Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
COVID-19, lockdowns, and the municipal bond market

Nhu Tran⁎, Cihan Uzmanoglu⁎,*

⁎University of Richmond
⁎Binghamton University, State University of New York, United States

A R T I C L E   I N F O

Article history:
Received 12 March 2021
Accepted 24 June 2022
Available online 25 June 2022

JEL codes:
G12
G18
G33
H72
H74
H84

Keywords:
COVID-19
Pandemic response
Stay-at-home orders
Nonsessential business shutdowns
Municipal bonds
Cost of borrowing
Local governments
States

A B S T R A C T

We study how investors in the US municipal bond market price the state lockdowns announced during the coronavirus (COVID) pandemic. To begin with, we examine the extent to which state-level COVID developments influence yield spreads of municipal bonds. We find that macro-level factors are the primary determinants of municipal bond spreads during the pandemic, but state-level COVID developments also matter at the margin. For instance, a doubling of new COVID cases in a state is associated with a 2% (1.4 basis points) increase in yield spreads of municipal bonds issued in that state. Accordingly, lockdowns may decrease municipal bond spreads by reducing COVID cases, but lockdowns may also increase them by reducing local economic activities. Overall, we find that yield spreads in both primary and secondary municipal bond markets increase by about 15% following lockdown announcements, suggesting that lockdown announcements increase the risk premiums investors require for holding municipal bonds.

© 2022 Elsevier B.V. All rights reserved.

1. Introduction

When the United States (US) was hit by the novel coronavirus (COVID-19, referred to here as simply COVID) pandemic in 2020, the federal government delegated the pandemic response to the states. States' responses to COVID varied considerably, with some states delaying or resisting lockdowns (e.g., Geller and Pitt, 2020; Mervosh and Healy, 2020; Woodward and Mahbubani, 2020). On the one hand, lockdowns may economically benefit states by reducing the spread of COVID (e.g., Yang et al., 2021; Bonardi et al., 2020), which would promote future local economic growth and lower healthcare expenses. On the other hand, lockdowns impose immediate local economic costs by reducing business activities (e.g., Alexander and Karger, 2020; Chetty et al., 2020). Lockdowns also have the wider social costs and benefits that are difficult to quantify. In this paper, we study how investors in the US municipal bond market price states' lockdown decisions.

To begin with, we investigate whether and to what extent state- and US-level COVID developments are priced in municipal bond spreads (the difference between yield to maturity of a municipal bond and a maturity-matched risk-free bond). Our sample includes over 85,000 weekly secondary market transactions of municipal bonds between January 2020 and July 2021. We regress the changes in weekly municipal bond spreads (in percentages) on the percentage changes in weekly new COVID cases at the state and US levels. This first-differences model accounts for observable and unobservable covariates that are time invariant during our analysis period (e.g., seniority of bonds and political affiliations of states).

We find that new COVID cases at both state and US levels are significant predictors of municipal bond spreads: a doubling of new COVID cases in a state (in the US) is on average associated with a 7.69% (15.38%) increase in municipal bond spreads. However, when we control for week fixed effects to account for the influence of macroeconomic factors, we find that a doubling of new COVID cases in a state is associated with only a 2% (equivalent to 1.4 basis points) increase in average municipal bond spreads. On the contrary, changes in the number of vaccines administered in a state are significantly negatively associated with changes in

---

⁎ We thank two anonymous referees, Carol Alexander (the editor), Alex Butler, David Hwang, Murali Jagannathan, Daniel McKeever, and Rajesh Narayanan for helpful comments, and Andrew Abbott for valuable assistance. Any remaining errors are our own.

* Corresponding author.

E-mail addresses: ntran@richmond.edu (N. Tran), cuzmanog@binghamton.edu (C. Uzmanoglu).
municipal bond spreads. The economic magnitude of this relation is about half of the influence new COVID cases has on municipal bond spreads, perhaps because investors consider that multiple doses are necessary to reach full vaccine efficacy. These findings lay the foundation for our main analysis as they show that, although macro-factors are the primary determinants of municipal bond spreads during the pandemic, lockdowns may still influence municipal bond spreads as investors also price states’ policy responses to COVID.

Next, we study the influence of lockdown announcements on municipal bond spreads. We find that the announcements of mandatory state shutdowns are associated with about a 15% increase in municipal bond spreads. We find a similar municipal bond market reaction to the announcements of stay-at-home orders, and this finding is robust to accounting for the dynamic relationships across state lockdowns, COVID cases, and vaccinations in a vector autoregression framework. Although our estimates suggest that state shut downs can also reduce bond spreads by almost 10% through reducing the number of new COVID cases, the positive shutdown announcement effect indicates that investors expect the decline in local economic activities following state shut downs to cause an even larger increase in bond spreads.

The economic magnitude of this shutdown announcement effect is comparable to that of a two- to three-notches downgrade in municipal bond ratings (e.g., Harris and Piwowar, 2006; Butler, 2008, 2009). Back-of-the-envelope calculations suggest that shutdowns may, on average, increase the annual interest expenses of states by $4.3 million, which is 0.14% of their general fund balances. As a caveat, our estimate of the shutdown announcement effect is relative to municipal bond spreads in states that did not announce shutdowns. States’ actual interest expenses depend on the general changes in yield spreads and benchmark Treasury yields during that period.

An empirical concern in our study is that states’ economic and demographic characteristics may be correlated with their decisions to order shutdowns. Although our first-differences model accounts for bond and state fixed effects (e.g., Wooldridge, 2010), we still test whether our results are robustness to controlling for bond features (e.g., whether bonds are secured and backed by revenues from specific projects) and state characteristics (e.g., political affiliations of governors and states’ demographic characteristics), and find that they are.

Another concern is that confounding events during the week of shutdown announcements may influence our estimate of the shutdown effect. To help alleviate this omitted variable bias, we implement an instrumental variable (IV) regression approach. Our IV is the lagged value of the average precipitation states get in a week. The intuition is that people would spend more time indoors than outdoors when precipitation levels are high, which would increase the risk of rising COVID cases in the following weeks as COVID spreads easier indoors. Accordingly, higher precipitation levels in a week may be associated with higher likelihood of state shutdowns in the following week, controlling for state characteristics. This weather-based instrument may satisfy the exclusion restriction for a valid IV as it is unlikely to be correlated with the events or policy actions in states during the shutdown week. We find that our IV is indeed a strong and positive predictor of state shutdowns, and our baseline estimate of the shutdown effect is robust to instrumenting for shutdown announcements. This IV approach provides additional evidence that shutdown announcements are associated with an increase in municipal bond spreads.

Having established the positive relation between shutdown announcements and municipal bond spreads, we now examine how this effect varies by bond and issuer characteristics. We find that, relative to bonds maturing within 5 years, bonds maturing in more than 5 years experience a smaller increase in their spreads after shutdown announcements. This finding suggests that investors expect the negative financial effects of shutdowns to be mitigated in the long run. Shutdown announcements mostly affect general obligation bonds and unsecured bonds whose credit risks are directly related to the financial health of their issuers. The shutdown effect is more pronounced among larger bond issues that have greater impact on their issuers’ financing costs, and also among bonds directly issued by states, consistent with states ultimately bearing the negative economic consequences of shutdowns. Bonds of states with lower credit ratings also experience a greater increase in their spreads following shutdown announcements. However, state reopenings do not have a significant influence on municipal bond spreads, suggesting that reopenings are priced ex-ante arguably because they are predictable events. Although the Fed’s liquidity injection to the municipal bond market alleviated the influence of shutdown announcements on municipal bond spreads, we find that it did not fully mitigate the increase in municipal bond spreads in states that ordered shutdowns before the Fed intervention.

As a final test, we examine the influence of shutdown announcements on the primary municipal bond market activities. Consistent with our earlier findings, we find that offering yield spreads increase with shutdown announcements. We do not find a strong association between shutdown announcements and other bond features such as offering amount and initial maturity. These findings suggest that shutdown announcements increase municipal bond spreads similarly in both primary and secondary markets, but states do not appear to alter their financing decisions in response to this increase.

Our findings contribute to the growing literature that studies the effects of COVID on financial markets, institutions, and the real economy (e.g., Acharya and Steffen, 2020; Alexander and Karger, 2020; Baig et al., 2020; Chetty et al., 2020; Dunn et al., 2020; Goodell and Huyhn, 2020; Landier and Thesmar, 2020; Shan and Tang, 2020; Yue et al., 2020). We add to the findings of these studies by examining how investors in the municipal bond market price states’ lockdown decisions. Our findings indicate that investors perceive lockdowns as negative financial events that may increase the borrowing costs of issuers in the lock-down states. A potential policy implication of this finding is that additional federal assistance may be necessary to help states recover from the negative financial effects of lockdowns.

Our findings also contribute to the academic literature on the pricing of municipal bonds. The literature shows that default risk, liquidity, and tax features are priced in municipal bond spreads (e.g., Wang et al., 2008; Ang et al., 2010, 2014; Longstaff, 2011; Novy-Marx and Rauh, 2012; Schwert, 2017). In addition to these factors, Gao et al. (2019) find that states’ distress resolution policies affect municipal bond spreads. Our paper documents that differences in governors’ policies can contribute to the cross-sectional variation in municipal bond spreads. As the pandemic response is highly politicized (Grossman et al., 2020; Tellis et al., 2020), our paper provides event-study evidence of how political affiliations of governors may influence municipal bond spreads and states’ finances. By showing that both US- and state-level COVID developments are priced in municipal bond spreads, our paper also complements the findings of Ang and Longstaff (2013) that both systematic and state-specific risks are priced in municipal bond spreads.

2. Data and summary statistics

We start constructing our sample by obtaining historical data on the number of COVID cases in states from the website of the
New York Times.¹ Next, we identify the dates when states initiated mandatory shutdowns of all nonessential businesses using the data compiled by Adolph et al. (2020).² Table 1 provides the distribution of states reporting COVID cases and implementing shutdowns during our sample period between January 2020 and July 2021. The state of Washington reported the first COVID case in the US on January 21, 2020, marking the beginning of our sample period. All 50 states reported COVID cases by March 20, 2020. Table 2 shows that states on average reported about 8,500 new COVID cases in a week. During our analysis period, 30 states ordered mandatory shutdowns of all nonessential businesses within the three-week period from March 20, 2020 to April 3, 2020. On average, states remained shut down for six weeks.

We next obtain trading data on municipal bonds issued in 50 US states as of the last trading day in each week between January 18, 2020 and July 30, 2021. The trading data and bond identifiers come from the website of the Electronic Municipal Market Access of Municipal Securities Rulemaking Board, which is a self-regulatory organization designated by the US Securities and Exchange Commission as the official source for municipal securities data. The initial sample includes 2,222,266 intraday transactions (344,460 unique municipal bonds). We drop bonds with missing key information (yield, trade amount, and maturity date) and exclude inter-dealer trades as these transactions may bias our estimates of daily market prices, reducing the sample size to 1,406,403 transactions (337,349 bonds).

Yield spreads on these bonds proxy for the risk premiums that investors demand for investing in municipal bonds. To compute yield spreads, we match municipal bond yields with Treasury bond yields of similar maturities obtained from the US Department of the Treasury’s website.³ We adjust Treasury bond yields via linear interpolation when a perfect maturity match is unavailable, and drop municipal bonds with time-to-maturities less than one

¹ See https://github.com/nytimes/covid-19-data for details.
² See https://github.com/COVID19StatePolicy/SocialDistancing for detailed information on the policies tracked and variable definitions.
³ See https://www.treasury.gov/resource-center/data-chart-center/interest-rates for details on daily Treasury yield curve rates.
or more than 30 years to minimize the error in yield spread estimations. This step leaves us with 1,233,181 transactions (313,197 bonds). To eliminate outliers, we further drop the transactions with yields that are outside the 1st and 99th percentiles. After this step, we have 1,208,679 transactions (309,697 bonds) in our sample.

