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Master Thesis

How have the health effects of COVID-19 impacted municipal bond liquidity and trading activity?

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Abstract

This paper examines the impact of the COVID-19 pandemic's health effects on the municipal bond market. We analyze liquidity and trading activity measures, and how they correlate with COVID-19 health variables. The goal is to understand the municipal bond market dynamics during the crisis. Results show that there has been a decrease in monthly bond trades during COVID-19, indicating a significant change. We find that COVID-19 has affected our measures differently. Lower liquidity in the Amihud and Effective Firm-Facing Spread, while the Imputed Round-trip Cost measure indicates higher liquidity. The Roll measure shows that the COVID-19 variables may differ, and it does not provide any substantial support for an increase or decrease in liquidity. Furthermore, we also find that COVID-19 has impacted bond trading activity, such as an increase in COVID-19 cases and deaths associated with higher bond trading activity. We believe our findings provide valuable insights for investors, market participants, and policymakers in understanding the effects of the pandemic on municipal bond markets and inform investment strategies, risk management approaches, and decision-making processes. Ultimately, this research contributes to a deeper understanding of COVID-19's impact on municipal bond trading and its implications for market stability and efficiency.

Keywords – COVID-19, Municipal Bonds, Credit Spread, Liquidity Risk, Trading Activities, States, Level Analysis

Contents

1 Introduction and Motivation

The outbreak of the COVID-19 pandemic has had a profound effect on the bond market, as well as on global markets. As investors and traders navigate the uncertainty and volatility caused by the pandemic, it's crucial to understand how municipal bond trading activity has been affected. In this thesis, we want to examine the impact of the health effects of COVID-19 on municipal bond trading activity and liquidity. Our research question is as follows:

"How have the health effects of COVID-19 influenced municipal bond liquidity and trading activity?"

By analyzing the different health effects, such as the distribution of vaccines, cases, deaths, and hospitalizations, we seek to understand how these factors have influenced the liquidity and trading activity of municipal bonds.

Our findings indicate varying effects of COVID-19 on different liquidity measures in the municipal bond market. While the Amihud and Effective Firm-Facing Spread measures indicate lower liquidity, the Imputed Round-trip Cost measure suggests higher liquidity. The Roll measure does not provide significant evidence of changes in liquidity due to COVID-19. We observe an impact of COVID-19 on bond trading activity, with an increase in trading activity associated with higher COVID-19 cases and deaths.

Understanding the relationship between the health effects of COVID-19 and municipal bond liquidity and trading activity is important for several reasons. Municipal bonds play a critical role in financing public projects and services, such as infrastructure development, healthcare facilities, and educational institutions. Any disruptions in the trading activity and liquidity of municipal bonds can have significant implications for funding these essential areas.

The impact of COVID-19 on public health has resulted in levels of uncertainty and volatility in financial markets. By studying the municipal bonds' overall dynamics of liquidity and trading activity, we can gain a better understanding of how market participants, including investors and issuers, have responded to the health crisis.

Our paper differs from the existing literature in that we analyze liquidity and trading activity measures and how they correlate with COVID-19 health variables. Previous papers focus on the pricing and impact of the COVID-19 pandemic through credit risk and the impact of the Federal Reserve.

2 Literature Review

Schwert (JF, 2017) provides a detailed analysis of the various factors that affect the pricing of municipal bonds, including credit risk, maturity, and yield. The COVID-19 pandemic has impacted the global economy, with financial markets experiencing significant volatility because of the pandemics' impact on businesses, governments, and consumers. This has resulted in changes in the demand and supply of bonds and the prices at which they are traded. Schwert's work suggests that both microeconomic and macroeconomic factors influence the pricing of municipal bonds. During the COVID-19 pandemic, we have seen significant changes in microeconomic and macroeconomic factors impacting bond trading activity. For example, the creditworthiness of issuers has been a critical microeconomic factor that has been affected by the pandemic, as the economic slowdown has caused many businesses and governments to experience financial difficulties. At the same time, macroeconomic factors such as interest rates and inflation have been affected by the pandemic, leading to changes in bond trading activity.

Schwert's research on municipal bond pricing helps us identify the key factors influencing bond pricing trading activity during the pandemic. The findings of this paper indicate that default risk plays a significant role in the pricing of municipal bonds. Furthermore, the paper reveals that the price of default risk is relatively high despite the rare occurrence of municipal defaults, indicating the presence of a significant risk premium associated with default risk in the pricing of municipal bonds.

BI & Marsh (2021) provides insights into the impact of the COVID-19 pandemic on the municipal bond market, particularly in terms of how the pandemic and policy responses have affected bond trading activity. The paper highlights that the COVID-19 pandemic has significantly affected municipal bond pricing through liquidity and credit risk channels. The pandemic has caused widespread economic disruption and uncertainty, reducing liquidity in the municipal bond market. This has resulted in higher transaction costs and price volatility, particularly for lower-rated bonds. The paper emphasizes that the severe economic downturn caused by the pandemic has led to significant financial stress for many local governments and states, resulting in effects on the municipal bond market in the United States. As a result, the paper finds that municipal bond spreads have widened significantly during the pandemic, particularly for lower-rated bonds and those with longer maturities.

Sánchez & Wilkinson (2020) provide perspective on how the pandemic has influenced the municipal bond market in both the short and long term. They attribute this impact to various factors such as changes in economic conditions, shifts in investor sentiment, and the response of the Federal Reserve. In the short term, the COVID-19 pandemic has led to significant volatility in the municipal bond market. Bond prices fluctuate rapidly in response to economic conditions and investor sentiment changes. In the long term, the authors argue that the pandemic has significantly changed the municipal bond market‘s structure and dynamics. For example, the authors note that the pandemic has led to an increased focus on credit risk in the municipal bond market, with investors paying closer attention to the financial health of issuers. Additionally, the authors argue that the pandemic has led to changes in the supply and demand dynamics of the municipal bond market, with increased demand for bonds from issuers looking to fund pandemic-related projects and decreased demand from investors seeking safe-haven assets. The authors also note that the Federal Reserve‘s response to the pandemic has significantly shaped the municipal bond market‘s response to the crises. For example, the Federal Reserve‘s decision to cut interest rates to near-zero levels and implement various monetary policy measures has significantly impacted the municipal bond market‘s pricing and trading activity.

In relation to our research where we focus on various measures such as liquidity metrics and trading activity, the research by Sánchez & Wilkinson (2020) is different because it specifically addresses municipal bonds and their response to the COVID-19 pandemic. The research explores how the pandemic has affected market volatility, credit risk, supply and demand dynamics, and the actions taken by the Federal Reserve.

Li et al.'s (2021) paper shed light on dealers' vital role in transmitting potential fragility risk posed by mutual funds to the municipal bond market, specifically in the context of the COVID-19 pandemic. The research is particularly relevant to understanding how the pandemic has influenced bond trading activity, especially in the municipal bond market. The findings suggest that mutual funds that invest in the municipal bond market experienced significant outflows during the early stages of the pandemic. This resulted in a reduction in liquidity and an increase in volatility in the municipal bond market. Furthermore, the paper highlights that the fragility of mutual funds is transmitted to the municipal bond market through dealers, which can amplify the risk of a broader market sell-off. Overall, the research by LI et al. (2021) provides an important understanding of the transmission of fragility risk from mutual funds to the municipal bond market during the COVID-19 pandemic.

Campbell & Wessel (2021) provide important understating on the impact of COVID-19 of the municipal bond market and how the Federal Reserve‘s response has influenced bond trading activity during the crises compared to times without a global health crisis. The authors argue that the pandemic has significantly impacted the municipal bond market, leading to increased volatility and uncertainty. The pandemic has caused widespread economic disruption, which has led to concerns about the creditworthiness of municipal issuers and increased the risk of default. Furthermore, The Federal Reserve has taken several actions to address these challenges to support the municipal bond market. One of the critical actions the Federal Reserve took was the creation of the Municipal Liquidity Facility (MLF), which provides financing to municipalities and states by purchasing their eligible short-term debt.

This action has helped to stabilize the municipal bond market by providing much-needed liquidity to the issuer during a period of uncertainty. The authors also assess whether the Federal Reserve‘s intervention stabilized the municipal bond market during the pandemic. They note that the MLF has positively impacted the municipal bond market, with borrowing costs for issuers declining significantly following the announcement of the MLF.

2.1 The COVID-19 shock

The first case of coronavirus in the United States was reported on January 20, 2020 (Holshue et al., 2020). In the following months, COVID-19 cases increased nationwide, leading to the implementation of quarantine and shelter-in-place orders by states in mid-March. These measures had a significant impact on the economy, causing a decline in business revenues and a sharp rise in unemployment. State and local governments, already ramping up spending to address the pandemic, faced a major blow to their revenues. The financial market also experienced turmoil, with prices of risky assets plummeting and investor demand for municipal securities decreasing as they shifted towards cash assets.

Figure A1 visualizes the COVID-19 outbreak and its effects, it shows the increase in COVID-19 cases, deaths, hospitalizations, and vaccinations from 2020 to 2022 across all states. These graphs provide a visual depiction of how the pandemic unfolded over time, highlighting the seriousness of the crisis.

2.2 Credit Spread

In accordance with the report from Sánchez & Wilkinson (2020), Figure A2 shows that in March 2020, there was a significant and rapid increase in municipal bond yields as investors perceived them to be less desirable. During periods of economic uncertainty, investors often seek haven investments to protect their capital from market volatility and risk. US Treasury bonds are typically perceived as a haven investment due to the creditworthiness of the US government and the low risk of default. As a result, during economic uncertainty, investors may shift their investments away from riskier assets, such as municipal bonds, and towards US Treasury bonds, which can lead to a decrease in demand for municipal bonds and a widening of credit spreads. If credit spreads increase, investors often expect a decrease in economic activity, and therefore credit spreads can be an important indicator for assessing the state of the economy (Ganti, 2022).

3 Hypothesis

Our research question investigates how the health effects of the COVID-19 pandemic have impacted municipal bond trading activity, by focusing on measuring the impact of changes in liquidity and bond trading activity. Specifically, we address the following research question:

"How have the health effects of COVID-19 impacted municipal bond liquidity and trading activity?"

