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Research Paper

Reverse stock splits effects on the liquidity of European stocks

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ABSTRACT

Purpose: It is common that firms listed at undesirably low prices perform reverse stock splits to increase prices while decreasing the number of shares outstanding. In addition to these impacts, it is important to understand whether this operation has any side effects on the liquidity, as this is a fundamental element for the proper functioning of the financial markets. Therefore, our main goal is to analyze the effect that reverse stock splits have on the liquidity of European stocks.

Methodology: To analyze the effect on the liquidity of the 30 firms, members of the STOXX Europe 600 index, which performed the 35 reverse stock splits identified between January 1, 2015, and December 31, 2019, we use the event study methodology and parametric and non-parametric tests. The analysis is done with a short-term (1 month) and a medium-term (6 months) event windows and to measure liquidity we use the turnover ratio and Liu's (2006) LMx measure.

Findings: In the short-term analysis, reverse stock splits contribute to increasing firms' stock liquidity. In the medium-term analysis, it is not possible to draw a clear conclusion on the effects of reverse stock split on stock liquidity.

Practical implications: The results have important implications for investors wishing to acquire shares in firms on the verge of executing this operation, as it clarifies the behavior of liquidity after the reverse stock split, which may influence their investment decision. They also contribute to helping the boards of directors of listed firms in the decision-making process.

Originality/value: This work contributes to the financial literature on the relationship between reverse stock splits and liquidity, and to a better knowledge of European markets.

Keywords: reverse stock splits, liquidity, Europe.

This research paper is an adapted version of the initial work of Antunes (2022).
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1. Introduction

A reverse stock split is a technical operation which consists in a reduction of the number of shares outstanding with a proportionate increase in stock price, without any changes in the market capitalization of the stock.

As this is an operation that has no effect on the firm's nominal value, it is important to understand the reasons that lead management to suggest it to shareholders. One of these reasons is increasing the stock price, placing it in an attractive price range for investors (Radcliffe & Gillespie, 1979), making the firm lose the connotation of penny stock (D. Peterson & P. Peterson, 1992) and meet the criteria imposed by some exchanges and indices (Martell & Webb, 2008). Other purposes that lead to the suggestion of this operation are the decrease in volatility (Iwatani, 2002), the decrease in the number of shareholders (D. Peterson & P. Peterson, 1992) and the intention of turning the firm into a privately held one (Iwatani, 2002).

Reverse stock splits are not as common as stocks splits, and this also reflects in the literature: much more attention has been given to stock splits than to reverse stock splits. According to West at al. (2020), the market usually reacts positively to the news of a stock split and negatively to the news of a reverse stock split. However, the arguments used to explain the positive reaction to a stock split, cannot be reversed to explain the negative reactions to a reverse split (West at al., 2020), so this operation should also be studied properly to ascertain all its specificities.

Liquidity is not only one of the key factors for the correct functioning of the financial markets, but it also has a profound influence on the stock performance. Financial markets and firms with high liquidity attract more investors, which ends up creating even more liquidity, thus becoming a cycle of great interest to all market participants. That said, it is of special interest for the boards of directors of listed firms to be aware of the tools capable of improving stock marketability, moving them away from the connotation of penny stocks and placing them in a more attractive price range for investors. Reverse stock splits are one such tool. However, the impact of this operation on stock liquidity has not received much attention from researchers and uncertainty still persists with respect to whether liquidity improves or deteriorates after splits (He & Wang, 2012).

The existing literature on the market reactions to stock splits and reverse stock splits is mainly focused on North American markets, given their relevance in global financial markets. Additionally, there is much more literature on stock splits than on reverse stock splits. More recently, these phenomena began to be studied in some European and emerging equity markets. However, most of the literature on reverse stock splits studies its impacts on stock returns (Hwang et al., 2012; Kolari et al., 2021; Martell & Webb, 2008; Raisová et al., 2016; Zaremba et al., 2019; among others), leaving the effects on stock liquidity as an open question.

Therefore, this study focuses on the relationship between reverse stock splits and stock liquidity and the main goals are to analyze the effect that reverse stock splits have on the liquidity of European stocks, comparing the results obtained with previous empirical evidence, and to contribute to financial literature on European markets, since these end up not receiving as much attention from authors as the American market.

For this, our sample consists of firms that were members of the STOXX Europe 600 index between the period of January 1, 2015, and December 31, 2019. The decision to choose the STOXX Europe 600 index is also taken due to the diversity of firms, industries, and countries that it encompasses, allowing for more robust results.

The measurement of liquidity is something that can be considered a point of divergence among authors since liquidity has several dimensions and different measures are used to measure it. With this in mind, we choose two liquidity measures to capture its multiple dimensions, namely the average daily turnover, to capture the depth dimension, and Liu's (2006) LMx measure, which manages to capture the depth, immediacy, and tightness dimensions. Turnover is one of the most used liquidity measures in the literature related to stock splits or reverse stock splits. However, to our knowledge, Liu's (2006) LMx measure was only used in studies about stock splits (Lin et al., 2009; Seguro et al., 2020), so this is the first study that applies this measure to analyze the effects of reverse stock splits on liquidity.

Additionally, we analyze the effect that reverse stock splits have on stock liquidity using two event windows to have a better perception of the longevity of the effect of this operation. We use a 1-month event window to measure the short-term effect, and a 6-month event window to measure the medium-term effect, which is also a novelty.

This article is divided into five sections. After this introduction, in section 2, we review the extant literature on the topic and present our research hypotheses. Then, in section 3, we describe the sources of information, the selected sample, and the methodology used. In section 4 we present and interpret the results obtained. Finally, in section 5, we conclude.

2. Literature Review and Hypotheses

2.1. Reverse stock splits

A reverse stock split is an event that consists in reducing the number of shares outstanding, making them proportionately more valuable. This operation is carried out using multiples, which indicate the reduction in shares outstanding and the consequent increase in their price. A reverse stock split operation is also known as a stock merger or consolidation.

As already mentioned, a reverse stock split is just a cosmetic operation, having no influence on the face value of the firm, either before or after the event. Despite this, numerous authors look at this operation as a negative sign of the state of the firm. Spudeck and Moyer (1985) state that this operation is a strong signal to the market of the lack of confidence that the firm's management has in a future increase in the value of the shares, resulting from the increase of the firm's results. Woolridge et al. (1983) suggest that investors should, upon learning of the imminence of a reverse stock split, sell their shares, as it has been observed that the share price tends to drop significantly on the day the reverse stock split is proposed, on the day of approval, and on the execution day.

