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Original Article

Instability of returns and liquidity during the Covid-19 pandemic: evidence from the brazilian stock market

Instabilidade dos retornos e liquidez durante a pandemia de Covid-19: evidências do mercado de ações brasileiro

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ABSTRACT

Purpose: This study aimed to analyze the impact of liquidity on the volatility of the Brazilian stock market, considering the effects resulting from the COVID-19 pandemic.
Design/methodology/approach: The sample for this research consisted of the IBOVESPA and the sectoral indices of B3. The analysis covers the period from January 2, 2019, to July 11, 2021. The estimations were performed using the two-regime Markov switching method.
Findings: The results show that liquidity has an asymmetric impact on return volatility, both for the IBOVESPA and the sectoral indices. This relationship is more pronounced during the pandemic period than before the crisis. Therefore, this research sought to contribute to the discussion on how the liquidity of the market would impact the returns in a crisis period. This also dialogues with and contributes to the literature in emergent countries on market liquidity and systematic risk.
Research limitations/implications: The results of this study do not allow for generalizations, as the data used considers a short time series from a single emerging country.
Originality/value: This study provides practical contributions to investors with additional information regarding market liquidity and systemic risk, as it can demonstrate better investment opportunities. There are also contributions to the literature from a behavioral perspective on liquidity and market volatility in an emerging country. Furthermore, the findings provide arguments about market efficiency as well as confirming the asset pricing theory.

Keywords: Volatility; Risk; Finance; Stock market

RESUMO

Propósito: Este estudo teve como objetivo analisar o impacto da liquidez na volatilidade do mercado de ações brasileiro, considerando os efeitos decorrentes da pandemia de COVID-19.
Design/metodologia/abordagem: A amostra para esta pesquisa consistiu no IBOVESPA e nos índices

setoriais da B3. A análise abrange o período de 2 de janeiro de 2019 a 11 de julho de 2021. As estimativas foram realizadas usando o método de alternância de regime de Markov de dois regimes.
Resultados: Os resultados mostram que a liquidez tem um impacto assimétrico na volatilidade de retorno, tanto para o IBOVESPA quanto para os índices setoriais. Essa relação é mais pronunciada durante o período da pandemia do que antes da crise. Portanto, esta pesquisa procurou contribuir para a discussão sobre como a liquidez do mercado impactaria os retornos em períodos de crise. Além disso, dialoga e contribui para a literatura em países emergentes sobre liquidez de mercado e risco sistêmico.
Limitações/implicações da pesquisa: Os resultados deste estudo não permitem generalizações, uma vez que os dados utilizados consideram uma série temporal curta de um único país emergente.
Originalidade/valor: Este estudo oferece contribuições práticas aos investidores com informações adicionais sobre liquidez de mercado e risco sistêmico, pois pode demonstrar melhores oportunidades de investimento. Também há contribuições para a literatura, a partir de uma perspectiva comportamental sobre liquidez e volatilidade de mercado em um país emergente. Além disso, os achados fornecem argumentos sobre a eficiência do mercado, assim como confirmam a teoria de precificação de ativos.

Palavras-chave: Volatilidade; Risco; Finanças; Mercado de ações

1 INTRODUCTION

In recent decades, countries worldwide have enjoyed economic growth generated by international trade, foreign investment, and globalization. However, the spread of COVID-19 was an unexpected external shock to the global economy (Yong & Laing, 2021). To prevent the transmission of the virus, several measures were implemented to restrict the movement of people. Public events were canceled, schools and universities were closed and non-essential trade was halted. This led to global economic uncertainty and affected the ability of businesses to generate revenue and meet their financial obligations. As a result, the financial market experienced an increased risk (Hong, Bian & Lee, 2021).

In the United States, the S&P 500 index experienced a significant decline of 31.32% over a three-month period. In a single day, it suffered a loss of 12.77% (Just & Echaust, 2020). Similar behavior was observed in other markets, both in developed and developing countries (Harjoto, Rossi, Lee & Sergi, 2021; Phan & Narayan, 2020; Rahman, Amin & Al Mamun, 2021). In Brazil, B3 implemented circuit breakers, which are temporary suspensions of trading in assets on the stock exchange when prices decrease by more than 10%, a total of six times within eight trading sessions (Caldas, Silva, Silva & Cruz, 2021). It is important to mention that the disruptions have negative effects on the liquidity of the market and the variability of prices (Subrahmanyam, 1994).

Despite the growth in trading volume in the stock market over the last 20 years (Foran, Hutchinson & O'Sullivan, 2015), the pandemic intensified this growth. The crisis announcement acted as an exogenous shock on global stock markets, leading to a rapid increase in research on liquidity and returns in developed countries (Harjoto et al., 2021; Kostas et al., 2022; Kocaarslan, 2023). Although research in emerging countries is increasing (Yaseen & Omet, 2021; El-Chaarani, 2023), it is important to note that the studies vary in terms of volatility and liquidity proxies, econometric models, period and country of analysis. This divergence makes it difficult to compare the studies.

The impact of the pandemic has led to empirical implications that contradict the efficient market hypothesis (Hong et al., 2021). In this context, traders and speculators have opportunities to make abnormal gains. The liquidity of each asset varies, and the correlation between securities affects the overall market movements. This correlation also leads to execution costs being related across stocks, which in turn, determines the systematic liquidity risk that investors face (Silva & Machado, 2020).

Based on the asset pricing theory, underlying returns are associated with their level of risk, since investors demand compensation to accept it. Given that investors are averse to costs related to liquidity risks of securities, it is suggested that returns are also related to trading volume (Machado & Medeiros, 2012). Hence, when forming portfolios, investors may prefer more liquid securities as they are traded more frequently and at lower costs.