We start our research by looking into if there is a significant difference between the average monthly trades in the sub-periods, pre-COVID-19 (2015-2019) and under COVID-19 (2020-2022) before we look closer to our research question. We formulate our first hypothesis as follows:

Hypothesis 1:

> H_1: *"The average trades per month during the COVID-19 period (2020-2022) have decreased compared to the pre-COVID- 19 period (2015-2019)."*

Further, we examine our measures for liquidity and bond trading activity on the COVID-19 variables. We want to explore whether the health effects have both positive or negative impacts on liquidity and trading activity, therefore we formulate our next hypothesis to answer our research question:

Hypothesis 2:

> H_1: *"There is a significant relationship between the liquidity/ trading activity measures and the COVID-19 variables.*

4 Theoretical frameworks

4.1 Investor Behavior under Distress

If the total number of deaths and hospitalizations increases, it could have various effects on the liquidity of municipal bonds as measured by the modified Amihud measure. An increase in risk perception among investors may occur. This could result in a higher perceived risk of investing in municipal bonds, potentially leading to a decrease in liquidity as investors become more cautious and demand higher returns.

One possible reason could be a "flight to quality." Loayza & Pennings (2020) highlight in their research that during times of increased uncertainty and risk, investors may seek stable investment entities. This could lead to an increased demand for municipal bonds, potentially improving liquidity.

Another potential factor to consider is market disruption. A significant increase in deaths and hospitalizations can disrupt financial markets and the overall economy. According to Cetorelli et al. (2007), market disruptions, such as increased volatility and uncertainty, can negatively impact liquidity across various asset classes. This could also include municipal bonds.

4.2 Liquidity Risk

Liquidity risk refers to the possibility that an investor or a company may not be able to buy or sell an asset, such as a stock, bond, or real estate quickly or at a reasonable price due to a lack of market participants or market disruptions (Hull, 2021). Municipal bond funds invest mainly in bonds issued by local and regional authorities, and these bonds may have lower liquidity than bonds issued by larger companies or governments. This may be the case for smaller bonds or issuers with longer maturities. If the market for municipal bonds experiences a reduction in liquidity, the liquidity risk on municipal bond funds refers to the risk that the fund's investors will have difficulty selling their shares in the fund at a reasonable price.

4.3 General Obligation Bond and Revenue Bond

Municipal bonds can be broadly categorized into two distinct types, General Obligation (GO) bonds, and revenue bonds. In our thesis, we focus on the general obligation bonds.

4.3.1 Revenue Bond

Revenue bonds are utilized to raise funds for a specific project that generates revenue, and they are secured solely by the income generated from that project (Bi & Marsh, 2021). Revenue bonds, secured by specific revenue streams, have a unique risk profile that is hard to measure. In contrast, focusing on general obligation bonds simplifies identification since the credit risk is primarily tied to the issuer's creditworthiness, rather than a blend of issuer and project credit risks.

4.3.2 General Obligation Bond

General obligation bonds are secured by the full faith and credit of the issuers, ensuring that all available revenue sources will be utilized to meet the debt obligations. In the case of local governments, approximately three-quarters of their tax revenues are derived from property taxes. On the other hand, state governments predominantly rely on sales and income taxes, which contribute to nearly 90 percent of their overall tax revenues. This indicates the primary sources of funding for local and state governments, highlighting the significance of property taxes for local governments and sales/income taxes for state governments in supporting their respective budgets and debt service (Bi & Marsh, 2011).

According to the Municipal Securities Rulemaking Board (MSRB), GO bonds constituted 68 percent of the trading activity in the municipal bond market in 2019. Similar to other bond markets, the municipal bond market predominantly operates as an over-the-counter (OTC) market. In this decentralized system, investors directly place their orders with dealers, rather than relying on a centralized clearinghouse. The MSRB currently reports the active participation of over 1,200 dealers in municipal bond trades (Bi & Marsh, 2021)

4.4 Investment- Grade and High Yield

Municipal bonds are classified into two main categories based on credit rating: investment-grade and high-yield. Investment-grade bonds, rated AAA to BBB, indicate a higher level of creditworthiness and lower risk of default. On the other hand, high-yield bonds, rated BB and below, have lower credit quality and carry a higher risk of default.

High-yield bonds are typically issued by entities with financial challenges, while investment-grade bonds are issued by financially stable state and local government entities (Feldstein & Fabozzi, 2008). General obligation bonds, a type of investment-grade bond, receive high credit ratings due to their repayment assurance backed by the full faith and credit of the issuing entity. GO bonds are attractive to investors seeking capital preservation and more conservative investments.

5 Data and Methodology

5.1 Introduction to Municipal Bonds

A bond is a type of financial instrument that a borrower issues to raise funds. By selling the bond to the lender, the borrower essentially promises to repay the loan, with interest, on specific dates. In essence, the bond serves as an "IOU" or a formal acknowledgment of debt between the borrower and the lender. The terms and conditions of the bond dictate the payments that the issuer must take to the bondholder. Municipal bonds are debt securities issued by state and local governments. Unlike other types of bonds, the interest income generated by municipal bonds is exempt from federal income tax, and often from state and local taxes within the state where the bonds are issued (Bodie et al., 2021).

5.1.1 Risk Factors for Investment-Grade Municipal GO Bonds

Investment-grade municipal general obligation bonds possess inherent risk factors that investors need to consider. Liquidity risk is a concern for investment-grade municipal GO bonds as limited market activity can hinder timely buy or sell transactions, resulting in variations in quoted prices. Additionally, interest rate risk is relevant, as bond market prices fluctuate inversely with interest rates, potentially leading to market value deviations from the bond's par value. Investors holding low fixed-rate municipal bonds may face losses if they sell before maturity due to decreased market value caused by prolonged periods of low U.S. interest rates (SEC Pub. No. 134).

5.1.2 The US Bond Market

The United States holds the top position in the bond market rankings, with total debt outstanding of 51.3 trillion, accounting for a significant 39% share of the global bond market. The majority of this market comprises government bonds, amounting to over 26 trillion in outstanding securities. In 2022, the Federal government incurred an interest expense of 534 billion in relation to this debt (Neufeld, 2023).

In the United States, the municipal securities market encompasses a vast landscape, involving more than 80,000 state and local governments. Among them, around 50,000 have been issued municipal securities, resulting in approximately one million distinct bond issues currently outstanding. Collectively, these municipal bonds amount to a total value of 3.9 trillion (Rigano & Bryden, 2021)

5.1.3 Municipal Securities Regulations

The regulation of the municipal securities market under federal securities law differs from the regulation of securities offered in the equity and corporate debt sectors of the U.S. capital markets. Municipal securities enjoy an exemption from the federal securities registration and reporting requirements that apply to other publicly offered securities. Federal laws explicitly prevent the Securities and Exchange Commission (SEC) from mandating a municipal issuer to submit any application, document, or report to the SEC prior to the sale of their securities (U.S. Securities and Exchange Commission, 2018).

5.2 Data source

The municipal bond data is downloaded from the Municipal Securities Rulemaking Board (MSRB). This data includes information on bond transactions from January 2005 to June 2022. It covers the complete available data during that period. While the data covers the period after the 19th century, it's important to note that customer trade information was not reported until 1998. This thesis focuses on general obligation municipal bonds, which provide a more reliable measure of the issuer's credit risk compared to revenue bonds.

In the data set obtained from the Municipal Securities Rulemaking Board, several key variables have been selected for analysis. MRSB is accessed with WRSD. These variables include the bond CUSIP[1], the date and time of the trade, the transaction price, the yield, the issue date of the bond, the maturity of the bond, the coupon rate, and a trade type indicator. The total number of bond trades from MRSB is 163,808,240. The bond data obtained from the Municipal Securities Rulemaking Board is supplemented with additional bond-specific information sourced from Bloomberg. This supplementary data includes details such as issuer name, market issue, and bond rating. The research specifically revolves around general obligation bonds issued by cities in 48 states, as these bonds are considered relatively safe investments.

We export a subset of 60,005 unique CUSIPs and merge them with the MRSB dataset. By merging the subset, we conduct a more thorough analysis that included additional bond attributes. Figure A3 shows the number of cities for each state. The provides an overview of the number of cities associated with each state, offering insights into the geographical representation of the analyzed data.

The paper incorporates COVID-19 data from the Centers for Disease Control and Prevention (CDC). Weekly data on COVID-19 cases and deaths are summed in a monthly format. For vaccines distributed, the last cumulative observation for each month is kept, giving us monthly data. Weekly data on hospitalizations are averaged into monthly data. All COVID-19 -variables are by month by state.

This data set includes essential information regarding the number of new and total COVID-19 cases and deaths, hospitalizations, and the distribution of vaccines, providing comprehensive insights into the impact of the COVID-19 pandemic.

[1]The Bond CUSIPs structure identifies the issuer through the initial six characters (CUSIP, 2023). For the available states, information is collected from Bloomberg regarding the six-digit issuer CUSIPs. This helps to identify bonds issued within each state.

The last date from our MSRB data is June 2022. To ensure compatibility, the COVID-19 data is set from 2020-01 to 2022-06. This alignment allows for meaningful comparison and analysis of the liquidity measures and trading activity in relation to the prevailing COVID-19 situation.

The primary objective of incorporating the COVID-19 data is to examine whether states experiencing higher fatality or infection rates witness significant changes in their monthly liquidity measures and trading activity. By exploring this relationship, the paper aims to uncover potential links between the severity of the pandemic and the financial market dynamics at the state level.

We have computed bond-level credit spreads by subtracting Treasury yields from municipal bond yields. To ensure comparability, we have used Treasury yields with approximately the same remaining time to maturity as the respective municipal bonds. Monthly Treasury yield data is provided by Yan Liu & Jing Cynthia Wu (JF, 2021).

5.2.1 Data Description

The presented variables in Table A1 offer insights into the description of our MRSB data, as well as the COVID-19 variables obtained from the Centers for Disease Control and Prevention.

5.3 Summary Statistics

5.3.1 Sample Construction

Table A2, Panel A provides a summary of the steps undertaken to construct the data sample for analysis. The data cleaning process involves the identification and removal of obvious data errors using the procedure outlined by Green Li and Schurhoff (2010) in Schwert's (JF, 2017) paper.

Following the data cleaning process, the MRSB data is merged with the Bloomberg data, resulting in a reduced sample size of 4,721,542 trades involving 56,771 unique bonds.