What could lead a firm's management to propose to its shareholders a reverse stock split? What benefits will this operation bring to the firm and its shareholders, if it has no impact on the nominal value? These are questions that several authors have addressed and presented different results, mainly using the NYSE, AMEX, and NASDAQ as samples.

Radcliffe and Gillespie (1979) state that one of the reasons that lead to the execution of this operation is the need to place the stock in a price range that is attractive to investors, contributing to the increase in the trading volume of the stock and reducing the bid-ask spread, thus increasing the stock liquidity.

All shares that are priced below 5 dollars are connoted by the Securities and Exchange Commission (SEC) as penny stocks, a connotation that repels institutional investors, mutual and pension funds, as these types of shares are generally used for day trading[3], given its volatility (D. Peterson & P. Peterson, 1992). The decrease in the stock volatility resulting

[3]Day trading consists of buying and selling assets on the same day to profit from small price fluctuations. It is mostly used in the stock and forex markets.

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from the reverse stock split, thus making it more attractive and eligible according to the above-mentioned investor criteria, was one of the reasons mentioned by Iwatani (2002) for the execution of this operation. In addition to the connotation of penny stock, the minimum share price is one of the determining criteria for a firm to have its shares listed on stock exchanges such as the NYSE, AMEX, or NASDAQ. In this regard, the need to increase the value of the share so that it is in accordance with the criteria of the stock exchanges or indices is also one of the reasons that leads to the execution of a reverse stock split (Martell & Webb, 2008).

The reduction in the number of shareholders resulting from the decrease in the number of shares outstanding is another of the reasons mentioned by D. Peterson and P. Peterson (1992). In their study, they conclude that due to the impossibility of holding fractional shares, minority shareholders might find themselves removed from the firm. These authors also conclude that this operation allows a reduction in shareholders' service costs[4], given the decrease of their number.

Finally, another reason given for carrying out a reverse stock split is the intention of turning the firm into a privately held one. Iwatani (2002) states that aggregating shares using a very high ratio implies that minority shareholders are left with non-whole lots and, after paying to these fractional shareholders the value of their shares, the number of shareholders is reduced below the minimum value required for the firm to continue to be listed on the stock exchange.

2.2. Liquidity

Liquidity is a key factor in defining the price of shares and, in recent decades, it has been the target of special attention in the valuation of financial assets, as well as the object of study of numerous authors. Liquidity is usually defined as the ease at which a large quantity is traded with minimum price impact and with low transaction costs (Liu, 2006; Naik & Reddy, 2021).

This definition makes it possible to understand the multidimensionality of the concept. Kyle (1985) presents three dimensions of market liquidity: market tightness – costs borne by the investor for the execution of a transaction; market depth – availability of a substantially large number of orders in the market so that the price of the asset remains balanced; market

[4]Service costs correspond to fees paid to answer shareholders' questions and provide them with information about their investments.

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resilience – how quickly prices recover from an unexpected event. Grossman and Miller (1988) suggest the addition of a fourth dimension: the market immediacy – the speed with which a market order is executed. In addition to these four dimensions, Bervas (2006) adds a fifth: market breadth – the ability of the market to allow the transaction of a certain number of shares without having a great influence on the price.

Given its multidimensional nature, there is no consensus on how liquidity should be measured. Liquidity has been analyzed using numerous measures, some that analyze the dimensions individually, while other measures attempt to analyze several dimensions of liquidity simultaneously.

One of the first dimensions analyzed in the literature was tightness, using the bid-ask spread as a measure of the transaction costs (Amihud & Mendelson, 1986b). Despite its simplicity, the intraday data necessary to compute this measure are not available for a wide range of markets nor for long periods, which conditions its use (Seguro et al., 2020).

Depth and breadth dimensions are interconnected as both are based on the number of existing orders around the equilibrium price (Díaz & Escribano, 2020). In the analysis of the dimensions above, one of the measures used is the Amihud's (2002) illiquidity measure (ILLIQ). Through the daily absolute stock return divided by the trading volume of the same day, this measure is able to capture price movements related to the trading volume and the orders flow. However, this measure has limitations when used for infrequently traded stocks. If on one day only one transaction is executed at the closing price of the previous session, the ratio will be null and the stock is considered to be liquid when it is not (Seguro et al., 2020).

A measure frequently used as a liquidity proxy is the turnover ratio, given the ease with which the necessary data are obtained and the simplicity of its calculation. This measure only needs the number of shares outstanding, and the number of shares traded, being able to capture the depth dimension. Turnover is used to measure the average holding period of the stock, and the lower its value, the longer the holding period of the stock. Amihud and Mendelson (1986a) state that stocks with a higher spread have a longer holding period. That said, they claim that the turnover ratio is negatively related to the spread and positively related to liquidity. However, Lee and Swaminathan (2000) question the use of the turnover ratio as a measure of liquidity when they find some evidence that it does not present a strong correlation with the bid-ask spread.

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The analysis of the immediacy dimension is performed using liquidity measures related to time, such as the number of transactions per unit of time or the number of orders per unit of time, thus allowing the analysis of the frequency of transactions or orders (Wanzala, 2018). One of the most frequently used measures and which has been subject to constant modifications is the negotiation elasticity coefficient (CET 1), initially introduced by Datar (2000). This measure uses the percentage change in trading volume divided by the percentage change in price. Suresha and Murugan (2014) identify a weakness in Datar's (2000) model, as it only uses the absolute values of changes in prices and trading volumes. Suresha and Murugan (2014) suggest a new model of the negotiation elasticity coefficient (CET 2), which aims to solve this problem. This new model consists of dividing the logarithm of the change in trading volume by the logarithm of the change in price. Wanzala (2018) also presents a new model of the trading elasticity coefficient (CET 3), which is an improvement of the previous model, as the model suggested by Suresha and Murugan (2014) does not include the waiting time between transactions. To fill this gap, the model suggested by Wanzala (2018) incorporates the waiting time estimation model suggested by von Wyss (2004) into CET 2.

The resilience dimension is analyzed with measures capable of capturing the ability of prices to return to their equilibrium level after unexpected events (Díaz & Escribano, 2020). One of the liquidity measures used is the variance ratio (VR). Initially proposed by Hasbrouck and Schwartz (1988), this measure corresponds to the difference in volatility between several days, thus making use of low-frequency data[5]. Later, this measure was adapted by Ranaldo (2001) to use high frequency data[6]. In this new version, the variance ratio corresponds to the difference in volatility between a very short period (10 minutes) and a long period (1 day). The fact that the variance ratio is sensitive to the period under analysis requires that it be constant, otherwise the results may be contrasting, which is one of the limitations pointed out by Wanzala et al. (2018).

