First, with the pandemic continuing to drag on, investors turned their focus to long-run credit concerns, as they expected a more bread-and-butter recession dynamic, rather than a financial panic, to follow the pandemic. Second, the establishment of the MLF, a joint effort by the Federal Reserve and the Treasury, provided a way for municipalities to issue short-term bonds. However, these programs didn't directly address long-run credit concerns for S&L issuers and left investors exposed at longer maturities.

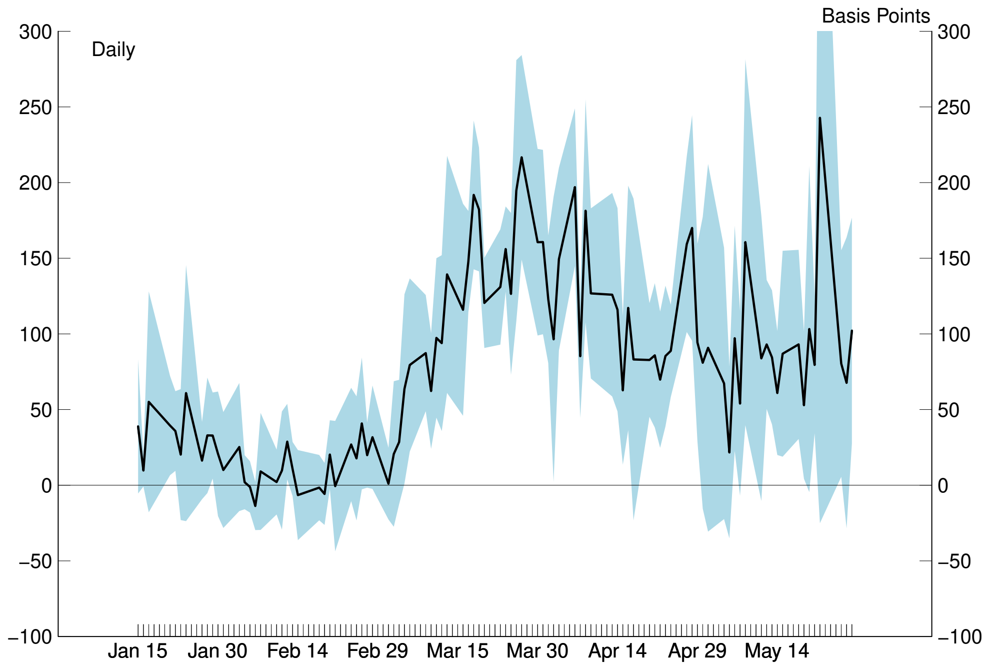
Overall, the comparison between Figures 6a and 6b highlights that policy interventions aimed at short-term bonds, as well as the pandemic, had drastically different impacts on bonds with different maturities. At the onset of the pandemic, near-term credit risks associated with shelter-in-place mandates and involuntary social distancing weighed on short-term, but not long-term, yields. Policy interventions successfully eased credit risks for short-term bonds by directly purchasing municipal bonds in the primary market and providing pandemic-related relief funds to state and local governments. However, long-run credit concerns became more prominent as the hope for a quick economic rebound were dashed and investors embraced a slower recovery.