To analyze our bond trades, certain criteria are applied to ensure the reliability and integrity of the data. Bonds lacking coupon and maturity information are excluded from the sample, as this information is essential for accurate analysis. Additionally, bonds with coupon rates exceeding 20% or listed maturities over 100 years are excluded to eliminate potential outliers. We also drop bonds with maturity equal to or lower than zero, which causes data errors in some measures. To maintain data accuracy trades with a price that is less than 50 are removed, considering the absence of extreme distress during our sample period (Schwert, JF, 2017; Sánchez & Wilkinson, 2020). This helps to filter out potential data errors. Similarly, observations with prices exceeding 150 with one year to maturity are also eliminated as they are likely to be data errors. Trades occurring after the bond maturity are excluded, as these instances are most likely clerical errors. Bonds with fewer than 10 transactions are also excluded from the sample, as their limited data does not provide substantial information for our research.

To ensure chronological order and avoid errors in the analysis, the data is sorted by CUSIP and date/time, arranging the trades from the earliest to the latest for each bond. This time-dependent sorting is crucial for maintaining consistency and accuracy. Following these criteria and sorting procedures, the final sample consists of 35,619 bonds with 3,935,878 trades.

Table A2, panel B provides an overview of the full sample of municipal bond transactions. On average, the bonds in our sample have a maturity of 10.37 years and have been outstanding for 3.46 years. It is worth noting that the majority of bonds (99%) have less than 28.46 years to maturity, reflecting the inclusion of both non-callable and callable bonds in our analysis. The average dollar value in millions is $19.41, with a median value of 3.01.

The size of individual transactions is also modest, with half of the transactions involving a dollar amount below $30,000. This suggests the significant presence of retail investors in the municipal bond market, as smaller transaction sizes are indicative of individual investor participation. It is important to note the presence of notable spikes in terms of bond size and maturity among a minority of bonds, representing less than 10 % of the total sample. It may indicate the influence of institutional investors or specific market conditions on certain bond offerings.

5.3.2 Correlation Table

Table A3 presents the pairwise correlations between our measures used as dependent variables in the panel regressions.

Comparing Panel A (2015-2022) and B (2015-2019) with Panel C (2020-2022), we observe some notable changes in the correlation between the liquidity and trading activity measures. The relationship between the Amihud and IRC measures is strengthened (-0.80) during COVID-19 compared to Panel A (-0.72) and B (-0.27). We find a similar trend for the relationship between Amihud and Roll (-0.84) in Panel C, compared to Panel A (-0.66) and B (-0.30).

Findings show that the EFFSP measure faces weakened relationships between the IRC measure in Panel C (-0.49) compared to Panel A (-0.73) and B (-0.42). There is also a decrease in the correlation between the EFFSP and Roll measure, which show (-0.29) in Panel C, compared to Panel A (-0.52) and B (-0.34). We find that the correlation between measures changes when looking at the time period during COVID-19 compared to the other sub-periods in Panel A and B.

When we compare the correlations of the trading activity measures across the different panels, the correlation between monthly trades and the change in trading activity has an increasing relationship when we look at the Panels in chronological order. Panel C shows a correlation of 0.57 compared to Panel A (0.42) and B (0.46). Comparing monthly trades with CVV, we experience a shift in the three panels. Panel C shows a negative relationship of -0.22, compared to Panel A (0.07) and B (0.20). The same goes for the correlation between the relationship between change in trading activities and CVV. Panel C (-0.22) has a negative correlation, compared to Panel A (-0.01) and B (0.25).

5.4 Sample selection

The sub-samples are created by dividing the data into two distinct groups based on different time periods: the pre-COVID-19 period (2015-2019) and the during-COVID-19 period (2020-2022). These sub-samples represent specific time periods of interest for the analysis of bond trading activity. By comparing the data from these sub-samples, we aim to assess the impact of the COVID-19 pandemic on bond trading activity. To obtain a validated result, we employ various statistical tests: Two Sample t-test, Shapiro Wilk test, and Levene‘s test.

5.4.1 T-test

To assess and potentially reject our null hypothesis, we establish a test methodology. T-test can be an appropriate statistical test to compare the average trades per month of the two sub-samples: the pre-COVID-19 and during-COVID-19 period. By conducting the t-test, we can assess whether there is a statistically significant difference in the average trading activity between the two time periods. The t-test is a statistical test developed by the British statistician William Sealy Gosset (Student, 1908).

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\left(\frac{s_1^2}{n_1}\right) + \left(\frac{s_2^2}{n_2}\right)}} \tag{5.1}$$

Where:

T: Test statistic

X_1: Mean of group 1

X_2: Mean of group 2

s_1: Standard deviation of group 1

s_2: Standard deviation of group 2

n_1: Sample size of group 1

n_2: Sample size of group 2

Further, the Shapiro-Wilk test is used to assess the normality of trade volume variables in the sub-periods (Shapiro & Wilk, 1965). Levene's test for homogeneity of variances is used to compare the variances of the average trades per month between the "Pre-COVID-19" and "COVID-19" periods (Levene, 1960).

5.5 Log- transformation and standardization

The COVID-19 variables seen in Table A1, and the liquidity- and trading activity measures are log-transformed and then standardized.

Log transformation helps to capture the exponential growth pattern of the COVID-19 variables, which makes them more precise for statistical analysis. Log-transforming our variables and measures before standardization can help to equalize the variance and improve our analysis further.

Standardization ensures that all variables and measures are on the same scale which leads to more precise comparisons and which reduces the effects of different measurement units.

To standardize the variables, the average and standard deviation are calculated for each variable within each state. Then, for each observation in the sample, the mean value of the variable is subtracted, and the result is divided by the standard deviation.

5.6 Variable Construction and Panel Regression Methodology

5.6.1 Liquidity measures

This section focuses on liquidity measures and their role in understanding financial market liquidity dynamics. We analyze liquidity metrics, with a particular emphasis on daily liquidity measures that we have averaged to get monthly data. The research question guiding our paper is to explore changes in the liquidity of municipal bonds across different cities in states in the United States and the impact of the COVID-19 crisis. The liquidity measures we focus on are the Amihud measure, Imputed round-trip costs (IRC), Effective Firm-Facing Spread (EFFSP), and Roll measure.

Amihud

We employ Schwert's (JF, 2017) modified Amihud measure to estimate the trade-by-trade price impact. The availability of transaction data for municipal bonds allows us to effectively utilize this measure. Each day, we calculate the modified Amihud measure by considering the number of trades, the bond price at each trade, and the par amount of each trade. This approach helps us understand the price impact of trades in the municipal bond market.

$$\text{Amihud}_{(i,t)} = \frac{1}{N_t}\sum_{j=1}^{N_t}\left|\frac{r_j}{Q_j}\right| = \frac{1}{N_t}\sum_{j=1}^{N_t}\left|\frac{P_j - P_{j-1}}{P_{j-1}}\right|\frac{1}{Q_j} \tag{5.1}$$

The modified Amihud measure is calculated by using the number of trades N_t on a given day, the price P_j of the bond at each trade j, and the par amount Q_j of each trade. To accurately estimate the measure, there must be at least two transactions on the given day. To obtain monthly estimates of the measure, the median of the daily estimates is taken for each month.

Imputed Round-trip Costs (IRC)

We will utilize the approach introduced by Feldhütter (2012) to measure transaction costs based on roundtrip trades. The calculations of the imputed round-trip costs (IRC) as used in Anderson & Stulz (2017) which is outlined in the methodology of Dick-Nielsen et al. (2012). IRC represents the average percentage change in price across all roundtrip trades within a given day.

$$\frac{1}{n}\sum_{i=1}^{n}\frac{P_{\max,i} - P_{\min,i}}{P_{\max,i}} \tag{5.2}$$

An imputed roundtrip trade is defined as any series of 2 or 3 days for a given bond on the same day with the same volume.

$P_{\max,i}$ og $P_{\min,i}$are the maximum and minimum transaction prices for imputed trade i , and n is the number of IRTs in a day. There must be at least one imputed roundtrip trade on each bond-day to calculate the IRC.

Effective Firm- Facing Spread (EFFSP)

EFFSP is the difference between the daily trade-weighted average customer purchase price and the daily trade-weighted customer sale price (Anderson, Mike & Stultz, 2017).

$$\text{EFFSP} = \bar{P}_{\text{buy}} - \bar{P}_{\text{sell}} \tag{5.3}$$

Where $\bar{P}$ is the daily trade-weighted price as a percent of the principal. Customer-initiated buy/sell transactions are identified by the trade type indicator from the MRSB data.

Roll

According to Roll (1984, cited in Schwert, JF, 2017), when there is a bid-ask spread in the market for a particular asset, successive returns on that asset will have negative autocorrelation. The effective bid-ask spread is measured as follows:

$$\text{Roll}_{(i,t)} = \sqrt{2 \cdot \text{Cov}(\Delta P_j, \Delta P_{(j-1)})} \tag{5.4}$$

The roll measure is calculated using the price at each trade P_j. When the covariance between successive price movements is positive, the measure is set to zero.

5.6.2 Bond Trading Activities

In this thesis, we use aggregated trade data to calculate monthly aggregated measures related to bond trading activities. We focus on monthly trades and two key measures: the change in Bond Trading Activity and the Coefficient of Variation of Volume (CVV). When we are using monthly trade data allows us to analyze the trading patterns and dynamics on a monthly basis during the COVID-19 pandemic.

Change in Bond Trade Activity

The formula for calculating the change in bond trading activity represents a measure of the relative fluctuation in the trading activity of a bond over a specific period. It can be expressed as the difference between the logarithm of the ratio of the dollar volume to the bond's price in the current period and the logarithm of the same ratio in the previous period (t-1). The increase in bond trade activity is measured as follows:

$$\text{Change in bond trade activity} = \log\left(\frac{\text{Dollar Volume}}{\text{price}}\right) - \log\left(\frac{\text{Dollar Volume}}{\text{price}}\right)_{t-1} \tag{5.5}$$

By taking the logarithm of the dollar volume/price ratio and comparing it to the lagged value, the formula effectively captures the percentage change in bond trade activity, accounting for price fluctuations. This measure provides information about the level of trading activity for a bond and helps evaluate its relative increase or decrease over the given time frame.