Next, we calculate the daily yield spreads as the weighted average of intraday yield spreads where the weights are based on trade amounts. This step collapses 1,208,679 intraday transactions into 622,895 daily data points observed at the end of each week. Finally, we compute weekly changes in yield spreads using trading data in two consecutive weeks, resulting in a final sample of 85,765 weekly changes in yield spreads contributed by 42,551 unique municipal bonds. Table 2 reports that the average yield spread is 0.65% during our analysis period.

3. The influence of COVID and vaccinations on municipal bond spreads

We begin our empirical analyses by investigating how investors in the municipal bond market price the spread of COVID and vaccination efforts during the pandemic. After understanding investor behavior during the pandemic, we examine the influence of states' shutdown decisions on municipal bond spreads in Section 4.

3.1. COVID cases and municipal bond spreads

We first visually investigate the trends in average yield spreads on municipal bonds during the pandemic. As Democratic states tend to take more stringent COVID measures than Republican states do (Grossman et al., 2020; Tellis et al., 2020), we separately plot the average spreads on municipal bonds issued in Republican and Democratic states—defined based on the political affiliations of their governors—for visual evidence on whether states' pandemic responses may influence their municipal bond spreads.

Consistent with the reports of the Fed (e.g., Cipriani et al., 2020; Sanchez and Wilkinson, 2020), Fig. 1 shows that bond spreads increase sharply until mid-March 2020 and gradually decline with the beginning of the Fed's liquidity injection program to the municipal bond market on March 23, 2020. More importantly, we observe in Panel A of Fig. 1 that the average municipal bond spreads of Republican and Democratic states follow similar patterns during the beginning of the pandemic, and Panel B of Fig. 1 shows that these patterns persist when we account for the differences across state characteristics. COVID seems to influence states similarly independent of their governors' political affiliations, suggesting that macro-level factors might be driving municipal bond spreads during the pandemic.

4 We find in untabulated results that controlling for bond characteristics does not influence the trends observed in Panel A of Figure 1.

---

Table 2
Summary statistics
This table reports the summary statistics for Spread, New Cases in the State, and Adj. New Cases in the US variables. Spread is the difference between the yield to maturities of municipal bonds and maturity-matched Treasury bonds. New Cases in the State is the number of weekly new COVID cases reported in a state. For each state and week, Adj. New Cases in the US equals the total number of new COVID cases in the US minus the new cases reported in the state. The sample includes 85,765 observations of weekly changes in municipal bond spreads contributed by 50 states in 4,050 state-weeks between January 18, 2020 and July 30, 2021. See Table 1 for detailed information on the sample selection process.

| Variables                          | N   | Mean | Median | St. Dev. |
|------------------------------------|-----|------|--------|----------|
| Spread (in percentages)            | 85,765 | 0.65 | 0.38   | 1.12     |
| New Cases in the State (in thousands) | 4,050 | 8.58 | 2.92   | 18.23    |
| Adj. New Cases in the US (in millions) | 4,050 | 0.42 | 0.30   | 0.42     |

---

Fig. 1. Average Bond Spreads of Republican and Democratic States
This figure plots yield spreads and orthogonalized yield spreads of municipal bonds issued in Republican and Democratic states. The sample includes 85,765 observations of weekly changes in municipal bond yield spreads contributed by 50 states between January 18, 2020 and July 30, 2021. We classify a state as Democratic (Republican) if the governor of a state is from the Democratic (Republican) party. There are 24 Democratic and 26 Republican states. Panel A reports the average yield spread, which is the difference between yields on a municipal bond and the maturity matched Treasury bond. Panel B reports the average of yield spreads orthogonalized to the following state characteristics: In(Population), Percent Population Over 65, Percent Black Population, Poverty Rate, In(Retail Sales per Capita), and Coastal State Dummy. “Fed Intervention” in the figure indicates the beginning of the Federal Reserve’s liquidity injection program to the municipal bond market on March 23, 2020. Refer to Table 1 for sample selection criteria and Table 2 for a detailed definition of yield spread.

Fig. 1 also shows that municipal bonds issued in Democratic states, relative to those in Republican states, experienced an increase in their yield spreads later during the pandemic, indicating that the differences in states’ COVID responses may also influence their municipal bond spreads. However, this difference in yield spreads of municipal bonds issued in Republican and Democratic states diminishes towards the end of our sample period. One possible explanation for this convergence could be-
cause COVID vaccination rates in Democratic states are on average higher than those in Republican states (Galston, 2021), which may help reduce the COVID-related relative increase in municipal bond spreads observed in Democratic states. We explore this possibility in Section 3.2.

Next, we formally investigate the influence of COVID cases on municipal bond spreads by running the following regression:

\[
\Delta \text{Spread}_{i,t} = \alpha + \beta \Delta \ln (1 + \text{NewCasesinTheState})_{j,t} + \gamma \Delta \ln (1 + \text{Adj. NewCasesinTheUS})_{j,t} + \epsilon_{i,j,t}
\]

(1)

where \( t \) is the week subscript, \( \Delta \) indicates the change in variables from week \( t-1 \) to week \( t \), \( \text{Spread}_{i,t} \) is the yield spread of municipal bond \( i \) issued in state \( j \), \( \ln (1 + \text{New Cases in the State})_{j,t} \) is the natural log of one of the new COVID cases reported during a week in state \( j \), \( \ln (1 + \text{Adj. New Cases in the US})_{j,t} \) is the natural log of one plus total new COVID cases reported during a week in the US minus the new COVID cases reported during the same week in state \( j \), and \( \epsilon_{i,j,t} \) is the error term. We use changes in variables, instead of their levels, to account for the influence of time invariant differences in bond and state characteristics (e.g., seniority, security, and purpose of bonds, and states’ economic and demographic characteristics that are unlikely to change within a week) on our estimates (e.g., Wooldridge, 2010). We adjust the total new cases in the US with the new cases in the state in each case to alleviate multicollinearity concerns, add one to new cases to keep observations during weeks with no reported cases (i.e., log of zero is undefined), and cluster standard errors at the state level to adjust for the correlation in errors within states.

First, we estimate Eq. (1) by only controlling for \( \Delta \ln (1 + \text{New Cases in the State}) \) and report the results in Column (1) of Table 3. We find that the coefficient estimate on \( \Delta \ln (1 + \text{New Cases in the State}) \) is 0.18 and significant at the 1% level, indicating that a 100% increase in state-level new cases is associated with an increase of 13 basis points (bps) in states’ bond spreads, which is 20% of the average bond spread in our sample. However, as we discuss below, the economic significance of this finding declines substantially with the inclusion of macro-level controls in the regression.

Column (2) of Table 3 reports the results from Eq. (1), which controls for changes in new COVID cases at both state and US levels, and shows that the coefficient on \( \Delta \ln (1 + \text{New Cases in the State}) \) is 0.07 and significant at the 5% level, and the coefficient on \( \Delta \ln (1 + \text{Adj. New Cases in the US}) \) is 0.14 and significant at the 1% level. The regression estimates suggest that a 100% increase in state- and US-level new cases are associated with a 5 bps (equivalent to 7.69%) and 10 bps (equivalent to 15.38%) increase in municipal bond spreads, respectively.

These findings show that changes in new US-level cases have a stronger influence on municipal bond spreads than changes in new state-level COVID cases. Perhaps, because COVID is highly infectious, investors place greater weight on US-level rather than state-level COVID developments. Consistent with this prediction, we find in Column (3) of Table 3 that including week fixed effects to control for macro-level covariates further reduces the coefficient estimate on \( \Delta \ln (1 + \text{New Cases in the State}) \) to 0.02, indicating a 1.4 bps (equivalent to about 2%) increase in municipal bond spreads with the doubling of new cases in states.

Although our first-differencing approach accounts for bond and state fixed effects, we test in Column (4) of Table 3 whether our findings are similar when controlling for bond and state characteristics as additional regressors. We are able to obtain bond characteristics from Bloomberg and state characteristics from United States Census Bureau for 73,636 out of 85,765 observations in our

Table 3

| Dependent Variable: | \( \Delta \text{Spread} \) |
|---------------------|-------------------------|
| \( \Delta \ln (1 + \text{New Cases in the State}) \) | \( 0.18^{\ast\ast\ast} \) |
|                     | (15.51)                 |
| \( \Delta \ln (1 + \text{Adj. New Cases in the US}) \) | \( 0.07^{\ast} \) |
|                     | (2.02)                  |
| Intercept           | Yes                     |
| Week Fixed Effects  | Yes                     |
| Bond-level Controls | Yes                     |
| State-level Controls| Yes                     |
| Number of Observations | 85,765                 |
| Adjusted R²         | 4.05%                   |

\( ^{\ast\ast\ast} \) denotes significance at the 10, 5, and 1 percent levels, respectively.

---

5 13 bps = \( 0.18 \times \ln(2) \), where 0.18 is the coefficient estimate on \( \Delta \ln (1 + \text{New Cases in the State}) \) and \( \ln(2) \) indicates the doubling of state-level new cases. This 13 bps increase is 20% of the average bond spread in our sample (85 bps).

---
sample. The bond-level controls are General Obligation Dummy, Secured Dummy, and In(Maturity), and the state-level controls are ln(Population), Percent Population Over 65, Percent Black Population, Poverty Rate, In(Retail Sales per Capita), Democratic Governor Dummy, and Coastal State Dummy.\(^6\)

In Table 3, Column (4) shows that the coefficient estimate on \(\Delta \ln(1+\text{Cases in the State})\) is 0.02 and significant controlling for bond and state characteristics. The economic magnitude of this estimate is similar to that of the earlier estimate in Column (3), suggesting that differences in bond or state characteristics are unlikely to influence our findings. Column (5) reports that the coefficient on \(\Delta \ln(1+\text{Cases in the State})\) is 0.05 and significant when estimated during the winter surge of COVID between December 2020 and February 2021. This estimate, which is economically more significant than our full sample estimates reported in Columns (3) and (4), indicates that when COVID cases are on the rise, investors pay greater attention to the state-level COVID developments.

These findings suggest that, although US level COVID developments are a strong determinant of municipal bond spreads, shutting down a state may still lower the municipal bond spreads through a reduction in local COVID cases. As a caveat, the influence of local COVID cases on municipal bond spreads is economically small, further supporting the possibility that US-level, rather than state-level, factors influence municipal bond spreads during the pandemic.

### 3.2. COVID vaccinations and municipal bond spreads

According to the Centers for Disease Control and Prevention (CDC), COVID vaccines help reduce the spread of COVID and the risk of COVID-related deaths.\(^7\) As vaccination efforts vary considerably across states, here we study the influence of vaccinations on municipal bond spreads. Our regression equation is as follows:

\[
\Delta \text{Spread}_{i,t} = \alpha + \beta \ln(1 + \text{Vaccinations in the State})_{i,t} + \gamma \Delta \ln(1 + \text{Adj. Vaccinations in the US})_{i,t} + \epsilon_{i,t}.
\]  

(2)

which is similar to Eq. (1) except that the independent variables are based on the number of vaccines administered. We obtain the number of vaccines administered in each state from the CDC’s website, and define Vaccinations in the State\(_{i,t}\) as the number of vaccines administered during week \(t\) in state \(j\). As before, we adjust the US-level control variable (adj. Vaccinations in the US\(_{i,t}\)) by the number of vaccines administered in states to alleviate multicollinearity concerns, and cluster the standard errors at the state level.