5.3 Robustness Checks

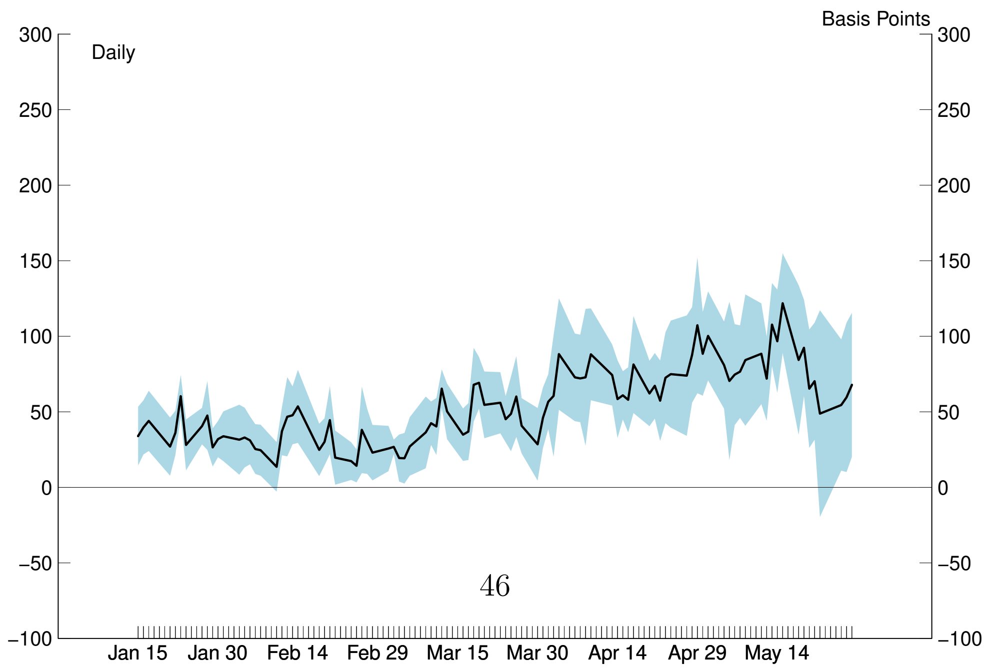
In this section, we explore alternative data samples to check the robustness of our results. Our baseline sample presented above uses only trades that can be matched to counties, thereby excluding state government issuers, in order to use a county-level fixed effect. This fixed effect controls for unobserved changes to the risk profile of counties, and because we use daily data, offers a higher frequency measure than most observable data can provide. The downside to that approach, however, is that we may be over-estimating the impact of policy interventions. All else equal, smaller governmental units are typically more risky, as they have fewer revenue sources and smaller budgets to cut during emergencies. By excluding state government issuers, we may bias our estimates upward for these reasons.

To address this concern, we follow Novy-Marx and Rauh [2012] and construct a sample of bonds issued by state governments. That is, we drop all bonds issued by counties, cities, or other municipalities. This sample, which contains 220,013 bond-day observations, provides a way to strictly compare pre-refunded and non-pre-refunded bonds from the same state issuer. Our regression specification is identical to the previously estimated specification, except that the county-time fixed effect is replaced with a state-time fixed effect. In this sample of only state-level issuers, the state fixed effect is equivalent to an issuer fixed effect. Standard errors are again clustered by state.

Figure 7: Credit Risk Premia of Non-Pre-Refunded Bonds by Maturity: State Government Issuers Only