Coefficient of Variation of Volume

The formula for the coefficient of variation of volume (CVV) is derived from Chordia, et. al. (2000).

$$CVV_{i,t} = \frac{\sqrt{\sum_{j=1}^{n}(x_j - \bar{x})^2}}{\sum_{j=1}^{n}|x_j - \bar{x}|} \tag{5.6}$$

This formula calculates the coefficient of variation of volume (CVV) for a specific state (i) and month (t). It quantifies the variation in trade activity among different bonds within the same state and month, taking into account the average number of bonds outstanding.

5.6.3 Panel Regression Methodology

In line with Schwert (JF, 2017), we use panel regression, where the measure that is the dependent variable is denoted by λ. Regression is a statistical technique that allows us to examine the relationship between the measure and the independent variables while accounting for cross-sectional and time-series variations. We estimate the following panel regression with US states as a fixed effect:

$$\lambda_{i,t} = \beta_0 + \beta_j \cdot c_j + \alpha_i + \epsilon_1 \tag{5.7}$$

In this model:

$\lambda_{i,t}$ represents the dependent variable (measure) for state i at time t.

β_0 is the intercept term, representing the constant effect on the measure.

β_j represents the coefficient of the different independent COVID-19 variable $\mathtt{c}_j$, indicating the impact of changes in vaccination distribution on the measure.

α_i represents the state-specific fixed effects, capturing unobserved heterogeneity across cities that might influence the measure.

ϵ_1 represents the error term, capturing the unexplained variation in the measure that is not accounted for by the independent variables or fixed effects.

This panel regression model estimates the relationship between the measure and the different independent COVID-19 variables while controlling for state-specific fixed effects. By examining the coefficient β_j, we can assess the significance and direction of the impact of changes in vaccination distribution on the measure of interest. The fixed effects α_i capture any state-specific characteristics that might influence the measure, accounting for potential confounding factors.

5.6.4 The Control Variable

We use the time to maturity (TTM) as a time-varying control variable in the panel regression. When using time-to-maturity as a time-varying control variable in the panel regression, the TTM values change for each observation across different time periods. This allows us to capture the potential impact of the remaining time to maturity on the dependent variable while accounting for variations in TTM over time.

We include TTM as a time-varying control variable in all regressions concerning liquidity measures. For the trading activity, we are inducing the control variable for monthly trades and Changes in Bond Trading Activity.

5.7 Autocorrelation

Since the COVID variables are increasing, we expect autocorrelation in our data. Based on this, we employ robust standard errors to address both autocorrelation and heteroscedasticity in the within-model regression analysis. Autocorrelation refers to the presence of correlation among the residuals at different time periods. If autocorrelation is present, it violates one of the assumptions of the regression model, namely the independence of the errors. By using robust standard errors, which are calculated using a heteroscedasticity-consistent covariance estimator, we adjust the regression results to account for the potential correlation in the residuals. This helps provide more reliable and efficient estimates of the model parameters.

Heteroscedasticity refers to the situation where the variance of the residuals is not constant across all levels of the independent variables. This violates another assumption of the regression model, namely the homoscedasticity of the errors. The robust standard errors, computed using the "HC1" estimator, are robust to heteroscedasticity, meaning they provide consistent estimates even if the assumption of constant variance is violated. By including robust standard errors in the regression output, as shown in the code provided, we account for both autocorrelation and heteroscedasticity in the within model analysis.

To compute robust standard errors, we use the method Heteroscedasticity-Consistent Covariance Matrix (HC1) estimator. The HC1 estimator takes into account the potential heteroscedasticity by using a robust variance-covariance matrix. This matrix allows for the calculation of robust standard errors, which can handle potential violations of the homoscedasticity assumption (White, 1980).

We acknowledge that the COVID-19 data, being related to a pandemic, is expected to exhibit some degree of serial correlation due to the cumulative nature of the variables. In this case, it is important for us to consider the specific context and nature of the data when interpreting the results. The presence of serial correlation in this context does not necessarily indicate a violation of the assumptions of the model but rather reflects the inherent nature of the data.

While it is valuable for us to acknowledge the presence of serial correlations, we can proceed with interpreting the coefficient estimates while considering the cumulative nature of the COVID-19 data and the specific context of the pandemic. By recognizing the serial correlation and its implications, we ensure a comprehensive understanding of the coefficient estimates in relation to the cumulative nature of the COVID-19 data and the unique circumstances of the pandemic.

6 Results and Analysis

This section is about the purpose of the thesis. Hypothesis 1 will be tested, then the results from the panel regressions with state-fixed effects outlined in equation 5.7 will be presented. Significant coefficients will indicate a relationship between the corresponding measure and the COVID-19 variables. Each coefficient is tested, giving us results with robust standard errors. Our panel regressions suggest whether hypothesis 2 will be rejected or not. Hopefully, our findings will contribute to answering the research question:

"How have the health effects of COVID-19 impacted municipal bond liquidity and trading activity?"

6.1 Monthly Trades: Sub-period Comparison

Under this section, we will present the findings related to Hypothesis 1, which is that the average trades per month during the COVID-19 period (2020-2022) have decreased compared to the pre-COVID-19 period (2015-2019).

Table A4 shows that the t-test yields a test statistic of t=5.82, with a p-value of approximately zero. These results provide substantial evidence to reject the null hypothesis. Specifically, we find significant differences in the average trades per month between the sub-periods. The 95 % confidence interval for the difference in means ranges from [0.78, 1.59], suggesting that trades per month under COVID-19 had a lower average compared to before COVID-19. We find that there has been a small, but significant impact on monthly trades during COVID-19.

The Shapiro-Wilk test results for the pre-COVID-19 period indicate a W statistic of 0.98 and a p-value of 0.35. As the p-value exceeds 0.05, we fail to reject the null hypothesis, indicating that the average trades per month during this period approximately adhere to a normal distribution. In contrast, for the COVID-19 period, the Shapiro-Wilk test results in a W statistic of 0.82 and a p-value of 0.0002. With a p-value significantly below 0.05, we reject the null hypothesis, suggesting that the average trades per month during the COVID-19 period do not follow a normal distribution.

Levene's test indicates that there is no significant difference in the variances between the two groups, as evidenced by the test statistic of F = 0.0002 and a corresponding p-value of 0.97. Therefore, we do not have enough evidence to reject the null hypothesis of equal variances, suggesting homogeneity of variances between the "Pre-COVID-19" and "COVID-19" periods for trades per month.

6.2 Liquidity Measures

In this section, we will present the findings related to Hypothesis 2 based on our liquidity measures. Our panel regressions in Table A8 have state-fixed effects, and time to maturity is included as a control variable. Regression (1-6) in each panel regresses the independent variables separately on the respective measures. Regression (7) includes all COVID-19 variables except new cases and deaths since they are highly correlated with total cases (0.93) and deaths (0.85). Regression (8-10) shows the impact the measures have on bonds with different times to maturity.

A higher Amihud value indicates greater price impact and lower liquidity. Executing trades for large quantities without significant price movement becomes more challenging. This is due to higher trade execution costs and potential difficulties in finding counterparties without impacting market prices significantly. Negative coefficients in panel A indicate an increase in liquidity.

Panel A (1-6) indicates that the coefficient of the distributed COVID-19 vaccines, deaths, and hospitalizations are significantly positive. One standard deviation increase in the independent variables is associated with an increase of 0.02, 0.01, and 0.03 in the Amihud measure. Regressing the independent variables separately results in a larger trade-by-trade price impact, which reflects lower market liquidity.

Panel A (7) shows significant values in cases, deaths, and hospitalizations. Hospitalizations and deaths have positive coefficients of 0.03 and 0.05, while cases have a negative coefficient of -0.07. Overall, the Amihud measure has increased, still indicating worse liquidity. The explanation power has a slight increase, when including more variables. However, the control variable TTM has the most impact in the R squared.

Panel A (8) indicates that the COVID-19 variables have a higher impact on the Amihud measure with bonds closer to maturity. Deaths and hospitalizations have positive coefficients of 0.1 and 0.09, and cases have a negative coefficient of -0.14. For municipal bonds closer to maturity, there is a decrease in liquidity measured by Amihud. Panel A (9-10) indicates that the longer maturity, the less impact the COVID-19 variables have on the Amihud measure, however, both regressions show an increase in liquidity for bonds with a time to maturity longer than 5 years. The control variable is also no longer significant at longer maturities.

A lower IRC value signifies better liquidity. It indicates that executing a roundtrip trade has a relatively small price impact, suggesting improved liquidity where the market can absorb transactions with minimal price impact. Negative coefficients in panel B indicate an increase in liquidity. Panel B (1-6) shows that all significant COVID-19 variables have a negative coefficient, indicating that one standard deviation increase in the independent variables is associated with better liquidity. Regressing the independent variables separately shows that a roundtrip trade gets a smaller price impact.

Panel B (7) shows significant values for all regressed variables. Vaccinations, deaths, and hospitalizations have negative coefficients of -0.07, -0.35, and -0.12, while cases have a positive coefficient of 0.41. In total, regressing the variables together results in better liquidity for the IRC measure under COVID-19.

Panel B (8-10) shows that all variables are still significant regardless of the time to maturity. For the three regressions, vaccinations, deaths, and hospitalizations have a negative coefficient, while cases have a positive coefficient. Overall, the liquidity has increased during COVID-19 based on the IRC measure.

A lower EFFSP value indicates that liquidity is better, as it suggests that the trading costs associated with the bid-ask spread are lower. Negative coefficients in panel C indicate an increase in liquidity.

Panel C (1-6) shows significant variables with a positive coefficient, except the control variable which has a constant negative coefficient of -0.03.

One standard deviation increase in the independent variables is associated with a decrease in liquidity. Regressing the variables separately shows that the trading costs associated with the bid-ask spread are higher.

Panel C (7) has all significant values at different significant levels. Vaccinations, cases, and hospitalizations have positive coefficients of 0.01, 0.06, and 0.01. Deaths have a negative coefficient of -0.07. In total, the independent variables are positive, resulting in a decrease in liquidity for the EFFSP measure.

Panel C (8-9) shows that bonds with a Time to Maturity below 10 years have significantly positive coefficients, which indicates a decrease in liquidity. Panel C (10) shows that cases and deaths have coefficients with the values 0.15 and -0.15, which indicates that the COVID-19 variables have approximately no impact on the liquidity for the EFFSP measure.