Given the interconnection between the various dimensions of liquidity, there are measures that can analyze more than one dimension at the same time. One of these measures results from the model of the proportion of zero returns developed by Lesmond et al. (1999), and it is able to analyze simultaneously the dimensions of tightness and depth. The authors

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[5]Also known as inter-daily data, they consist of data from a certain time series collected on a daily, weekly, monthly, or annual basis, for example.
[6]Also known as intraday data, they consist of data from a given time series collected with an extremely short frequency.

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developed this model under the premise that if the value of the information held by the marginal investor is not enough to cover the transaction costs, he will choose to reduce the size of his investment or not invest at all, thus having zero return. Bekaert et al. (2007), in their study on liquidity and expected returns in emerging markets, show that the proportion of zero returns is correlated with some other liquidity measures, such as the turnover ratio and the bid-ask spread. Another example of a measure capable of analyzing multiple dimensions is the Amihud's (2002) illiquidity measure. This measure is able to analyze the dimensions of depth and breadth and it is among the most used measures of liquidity in the literature. Another liquidity measure that manages to capture several dimensions of liquidity is the measure presented by Liu (2006), which has a special focus on the speed with which transactions are executed. Using the number of days with zero trading volume, the turnover, and the number of trading days in the period under analysis, it is possible to analyze the depth, immediacy, and tightness dimensions with a single measure. (Díaz & Escribano, 2020). This measure has, however, a limitation that lies in the fact that it does not take price variations into account (Chai et al., 2010).

2.3. Reverse stock splits and liquidity

The effect of reverse stock splits on stock liquidity is something that, to date, has not yet received much attention from researchers. However, the reverse operation, stock splits, is much more popular among researchers given the extensive number of existing articles addressing the topic.

As mentioned above, it is expected that, by raising the transaction stock price to more attractive levels, the reverse stock split is an event that attracts the attention of investors, which contributes to increase liquidity, either by increasing the trading volume or by decreasing the bid-ask spread (Radcliffe & Gillespie, 1979). Nevertheless, given the mixed previous empirical evidence, uncertainty persists with respect to the effects of reverse stock splits on liquidity (He &Wang, 2012).

One of the first studies on this topic was carried out by Han (1995), who investigated the effect of reverse stock splits on the liquidity of the shares of firms listed on the American markets, between 1963 and 1990. In this research, he uses as a sample of 61 firms listed in NYSE/AMEX and 75 listed in NASDAQ, and, using a control group made up of firms with the same industry standard classification (SIC), the author analyzes the evolution of stock liquidity 50 days before and after the reverse stock split. As liquidity measures, he uses the bid-ask spread and the trading volume. Han (1995) shows that there is an effective reduction

(35.8%) in the bid-ask spread, and an increase (11.8%) in the trading volume after the reverse stock split, thus concluding that this operation leads to an increase in liquidity.

Wu et al. (2015) also provide evidence consistent with Han (1995). When investigating the effect of reverse stock splits on the stock liquidity of firms of the biotechnology industry listed in the NASDAQ, with an event window of 6 months, Wu et al. (2015) conclude that this event attracts positive attention and leads to an increase in trading, thus contributing to the increase in liquidity.

In order to study the effect of reverse stock splits on the price and liquidity of shares in the Japanese market, Iwatani (2002) identifies 15 firms that conducted this operation, between 1998 and 2002, To measure the effect on liquidity, the author analyzes the trading volume 50 days before and after the event, having observed a 5% increase after the reverse stock split. However, the author warns that, given the small size of the sample and the fact that no control group was used, this increase in the trading volume may not be exclusively due to the reverse stock split, and thus cannot prove the existence of a correlation between the event and the increase in the liquidity.

To the best of our knowledge, Asyngier (2015) and Gamlemoen and Bornstedt (2016) are the only ones that studied the topic with European samples. Asyngier (2015) analyzes the impact of reverse stock splits on liquidity at the Warsaw Stock Exchange. His sample consists of 37 firms that, between 2009 and 2014, carried out a reverse stock split. Using the trading volume, 6 months before and after the event, this author observes a considerable increase in the trading volume. Gamlemoen and Bornstedt (2016) analyze 69 reverse stock splits at the Oslo Stock Exchange in the period from 1996 to 2015. With an event window of 50 days and the relative bid-ask spread as a liquidity measure, the authors find a reduction in the relative bid-ask spread, which suggests an increase in liquidity.

In a study carried out in the Indonesian market, a different result was obtained. Fransika and Purwaningsih (2011) identify 23 firms that performed reverse stock splits between 2001 and 2007. As a measure of liquidity, they use the trading volume during the 5 days before and after the event and conclude that the reverse stock split contributes to decrease stock liquidity. The authors indicate that the negative signal that the reverse stock split operation transmits to investors is the main reason behind the decrease in liquidity, ending up decreasing investors’ attention and, consequently, reducing the trading volume of these stocks. More recently, Nurwulandariet al. (2021) conclude that the Indonesian market do not

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show a significant reaction to reverse stock splits. Using a sample of only 7 reverse stock splits made by Indonesian growing and non-growing energy consuming firms, in the period between 2014 and 2018, and an event window of 5 days, the authors show that there are no significant changes in liquidity, measured by the turnover.

Also, Crutchley and Swidler (2015) find results that suggest that liquidity decreases after reverse stock splits, especially for firms that declare multiple reverse stock splits. These authors study the impact on liquidity of reverse stock splits for public firms in the United States, between 1990 and 2010. They conclude that liquidity decreases in the period of 50 days after the split, as the mean number of non-trading days increases and the mean trading volume, in dollars, decreases. In addition, firms that perform multiple reverse splits tend to have less liquidity than one reverse split firms.

F. Adjei and M. Adjei (2017) analyze 258 reverse stock splits conducted by firms listed in NYSE/AMEX and in NASDAQ between 1995 and 2004, with an event window of 90 days. They find mixed evidence regarding the effects of the reverse splits on liquidity. For the NASDAQ subsample there is a significant increase in the mean dollar trading volume and in the bid-ask spreads. In the NYSE/AMEX subsample no significant changes are observed for mean dollar trading volume, but there is a significant reduction of the spreads. The bid-ask spread decline, hence a liquidity increase, is confirmed for reverse splits with a pre-split price above 2 dollars, which lead the authors to conclude that for this subsample the reverse splits are motivated by a desire to improve liquidity.