Column (1) of Table 4 reports the results of estimating Eq. (2) controlling for only \(\Delta \ln(1+\text{Vaccinations in the State})\) and shows that its coefficient estimate is \(-0.01\) and statistically significant at the 1% level. Columns (2), (3), and (4) of Table 4 show that this finding is robust to controlling for the US-level vaccinations, week fixed effects, and bond- and state-level covariates, respectively. As the previous section shows that new COVID cases in states is a significant determinant of bond spreads, we also include \(\Delta \ln(1+\text{New Cases in the State})\) as an additional control in Column (5) of Table 4 and find that the coefficient estimate on \(\Delta \ln(1+\text{Vaccinations in the State})\) remains negative and significant. However, the economic magnitude of the coefficient estimate on \(\Delta \ln(1+\text{Vaccinations in the State})\) is about half of that on \(\Delta \ln(1+\text{New Cases in the State})\) as reported in Column (4) of Table 3, perhaps reflecting investors’ expectations that multiple shots are necessary for effective protection against COVID. These findings suggest that vaccines may help mitigate the COVID-related increase in municipal bond spreads.\(^8\)

### 4. The influence of shutdowns on municipal bond spreads

Shutting down nonessential businesses slows the spread of COVID, but it also comes with significant local economic consequences. In this section, we investigate the influence of ordering nonessential business shutdowns on municipal bond spreads. We then implement additional tests to address the endogeneity of shutdown decisions. Finally, we examine how new COVID cases and local economic activities are affected during the period states remain shut down.

#### 4.1. State shutdowns and changes in municipal bond spreads

To investigate the relation between states’ shutdown announcements and municipal bond spreads, we run the following regression:

\[
\Delta \text{Spread}_{i,t} = \alpha + \alpha_t + \beta \ln(1 + \text{New Cases in the State})_{i,t} + \gamma \text{Shutdown Announcement}_{i,t} + \epsilon_{i,t}.
\]  

(3)

where \(\Delta \text{Spread}_{i,t}\) is the weekly (t) change in the yield spread of municipal bond i issued in state j, \(\alpha_t\) is the intercept, \(\alpha_t\) indicates week fixed effects. \(\Delta \ln(1+\text{New Cases in the State})_{i,t}\) is the change in natural log of one plus state j’s weekly new COVID cases from week \(t−1\) to week \(t\). Shutdown Announcement\(_{i,t}\) is a dummy variable indicating whether state j announced the shutdown of nonessential businesses during week \(t\), and \(\epsilon_{i,t}\) is the error term.\(^9\) We control for \(\Delta \ln(1+\text{New Cases in the State})\) in this regression as the earlier section shows that it is a significant determinant of bond spread changes. Although \(\Delta \ln(1+\text{Vaccination in the State})\) is also a significant determinant of bond spread changes, we do not control for it as vaccines were unavailable during the period shutdowns were announced. In this regression model, the coefficient on Shutdown Announcement\(_{i,t}\) estimates the changes in municipal bond spreads following shutdown announcements. We cluster standard errors at the state level to adjust the statistical significance of our estimates for the correlation in errors within states.

During our analysis period, shutdowns are announced within three consecutive weeks between March 20, and April 3, 2020. Accordingly, we estimate Eq. (3) using a subsample of bond trades executed during this three-week period. When a state orders a shutdown, we drop that state’s municipal bonds from the sample in the subsequent weeks to estimate the influence of shutdowns on yield spreads of municipal bonds issued in shut-down states relative to those issued in states that did not shut down.

In Table 5, Column (1) reports the regression results and shows that the coefficient estimate on Shutdown Announcement is 0.10

---

\(^6\) For brevity, we omit the definitions of these variables whose labels are self-explanatory.

\(^7\) “Benefits of Getting a COVID-19 Vaccine.” Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, https://www.cdc.gov/coronavirus/2019-ncov/vaccines/vaccine-benefits.html.

\(^8\) As states respond to the COVID crisis differently, changes in unemployment claims in states also vary cross-sectionally based on their COVID exposures. In Appendix A1, we examine how state-level unemployment claims influence municipal bond spreads during the pandemic. We find that, although there is a positive association between changes in state-level new unemployment claims and changes in municipal bond spreads, this relationship is driven by macro-level developments as captured by week fixed effects. It appears that investors pay more attention to macro-level than state-level developments during the pandemic when pricing municipal bonds.

\(^9\) We find that states announce their shutdown decisions in the same week they initiate shutdowns. Because New York, New Jersey, Connecticut, and Pennsylvania joined a coalition to combat COVID, however, we assume that the shutdown announcement date for these states is the earliest shutdown announcement date in the coalition.
Table 4
The influence of vaccinations on municipal bond spreads
This table presents the results from regressions that examine the influence of COVID vaccinations on yield spreads of municipal bonds. Our regression equation is as follows:
\[ \Delta \text{Spread}_{ij,t} = \alpha + \beta \Delta \ln (1 + \text{Vaccinations in State})_j + \gamma \Delta \ln (1 + \text{Adj. Vaccinations in US})_j + \epsilon_{ij,t} \]
where \( i, j, t \) denote bond, state, and week, respectively. \( \Delta \text{Spread} \) is the difference between the current week’s and the previous week’s yield spread on municipal bonds. \( \Delta \ln (1 + \text{Vaccinations in the State}) \) is the difference between the current week’s and the previous week’s natural log of one plus the number of COVID vaccines administered. \( \Delta \ln (1 + \text{Adj. Vaccines in the US}) \) is the difference between the current week’s and the previous week’s natural log of one plus the number of vaccines administered in the US adjusted for the number of vaccines administered in a state in a week. \( \alpha \) and \( \epsilon_{ij,t} \) indicate the intercept and the error term, respectively. The sample includes 85,765 observations of weekly changes in municipal bond yield spreads contributed by 50 states between January 18, 2020 and July 30, 2021. In Column (4), the bond-level controls are General Obligation Dummy, Secured Dummy, and In(Maturity), and the state-level controls are In(Population), Percent Population Over 65, Percent Black Population, Poverty Rate, In(Retail Sales per Capita), Democratic Governor Dummy, and Coastal State Dummy. In Column (5), we include \( \Delta \ln (1 + \text{New Cases in the State}) \) as an additional control variable to the regression specification in Column (4). Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

| Dependent Variable: | \( \Delta \text{Spread} \) (1) | \( \Delta \text{Spread} \) (2) | \( \Delta \text{Spread} \) (3) | \( \Delta \text{Spread} \) (4) |
|---------------------|------------------|------------------|------------------|------------------|
| \( \Delta \ln (1 + \text{Vaccinations in the State}) \) | \(-0.01^{***}\) | \(-0.02^{***}\) | \(-0.01^{***}\) | \(-0.01^{***}\) |
| \( \Delta \ln (1 + \text{Adj. Vaccinations in the US})/10 \) | \(-0.37^*\) | \(-0.49^*\) | \(-5.05^*\) | \(-4.15^*\) |
| Intercept | Yes | Yes | Yes | Yes |
| Week Fixed Effects | No | No | Yes | Yes |
| Bond- and State-level Controls | No | No | No | Yes |
| \( \Delta \ln (1 + \text{New Cases in the State}) \) | No | No | No | Yes |
| Number of Observations | 85,765 | 85,765 | 85,765 | 73,636 |
| Adjusted R\(^2\) | 0.05% | 0.05% | 42.44% | 42.40% |

\*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.

Table 5
The Influence of State Shutdowns on Municipal Bond Spreads
This table presents the results from regressions that investigate the influence of nonessential business shutdowns on municipal bond spreads. Our regression equation is as follows:
\[ \Delta \text{Spread}_{ij,t} = \alpha + \beta \Delta \ln (1 + \text{NewCasesintheState})_j + \gamma \Delta \ln (1 + \text{ShutDownAnnouncement})_j + \epsilon_{ij,t} \]
where \( i, j, t \) denote bond, state, and week, respectively. \( \Delta \text{Spread} \) is the difference between the current week’s and the previous week’s yield spread on municipal bonds. \( \Delta \ln (1 + \text{New Cases in the State}) \) is the difference between the current week’s and the previous week’s natural log of one plus new cases. The variable of interest is Shutdown Announcement, that indicates whether a state announced a mandatory shutdown of nonessential businesses in week \( t \), \( \alpha \), and \( \epsilon_{ij,t} \) indicate the intercept, week fixed effects, and the error term, respectively. The sample in Column (1) includes 5,111 observations of weekly changes in municipal bond yield spreads contributed during the three-week period between March 20, and April 3, 2020. Column (2) investigates whether the results in Column (1) are robust to controlling for bond and state characteristics. These variables, whose labels are self-explanatory, are General Obligation Dummy, Secured Dummy, In(Maturity), In(Population), Percent Population Over 65, Percent Black Population, Poverty Rate, In(Retail Sales per Capita), Democratic Governor Dummy, and Coastal State Dummy. Column (3) reports the first stage regression results predicting state shutdowns using Average Precipitation (the instrument), and bond and state characteristics. Column (4) reports the second stage regression results, and the variable of interest is Instrumented Shutdown Announcement. Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread and New Cases in the State. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

| Dependent Variable: | \( \Delta \text{Spread} \) (1) | \( \Delta \text{Spread} \) (2) | \( \Delta \text{Spread} \) (3) | \( \Delta \text{Spread} \) (4) |
|---------------------|------------------|------------------|------------------|------------------|
| Shutdown Announcement | 0.10\(^*\) | 0.08\(^*\) | . | . |
| \( \text{Average Precipitation} \) | (2.07) | (2.05) | . | . |
| Instrumented Shutdown Announcement | 1.43\(^*\) | 1.43\(^*\) | . | . |
| Intercept | Yes | Yes | Yes | Yes |
| Week Fixed Effects | Yes | Yes | Yes | Yes |
| \( \Delta \ln (1 + \text{New Cases in the State}) \) | Yes | Yes | Yes | Yes |
| Bond-level Controls | No | Yes | Yes | Yes |
| State-level Controls | No | Yes | Yes | Yes |
| Number of Observations | 5,111 | 4,379 | 4,379 | 4,379 |
| Adjusted R\(^2\) | 65.84% | 66.35% | 48.14% | 66.19% |

\*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.
and significant, and Column (2) reports that it is 0.08 and significant controlling for bond and state characteristics. These estimates suggest that, on average, municipal bonds issued in the shut-down states experience an increase of 8 bps to 10 bps (equivalent to 12.31% to 15.39%) in their yield spreads relative to those issued in states that do not shut down. To put this estimate into economic perspective, a 10 bps increase in borrowing costs would increase the average annual interest expenses of shut-down states by $4.3 million, which is 0.14% of their general fund balances. However, these estimates are relative to the borrowing costs in states that did not shut down. States’ actual interest expenses may increase less with shutdown announcements because bond spreads in general decreased following the Federal Reserve’s (Fed) intervention in April 2020, and the benchmark Treasury yields also declined during that period.

Our findings in this section indicate that investors appear to expect the negative financial effects of state shutdowns to outweigh their positive financial effects.