A higher Roll value indicates a larger price impact, suggesting lower liquidity and higher trading costs. Negative coefficients in panel D indicate an increase in liquidity. Panel D (1-6) shows that the independent variables that are significant have a negative coefficient. One standard deviation increase in the independent variables indicates an increase in liquidity. Regressing the variables separately results in lower trading costs overall. The control variable has a constant positive coefficient of 0.29.

Panel D (7) indicates a change in the impact of the COVID-19 variables. Where vaccinations and deaths have a negative coefficient of -0.05 and 0.46, while cases and hospitalizations have positive coefficients of 0.53 and 0.14. Overall, regressing the independent variables together indicates a higher roll value with an increase in standard deviations, indicating a larger price impact, and suggesting lower liquidity in the Roll measure.

Panel D (8) shows that bonds with a shorter Time to Maturity have higher absolute coefficients than (7), while they still are negative in total, suggesting lower liquidity in the measure. For (9-10) vaccinations are no longer significant, but the independent variables are still indicating a decrease in liquidity.

6.3 Trading Activities

In this section, we will present the findings related to Hypothesis 2 based on trading activities. Our panel regressions in Table A9 have state-fixed effects, and time to maturity is included as a control variable in Panel A-B. Regression (1-6) in each panel regresses the independent variables separately on the respective measures. Regression (7) includes all COVID-19 variables except new cases and deaths since they are highly correlated with total cases (0.93) and deaths (0.85). Regression (8-10) shows the impact the measures have on bonds with different Times to Maturity.

An increase in monthly trades results in an increase in bond trading activity. Positive coefficients in the regression indicate a higher trading activity. Panel A (1-6) shows that the coefficients for total cases, new cases, and total deaths of COVID-19 are estimated to be 0.02, indicating a positive relationship between these independent variables and bond trading activity. This means that as the number of COVID-19 cases and deaths increases, bond trading activity tends to increase. The coefficient for average hospital admissions is estimated to be -0.03, suggesting a negative effect. This implies that higher average hospital admissions are associated with lower bond trading activity. Additionally, the control variable time to maturity has a constant positive coefficient of 0.12.

Panel A (7) shows that the variable for distributed COVID-19 vaccines is non-significant with a coefficient of 0.02. Cases have a highly significant positive relationship with a coefficient of 0.31, indicating higher case numbers are associated with increased bond trading activity. Deaths have a highly significant negative relationship with a coefficient of -0.25, suggesting that higher death tolls are linked to reduced bond trading. Hospitalizations have a highly significant negative relationship with a coefficient of -0.10, indicating that higher average admissions correspond to lower market liquidity. The control variable time to maturity is significant with a coefficient of 0.12, implying that increased monthly trades lead to higher bond trading activity.

In Panel A (8-10), for bonds with a time to maturity of fewer than five years, the coefficient for vaccines is not statistically significant at 0.03. The coefficients for cases, deaths, and hospitalizations are all statistically significant. A one-unit increase in total COVID-19 cases is associated with a 0.43 increase in bond trading activity. A one-unit increase in deaths is linked to a 0.34 decrease in bond trading activity. The coefficient for hospitalizations is -0.13, indicating that higher average hospital admissions are associated with reduced market liquidity for bonds with a time to maturity of fewer than five years.

When the value of change in bond trade activity is positive, it indicates an increase in bond trade activity compared to the previous period. A negative coefficient suggests a decrease in trading activity. Panel B (1-6) shows that the coefficient for vaccines is highly significant at 0.15, indicating an increase in bond trading activity. Cases, deaths, and hospitalizations also have significant positive coefficients, suggesting that higher values of these variables are associated with increased trading activity. The control variable time to maturity has a significant negative coefficient of -0.03, implying that a longer time to maturity is linked to decreased trading activity.

Panel B (7), the coefficient for distributed vaccines is 0.16, indicating a significant increase in bond trade activity. Cases have a strong positive relationship with a coefficient of 0.63, while deaths have a negative coefficient of -0.61, both significantly impacting bond trade activity. Hospitalizations exhibit a negative coefficient of -0.08, indicating reduced market liquidity. The control variable time to maturity has a negative coefficient of -0.03, showing a significant decrease in bond trading activity with an increase in monthly trades.

Panel B (8-10), results indicate that a higher distribution of vaccines is associated with increased bond trade activity with a coefficient of 0.15 for bonds with a time to maturity of fewer than 5 years and between 5 and 10 years. Higher cases are linked to increased bond trading activity, while higher deaths and hospitalizations correspond to decreased trading activity. The control variable for time to maturity shows a negative coefficient for bonds with a time to maturity of fewer than 5 years and between 5 and 10 years, suggesting that increased monthly trades lead to decreased bond trading activity.

A lower CVV indicates a lower dispersion in trade volumes among the bonds, suggesting a higher level of homogeneity in trading activity. This suggests more consistent levels of liquidity or market interest across the bonds. Negative coefficients in the regression indicate a potential decrease in the homogeneity of trade volumes as a result of the independent variables.

In Panel C (1-6), the regression results show that the variable deaths have a significant positive coefficient of 0.01, suggesting a potential increase in the heterogeneity of trade volumes. This implies that deaths related to COVID-19 may contribute to greater trading volumes among the bonds.

In Panel C (7), the distribution of vaccines has a coefficient of -0.07, potentially decreasing the homogeneity of trade volumes, although the statistical significance is weak. Hospitalizations have a statistically significant positive relationship with homogeneity, with a coefficient of 0.08.

Panel C (8-10), for bonds with a time to maturity of fewer than 5 years, the distribution of COVID-19 vaccines, cases, deaths, and hospitalizations do not significantly impact trading volume homogeneity. For bonds with a time to maturity between 5 and 10 years, the distribution of COVID-19 vaccines. For bonds with a time to maturity exceeding ten years, none of the variables, including the vaccines, cases, and deaths, have statistically significant effects on trading volume homogeneity.

7 Discussion

While our paper offers an understanding and knowledge about the impact of the health effects of COVID-19 on municipal bond liquidity and trading activity, we mean it is important to acknowledge certain limitations of this paper. One limitation we find is significant, is the availability of data variables extracted from the Bloomberg terminal. Even though we were able to access and analyze general obligation bonds from different states, there were additional variables that could have provided us with more information about the municipal bond market. Expanding our data to include more issuer-specific information about face values, the principal amount outstanding, and municipal bond ratings, could have extended our analysis to bond turnover, as well as included more control variables, such as notional outstanding in our panel regressions. This would have strengthened our paper, providing a more robust examination of the relationship between our measures and variables. Regardless of the limitations, we are confident that our paper provides a deeper understanding of the municipal bond market, and how the COVID-19 pandemic has influenced municipal bond liquidity and trading activities.

Before studying the impact the health effects of COVID-19 have had on the municipal bond market, we had certain expectations derived from our literature review and observations from times during the crisis. Even though specific outcomes may differ, we expect some common trends for our research on municipal bonds.

In times with higher market volatility and uncertainty such as COVID-19, it is typically expected that the liquidity in financial markets would decline. Investors get more risk-averse, reduced market participation, and greater uncertainty about financial conditions and the economy. Health effects, such as our COVID-19 variables may disrupt the market and affect investor confidence.

Regarding our first hypothesis, the finding of a significant decrease in monthly trades between the COVID-19 period (2020-2022) and the pre-COVID-19 period (2015-2019) aligns with the hypothesis. We had expected this result, and the findings support hypothesis 1. The significant decrease in monthly trades suggests that the COVID-19 pandemic had a noticeable impact on bond trading activity. The pandemic brought about significant economic uncertainty, market volatility, and disruptions in various sectors, which likely influenced investor behavior and trading patterns, which may have led to a decrease in average trades.

We expect that there will be a decrease in most of the liquidity measures. As the pandemic gets worse, we anticipated that the market participants may encounter difficulties to some degree in executing trades for larger quantities without influencing the price change substantially. We believe that there would be an increase in trade execution costs, while they are harder to find willing counter-parties without affecting the market prices significantly. In the Amihud measure, we expect it to increase, indicating a greater price impact and lower liquidity.

From our correlation table, there is a positive relationship between the Amihud measure and vaccines, deaths, and hospitalizations. An increase in the COVID-19 variables indicates a higher price impact and lower liquidity. The correlation between Amihud and the variables supports our expectations that the health effects of the pandemic may have an effect on municipal bond liquidity, as it will increase the trade-by-trade price impact.

From our results, the COVID-19 variables increase the Amihud measure, indicating that executed trades of higher quantity have a hard time not causing a significant price movement, which implies lower liquidity. The positive coefficient from the analysis for vaccinations, deaths, and hospitalizations supports our expectations that the Amihud measure has a positive correlation and an increased lead to higher price impact and lower market liquidity.

IRC assesses the ability to absorb transactions with minimal price impact, we expect the measure to decrease during times of crisis, such as COVID-19. Investors may tend to be more cautious and more selective in their trading, resulting in lower liquidity. When IRC decreases, executing round-trip trades has a relatively bigger price impact, which can indicate lower liquidity and higher trading costs.

There is a negative relationship between our IRC measure and the COVID-19 variables, which may show that higher values of vaccines, deaths, and hospitalizations will increase the liquidity and the price impact will decrease. The negative relationship between the measure and variables does not support our expectations, which is lower liquidity due to the health effects of COVID-19.

The results from the IRC regression analysis did surprise us. The negative coefficients of the COVID-19 variables in the regression indicate that a higher value of vaccinations, deaths, and hospitalizations are linked to better liquidity, and it becomes more feasible to execute trades with minimal price impact. It is possible that the presence of a significant number of retail investors in the municipal bond market can influence liquidity dynamics. It can be that they have different trading strategies compared to institutional investors. However, these findings may suggest that in spite of the overall lowered liquidity, some market participants were able to process transactions more efficiently during the pandemic.

EFFSP, which measures the bid-ask spreads and trading costs, is also expected to be affected by COVID-19. We believe that market participants seek higher compensation for the increased risk and uncertainty caused by the pandemic, which may result in wider bid-ask spreads and higher trading costs. We believe that the EFFPS measure will increase from the impact of our COVID-19 variables, indicating higher trading costs and decreased market efficiency causing lower liquidity.

