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The effect of the introduction of market makers on stock liquidity: evidence from the Brazilian stock market

El efecto de la introducción de market makers en la liquidez de las acciones: evidencia en el mercado de valores brasileño

O efeito da introdução de *market makers* na liquidez das ações: evidências no mercado acionário brasileiro

Authors

Gabriel Augusto de Carvalho
Master in Administration from the Postgraduate Program in Administration (PPGA) of the Federal Center for Technological Education of Minas Gerais (CEFET-MG). Address: Amazonas Avenue, 5253 - Nova Suíça - CEP 30421-169 - Belo Horizonte - MG, Brazil. Phone: +55 (31) 3319-7022. Identifiers (ID):
ORCID: https://orcid.org/0000-0002-3908-1552
Lattes: http://lattes.cnpq.br/3097210573149816
Email: ga09carvalho@gmail.com

João Eduardo Ribeiro
Master in Administration from the Postgraduate Program in Administration (PPGA) of the Federal Center for Technological Education of Minas Gerais (CEFET-MG). Doctoral Student in Administration at the Federal University of Minas Gerais (UFMG). Address: Presidente Antônio Carlos Avenue, 6627 - Room 4012 - Pampulha - CEP: 31270-901 - Belo Horizonte - MG, Brazil. Phone: +55 31 3409-7050. Identifiers (ID):
ORCID: https://orcid.org/0000-0001-6969-6972
Lattes: http://lattes.cnpq.br/6348617569538272.
Email: joaoribeiro.cco@gmail.com

Laíse Ferraz Correia
PhD in Administration from the Federal University of Minas Gerais (UFMG), Professor of the Postgraduate Program in Administration (PPGA) at the Federal Center for Technological Education of Minas Gerais (CEFET-MG). Address: Amazonas Avenue, 5253 - Nova Suíça - CEP 30421-169 - Belo Horizonte - MG, Brazil. Phone: +55 (31) 3319-7022. Identifiers (ID):
ORCID: https://orcid.org/0000-0002-0977-9298
Lattes: http://lattes.cnpq.br/3555901127891549
Email: laiseferraz@gmail.com

Abstract

Purpose: This study aimed to analyze whether the introduction of market makers as specialized intermediaries in the trading of stocks listed on the Brazilian stock exchange is a useful procedure for increasing the market liquidity of these assets.

Methodology: The Chow structural break test was performed in the time series of the liquidity proxies, average spread, turnover ratio, and financial volume on a sample of 55 stocks. We chose to consider data in the window of 260 days before and after the start of the market maker's activity, because it represents the approximate number of trading sessions in a year, and to avoid erroneous conclusions due to the volatility of the Brazilian stock market.

Results: The results showed with a 99% confidence level that after the introduction of market makers, (i) 67% of the stocks analyzed had abrupt and statistically significant changes in the average spread; (ii) 47% in the turnover ratio; and (iii) 60% had changes in the volume transactions. At the confidence level of 95%, (i) 76% of the stocks analyzed showed abrupt changes in the average spread; (ii) 65% had changes in turnover; (iii) and 69% had changes in the trading volume. Using a lower confidence level of 90%, the results revealed 85% of the stocks had abrupt and statistically significant changes in the average spread, 78% in the turnover ratio, and 73% in the trading volume.

Contributions of the Study: This paper provides strong evidence on the performance of market makers and the influence they have on the market liquidity of stocks traded on the Brazilian stock exchange. We found that contracting market makers increase market liquidity and contribute significantly to the assets' transactions.

Keywords: Market Makers, Market Liquidity, Capital Markets.

Resumen

Objetivo: El objetivo de este estudio fue analizar si la introducción de formadores de mercado en la negociación de acciones listadas en la bolsa de valores brasileña es una medida válida para incrementar la liquidez de mercado de estos activos.

Metodología: La prueba de estabilidad estructural de Chow se realizó en la serie temporal de las proxies de liquidez, spread medio, turnover y volumen financiero en una muestra de 55 activos. Consideramos datos con una ventana de 260 días antes y después del inicio de la actividad de los formadores de mercado, porque representa el número aproximado de sesiones de negociación en un año y también para evitar conclusiones erróneas debido a la volatilidad del mercado brasileño.

Resultados: Los resultados apuntan que después de la introducción de los formadores de mercado (i) 67% de los activos analizados tuvieron cambios abruptos y estadísticamente significativos en el spread medio, (ii) 47% tuvieran cambios abruptos en el turnover y (iii) 60% tuvieron cambios en el volumen de negociación con un nivel de confianza de 99%. Al reducir el nivel de confianza al 95%, 76% de los activos analizados mostraron cambios abruptos en el spread medio, 65% tuvieron cambios en el turnover y 69% en el volumen de operaciones. Con un nivel de confianza del 90%, los resultados encontrados fueron 85% de los activos con

cambios abruptos en el spread medio, 78% con cambios en el turnover y 73% con cambios abruptos y estadísticamente significativos en el volumen negociado.

