The COVID-19 pandemic and stock liquidity: Evidence from S&P 500

Abstract

This study examines the influence of the COVID-19 pandemic on the stock liquidity of S&P 500 firms. We construct a daily data set for stock liquidity and the numbers of COVID-19 reported cases and deaths for the period from 1 January 2020 to 31 December 2020. The regression results show that there is a significant negative relationship between COVID-19 (as measured by the daily growth in the numbers of cases and deaths) and stock liquidity, implying that the COVID-19 pandemic decreases firm liquidity. Furthermore, our analysis reveals a significant difference in liquidity between sectors. In addition, our results remain robust to the use of an alternative proxy for liquidity and to alternative estimation approaches. The results of this study will allow key players in the stock market to recognize and forecast the behavior of stock liquidity during periods marked by pandemic diseases.

Keywords: COVID-19; stock liquidity; financial market; S&P 500.

1. Introduction

A new coronavirus emerged in Wuhan, China, towards the end of 2019, later named severe acute respiratory syndrome-coranvirus-2 (SARS-CoV-2), the cause of the condition now known as COVID-19. It spread across the world and infected more than 134 million people in 219 countries.[1] The World Health Organization (WHO) declared it to be a global pandemic. The associated macroeconomic shock was evident in early March 2020, with global financial markets witnessing volatility and stock market moves on a scale not seen since the 2008 world financial crisis (Zhang *et al.*, 2020; UN, 2020). Even though previous pandemics have left traces on financial markets, no prior contagious disease, including the Spanish Flu, has affected the stock market as strongly as the COVID-19 pandemic (Baker *et al.*, 2020). By mid-March, the U.S. stock market bull run that had lasted 11 years (the lengthiest on record) had ended and the fastest decline on record followed. The Dow Jones Industrial Average (DJIA) had fallen nearly 6,400 points (approximately 26%). The S&P 500 Index had closed on a record high of 3386.15 on 19 February 2020 but in March it dropped by over 30% (Zhang *et al.*, 2020).

The key features of financial markets are liquidity and stability. Liquidity is often studied as an important attribute of financial assets and it plays a vital role in the financial markets' operations (Ahmed *et al*., 2020). Tran *et al.* (2018) indicate that markets characterized by high liquidity are inclined to attract more attention from investors. Glosten and Milgrom (1985) and Hasbrouck (1988) mention that economic theory proposes that bid-ask spread widens when there exists greater uncertainty and risk, but, in addition, bid-ask spread is linked to illiquidity. Amihud *et al*. (1990) indicate that market deteriorations can result from market illiquidity. They claim that the 1987 stock market crash, at least to some extent, stemmed from problems in stock trading and a fall in liquidity. Accordingly, liquidity is important for investors, and its significance increases at times of financial crisis, when markets are highly uncertain (Ben-Rephael, 2011). Adrian and Natalucci (2020) point out that liquidity is considered as a key concern at the time of COVID-19 and we agree that evaluating and understanding the impact of pandemic diseases such as COVID-19 on stock liquidity has become an important issue.

In this study, we focus on the S&P 500 stocks, for several reasons. First, previous studies (e.g., Dooley & Hutchison, 2009; Gulzar *et al.*, 2019) provide evidence of a substantial spillover from the U.S. stock market to other stock markets in crisis periods. Second, the U.S. has had the largest number of reported cases and deaths due to COVID-19 among all affected countries and territories. Based on the daily data released by Johns Hopkins University, as of 7 August 2020, worldwide there had been 18,982,658 (4,873,747 in the U.S.) detected cases and 712,266 deaths (159,990 in the U.S.) from COVID-19. Therefore, by examining the impact of COVID-19 on the firms included in the S&P 500 Index, we can gain valuable understanding of the effects of the pandemic and the spillover to other markets.

We use S&P 500 firms' stock data and the numbers of reported cases of COVID-19 and associated deaths to empirically analyze the influence of the pandemic on the liquidity of stocks. Using a panel regression approach and two measures of stock liquidity (tightness of the order book and the Amihud measure), we find evidence of a negative and significant

[1] https://www.worldometers.info/coronavirus/countries-where-coronavirus-has-spread/
[accessed on April 8, 2021]

effect on stock liquidity of the daily growth in the numbers of both COVID-19 cases and deaths. This finding is robust to using alternative estimation methods and an alternative proxy for liquidity. Our results also suggest a significant difference in stock liquidity between sectors. In particular, the pandemic significantly impacts the consumer staples, consumer discretionary, financial, information technology, basic materials, energy and industrial sectors. However, the healthcare and communications sectors have better liquidity than the market overall, implying that these sectors benefit from the COVID-19 pandemic. It is worth noting that the real estate sector's liquidity is insignificantly affected by the growth in the numbers of confirmed cases and confirmed deaths. These results indicate that some industry sectors perform better than others throughout the spread and outbreak of COVID-19.

This study makes several contributions to the literature on the effects of a pandemic on financial markets. Firstly, while prior studies focus on the impact of COVID-19 on many issues, such as stock market returns (Al-Awadhi *et al.*, 2020; Alber, 2020; Liu *et al*., 2020. O'Donnell *et al.*, 2021), volatility (Albulescu, 2020; Corbet et al., 2020;), financial markets (Ali et al., 2020), stock market risk (Zhang *et al*., 2020), stock price (Ramelli & Wagner, 2020) and corporate performance (Shen *et al.*, 2020), in this study we perform a novel analysis of how the COVID-19 pandemic has driven firm-level liquidity for S&P 500 firms. Secondly, we perform a unique sector analysis to examine the effect of COVID-19 on stock liquidity between various sectors. Thirdly, we employ different estimation methods to analyze the impact of the COVID-19 pandemic on stock liquidity. These results indicate that COVID-19 influences stock liquidity and there are liquidity differences across sectors (certain sectors perform better than others during the spread and outbreak of COVID-19). Finally, our findings have implications for financial market participants such as financial securities regulators, firms, and investors.