EFFSP has a positive relationship between vaccinations, cases, and hospitalizations, which may indicate that the health effects of COVID-19 are associated with lower liquidity and higher trading costs. The positive relationship supports our expectations that the bid-ask spreads are higher because of the pandemic.

Our results from the EFFSP measure indicate lower liquidity as the COVID-19 variables increase. This supports our expectations and understanding that uncertain periods with market stress can result in a wider bid-ask spread and higher trading costs, which makes it more expensive to execute trades.

For the Roll measure, which indicates price impact and trading costs, we expect a decrease in liquidity during COVID-19. Disruptions in the market and higher uncertainty may result in an increase in transaction costs, which lowers the liquidity in the market.

The roll measure shows a combination of positive and negative correlations in the relationship with the COVID-19 variables. Vaccinations and deaths show a negative correlation, indicating that higher values of the variables are associated with lower price impact and better liquidity. On the other hand, cases and hospitalizations show a positive correlation, indicating a higher price impact and lower liquidity when the variables increase. This may or may not support our expectations of overall reduced liquidity.

Regression results for the Roll measure show that there are varied effects, depending on the COVID-19 variables. While vaccinations and deaths indicate a lower price impact and liquidity, cases and hospitalizations indicate the opposite. We expected it to be an overall decrease in liquidity, but our analysis shows that the municipal bond market's reaction to our COVID-19 variables may differ and is potentially influenced by other factors such as investor behavior, government interventions, and market sentiment.

From monthly trades, a higher number of COVID-19 cases is expected to be associated with increased bond trading activity. We observe from Figure A4 that there was an increase in trade at the beginning of COVID-19. We expect this because investors, through flight to safety, tend to seek safer investment options (Loayza & Pennings, 2020). US municipal bonds are relatively safe investments because state and local governments back them. Another explanation for the increase in trades at the beginning of COVID-19 concerns market liquidity. Investors became concerned about liquidity as the pandemic caused significant disruption to financial markets. Many investors tried to sell their holdings to adjust their portfolios, which increased trading volumes in the US municipal bond market.

Furthermore, we observe a significant decline in trading in Figure A4 after the COVID-19 shock and this is also in line with our first hypothesis. The decline in trading may indicate that investors held on to their municipal bonds. A decrease in trading activity is expected as investors choose to keep their existing municipal bonds instead of trading them. This may be due to increased uncertainty and volatility in the market during COVID-19. Another explanation is the flight to quality, as municipal bonds are often seen as safe investments. During economic uncertainty, investors sought safety by holding onto these safe-haven securities, resulting in reduced trading activity and reduced trades during COVID-19.

From the Change in Bond Trade Activity, we expect an increase in COVID-19 cases and deaths associated with higher bond trading activity. This could be because rising cases and fatalities indicate a worsening health and economic situation, which may motivate investors to restructure their portfolios and engage in more bond trading. It may be unexpected that the control variable time to maturity has a negative effect on the change in bond trading activity. One possible reason could be that bonds with longer maturities are often considered less liquid, and investors may be less willing to trade them during turbulent periods like the COVID-19 pandemic. This could result in a larger reduction in trading activity for bonds with a longer time to maturity than a shorter time to maturity. From the CVV, it is unexpected that none of the COVID-19 variables show a significant relationship with the variation in trading volume. One possible explanation could be that trading volume is influenced by other factors not included in the regression, such as broader economic indicators and policy decisions.

Our paper aimed to investigate how our selected health variables of the COVID-19 pandemic had impacted municipal bond liquidity and trading activity. We have analyzed liquidity- and trading activity measures and their relationship to variables including vaccinations, cases, deaths, and hospitalizations. We have gained a new understanding and knowledge regarding the dynamics of municipal bonds during the pandemic.

Our findings show that there is a significant relationship between our measures and the COVID-19 variables. These findings provide sufficient support for our second hypothesis, which states that the health effects of COVID-19 have impacted the liquidity and trading activity of municipal bonds in the US.

8 Conclusion

Based on the hypothesis and analysis provided in our paper, we believe that we have gained enough information and results to confidently answer our research question: "How have the health effects of COVID-19 impacted municipal bond liquidity and trading activity?".

Our findings demonstrate that there has been an impact on the liquidity and trading activity of municipal bonds from the health effects of COVID-19. Higher market volatility and economic uncertainty have influenced investor behavior and trading patterns. We conclude that the overall impact COVID-19 has had on municipal GO bonds is characterized by lower monthly bond trades during the pandemic, as well as significant changes in liquidity and trading activity measures.

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10 Appendix

A1 Tables

Table A1: Data Description

MRSB variables	*Description*
CUSIP	CUSIP of issue traded
Trade type indicator	Customer purchase/sale, inter-dealer transactions
Trade date	Date trade was effected
Time of trade	Time of trade execution
Dated traded	Date of issuance
Settlement date	Date trade was settled
Maturity date	Maturity date of issue
Coupon	Interest of issue
Yield	Yield to maturity
TTM	Time to maturity
Par traded	Trade dollar amount
Dollar price	Principal dollar amount at issuance
Dollar Value	Value of a individual trade
Dollar Volume	Total value of a traded CUSIP
COVID-19 variables	*Description*
Dist_vaccines	Number of total vaccine doses distributed
Tot_cases	Total number of cases
New_cases	Number of new cases
Tot_deaths	Total number of deaths
New_deaths	Number of new deaths
Avg_hospitals_admissions	Average monthly number of new hospital admissions

Table A1: This table presents a detailed description of the variables included in the Municipal Securities Rulemaking Board (MSRB) data and the COVID-19 variables.

Table A2: Statistical Summary

Panel A: Transaction Data Cleaning Steps							
Steps				*Bonds*		*Trades*	
MRSB full sample				NA		163 808 240	
Bloomberg sample				60 005		60 356	
MRSB - Bloomberg merge				56 771		4 721 542	
Data Errors removed				35 619		3 935 878	
Final sample				35 619		3 935 878	
2015-2019 sample				24 599		1 565 373	
2020-2022 sample				15 792		654 100	

Panel B: Bond Characteristics 2005-2022							
	Mean	*StDev*	*p1*	*p10*	*p50*	*p90*	*p99*
Years to Maturity	10.37	6.80	0.26	2.07	9.38	19.90	28.46
Years since Issuance	3.46	3.11	-0.06	-0.01	2.82	8.09	10.93
Coupon Rate %	4.43	1.01	1.82	3.00	5.00	5.05	6.82
Dollar Amount K	178.13	1 085.02	5.00	10.00	30.00	225.00	3 000.00
Dollar Value MM	19.41	116.52	0.49	1.00	3.01	24.26	345.41
Dollar Volume MM	2 144.86	6 640.47	21.10	86.03	533.87	4 422.40	29 376.83
Amihud (% per million)	3.96	10.24	0.01	0.12	1.66	9.84	32.26
IRC (%)	0.70	0.79	0.01	0.07	0.42	1.77	3.30
EFFSP (%)	-4.98	24.07	-86.97	-23.90	-0.51	2.25	66.15
Roll	0.84	1.14	0.00	0.00	0.46	2.19	5.17
Monthly Trades	6.47	16.12	1.00	1.00	4.00	12.00	49.00
Log Change in TA (%)	0.05	0.36	-0.84	-0.35	0.03	0.46	0.97
Log CVV (%)	6.09	0.40	4.67	5.16	6.16	6.45	6.69

Panel C: Bond Characteristics 2015-2019							
	Mean	*StDev*	*p1*	*p10*	*p50*	*p90*	*p99*
Years to Maturity	9.87	6.66	0.24	1.85	8.76	19.46	26.7
Years since Issuance	4.02	3.29	-0.06	0.00	3.61	8.79	11.20
Coupon Rate %	4.38	1.05	2.00	3.00	5.00	5.00	6.57
Dollar Amount K	167.93	1 108.32	5.00	10.00	25.00	220.00	3 000.00
Dollar Value MM	18.37	117.36	0.49	1.00	2.99	23.98	320.37
Dollar Volume MM	1 169.17	4 077.74	3.00	18.66	245.81	2 319.37	17 042.14
Amihud (% per million)	3.62	13.62	0.01	0.12	1.55	8.85	29.09
IRC (%)	0.61	0.68	0.01	0.07	0.36	1.52	2.80
EFFSP (%)	-4.19	25.11	-88.78	-22.25	-0.39	3.65	70.66
Roll	0.62	0.82	0.00	0.00	0.36	1.60	3.51
Monthly Trades	6.89	14.85	1.00	2.00	4.00	13.00	51.00
Log Change in TA (%)	0.08	0.20	-0.28	-0.12	0.04	0.35	0.65
Log CVV (%)	7.84	0.49	7.00	7.28	7.77	8.59	8.99

Panel D: Bond- and COVID-variable Characteristics 2020-2022							
	Mean	*StDev*	*p1*	*p10*	*p50*	*p90*	*p99*
Years to Maturity	8.29	6.44	0.15	1.17	6.88	17.84	27.71
Years since Issuance	4.59	3.36	-0.05	0.37	4.25	9.11	13.88
Coupon Rate %	4.33	1.06	1.10	3.00	5.00	5.00	6.26
Dollar Amount K	188.58	997.70	5.00	10.00	25.00	250.00	3 530.01
Dollar Value MM	20.98	112.20	0.50	1.01	2.99	25.74	400
Dollar Volume MM	869.11	3 552.80	2.00	10.50	130.45	1 741.24	12 809.30
Amihud (% per million)	4.28	7.31	0.01	0.13	1.90	10.79	33.42
IRC (%)	0.44	0.59	0.01	0.05	0.23	1.10	2.47
EFFSP (%)	-2.15	25.65	-90.11	-18.25	-0.16	7.24	84.68
Roll	0.55	0.86	0.00	0.00	0.28	1.43	3.87
Monthly Trades	5.75	7.78	1.00	2.00	4.00	12.00	33.00
Log Change in TA (%)	0.17	0.36	-0.40	-0.24	0.12	0.68	0.96
Log CVV (%)	8.66	0.30	8.13	8.37	8.61	8.98	9.42
Dist_vaccines MM	5.91	11.15	0.00	0.00	1.42	16.19	57.77
Total_cases K	673.79	1 105.99	0.00	2.14	280.49	1 671.08	5 899.98
New_cases K	58.09	129.17	0.00	0.82	20.89	133.94	502.03
Total_deaths K	10.15	14.49	0.00	0.05	4.74	26.46	75.31
New_deaths K	0.68	1.21	0.00	0.01	0.27	1.79	5.44
Avg_hospital_admissions K	0.76	1.44	0.00	0.00	0.27	2.07	6.73

Table A2: This table provides a statistical summary of the data used in the thesis. Panel A focuses on the transaction data cleaning steps, including the number of bonds and trades at each stage of data processing. Panel B presents the characteristics of bonds from 2005 to 2022, including mean, standard deviation, and percentiles for variables such as years to maturity, coupon rate, and dollar volume. Panel C focuses on bond characteristics from 2015 to 2019, while Panel D focuses on bond and COVID-variable characteristics from 2020 to 2022.