Contribuciones del Estudio: Este articulo proporciona una fuerte evidencia sobre el desempeño de los formadores de mercado y su influencia en la liquidez de mercado de los activos negociados en la bolsa brasileña, al demostrar que su contratación puede incrementar la liquidez y contribuir significativamente con negociaciones de activos.

Palabras clave: Formadores de mercado, Liquidez de mercado, Mercados de capitales.

Resumo

Objetivo: Este estudo teve por objetivo analisar se a introdução de *market makers* nas negociações das ações de empresas brasileiras listadas na bolsa de valores brasileira, é uma medida válida para a elevação da liquidez de mercado desses ativos.

Metodologia: Foi realizado o teste de quebra estrutural de Chow nas séries temporais das *proxies* de liquidez *spread* médio, índice *turnover* e volume financeiro, em uma amostra de 55 ativos. Optou-se por considerar dados na janela de 260 dias antes e após o início da atuação do *market maker*, por representar o número aproximado de pregões em um ano, e para evitar conclusões errôneas devido à volatilidade do mercado brasileiro.

Resultados: Os resultados evidenciaram que após a introdução dos *market makers,* e considerado um nível de confiança de 99%, 67% dos ativos estudados tiveram mudanças abruptas e estatisticamente significativas no s*pread* médio, 47% apresentaram mudanças abruptas no *turnover* e 60% tiveram mudanças no volume de negociação. Flexibilizando o nível de confiança para 95%, 76% dos ativos estudados apresentaram mudanças abruptas no s*pread* médio, 65% tiveram mudanças no índice *turnover* e 69% apresentaram mudanças no volume de negociações. Ao nível de confiança de 90%, os resultados encontrados foram de 85% dos ativos apresentando mudanças abruptas no s*pread* médio, 78% apresentando mudanças no *turnover* e 73% apresentando mudanças abruptas e estatisticamente significativas no volume negociado.

Contribuições do Estudo: Este artigo fornece fortes evidências sobre a atuação dos *market makers* e a influência que esses agentes exercem na liquidez de mercado dos ativos negociados pela bolsa de valores brasileira, ao demostrar que, a sua contratação pode aumentar a liquidez e contribuir de forma significativa com as negociações dos ativos.

Palavras-chave: *Market Makers,* Liquidez de Mercado, Mercado de Capitais.

1 Introduction

Defined as the ease of trading an asset, without major discounts and costs for trading, market liquidity is an important risk factor in the stock market (Amihud & Mendelson, 1991; Black, 1971; Liu, 2006). Amihud and Mendelson (1986) argue that low liquidity stocks represent a greater risk for the investor, given the difficulty of trading these assets without a discount in their value. These authors make two propositions about the impact of liquidity on the investors' decision making: the first proposition refers to the clientele effect, in which stocks

with less liquidity are allocated to portfolios with longer expected holding periods; the second proposition defines that, in equilibrium, the return of the stock is a concave and growing function of its spread, which is a measure of illiquidity.

Recent studies that analyze liquidity and asset pricing indicate that market liquidity is an important factor to be considered by investors. Perobelli, Fama and Sacramento (2016), in opposition to that of Amihud and Mendelson (1986), show a positive and significant relationship between liquidity and return on assets. Ganz, Ames and Jacintho (2019) and Carvalho, Ribeiro, Amaral, Pinheiro and Correia (2020) also indicate to liquidity as another relevant factor related to the stock returns.

In the light of these findings, market liquidity affects both investors, who require higher returns for less liquid stocks, and managers, since investors' reactions affect the expected return and, as a result, the companies' cost of capital (Amihud & Mendelson, 2008). Therefore, strategies designed to increase the liquidity of stocks positively influence investors, with the reduction of transaction costs, and companies, with the reduction of their cost of capital. The figure of the market maker appears in the context of the benefits associated with higher stock liquidity in financial markets. The market maker, as described by Ambrozini, Gaio, Bonacim and Cicconi, (2009), is expected to increase liquidity, attract new investors, and increase the stockholder base of stocks in which he operates.

Several markets, such as NYSE, NASDAQ, and Euronext, use market makers in their trading structures (Ribeiro, Souza, Carvalho & Amaral, 2019). In Brazil, this use was regulated in 2003, with CVM Instruction 384, of 03/17/2003. As Perlin (2013) points out, the use of this mechanism is a competitive strategy for the Brasil, Bolsa, Balcão (B3) and for the listed firms, since the stock market liquidity can be increased. According to the rules established by B3, the main duty of the market maker is to maintain a regular and continuous flow of orders during the trading session. The consequence is the easiness of transactions and the reduction of artificial movements in stock prices. Namely, the market maker is expected to contribute to the efficiency of the market in which he operates.

According to Perlin (2013), the way a market maker operates differs from that of an ordinary investor, given that his interest is not in financial speculation or portfolio immunization, but in the compensation received in the form of the spread for providing liquidity to the market. He points out that the spread will be higher for assets with less price volatility, given the higher inventory risk that market makers bear in holding these assets in their portfolios.