The rest of this study is organized as follows. In section 2, we report the related literature upon which our hypothesis development is grounded. In section 3, we present the research design and review the data and variables of the study. Section 4 introduces the empirical analysis and findings as well as the additional and robustness analyses. Finally, section 5 presents the conclusion of our study.

2. Literature review and hypothesis development

Globally, financial markets have shown a response to pandemic diseases. For instance, Chen *et al.* (2007) document that seven Taiwanese-listed hotels firms suffered a dramatic decrease in their earnings and stock prices during SARS outbreak in 2003. Further, Chen *et al.* (2009) indicate that the outbreak of the SARS epidemic adversely influenced Taiwan industries, with a more significant negative effect on the tourism, wholesale and retail sectors. In another study, Chen et al. (2013) show that the stock returns in the service industry sector in the Philippines and the basic material industry sector in Hong Kong were affected by the SARS outbreak. Ichev and Marinč (2018) find that the Ebola epidemic intensely impacted the stocks of listed companies with operations in West African countries.

More recently, Al-Awadhi *et al.* (2020) find that the stock return for firms listed in the Shanghai Stock Exchange Composite Index and Hang Seng Index are significantly and negatively influenced by the daily growth in the number of positive cases and the number of deaths due to COVID-19. Alber (2020) reports that the stock market return appears to be more sensitive to COVID-19 cases than deaths. His study uses data from the U.S., Spain, Italy, Germany, France and China. Similarly, Corbet *et al.* (2020) show that an announcement of the existence of COVID-19 had a significant negative effect on stocks' hourly returns and it significantly increased hourly volatility. In the same vein, Liu *et al.* (2020) indicate that after the outbreak of COVID-19, the stock markets fell in most affected countries; Asian countries experienced more negative abnormal returns than other regions.

In relation to the stock price, Ramelli and Wagner (2020) determine that COVID-19 resulted in exceptionally negative and volatile aggregate market reactions in the U.S. Lee *et al.* (2020) report that higher numbers of COVID-19 cases in Malaysia tended to adversely affect the performance of the Kuala Lumpur Composite Index (KLCI) and all sectoral indices, except for the real estate investment fund index. Similarly, Shen *et al.* (2020) show that COVID-19 has had a negative influence on the performance of listed Chinese companies.

In terms of liquidity and economic crisis, Liu (2006) reports that U.S. stock market liquidity was reduced during various significant financial and economic events (e.g., the 1987 crash, the Asian financial crisis in 1997, the high-tech bubble in 2000 and the September 11, 2001 terrorist attacks). Yeyati *et al.* (2008) reveal that times of crisis are linked to greater liquidity costs. Enhancing this claim, Rösch and Kaserer (2013) show that the liquidity of the German stock market declines at times of worldwide crisis.

Zhang *et al.* (2020) highlight that global financial market risk has risen as a result of the COVID-19 pandemic. They also point out that the outbreak led markets to be unstable and unpredictable. In a similar study, Albulescu (2020) indicates that the financial market volatility index is positively influenced by COVID-19 new cases documented outside China. Further, his results suggest that the death rate has a positive and significant influence on the volatility index inside and outside China.

Furthermore, Mirza *et al*. (2020) report that the solvency profile of all firms in the European Union have declined due to COVID-19 and many firms have had a decrease in their market capitalization. In addition, Alfaro *et al.* (2020) report the negative influence of COVID-19 on the returns on U.S. stocks. Ashraf (2020) examines the impact of COVID-19 on the performance of the stock market in 64 countries and reveals that there are negative associations between stock returns and larger numbers of confirmed cases. Baig *et al*. (2020) examines the effect of COVID-19 on the U.S. equity markets. Their findings indicate that the increase in market illiquidity and instability was related to the numbers of COVID-19 confirmed cases and deaths.

Khatib and Nour (2021) examine the impact of COVID-19 on the relationship between characteristics of corporate governance and firm performance on a sample of Malaysian firms. They reveal that COVID-19 has influenced firm performance, liquidity, dividends and the structure of corporate governance. Zaremba *et al*. (2021) investigate the daily data of 49 countries during January-April 2020. They find that the closures of schools and workplaces as a result of the COVID-19 pandemic decreased liquidity in emerging markets. Rahman *et al.* (2021) investigate the reactions of the Australian stock market to the uncertainties produced by the pandemic. They found a negative reaction of that stock market to the COVID-19 announcement. They also report that firms' size and liquidity are two important factors influencing abnormal returns.

Based on the above discussions, this study hypothesizes that there is a negative and significant association between daily growth in the total numbers of cases of COVID-19 and associated deaths and firm stock liquidity (H_1).

3. Data and methodology

3.1. Sample

The sample of this study compromises of S&P 500 firms which represents a significant part of the equity market in U.S. This index represents the traded stocks on the New York Stock Exchange and Nasdaq and captures more than 80 percent of the entire float-adjusted market capitalization of U.S. equity. We employ daily data in our analysis, gathered from two sources. Following Ahmed et al. (2020), the financial data were collected from Bloomberg. The daily data on the number of COVID-19 reported cases and deaths were extracted from the European Centre for Disease Prevention and Control (ECDC). Firms with missing values are excluded. Consequently, the final sample contains 87026 observations of 500 firms covering the period 1 January 2020 to 31 December 2020.

