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HOW STOCK SHORT SELLING IMPACTS THE STOCK MARKETS: EVIDENCE FROM NASDAQ-100

Yuliya Bilska

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Supervisor:
Professor Doutor José Dias Curto, ISCTE Business School
Associate Professor
Department of Quantitative Methods for Management and Economics

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Abstract

Several researchers have analyzed the impact of short selling on stock price. Some of the authors have concluded that short selling improves price efficiency, while others did not find any statistically significant relation.

This study investigates the relationship between short selling and stock returns on a monthly basis, using a panel data setup. To do that, the relation between changes in short positions and stock returns, as well as the relation between the short interest ratio and abnormal return, were estimated. Short interest data for period from April 2010 through August 2019 from NASDAQ-100 companies were used to examine the expected negative relationship. However, the obtained results do not support previous research results. This analysis indicates that changes in short positions have a negative but statistically insignificant impact on stock returns. Furthermore, this study finds that the relation between the short interest ratio and abnormal return is positive and statistically significant.

The obtained results suggest that short selling does not have a negative impact on prices, in line with what was reported by several papers.

JEL Classification: C33, G12, G14

Keywords: Short interest, NASDAQ, abnormal return, panel data.

Resumo

O impacto da venda a descoberto na rendibilidade das ações foi analisado por vários autores. Alguns dos estudos demonstraram que esta prática promove a eficiência dos preços, no entanto outros não encontraram uma relação estatisticamente significativa.

Este estudo investiga a relação entre a venda a descoberto e a rendibilidade mensal das ações, usando dados em painel. Para tal foram estimadas duas regressões: a relação entre as mudanças na posição da taxa de "short" e a rendibilidade das ações e a relação entre o rácio de taxa de "short" e as rendibilidades anormais.

Os dados utilizados nesta análise referem-se a ações de empresas cotadas no NASDAQ 100, no período compreendido entre Abril de 2010 e Agosto de 2019. De acordo com a revisão de literatura o resultado expectável seria uma relação negativa entre a venda a descoberto e a rendibilidade das ações. No entanto, os resultados obtidos não corroboram com a evidência empírica apresentada pelas investigações anteriores.

Esta análise revela que alterações na posição da taxa de "short" têm uma relação negativa com a rendibilidade das ações, no entanto esta não é estatisticamente significativa. Adicionalmente, este estudo demonstra que o rácio de taxa de "short" tem um efeito positivo e estatisticamente significativo nas rendibilidades anormais.

Os resultados obtidos sugerem que as vendas a descoberto não têm impacto negativo nos preços das ações, contrariamente ao que foi reportado por vários artigos.

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1. Introduction

Short selling has been the focus of several authors over the years. According to the Securities and Exchange Commission (SEC), the short sale mechanism corresponds to the sale of a borrowed security in the market (D'Avolio, 2002). Typically, this strategy is conducted by selling a security that the investor borrowed from a broker-dealer or an institution, since the investor does not own it (D'Avolio, 2002). Afterwards, the investor closes out the position by buying the security back in the open market. This type of strategy is based on the speculation that the stock price will fall. Therefore, when the position is closed, the gain or loss will be recognized based on the differences between the selling and buying prices (SEC.gov | Short Sales, 2019).

There are two different types of short selling: covered short sale and naked short sale. According to the SEC (2019), the naked short sale occurs when the investor does not have the security to deliver to the buyer in time, which results in a "failure to deliver". The covered short sale occurs when the investor borrows the security prior to the delivery time (SEC.gov | Short Sales, 2019).

This strategy is commonly used with the expectation of a price decrease; however, to achieve profits, a price decrease is not enough. A short selling strategy implies high risk; for this reason, it is more expensive compared to a long position (Kot, 2007). The risk of short selling is associated with its achievable profit and loss. For instance, the profit of a short selling is limited, since it is restricted to the stock sale price, meaning that it is only possible to achieve the highest profit when the price decreases to zero (Kot, 2007). On the other hand, the loss of a short selling is unlimited, since from a theoretical point of view, the price of a stock can increases unlimitedly (Kot, 2007). Therefore, the investors' willingness to bear the high risk associated with this strategy means it is essential to understand their motivations to short sale.

Several researches have investigated the effect of short selling on the markets, and the impact of constraints. However, the conclusions are controversial. Miller (1977) was first to study this effect by analyzing the Overpricing Hypothesis. This author concluded that because of the short sale constraints, and with different opinions regarding the security price, only the beliefs of the most optimistic investors are incorporated into the price movements (Miller, 1977). This means that the negative information is not reflected into prices, and thus the price is upwardly biased (Miller, 1977). Diamond and Verrecchia (1987) confronted Miller's theory by arguing that the short selling constraints reduce the informational efficiency, as it reduces the speed of price adjustment to new information.