(a) Short-term Bonds

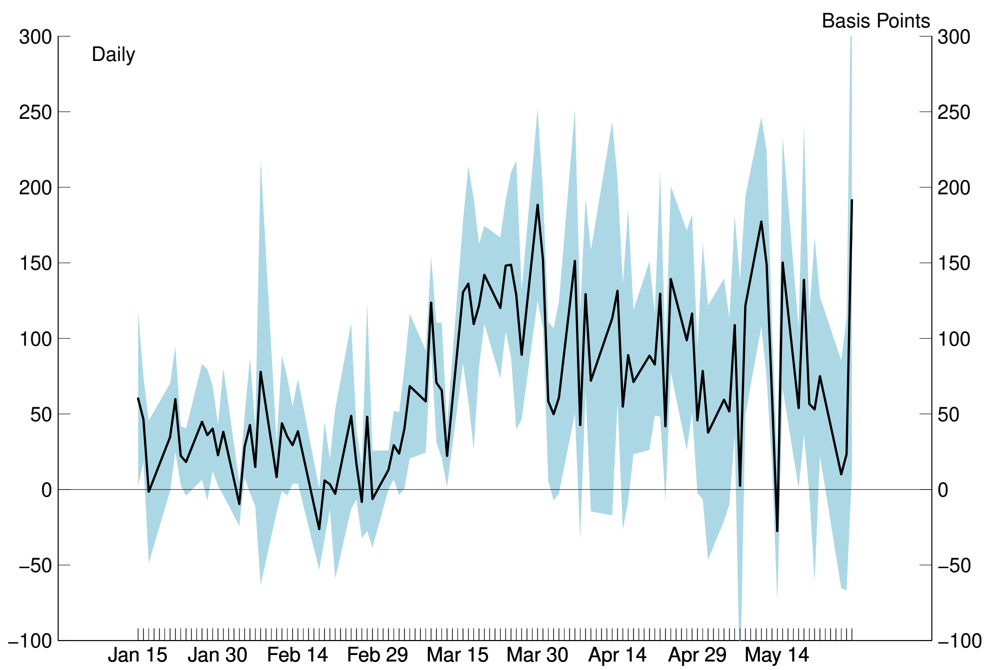


(b) Long-term Bonds

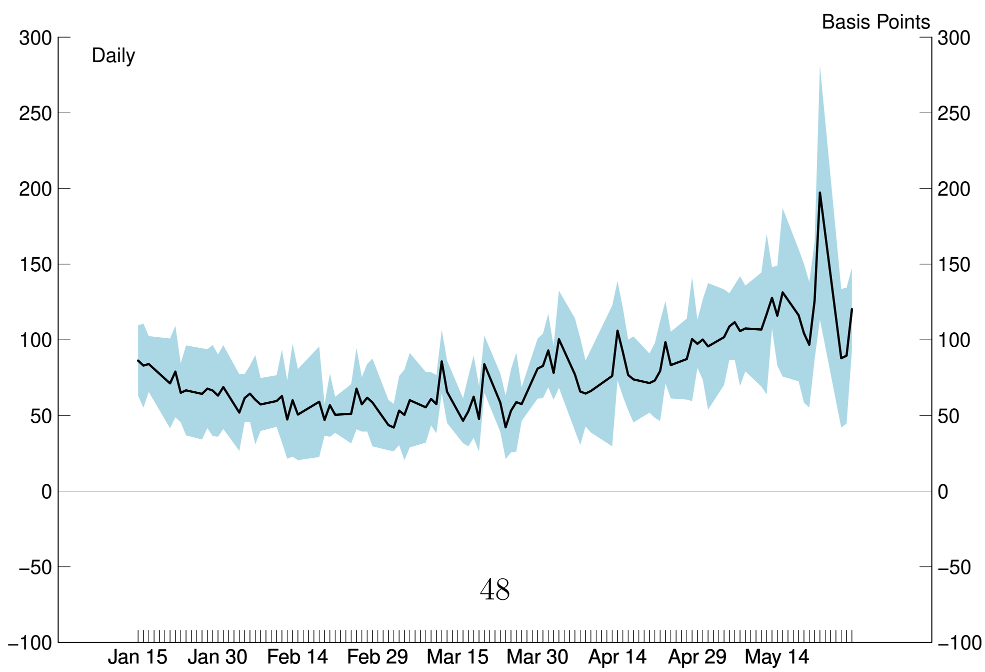
The distinct impacts of policy interventions as well as the pandemic on short- versus longer-term bonds remain unchanged in this case. Figure 7a shows the estimates of $\beta_t(n)$ comparing short-term, non-pre-refunded bonds with pre-refunded bonds among state issuers. Credit risk premia surged for short-term bonds during the peak of the crisis, but declined following policy interventions. Figure 7b, on the other hand, shows that longer-term bonds saw steady increases in their risk premia after April. The comparison is very similar to the baseline case, although the estimates are more volatile. Consistent with broader support for states compared to counties and municipalities, though, longer-term spreads are notably lower in this sample than the county-matched sample.

A second concern with our estimation is omitted variable bias. Schwert [2017] cautioned against using a market-wide pool of pre-refunded bonds with no controls for omitted issuer or bond-specific factors. We address this concern in our baseline case using only county-matched bonds in order to include a county-time fixed effect and hence compare bonds within the same county. In addition, we also include bond-specific controls. However, Schwert [2017]'s concern is particularly valid during a crisis when issuer qualities may change quickly and suddenly. Therefore, we go a step further and constrain the data sample to issuers that have both pre-refunded and non-prerefunded bonds traded on the same day. With this sample, we modify our specification to include an issuer fixed effect that controls for issuer-specific unobservables. We also include the security-level controls as before. This restriction leads to a smaller data sample, with 97,463 bond-day observations.