The contract for market makers to perform on B3 establishes some activity parameters, such as the minimum trading quantity, percentage of activity during the trading session and the liquidity-providing agent's activity time for the asset in question. In addition, the market maker maximum spread in the transactions he made is established. Such parameters are determined according to the characteristics of the asset and the dynamics of the market (Ribeiro et al., 2019). In accordance with Art. 6 of CVM Instruction 384, the activity of this agent in the market must take place on an equal basis with other investors, that is, his decisions are supported only by public information available in the time.

Given the relevance of market liquidity and the consequent interest of companies in raising the liquidity of their stocks, the following research question emerges: **the introduction of market makers increases the market liquidity of stocks listed on the Brazilian stock market?** To answer this question, this paper aimed to analyze whether the introduction of market makers in the trading of Brazilian stocks listed on B3 is a valid procedure for increasing the market liquidity of these assets. Achieving this goal would generate valuable results to

investors, managers, and market regulators, insofar as it points out the validity of one of the possible strategies to increase the market liquidity of a specific asset.

2 Literature Revision

Black (1971) defines the market liquidity of a stock as the facility in trading it, in a short period of time, at a price similar to the one that would be obtained if the investor had chosen to wait to sell it. Amihud and Mendelson (1991) state that illiquidity is reflected in a higher transaction cost for the investor (brokerage costs, taxes and fees paid for trading on the stock), which would then demand a higher return to trade less liquid stocks.

In this perspective, Amihud and Mendelson (1991) separate the illiquidity costs into different dimensions, namely: (i) bid-ask spread - difference between the lowest sell price and the highest buy price of an asset; (ii) market impact costs - costs incurred in trading large quantities of an asset; (iii) search and delay costs - costs incurred by an investor who decides to wait to have better trading terms to execute an order and; (iv) direct transaction costs - include aspects such as brokerage commissions, exchanges' fees and transaction taxes.

In a pioneering study on the liquidity effect, Amihud and Mendelson (1986) found a concave and growing relationship between stock returns and illiquidity. In addition, they highlighted the presence of a clientele effect, in which stocks with less market liquidity are better suited to the portfolio of investors with long-term expectations, since in this case there is a longer time for the amortization of transaction costs.

Besides, Amihud and Mendelson (2008) highlighted that the stock liquidity also affects the capital structure of companies, given that, the smaller the liquidity of stocks and bonds traded by a company, the higher the rate of return required by investors, what consequently results in a higher cost of capital. For these authors, financial management policies that increase the stocks liquidity are then beneficial for the companies. However, these strategies generate costs for the companies, requiring a balance between their benefits and costs, at an optimum point of liquidity. In this context, several studies such as the ones by Ambrozini et al. (2009), Lipson and Mortal (2009), Nadarajah, Ali, Liu and Huang (2018) and Ribeiro et al. (2019) were conducted to verify the relationship between liquidity and other firm-characteristic variables, as well as to test the effects of policies carried out to increase the market liquidity of stocks.

Lipson and Mortal (2009) analyzed the effects of stock liquidity on firms' capital structure and found that firms with higher market liquidity have a lower level of leverage. This is due to the lower return required by investors when allocating their resources in stocks with higher liquidity, which culminates in a preference for equity financing. In line with Lipson and Mortal (2009), Nadarajah et al. (2018) also found a negative relationship between stock liquidity and firms' leverage. For these authors, the decrease in leverage is due to a higher level of corporate governance, an effect that exists only in firms with high-liquidity stocks.

The relationship between market liquidity and return has also been widely analyzed in financial literature. Among the studies carried out in this field, we call attention to the heterogeneity in the results, especially those conducted in the emerging markets context. For instance, Jun, Marathe and Shawky (2003) and Correia, Amaral and Bressan (2008) found a positive relationship between stock liquidity and return, whereas Machado and Medeiros (2011) and Amihud, Hameed, Kang and Zhang (2015) found a negative relationship between these variables.

Given the relevance of stock liquidity for firms and investors, several studies have specifically explored the effects of using a market maker to make transactions. This agent operates in the market buying and selling stocks to attract more investors and to increase the

stockholder base for firms. In high frequency markets, the market maker seeks to obtain small gains, that expands as the transactions increase in number of orders. According to Ambrozini et al. (2009) this activity can provide a direct increase in liquidity.

Venkataraman and Waisburd (2007) observed that the French stock market reacts positively to the announcement of the use of market makers in the negotiations, with a positive and significant variation in liquidity and return right after the announcement of this mechanism. In the same vein, Perotti and Rindi (2010) examined the effect of the introduction of market makers on stocks of the Italian Stock Exchange. They concluded that the entry of these liquidity providers increased the number of trades and decreased spreads and price volatility.