Measurement of variables

Dependent variable

Three measures of liquidity are widely used in the literature: (i) the bid-ask spread (Demsetz, 1968), (ii) the Kyle measure (Kyle, 1985), and (iii) the illiquidity measure of Amihud (Amihud & Mendelson, 1986). Kyle (1985) implements three measures to define the liquidity of a firm, namely, the depth of the order book, the tightness of the order book, and resiliency. The first measure determines the ability of the market to absorb quantities with no strong influence on the price. The second calculates the cost of turning over a position in a short period. The last determines the rate at which the prices bounce back from an uninformative shock and the speed with which prices have a propensity to converge on the underlying liquidation value. Consistent with Kyle (1985), Demsetz (1968), and Dunham and Garcia (2020), we measure liquidity by employing the tightness of the order book. It is measured by utilizing the daily average of all bid-ask spreads, which is calculated as a proportion of the mid-price for every firm on a given trading day. Following Dunham and Garcia (2020), we use the same proxy for liquidity, as it is considered among the most suitable (Fang *et al.*, 2009). Fong *et al.* (2017) show that illiquidity is considered an excellent cost-per-dollar volume proxy. Therefore, we check the robustness of our results by utilizing the Amihud illiquidity measure. It is important to note that, like the bid-ask spread, a higher (lower) of value of the Amihud measure indicates a lower (higher) level of liquidity.

Independent variables

On 31 December 2019, the World Health Organization (WHO) declared the first case affected by COVID-19 in China. COVID-19 thereafter spread to more than 190 countries and WHO officially classified COVID-19 as a pandemic on March 11, 2020. To measure exposure to the pandemic, we follow Al-Awadhi et al. (2020) and use two measures: (i) the daily percentage change in the number of cases; and (ii) the daily percentage change in the number of confirmed deaths in the U.S. on a given day. These data were taken from the European Centre for Disease Prevention and Control (ECDC).

Control variables

To examine the influence of the pandemic on bid-ask spreads, we also include several firm-specific attributes as controls, as commonly employed in other studies (e.g., Chordia *et al.*, 2000, 2001; Bollen *et al.*, 2004; Dunham & Garcia, 2020). The firm characteristics consist of: (i) firm size, which is computed by taking the logarithm for market capitalization, (ii) firm risk, which is calculated by BETA, (iii) the absolute value of the five- day average daily return as absolute daily returns offer measurement for the information asymmetry that impacts the liquidity of shares (Hasbrouck & Seppi, 2001), (iv) share price volatility, which is calculated as the trading range of daily share price over the closing price of the share on the previous day, (v) daily share turnover, computed by dividing the volume of daily trading on outstanding shares. Additionally, we use the put-call ratio (PCR) to measure the overall market sentiment. The PCR is extensively used as a measurement of the daily sentiment of the overall market (Simon & Wiggins, 2001; Guo, 2004; Bandopadhyaya & Jones, 2006, 2008). All the data on control variables were collected from the Bloomberg database.

Descriptive statistics

The summary statistics for all the variables employed are presented in Table 1. The means of the two liquidity measures, bid-ask spread and Amihud illiquidity, are 0.0849 and 0.0141, respectively. These values are higher than those reported by Dunham and Garcia (2020) for the period 2015-2018, which signifies that firm liquidity had decreased during the COVID-19 pandemic period. The average growth rates of total cases and total deaths are 12.52% and 1.03%, respectively, suggesting that numbers of cases and deaths increased on average every day in the U.S. over the study period. The mean of market capitalization is found to be $10.32 bn and volatility in the daily share price is 9.98%. Finally, the median values of daily share turnover, put-call ratio and beta are 0.0145, 0.5806 and 0.9561, respectively.

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Table 1: Summary statistics

Variables	N	Mean	STD	5th percentile	25th percentile	Median	75th percentile	95th percentile
$SPREAD_{i,t}$	87026	0.0849	0.0974	0.0219	0.0434	0.0698	0.1055	0.2117
$AMIHUD_{i,t}$	87026	0.0141	0.0225	0.0002	0.0022	0.0067	0.0168	0.0523
$CASESGROWTH_{i,t-1}$	87026	0.1252	0.0988	0.0182	0.0723	0.1009	0.1501	0.3016
$DEATHSGROWTH_{i,t-1}$	87026	0.0103	0.3292	-0.6539	-0.0640	0.0654	0.1810	0.6384
$SIZE_{i,t-1}$	87026	10.3228	1.2004	9.6730	10.0932	10.3740	10.7341	11.3168
$BETA_{i,t-1}$	87026	0.9757	0.5695	0.3871	0.7536	0.9561	1.1922	1.6408
$ABSRETURN_{i,t-1}$ (%)	87026	1.6943	0.8539	0.0130	0.1443	0.3592	0.9744	9.6364
$VOL_{i,t-1}$ (%)	87026	9.9804	3.2947	1.4889	3.9875	4.4778	6.4467	10.7685
$TURNOVER_{i,t-1}$	87026	0.0658	0.6340	0.0053	0.0099	0.0145	0.0234	0.0578
$PUTCALL_{i,t-1}$	87026	1.0026	1.5550	0.0922	0.3223	0.5806	1.0076	3.2105

Notes: This table shows descriptive statistics for all variables employed in our models. The study sample contains 87026 observations that cover 500 U.S. firms throughout the period beginning from 1 January, 2020 to 31 December, 2020. The definitions of the study variables and the data sources for variables are reported in Appendix A.