Wooldridge and Dickinson (1994) presented empirical result by analyzing short selling impact on the stock prices and concluded that short selling does not lead to lower prices and therefore short sales are not necessarily informed. However, other empirical results showed a negative relationship between high Short Interest Ratio (SIR) and abnormal returns (Asquith & Meulbroek, 1995 and Desai *et al*., 2002). Additionally, Aitken *et al*. (1998) suggested that the impact of short selling is negative, and the information is incorporated quickly into stock prices.

More recent literature review documented that short selling improve efficiency (Boehmer *et al*., 2008 and Boehmer & Wu, 2012).

The goal of this paper is to analyze the relationship between short selling interest and stock returns. To do that our study encompasses two analyses. First, we analyze the relation between short selling and stock return. Second, we analyses the relation between short interest ratio and abnormal returns. This study aims to provide recent empirical evidence on short selling impact on stocks market taking into account the recent short selling constraints.

For this analysis we consider the period between April 2010 and August 2019 and estimated the short selling impact on abnormal returns of stocks from NASDAQ – 100. For the first analysis, we use panel data random effects regression model. Our results suggest that there is no statistically significant association between the short interest change and the stock return. In contrast, we find a positive and statistically significant impact of the short interest ratio on the abnormal return, by using a panel data fixed effects regression model and considering the Market Capitalization as control variable.

This thesis is organized as follows. Section 2 reviews prior literature related with the short sellers' motivations, short selling impact on the market as well as the short selling regulation. Additionally, this section provides the hypotheses of this study. Section 3 explains the methodology used in this analysis. Section 4 describes sample constructions and summarizes the data. Section 5 provides empirical results. Finally, section 6 provides conclusions of this analysis.

2. Literature Review

In this section, the literature review related to short selling is described. Firstly, the investors' motivations to enter on short selling strategies are explored. At a second stage, the focus will be on the impact of short selling on the market performance: impact on liquidity, volatility and price. The literature review related to the short selling impact on price will be helpful to understand the possible relationships between the short selling and stock returns. Additionally, it will help to formulate and indicate the hypothesis for this thesis. Finally, the current regulation on short selling will be presented.

2.1. Short-selling motivations

Short selling is a common strategy among investors, and its activity has been increasing in the past years. The annual growth rate of short interest in the NASDAQ was approximately 23% from 1988 to 2002 (Kot, 2007). According to Angel *et al. (*2003), who focused their study on the frequency of short selling at NASDAQ, approximately one out of every forty-two trades is short selling. Moreover, they found out that, on average, approximately one out of every thirty-five shares traded are shorted (Angel *et al*., 2003). Nevertheless, despite its popularity, this strategy has high borrowing costs and other risks associated (Miller, 1977). For this reason, it is imperative to understand the motivations behind the short selling strategy.

Several different motivations for short selling can be pinpointed. Brent *et al.* (1990) defended that not all strategies of short selling have similar motivation. Traders can use short sales for hedging purposes, to achieve convertible or index arbitrage, for tax reasons or due to a purely speculative motive (Brent *et al*., 1990).

Kot (2007) presented a study that summarizes the motivations of investors for short selling in four different hypotheses: Trend Hypothesis, Overpricing Hypothesis, Arbitrage Hypothesis and Taxation Hypothesis.

According to the Trend Hypothesis, investors trade based on the past price movement (Kot, 2007). In this case, short selling is linked to the stock performance, and thus, if the stock price has been increasing, the short seller will close the position. He reaches the conclusion that a stock with a high (low) rate of return repeats this high (low) rate of return in the following year (Kot, 2007).

The Overpricing Hypothesis assumes that investors have inside information. Thus, when investors expect that the stock is overpriced, short selling is a way to profit from it (Linnertová, 2016). There is a considerable amount of literature on the Overpricing Hypothesis. Miller (1977) was one of the first authors to mention this hypothesis. This author defended that uncertainty and risk are responsible for the divergence of opinions. Therefore, the divergence in investors' opinions increases with the risk. Additionally, this author stated that well-informed investors prevent the market from the undervaluing of securities. However, badly informed investors could contribute to the overpricing of some securities. In the same research, Miller (1977) showed that the short sale of a stock helps moderating its overpricing. The author argues that this strategy is only profitable with stocks whose prices decrease a sufficient amount to cover the costs of the borrowed stock (Miller, 1977). Diamond and Verrecchia (1987) emphasized the importance of short selling costs and associated risks. Their findings indicated that short sellers need to have a compensation for additional costs in order to trade. More recent research (Dechow, 2001) studied the relationship between company fundamentals and the level of short selling.