From the literature analyzed on the effect of reverse stock splits on stock liquidity, it is possible to observe some mixed evidence. Therefore, the impact on stock liquidity of a reverse stock split is still an open question.

Regarding the effect of stock splits on liquidity, previous empirical evidence is also mixed, both in the short-term and in the medium-term, being reported positive relations (Dennis, 2003; Lin et al., 2009; Rudnicki, 2012; Seguro et al., 2020), negative relations (Desai et al., 1998; Huang et al., 2013; Lamoureux & Poon, 1987; Yagüe & Gómez-Sala, 2005) and non-significant relations (Alves & Alves, 2001; Pecchioli, 2012; Walker, 2021).

That said, it is possible to verify that, in general, both reverse stock splits and stock splits manage to capture the attention of investors, thus contributing to the increase of stock marketability. In a short-term horizon (50 days), Gamlemoen and Bornstedt (2016), Han (1995) and Iwatani (2002) observe an increase in liquidity after the execution of a reverse

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stock split. Dennis (2003) finds an increase in liquidity in small-scale transactions of firms that perform a stock split. In a medium-term horizon (6 months), Asyngier (2015) and Wu et al. (2015) observe an increase in stock liquidity of firms that performed reverse stock splits. In a long-term horizon, Lin et al. (2009), Rudnicki (2012) and Seguro et al. (2020) report an increase in stock liquidity of firms after a stock split.

Continuing this line of thought, we will use in this study two event windows, a short-term (1 month) and a medium-term (6 months) windows, for which we formulate the following research hypotheses:

Hypothesis 1**:** The reverse stock split generates an increase in stock liquidity with a short-term effect.

Hypothesis 2**:** The reverse stock split generates an increase in stock liquidity with an effect in the medium-term.

3. Methodology

3.1. Sample and sources of information

This study's sample consists of firms that belong to the STOXX Europe 600 index, in the period from 01/01/2015 to 12/31/2019.

The STOXX Europe 600, also known as the STOXX 600, is an index developed by STOXX Ltd. This index is derived from the STOXX Europe Total Market Index (TMI) and is a subset of the STOXX Global 1800 Index. Comprising a fixed number of 600 large, medium and small firms, this index represents 90% of the European market capitalization and is updated quarterly. Currently, it comprises firms from 17 countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland and United Kingdom.

The quarterly constitution of the STOXX Europe 600 index between 01/01/2015 and 12/31/2019 was provided by Qontigo. The stock market information of the constituent firms, namely market capitalization, volume, number of shares issued, free-float, and the adjusted price, was collected via the Eikon + Datastream database. To ensure that the necessary data were obtained for the event window of six months before and after the reverse stock split, as well as one month before and after the event, market data were collected from 05/30/2014 to 01/06/2020.

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Since the index STOXX Europe 600 is updated on a quarterly basis, we obtain a total of 833 firms that, during the sample period, were included in the index. The identification of the firms that performed reverse stock splits was a process divided into three steps, following Han (1995) and Seguro et al. (2020). The first step consisted of researching news from each of the 833 firms on the execution of reverse stock splits, thus functioning as a first screening process. The second step consisted of researching and analyzing information made available by firms to investors about reverse stock splits. The third and final step consisted of confirming the operation using the number of shares issued. After completing this process, we identified 30 firms that performed at least one reverse stock split in the period under analysis, and a total of 35 reverse stock splits, since some firms performed more than one reverse stock split.

In Table 1 we present the number of firms that performed reverse stock splits in the sample period, and it is possible to verify that 2015 was the year in which more reverse stock splits were performed, although there are no significant differences between the number of operations performed annually.

Table 1: Reverse stock splits by year

Year	Number of reverse stock splits	Sample percentage
2015	9	25.714%
2016	7	20.000%
2017	8	22.857%
2018	5	14.286%
2019	6	17.143%
Total	**35**	**100%**

Source: Own elaboration

In Table 2 we present the multiplication factors of the reverse stock splits in the sample. Given the diversity of factors observed in the sample, we choose to group the factors into intervals. It is possible to observe that the multiplication factors concentrate on two intervals: [0.815; 0.976], representing 68.571% of the sample, and [0.010; 0.171[, representing 22.857% of the sample.

Table 2: Reverse stock splits by multiplication factor

Multiplication factor	Number of reverse stock splits	Sample percentage
[0.010; 0.171[	8	22.857%
[0.171; 0.332[	1	2.857%
[0.332; 0.493[	1	2.857%
[0.493; 0.654[	1	2.857%
[0.654; 0.815[	0	0.000%
[0.815; 0.976]	24	68.571%
Total	**35**	**100%**

Note: The intervals shown were created according to Sturges' rule.
Source: Own elaboration

To ascertain whether the changes in liquidity levels are due to the reverse stock split, we create a control group made up of 35 firms as similar as possible to each of the firms in the sample, but which have not carried out any reverse stock split. The selection criteria used for the control group follows Han (1995) and Seguro et al. (2020), and they are based on the size (market capitalization) of the firm one month before the reverse stock split, and the closing price adjusted one month before the event. Thus, for each reverse stock split firm in the sample, we select a matching firm that had not carried out this operation two years before or after, and that had a market capitalization and an adjusted closing price one month before as close as possible.

3.2. Liquidity measures

To measure liquidity we use the turnover ratio and Liu's (2006) LMx measure. Given the existing limitations for obtaining high-frequency (intraday) data, we only use low-frequency (daily) data. Although these data do not have the same level of precision and detail as the high-frequency data, when used together with the liquidity measures mentioned above, we can expect very robust results, as demonstrated in the existing literature that used these measures.

3.2.1. Turnover ratio

The turnover ratio consists of dividing the number of shares traded on a given day by the number of shares outstanding on that same day (Wu et al., 2015). A high value of this ratio indicates that the stock is traded more frequently, thus being a stock with higher liquidity and a shorter holding period.

Despite being a measure characterized by its simplicity, it has been used in several studies as a liquidity proxy (Amihud & Mendelson, 1986a; Datar et al., 1998; Asyngier, 2015; Wu et al., 2015; among others).