Anand, Tanggaard and Weaver (2009) analyzed several dimensions of the impact of the introduction of liquidity-providers by firms listed on the Stockholm Stock Exchange, in the period between September 2002 and March 2004. The authors point out that firms with higher spreads, less market activity and higher asymmetric information are more likely to hire a market maker. Analyzing the impacts of the introduction of a market maker, Anand et al. (2009) showed that, when considering a window of 5 days before the announcement of the hiring of a liquidity provider, and 10 days after the date of that event, at the end of the period there is an accumulated abnormal return of 7.08% significant at 1% level. In regard of the impacts on liquidity, these authors point out to a reduction in the stock spread, with benefits even greater in days of higher volatility in the market. Finally, the authors highlighted the gains from the reduction of firms' cost of capital after the introduction of market makers.

Menkveld and Wang (2013) investigated the impacts that hiring a market maker causes on small-caps traded in the Amsterdam stock market. These authors found a statistically significant reduction in spreads of firms that hired a market maker. Menkveld and Wang (2013) used the Liquidity-adjusted Capital Asset Pricing Model (LCAPM) proposed by Acharya and Pedersen (2005) to measure the liquidity risk. As a result, they found a reduction in the three liquidity betas after the event for firms hiring market makers in relation to the ones obtained for non-hiring firms. Finally, these authors showed that there are abnormal returns in firms that use market makers, which can be explained by the level of liquidity and the liquidity risk of these firms.

Ambrozini et al. (2009) carried out a study in the Brazilian stock market to verify if there is empirical evidence that the activity of a market maker is capable of increasing the liquidity of the stocks. In doing so, to estimate the univariate time series models, these authors used daily closing volume data of 61 stocks with market makers from 2000 to 2007. Further, the Chow test was used to check if there were structural breaks in the models' estimated parameters, after the introduction of the market maker. These authors found structural breaks for firms in the sample: (i) 28 firms at the significance level of 5 %; and (ii) 32 firms at the significance level of 10%. Ambrozini's et al. (2009) results showed that, even though there is not a large prevalence of structural breaks in the sample, hiring a market maker can be a valid strategy for increasing the liquidity of the stocks traded on B3.

As well as Ambrozini et al. (2009), Costa and Salles (2010) used time series models to analyze the influence of the introduction of market makers on the liquidity of stocks traded on B3. In doing so, these authors selected a sample of 10 stocks with trades from January to May 2009. To estimate liquidity, they run heteroscedastic volatility models – i.e., time series regressions. The results showed that the benefits of hiring market makers were valid only for part of the analyzed assets, and their benefits were not extended in the same way in all firms in the sample.

Sanvitto (2011) examined the results of the activity of market makers in the stocks of Brazilian firms that had chosen to hire this service from 2003. The results showed that the

introduction of market makers increased the liquidity of the stocks and positively affected the market value of the firms. In line with these studies, Silva (2012) analyzed firms traded on B3 that had hired market makers to identify whether the stocks of these firms had a significant increase in number of trades, in traded volume and, consequently, in their market liquidity. This author found positive differences in all the analyzed variables after the hiring of market makers, mainly in the number of trades and the volume. He demonstrated that the activity of market makers increased the liquidity of the analyzed stocks.

Perlin (2013) studied the impact of the introduction of a market maker in the trading of stocks of Brazilian firms. This author used high frequency data on asset prices and volumes to conduct an event study in the 4 months before and after the introduction of the market maker. He analyzed the behavior of the variables number of trades, average volume, autocorrelation of the transaction signals, autocorrelation of the difference in prices and PIN (probability of occurrence of information-based transactions), proposed by Easley, Kiefer, O'Hara and Paperman (1996). As a result, Perlin (2013) highlights that the number of daily transactions with the asset increased by an average of 31% after the entry of the market maker. In the regard of the average volume per transaction, there was a downward trend of 6%, approximately. He justifies this result as a strategy of the market maker to reduce the volume of stocks in his possession and, thus, avoid major changes in his portfolio composition and manage more easily the flow of market orders.

Rogers and Mamede (2014) conducted two events studies with data from 66 firms that hired market makers from January 2013 to December 2014. The first event considered the date of disclosure of the hiring of market makers, and the second considered the starting date of their activity. The results showed that between 15 days before and after the market maker entry, there were positive abnormal returns. As the authors argue, these results give support to the discussion of the pricing of liquidity.

In a recent study, Ribeiro et al. (2019) analyzed the effect of the introduction of market makers on the liquidity of Brazilian Depositary Receipts (BDRs), in the period between 2010 and 2017. They estimated an AR (1) time series model for each of the liquidity proxies and used the Chow test to check the stability of the parameters of the model. Ribeiro's et al. (2019) results revealed that at the 95% confidence level: (i) 32 BDRs (76%) had changes in the bid-ask-spread; (ii) 29 BDRs (69%) had changes in the number of trades; and (iii) 29 BDRs (69 %) had statistically significant changes in volume. The results documented by Ribeiro et al. (2019) provided strong evidence on the influence of market makers on the market liquidity of BDRs, suggesting that the hiring of market makers can increase the liquidity of these assets.

Altogether, these studies converge to a common result: the introduction of market makers in the negotiations seems to increase the liquidity of the stocks. For this reason, it is expected in this study, to find results similar to those found in Ambrozini et al. (2009), Silva (2012), Perlin (2013), Rogers and Mamede (2014), Ribeiro et al. (2019), among others, in the Brazilian stocks traded on B3. Given these points, the hypothesis tested in this work is the following:

H1: The introduction of market makers in the trading of Brazilian stocks listed on B3 is a mechanism capable of increasing their market liquidity.