Figure 8: Credit Risk Premia of Non-Pre-Refunded Bonds by Maturity: Issuers with Pre- and Non-Pre-Refunded Bonds



(a) Short-term Bonds



(b) Long-term Bonds

The result again indicate that the comparison of credit risk premia between short-term and longer-term bonds is very similar to the baseline case, albeit the estimates are more volatile. As shown in Figures 8a and 8b, short-term bond spreads peaked around late-March before declining with policy support. On the other hand, longer-term spreads remained muted through the worst of the crisis before starting to rise gradually in April. Spreads peaked at more than 100 basis points above comparable pre-refunded bond spreads, an economically meaningful amount.

5.4 Credit Risks Across Ratings

Lastly, we explore how credit risk pricing changed across bond ratings. As shown in equation 5, we regress a pricing measure of bond i on its non-pre-refunded status, a rating threshold indicator, and a policy intervention indicator. We interact these indicators to give a triple-difference model. The triple interaction estimates how the difference between pre-refunded and non-pre-refunded bond spreads among high- and low-rated issuers changed following federal interventions into the municipal market.

$$\begin{aligned} \rho_{i,t} &= \alpha_{s,t} + \beta_1^r I_i^{rate} + \beta_1^n I_i^{npre} \\ &+ \beta_2^{rp} I_i^{rate} \times I_t^{policy} + \beta_2^{rn} I_i^{rate} \times I_i^{npre} + \beta_2^{np} I_i^{npre} \times I_t^{policy} \\ &+ \beta_3 I_i^{rate} \times I_i^{npre} \times I_t^{policy} + \gamma^c X_{c,t} + \gamma^i X_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{5}$$

We use the bond yield, as well as the spread between municipal bond yields against comparable maturity Treasury yields, as the dependent variable $\rho_{i,t}$. The policy indicator I^{policy} is 1 for periods after April 9, 2020, the date of the last policy announced policy intervention in our sample, the Federal Reserve's MLF. The rating dummy is 1 for bonds with ratings below a certain threshold. We explore two rating thresholds: AA & below and A & below. About 10 percent of bonds in our sample are rated at or below the A level, with BBB rated generally being the lowest rated class. We also categorize bonds that are not rated under the rating threshold of A & below because issuers may choose not to get a rating if they are more likely to receive a poor rating.

In addition to a state-time fixed effect, we also include county-level controls, including COVID cases per 100 residents, hospitals per 1000 residents, and the share of COVID affected employment. Specifically, we pair the MSRB transaction data with several data sets on local pandemic measures.[20] Daily county COVID case totals are from the New York Times, and the total number of hospitals per county level are from the Department of Homeland Security.[21] Using county population totals in 2019 from the Census Bureau, we derive per-capita measures for both COVID-19 cases and the 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, with industries in the bottom quartile being considered the most affected. We then take these 3-

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

[21]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.

digit industry codes and calculate the share of employment in these affected sectors for each county as of 2019:Q4 using the BLS' Quarterly Census of Employment and Wages.

In general, bonds that are not pre-refunded or have very low ratings had higher yields. As shown in the first row of Table 8, bonds that are not pre-refunded had higher yields and spreads across the whole sample, as investors demanded to be compensated for credit risks. We also find that bonds with ratings at A or below had higher yields and spreads, but the difference becomes insignificant when we compare bonds using the threshold of AA and below, as shown in the second row. In addition, among the non-pre-refunded bonds, we find that bonds from more poorly rated issuers were priced significantly lower than better rated bonds in general, with a notable gap as shown in the third row of the table.

Policy interventions removed some, but not all, credit risk concerns. Spreads on pre-refunded bonds declined more than those of non-pre-refunded bonds during the post-intervention period, as shown by the positive and significant coefficients in the fourth row of Table 8. This result indicates that policy interventions did not completely remove credit risk concerns, which is consistent with rising longer-term bond spreads as shown in the rolling-window regressions.