Table 2 reports Pearson's correlation to test for problems of multicollinearity between all the variables used in our baseline model. The correlation coefficients between bid-ask spread and both proxies of COVID-19 (CASESGROWTH and DEATHGROWTH) are positive. Bid-ask spread is further significantly correlated with control variables. Among control variables, no correlation coefficient surpasses 0.42, which alleviates the issue that multicollinearity might impact the regression results. In addition, we compute the variance inflation factor (VIF). VIF values for each independent variable do not surpass the critical value of 10, guaranteeing that multicollinearity is not a problem.

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Table 2: Pearson correlation

Variables	SPREAD$_{i,t}$	AMIHUD$_{,it}$	CASESGROWTH$_{i,t-1}$	DEATHSGROWTH$_{i,t-1}$	SIZE$_{i,t-1}$	BETA$_{I,t-1}$	VOL$_{i,t-1}$	TURNOVER$_{i,t-1}$	PUTCALL$_{i,t-1}$
SPREAD$_{i,t}$	1								
AMIHUD$_{i,t}$	0.3958^{***}	1							
CASESGROWTH$_{i,t-1}$	0.0120^{**}	0.0250^{***}	1						
DEATHSGROWTH$_{i,t-1}$	0.0141^{***}	0.0208^{***}	0.5429^{***}	1					
SIZE$_{i,t-1}$	-0.4366^{***}	-0.6399^{***}	0.0040	0.0029	1				
BETA$_{i,t-1}$	0.1268^{***}	0.1402^{***}	0.0402^{***}	0.0221^{***}	-0.1325^{***}	1			
VOL$_{i,t-1}$	0.2901^{***}	0.3159^{***}	0.099^{***}	0.0418^{***}	-0.2744^{***}	0.4242^{***}	1		
TURNOVER$_{i,t-1}$	0.1319^{***}	0.0876^{***}	-0.0451^{***}	-0.0384^{***}	-0.1916^{***}	0.1054^{***}	0.1488^{***}	1	
PUTCALL$_{i,t-1}$	0.1308^{***}	-0.0022	-0.0132^{**}	-0.0146^{***}	0.0331^{***}	0.0389^{***}	0.0752^{***}	0.0215^{***}	1

Notes: This table displays the coefficients of Pearson correlation of all variables of the study. The sample contains 87026 observations that cover 500 U.S. firms through the period beginning from 1 January, 2020 to 31 December, 2020. The definitions of the study variables and the data sources for variables are reported in Appendix A. *, **, and *** display the significance levels at 10%, 5%, and 1%, respectively.

4. Empirical results

4.1. Model of stock liquidity

We estimate the following model to examine empirically the effect of the COVID-19 crisis on stock liquidity.

$$LIQ_{i,t} = \beta_0 + \beta_1 COVID\text{-}19_{i,t-1} + \beta_2 SIZE_{i,t-1} + \beta_3 BETA_{i,t-1} + \beta_4 ABSRETURN_{i,t-1} + \beta_5 VOL_{i,t-1} + \beta_6 TURNOVER_{i,t-1} + \beta_7 PUTCALL_{i,t-1} + Industry\ dummies + Year\ dummies + \varepsilon_{i,t} \quad (1)$$

Where $LIQ_{i,t}$ represents the firm's stock liquidity, and $COVID\text{-}19_{i,t-1}$ is the primary variable of interest, measured as the daily growth of total number of confirmed cases and total number of confirmed deaths. The control variables represent a group of firm attributes which are commonly utilized in previous studies as determinants of stock liquidity. They include SIZE, BETA, ABSRETURN, VOL, TURNOVER and PUTCALL. To account for inter-temporal variation and the variation by industry, we further include *industry dummies* and *year dummies* where industries are classified based on the Bloomberg Industry Classification System, which categorizes firms into 11 sets. Appendix A gives the detailed definitions for all the variables.

The ordinary least squares (OLS) method was employed to estimate Equation (1). To control the issue of independence of observations for a given firm, we use robust standard errors adjusted for heteroskedasticity and corrected for clustering at the firm level.

Our coefficient of primary interest is β_1, which represents the relationship between stock liquidity and COVID-19. Consistent with our stated hypothesis, H_1, we expect a strong negative association between daily growth in the total numbers of cases and deaths and firm liquidity.

4.2. Empirical results

Table 3 demonstrates the findings from regressing SPREAD on daily growth rate of total cases and total deaths caused by COVID-19 using OLS. As noted above, higher (lower) bid-ask spread implies lower (higher) liquidity.

In Model 1, we regress firm liquidity (SPREAD) on the first proxy of COVID-19 (CASESGROWTH). The coefficient on CASESGROWTH is positive and statistically significant in determining SPREAD, implying that an increase in the daily growth in the total number of confirmed cases leads to a lower level of firm liquidity. A similar result is found in Model 2, where we utilize the second measurement of COVID-19 (DEATHSGROWTH). The results show that DEATHSGROWTH has a positive and significant effect on the level of SPREAD. These results support our hypothesis, H_1, indicating a negative association between COVID-19 and stock liquidity.