Considering that liquidity constitutes a source of non-diversifiable risk, understanding the dynamics of asset liquidity is something that every investor is, or should be, concerned about (Leirvik, Fiskerstrand & Fjellvikas, 2017). The analysis of liquidity is important because investors may not consider it a significant risk factor when the financial market is stable, as it is faster to buy or sell an asset at a desired price. However, their perception of liquidity becomes more variable when the market becomes volatile (Będowska-Sójka & Echaust, 2020). Thus, the objective is to analyze how liquidity instability explains the volatility of returns in the Brazilian stock market during the COVID-19 pandemic.

Additionally, this study conducted a sectoral analysis of liquidity and return volatility, considering that the pandemic influenced economic sectors differently (Chebbi, Ammer & Hameed, 2021). The segments analyzed include the industrial, consumer, financial and utilities sectors, as they have the highest liquidity in the Brazilian market. Understanding how liquidity and volatility affect sectoral portfolios helps in clarifying how the financial market performs during market declines.

The choice of Brazil as the object of study is justified because it is an emerging country. Developing countries face challenges such as political instability, economic fragility, and limited protection for companies and investors. Furthermore, the financial markets in these countries have limited trading volume and information asymmetry, with investors tending to be more cautious about taking risks (Bilel & Mondher, 2021). Given these characteristics, the impact of liquidity on volatility may vary between developing and developed countries.

2 ACADEMIC BACKGROUND AND RESEARCH HYPOTHESIS

On December 31, 2019, the World Health Organization (WHO) received the first notification about cases of pneumonia with an unknown cause in the city of Wuhan, China (WHO, 2019). In January 2020, the virus spread rapidly, with reported cases in various Asian countries, North America, Europe, and the United Arab Emirates (Au Yong & Laing, 2021). The rapid spread of the virus prompted the WHO to declare a global public health emergency on January 30, 2020. Subsequently, on March 11 of the same year, the Sars-CoV-2 infection was declared a pandemic. In Brazil, the Ministry of Health confirmed the first case of COVID-19 on February 26, 2020 (Brazil, 2020).

The lockdowns and other COVID-19-related measures had a significant impact on businesses and productivity, leading to disruptions in the global supply chain. This, in turn, resulted in financial losses and liquidity issues for the financial market (Au Yong & Laing, 2021). Pessimistic investors were selling their stocks, while optimistic investors were buying these securities. Thus, uncertainty is a determinant of liquidity (Chung & Chuwonganant, 2014).

Liquidity refers to how easily and quickly an asset can be bought or sold in the market without incurring high costs (Liu, 2006). Costs can be explicit, such as bid-ask spreads, or implicit, such as adverse price changes resulting from trading (Zaremba, Aharon, Demir, Kizys & Zawadka, 2021). The literature also indicates that liquidity can display asymmetric behavior, with significant decreases during periods of financial turbulence (Ruenzi, Ungeheuer & Weigert, 2020). These changes in trading volume can result in changes in asset returns.

Different classes of investors provide liquidity (Butt, Högholm & Sadaqatc, 2021).

There are two groups in the financial market: informed traders also referred to as rational traders, and liquidity traders, also known as irrational traders (Lesmond, Ogden & Trzcinka, 1999). The first group has the advantage of having information, while the irrational traders either do not have access to private information or struggle to interpret it (Bloomfield, O'Hara & Saar, 2005).

The movement of risk aversion and economic uncertainty drives changes in liquidity (Zhang, Choudhry, Kuo, Liu &, 2021). During crises, rational investors tend to be more cautious and may choose to sell stocks to preserve previous gains or minimize losses. On the other hand, irrational investors, without proper access or interpretation of information, may perceive stocks as trading at a discount or with growth prospects and seek to buy them. In this context, the participation of active investors are implicitly linked to increased liquidity in the market and, consequently, impact return volatility (Butt et al., 2021).

Studies suggest that liquidity can predict future stock returns due to changes in transaction costs or behavioral biases, such as over-optimism (Zhang et al., 2021). Similarly, stocks that have lower liquidity are traded at a reduced price, allowing new investors to enter the market (Amihud & Mendelson, 1986). Therefore, irrational investors may be more inclined to engage in trades during these periods because they perceive it as an opportunity to gain positive returns (Baker & Wurgler, 2006). Consequently, when these investors participate, they increase liquidity in the market.

During periods of market stress, investors seek more liquid stocks, and those becoming less liquid become less attractive (Ruenzi et al., 2020). These investors may be willing to pay a premium for stocks with higher market liquidity (Perobelli, Famá & Sacramento, 2016) and may combine different assets to explore the trade-offs between liquidity, risk, and return (Henriques & Neves, 2021).

Liquidity can affect stock prices asymmetrically, depending on the economic regime and the level of idiosyncratic risk (Malagon, Moreno & Rodriguez, 2018). Different sectors of the Brazilian stock market were also influenced by the COVID-19 pandemic, where certain segments were more impacted than others (Caldas et al., 2021). For example, the consumer sector includes organizations related to tourism, leisure, hotels, and restaurants. On the other hand, the industrial sector heavily relies on commodities from global supply chains. Both sectors are significantly impacted by lockdowns (Avelar et al., 2020), while the utilities sector, which includes public and essential services, had a lesser impact. Similarly, Acharya, Amihud, and Bharath (2013) demonstrate that liquidity shocks have a stronger impact on asset prices during crisis periods.

Phan and Narayan (2020) provided evidence that in the 25 countries most affected by COVID-19 in terms of infection and death cases, there was a possible overreaction and market correction, where at the initial stage of the pandemic, stock prices reacted negatively. However, over time, the reaction in at least 50% of the markets turned positive, suggesting a probable market correction. Thus, liquidity shocks are absorbed by the market over time, leading to price corrections after recessions (Malagon et al., 2018; Będowska-Sójka, 2021; Zhang et al., 2021).

Chebbi et al. (2021) found evidence that the pandemic negatively influenced the liquidity of companies listed in the S&P 500. Baig, Butt, Haroon & Rizvi (2021) showed that increases in confirmed COVID-19 cases and deaths, as well as the implementation of restrictions like lockdowns, contributed to liquidity and market volatility instability.