Importantly, we find that non-pre-refunded bonds from more poorly rated issuers had higher spreads compard to pre-refunded bonds following the MLF announcement. Tax adjusted yields were about 70 basis points higher for issuers with ratings below A, and spreads were about 75 basis points higher. These effects, however, only applied to the lowest rated issuers. In columns (3) and (4), we find positive,

Table 8: Post-Intervention Credit Pricing

	Below A		Below AA	
	(1)	(2)	(3)	(4)
	Yield	Spread	Yield	Spread
Not Prerefunded	85.081***	83.379***	81.595***	79.704***
	(10.310)	(10.234)	(9.846)	(9.754)
Rating	35.864***	34.879***	8.558	6.775
	(11.453)	(11.472)	(9.290)	(9.533)
Not Prerefunded × *Rating*	85.624***	82.264***	52.729***	52.851***
	(21.442)	(22.126)	(15.172)	(15.349)
Not Prerefunded × *Intervention*	25.434***	27.131***	25.243***	26.691***
	(3.723)	(3.840)	(4.098)	(4.182)
Rating × *Intervention*	-0.827	-1.763	10.513	9.368
	(22.908)	(22.003)	(12.699)	(12.443)
Not Prerefunded × *Rating* × *Intervention*	69.991***	74.319***	19.403	22.540
	(23.440)	(22.520)	(13.880)	(13.660)
Observations	926,898	926,898	926,898	926,898
Adjusted R^2	0.62	0.68	0.61	0.67

Notes: Sample is bonds traded between January 2 and May 29, 2020. The intervention dummy takes the value of 1 on or after April 9, 2020, as the last policy announcement in our sample was on the Federal Reserve's MLF on April 7, 2020. Regressions include issuer state domicile by trade date fixed effects. County level controls include covid cases per 100 residents, hospitals per 1000 residents, and share of COVID affected employment. Bond controls include log of trade amount, log of principal amount, log of remaining maturity, and an indicator for trade type. Standard errors clustered by issuer domicile state and trade date.

Clustered standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

but statistically insignificant effects when we include AA rated issuers in the low rated group. Thus, we conclude that bonds from lower-rated issuers were most likely to experience elevated spreads following federal interventions. This confirms our hypothesis that federal interventions helped reduce liquidity risk on all bonds, and reduced credit risk concerns on short-term bonds, but left longer-term bonds with more credit risk exposed.

6 Conclusion

We examine how policy interventions during the COVID pandemic impacted municipal bond market pricing through the liquidity and credit risk channels. Focusing on narrow trading windows around each policy action, we find that announcements on fiscal policy and direct monetary policy interventions reduced liquidity risk concerns and helped quickly stabilize the municipal bond market. However, these actions didn't immediately ease credit concerns about municipal issuers.

Next, using rolling-window regressions to explore the longer-term impact of these actions, we find that credit risk concerns were an important component of short-term bond yields early on in the pandemic, but did not affect longer-term bond yields. Fiscal and monetary policy interventions successfully eased credit risk concerns for short-term bonds over time, but during the same period, longer-term bonds saw considerable increases in their credit risk premia. The shift in credit risk pricing from short- to longer-term bonds over the course of the pandemic likely reflected the design of policy interventions, which primarily benefited short-term bonds, as well as investor expectations that longer-lasting recession dynamics would impact state and local government budgets.

Our results provide at least three key takeaways for policymakers responding to crises. First, the design of the policy intervention matters. We demonstrate that segments of the market more directly affected by the intervention experienced more relief from pressures brought on by the pandemic. Second, news of the policy interventions matters possibly as much as the operational aspects. We demonstrate that much of the decline in municipal bond spreads was brought on simply through news that relief was likely. Third, and relatedly, policymakers can influence market dynamics by simply the appearance of support. Our results show that credit risk concerns continued to decline for short-term debt once the Federal Reserve direct lending facility became operational. However, actual use of the facility was limited.

Finally, our results are important for others trying to understand the dynamics of municipal bond market pricing. We show that, at least during a crisis, liquidity concerns can be a substantial factor for the bond market as a whole. Indeed, even spreads on pre-refunded bonds which lack credit risk increased sharply during March of 2020. However, credit risk pricing dynamics can be more nuanced and related to both macroeconomic developments, local facors, and the underlying bond's characteristics.

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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, Dice, Friedrichs, Gupta, Hayes, Kitschelt, Lee, Marsh, Mislang, Shaton, Sicilian, and Webster.

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".[22]

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

5. When issuers match to both county and city names, we use the county name if we find "cnty" in the issuer name. Otherwise we use the county associated with the city match.

6. 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.

7. 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.