Table A3: Correlation Table

Panel A: 2015-2022							
	Amihud	IRC	EFFSP	Roll	Trades	Change	CVV
Amihud	1.00	-0.72	0.58	-0.66	-0.61	-0.16	-0.07
IRC	-0.72	1.00	-0.73	0.90	0.71	0.09	0.15
EFFSP	0.58	-0.73	1.00	-0.52	-0.56	0.16	-0.23
Roll	-0.66	0.90	-0.52	1.00	0.70	0.27	0.06
Trades	-0.61	0.71	-0.56	0.70	1.00	0.42	0.07
Change	-0.16	0.09	0.16	0.27	0.42	1.00	-0.01
CVV	-0.07	0.15	-0.23	0.06	0.07	-0.01	1.00
Panel B: 2015-2019							
	Amihud	IRC	EFFSP	Roll	Trades	Change	CVV
Amihud	1.00	-0.27	0.10	-0.30	-0.31	-0.32	-0.09
IRC	-0.27	1.00	-0.42	0.95	0.62	0.33	0.07
EFFSP	0.10	-0.42	1.00	-0.34	-0.40	-0.04	-0.17
Roll	-0.30	0.95	-0.34	1.00	0.52	0.33	0.00
Trades	-0.31	0.62	-0.40	0.52	1.00	0.46	0.20
Change	-0.32	0.33	-0.04	0.33	0.46	1.00	0.25
CVV	-0.09	0.07	-0.17	0.00	0.20	0.25	1.00

Panel C: 2020-2022

	Amihud	IRC	EFFSP	Roll	Trades	Change	CVV	DV	TC	NC	TD	ND	HA
Amihud	1.00	-0.80	0.29	-0.84	-0.70	-0.36	0.29	0.37	0.15	0.06	0.20	0.04	0.47
IRC	-0.80	1.00	-0.49	0.90	0.70	0.18	-0.01	-0.54	-0.31	-0.17	-0.37	-0.20	-0.58
EFFSP	0.29	-0.49	1.00	-0.29	-0.46	0.22	-0.14	0.49	0.24	0.21	0.25	0.27	0.40
Roll	-0.84	0.90	-0.29	1.00	0.72	0.39	-0.05	-0.39	-0.17	-0.08	-0.25	-0.10	-0.52
Trades	-0.70	0.70	-0.46	0.72	1.00	0.57	-0.22	-0.03	0.10	0.05	0.06	-0.08	-0.20
Change	-0.36	0.18	0.22	0.39	0.57	1.00	-0.22	0.55	0.37	0.23	0.34	0.11	0.32
CVV	0.29	-0.01	-0.14	-0.05	-0.22	-0.22	1.00	-0.14	0.20	0.27	0.17	0.28	0.19
DV	0.37	-0.54	0.49	-0.39	-0.03	0.55	-0.14	1.00	0.68	0.48	0.71	0.40	0.71
TC	0.15	-0.31	0.24	-0.17	0.10	0.37	0.20	0.68	1.00	0.93	0.86	0.95	0.76
NC	0.06	-0.17	0.21	-0.08	0.05	0.23	0.27	0.48	0.93	1.00	0.92	0.95	0.68
TD	0.20	-0.37	0.25	-0.25	0.06	0.34	0.17	0.71	0.86	0.95	1.00	0.85	0.77
ND	0.04	-0.20	0.27	-0.10	-0.08	0.11	0.28	0.40	0.86	0.95	0.85	1.00	0.62
HA	0.47	-0.58	0.40	-0.52	-0.20	0.32	0.19	0.71	0.76	0.68	0.77	0.62	1.00

DV= Distributed Vaccines, TC = Total Cases, NC = New Cases, TD= Total Deaths, ND=New Deaths, HA = Hospital Admissions

Table A3: Panel A shows the correlation coefficients between the variables Amihud, IRC, EFFSP, Roll, Trades, Change, and CVV for the period 2015-2022. Panel B displays the correlations for the same variables but is limited to the period 2015-2019. Finally, Panel C presents the correlations for an even more specific period, 2020-2022, including additional variables such as DV, TC, NC, TD, ND, and HA.

Table A4: t-test

Monthly Trades Sub-period comparison	
t-value	5.82
Degrees of freedom	88
p-value	0

Table A4: This table presents the results of a t-test conducted to examine Hypothesis 1 regarding the comparison of monthly trades sub-periods. The t-test evaluates the significance of the difference between the sub-periods.

Table A5: Panel Regression Liquidity Measures

Panel A: Amihud										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) TTM<5	(9) TTM 5-10	(10) TTM>10
Dist_vaccines	0.02***						0.02	-0.01	0.02	0.01
	[3.96]						[1.38]	[-0.37]	[1.61]	[0.93]
Tot_cases		0.01					-0.07***	-0.14***	-0.07*	0.07*
		[1.48]					[-3.15]	[-4.12]	[-2.45]	[1.93]
New_cases			0.00							
			[0.22]							
Tot_deaths				0.01*			0.05**	0.10***	0.05	-0.09*
				[1.68]			[2.12]	[3.67]	[1.61]	[-2.52]
New_deaths					-0.00					
					[-0.12]					
Avg_hospital_admissions						0.03***	0.03***	0.09***	0.02	0.02
						[6.51]	[3.47]	[7.70]	[1.09]	[1.44]
Control - TTM	0.07***	0.07***	0.07***	0.07***	0.07***	0.07***	0.07***	0.12***	-0.01	0.01
	[6.09]	[6.09]	[6.12]	[6.10]	[6.11]	[6.06]	[6.10]	[12.45]	[-0.52]	[0.75]
State FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	113835	113835	113835	113835	113835	113835	113835	49655	35820	28552
R^2	0.0050	0.0046	0.0046	0.0046	0.0046	0.0052	0.0056	0.0174	0.0006	0.0010

Panel B: Imputed Round-trip Costs (IRC)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) TTM<5	(9) TTM 5-10	(10) TTM>10
Dist_vaccines	-0.09***						-0.07***	-0.08***	-0.05**	-0.08***
	[-17.53]						[-3.66]	[-3.61]	[-2.13]	[-3.80]
Tot_cases		-0.04***					0.41***	0.54***	0.48***	0.44***
		[-4.91]					[6.11]	[9.74]	[7.61]	[3.28]
New_cases			-0.01							
			[-0.94]							
Tot_deaths				-0.05***			-0.35***	-0.46***	-0.39***	-0.38***
				[-4.33]			[-6.62]	[-7.92]	[-5.40]	[-3.34]
New_deaths					0.00					
					[0.12]					
Avg_hospital_admissions						-0.11***	-0.12***	-0.19***	-0.16***	-0.10***
						[-22.33]	[-8.90]	[-18.75]	[-13.15]	[-4.08]
Control - TTM	0.36***	0.36***	0.36***	0.36***	0.36***	0.36***	0.36***	0.24***	0.08***	0.22***
	[33.88]	[33.94]	[33.82]	[34.05]	[33.68]	[34.31]	[34.67]	[32.90]	[8.07]	[20.24]
State FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	81069	81069	81069	81069	81069	81069	81069	34024	24360	22746
R^2	0.1335	0.1273	0.1257	0.1279	0.1255	0.1364	0.1427	0.0964	0.0267	0.0610

Panel C: Effective Firm-Facing Spread (EFFSP)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) TTM<5	(9) TTM 5-10	(10) TTM>10
Dist_vaccines	0.02***						0.01*	-0.00	0.02**	0.01
	[3.49]						[1.78]	[-0.28]	[2.04]	[0.93]
Tot_cases		0.01**					0.06*	0.01	0.03	0.15***
		[2.29]					[1.95]	[0.40]	[0.72]	[4.45]
New_cases			0.01**							
			[2.35]							
Tot_deaths				0.01			- 0.07**	-0.03	-0.04	-0.15***
				[1.42]			[-2.50]	[-1.09]	[-1.18]	[-5.24]
New_deaths					0.01**					
					[2.25]					
Avg_hospital_admissions						0.02***	0.01**	0.02***	0.00	0.01
						[4.65]	[2.26]	[4.29]	[0.38]	[0.54]
Control - TTM	-0.03***	-0.03***	-0.03***	0.03***	-0.03***	-0.03***	-0.03***	0.00	-0.00	-0.04***
	[-6.02]	[-6.02]	[-6.01]	[-6.03]	[-5.99]	[-6.03]	[-6.03]	[0.04]	[-0.90]	[-4.36]
State FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	81074	81074	81074	81074	81074	81074	81074	36133	23964	20962
R^2	0.0011	0.0009	0.0009	0.0008	0.0009	0.0011	0.0013	0.0003	0.0004	0.0029

Panel D: Roll										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) TTM<5	(9) TTM 5-10	(10) TTM>10
Dist_vaccines	-0.07***						-0.05**	-0.08**	-0.04	-0.04
	[-14.89]						[-2.03]	[-2.58]	[-1.45]	[-1.45]
Tot_cases		-0.03***					0.53***	0.75***	0.61***	0.35***
		[-2.98]					[11.82]	[9.18]	[9.47]	[6.80]
New_cases			-0.01							
			[-0.63]							
Tot_deaths				-0.04***			-0.46***	-0.66***	-0.51***	-0.30***
				[-2.93]			[-7.43]	[-6.00]	[-6.27]	[-6.53]
New_deaths					0.00					
					[0.08]					
Avg_hospital_admissions						-0.10***	0.14***	-0.17***	-0.19***	-0.10***
						[-10.31]	[-11.05]	[-11.73]	[-12.18]	[-6.60]
Control - TTM	0.29***	0.29***	0.29***	0.29***	0.29***	0.29***	0.29***	0.23***	0.04***	0.15***
	[33.09]	[33.23]	[33.53]	[33.18]	[33.36]	[32.03]	[33.35]	[44.77]	[4.90]	[18.63]
State FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	77263	77263	77263	77263	77263	77263	77263	31399	23309	21727
R^2	0.0848	0.0805	0.0795	0.0812	0.0795	0.0896	0.0986	0.0880	0.0268	0.0310

Table A5: T-statistics are reported in brackets. Significance code : * p<0.10, ** p<0.05, *** p<0.01. The measures and COVID-19 variables are log-transformed and then standardized.