4.2. Addressing identification concerns

Next, we try to address the identification concerns associated with our baseline estimate of the shutdown announcement effect reported in Column (2) of Table 5. Our estimates may suffer from an omitted variable bias if our regressions fail to fully account for the differences in states’ policy responses to the pandemic that may be correlated with their shutdown decisions. Our dependent variable is weekly changes in municipal bond spreads, and thus states’ policy actions in a week other than their decisions to shut down may drive the increase in municipal bond spreads. Accordingly, estimating the causal effect of shutdown announcements on municipal bond spreads is challenging. Nevertheless, we implement an instrumental variable (IV) regression approach to strengthen our baseline findings.

We construct a weather-based instrument to predict states’ shutdown announcements. We argue that the average amount of precipitation (rain, hail, and snow) states get during a week may be positively associated with their shutdown decisions in the following week, controlling for state characteristics such as their governors’ political affiliations. Higher precipitation levels would lead to more indoor activities than outdoor activities. As COVID spreads more easily indoors than outdoors, we expect states that experience higher levels of precipitation in a week to face a higher risk of rising COVID cases in the following weeks as the incubation period of COVID is two weeks. Accordingly, on the margin, governors that worry about a rise in COVID cases due to high precipitation levels may be more inclined to implement mandatory shutdowns. Our IV is likely to satisfy the exclusion restriction condition for a valid instrument as the average precipitation level in a week is unlikely to be correlated with the economic decisions of governors in the following week.

For each state, we obtain the daily precipitation data from the National Centers for Environmental Information’s website. We then construct our IV—Average Precipitation—as the average of daily precipitation levels reported from weather stations in each state and week. The mean and standard deviation of Average Precipitation in our sample are 0.11 inches and 0.09 inches, respectively. Using the control variables in Column (2) of Table 5, we implement a two-stage least squares regression using Average Precipitation as the instrument for Shutdown Announcement.

Column (3) of Table 5 reports the first stage regression results and shows that, as expected, Average Precipitation is a positive and significant predictor of state shutdowns. Average Precipitation appears to be a strong instrument as its F-statistic (10.28) is above the threshold F-statistic (10) for a strong instrument (e.g., Staiger and Stock, 1997). Column (4) of Table 5 reports the second stage regression results and shows that the coefficient estimate on Instrumented Shutdown Announcement is 0.24 and significant. This coefficient estimate is larger than those reported in Columns (1) and (2), suggesting that omitted variables may bias down our baseline estimate of the increase in municipal bond spreads associated with shutdown announcements. Perhaps this is because states that order shutdowns also undertake other actions that mitigate the influence of shutdown announcements on municipal bond spreads.

To summarize, our findings show that the increase in municipal bond spreads following the announcements of state shutdowns is robust to implementing an IV regression approach. As a caveat, estimating the causal effects of shutdown announcements is a daunting task because there are many confounding factors correlated with shutdown decisions. Accordingly, we interpret the results in this section as providing additional support for our baseline findings rather than as being the causal estimates of the shutdown effects.

4.3. The influence of state shutdowns on new COVID cases and local economic activity

Our findings in the earlier section show that municipal bond spreads increase with the announcements of state shutdowns. Nevertheless, state shutdowns are also expected to reduce bond spreads through reducing new COVID cases. We now try to estimate the potential decline in bond spreads associated with the reduction in new COVID cases after state shutdowns.

To do so, we first estimate the reduction in new COVID cases during the period states remain shut down. We run the following regression of changes in natural log of one plus new COVID cases reported in states:

$$
\Delta \ln (1 + \text{NewCases in the State})_{jt} = \alpha + \alpha_{t} + \beta \text{Shutdown}_{jt-2} + X'j \theta + \epsilon_{jt},
$$

where $\alpha$ is the intercept, $\alpha_{t}$ indicates week fixed effects, $\text{Shutdown}_{jt-2}$ is a dummy variable indicating whether in week $t-2$ nonessential businesses are shut down in state $j$, $X'j$ is a vector of state-level controls (ln(Population), Percent Population Over 65, Percent Black Population, Poverty Rate, ln(Retail Sales per Capita), Democratic Governor Dummy, and Coastal State Dummy), and $\epsilon_{jt}$ is the error term. As before, we cluster standard errors at the state level. We lag the shutdown variable by two weeks to match the incubation period of COVID. This way, our model accounts for the fact that new COVID cases would start to decline within two weeks after states shut down.

Column (1) of Table 6 reports the results from estimating the above regression and shows that the coefficient estimate on Shutdown is –0.15 and significant. This coefficient estimate suggests that two weeks after initiating a mandatory shutdown of nonessential businesses, the number of new COVID cases in states on average declines by 13.93% ($e^{-0.15} - 1 = 0.1393$) every week during the period they remain shut down. As the average state in our sample is shut down for six weeks, a mandatory shutdown of

---

10 Based on their 2019 financial reports obtained from Bloomberg, the average shut-down state in our sample had total liabilities of $4.3 billion and total fund balances of $3.2 billion.

11 See www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/outdoor-activities. html for details.

12 Unpublished coefficient estimates in Column (3) of Table 5 show that democratic-run states, more populated states, and states that experience greater increases in COVID cases are more likely to be shut down. The strongest predictor of state shutdowns by far—both statistically and economically—is the political affiliation of the governor.
nonessential businesses may reduce new COVID cases in states by 59.34% ($e^{-0.0153} - 1 = 0.5934$). This estimate is consistent with the case study results of Yang et al. (2021) that lockdown measures in New York City were associated with a greater than 50% reduction in the transmission of COVID. These findings illustrate that ordering mandatory shutdowns is indeed an effective way to contain the spread of COVID.

We next estimate the influence of this 59.34% decline in new COVID cases on municipal bond spreads. Columns (2)-(5) of Table 3 report that the sensitivity of changes in bond spreads to changes in new COVID cases ranges between 0.02 and 0.07 when the basic controls are included, suggesting that state lockdowns may reduce bond spreads by 1.8 to 6.3 basis points (e.g., 0.02 × ln(1−0.5934) = 0.018) through a 59.34% reduction in new COVID cases. It appears that the decline in bond spreads associated with the shutdown-related reduction in new COVID cases is not large enough to mitigate the 8 to 24 bps increase in bond spreads following the announcements of state shutdowns reported in Table 5.

To also quantify the local economic consequences of state shutdowns, we obtain data on small business revenues in states and credit card spending by states’ residents from Chetty et al. (2020). The authors put together anonymized data from multiple sources and estimate daily seven-day moving averages of small business revenues and credit card spending in states. They then report the percentage changes in the daily values of these variables relative to their average daily values in January 2020. We index these variables to their average levels observed in January 2020, allowing us to calculate the percentage change in economic activity in each week.

To have a snapshot of local economic activity in weekly frequency, we merge these variables with our trading dates at the end of the weeks. We find that the averages of % Small Business Revenue Index and Credit Card Spending Index are 0.79 and 0.90, respectively. These statistics suggest that, on average, small business revenues and credit card spending during our analysis period are 21% and 10% lower than their levels observed in January 2020, respectively.

We run the following regression equation to study the local economic influences of state shutdowns:

$$\Delta \ln (\text{EconomicActivity})_{jt} = \alpha + \alpha_{l} + \beta \text{Shutdown}_{jt} \times X_{jt}^{\prime} + \epsilon_{jt}$$

where $\Delta \ln[\text{EconomicActivity}]_{jt}$ is the change in natural log of Small Business Revenue Index or Credit Card Spending Index for state $j$ from week $t-1$ to week $t$, $\alpha$ is the intercept, $\alpha_{l}$ indicates week fixed effects, $\text{Shutdown}_{jt}$ indicates the shutdown status of a state in week $t$, $\Delta \ln[1+\text{New Cases in the State}]_{jt}$ is the change in natural log of one plus state $j$’s weekly new COVID cases from week $t-1$ to week $t$, $X_{jt}^{\prime}$ is a vector of state-level controls as in Eq. (4), and $\epsilon_{jt}$ is the error term. We do not lag $\text{Shutdown}$ by two weeks in these regressions because the local economic effects of shutdowns should be visible immediately. We cluster standard errors at the state level.

Columns (2) and (3) of Table 6 report the results from the above regression using small business revenues and credit card spending by residents, respectively, as proxies for local economic activity. The coefficient estimates on $\text{Shutdown}$ are −0.04 in Column (2) and −0.02 in Column (3), and they are statistically significant. For the six-week period that states on average shut down all of their nonessential businesses, these coefficient estimates indicate a 21.34% (1−$e^{-0.04\times 6} = 0.2134$) and an 11.31% (1−$e^{-0.02\times 6} = 0.1131$) decline in small business revenues and local credit card spending, respectively. These estimates, which are in line with the aggregate economic activity trends documented by Chetty et al. (2020) and the county-level effects of lockdowns estimated by Alexander and Karger (2020), provide some context for the local economic costs of state lockdowns.

4.4. Studying the variation in the shutdown effect

Having established the positive relation between shutdown announcements and municipal bond spreads in the earlier sections, we now study how this shutdown effect varies with bond characteristics and issuer types, and whether it is mitigated by the Fed’s intervention and state reopenings.

---

Table 6

The influence of State Shutdowns on the Spread of COVID and Economic Activity

| Dependent Variable: $\Delta \ln (1+\text{New Cases in the State})$ | $\Delta \ln (\text{Small Business Revenue Index})$ | $\Delta \ln (\text{Credit Card Spending Index})$ |
|-------------------------------------------------------------|----------------------------------------|----------------------------------------|
| **Independent Variables** | **(1)** | **(2)** | **(3)** |
| Shutdown<sub>−1</sub> | −0.15** | −0.04** | −0.02*** |
| Shutdown<sub>−2</sub> | (−3.51) | (−6.38) | (−4.88) |
| Intercept | Yes | Yes | Yes |
| Week Fixed Effects | Yes | Yes | Yes |
| State-Level Controls | Yes | Yes | Yes |
| $\Delta \ln (1+\text{New Cases in the State})$ | No | Yes | Yes |
| Number of Observations | 3,650 | 3,330 | 3,700 |
| Adjusted R<sup>2</sup> | 40.77% | 45.26% | 39.50% |

*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.
Table 7
Shutdown Announcement Effects by Bond and Issuer Characteristics

This table presents the results from regressions that investigate how the influence of state shutdowns on municipal bond spreads varies by bond and issuer characteristics. The columns in this table run the regression model in Column (2) of Table 5 using alternative subsamples. The samples in Columns (1) and (2) include bonds maturing within 5 years and greater than 5 years, respectively. The samples in Columns (3) and (4) include general obligation and revenue bonds, respectively. The samples in Columns (5) and (6) include unsecured and secured bonds, respectively. The samples in Columns (7) and (8) include large issuer and small issuer, respectively. The samples in Columns (9) and (10) include state issuers and other issuers, respectively. The samples in Columns (11) and (12) include bonds issued by states with below AAA credit ratings and AAA credit ratings, respectively. Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread and New Cases in the State. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

| Dependent Variable: ASpread | Mat. | Gen. | Rev. | Unsec. | Sec. | Large | Small | State | Others | Below | AAA |
|-----------------------------|------|------|------|--------|------|-------|-------|-------|--------|-------|-----|
|        | <5 yr. | >5 yr. | Bonds | Bonds | Bonds | Issues | Issues | Innov. | Issues | AAA | Rated |
| Shutdown Announcement       | 0.17*** | 0.05 | 0.12** | 0.08 | 0.11** | –0.28 | 0.16*** | 0.02 | 0.22*** | 0.10 | 0.45*** | 0.32** |
|                            | (2.78) | (1.03) | (2.06) | (1.54) | (2.52) | (–1.90) | (3.07) | (0.34) | (4.26) | (1.95) | (3.35) | (2.82) |
| Intercept                   | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Week Fixed Effects          | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Bond- and State-level Controls | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of Observations      | 1,345 | 3,034 | 1,134 | 3,245 | 4,056 | 323 | 2,174 | 2,205 | 8,37 | 3,454 | 569 |
| Adjusted R²                 | 69.63% | 65.10% | 71.61% | 64.39% | 67.62% | 48.75% | 68.31% | 64.72% | 77.83% | 63.09% | 76.67% | 80.85% |

*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.