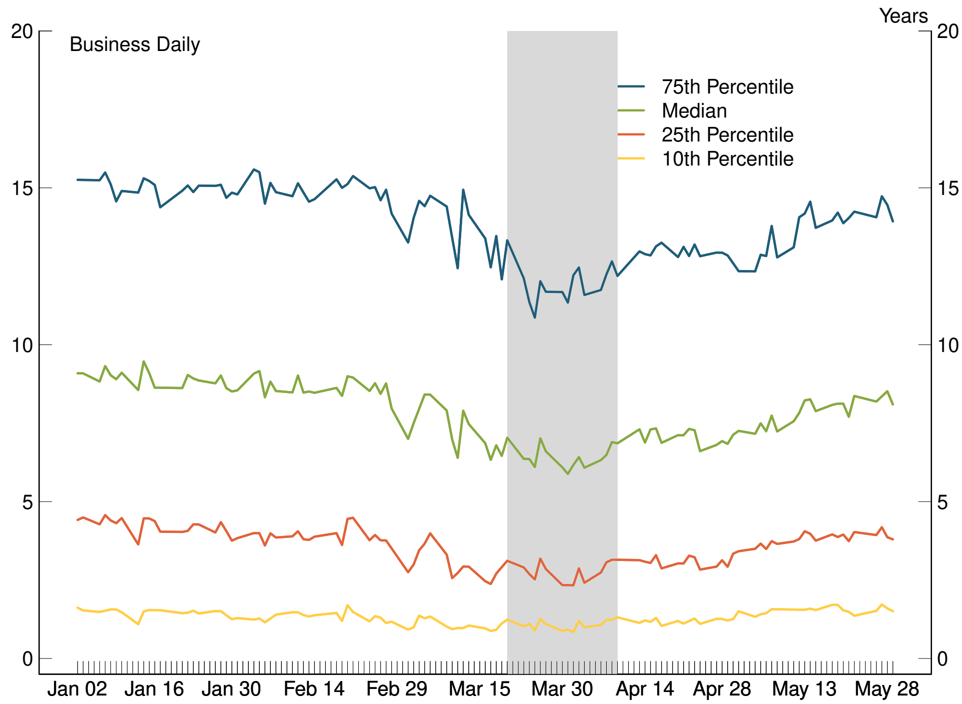
[22]For the state of Louisiana, we replace the search for "cnty" with "parish".

D Additional Data Statistics

In line with the acute stress affecting shorter maturity bonds, the average remaining maturity of traded bonds declined at the peak of the crisis. Figure D1 shows that prior to the pandemic, the trading distribution across maturities was fairly stable, with the top quartile of daily trades having a remaining maturity of 15 years throughout January and February. In late March, however, the top quartile saw a notable decline, reaching about 12 years at its trough. The median maturity level of trades followed a similar pattern, but to a lesser degree. Notably, the remaining maturity for the bottom 10th percentile of trades was largely unchanged throughout the period at around 1 year, even though these bonds experiencing sharp increases in their yields. The comparison highlights that trading activities shifted from the very long maturity bonds, those above 15 years, to the range of 10 to 15 years, while trading was not dominated by the securities experiencing the highest increases in yields.