Investors may be willing to pay more for easily tradable assets (Perobelli et al., 2016) and have the ability to create different sets of assets to assess the balance between liquidity, risk and return (Henriques & Neves, 2021). On the one hand, investors can sell their shares to minimize losses or secure profits made in stable times. On the other hand, some investors may buy these stocks because they believe there has been an exaggerated reaction and they anticipate a possible price correction (Phan & Narayan, 2020).

In this context, it is observed that liquidity shocks influence asset prices, especially intensifying during crisis periods, as indicated by Acharya et al. (2013). As a result, liquidity asymmetrically affects market volatility (Butt et al., 2021; Malagon et al., 2018). In light of this information, the following research hypothesis emerges:

H1: Liquidity has a greater impact on return volatility during the COVID-19 pandemic.

3 RESEARCH METHODOLOGY

To analyze the Brazilian stock market, data from the São Paulo Stock Exchange Index (IBOVESPA) was used, which is the main index of the country's financial market and is widely used by investors and researchers to analyze the stock market behavior. For the sectoral investigation, data from the B3 Indices and Segments and Sectors were used, for example, the Financial Index (IFNC), which includes the financial intermediaries, various financial services, pension, and insurance sectors; the Consumption Index (ICON), comprising the cyclical and non-cyclical consumer sectors, and healthcare; the Industrial Sector Index (INDX), covering basic materials, industrial goods, and information technology; and the Utilities Index (UTIL), including sectors like the electricity, water, sanitation, and gas. These sector indexes have the highest level of liquidity in the Brazilian market.

Market data was collected from the Refinitiv Eikon platform, and exchange rate and risk-free rate data were obtained from the website of the Central Bank of Brazil.

The data covers the period from January 2, 2019, to May 11, 2021, including 584 trading days. The choice of this interval is justified as it includes the period before the crisis and the period that encompasses part of the instability caused by COVID-19. Furthermore, we have chosen to keep the same number of days for the different regimes, taking into account the transition date given by the Markov switching method. All the data were collected on a daily basis, as reported by Hong et al. (2021) daily stock prices reflect the available information. To minimize potential problems caused by outliers, we performed winsorization at the 5th and 95th percentiles.

3.1 Variables and Econometric Model

3.1.1 Measurement of return volatility - ARCH/GARCH

For volatility, the conditional volatility obtained by estimating a GARCH (1,1) was considered, based on the time series of historical daily returns. In addition, it was necessary to analyze the behavior of the returns in the period based on the ARCH model, which provided statistically significant statistics at the 5% level for the index returns. As a result, the hypothesis of homoscedasticity for the series residuals is rejected through the Lagrange Multiplier Test (Engle, 1982).

The changes in index prices tend to cluster, indicating a potential ARCH effect that is best observed through the GARCH (1, 1) model. The use of these models on the index series is justified since they provide greater accuracy in modeling and allow for adaptation in volatility over time (Maciel & Ballini, 2017). The models can be operationalized through Equations 1 and 2.

$$r_t = \sigma_t \epsilon_t \quad (1)$$

$$\sigma_t^2 = \omega + \sum_{i=1}^{1} \alpha_i \chi_{t-i}^2 + \sum_{j=1}^{1} \beta_i \sigma_{t-j}^2 \quad (2)$$

In the equation r_t, represents the market return, given by the logarithm of the ratio between the closing score of day t and t $_{-1}$. The term € $_t$ $\epsilon_t \epsilon_t$ ~ i.i.d. (0.1) represents the white noise with zero mean, and it is assumed to follow a normal distribution. σ^2_t is a deterministic function of the time-varying volatility, σ^2_t representing the volatility in month t, ω is the constant of the model, α_i is the short-term impact coefficient of € $_t$ in σ^2_t, and β_i is the long-term coefficient in σ^2_t,

According to the GARCH model, the persistence of changes in volatility will take longer to dissipate if the value of γ is close to 1.

3.1.2 Proxies for liquidity

Liquidity was determined by using Equation 3 to calculate the daily ratio between the traded financial volume of the studied index and its market capitalization. This proxy was also used by Zaremba et al. (2021) research.

$$\text{Liq}_{i,t} = \frac{\text{VOLFIN}_{i,t}}{\text{CAPMKT}_{i,t}} \quad (3)$$

Liq $_{i,t}$ is the liquidity of index *i*, for day *t*; $\text{VOLFIN}_{i,t}$ is the financial volume traded of index *i* on day *t*, and $\text{CAPMKT}_{i,t}$ $\text{CAPMKT}_{i,t}\text{CAPMKT}_{i,t}$ is the financial capitalization of index *i* for day *t*.

As for the control variables, they were used according to previous research (Hong et al. 2021; Zaremba et al. 2021). The authors anticipate a positive relationship between the control variables and volatility, as investors typically seek greater returns for investments in more volatile assets. Table 1 highlights the calculation of the proxies.

Table 1 – Control variables

Variable	Abbreviation	Calculation
Idiosyncratic Risk Premium	DEFAULT	Average return of cpompanies with Aaa rating – average return of companies with Baa rating (Moody´s)
Exchange Rate	EXCH	Variation in the exchange rate of the US Dollar on day t–t-1
Market Risk Premium	MKT	Market return – risk free rate (Special System of Settlement and Custody)
Investiment Horizon Premium	TERM	Average return of 10 years government bonds subtracted from average return of 3-month government bonds

Source: Own elaboration

After calculating the variables, the impact of liquidity on return volatility was estimated through Equation 4:

$$VOLAT_{i,t} = \beta_0 + \beta_1 Liq_{i,t} + \beta_2\ DEFAULT_t + \beta_2\ EXCH + \beta_3 MKT_t + \beta_4\ TERM_t + \varepsilon_{\ i,t} \quad (4)$$

$VOLAT_{i,t}$ is a volatility of index *i*, for day *t*; Liq $_{i,t}$ é a liquidity of index *i*, for day *t*; $DEFAULT_t$ is the premium for unsystematic risk, on day *t*; $EXCH_t$ is the exchange rate on day *t*; MKT_t is the market risk premium on day *t*; $TERM_t$ is the premium for the investment horizon, on day *t*.