Regarding control variables, all the estimated coefficients are statistically significant except that of PUTCALL. This result is consistent with that of Chordia *et al.* (2001), and Dunham and Garcia (2020). In particular, SPREAD is negatively related to SIZE, TURNOVER and BETA, whereas, ABSRETURN, PUTCALL and VOL have a positive impact on SPREAD.

Overall, both measures of COVID-19 show a positive and significant impact on stock illiquidity, which supports the expectation of our hypothesis (H_1) that the pandemic decreased firm liquidity.

Table 3: The influence of COVID-19 on stock liquidity

	Expected Sign	(1)	(2)
Intercept		0.4272***	0.4234***
		(107.37)	(106.97)
CASESGROWTH $_{i,t-1}$	+	**0.0180*** **	
		(11.96)	
DEATHSGROWTH $_{i,t-1}$	+		**0.0022*** **
			(4.64)
SIZE $_{i,t-1}$	-	-0.0345***	-0.0344***
		(-93.22)	(-93.03)
BETA $_{i,t-1}$	-	-0.0117***	-0.0114***
		(-22.95)	(-22.53)
ABSRETURN $_{i,t-1}$	+	0.0008	-0.0008
		(-1.46)	(-1.39)
VOL $_{i,t-1}$	+	0.0640***	0.0645***
		(61.66)	(62.11)
TURNOVER $_{i,t-1}$	-	-0.0029***	-0.0028***
		(-5.75)	(-5.61)
PUTCALL $_{i,t-1}$	+	0.0012***	0.0001***
		(34.26)	(34.70)
Year dummy		Yes	Yes
Industry dummy		Yes	Yes
Sample size		87026	87026
Adjusted R^2		0.2524	0.2517

Notes: This table notifies the panel regressions results by regressing liquidity firm on COVID-19 and the control variables. Our sample contains 87026 observations that cover 500 U.S. firms for the period from 1 January, 2020 to 31 December 2020. Models 1 and 2 regress SPREAD on CASESGROWTH (measured by daily growth rate of total positive cases) and DEATHSGROWTH (measured by daily growth rate of total definite deaths), respectively. The control variables consists of firm size (SIZE), firm risk (BETA), the absolute value of the five-day average daily return (ABSRETURN), share price volatility (VOL), daily share turnover (TURNOVER) and daily overall market sentiment (PUTCALL). The definitions of the study variables and the data sources for variables are reported in Appendix A. Industry dummy is based on the Global Industry Classification Standard. T-statistics reported in parentheses are based on robust standard errors corrected for heteroskedasticity and firm level clustering. *, **, and *** display the significance levels at 10%, 5%, and 1%, respectively.

4.3. Additional analysis

We would expect the impact of COVID-19 on firm liquidity to be significantly different between sectors. For the firms in the S&P 500 Index, we use the Bloomberg Industry Classification System to categorize them into 11 sets. We use a panel data set with dummies for each industry sector, which takes the value of 1 if the stock belongs to that particular sector, or zero otherwise.

Prior research suggests that a particular sector may be impacted in a specific way during a pandemic, for example pharmaceutical, biotechnological and hotels sectors (Chen *et al.*, 2007, Chen *et al.*, 2009; Ichev & Marinč, 2018). Consistent with these studies, we conduct our regressions after categorizing sectors using Global Industry Classification Standards. These sectors are: basic materials, communications, consumer discretionary, consumer staples, real estate, energy, financial, health care, industrial, information technology and utilities.

Tables 4.A and 4.B report the results of our regressions for the panel data with a dummy variable for industry sectors. The results indicate significant differences in liquidity between sectors. The healthcare and communications sectors have better liquidity than the overall market. In comparison, stock liquidity in the sectors of consumer staples, consumer discretionary, financial, information technology, utilities, basic materials, energy and industrial is lower than in the market overall. The real estate sector's liquidity is insignificantly impacted by the growing numbers of confirmed cases and confirmed deaths. This result lends support to Lee *et al.* (2020), who find that the performance of all Malaysian sectoral indices were adversely affected by COVID-19 cases except for the real estate investment fund index.

Table 4.A: The effect of growth rate of total cases on stock liquidity across sectors

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
CASESGROWTH	0.0235***	0.0235***	0.0235***	0.0235***	0.0235***	0.0235***	0.0235***	0.0235***	0.0235***	0.0235***	0.0235***
	(3.94)	(3.94)	(3.94)	(3.94)	(3.94)	(3.94)	(3.94)	(3.94)	(3.94)	(3.94)	(3.94)
Controls and Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Consumer discretionary	**0.2657*** **										
	(20.30)										
Consumer Staples		**0.4083*** **									
		(33.02)									
Health Care			**-0.6420*** **								
			(-40.06)								
Financials				**0.4465*** **							
				(34.28)							
Information Technology					**0.5184*** **						
					(57.61)						
Communication Services						**-0.4721*** **					
						(-40.75)					
Utilities							**0.2429*** **				
							(12.73)				
Real Estate								0.2696			
								(2.6)			
Industrials									**0.3997*** **		
									(28.24)		
Materials										**0.2256*** **	
										(8.84)	
Energy											**0.5947*** **
											(44.49)
Sample size	87026	87026	87026	87026	87026	87026	87026	87026	87026	87026	87026
Adjusted R^2	0.1858	0.4827	0.3100	0.1735	0.2722	0.7729	0.3728	0.2312	0.2651	0.2096	0.4602