4.4.1. The variation in the shutdown effect by bond and issuer characteristics

We begin with examining the influence of shutdown announcements on the term-structure of bond spreads. Columns (1) and (2) of Table 7 report the regression results in Column (2) of Table 5 for bonds maturing within 5 years and greater than 5 years, respectively. We find that the coefficient estimate on Shutdown Announcement is 0.17 and significant at the 1% level for shorter-maturity bonds, and it is 0.05 and statistically insignificant for longer-maturity bonds. These findings suggest that investors expect the influence of shutdowns on states’ financing cost to be alleviated in the long run.

In Table 7, we also investigate the variation in shutdown effects by other bond characteristics. Prices of general obligation bonds should be more sensitive to changes in credit risk of their issuers than prices of revenue bonds that are backed by specific project revenues. Accordingly, we expect shutdown announcements to have a greater influence on general obligation bonds than on revenue bonds. By the same token, we expect a more pronounced announcement effect on unsecured bonds than on secured bonds, which we define as bonds collateralized by specific assets or guaranteed by insurers. In Columns (3) and (4), we estimate our baseline regression for general obligation and revenue bonds, respectively, and find that the coefficient estimate on Shutdown Announcement is 0.12 and significant at the 5% level in Column (3), and it is 0.08 but insignificant in Column (4). Thus, the shutdown effect appears to be more pronounced for general obligation bonds than for revenue bonds. Similarly, comparing the influence of shutdowns on unsecured and secured municipal bonds in Columns (5) and (6), respectively, we find that the coefficient estimate on Shutdown Announcement is positive and significant only among unsecured bonds.13 These results suggest that, as predicted, shutdown announcements particularly increase the spreads on general obligation and unsecured municipal bonds.

We next examine the variation in the shutdown effect by bonds’ issue sizes to understand whether our findings are driven by larger (smaller) bond issues that have more (less) importance for issuers’ borrowing costs. To do so, in each week and for each state, we rank the bonds in our sample by their offering amounts and classify the bonds with above (below) median issue sizes as large (small) issues. Columns (7) and (8) in Table 7 report the results of our baseline regression for the large and small issue subsamples, respectively, and show that the shutdown effect is more pronounced among larger bond issues. These findings suggest that shutdowns may on average increase the cost of borrowing of issuers in a state.14

We next examine our findings by the issuer type. As states can allocate funding to their subdivisions such as cities and counties, we test whether the announcements of state shutdowns influence states’ bonds or other issuers’ bonds as well. Columns (9) and (10) of Table 7 show that shutdowns are associated with a significant increase in yield spreads of municipal bonds issued by both states and other issuers, respectively. However, the shutdown effect is more pronounced among bonds issued by states, consistent with states ultimately bearing the financial consequences of shutdowns. Columns (11) and (12) show that states with lower credit ratings (rated below AAA by the Standard & Poor’s (S&P), as obtained from S&P Global) experience even a larger increase in their bond spreads compared to those with AAA ratings. It appears that riskier states experience a greater increase in their bond spreads.

In summary, yield spreads on shorter-term bonds, general obligation bonds, unsecured bonds, larger bond issues, and bonds directly issued by riskier states increase more with shutdown announcements. These findings document that state shutdowns have heterogeneous effects on the municipal bond market.

4.4.2. The fed intervention and municipal bond spreads

In this section, we investigate whether the Fed’s liquidity injections mitigate the influence of state shutdowns on municipal bond spreads. To do so, we estimate Eq. (3) before and after the beginning of the Fed’s liquidity injections to the municipal bond market. The Fed took several actions in response to the strains in the municipal bond market beginning with the inclusion of mu-

13 Column (6) of Table 7 shows that, when the sample includes only secured bonds, the coefficient estimate on Shutdown Announcement becomes negative and significant at the 10 percent level. We interpret this coefficient estimate cautiously as the sample size in this regression is quite small and it is statistically significant only if we also control for whether the state is a coastal state.

14 We also run regressions of weighted average bond spreads in which we compute the weights based on bonds’ issue sizes. We find that the influence of shutdowns on municipal bond spreads is statistically weaker in this approach compared to the baseline bond-level regression approach. Using the weighted averages of variables in regressions reduces the sample size substantially, which may explain the weaker results.
Table 8
The Influence of Federal Reserve Intervention on the Announcement Effects of State Shutdowns
This table investigates the influence of the Fed’s liquidity programs on yield spreads of municipal bonds issued in shut-down states. The Fed responded to the strains in the municipal bond market on March 23, 2020 (MMMFPL and CPFF programs) and on April 9, 2020 (MLF program). To investigate whether the Fed’s intervention mitigated the effect of shutdown announcements on municipal bond spreads, Columns (1), (2), and (3) replicate the result in Column (2) of Table 5 during the week before, one week after, and two weeks after the beginning of the Fed’s intervention on March 23, 2020, respectively. Column (4) tests whether the Fed’s intervention mitigated the increase in the borrowing costs of states that announced shutdowns before the Fed’s intervention. For this, we first find the bonds in our sample that are traded both before the beginning of shutdowns (March 13, 2020) and after the end of the Fed’s intervention (April 9, 2020). We then obtain their yield spreads before the beginning of shutdowns and after the end of the Fed’s intervention, and run the following regression:

\[ \text{Spread}_{ij,t} = \alpha + \alpha_i + \alpha_j + \beta \ln (1 + \text{New Cases in the State})_{ij,t} + \gamma \text{Post} + \delta \text{Early Shut-down State} \times \text{Post} + \epsilon_{i,j,t} \]

where \( i, j, t \) denote bond, state, and week, respectively. \( \text{Spread} \) is the weekly yield spread on municipal bonds, \( \ln (1 + \text{New Cases in the State}) \) is the natural log of one plus new cases in a state, and \( \text{Post} \) indicates the period after April 9, 2020. Early Shut-down State is a dummy variable indicating the states that announced shutdowns in the week of March 20, 2020, and zero otherwise. \( \alpha, \alpha_i, \alpha_j, \text{and} \epsilon_{i,j,t} \) denote the intercept, bond fixed effects, week fixed effects, and the error term, respectively. Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread and New Cases in the State. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

| Dependent Variable: Spread | Independent Variables | \( \Delta \text{Spread} \) | Spread |
|----------------------------|-----------------------|----------------|--------|
| Shutdown Announcement      |                       | (1) | (2) | (3) | (4) |
| \( \ln (1 + \text{New Cases in the State}) \) | -0.06 | -0.03 |   |   |
| (2.74)                     | (-0.84)               | (-0.23) |   |   |
| Post                       |                       |   |   |   |   |
| Early Shut-down State \times Post |   |   |   |   |
| Intercept                  | Yes                    | Yes | Yes | Yes | Yes |
| \( \Delta \ln (1 + \text{New Cases in the State}) \) | Yes | Yes | Yes | No | No |
| Bond- and State-level Controls | Yes | Yes | Yes | No | No |
| Week and Bond Fixed Effect | No                    | No | No | Yes | No |
| Number of Observations     | 2,638                  | 1,220 | 521 | 280,886 | 280,886 |
| Adjusted R²                | 5.72%                  | 5.36% | 0.37% | 25.45% |

\( *, **, *** \) denotes significance at the 10, 5, and 1 percent levels, respectively.

Municipal bonds in the Money Market Mutual Fund Liquidity Facility (MMMFPL) and the Commercial Paper Funding Facility (CPFF) programs on March 23, 2020, and then initiated the Municipal Liquidity Facility (MLF) program on April 9, 2020 (see Cipriani et al., 2020 for details). Accordingly, we use the initiation of the Fed’s liquidity programs on March 23, 2020 as the beginning of the Fed intervention.

Column (1) of Table 8 reports that the coefficient estimate on Shutdown Announcement is 0.17 and significant during the week before the Fed’s liquidity injection (week of March 20, 2020). Accordingly, states that shut down before the Fed’s liquidity injection experience a 17 bps (equivalent to 26.15%) increase in their municipal bond spreads. This effect is greater than the average effect of shutdowns reported earlier. During the two weeks after the Fed’s liquidity injection, however, Column (2) and (3) of Table 8 show that shutdown announcements do not significantly increase municipal bond spreads. It appears that the Fed’s intervention calmed the municipal bond market, alleviating the influence of shutdown announcements on the municipal bond spreads. This finding may also suggest that the shutdown announcements during the later periods are predicted by investors and already priced in the municipal bond market. This would bias our estimates down and may lead to insignificant findings during the period after the Fed’s liquidity injection.

As the Fed announced additional liquidity provisions on April 9, 2020, we next investigate the overall effect of the Fed’s interventions on the shut-down states’ municipal bond spreads. The above results show that shutdown announcements particularly increased the municipal bond spreads in states that announced shutdowns earlier in our sample period during the week of March 20, 2020. We label these states as the early shut-down states and investigate whether the Fed’s liquidity provisions mitigated the increase in their municipal bond spreads.

To test this, we first identify the bonds in our sample that are traded during the weeks both before the beginning week of shutdowns (week of March 20, 2020) and after the announcement week of the Fed’s last liquidity provision (week of April 9, 2020). We construct this subsample of bonds to ensure that the composition of the bonds during the pre- and post-intervention periods is identical. We then obtain their weekly yield spreads before the beginning of shutdowns and after the end of the Fed’s intervention, and run the following regression:

\[ \text{Spread}_{ij,t} = \alpha + \alpha_i + \alpha_j + \beta \ln (1 + \text{New Cases in the State})_{ij,t} + \gamma \text{Post} + \delta \text{Early Shut-down State} \times \text{Post} + \epsilon_{i,j,t} \]

where \( i, j, t \) denote bond, state, and week, respectively. \( \text{Spread}_{ij,t} \) is the weekly yield spread on municipal bonds, \( \ln (1 + \text{New Cases in the State}) \) is the natural log of one plus new cases in a state, \( \text{Post} \) indicates the period after April 9, 2020. Early Shut-down State is a dummy variable indicating the states that announced shutdowns in the week of March 20, 2020, and zero otherwise. \( \alpha, \alpha_i, \alpha_j, \text{and} \epsilon_{i,j,t} \) indicate the intercept, bond fixed effects, week fixed effects,
and the error term, respectively. This regression does not control for Early Shut-down State because bond fixed effects account for it. As we discuss below, the variable of interest is the interaction of Post and Early Shut-down State variables. We cluster the standard errors at the state level.

Column (4) in Table 8 reports that the coefficient estimate on the interaction of Post and Early Shut-down State is 0.13 and significant at the 10% level. This finding shows that the municipal bond spreads in early shut-down states are 13 bps higher than those in other states even after the implementation of the Fed’s liquidity programs. This finding suggests that the Fed intervention was not able to fully mitigate the increase in municipal bond spreads of early shut-down states.