The model estimation was performed using Markov Switching (Hamilton, 1989). This approach assumes that the data series can exhibit different behavior regimes. There may be changes in volatility and liquidity, as the data is analyzed in each of the proposed regimes. The Markov Switching method is used to identify the date when a change in regime occurs within a time series. On this basis, we attempted to establish the same period for the regimes: 292 days before the pandemic and 292 days during it.

4 RESULTS AND DISCUSSION

4.1 Descriptive Statistics

The analysis of liquidity and volatility was conducted for the period from January 2, 2019, to May 11, 2020. Table 1 presents the statistics of the variables used in the present study, divided into the pre-pandemic period and during the COVID-19 pandemic. When using the Markov-Switching method, the cut-off date that marks the transition from the pre-pandemic period to the crisis period is March 6, 2020.

This date represents the trading session before the first circuit breaker of the period of instability.

Table 2 – Descriptive Statistics of the Variables

VAR	PRÉ-COVID Pandemic					COVID Pandemic					Mann Whitney (p-value)
	Min	Average	Median	Standard Deviation	Max	Min	Average	Median	Standard Deviation	Max	
$VIBOV_t$	0,0008	0,0019	0,0015	0,0082	0,0013	0,0008	0,0030	0,0024	0,0082	0,0021	0,0000
$VICON_t$	0,0009	0,0019	0,0016	0,0083	0,0011	0,0011	0,0031	0,0024	0,0083	0,0020	0,0000
$VIFNC_t$	0,0014	0,0024	0,0022	0,0084	0,0010	0,0014	0,0050	0,0037	0,0129	0,0035	0,0000
$VINDX_t$	0,0009	0,0018	0,0015	0,0062	0,0010	0,0010	0,0026	0,0021	0,0062	0,0014	0,0000
$VUTIL_t$	0,0007	0,0018	0,0015	0,0080	0,0011	0,0007	0,0032	0,0024	0,0085	0,0023	0,0000
$LIBOV_t$	0,0027	0,0036	0,0035	0,0077	0,0008	0,0031	0,0058	0,0057	0,0077	0,0010	0,0000
$LCONS_t$	0,0031	0,0043	0,0040	0,0100	0,0012	0,0035	0,0071	0,0070	0,0100	0,0018	0,0000
$LFINAN_t$	0,0019	0,0028	0,0026	0,0066	0,0008	0,0026	0,0048	0,0046	0,0068	0,0011	0,0000
$LINDX_t$	0,0029	0,0040	0,0038	0,0079	0,0010	0,0029	0,0060	0,0058	0,0079	0,0011	0,0000
$LUTIL_t$	0,0027	0,0036	0,0036	0,0066	0,0008	0,0027	0,0048	0,0046	0,0066	0,0010	0,0000
$DEFAULT_t$	-0,1908	-0,0098	-0,0126	0,2195	0,0888	-0,1908	0,0109	0,0139	0,0095	0,1190	0,5757
$PRAZO_t$	-0,0378	0,0006	0,0009	0,0525	0,0129	-0,0507	0,0005	0,0001	0,0525	0,0290	0,9763
$DOLAR_t$	-0,0234	0,0007	0,0006	0,0007	0,0296	-0,0330	0,0004	0,0009	0,0136	0,0366	0,0000
MKT_t	-0,0290	-0,0039	-0,0033	0,0212	0,0112	-0,0290	-0,0005	0,0002	0,0212	0,0148	0,0033
	n = 292					n = 292					

Note: $VIBOV_t$ is the volatility of IBOVESPA on day *t*; $VICON_t$ is the volatility of the consumer sector, on day *t*; $VIFNC_t$ is the volatility of the financial sector, on day *t*.; $VINDX_t$ is the volatility of the industrial sector, on day *t*; $VUTIL_t$ is the volatility of the utility sector, on day *t*. $LIBOV_t$ is the liquidity of IBOVESPA on day *t*;$LCONS_t$ is the liquidity of the consumer sector on day *t*; $LFINAN_t$ is the liquidity of the financial sector on day *t*; $LINDX_t$ is the liquidity of the industrial sector on day *t*; $LUTIL_t$ is the liquidity of the utility sector on day *t*. $DEFAULT_t$ is the premium for unsystematic risk, on day *t* ; $EXCH_t$ is the exchange rate on day *t*; MKT_t is the market risk premium on day *t*; $TERM_t$ is the premium for the investment horizon, on day *t*.

Source: Own elaboration based on data from Refinitiv Eikon and Central Bank of Brazil

Part of the proxies has medians that are higher than the mean, suggesting that the distribution of the measures is skewed to the left, and extreme values are still present in the analysis, despite the winsorization process. Based on the standard deviation, it is evident that the data exhibits significant variability. The range of returns and liquidity is greater during the COVID-19 pandemic period, as shown by the differences between the minimum and maximum values. This result indicates that the crisis caused an increase in the levels of volatility and trading of the stocks that comprise the indices.

Overall, all indices showed an increase in liquidity. This result is in line with the literature (Chung & Chuwonganant, 2014; Zhang et al., 2021), which suggest that liquidity tends to increase during periods of instability. The Mann-Whitney U test was conducted to analyze the difference in medians. Regarding volatility and liquidity, the result indicates that these measures are significantly different at the 1% level between the pre-pandemic and during the pandemic periods.

According to the results, there was an increase in trading volume and volatility in all sectors analyzed during the crisis period, with financials showing the highest increase. The utilities sector showed the lowest variation in trading volume, while the industrial sector had the least change in volatility. It is worth noting that the industrial and consumer sectors had the highest level of liquidity, both before and during the pandemic.