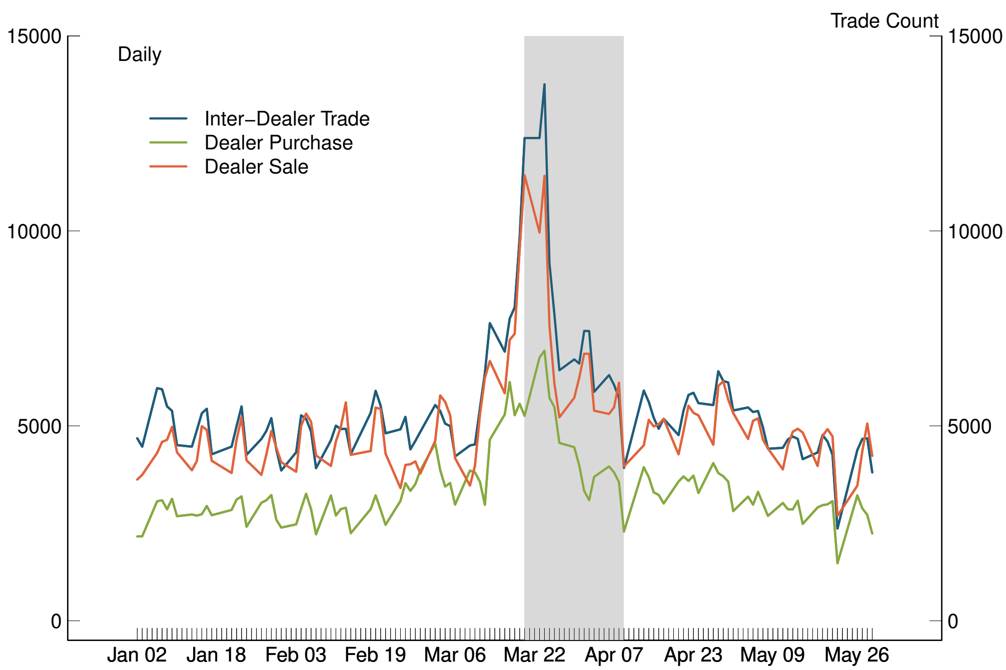
Figure D2 compares three types of municipal market trading activities: inter-dealer transactions, bond sales from dealers to customers, and dealer bond purchases from customers. While all three types of trading activities increased in mid- and late-March, dealer sales and inter-dealer transactions rose 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.

Figure D1: Remaining Maturity Distribution



Source: Municipal Securities Rulemaking Board.

Figure D2: Trade Count: Purchase, Sale, and Inter-dealer Transactions



Source: Municipal Securities Rulemaking Board.

E Event Study Summary Stats

Table E3: Event Study Summary Stats

	Full Sample		MMLF		MMLF Revised		Agreement		CARES Senate		CARES House		MLF	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	No Intervention	3/19-4/9	excluded	included	excluded	included	excluded	included	excluded	included	excluded	included	excluded	included
Tax-Adjusted Spread	195.860	401.085	468.918	484.728	526.779	532.035	521.964	535.792	377.830	364.560	319.144	304.254	288.489	308.194
	(152.770)	(157.679)	(145.399)	(137.753)	(137.218)	(132.199)	(125.449)	(129.464)	(131.094)	(137.259)	(128.517)	(131.120)	(127.768)	(159.520)
Maturity (years)	8.793	7.667	7.666	9.021	7.586	9.269	7.436	7.871	7.348	7.521	7.531	8.630	7.552	8.673
	(6.870)	(6.401)	(6.278)	(7.410)	(6.316)	(7.349)	(6.132)	(6.468)	(5.970)	(6.140)	(6.130)	(6.820)	(6.215)	(6.958)
Maturity < 1 year	0.086	0.097	0.093	0.083	0.096	0.072	0.096	0.092	0.105	0.096	0.095	0.077	0.092	0.062
	(0.280)	(0.296)	(0.290)	(0.275)	(0.295)	(0.259)	(0.294)	(0.289)	(0.306)	(0.295)	(0.293)	(0.266)	(0.290)	(0.242)
Investment Grade	0.964	0.966	0.965	0.978	0.962	0.984	0.962	0.975	0.958	0.972	0.962	0.975	0.966	0.980
	(0.185)	(0.182)	(0.184)	(0.146)	(0.190)	(0.125)	(0.190)	(0.155)	(0.200)	(0.164)	(0.190)	(0.157)	(0.181)	(0.141)
Speculative Grade	0.032	0.033	0.034	0.022	0.037	0.016	0.037	0.024	0.040	0.026	0.036	0.021	0.032	0.019
	(0.177)	(0.178)	(0.181)	(0.146)	(0.188)	(0.125)	(0.189)	(0.154)	(0.196)	(0.159)	(0.187)	(0.145)	(0.175)	(0.138)
Not Rated	0.003	0.001	0.001	0.000	0.001	0.000	0.001	0.000	0.002	0.002	0.001	0.004	0.002	0.001
	(0.057)	(0.037)	(0.033)	(0.000)	(0.025)	(0.000)	(0.027)	(0.015)	(0.042)	(0.042)	(0.037)	(0.061)	(0.050)	(0.029)
Principal Amount	30.224	28.376	14.241	52.319	13.669	57.313	13.157	51.183	12.728	62.292	14.287	71.975	16.233	140.708
	(227.812)	(192.553)	(97.223)	(134.675)	(49.365)	(175.968)	(56.943)	(191.130)	(44.780)	(359.365)	(51.452)	(400.362)	(53.353)	(778.772)
Trade Amount	0.155	0.183	0.256	0.321	0.242	0.284	0.184	0.235	0.131	0.183	0.130	0.215	0.168	0.304
	(0.974)	(1.150)	(1.743)	(1.508)	(1.608)	(1.604)	(1.168)	(1.674)	(0.752)	(0.872)	(0.723)	(0.953)	(1.271)	(1.491)
Observations	914,638	278,846	33,207	14,212	37,227	14,410	38,008	16,956	27,440	10,039	23,017	8,925	16,553	4,884