4.4.3. State reopenings and municipal bond spreads

As a final test in this section, we investigate the influence of state reopenings on municipal bond spreads. We run a regression similar to Eq. (3) by replacing Shutdown Announcement with a dummy variable indicating the week of reopening. Unabulated regression results show that the coefficient estimate on the reopening indicator is insignificant, suggesting that state reopenings are not associated with a significant change in municipal bond spreads. It is possible that state reopenings are priced in the municipal bond market ex-ante as state shutdowns were clearly temporary, and investors might be able to predict the timing of state reopenings.15

4.5. State shutdowns and the primary municipal bond market activities

In addition to studying the secondary market transactions, we also investigate the influence of state shutdowns on the primary municipal bond market activities. To do so, we obtain bond issuance data surrounding the shutdown announcement dates from Bloomberg. Our sample period is between January 18, 2020, and July 10, 2020. This 25-week period is centered around the weeks states remained shut down (see Table 1 for details) and allows us to study the primary bond activity before and after state shutdowns.

We run the following regression in the spirit of a generalized differences-in-differences model:

\[ y_{i} = \alpha + \alpha_i + \alpha_t + \beta \text{Post Shutdown Announcement}_{i,t} + \gamma \text{Tax Exempt}, + \delta \epsilon_{i,t} \]  

where \( y_i \) is the dependent variable—ln(Bond Maturity at Issue), ln(Issue Amount), or Offering Yield Spread—, \( \alpha \) is the intercept, \( \alpha_i \) is the fixed effects for the state in which bonds are issued, \( \alpha_t \) is the fixed effects for the week in which bonds are issued, Post Shutdown Announcement is a dummy variable identifying the weeks after shutdown announcements, Tax Exempt indicates whether bond is exempt from state and federal taxes, and \( \delta \epsilon_{i,t} \) is the error term. Because each bond is represented only once in this primary market test, our dependent variables are in levels, instead of their first differences as in our baseline specifications. Accordingly, we include state fixed effects to capture the within-state variation in bond issuance characteristics following shutdown announcements. We also control for whether a bond is tax exempt to account for issuers’ incentives to offer taxable bonds during the pandemic to take advantage of low yields. As usual, we cluster the standard errors at the state level.

Columns (1) and (2) of Table 9 show that the coefficient estimates on Post-Shutdown Announcement are insignificant in regressions of ln(Bond Maturity at Issue) and ln(Issue Amount), respectively.16 It appears that shutdown announcements do not have a significant impact on the maturity and amount of new bond issues, or alternatively our analysis period may not be long enough to capture these effects. However, Column (3) shows that the coefficient estimate on Post-Shutdown Announcement is 0.14 and significant when the dependent variable is Offering Yield Spread. This finding suggests that offering yields increases by 14 bps (equivalent to an average increase of 21.54%) following shutdown announcements, consistent with the evidence from studying the secondary market transactions. These findings suggest that shutdown announcements influence municipal bond prices similarly in both primary and secondary markets.

5. Robustness tests

This section reports the results of robustness tests for the main findings in our study.

5.1. Using expected—instead of actual—changes in new COVID cases

In Table 3, we regress the changes in municipal bond spreads on the changes in state- and US-level new COVID cases, and find that US-level cases have a stronger influence on municipal bond spreads than state-level cases. As security prices reflect expectations about future economic activity, however, our conclusions from this regression analysis may be biased.

More specifically, bond prices in week t-1 may reflect the expected number of new COVID cases in week t. In this case, bond spreads in week t would change with the surprise in new COVID cases. We, however, use the changes—instead of the surprise—in new COVID cases in our regressions of bond spread changes. In other words, the implicit assumption in our regressions is that the number of new COVID cases in week t-1 is a proxy for the expected number of new COVID cases in week t. In this section, we examine the sensitivity of our findings to this assumption and whether our conclusions are robust to using a rigorous surprise measure of new COVID cases.

We begin with estimating the number of new COVID cases in states using its lagged values as follows:

\[ \text{ln}(1 + \text{New Cases})_{j,t} = \alpha + \beta \text{ln}(1 + \text{New Cases})_{j,t-1} + \gamma \text{Tax Exempt}_{j,t-1} + \delta \text{ln}(1 + \text{New Cases})_{j,t-2} + \epsilon_{j,t} \]  

where \( j \) and \( t \) denote state and week, respectively, \( \alpha \) is the intercept, ln(1 + New Cases)\( _{j,t-1} \) is the natural log of one plus the number of new cases in a state, and \( \epsilon_{j,t} \) is the error term. We control for two lags of new COVID cases in regressions, as the incubation period for the virus is two weeks. In an alternative specification, we also control for the square terms of the lagged variables to account for the potential nonlinear relation between the number of current and past COVID cases. The regression equation for the nonlinear prediction model is as follows:

\[ \text{ln}(1 + \text{New Cases})_{j,t} = \alpha + \beta \text{ln}(1 + \text{New Cases})_{j,t-1} + \gamma \text{ln}(1 + \text{New Cases})_{j,t-2} + \delta \text{ln}(1 + \text{New Cases})_{j,t-1} + \theta \text{ln}(1 + \text{New Cases})_{j,t-2} + \epsilon_{j,t} \]  

We estimate these regressions using our sample of 3,950 weekly state-level observations and report the results of the linear and nonlinear models in Columns (1) and (2) of Table 10, respectively.

---

15 The lack of ventilators was the primary reason for initiating mandatory shutdowns. Perhaps, investors were able to predict the change in the demand for ventilators following state shutdowns and accordingly estimate states’ reopening dates ex-ante. Furthermore, some states indicated reopening dates at the time of the shutdown announcements, reducing the uncertainty around predicting reopening dates (for instance, see “What’s Closed? What’s Mandatory? How Tri-State Covid-19 Action Affects Daily Life.” NBC New York, NBC New York, 10 Apr. 2020.)

16 The results of unabulated tests show that total offering amounts at the state-level do not change significantly after shutdown announcements either.
Table 9
State Shutdowns and the Primary Municipal Bond Market Activities
This table presents the results from regressions that investigate the influence of state shutdowns on the primary municipal bond market activities. Our regression equation is as follows:

\[ y_i = \alpha + \alpha_t + \alpha_s + \beta \text{Post Shutdown Announcement}_i, + \gamma \text{Week and State Fixed Effects}_i, + \epsilon_i \]

where \( i, j, t \) denotes bond, state, and week, respectively. \( y_i \) is the dependent variable—ln(Bond Maturity at Issue), ln(Issue Amount), or Offering Yield Spread. \( \alpha_t \) is the intercept, \( \alpha_s \) is the fixed effects for the state of bond issuance, \( \alpha_t \) is the fixed effects for the week of bond offering date. Post Shutdown Announcement\(_i,\) is a dummy variable identifying the weeks after shutdown announcements. The sample includes 26,354 observations of newly issued municipal bonds between January 18, and July 10, 2020, for which Tax Exempt variable is also available. Refer to Table 1 for detailed sample selection criteria. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

| Dependent Variable: | ln(Bond Maturity at Issue) (1) | ln(Issue Amount) (2) | Offering Yield Spread (3) |
|---------------------|--------------------------------|----------------------|-------------------------|
| Post Shutdown Announcement | -0.00 (-0.10) | 0.11 (0.70) | 0.14*** (2.81) |
| Intercept | Yes | Yes | Yes |
| Week and State Fixed Effects | Yes | Yes | Yes |
| Tax Exemption Status | Yes | Yes | Yes |
| Number of Observations | 26,354 | 26,354 | 26,354 |
| Adjusted R\(^2\) | 2.51% | 17.24% | 61.98% |

\(^*, **, ***\) denotes significance at the 10, 5, and 1 percent levels, respectively.

Table 10
The Influence of Surprise in COVID Cases on Municipal Bond Spreads
This table examines whether our findings reported in Column (2) of Table 3 are robust to using the surprise in new COVID cases as a control variable in regressions. To compute the surprise in weekly new COVID cases, we first predict the number of new COVID cases in states using both linear and nonlinear autoregressive models:

\[ \text{ln(1 + New Cases)}_{t,i,j} = \alpha + \beta \text{ln(1 + New Cases)}_{t-1,i,j} + \gamma \text{ln(1 + New Cases)}_{t-2,i,j} + \epsilon_{t,i,j} \]

where \( j \) and \( t \) denote state and week, respectively, \( \alpha \) is the intercept, \( \text{ln(1 + New Cases)} \) is the natural log of one plus the number of new cases in a state, and \( \epsilon_{t,i,j} \) is the error term. This prediction sample includes 3,950 state-week observations from January 18, 2020 and July 30, 2021. Columns (1) and (2) report the results from these linear and nonlinear models, respectively. Using these coefficient estimates, we then predict the number of new COVID cases at the state- and US-levels in each week. We compute Surprise Cases in a week as the difference between natural log of one plus new cases minus natural log of one plus predicted new cases. Finally, we run the regressions of \( \Delta \text{Spread} \) as in Column (2) of Table 3 controlling for Surprise Cases in the State and Surprise Cases in the US. \( \Delta \text{Spread} \) is the difference between the current week’s and the previous week’s yield spread on municipal bonds. Columns (3) and (4) report the results of these regressions using the linear and nonlinear methods to predict new COVID cases, respectively. The sample in these regressions includes 85,765 observations of weekly changes in municipal bond yield spreads between January 18, 2020 and July 30, 2021. Refer to Table 1 for detailed sample selection criteria and Table 2 summary statistics on Spread and New Cases in the State. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

| Dependent Variable: | ln(1 + New Cases) Linear (1) | ln(1 + New Cases) Nonlinear (2) | \( \Delta \text{Spread} \) Linear (3) | \( \Delta \text{Spread} \) Nonlinear (4) |
|---------------------|-----------------------------|--------------------------------|--------------------------------|--------------------------------|
| \( \text{ln(1 + New Cases)}_{t,1} \) | 1.10*** (8.89) | 1.28*** (7.73) | . | . |
| \( \text{ln(1 + New Cases)}_{t,2} \) | -0.16 (-1.35) | -0.34** (-2.14) | . | . |
| \( \text{ln(1 + New Cases)}_{t,3} \) | -0.02*** (-2.83) | . | . | . |
| \( \text{ln(1 + New Cases)}_{t,4} \) | 0.02** (2.96) | . | . | . |
| Surprise Cases in the State | . | . | 0.05 (0.04) | . |
| Surprise Cases in the US | . | . | 0.20*** (0.97) | 0.15*** (5.25) |
| Intercept | Yes | Yes | Yes | Yes |
| Number of Observations | 3,950 | 3,950 | 85,765 | 85,765 |
| Adjusted R\(^2\) | 95.64% | 95.68% | 3.81% | 2.84% |

\(^*, **, ***\) denotes significance at the 10, 5, and 1 percent levels, respectively.
Table 10 shows that the adjusted $R^2$ of the linear model is 95.64%, and that of the nonlinear model is 95.68%, suggesting that the linear model fits the data well and the inclusion of the square terms does not substantially improve the model fit. In both models, the coefficient estimate on the first lag of new COVID cases has the largest economic and statistical significance. For instance, Column (1) reports that the coefficient estimate on the first lag is 1.10 and significant at the 1% level, and that on the second lag is -0.16 but it is statistically insignificant. As the coefficient estimate on the first lag is close to one and that on the second lag is close to zero, our implicit assumption in our baseline regressions that new COVID cases in week $t-1$ is a proxy for the expected new COVID cases in week $t$ appears to be a reasonable one.

Nevertheless, these coefficient estimates also indicate that expected new COVID cases may differ from lagged new COVID cases. For instance, they predict that when the number of cases is on the rise (e.g., the number of cases in week $t-1$ is greater than that in week $t-2$), it is expected to continue to rise, or vice versa. In addition, because the sum of the two coefficient estimates is less than one, if the number of COVID cases is the same in two consecutive weeks, it is expected to decline in the following week, indicating that cases are reaching their peak. We next construct a surprise measure and use this measure in our regressions.