3 Methodological Procedures

3.1 Sample and Data

To test the impact of the introduction of market makers in the trading of Brazilian stocks, we carried out a search in the B3 website to find: (i) the assets that used a market maker; and (ii) the starting date of the market maker activity for the asset in question. In doing so, we obtained a total of 255 assets that hired a market maker at some point, from the regulation of their activity by CVM in 2003 (Instruction 384/03) to the date of this search (November 30, 2017). Of these 255 assets, 5 were units (Stock Deposit Certificate), 4 FII (Real Estate Investment Fund), 15 ETF (Exchange Traded Funds), 127 BDR (Brazilian Depositary Receipts) and 104 stocks. The sample of our study was then composed by stocks and units, totaling 109 assets. With the sample in hand, the data necessary for the development of the study were obtained from Bloomberg's financial information terminal.

In this study, we chose to consider data in the window of 260 days before and after the start of the market maker's activity, which is the same window used by Ribeiro et al. (2019). This period consists of the approximate number of trading sessions in year, and therefore provides a sufficiently large sample for the development of the study. In doing so, we sought to avoid erroneous conclusions that could be produced by the Brazilian market volatility.

As data for several assets were unavailable in the estimation window, they were excluded from the study. Thus, our final sample was composed by only 55 assets, including stocks and units. Table 1 shows the assets in our sample, as well as the market maker who was hired and the starting date of his activity.

Table 1
The Study Sample in the period 2003 - 2017

Ticker	Market Maker	Start of Operation	Ticker	Market Maker	Start of Operation
KEPL3	Brasil Plural	2/13/2013	BSEV3	Brasil Plural	6/29/2015
MRFG3	Credit Suisse Brasil	4/11/2013	SMTO3	BTG PACTUAL	7/2/2015
CLSC4	Brasil Plural	4/19/2013	FLRY3	Credit Suisse Brasil	7/27/2015
TOTS3	BTG PACTUAL	6/10/2013	TUPY3	BTG PACTUAL	8/3/2015
WEGE3	Itaúvest	7/15/2013	JBSS3	Credit Suisse Brasil	8/17/2015
TRPL4	Credit Suisse Brasil	7/18/2013	EVEN3	BTG PACTUAL	9/17/2015
PFRM3	Brasil Plural	8/1/2013	LEVE3	Brasil Plural	10/19/2015
BRSR6	Brasil Plural	9/17/2013	SUZB5	BTG PACTUAL	11/9/2015
DTEX3	Brasil Plural	11/13/2013	SANB11	Brasil Plural	12/9/2015
LOGN3	Credit Suisse Brasil	11/18/2013	BGIP3	Brasil Plural	2/29/2016
GSHP3	Bradesco	12/26/2013	BGIP4	Brasil Plural	2/29/2016
RANI3	Brasil Plural	1/8/2014	VIVT3	Credit Suisse Brasil	3/14/2016
RANI4	Brasil Plural	1/8/2014	VIVT4	Credit Suisse Brasil	3/14/2016
MILS3	BTG PACTUAL	2/3/2014	CARD3	Credit Suisse Brasil	5/9/2016
GPCP3	Brasil Plural	2/24/2014	VVAR11	Credit Suisse Brasil	6/1/2016
HBOR3	Bradesco	3/18/2014	MYPK3	BTG PACTUAL	7/11/2016
VLID3	BTG PACTUAL	4/3/2014	CYRE3	BTG PACTUAL	7/14/2016
MGLU3	Credit Suisse Brasil	5/19/2014	ECOR3	BTG PACTUAL	7/14/2016

OIBR3	BTG PACTUAL	7/28/2014	EGIE3	Itaúvest	7/21/2016
OIBR4	BTG PACTUAL	7/28/2014	BRPR3	Credit Suisse Brasil	9/6/2016
ROMI3	BTG PACTUAL	9/17/2014	RENT3	Credit Suisse Brasil	11/18/2016
LIGT3	Credit Suisse Brasil	9/24/2014	MDIA3	BTG PACTUAL	1/5/2017
BRKM5	Credit Suisse Brasil	9/29/2014	MRVE3	Itaúvest	1/9/2017
SGPS3	Brasil Plural	11/24/2014	TIET11	Credit Suisse Brasil	5/29/2017
RNEW11	BTG PACTUAL	1/16/2015	ELPL4	Credit Suisse Brasil	6/5/2017
ABEV3	OPTIVER VOF	2/5/2015	PSSA3	Credit Suisse Brasil	6/12/2017
DIRR3	BTG PACTUAL	3/16/2015	RADL3	Itaú Unibanco S.A.	6/19/2017
PMAM3	Brasil Plural	6/8/2015			

Source: *Own elaboration.*

Given the multidimensional nature of liquidity, we considered three proxies for it in the development of this study:

(i) average spread, measured by Bloomberg as the average of the spreads for a stock over the last 5 trading days. This is a measure that captures the dimension of the bid-ask spread highlighted by Amihud and Mendelson (1991). A similar proxy was used by Anand et al. (2009), Menkveld and Wang (2013) and Ribeiro et al. (2019) in their studies;

(ii) turnover ratio, the number of stocks traded in one day divided by the total number of outstanding stocks. This is a measure focused on the number of trades for the asset carried out in a day. Therefore, as mentioned by Amihud and Mendelson (1991), it can be considered a proxy for the dimension of market impact costs, since the greater the stock turnover ratio, the greater its capacity to absorb large orders without impacting traded prices. This measure is also present in the analyzes of Correia et al. (2008) and Machado and Medeiros (2011);

(iii) traded financial volume, which is a measure that emphasizes the dimension of market impact costs. Ambrozini et al. (2009) and Ribeiro et al. (2019) are some of the authors who have used this proxy to measure liquidity.

3.2 Data Analysis

With data in hands, the Chow test was used to verify whether there was a structural break in the models that describe the liquidity behavior of each of the analyzed assets. Chow (1960) proposes a methodology to test whether there is a statistically significant difference between the parameters of linear regression models estimated for different sample periods. As a result, this is a test that requires the determination of the structural break dates. In this study, it is the entry date of the market maker, i. e., the starting date of his activity.

As proposed by Chow (1960), it is necessary to estimate 3 models to calculate the test statistics: (i) in the first model, the entire sample period is considered; (ii) in the second model, only data prior to the starting date of the market maker's activity are considered; and (iii) in the third model, only the data after the starting date of the market maker's activity in the asset of interest is considered.

In conducting of this study, we used univariate time series models, given that the impact of the introduction of the market maker on each of the variables proposed in the research will be analyzed in isolation. In this way, first-order autoregressive models – AR (1) – were estimated, with a structure similar to that described by Equation 1 (Wooldridge, 2011).

$$Y_t = \alpha + \beta_1 Y_{t-1} + u_t \quad (1)$$

Where: Y_t is the explanatory variable of interest; Y_{t-1} is are the values of that same variable lagged in a period; α represents the intercept of the model; β_1 is the slope coefficient of this model; and u_t is a random error, normally distributed with zero mean and standard deviation σ.

The estimated results will provide the necessary information to calculate the test statistic, which requires the values of the residuals sum of squares (RSS) of each model, the number of models parameters (k), the models' sample size before the market maker activity (n1), and the models' sample size after the introduction of the market maker for the asset (n2). Then, the F statistic was calculated as described in Equation 2 (Wooldridge, 2011).

$$F_{(k,\ n_{1+n_2-2\times k})} = \frac{(S_c - (S_1 + S_2))/k}{(S_1 + S_2)/(n_{1+}n_2 - 2 \times k)} \quad (2)$$

Where, in addition to n1, n2 and k, which have already been discussed previously, there is: Sc, which is the SQR of the model with the complete sample period; S1 which is the SQR of the second model; and S2, which is the SQR of the third model, previously described.

The models and the test statistics of this study were estimated via python. To reduce the probability of type 1 and type 2 errors, and to measure the sensitivity of the results to the level of significance used for the test (Ambrozini et al. 2009), we perform the Chow tests at three different levels of statistical significance (1%, 5% and 10%).

The Chow test has the following null hypothesis (H0): The parameters of the models before and after the introduction of the market maker are the same, that is, there are no structural breaks. If the null hypothesis is rejected, it means that hiring a market maker influenced the analyzed proxies (average spread, volume, and turnover), what results in changes in the liquidity of the stocks.

4 Results and Analysis

Table 2 shows the p-values from the Chow test for the 55 stocks and the three liquidity proxies used in this study. At the significance level of 10%, it was not possible to reject null hypothesis in the analysis of the stocks BRSR6, DTEX3, HBOR3, ROMI3, LIGT3, ABEV3, SUZB5 and ECOR3. That is, in only 8 of the 55 assets analyzed there did not seem to have been an abrupt change in the market liquidity, when measured by the average spread. The Chow test p-value for the turnover ratio shows no abrupt structural changes in the parameters of the stocks MRFG3, WEGE3, BRSR6, LOGN3, VLID3, LIGT3, ABEV3, DIRR3, SUZB5, BGIP4, ECOR3 and TIET11. That is, in 12 out of 55 stocks analyzed, it was not possible to reject the null hypothesis, indicating that the hiring of market makers does not seem to have had an impact on the liquidity of these assets (measured by the proxy turnover).

The Chow's structural break test was performed for another proxy of market liquidity, the trading volume, as well as for the average spread and the turnover ratio. At the significance level of 10%, from the p-value results, it was not possible to reject null hypothesis for the stocks WEGE3, BRSR6, LOGN3, MILS3, ROMI3, BRKM5, SGPS3, RNEW11, SUZB5, BGIP4, VIVT3, VIVT4, CYRE3, EGIE3 and TIET11. These results are in line with those of Rogers and Mamede (2014), who found an increase in the stock liquidity of firms that hired market makers in the period from January 2013 to December 2014.