Table A6: Panel Regression Trading Activities

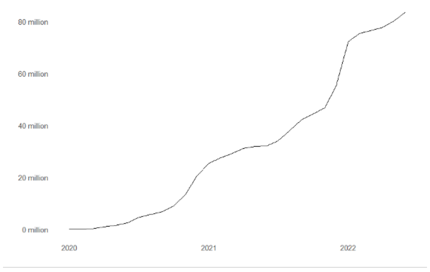
Panel A: Monthly Trades										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) TTM<5	(9) TTM 5-10	(10) TTM>10
Dist_vaccines	0.00						0.02	0.03	0.04***	-0.02
	[0.66]						[1.13]	[1.33]	[3.12]	[-1.07]
Tot_cases		0.02***					0.31***	0.43***	0.25***	0.23**
		[2.82]					[5.69]	[9.47]	[6.23]	[2.10]
New_cases			0.02*							
			[1.73]							
Tot_deaths				0.02**			-0.25***	-0.34***	-0.19***	-0.19**
				[2.13]			[-5.95]	[-9.20]	[-5.74]	[-2.09]
New_deaths					0.00					
					[0.26]					
Avg_hospital_admissions						-0.03***	-0.10***	-0.13***	-0.10***	-0.05***
						[-5.35]	[-13.96]	[-14.92]	[-8.70]	[-5.14]
Control - TTM	0.12***	0.12***	0.12***	0.12***	0.12***	0.12***	0.12***	-0.01	0.03***	0.19***
	[4.69]	[4.70]	[4.70]	[4.70]	[4.69]	[4.67]	[4.66]	[-0.46]	[4.30]	[6.30]
State FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	113835	113835	113835	113835	113835	113835	113835	49655	35820	28552
R^2	0.0165	0.0170	0.0168	0.0167	0.0165	0.0172	0.0229	0.0125	0.0068	0.0400

Panel B: Change in Bond Trading Activity										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) TTM<5	(9) TTM 5-10	(10) TTM>10
Dist_vaccines	0.15***						0.16***	0.15***	0.18***	0.15**
	[7.09]						[3.18]	[3.31]	[3.15]	[2.52]
Tot_cases		0.11***					0.63***	0.49***	0.72***	0.70***
		[11.46]					[4.79]	[4.23]	[4.54]	[5.08]
New_cases			0.08***							
			[10.78]							
Tot_deaths				0.09***			-0.61***	-0.54***	-0.71***	-0.62***
				[7.65]			[-3.83]	[-3.60]	[-3.71]	[-3.88]
New_deaths					0.02***					
					[3.08]					
Avg_hospital_admissions						0.09***	-0.08***	-0.00	-0.08***	-0.11***
						[7.61]	[-6.31]	[-0.00]	[-4.85]	[-4.65]
Control - TTM	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.03***	-0.04***	-0.02***	-0.70
	[-4.81]	[-5.00]	[-4.85]	[-4.93]	[-4.65]	[-4.92]	[-4.76]	[-5.21]	[-4.00]	[-0.01]
State FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	113490	113490	113490	113490	113490	113490	113490	49273	35497	28462
R^2	0.0245	0.0129	0.0066	0.0087	0.0016	0.0084	0.0363	0.0294	0.0436	0.0417

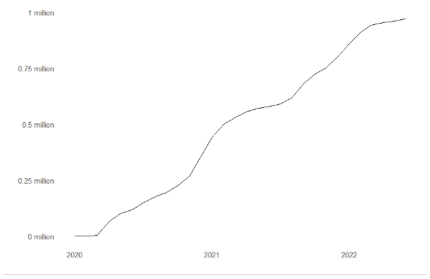
Panel C: Coefficient of Variation of Volume (CVV)										
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) TTM<5	(9) TTM 5-10	(10) TTM>10
Dist_vaccines	-0.01						-0.07***	0.02	0.09**	0.01
	[-0.56]						[-2.69]	[0.68]	[2.39]	[0.21]
Tot_cases		0.02					0.11	-0.02	0.21	0.07
		[0.69]					[1.14]	[0.13]	[1.33]	[0.57]
New_cases			0.03							
			[1.29]							
Tot_deaths				0.01			-0.11	0.09	-0.24	-0.13
				[0.58]			[-1.13]	[0.69]	[-1.49]	[-1.07]
New_deaths					0.04*					
					[1.90]					
Avg_hospital_admissions						0.03	0.08***	-0.01	-0.02	0.02
						[1.32]	[2.87]	[-0.33]	[-0.61]	[0.69]
State FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
N	1372	1372	1372	1372	1372	1372	1372	1340	1308	1253
R^2	0.0005	0.0008	0.0020	0.0005	0.0035	0.0028	0.0105	0.0194	0.0113	0.0052

Table A6: T-statistics are reported in brackets. Significance code: * p<0.10, ** p<0.05, *** p<0.01. The measures and COVID-19 variables are log-transformed and standardized

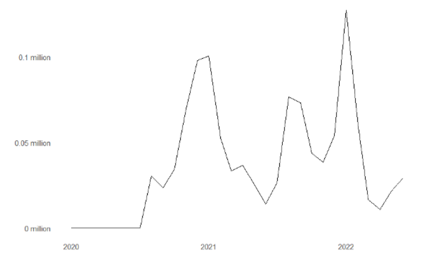
A2 Figures



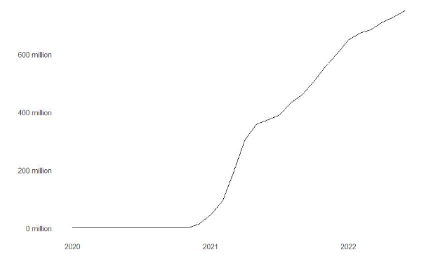
a) Cases



b) Deaths



c) Hospitalizations



d) Vaccines

Figure A1: Aggregated COVID-19 variables across all states

Figure A1: This figure illustrates the significant and rapid increase in municipal bond yields in March 2020.

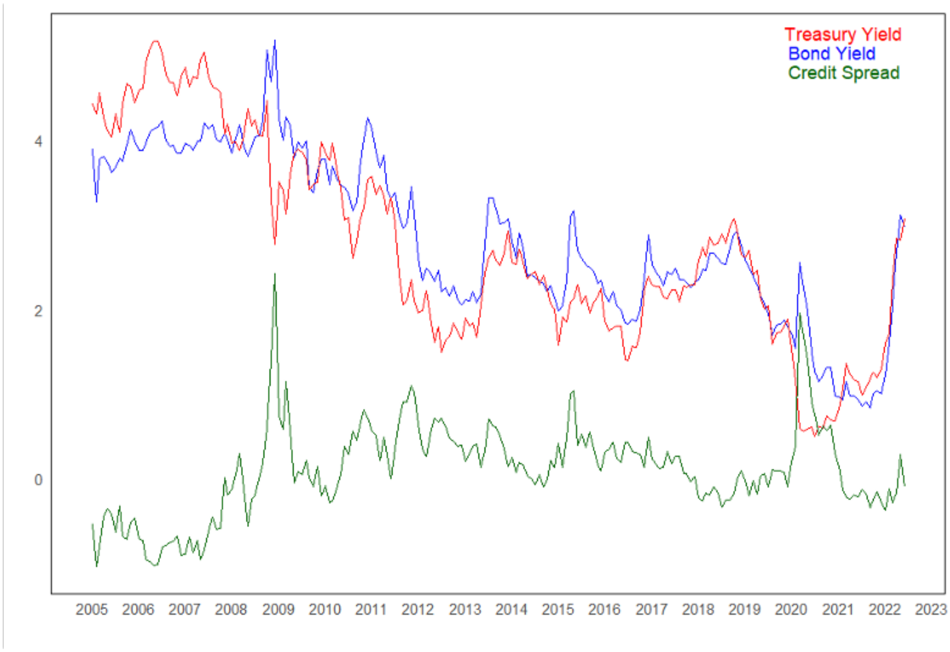


Figure A2 Municipal bond yields during 2005-2022

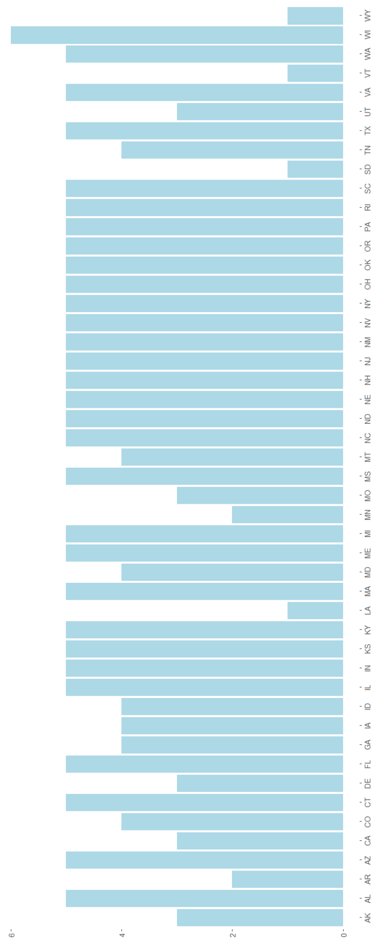


Figure A3 Number of cities in each State

Figure A3: The figure shows the number of cities in each state in the US. It represents the geographic distribution of cities across US states.

Figure A4 Bond Trading Activity

Figure A4: The figure illustrates the bond trading activity during the period before and during the COVID-19 pandemic.