Using the coefficient estimates from the above regressions, we predict new COVID cases at state and US levels in each week. We compute Surprise Cases in a week as the difference between the natural logarithm of one plus actual new cases and the natural log of one plus predicted new cases. Finally, we run the regression of $\Delta$Spread as in Column (2) of Table 3 controlling for Surprise Cases in the State and Surprise Cases in the US. Columns (3) and (4) of Table 10 report the results of these regressions using the linear and nonlinear methods to predict new COVID cases, respectively.

The regression results show that our conclusions remain broadly unchanged in that surprises in US-level COVID cases have a stronger influence on municipal bond spreads than surprises in state-level COVID cases. For instance, Column (3) reports that the coefficient estimate on Surprise Cases in the US is 0.20 and significant at the 1% level, and that on Surprise Cases in the State is 0.05 but it is insignificant. Compared with the estimates in Table 3, these estimates place greater emphasis on US-level cases than state-level COVID cases.

By controlling for the surprise measure of new COVID cases in our regressions, in spirit, we include two additional lags of state- and US-level cases in our baseline regressions. As US-level COVID cases, relative to state-level COVID cases, are a stronger predictor of bond spreads, it appears that including the lagged values of US-level cases further reduces the importance of state-level COVID cases in explaining bond spreads. These results reiterate the importance of US-level COVID developments on the municipal bond market.

5.2. The long-term influence of shutdowns on municipal bond spreads

Our findings in the earlier sections show that lockdown announcements, COVID cases, and vaccinations are significant determinants of bond spreads. These variables are jointly determined and may influence bond spreads in opposite directions in the long run. For instance, state lockdowns would increase bond spreads by slowing local economic activity, but they may also decrease bond spreads by reducing new COVID cases in the subsequent weeks. Moreover, states’ vaccination efforts that reduce bond spreads may be correlated with their COVID exposures, which would also be influenced by their lockdown decisions. In this section, we estimate a vector autoregression (VAR) model to examine the influence of lockdowns on bond spreads accounting for the dynamic relationships across lockdowns, COVID cases, and vaccinations.

To implement a VAR model, we first compute weekly average bond spreads at the state level between January 2020 and July 2021 using our sample of 86,765 observations (see Table 3 for sample details). We then run a VAR regression using $\text{Average Spread}$, $\ln(1 + \text{New Cases in the State})$, $\ln(1 + \text{Vaccination in the State})$, and $\text{Shutdown}$, which is a dummy variable indicating the weeks during which states remain shut down. Based on the Akaike information criterion, we use three lags of the variables in our VAR model. At three lags, Hansen’s (1982) J statistic also becomes insignificant (i.e., error terms are uncorrelated with additional lags), giving us further confidence that our model is set properly. Finally, we construct an impulse response function (IRF) graph using the VAR estimates that will allow us to examine the influence of lockdowns on bond spreads and the persistence of this influence through time.

Appendix A2 reports the IRF graph that plots the response of $\text{Average Spread}$ to a shock in $\text{Shutdown}$. The IRF graph shows that state shutdowns are associated with a 5 bps increase in bond spreads in the same week. This effect declines to 2 bps in the long run, but remains significant even 20 weeks after shutdowns. These findings are consistent with our conclusion from studying the influence of shutdown announcements on the term-structure of bond spreads in Section 4.4.1 that investors expect the influence of shutdowns to be largely alleviated in the long run. Nevertheless, our VAR estimates provide evidence of the long term influence of state shutdowns accounting for the dynamic relationships between shutdowns, new COVID cases, and vaccinations.

5.3. The influence of stay-at-home orders on municipal bond spreads

We next study the influence of stay-at-home orders, instead of nonessential business shutdowns, on municipal bond spreads. According to the nonpharmaceutical intervention data from Adolph et al. (2020), 46 states initiated stay-at-home orders during our analysis period for an average of seven weeks. Appendix A3 reports our baseline findings reported in Columns (1) and (2) of Table 5 using stay-at-home orders as a proxy for state lockdowns.

Column (1) of Appendix A3 reports that the coefficient estimate on Stay-at-home Announcement is 0.09 and significant at the 5% level, and Column (2) shows that this finding is robust to controlling for bond and state characteristics. These findings using stay-at-home orders are similar to those using shutdowns of nonessential businesses. Accordingly, both shutdown and stay-at-home orders appear to increase municipal bond spreads.

5.4. The robustness of the shutdown effect to additional controls

In this section, we examine the robustness of our baseline result presented in Column (2) of Table 5 to additional state-level controls and report the findings in Appendix A4. We first control for states’ financial flexibility as proxied by their rainy day fund reserve balances and balanced budget requirements. We obtain states’ rainy day fund reserves prior to the pandemic from Center on Budget and Policy Priorities and their balanced budget requirements from the Tax Policy Center’s website. Columns (1) and (2) show that the coefficient estimates on Shutdown Announcement are positive and significant controlling for $\ln(\text{Rainy Day Fund Reserves})$ and dummy variables indicating the strength of their balanced budget requirements (No Requirement Dummy, Weak Requirement Dummy, Strong Requirement Dummy), respectively.

Next, we try to account for the heterogeneity in states’ health care spending in response to COVID. As we do not directly observe this variable, we proxy for it using the Containment and Health
Index from the Oxford COVID-19 Government Response Tracker. This is an index (out of a 100) that captures the financial and non-financial policy responses to COVID, and it is available at the state level in daily frequency. We take the weekly average of the Containment and Health Index for each state and control for it in our baseline regression. Column (3) shows that our finding is robust to this additional control.

We also contemplate whether the eligibility of issuers to borrow from the MLF may influence our estimates. The Fed announced this $500 billion short-term lending program on April 9, 2020 to help municipalities manage their short-term liquidity challenges. Conditional on meeting certain credit rating requirements (loosely speaking, having an investment grade rating as of April 8, 2020), all of the states, cities with a population over 250,000, counties with a population above 500,000, multi-state entities, and other governor-designated issuers were eligible to borrow from the MLF. Because the terms of the MLF allowed eligible issuers to use their borrowings to support their subdivisions, the MLF funding can be transferred to entities that do not meet the eligibility criteria, making these funds accessible to many issuers in the municipal bond market (Haughwout et al., 2021). Accordingly, the MLF eligibility of issuers is unlikely to influence our estimate of the shutdown effects.

Nevertheless, the MLF rates are punitive and only two issuers—the state of Illinois and New York's Metropolitan Transportation Authority—utilized the MLF funding (Haughwout et al., 2021). Although the MLF was announced after shutdown announcements, it is possible that investors ex-ante account for this MLF access when pricing shutdowns, potentially biasing our estimates. We test this possibility in Column (4) of Appendix A4 by controlling for whether issuers borrowed from the MLF, and find that our findings are robust to this additional control.

Another possibility is that mutual fund outflows might be driving the increase in municipal bond spreads associated with shutdowns. As Li et al. (2021) show, fixed income funds experienced significant outflows during the pandemic and yield spreads increased significantly more for municipal bonds with greater mutual fund exposures. If mutual funds that hold municipal bonds issued in the shut-down states experience greater outflows, the increase in municipal bond spreads associated with state shutdowns may be explained by investor flows. This would suggest that our findings reflect the influence of liquidity shocks rather than the local economic effects of shutdowns. Unfortunately, we do not have access to municipal bond ownerships and flows data to disentangle these two mechanisms. Thus, we interpret our findings as reflecting the equilibrium effects of shutdown announcements.

6. Conclusion

The novel coronavirus was first identified in China in December 2019, but it quickly spread to the rest of the world and led to one of the deadliest pandemics in history. The first confirmed COVID case in the US was in January 2020, and within two months all 50 states reported COVID cases. During this period, the US government largely delegated the pandemic response to the states.

In this paper, we study how investors in the US municipal bond market price the announcements of state lockdowns. As lockdowns can both reduce new COVID cases and local economic activities, and also come with the wider social costs and benefits, whether and to what extent lockdowns influence municipal bond spreads is an empirical question. We find that the announcements of state lockdowns are associated with about a 15% increase in municipal bond spreads. This effect, which is robust to alternative specifications and implementing an IV regression approach, is more pronounced among general obligation, unsecured, and shorter-term bonds, larger bond issues, bonds issued directly by states and particularly those issued by riskier states, and for shutdowns announced before the Fed’s liquidity injection to the municipal bond market. Offering yield spreads in the primary municipal bond market also increase with state shutdowns. These findings suggest that investors price lockdowns as negative financial events that may increase the borrowing costs of issuers in the municipal bond market.

Our findings also contribute to the literature that studies the determinants of municipal bond spreads. As political affiliations of governors are correlated with their lockdown decisions, our paper shows how political affiliations of governors can influence municipal bond spreads. In addition, by documenting that both US- and state-level COVID developments are priced in municipal bond spreads, our paper provides evidence from the pandemic period that both systematic and state-specific risks are priced in the municipal bond market.

Credit author statement

The authors—Nhu Tran and Cihan Uzmanoglu—contributed equally to this paper.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A1. Unemployment claims and municipal bond spreads during the pandemic

This table reports the results from regressions that examine the influence of unemployment claims on municipal bonds’ yield spreads. We obtain the weekly unemployment insurance claims filed in each state from the US Department of Labor and run the following regression of weekly changes in municipal bond spreads:

$$\Delta \text{Spread}_{i,j,t} = \alpha + \beta \Delta \ln (1 + \text{New Unemployment Claims in the State})_{i,t} + \gamma \Delta \ln (1 + \text{Adj New Unemployment Claims in the US})_{i,t} + \epsilon_{i,j,t}$$

where $i, j, t$ denote bond, state, and week, respectively. $\Delta \text{Spread}$ is the difference between the current week’s and the previous week’s yield spread on municipal bonds. $\ln (1 + \text{New Unemployment Claims in the State})$ is the difference between the current week’s and the previous week’s natural log of one plus the number of new initial unemployment claims. $\ln (1 + \text{Adj New Unemployment Claims in the US})$ is the difference between the current week’s and the previous week’s natural log of one plus the number of new initial unemployment claims in the US adjusted for the number of new initial claims in a state in a week. $\alpha$ and $\epsilon_{i,j,t}$ indicate the intercept and the error term, respectively. As in our baseline specification, we adjust the US-level control variable—Adj. New Unemployment Claims in the US—by the number of new unemployment claims in states to address multicollinearity problems, and cluster

[17] For details, visit https://ourworldindata.org/grapher/covid-containment-and-health-index.

[18] See https://www.federalreserve.gov/monetarypolicy/muni.htm for details.