Notes. This table notifies the panel regressions results for firms listed in S&P Index through the period 1 January to 31 December, 2020, with taking into account the specific sectors. The dependent variable is SPREAD, the independent variable is CASESGROWTH (measured by daily growth rate of total confirmed cases). The control variables are firm size (SIZE), firm risk (BETA), the absolute value of the five-day average daily return (ABSRETURN), share price volatility (VOL), daily share turnover (TURNOVER) and daily overall market sentiment (PUTCALL). The definitions of the study variables and the data sources for variables are reported in Appendix A. Unreported industry controls are in line with Global Industry Classification Standard. Consumer staples, healthcare, communication, utilities, consumer discretionary, financial, information technology, basic materials, energy, industrial and real estate are the dummy variables for sectors that take the value of one if the stock belongs to that particular sector, and zero otherwise. Heteroskedasticity robust t-statistics corrected for clustering at the firm level are reported in parentheses. *, **, and *** display the significance levels at 10%, 5%, and 1%, respectively.

Table 4.B: The effect of growth rate of total deaths on stock liquidity across sectors

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
DEATHSGROWTH	0.0028***	0.0028***	0.0028***	0.0027***	0.0028***	0.0028***	0.0028***	0.0028***	0.0028***	0.0028***	0.0029**
	(4.15)	(4.15)	(4.15)	(6.27)	(4.44)	(4.15)	(4.15)	(4.15))	(4.15)	(4.15)	(2.13)
Controls and Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Consumer discretionary	**0.2613***										
	(20.04)										
Consumer Staples		**0.4078***									
		(33.06)									
Health Care			**-0.6398***								
			(-40.04)								
Financials				**0.4731***							
				(41.45)							
Information Technology					**0.4398***						
					(33.90)						
Communication Services						**-0.5166***					
						(-57.70)					
Utilities							**0.2420***				
							(12.70)				
Real Estate								0.2658			
								(2.43)			
Industrials									**0.3944***		
									(27.94)		
Materials										**0.2193***	
										(8.59)	
Energy											**0.5900***
											(44.65)
Sample size	87026	87026	87026	87026	87026	87026	87026	87026	87026	87026	87026
Adjusted R^2	0.1848	0.4827	0.3099	0.1717	0.7735	0.2720	0.3728	0.2303	0.2639	0.2067	0.4599

Notes. This table notifies the panel regressions results for firms listed in S&P Index through the period 1 January to 31 December, 2020, with taking into account the specific sectors. The dependent variable is SPREAD; the independent variable is DEATHSGROWTH (measured by daily growth rate of total confirmed deaths). The control variables are firm size (SIZE), firm risk (BETA), the absolute value of the five-day average daily return (ABSRETURN), share price volatility (VOL), daily share turnover (TURNOVER) and daily overall market sentiment (PUTCALL). The definitions of the study variables and the data sources for variables are reported in Appendix A. Unreported industry controls are in line with Global Industry Classification Standard. Consumer staples, healthcare, communication, utilities, consumer discretionary, financial, information technology, basic materials, energy, industrial and real estate are the dummy variables for sectors that take the value of one if the stock belongs to that particular sector, and zero otherwise. Heteroskedasticity robust t-statistics corrected for clustering at the firm level are reported in parentheses. *, **, and *** display the significance levels at 10%, 5%, and 1%, respectively.

4.4. Robustness checks

Alternative estimation methods

Following Petersen (2009) and Gow *et al.* (2010), we change the estimation method to account for cross-sectional and serial dependence. In Table 5, we test the association between COVID-19 and liquidity through alternative estimation models. We use the White (1980) procedure in Model 1 and we use a generalized linear model estimation in Model 2. For Model 3, we employ the Fama-MacBeth procedure, and in Model 4 the quantile regression method is utilized. The Newey-West (1987) procedure is used in Model 5, and we conduct two-way clustering at the firm and year level in Model 6.

The coefficients on CASESGROWTH and DEATHSGROWTH remain positive and significant in determining the SPREAD. This shows strong evidence of a negative association between the pandemic and stock liquidity, which remains unchanged with the use of alternative estimation techniques.

An alternative proxy for firm liquidity

We use another well-accepted proxy of liquidity as an alternative to SPREAD and employ the Amihud measure as the dependent variable (Amihud, 2002). Similar to SPREAD, a lower value implies lower illiquidity (higher liquidity). The Amihud measure is calculated by utilizing the readily available data on daily returns and volumes (Le & Gregoriou, 2020). The Amihud measure is considered a better measure of liquidity than other liquidity ratios (Goyenko *et al.,* 2009). Further, Hasbrouck (2009) indicates that the Amihud measure is a good alternative to price impact when employing intraday data. Le and Gregoriou (2020) show that the advantage of the Amihud measure is that it permits researchers to calculate the illiquidity ratio for days covering long time periods for most financial markets. In the same vein, Lou and Shu (2017) suggest that the value of the Amihud measure is its association with the volume of trading. This allows the measure to consider price impact through its trading volume element.

Table 6 presents the findings from the two regression models in Table 3 but now using the Amihud liquidity measure as our dependent variable. The results remain largely the same as those shown in Table 3, as CASESGROWTH and DEATHSGROWTH are positively associated with the Amihud liquidity measure.