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In this study, we use the average of daily turnovers, also used by Wu et al. (2015), since it is a simple measure, and the necessary data are obtained with relative ease. The equation for the average of daily turnovers is presented as follows:

$$\text{Turnover} = \frac{1}{T}\sum_{t=1}^{T}\frac{\text{Trading volume}_t}{\text{Shares outstanding}_t}$$

where T corresponds to the number of trading days in a period of one month or six months and the number of shares outstanding is obtained by multiplying the number of shares issued by the free-float ratio.

3.2.2. Liu's (2006) LMx measure

Liu's (2006) LMx measure is a measure capable of capturing multiple dimensions of liquidity, namely the trading volume, the cost of trading and the speed of trading, with a special focus on the latter since this dimension had not received much attention from researchers. This measure has a high correlation with other liquidity measures that are based on turnover, as the bid ask spread, and the Amihud's (2002) ILLIQ measure.

Given its multidimensionality, the ease with which the necessary data are obtained and the correlation with other measures, we consider that Liu's (2006) LMx is a robust measure for the analysis.

Liu's (2006) LMx measure is determined as follows:

$$\text{LMx} = \left(\#\text{ZV}_{\text{x-months}} + \frac{\frac{1}{\text{Turnover}_{\text{x-months}}}}{\text{Deflator}}\right) \times \frac{21 \cdot \text{x}}{\#\text{TD}}$$

where $\#\text{ZV}_{\text{x-months}}$ represents the number of days with zero trading volume in the previous x months; $\text{Turnover}_{\text{x-months}}$ is the sum of daily turnover over the previous x months; $\#\text{TD}$ is the total number of trading days in the previous x months and the Deflator is a value selected so that $0 < \frac{\frac{1}{\text{Turnover}_{\text{x-months}}}}{\text{Deflator}} < 1$ for all stocks in the sample. In this study, the measure will be calculated for a period of one month (x = 1) and for a period of six months (x = 6). We use the same values that Liu (2006) used for Deflator, that is, 480,000 for LM1 and 11,000 for LM6.

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According to Liu (2006), the special focus on the trading speed of this measure is noticeable in the component $\#ZV_{x-months}$, which captures trading continuity and the potential delay or difficulty in executing an order, that is, the more days of zero trading volume a stock has the more illiquid it is. In extreme cases of zero trading volume, this measure manages to capture the lock-in risk, which consists of the risk that the investor may not be able to sell the share.

The adjustment for turnover, observed in the component $0 < \frac{\frac{1}{\text{Turnover}_{x-months}}}{\text{Deflator}} < 1$, allows measuring, to a certain extent, the size of the quantities traded. This part serves to distinguish, within the group of most frequently traded stocks, which are more or less liquid. Finally, this measure reflects the dimension of the trading cost, as the more liquid the share, the lower the cost of trading it. Liu's (2006) LMx is a measure of illiquidity, which means that, the higher the values presented, the lower the stock liquidity.

3.3. Event study

We will use the event study methodology as well as parametric and/or non-parametric tests to perform the statistical analysis, performed using the software IBM SPSS.

The main purpose of the event study methodology is to measure the impact that a given event has on a variable under study, being necessary to measure the variable in question before and after the event (Corrado, 2011). There is no consensus in the community as to when this methodology was developed, however Mackinlay (1997) indicates that "possibly the first published study was that of Dolley (1933)" (p.13). Nevertheless, the event study methodology introduced by Fama et al. (1969) has been the reference ever since.

Applying the flow of procedures indicated by Mackinlay (1997), the target event of our study is the reverse stock split operation, at the moment it is executed. To analyze its effect on the stock liquidity, we use two event windows: one short-term (1 month), following Han (1995), Iwatani (2002) and Seguro et al. (2020); and the other medium-term (6 months), based on Asyngier (2015) and Wu et al. (2015). We also use two estimation windows that have the same size as the event windows mentioned above, measuring the normal liquidity values 1 month (short-term) and 6 months (medium-term) before the reverse stock split. To measure the variations resulting from the event, we use some measures of descriptive statistics, parametric tests, and non-parametric tests.

Parametric tests are a type of statistical tests that aim to analyze the variation in the results of the dependent variable, as a function of the manipulation of independent variables (Newbold et al., 2020). These tests have greater statistical power when compared to non-parametric tests and, when possible, should be chosen (Stojanović et al., 2018). Despite their superior statistical power, parametric tests require that certain assumptions are met so that they can be used, namely that the sample under study has a normal distribution, especially if the sample has a size smaller than 30; the existence of variance homogeneity, that is, the variability of the results must be approximately the same; and, finally, the data must have an independent relationship between them and must be presented in intervals (Stojanović et al., 2018).

Nonparametric tests do not require that assumptions such as normality be met to be used. These tests are used to analyze samples smaller than 30 and samples with ordinal or nominal scale data (Newbold et al., 2020) and are also suitable for analyzing samples that come from different populations.

Since in event studies the objective is to analyze the values of a variable before and after a given event, the most suitable parametric test is the t-student test for paired samples, which allows comparing the mean values of two paired or dependent samples. When the necessary assumptions for the use of this parametric test are not met, a non-parametric test must be carried out, and the Wilcoxon signed rank test is the most suitable for this situation (Newbold et al., 2020).

Corrado (2011) observed that both parametric and non-parametric tests are used, but non-parametric tests are used more frequently, given the difficulty in satisfying the assumption of normality.

To analyze the normality of the distribution of the variable under study, we perform the Kolmogorov-Smirnov and Shapiro-Wilk tests. The Kolmogorov-Smirnov test is the most suitable test for samples that have a dimension equal to or greater than 30, while the Shapiro-Wilk test is the most suitable test for samples smaller than 30. Bearing in mind that our sample size is of 35 observations, we used both tests to increase the robustness of the analysis.

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4. Results and Discussion

4.1. Short-term analysis

In Table 3 we present the values of the descriptive statistics for the liquidity (turnover) and illiquidity (LM1) measures, in the period of 1 month before and after the reverse stock split, for the reverse stock split subsample and the control group subsample.