The results revealed that the average spread had the greatest impact with the introduction of market makers, followed by turnover and lastly, the volume of negotiations. Despite this divergence between the liquidity proxies analyzed, hiring a market maker proved to be a good alternative for firms that wish to increase the liquidity of their stocks. Our results are in line with those found by Perlin (2013) for the Brazilian capital market, and they are superior to those found by Ambrozini et al. (2009), since these authors found evidence of an increase in liquidity in only 52% of the stocks at a significance level of 10%.

Table 2
P-value of the Chow structural break tests

Ticker	*Average Spread*	*Turnover*	Volume	*Ticker*	*Average Spread*	*Turnover*	Volume
KEPL3	0.0000	0.0002	0.0000	BSEV3	0.0000	0.0204	0.0336
MRFG3	0.0000	0.1288	0.0000	SMTO3	0.0591	0.0000	0.0000
CLSC4	0.0000	0.0398	0.0002	FLRY3	0.0000	0.0000	0.0000
TOTS3	0.0000	0.0006	0.0056	TUPY3	0.0001	0.0000	0.0000
WEGE3	0.0000	0.7246	0.9581	JBSS3	0.0003	0.0000	0.0003
TRPL4	0.0000	0.0619	0.0013	EVEN3	0.0017	0.0000	0.0000
PFRM3	0.0000	0.0000	0.0000	LEVE3	0.0000	0.0000	0.0000
BRSR6	0.5718	0.1503	0.4546	SUZB5	0.8691	0.5129	0.4109
DTEX3	0.3182	0.0857	0.0001	SANB11	0.0000	0.0001	0.0000
LOGN3	0.0000	0.1081	0.2094	BGIP3	0.0118	0.0000	0.0000
GSHP3	0.0805	0.0267	0.0009	BGIP4	0.0000	0.1876	0.4208
RANI3	0.0191	0.0000	0.0041	VIVT3	0.0000	0.0591	0.2265
RANI4	0.0000	0.0000	0.0009	VIVT4	0.0000	0.0302	0.3826
MILS3	0.0001	0.0005	0.2100	CARD3	0.0000	0.0000	0.0197
GPCP3	0.0000	0.0000	0.0000	VVAR11	0.0232	0.0005	0.0000
HBOR3	0.1154	0.0000	0.0156	MYPK3	0.0222	0.0005	0.0000
VLID3	0.0985	0.1279	0.0000	CYRE3	0.0723	0.0760	0.2473
MGLU3	0.0000	0.0058	0.0008	ECOR3	0.3225	0.7898	0.0000
OIBR3	0.0000	0.0209	0.0608	EGIE3	0.0002	0.0164	0.1087
OIBR4	0.0001	0.0001	0.0095	BRPR3	0.0000	0.0706	0.0615
ROMI3	0.1421	0.0254	0.5812	RENT3	0.0061	0.0009	0.0000
LIGT3	0.6496	0.8947	0.0146	MDIA3	0.0000	0.0231	0.0000
BRKM5	0.0000	0.0031	0.3670	MRVE3	0.0800	0.0045	0.0000
SGPS3	0.0000	0.0212	0.2507	TIET11	0.0000	0.6701	0.9459
RNEW11	0.0000	0.0967	0.7302	ELPL4	0.0000	0.0000	0.0000
ABEV3	0.5765	0.6267	0.0087	PSSA3	0.0000	0.0520	0.0000
DIRR3	0.0005	0.8532	0.0000	RADL3	0.0403	0.0425	0.0467
PMAM3	0.0001	0.0009	0.0067				

Source: *Research data.*

In the final analysis, the results presented in Table 2 are summarized in Tables 3, 4 and 5. These tables show the percentage of assets that rejected the null hypothesis for the levels of significance of 1%, 5% and 10% for all the liquidity proxies. That is, the results in these tables show the number and the percentage of assets, among the 55 assets analyzed, that showed an increase in liquidity after the market makers started to operate.

In Table 3, it can be seen that market makers activity seems to decrease the average spread of the assets in the sample. The results suggest an increase in the liquidity of 37 of the analyzed assets (67%) at the 1% significance level. There was also an increase in the liquidity of 42 (76%) and 47 (85%) of the analyzed assets at the level of significance of 5% and 10%, respectively. In the analysis of the time series of the average spread, it was noticed that market makers seem to contribute to promoting the liquidity of the stocks listed on B3. The increase in liquidity associated with the introduction of a market maker suggests that his hiring may be interesting for the trading of assets, since only in 15% of the analyzed assets (at the 10% significance level) there seems not to have a decrease in the average spread, that is, an increase in the stock liquidity.