Table 5: The effect of COVID-19 on stock liquidity using alternative estimation methods

Variables	White		GLM		Fama Macbeth		Quantile		Newey-West		Clustering by firm and year	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Intercept	0.4095***	0.4055***	0.4350***	0.4345***	0.4996***	0.5126***	0.3882***	0.3864***	0.4095***	0.4055***	0.5001***	0.5046***
	(11.01)	(10.63)	(35.90)	(35.84)	(21.16)	(25.21)	(95.44)	(96.89)	(11.01)	(11.63)	(83.45)	(94.10)
CASESGROWTH	**0.0188*****		**0.0171*****		**0.0218*****		**0.0199*****		**0.0188*****		**0.0152****	
	(12.15)		(14.01)		(4.69)		(5.47)		(12.15)		(2.71)	
DEATHSGROWTH		**0.0023*****		**0.0023*****		**0.0082*****		**0.0027*****		**0.0023*****		**0.0066*****
		(4.71)		(6.37)		(5.20)		(5.03)		(4.71)		(4.70)
SIZE $_{i,t-1}$	-0.0324***	-0.0323***	-0.0358***	-0.0361***	-0.0421***	-0.0421***	-0.0315***	-0.0315***	-0.0324***	-0.0323***	-0.0406***	-0.0406***
	(-97.13)	(-96.85)	(-31.37)	(-31.54)	(-28.15)	(-28.15)	(-83.66)	(-84.83)	(-97.13)	(-96.85)	(-105.80)	(-105.79)
BETA $_{i,t-1}$	-0.0118***	-0.0116***	-0.0061***	0.0057***	0.0104***	0.0104***	-0.0040***	-0.0039***	-0.0118***	-0.0116***	0.0024***	0.0024***
	(-24.39)	(-24.03)	(-16.30)	(-15.37)	(7.10)	(7.10)	(-8.53)	(-8.37)	(-24.39)	(-24.03)	(4.70)	(4.70)
ABSRETURN $_{i,t-1}$	0.00002	0.00002	-1.68e-06	2.20e-06	0.0012	0.0012	-0.0002***	-0.0002***	0.00002	0.00002	-0.0002***	-0.0002***
	(0.40)	(0.48)	(-0.05)	(0.07)	(0.15)	(0.15)	(-4.80)	(-4.91)	(0.40)	(0.48)	(-4.57)	(-4.57)
VOL $_{i,t-1}$	0.0616***	0.0621***	0.0758***	0.0763***	-0.0053**	-0.0053**	0.0382***	0.0383***	0.0616***	0.0621***	-0.0018**	-0.0017**
	(59.70)	(60.13)	(182.75)	(184.65)	(-2.35)	(-2.35)	(69.98)	(71.58)	(59.70)	(60.13)	(-1.99)	(-1.99)
TURNOVER $_{i,t-1}$	-0.0033***	-0.0033***	-0.0029***	-0.0028**	-0.0981*	-0.0981*	0.0004	0.0005	-0.0033***	-0.0033***	-0.0038***	-0.0038***
	(-6.44)	(-6.32)	(-3.58)	(-3.48)	(-1.94)	(-1.94)	(0.49)	(0.57)	(-6.44)	(-6.32)	(-3.94)	(-3.94)
PUTCALL $_{i,t-1}$	9.64e-03***	9.90e-03***	1.81e-03**	1.84e-03**	0.0011***	0.0011***	8.46e-08	8.57e-03	9.64e-08***	9.90e-08***	-6.82e-08	-6.81e-08
	(24.49)	(25.03)	(2.82)	(2.85)	(5.48)	(5.48)	(0.88)	(0.91)	(24.49)	(25.03)	(-0.72)	(-0.72)
Year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Indus----try dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	87026	87026	87026	87026	87026	87026	87026	87026	87026	87026	87026	87026
AdjR^2 / R^2	0.2174	0.2167	0.3438	0.3426	0.1807	0.1807	0.1188	0.1187	0.2452	0.2658	0.3300	0.3300

Notes. This table notifies the panel regressions results for firms listed in S&P Index through the period 1 January to 31 December, 2020, with taking into account the specific sectors. The used control variables in the models are firm size (SIZE), firm risk (BETA), the absolute value of the five-day average daily return (ABSRETURN), share price volatility (VOL), daily share turnover (TURNOVER) and daily overall market sentiment (PUTCALL). We show the heteroskedasticity-consistent standard errors using the White (1980) procedure in Model 1 and in Model 2 we use a generalized linear model estimation. For the Model 3, we employ the Fama-MacBeth procedure and in Model 4, the quantile regression procedure is utilized. Finally, while the Newey-West (1987) procedure is used in Model 5, we conduct the two-way clustering by firm and year in Model 6. All models include industry and year fixed effects. The definitions of the study variables and the data sources for variables are reported in Appendix A. Unreported industry controls are in line with Global Industry Classification Standard. Heteroskedasticity robust t-statistics corrected for clustering at the year and firm level are presented in parentheses. *, **, and *** display the significance levels at 10%, 5%, and 1%, respectively.