Table 3: Descriptive statistics – Liquidity/illiquidity measures – Short-term

	Reverse stock split group			Control group		
	Mean	Median	Standard deviation	Mean	Median	Standard deviation
Turnover						
Turn.Pre.1m	0.002	0.002	0.001	0.004	0.003	0.003
Turn.Pos.1m	0.005	0.003	0.006	0.003	0.003	0.003
LM1						
LM1.Pre.1m	0.980	0.913	1.150	0.979	0.001	0.001
LM1.Pos.1m	0.612	0.000	0.834	0.818	1.138	1.160

Note: Turn.Pre.1m represents the average daily turnover for the month prior to the reverse stock split. Turn.Pos.1m represents the average daily turnover for the month after the reverse stock split. LM1.Pre.1m represents Liu's (2006) measure in the month before the reverse stock split. LM1.Pos.1m represents Liu's (2006) measure in the month after the reverse stock split. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

Analyzing the turnover, we can see that the mean value in the reverse stock split group exhibits a significant increase after the split. Comparing the mean values with the median, we can observe a difference between the two values, justified by the dispersion and confirmed by the standard deviation. There is also an increase in the median after the reverse stock split. The increase in the mean and median after the reverse stock split suggests that this operation contributes to increase liquidity in the short-term. Regarding the control group, there are no significant changes in either the mean or the median after the reverse stock split.

As for the LM1 measure, it is possible to verify that the mean and median values in the reverse stock split group are lower in the period after the operation when compared to the values of the month before the reverse stock split. This suggests that, in the short-term, after the reverse stock split, there is in fact an increase in the stock liquidity of the firms that carry out this operation. It is also possible to observe that the mean value in the period after the reverse stock split is much higher than the median value, which demonstrates a large dispersion in the observed values. In the control group, a slight decrease in the mean is observed in the period after the reverse stock split while, in the same period, the median and the standard deviation present a significant increase.

The results of the Kolmogorov-Smirnov and Shapiro-Wilk normality tests are shown in Table 4.

Table 4: Normality test – Short-term

		Kolmogorov-Smirnov		Shapiro-Wilk	
		Statistic	**Sig.**	**Statistic**	**Sig.**
Reverse stock split group	Turn.Pre.1m	0.113	0.200	0.953	0.139
	Turn.Pos.1m	0.349	0.000***	0.617	0.000***
	LM1.Pre.1m	0.264	0.000***	0.794	0.000***
	LM1.Pos.1m	0.340	0.000***	0.742	0.000***
Control group	Turn.Pre.1m	0.125	0.186	0.919	0.013**
	Turn.Pos.1m	0.228	0.000***	0.728	0.000 ***
	LM1.Pre.1m	0.310	0.000***	0.758	0.000***
	LM1.Pos.1m	0.330	0.000***	0.733	0.000***

Note: Statistic represents the value for the test statistic; Sig. represents the level of statistical significance of the test. Turn.Pre.1m represents the average daily turnover in the month prior to the reverse stock split. Turn.Pos.1m represents the average daily turnover in the month following the reverse stock split. LMx.Pre.1m represents Liu's (2006) measure in the month before the reverse stock split. LMx.Pos.1m represents Liu's (2006) measure in the month after the reverse stock split. *, ** and *** represent significance at the level of 10%, 5% and 1%, respectively. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

In Table 4, we see that in the reverse stock split group, the variable Turn.Pre.1m is the only one that is normally distributed, according to both the Kolmogorov-Smirnov test and the Shapiro-Wilk test. For the remaining variables of the reverse stock split group, the rejection of the null hypothesis of normality is confirmed in both tests and with a significance of 1%. In the control group, the variable Turn.Pre.1m is the only one that, according to the Kolmogorov-Smirnov test, is normally distributed. For the remaining variables, the rejection of the null hypothesis is confirmed with a significance of 1%. According to the Shapiro-Wilk test, the null hypothesis of normality is rejected for all variables.

Since the results for the normality tests are mixed, we use the parametric t-student test for paired samples and the non-parametric Wilcoxon signed rank test to verify whether firms that perform a reverse stock split observe an increase in liquidity after the event. With these tests, we seek to confirm or reject hypothesis 1, that reverse stock splits generate an increase in stock liquidity in the short-term.

The results obtained for the t-student test for paired samples are shown in Table 5.

Table 5: Paired samples t-test – Short-term

		Paired differences		
		Mean	**t**	**Sig.**
Reverse stock split group	Turn.Pos.1m – Turn.Pre.1m	0.003	2.885	0.007***
	LM1.Pos.1m – LM1.Pre.1m	-0.368	-1.511	0.140
Control group	Turn.Pos.1m – Turn.Pre.1m	0.000	-0.029	0.977

LM1.Pos.1m – LM1.Pre.1m	-0.162	-0.555	0.583

Note: Mean represents the difference of the means of the paired variables. t represents the test statistic. Sig. represents the statistical significance. Turn.Pre.1m represents the average daily turnover in the month prior to the reverse stock split. Turn.Pos.1m represents the average daily turnover in the month following the reverse stock split. LM1.Pre.1m represents Liu's (2006) measure in the month before the reverse stock split. LM1.Pos.1m represents Liu's (2006) measure in the month following the reverse stock split. *, ** and *** represent significance at the level of 10%, 5% and 1%, respectively. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

Analyzing Table 5, it is possible to verify that, in the reverse stock split group, the difference between the mean turnover after and before the reverse stock split is positive and significant at 1%. As for the control group, the observed value leads us not to reject the hypothesis of equality of means. Thus, the positive difference between the mean turnover after and before the event is statistically relevant and it is due to the reverse stock split. Therefore, we can conclude that reverse stock splits contribute to increase turnover in the short-term.

For the LM1 measure, the hypothesis of equality of means cannot be rejected. However, as the assumption of normality of distribution of this measure is not verified, these results are not robust.

In Table 6 we present the results obtained for the Wilcoxon signed rank test.

Table 6: Wilcoxon signed rank test – Short-term

	Reverse stock split group		Control group	
	Z	**Sig.**	**Z**	**Sig.**
Turn.Pos.1m – Turn.Pre.1m	-3.784	0.000***	-0.442	0.658
LM1.Pos.1m – LM1.Pre.1m	-2.440	0.015**	-1.163	0.245

Note: Z represents the test statistic value. Sig. represents the statistical significance of the test. Turn.Pre.1m represents the average daily turnover in the month prior to the reverse stock split. Turn.Pos.1m represents the average daily turnover in the month following the reverse stock split. LM1.Pre.1m represents Liu's (2006) measure in the month before the reverse stock split. LM1.Pos.1m represents Liu's (2006) measure in the month after the reverse stock split. *, ** and *** represent significance at the 10%, 5% and 1% level, respectively. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

Table 6 shows a 1% significant difference in the turnover before and after the event in the reverse stock split group. Since the median of turnover before the split is 0.002 and after is 0.003, the Wilcoxon test suggests an increase in liquidity after the reverse stock split. In the control group, the differences in the turnover are not statistically significant. That said, we can conclude that the increase in the turnover of the reverse stock split group is due to the execution of the reverse split.