Regarding the control variables, there was no significant difference in the premium of companies based on idiosyncratic risk or investment horizon. The exchange rate and market risk premium experienced an increase during the pandemic period, which further contributed to greater volatility in the indices.

When analyzing the descriptive statistics in Table 1, we observed an increase in the measures of central tendency in the variables of interest during the transition from the pre-pandemic to the pandemic period. With this in mind, we attempted to test for the presence of a unit root using the Augmented Dickey-Fuller test. As shown in Table 2, no unit root was found in the data at the 1% level, and as a result, the variables do not have a trend.

Table 3 – Unit Root Test - Augmented Dickey-Fuller

Varianle	Calculated Value	Critical Value - 1%	Critical Value - 5%
$VIBOV_t$	-4,9764	-3,43	-2,86
$VICON_t$	-4,7535	-3,43	-2,86
$VIFNC_t$	-4,1220	-3,43	-2,86
$VINDX_t$	-4,9635	-3,43	-2,86
$VUTIL_t$	-4,4910	-3,43	-2,86
$LIBOV_t$	-3,6800	-3,43	-2,86
$LCONS_t$	-3,9070	-3,43	-2,86
$LFINAN_t$	-3,4987	-3,43	-2,86
$LINDX_t$	-3,5677	-3,43	-2,86
$LUTIL_t$	-4,8804	-3,43	-2,86
$DEFAULT_t$	-7,9584	-3,43	-2,86
$PRAZO_t$	-18,8797	-3,43	-2,86
$DOLAR_t$	-11,2535	-3,43	-2,86
MKT_t	-9,7879	-3,43	-2,86

Note: $VIBOV_t$ is the volatility of IBOVESPA on day *t*; $VICON_t$ is the volatility of the consumer sector, on day *t*; $VIFNC_t$ is the volatility of the financial sector, on day *t*.; $VINDX_t$ is the volatility of the industrial sector, on day *t*; $VUTIL_t$ is the volatility of the utility sector, on day *t*. $LIBOV_t$ is the liquidity of IBOVESPA on day *t*;
$LCONS_t$ is the liquidity of the consumer sector on day *t*; $LFINAN_t$ is the liquidity of the financial sector on day *t*; $LINDX_t$ is the liquidity of the industrial sector on day *t*; $LUTIL_t$ is the liquidity of the utility sector on day *t*. $DEFAULT_t$ is the premium for unsystematic risk, on day *t* ; $EXCH_t$ is the exchange rate on day *t*; MKT_t is the market risk premium on day *t*; $TERM_t$ is the premium for the investment horizon, on day *t*.

Source: Own elaboration based on data from Refinitiv Eikon and Central Bank of Brazil

4.2 Liquidity and Return Volatility

Table 3 presents the results of the current study. Overall, liquidity has a positive impact on return volatility in at least part of the analyzed period. This means that higher liquidity leads to higher return volatility. During regime 1, liquidity affected the volatility of IBOVESPA, the consumer, finance, and industrial sectors, but there was no significance regarding the utilities sector.

Table 4 – Markov Switching Model Results showing the Regime Shifts

(Continued)

Regime 1			Regime 2		
IBOV and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
$Intercept_i$	-0,9740***	0,6840	Intercept	-0,7915***	0,5890
$LIQ_{i,t}$	0,1353*	0,0021	$LIQ_{i,t}$	1,4704***	0,0228
$DEFAULT_t$	-0,0204	0,3646	$DEFAULT_t$	-0,3555	0,8649
$EXCH_t$	0,3558***	0,1230	$EXCH_t$	0,5433***	0,2230
MKT_t	0,3370*	0,1654	MKT_t	0,3397*	0,1658
$TERM_t$	-0,1967	1,2171	$TERM_t$	0,3891***	1,2171
Multiple R^2	0,3273		Multiple R^2	0,5372	
Sigma	0,4489		Sigma	0,6220	
Pli	0,9573	0,0426	P2ii	0,0275	0,9724
CONS and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,9586***	0,4510	Intercept	-2,3134	1,9870
$LIQ_{i,t}$	0,1313**	0,0624	$LIQ_{i,t}$	1,3331***	0,2323
$DEFAULT_t$	-0,0750	0,1073	$DEFAULT_t$	-0,8931**	0,4299
$EXCH_t$	0,3449***	0,0325	$EXCH_t$	0,3668*	0,1890
MKT_t	0,4072***	0,1529	MKT_t	0,39155**	0,6685
$TERM_t$	0,0888	0,4628	$TERM_t$	2,1580	1,4688
Multiple R^2	0,4935		Multiple R^2	0,6843	
Sigma	0,2986		Sigma	0,5689	
Pli	0,9902	0,0237	P2ii	0,0097	0,9902
FINAN and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,9860***	0,4514	Intercept	-0,8533***	0,6114
$LIQ_{i,t}$	0,2709***	0,0596	$LIQ_{i,t}$	4,3671 ***	1,20809
$DEFAULT_t$	0,1166	0,1417	$DEFAULT_t$	-0,6212**	0,2342
$EXCH_t$	0,3092***	0,0312	$EXCH_t$	0,6800***	0,0447
MKT_t	0,3020***	0,2699	MKT_t	0,3546*	0,1430
$TERM_t$	0,0200	0,5124	$TERM_t$	2,1580	0,9634
Multiple R^2	0,5313		Multiple R^2	0,8358	
Sigma	0,2856		Sigma	0,2614	
Pli	0,9854	0,0291	P2ii	0,0145	0,9708

Table 4 – Markov Switching Model Results showing the Regime Shifts

(Conclusion)