[19] We also examine how the influence of state shutdowns on municipal bond spreads varies by In(Rainy Day Fund Reserve), Balanced Budget Requirement Dummy, Containment and Health Index, and MLF Borrower Dummy variables. To do so, we include the interactions of these variables with Shutdown Announcements as additional variables in the corresponding regressions in Appendix A4. We report in Appendix A5 that these interaction terms are statistically insignificant, suggesting that the shutdown effect does not vary significantly by these state characteristics. As all of the states in our sample have investment grade ratings, perhaps there is not sufficient heterogeneity in their distress characteristics to observe a variation in the shutdown effect by these variables. We also test in Appendix A5 whether the shutdown effect varies by the political affiliations of state governors. We do not find this to be the case either.
the standard errors at the state level. The sample includes 85,765 observations of weekly changes in municipal bond yield spreads contributed by 50 states between January 18, 2020 and July 30, 2021. In Column (4), the bond-level controls are General Obligation Dummy, Secured Dummy, and ln(Maturity), and the state-level controls are ln(Population), Percent Population Over 65, Percent Black Population, Poverty Rate, ln(Retail Sales per Capita), Democratic Governor Dummy, and Coastal State Dummy. In Column (5), we also include Δln(1 + New Cases in the State) and Δln(1 + Vaccinations in the State) as additional control variables. Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

Appendix A2. Estimating the shockdown effect using a vector autoregression approach

This impulse response graph reports the influence of Shutdown (impulse) on Average Spread (response). The underlying vector autoregression regression dynamically models Average Spread, ln(1 + New Cases in the State), ln(1 + Vaccination in the State), and Shutdown variables. Based on the Akaike information criterion and Hansen’s (1982) J statistic, we use three lags of the variables to estimate this model. Shutdown is a dummy variable that indicates if a state is shut down in a week. Using our sample of 86,765 bond-level observations in Table 3, we compute Average Spread as the average of weekly bond spreads at the state-level. Tables 3 and 4 provide the definitions of New Cases in the State and Vaccination in the State, respectively. We orthogonalize the impulse response function based on the Choleski decomposition. We assume that, within a week, state shutdowns contemporaneously affect bond spreads, but they affect new COVID cases and vaccinations with a lag. The shaded area indicates the 95% confidence interval constructed based on 200 Monte Carlo simulations.

Appendix A3. The influence of stay-at-home orders on municipal bond spreads

This table presents the results from regressions that examine the robustness of our findings reported in Columns (1) and (2) of Table 5 to using stay-at-home orders—instead of shutdown of nonessential businesses—as a proxy for state lockdowns. Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread and New Cases in the State. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

Appendix A4. Additional robustness tests for the shutdown effect

This table presents the results from regressions that investigate the robustness of the shutdown effect reported in Column (2) of Table 5 to additional state level controls. Columns (1), (2), (3), and (4) report the results controlling for ln(Rainy Day Fund Reserve), Balanced Budget Requirement Dummies, Containment and Health Index, and MLF Borrower Dummy as additional variables, respectively. ln(Rainy Day Fund Reserve) is the natural logarithm of states’ rainy day fund reserve balances in 2019. Balanced Budget Requirement Dummies are dummy variables indicating whether a state has no, weak, or strong balanced budget requirements. Containment and Health Index is the state-week level average of the Containment and Health Index from the Oxford COVID-19 Government Response Tracker. MLF Borrower is a dummy variable indicating whether an issuer borrows from the Fed’s MLF facility. Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread and New Cases in the State. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

\[ \Delta \text{Spread} = \alpha + \beta \Delta \text{Cases} + \gamma \Delta \text{Vaccinations} + \delta \Delta \text{Spread}_{t-1} + \epsilon \]

where \( \Delta \) denotes the difference operator, and \( \alpha, \beta, \gamma, \delta, \) and \( \epsilon \) are coefficients to be estimated.
Appendix A5. The variation in the shutdown effect with additional state characteristics

This table presents the results from regressions that investigate the variation in the shutdown effect reported in Column (2) of Table 5 by additional state characteristics. Columns (1), (2), (3), (4), and (5) report the results controlling for the interactions of Shutdown Announcement with Ln(Rainy Day Fund Reserve), Containment Health Index, No Balanced Budget Requirement Dummy, Weak Balanced Budget Requirement Dummy, and Democratic Governor Dummy, respectively. These regressions also include the first order terms of the corresponding interaction variables. Ln(Rainy Day Fund Reserve) is the natural logarithm of states’ rainy day fund reserve balances in 2019. Containmco (weak) balanced budget requirements. Democratic Governor Dummy is a dummy variable indicating whether the political affiliation of a state’s governor is Democratic. We do not report the regression results for the interaction of Shutdown Announcement with MLF Borrower as we are unable to estimate its coefficient estimate. This is because the interaction of Shutdown Announcement with MLF Borrower variable is identical to Shutdown Announcement. Refer to Table 1 for detailed sample selection criteria and Table 2 for summary statistics on Spread and New Cases in the State. Reported in parentheses are t-statistics calculated using robust standard errors clustered at the state level.

| Dependent Variable: | ΔSpread | (1) | (2) | (3) | (4) | (5) |
|---------------------|---------|-----|-----|-----|-----|-----|
| Interaction Term    | 0.02    | −0.00 | 0.06 | −0.05 | −0.04 | |
|                     | 1.64    | (−0.79) | 0.65 | (−0.52) | (−0.31) | |
| Intercept            | Yes     | Yes  | Yes  | Yes  | Yes  | Yes  |
| Week Fixed Effects   | Yes     | Yes  | Yes  | Yes  | Yes  | Yes  |
| Δln (1 + New Cases in the State) | Yes | Yes | Yes | Yes | Yes | Yes |
| Bond- and State-level Controls | Yes | Yes | Yes | Yes | Yes | Yes |
| Number of Observations | 4,379 | 4,379 | 4,379 | 4,379 | 4,379 |
| Adjusted R²          | 66.75%  | 66.34% | 66.34% | 66.34% | 66.35% |

*, **, *** denotes significance at the 10, 5, and 1 percent levels, respectively.

References

Acharya, V.V., Steffen, S., 2020. The risk of being a fallen angel and the corporate dash for cash in the midst of COVID. Rev. Corp. Financ. Stud. 9 (3), 430–471.
Adolph, C., Amano, K., Bang-Jensen, B., Fullman, N., Willkorn, J., 2020. Pandemic politics: timing state-level social distancing responses to COVID-19. J. Health Politics Policy Law.
Alexander, D., Karger, E., 2020. Do stay-at-home orders cause people to stay at home? Effects of stay-at-home orders on consumer behavior. Rev. Econ. Stat. 1–25.
Ang, A., Bhausali, V., Xing, Y., 2010. Taxes on tax-exempt bonds. J. Financ. 65 (2), 565–601.
Ang, A., Bhausali, V., Xing, Y., 2014. The Muni Bond Spread: Credit, Liquidity, and Tax. BlackRock, Inc Working Paper.
Ang, A., Longstaff, F.A., 2013. Systemic sovereign credit risk: lessons from the U.S. and Europe. J. Monet. Econ. 60 (5), 493–510.
Bag, A.S., Buit, H.A., Haroon, O., Rufu, S.A.R., 2020. Deaths, panic, lockdowns and US equity markets: the case of COVID-19 pandemic. Financ. Res. Lett. 38, 101701.
Bonard, J., Gallea, Q., Kalanoski, D., Lalive, R., 2020. Fast and Local: How did Lockdown Policies Affect the Spread and Severity of the COVID-19. University of Lau-

Butler, A.W., 2008. Distance still matters: evidence from municipal bond underwrit-
ing. Rev. Financ. Stud. 21 (2), 763–784.
Butler, A.W., Fauver, L., Mortal, S., 2009. Corruption, political connections, and mu-
nicipal finance. Rev. Financ. Stud. 22 (7), 2873–2905.
Ciprani, M., Haughwout, A., Hyman, B., Kovner, A., Spada, G.G., Lieber, M., Nee, S., 2020. Municipal Debt Markets and the COVID-19 Pandemic. Federal Reserve Bank of New York June 29.
Chetty, R., Friedman, J.N., Hendren, N., Stepner, M., 2020. How Did COVID-19 and Stabilization Policies Affect Spending and Employment? A New Real-Time Eco-

Dunn, A.C., Hood, K.K., & Driessen, A. (2020). Measuring the effects of the COVID-19 pandemic on consumer spending using card transaction data. Bureau of Eco-
nomic Analysis Working Paper Series, WP2020–5.
Galston, W., 2021. For COVID-19 Vaccinations, Party Affiliation Matters More Than Race and Ethnicity. Brookings Institution October 1.
Gao, P., Lee, C., Murphy, D., 2019. Municipal borrowing costs and state policies for distressed municipalities. J. Financ. Econ. 132 (2), 404–426.
Geller, A., Pitt, D., 2020. Even As US Coronavirus Cases Surge Past 9 Million, Officials in Many Hard-Hit States Resist Taking Stronger Action. Chicago Tribune October 30.
Goodell, J.W., Huynh, T.L., 2020. Did congress trade ahead? Considering the reaction of US industries to COVID-19. Financ. Res. Lett. 36, 101578.
Grossman, C., Kim, S., Rover, J.M., Thrumurthy, H., 2020. Political partisanship influ-
ences behavioral responses to governors’ recommendations for COVID-19 pre-
vention in the United States. Proc. Natl. Acad. Sci. U.S.A. 117 (39), 24144–24153.
Hansen, L.F., 1982. Large sample properties of generalized method of moments esti-
mators. Econometrica 50, 1029–1054.
Harris, L.E., Piwowar, M.S., 2006. Secondary trading costs in the municipal bond market. J. Financ. 61 (3), 1361–1397.
Haughwout, A., Hyman, B., Shachar, O., 2021. The Option Value of Municipal Liqui-
dity: Evidence from Federal Lending Cutoffs During COVID-19. Federal Reserve Bank of New York February.
Landier, A., Thesmar, D., 2020. Earnings expectations in the COVID Crisis. Rev. Asset Pricing Stud. 10 (4), 598–617.
Li, Y., O’Hara, M., Zhou, X., 2021. Mutual Fund Fragility, Dealer Liquidity Provisions, and the Pricing of Municipal Bonds. Board of Governors of the Federal Reserve System November 22.
Longstaff, F.A., 2011. Municipal debt and marginal tax rates: is there a tax premium in asset prices? J. Financ. 66 (3), 721–751.
Mervosh, S., & Healy, J. (2020). Holdout states resist calls for stay-at-home orders: what are you waiting for? N.Y. Times, April 3.
Noy-Mark, R., Raub, J.D., 2012. Fiscal imbalances and borrowing costs: evidence from state investment losses. J. Econ. Perspect. 23 (4), 191–210.
Sanchez, J.M., Wilkinson, O., 2020. How COVID-19 Has Affected the Municipal Bond Market. Federal Reserve Bank of St. Louis October 22.
Schwert, G., 2017. Municipal bond liquidity and default risk. J. Financ. 72 (4), 1683–1722.
Shan, C., & Tang, D.Y. (2020). The value of employee satisfaction in disaster times: evidence from COVID-19. Working Paper, Shanghai University of Finance and Economics.
Steiger, D., Stock, J., 1997. Instrumental variables regression with weak instruments. Econometrica 65 (3), 557.
Tellis, G.J., Sood, N., Sood, A., 2020. Why did us governors delay lockdowns against COVID-19? Disease Science vs. Learning, Cascades, and Political Polarization. University of Southern California Working Paper.
Wang, C., Wu, J., Zhang, X.K., 2008. Liquidity, default, taxes and yields on municipal bonds. J. Bank Financ. 32 (6), 1133–1149.
Woodward, A., Mabahubani, A., 2020. Fauci says he ‘does not understand’ why the entire US is not under a stay-at-home order. Here is why its absence could make America’s coronavirus problem even worse. Bus. Insider April 3.
Woodridge, J.M., 2010. Econometric Analysis of Cross Section and Panel Data. MIT Press Books Edition 2.
Yang, W., Shaff, J., Shuman, J., 2021. Effectiveness of non-pharmaceutical interven-
tions to contain COVID-19: a case study of the 2020 spring pandemic wave in New York City. J. R. Soc. Interface 18 (175).
Yue, P., Korkmaz, A.C., Zhou, H., 2020. Household financial decision making amidst the COVID-19 pandemic. Emerg. Mark. Financ. Trade 56 (10), 2363–2377.