Table 3
The Percentage of Assets with Structural Break in the Average Spread

	1%	5%	10%
There is structural break	37 (67%)	42 (76%)	47 (85%)
There is no structural break	18 (33%)	13 (24%)	8 (15%)
Total	55 (100%)	55 (100%)	55 (100%)

Source: *Research data.*

Table 4 presents evidence that the market makers activity in trading assets increases the turnover ratio of these assets. The results of the tests suggest an increase in liquidity in 26 (47%) of the analyzed assets, at a significance level of 1%. Raising the level of significance to 5% and 10%, the increase in the turnover ratio can be seen in 36 (65%) and 43 (78%) of the analyzed assets, respectively. Comparing these results with those from the proxy analyzed earlier, it is noted that the hiring of market makers may have decreased the average spread of more assets than it increased the turnover ratio. At the 10% significance level, for example, it is noted that 85% of the analyzed assets had a decrease in the average spread, and thus showing an increase in stock liquidity. On the other hand, in 78% of the analyzed assets, there was an increase in the turnover ratio. It is also worth to note that some assets that did not had changes in the average spread, did had in the turnover ratio.

Table 4
The Percentage of Assets with Structural Break in the Turnover Ratio

	1%	5%	10%
There is structural break	26 (47%)	36 (65%)	43 (78%)
There is no structural break	29 (53%)	19 (35%)	12 (22%)
Total	55 (100%)	55 (100%)	55 (100%)

Source: *Research data.*

The results shown in Table 5 show that the market makers activity in the trading of stocks seems to increase the trading volume of these assets. The results of the tests suggest an increase in the liquidity of 33 of the analyzed assets (60%), at the 1% significance level. Raising the significance level to 5% and 10%, there is an increase in the liquidity of 38 (69%) and 40 (73%) of the analyzed assets, respectively. This result is in line with those found in Perlin (2013) and Ribeiro et al. (2019). Even though this result is below the ones we found for the average spread and the turnover ratio, it exceeds the result of Ambrozini's et al. (2009), who found

evidence of an increase in liquidity for only 52% of the Brazilian stocks analyzed, at a significance level of 10%.

Table 5
The Percentage of Assets with Structural Break in the in Trading Volume

	1%	5%	10%
There is structural break	33 (60%)	38 (69%)	40 (73%)
There is no structural break	22 (40%)	17 (31%)	15 (27%)
Total	55 (100%)	55 (100%)	55 (100%)

Source: *Research data.*

The results indicate that the benefits of the introduction of market makers to promote stock market liquidity were valid for most of the analyzed assets, despite the different impact for each proxy studied. The results exceed those found in Ambrozini et al. (2009) and Costa and Salles (2010). They are also in line with those documented in the studies carried out by Sanvitto (2011), Silva (2012), Rogers and Mamede (2014) and Ribeiro et al. (2019), as it shows that the activity of market makers provided liquidity and positively affect firms that used this liquidity provider mechanism. Thus, the research hypothesis of this work was corroborated.

5 Concluding remarks

Market liquidity is an extremely important factor for investors' decision-making when forming portfolios in the stock market. In view of this, the purpose of this study was to analyze whether the introduction of market makers in the trading of the Brazilian stocks listed on B3 is a valid mechanism to increase the market liquidity of these assets. To carry out this objective, the structural break test proposed by Chow (1960) was applied to the 55 assets that composed the study sample. The purpose of the Chow test was to assess whether there were abrupt changes in the time series of the liquidity proxies, average spread, turnover ratio, and trading volume, after the introduction of market makers in the negotiations of the asset in the sample.

Based on the analysis of the p-value of each test, it could be seen that the use of market makers in the negotiations leaded to abrupt changes in the three liquidity proxies in most of the analyzed assets. The Chow test results indicated at the 99% confidence level that, after the introduction of market makers, 37, that is, 67% of the analyzed assets, had abrupt and statistically significant changes in the average spread, 26 (47%) had abrupt changes in the turnover ratio, and 33 (60%) had changes in the trading volume.

At the confidence level of 95%, 42 (76%) had abrupt changes in the average spread, 36 (65%) had changes in the turnover ratio, and 38 (69%) had changes in the trading volume. At the 90% confidence level, the results showed that 47 (85%) assets had abrupt changes in the average spread, 43 (78%) in the turnover ratio, and 40 (73%) had abrupt and statistically significant changes in the trading volume.

As has been noted, the null hypothesis of no abrupt changes in the time series of the liquidity proxies analyzed was rejected for most of the assets in the sample. Therefore, our findings provide strong evidence on the role of market makers as liquidity-providers for the assets traded on B3. Our results show that the hiring of market makers can increase liquidity and contribute significantly to increase assets trading, and thus enables the transactions by investors. Overall, the evidence documented in this paper corroborates the findings of other studies, such as Ambrozini et al. (2009), Costa and Salles (2010), Sanvitto (2011), Silva (2012), Perlin (2013), Rogers and Mamede (2014) and Ribeiro et al. (2019).

The emphasis only on the structural breaks in liquidity proxies after the introduction of a market maker, without testing the impact of such event on the assets price, is a limitation of this study. Despite the limitation, the results are in line with the research objective and contribute to the study of how market makers affect the stock liquidity. It is suggested for the future studies, an evaluation of how the activity of market makers affects the assets' return and risk.

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