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.

F Money Market Mutual Fund Effects

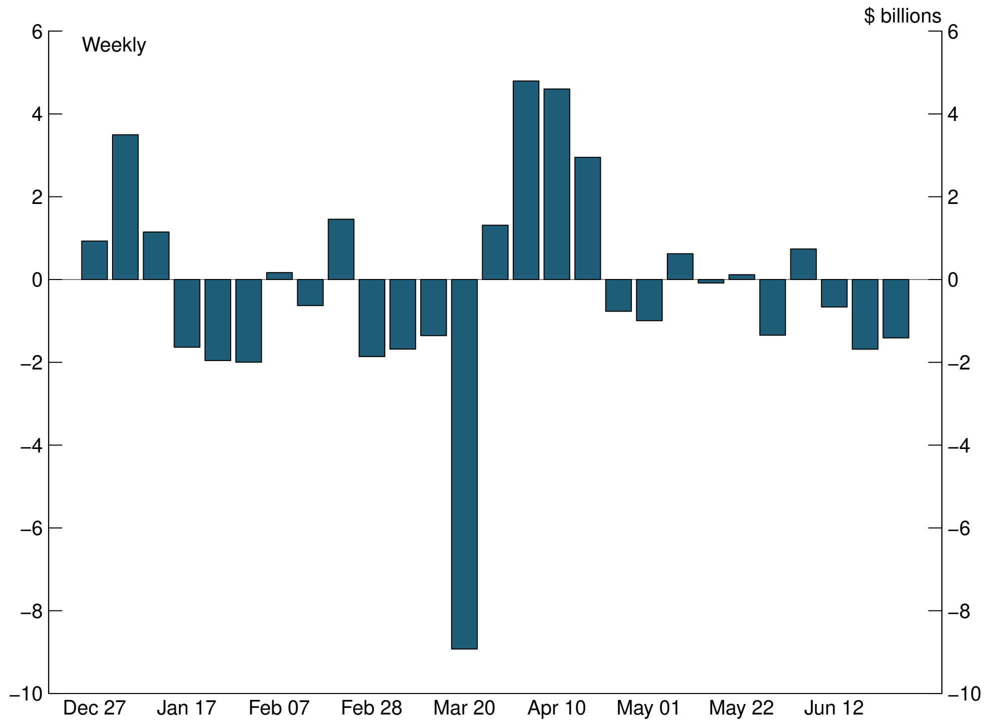
The Federal Reserve established the MMLF to directly assist MMMFs and to stabilize the broad financial conditions. During the height of the crisis, investors quickly pulled cash from money market funds, and MMMFs needed to sell their asset holdings to generate cash in order to meet redemption requests. 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.

Tax-exempt money market fund redemptions also slowed as shown in Figure F3. 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.

We follow the approach in Duygan-Bump et al. [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

Figure F3: Net Subscriptions of Tax Exempt Money Market Funds



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

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.[23]

Accordingly, we estimate the following equation,

$$y_{i,t} = \beta_0 + \beta_1 MMLF_t + \beta_2 MMLF_t \times s_i^{eligible} + \gamma X_i + \varepsilon_{i,t}. \tag{6}$$

$y_{i,t}$ is net fund subscriptions at fund i in week t scaled by end-of-month net assets.

[23]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).

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.[24] 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 F4: 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. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[24] 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 F4, 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.