Regime 1			Regime 2		
INDX and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,8699***	0,5509	Intercept	-0,4688*	2,3257
$LIQ_{i,t}$	0,1859**	0,0791	$LIQ_{i,t}$	2,2035***	0,2898
$DEFAULT_t$	-0,0502	0,1121	$DEFAULT_t$	-0,9727**	0,4665
$EXCH_t$	0,2110***	0,0352	$EXCH_t$	0,0895	0,1963
MKT_t	0,9907	1,2324	MKT_t	1,1679*	0,6575
$TERM_t$	0,0752	0,4545	$TERM_t$	2,4557	1,5755
Multiple R²	0,2753		Multiple R²	0,7161	
Sigma	0,3319		Sigma	0,4948	
Pli	0,9799	0,0970	P2ii	0,0200	0,9029
UTIL and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,6861***	0,5255	Intercept	-0,6244***	2,1812
$LIQ_{i,t}$	0,3832	0,0783	$LIQ_{i,t}$	1,1014 ***	0,3366
$DEFAULT_t$	0,1881	0,1261	$DEFAULT_t$	-0,8472*	0,6838
$EXCH_t$	0,1012***	0,0307	$EXCH_t$	0,6739***	0,1405
MKT_t	0,3305**	1,4050	MKT_t	2,1314**	2,3398
$TERM_t$	-0,2049	0,5719	$TERM_t$	1,8631	1,7611
Multiple R²	0,1878		Multiple R²	0,7055	
Sigma	0,3636		Sigma	0,6130	
Pli	0,9860	0,0505	P2ii	0,0139	0,9494

Note: $VIBOV_t$ is the volatility of IBOVESPA on day *t*; $VICON_t$ is the volatility of the consumer sector, on day *t*; $VIFNC_t$ is the volatility of the financial sector, on day *t*.; $VINDX_t$ is the volatility of the industrial sector, on day *t*; $VUTIL_t$ is the volatility of the utility sector, on day *t*. $LIBOV_t$ is the liquidity of IBOVESPA on day *t*;
$LCONS_t$ is the liquidity of the consumer sector on day *t*; $LFINAN_t$ is the liquidity of the financial sector on day *t*; $LINDX_t$ is the liquidity of the industrial sector on day *t*; $LUTIL_t$ is the liquidity of the utility sector on day *t*. $DEFAULT_t$ is the premium for unsystematic risk, on day *t* ; $EXCH_t$ is the exchange rate on day *t*; MKT_t is the market risk premium on day *t*; $TERM_t$ is the premium for the investment horizon, on day *t*.
Note²: Sigma is the residual standard deviation**.**
Note³: p1i and p2ii are the transition probabilities to remain in regimes i and ii, respectively**.**
Note⁴: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source: Own elaboration based on data from Refinitiv Eikon and Central Bank of Brazil

In the second regime, market liquidity better explains the volatility of all indices. This is supported by higher and more significant coefficient levels, indicating a measurable impact, along with a higher R², suggesting a strong explanation of variability. The utilities sector, which was not significant during the initial regime of the crisis, became statistically significant during the second one. Moreover, the influence of liquidity on all indices was greater during regime 2 compared to regime 1. This regime suggests that the crisis led to an increase in trading volume, which consistently resulted in higher return volatility. The financial sector, which had the highest variation in trading volume and returns during the pandemic, was the sector where liquidity had the strongest impact on volatility.

Historically, the financial sector is one of the more stable segments concerning dividend payments to shareholders, both in terms of frequency and dividend amounts. This income offers emotional security to investors because it helps them generate positive returns or minimize losses caused by asset devaluation. (Bilel & Mondher, 2021).

However, the financial sector also has a significant amount of debt and faces close supervision from authorities. This results in increased operational risks, particularly during times of crisis (Damodaran, 2012). While some investors choose to buy shares in this sector in order to receive dividends, others may sell their stocks to avoid exposure to idiosyncratic risks and potential asset devaluation. The presence of different groups with distinct behaviors leads to an increase in the trading volume and liquidity of financial securities.

The utilities sector showed the smallest variation in liquidity, and in the model, it presented the lowest impact of trading on volatility. One possible explanation is that investors may have decided to keep the securities in their portfolios because the sector had lower idiosyncratic risk during the pandemic. The lower risk may be related to the fact that electricity, water, sanitation, and gas companies have long-term contracts and concessions, greater revenue predictability, difficulty for new entrants in the market, and a record of accomplishment of paying dividends.

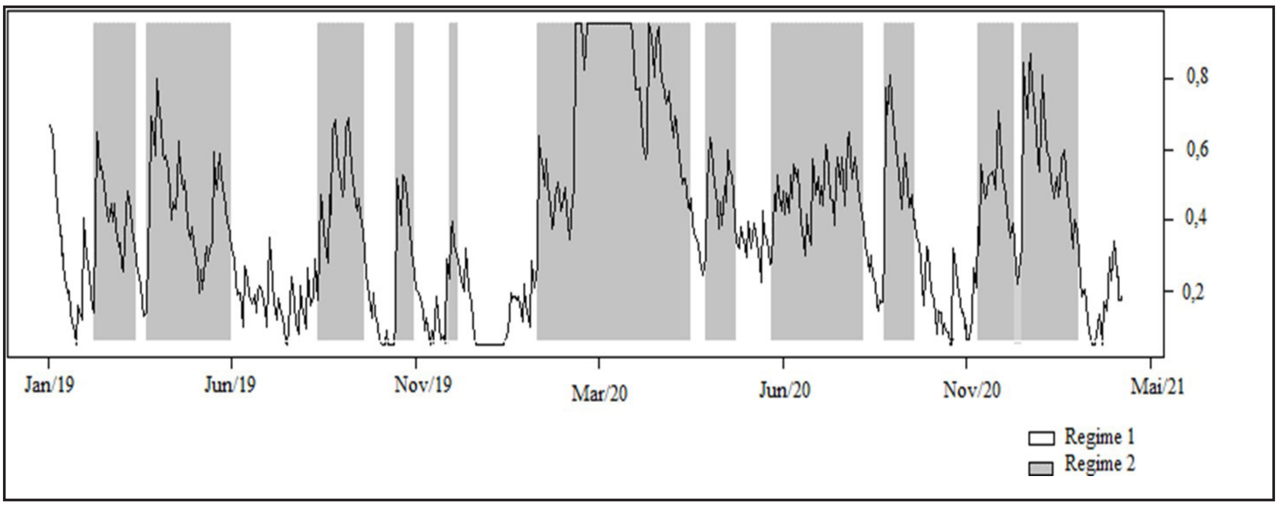
The industrial sector, among those analyzed, was the one where lower liquidity explained return volatility. Historically, the industry has been one of the sectors with the most liquidity in the stock market. With the pandemic causing disruptions in various industries, stock prices experienced a decline. However, as activities began to resume, the stock market showed a remarkable rebound, making it one of the sectors that recovered at a faster pace. The model's result can be supported by the asset pricing theory, as investors tend to favor stocks that have higher trading volume. In this context, as one of the most liquid sectors, the liquidity risk is low. As a result, investors require lower returns.