When analyzing the LM1 measure, it is possible to observe that the differences before and after the split are statistically significant at 5%, in the reverse stock split group. The medians for LM1 are 0.913 and 0.000 before and after the reverse stock split, respectively. As LM1

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is a measure of illiquidity, these lower values indicate a decrease in illiquidity or an increase in liquidity after the split. In the control group, the differences in the LM1 measure are not statistically significant. Therefore, we can conclude that the reverse stock split contributes to increase stock liquidity.

In conclusion, the results obtained allow us to conclude that the reverse stock splits increase the liquidity of European stocks in a short-term horizon, thus confirming hypothesis 1 of this study. In addition, these results are consistent with the results of Gamlemoen and Bornstedt (2016), Han (1995) and Iwatani (2002). These authors observed that, after performing the reverse stock split, firms benefit from an increase in stock liquidity in a short time horizon (50 days).

4.2. Medium-term analysis

In Table 7 we present the values of the descriptive statistics for the liquidity (turnover) and illiquidity (LM6) measures, in the period of 6 months before and after the reverse stock split, for the group that performed this operation and for the control group.

Table 7: Descriptive statistics – Liquidity/illiquidity measures – Medium-term

	Reverse stock split group			**Control group**		
	Average	**Median**	**Standard deviation**	**Average**	**Median**	**Standard deviation**
Turnover						
Turn.Pre.6m	0.002	0.002	0.001	0.004	0.003	0.003
Turn.Pos.6m	0.004	0.003	0.004	0.004	0.003	0.003
LM6						
LM6.Pre.6m	4.899	3.907	4.477	5.351	3.907	4.383
LM6.Pos.6m	3.164	2.886	1.821	3.848	3.790	2.416

Note: Turn.Pre.6m represents the average daily turnover for the 6 months prior to the reverse stock split. Turn.Pos.6m represents the average daily turnover of the 6 months after the reverse stock split, LM6.Pre.6m represents the Liu's (2006) measure in the 6 months before the reverse stock split. LM6.Pos.6m represents Liu's (2006) measure in the 6 months after the reverse stock split. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

Analyzing the results of the turnover, we can observe a significant increase in the values of the reverse stock split group after the event. The mean values are above the median values, indicating that there is a significant dispersion of observed values that contribute positively to the rise in the mean value. This dispersion of observed values is justified by the value of the standard deviation. It is also possible to observe that the median increased after the reverse stock split. These increases suggest that the reverse stock split contributes to increase the liquidity in the medium-term. When analyzing the control group, it appears that the values of the turnover remain practically unchanged, with only slight variations.

Regarding the LM6 measure, in the reverse stock split group, it is possible to verify a decrease in the mean, median and standard deviation after the event. A very sharp reduction in the standard deviation is also observed, indicating a decrease in the dispersion of observed values. The mean presents values slightly higher than the median, suggesting a dispersion in the observed values. This decrease in the mean and median values suggests that the reverse stock split contributes to increase the liquidity in the medium-term. In the case of the control group, there is a marked reduction in the mean and in the standard deviation. However, the median shows only a slight decrease, indicating that the mean values before the reverse stock split are heavily influenced by the dispersion.

Table 8 shows that, in the reverse stock split group and according to the Kolmogorov-Smirnov test, the variables Turn.Pre.6m and LM6.Pos.6m are normally distributed. For the remaining variables, the null hypothesis of normality is rejected with a significance of 1%. According to the Shapiro-Wilk test, the null hypothesis of normality is rejected for all variables. In the control group, the null hypothesis of normality is rejected for all variables, independently of the test used.

Table 8: Normality test – Medium-term

		Kolmogorov-Smirnov		Shapiro-Wilk	
		Statistic	**Sig.**	**Statistic**	**Sig.**
Reverse stock split group	Turn.Pre.6m	0.117	0.200	0.937	0.044**
	Turn.Pos.6m	0.311	0.000***	0.681	0.000***
	LM6.Pre.6m	0.272	0.000***	0.569	0.000***
	LM6.Pos.6m	0.131	0.134	0.910	0.007***
Control group	Turn.Pre.6m	0.167	0.014**	0.918	0.012**
	Turn.Pos.6m	0.144	0.065*	0.885	0.002***
	LM6.Pre.6m	0.281	0.000***	0.610	0.000***
	LM6.Pos.6m	0.174	0.009***	0.923	0.017**

Note: Statistic represents the value for the test statistic. Sig. represents the level of statistical significance of the test. Turn.Pre.6m represents the average daily turnover in the months prior to the reverse stock split. Turn.Pos.6m represents the average daily turnover over the six months following the reverse stock split. LM6.Pre.6m represents Liu's (2006) measure in the six months prior to the reverse stock split. LM6.Pos.6m represents Liu's (2006) measure in the six months following the reverse stock split. *, ** and *** represent significance at the level of 10%, 5% and 1%, respectively. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

Considering that some variables have a normal distribution and others do not, we perform the same parametric and non-parametric tests used in the short-term analysis. With these tests we seek to confirm or reject hypothesis 2, that reverse stock splits generate an increase in stock liquidity in the medium-term.

We present in Table 9 the results obtained for the parametric t-student test for paired samples.

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Table 9: Paired samples t-test – Medium-term

		Paired differences		
		Mean	**t**	**Sig.**
Reverse stock split group	Turn.Pos.6m – Turn.Pre.6m	0.002	2.959	0.006***
	LM6.Pos.6m – LM6.Pre.6m	-1.734	-2.593	0.014**
Control group	Turn.Pos.6m – Turn.Pre.6m	0.000	1.970	0.845
	LM6.Pos.6m – LM6.Pre.6m	-1.504	-2.071	0.046**

Note: Mean represents the difference of the means of the paired variables. t represents the value of t-student. Sig. represents statistical significance. Turn.Pre.6m represents the average daily turnover for the six months prior to the reverse stock split. Turn.Pos.6m represents the average daily turnover in the six months following the reverse stock split. LM6.Pre.6m represents Liu's (2006) measure of the six months prior to the reverse stock split. LM6.Pos.6m represents Liu's (2006) measure in the six months following the reverse stock split. *, ** and *** represent significance at the 10%, 5% and 1% level, respectively. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

By analyzing Table 9, it is possible to verify that, in the reverse stock split group, the mean difference of the turnover is positive, which indicates that the turnover after the reverse stock split is higher than the turnover before the operation. It is possible to reject the hypothesis of equality of means with a significance of 1%. Regarding the control group, the mean difference of the turnover is not statistically significant. Thus, the evidence found suggests that the increase in the turnover after the event is statistically relevant and it is due to the reverse stock split.