Table 6: An alternative proxy for firm liquidity

Variables	OLS		Fixed-effects	
	(1)	(2)	(3)	(4)
Intercept	0.2103*** (123.75)	0.2091*** (124.07)	0.2029*** (28.66)	0.2179*** (15.36)
CASESGROWTH $_{i,t-1}$	**0.0037***** (8.44)		**0.0684**** (2.73)	
DEATHSGROWTH $_{i,t-1}$		**0.0019***** (11.97)		**0.0050***** (13.59)
SIZE$_{i,t-1}$	-0.0194*** (-120.52)	-0.0193*** (-120.58)	-0.0195*** (-29.27)	-0.0201*** (-14.72)
BETA$_{i,t-1}$	0.0009 (0.58)	0.0001 (0.77)	0.0008 (1.90)	-0.0005* (-2.28)
ABSRETURN $_{i,t-1}$	-0.0004 (-1.40)	-0.0004 (-1.37)	-0.0006** (-2.72)	0.0002 (0.55)
VOL $_{i,t-1}$	0.0155*** (32.42)	0.0158*** (32.99)	0.0138*** (8.51)	0.0162*** (16.11)
TURNOVER $_{i,t-1}$	0.0004** (2.78)	0.0004*** (2.89)	0.0002 (1.50)	-0.0015** (-2.69)
PUTCALL $_{i,t-1}$	8.39e-03*** (55.36)	8.46e-03*** (55.23)	4.65e-03*** (14.19)	9.56e-03*** (31.32)
Year dummy	Yes	Yes	Yes	Yes
Industry dummy	Yes	Yes	Yes	Yes
Sample size	87026	87026	87026	87026
Adjusted R^2	0.2933	0.2939	0.2731	0.2936

Notes: This table reports the findings of a group of robustness regressions employing an alternative proxy of firm liquidity. In models 1 and 2, Amihud is regressed on CASESGROWTH (measured by daily growth rate of total confirmed cases) and DEATHSGROWTH (measured by daily growth rate of total confirmed deaths), respectively. The used control variables are firm size (SIZE), firm risk (BETA), the absolute value of the five-day average daily return (ABSRETURN), share price volatility (VOL), daily share turnover (TURNOVER) and daily overall market sentiment (PUTCALL). The definitions of the study variables and the data sources for variables are reported in Appendix A. Unreported industry controls are in line with Global Industry Classification Standard. Heteroskedasticity robust t-statistics corrected for clustering at the firm level are presented in parentheses. *, **, and *** display the significance levels at 10%, 5%, and 1%, respectively.

5. Conclusion

The COVID-19 pandemic has had adverse effects on stock markets around the world. This study is one of the pioneer studies in investigating the impact of the COVID-19 pandemic on financial markets. More specifically, it explores the influence of COVID-19 pandemic (as measured by the daily growth rate in the number of positive cases and the daily growth rate in the number of confirmed deaths) on stock liquidity of S&P 500 firms.

The results of this study show a negative and significant relationship between COVID-19 and stock liquidity, indicating that an increase in the daily growth rate in the total number of confirmed cases and in the total number of confirmed deaths led to a lower level of firm liquidity. These findings imply that pandemics decrease firm liquidity. In addition, our results indicate that there are significant differences in liquidity between sectors. Some sectors like healthcare and communications have better liquidity than the market overall. On the other hand, stock liquidity in the consumer staples, consumer discretionary, financial, information technology, basic materials, energy and industrial sectors is lower than that in the market overall. Interestingly, the real estate sector's liquidity is insignificantly affected by the growing numbers of confirmed cases and confirmed deaths.

Our study contributes to the literature by examining whether COVID-19 has influenced the stock liquidity of S&P 500 firms. The findings are expected to support the research and academic communities. They have practical implications for shareholders, policy-makers and firms' management. The findings might help shareholders to deal appropriately with the stock liquidity risk and variation of returns through the COVID-19 pandemic and consequently make the best financial decisions. The results can be also valuable for portfolio managers in forecasting market risk. Our results may help investors in considering the dynamics of the stock markets in the short-run in order to learn how to invest in comparable conditions in the future.

Further, our findings have significant implications for policy-makers. Effective partnerships in relation to policy among governments and central banks in addition to securities regulators may help them to deal with this pandemic challenge. This could make investors more optimistic about firms' future earnings, which, in turn, might lessen market instabilities. Further, regulatory authorities should plan some proactive workshops to increase the confidence of investors after bad events such as COVID-19. In order to protect stock markets from severe falls, the regulatory authorities, in the event of future pandemics, need to undertake early control actions and make practical responses.

Like other studies, our paper is subject to some limitations that need to be mentioned in order to give a fair interpretation of the results. These limitations provide a good basis for future research. First, the study focuses only on the U.S. stock market, as represented by S&P 500. Thus, future studies may enrich the literature by examining the impact of COVID-19 on stock liquidity in other developed or developing financial markets. Another extension of this research would be to investigate the effect of governmental and monetary policies on reducing the influence of COVID-19 on stock liquidity.

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Appendix A: Variable definitions sources of variables

Variables	Definition	Source
SPREAD	The daily average of all bid-ask spreads computed as a proportion of the mid-price	Bloomberg
AMIHUD	Illiquidity measure by Amihud (2002) measured as follows: $Amihud_{i;t}$ = (Return*10^6)/ (Volume*Price)	Bloomberg
CASESGROWTH	daily growth in total confirmed cases caused by COVID-19	The European Centre from Disease Prevention and Control (ECDC)
DEATHGROWTH	Daily growth in total deaths because of the COVID-19	The European Centre from Disease Prevention and Control (ECDC)
SIZE	The log of the market capitalization of specific firm	Bloomberg
BETA	The stock price volatility divided by the market index volatility	Bloomberg
ABSRETURN	The absolute value of the rolling five-day average of the day to day total share return	Bloomberg
VOL	The daily volatility of the share price calculated as the intraday trading range (high price minus low price) divided by closing share price in the previous day	Bloomberg
TURNOVER	The percentage of total number of the traded shares of a firm on the present day to the total present number of outstanding shares	Bloomberg
PUTCALL	The percentage of the traded volume of put to call options	Bloomberg