Regarding the control variables, the idiosyncratic risk premium had a negative impact on volatility in all sectors only during the crisis period. This suggests that safer companies have less volatile returns, while riskier companies have returns that are more volatile. As for the exchange rate, there was a positive signal, indicating that the higher the dollar fluctuation, the greater the volatility of the indices. Moreover, this relationship is stronger during the second regime.

The market risk premium indicated a positive effect on volatility across all sectors during regime 2. This suggests that the variation in returns caused by market conditions is higher during periods of crisis. As for the investment horizon premium, there was no significance in most of the indices and in both regimes.

According to Figure 1, the first regime consists of periods of low volatility, while the second regime includes periods of high volatility. Additionally, the presence of regime 2 is more significant during the pandemic period than before the crisis. Thus, this confirms that volatility is higher during periods of market crisis.

Figure 1 – Regime Shift, considering IBOVESPA volatility



Source: Own elaboration based on data from Refinitiv Eikon

In this regard, it is possible that pessimistic investors sell their stocks to minimize losses or secure any gains acquired during stable periods. Similarly, overly optimistic investors may buy these stocks, believing that there was an exaggerated reaction, and there will be a potential price correction (Phan & Narayan, 2020).

Likewise, stocks with low liquidity are traded at a lower price compared to those with high liquidity. This, in turn, allows overly optimistic investors to enter the market (Amihud & Mendelson, 1986). Investors may be willing to pay a premium for more liquid assets (Perobelli et al., 2016) and may combine different assets to explore the trade-offs between liquidity, risk, and return (Henriques & Neves, 2021). In this context, liquidity shocks affect asset prices and increase the volatility of returns, with this relationship being even more intense in times of crisis (Acharya et al., 2013).

The findings of Just and Echaust (2020) differ from the result obtained in our study, as they did not discover a significant correlation between returns and market liquidity in the US market. The reasons for the divergence in results, in addition to the analyzed market, are that the authors employed a different liquidity measure, namely the Amihud index. The findings align with previous research (Arcarya et al., 2013; Phan & Narayan, 2020; Butt et al., 2021; Malagon et al., 2018) indicating that liquidity has an asymmetric impact on market volatility. Consequently, H1 should not be rejected.

4.2.1 Sensitivity Analysis

Considering the divergences in the literature regarding the proxies used to measure for liquidity, and to capture its characteristics, it was necessary to use a second proxy for greater robustness of the results. This measure was also utilized by Baker and Wurgler (2006) and is calculated using Equation 5.

$$\mathrm{TURN}_{i,t} = \frac{\mathrm{NTIT}_{i,t}}{\mathrm{OUTSTANDING}_{i,t}} \quad (5)$$

$TURN_{i,t}$ Turnover of sector i in period t; $NTIT_{i,t}$ = Number of securities traded for sector i in period t; $OUTSTANDING_{i,t}$ = Number of outstanding shares of sector i in period t.

Table 4 shows that even with the substitution of the proxy for trading volume, the results remain consistent. Liquidity still has a positive effect on the volatility of the analyzed indices' returns. Nevertheless, the robustness analysis confirms that trading volume explains volatility more intensely during the crisis period (Regime 2). Regarding the control variables, some models showed a decrease in significance, while others showed an increase in significance compared to the previous model's results.

Table 5 – Markov Switching Model Results showing the Regime Shift

(Continued)

Regime 1			Regime 2		
IBOV and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,7818***	0,6764	Intercept	-0,5827	0,8837
$LIQ_{i,t}$	0,2512**	0,0945	$LIQ_{i,t}$	1,2143 ***	0,1201
$DEFAULT_t$	0,1915	0,1718	$DEFAULT_t$	-0,2853	0,2296
$EXCH_t$	0,0383	0,0409	$EXCH_t$	0,1314*	0,0551
MKT_t	0,3794**	0,1582	MKT_t	0,5214 **	0,1647
$TERM_t$	-0,8485	0,8222	$TERM_t$	0,2201*	0,9784
Multiple R^2	0,3371		Multiple R^2	0,5071	
Sigma	0,2956		Sigma	0,3474	
Pli	0,9663	0,0400	P2ii	0,0336	0,9599
CONS and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,8914***	0,4059	Intercept	-3,0921***	0,7547
$LIQ_{i,t}$	0,2233***	0,0615	$LIQ_{i,t}$	1,0348***	0,1030
$DEFAULT_t$	-0,0102	0,1120	$DEFAULT_t$	-0,2413	0,2244
$EXCH_t$	0,2871***	0,0272	$EXCH_t$	0,0922	0,0590
MKT_t	0,4572**	0,1178	MKT_t	0,4336*	0,6203
$TERM_t$	-0,0727	0,9070	$TERM_t$	0,2886	0,9733
Multiple R^2	0,5242		Multiple R^2	0,6801	
Sigma	0,2532		Sigma	0,3074	
Pli	0,9771	0,040	P2ii	0,0228	0,9590

Table 5 – Markov Switching Model Results showing the Regime Shift

(Conclusion)