With respect to the LM6 measure, it is possible to observe that the mean difference in liquidity is statistically significant at 5%, in both the reverse stock split group and the control group. This suggests an increase in liquidity in both groups and thus prevents us from conclude that the reverse stock split operation contributes to increase stock liquidity in the medium-term.

In Table 10 we present the results obtained for the Wilcoxon signed rank test.

Table 10: Wilcoxon signed rank test – Medium-term

	Reverse stock split group		Control group	
	Z	**Sig.**	**Z**	**Sig.**
Turn.Pos.6m - Turn.Pre.6m	-3.456	0.001***	-0.999	0.318
LM6.Pos.6m - LM6.Pre.6m	-2.784	0.005***	-2.195	0.028**

Note: Z represents the test statistic value. Sig. represents the statistical significance of the test. Turn.Pre.6m represents the average daily turnover in the six months prior to the reverse stock split. Turn.Pos.6m represents the average daily turnover over the six months following the reverse stock split. LM6.Pre.6m represents Liu's (2006) measure in the six months prior to the reverse stock split. LM6.Pos.6m represents Liu's (2006) measure in the six months following the reverse stock split. *, ** and *** represent significance at the level of 10%, 5% and 1%, respectively. The statistics presented in this table were obtained using the SPSS software.
Source: Own elaboration

Analyzing Table 10, it is possible to observe that, in the reverse stock split group, the difference between the medians of turnover before (0.002) and after (0.003) the reverse stock split is statistically significant at 1%. This suggests an increase in liquidity after the reverse stock split. In the control group, the difference between the medians of turnover before and after the event is not statistically significant. That said, we can conclude that the increase in the turnover in the medium-term of the group that carried out the reverse stock split is due to its execution.

Regarding LM6, it is possible to observe that the medians before and after the reverse stock split are statistically different with a significance of 1% in the reverse stock split group and with a significance level of 5% in the control group. In both groups, the medians after the event are lower than the medians before, which suggest an increase in stock liquidity. Therefore, we cannot conclude that the increase in liquidity in the group that performed the reverse stock split is exclusively due to its execution, since the control group presents the same behavior.

The results obtained in this analysis indicate that the reverse stock split contributes to increase the stock liquidity of European firms in a medium-term horizon, especially when liquidity is measured by turnover. However, with Liu's (2006) measure the results are not as clear, which prevents the confirmation of hypothesis 2. Asyngier (2015) and Wu et al. al. (2015) found that firms that performed reverse stock splits saw an improvement in the stock liquidity in a medium-term horizon (6 months). The difference in the results obtained can be explained by the fact that the measures used by Asyngier (2015) and Wu et al. (2015) did not analyze the immediacy dimension, a dimension that is analyzed in this study using Liu's (2006) LMx measure and that corresponds to the speed with which transactions are executed.

5. Conclusions

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Liquidity is fundamental for the proper functioning of the financial markets, and it also impacts stock performance. Investors are attracted to more liquid financial markets and liquid firms. Therefore, the boards of directors of listed firms should be aware of the tools capable of improving stock marketability and liquidity. One of those tools are reverse stock splits. Nevertheless, the effects of this operation on stock liquidity have not been receiving much attention in the literature. Despite the existence of some studies addressing various markets, most studies focus on American markets.

Thus, to expand previous empirical evidence, this work studies the effect of reverse stock splits on stock liquidity of European firms. With a sample of 35 reverse stock splits executed by 30 firms belonging to the STOXX Europe 600 index, between 2015 and 2019, using the event study methodology and two liquidity measures (average daily turnover and Liu's (2006) LMx), we analyze the effects of reverse stock splits on stock liquidity in a short (1 month) and medium (6 months) term horizons.

In the short-term horizon, the results obtained with the two liquidity measures allow us to conclude that the reverse stock splits have a positive effect on the stock liquidity of the firms that execute this operation, thus confirming our first investigation hypothesis. This result is also consistent with the results of Gamlemoen and Bornstedt (2016), Han (1995), and Iwatani (2002), who observed an increase in liquidity in a short-term horizon. This increase in liquidity may be explained by the rise in stock prices, placing them in a more attractive price range for investors, thus contributing to an increase in the trading volume.

In the medium-term horizon, the results are less clear. It is possible to observe an increase in liquidity, measured by the average daily turnover, after the reverse stock split, when compared to the control group. However, with Liu's (2006) LM6 measure, an increase in liquidity is observed both in firms that performed the reverse stock split and in the control group, which raises doubts whether this increase in liquidity is due to the reverse stock split or to another factor. Hence, we cannot confirm our second research hypothesis. This result may be justified by the fact that some of the effects pointed out in the short-term analysis have already been diluted by the market. Additionally, with a longer event window, there is the possibility of existence of other events that could capture the attention of investors. Previous empirical evidence suggests that the reverse stock split contributes to increase stock liquidity in the medium-term horizon (Asyngier, 2015; Wu et al., 2015), which is consistent with our findings for the turnover. Since the multidimensional liquidity measure of Liu's (2006) was not used by other authors, an accurate comparison is not possible.

This study contributes to the financial literature on the relationship between reverse stock splits and liquidity. In addition, it contributes to increase the existing literature on European markets. The results obtained in this study also contribute to helping the boards of directors of listed firms in the decision-making process, providing them with evidence of the results obtained with this type of operations. These results are also relevant for investors wishing to acquire shares of firms on the verge of executing this operation, and this study clarifies the behavior of liquidity after the reverse stock split, which, given the risk profile of investors, may impact their investment decisions.

Despite the results obtained, this study has some limitations. One of these limitations is the fact that this type of operation or the multiplication factor used are not properly disclosed on the webpages of firms dedicated for investor relations. The reduced number of reverse stock splits in the sample is another limitation, which prevents a more generalized assessment of the impacts.

As future research, it would be interesting to analyze the market reaction at the time of the announcement of a reverse stock split, in terms of liquidity, return and volatility. It would also be interesting to analyze the effect of reverse stock splits on stock liquidity using high frequency data.

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