	Regime 1			Regime 2	
FINAN and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,8154***	0,4661	Intercept	-1,8881***	0,6092
$LIQ_{i,t}$	0,2873***	0,0624	$LIQ_{i,t}$	5,4266***	1,1825
$DEFAULT_t$	0,1252	0,1423	$DEFAULT_t$	-0,5841*	0,2325
$EXCH_t$	0,2972***	0,0329	$EXCH_t$	0,6630***	0,0444
MKT_t	0,2937*	1,2663	MKT_t	1,3069*	1,4078
$TERM_t$	-0,0172	0,3310	$TERM_t$	0,2074	0,9641
Multiple R^2	0,5369		Multiple R^2	0,8407	
Sigma	0,2849		Sigma	0,2576	
Pli	0,9849	0,0295	P2ii	0,0150	0,9704
INDX and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-0,7973***	0,4389	Intercept	-0,2870***	0,3587
$LIQ_{i,t}$	0,3336***	0,0677	$LIQ_{i,t}$	1,0079 ***	0,0679
$DEFAULT_t$	-0,0382	0,1283	$DEFAULT_t$	-0,2336	0,2103
$EXCH_t$	0,1870***	0,0253	$EXCH_t$	0,0003*	0,0062
MKT_t	1,9552	1,1639	MKT_t	1,6687*	0,4463
$TERM_t$	-0,1431*	0,6434	$TERM_t$	1,1133	0,8653
Multiple R^2	0,2252		Multiple R^2	0,5543	
Sigma	0,4722		Sigma	0,2849	
Pli	0,9361	0,0817	P2ii	0,0638	0,9182
UTIL and Liquidity					
	Coefficient	**Standard Error**		**Coefficient**	**Standard Error**
Intercept	-1,6696***	0,6756	Intercept	-0,828***	0,7686
$LIQ_{i,t}$	-0,0347	0,1055	$LIQ_{i,t}$	0,9383***	0,1090
$DEFAULT_t$	-0,0095	0,2106	$DEFAULT_t$	-0,4915*	0,2150
$EXCH_t$	0,3279**	0,0328	$EXCH_t$	0,2662***	0,0431
MKT_t	0,5542*	1,7817	MKT_t	0,8693***	1,6414
$TERM_t$	-0,0698	1,1617	$TERM_t$	2,1085*	0,9910
Multiple R^2	0,3918		Multiple R^2	0,5329	
Sigma	0,3140		Sigma	0,3581	
Pli	0,9736	0,0286	P2ii	0,0263	0,9713

Note: $VIBOV_t$ is the volatility of IBOVESPA on day *t*; $VICON_t$ is the volatility of the consumer sector, on day *t*; $VIFNC_t$ is the volatility of the financial sector, on day *t*.; $VINDX_t$ is the volatility of the industrial sector, on day *t*; $VUTIL_t$ is the volatility of the utility sector, on day *t*. $LIBOV_t$ is the liquidity of IBOVESPA on day *t*;
$LCONS_t$ is the liquidity of the consumer sector on day *t*; $LFINAN_t$ is the liquidity of the financial sector on day *t*; $LINDX_t$ is the liquidity of the industrial sector on day *t*; $LUTIL_t$ is the liquidity of the utility sector on day *t*. $DEFAULT_t$ is the premium for unsystematic risk, on day *t* ; $EXCH_t$ is the exchange rate on day *t*; MKT_t is the market risk premium on day *t*; $TERM_t$ is the premium for the investment horizon, on day *t*.
Note²: Sigma is the residual standard deviation**.**
Note³: p1i and p2ii are the transition probabilities to remain in regimes i and ii, respectively**.**
Note⁴: *** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Source*:* Own elaboration based on data from Refinitiv Eikon and Central Bank of Brazil

4 CONCLUSION

The aim of this study was to analyze the impact of liquidity on the volatility of the Brazilian stock market, considering the effects of the COVID-19 pandemic. The relationship between liquidity and volatility showed asymmetrical aspects, as the variation in traded volume explains returns more consistently in the crisis period than in the pre-crisis period.

On the one hand, the financial sector had the greatest impact of liquidity on volatility both before and after the crisis. While some investors choose to acquire stocks in this sector for the dividends, others may prefer to sell their shares to avoid exposure to idiosyncratic risks. On the other hand, the utilities sector, with the least liquidity swings and the least impact of trading on volatility during the pandemic, may have retained investor preference due to its lower risk.

The pandemic presented opportunities for arbitrageurs and speculators. Many investors sold their stocks to minimize losses, while others seized the recession to acquire new assets at discounted prices Investors may be willing to pay more for assets that are easier to sell, and they may combine different assets to balance the trade-offs between liquidity, risk and return.

This study has limitations, as it does not take into account other external factors during the period, such as the presidential transition in the country. In addition, the indices used are based on liquid assets, which can lead to distortions as companies with low or no liquidity are overlooked. It is important to note that the results cannot be generalized, as the analysis is limited to a short time series of a single emerging country.

Future research may utilize alternative estimation methods, such as quantile regression, to analyze the effects of the pandemic on liquidity and volatility. It is recommended to use longer time series and other indicators of liquidity. Similarly, other market indices or portfolio formations should be analyzed, for example, based on company characteristics. Similarly, it is possible to conduct a comparison of how liquidity affects market returns in both developed and emerging countries. Another opportunity for investigation would be to study this relationship in different crises, such as the 2008 financial crisis, the European crisis in 2011, and the Brazil crisis in 2015-2016.

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Contribution of authors

Contribution	[Author 1]
1. Definition of research problem	√
2. Development of hypotheses or research questions (empirical studies)	√
3. Development of theoretical propositions (theoretical work)	√
4. Theoretical foundation / Literature review	√
5. Definition of methodological procedures	√
6. Data collection	√
7. Statistical analysis	√
8. Analysis and interpretation of data	√
9. Critical revision of the manuscript	√
10. Manuscript writing	√

Conflict of Interest

The authors have stated that there is no conflict of interest.

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