According to Linnertová (2016), the Arbitrage Hypothesis defends that investors profit from the price differential between a stock and a convertible security. Kot (2007) also studied this hypothesis and found that there is a significant demand for hedging and arbitrage for short selling.

Finally, the Taxation Hypothesis suggests that investors will profit from tax gain by shorting a stock while holding a long position of this stock (Kot, 2007). This strategy not only allows the investor to lock the profit, but also to defer the capital gain tax (Brent *et al*., 1990).

Kot (2007) analyzed all the hypotheses and concluded that short selling can be explained by all the hypotheses except for the Taxation Hypothesis. He claims that the Taxpayer Relief Act 1997 eliminated the opportunity profit from this strategy. To support these conclusions, Linnertová (2016) investigated the validity of these hypotheses for NYSE in the period of 1990-2015 and concluded that short sales can be explained by the Trend Hypothesis and by the Overpricing Hypothesis. Moreover, this author documented that short selling can be influenced by the existence of an option.

2.2. Short Selling impact on financial markets

There are different opinions regarding short selling, since there are many benefits and costs associated. The main benefits of this strategy are efficient pricing and the incorporation of negative information in prices, as already described (Linnertová, 2016). The most common criticism is that short selling can affect the stock price in such a way that it can decrease below its fundamental value (Linnertová, 2016). Still, the short sale strategy has other effects. This strategy affects the market liquidity, volatility, investor behavior, and the efficiency of a price discovery process (Chen & Zheng, 2009). The main purpose of this thesis is to study the impact of short selling on the price of the stock.

2.2.1. Impact on Liquidity

Short selling has several effects on the market performance, namely on the liquidity (Chen & Zheng, 2009). There are several empirical studies that provide evidence related with the impact of short selling on market liquidity.

Wooldridge and Dickinson (1994) point out that short sellers provide liquidity to the market, since resorting to this trade strategy increases in bull markets and decreases in bear markets.

According to Daouk and Charoenrook (2005), when there are no short selling constraints, the liquidity increases. Therefore, they concluded that short selling constraints impact market liquidity negatively.

Conversely, Alexander and Peterson (2008) and Diether *et al.* (2009a) found out that a reduction in short selling constraints does not affect the market liquidity. Notwithstanding, none of the studies found strong evidence on the impact of short selling in liquidity.

To summarize, there are mixed conclusions regarding the impact of short selling on market liquidity.

2.2.2. Impact on Volatility

Short selling, besides the effect on market liquidity, may have further effects on market performance, namely market volatility (Chen & Zheng, 2009).

Hong and Stein (2003) developed a model that concludes that short sale constraints in the market lead to a higher frequency of negative stock returns. However, Bris *et al.* (2003) study contradicts the Hong and Stein's (2003) findings, by stating that short-selling constraints lead to lower negative skewness in the individual stock returns. Another study, conducted by Chang *et al.* (2007), supports these findings by concluding that the absence of short selling constraints leads to high volatility and less positive skewness in individual stock returns.

On top of that, Alexander and Peterson (2008) and Diether *et al*. (2009a) analyzed the impact of a suspension in short sale constraints on market volatility. They observed insignificant increases in returns' volatility.

More recent empirical paper focused it analysis on the impact of short selling constraints on stock return volatility for the German stock market (Bohl *et al.,* 2016). They concluded that short selling constraints increase stock return volatility. Additionally, they suggested that investors in presence of short selling restriction, prefer alternative marketplaces without short selling regulations (Bohl *et al.,* 2016).

Therefore, there are mixed conclusions when it comes to the short selling's impact on the stock returns' volatility.

2.2.3. Impact on price

The main criticism of short selling is that it is responsible for declines in both market and individual security prices (Woolridge & Dickinson, 1994). Thus, many authors have studied the effect of short selling on the markets. Among the several researches that were carried out, two particular theories can be highlighted: The Overpricing Hypothesis (Miller, 1977) and Rational Expectation Model (Diamond & Verrecchia, 1987).

Miller (1977) was one of the first authors to study the effect of short sale constraints on stock prices. This author analyzed the Overpricing Hypothesis and the impact of divergence in investors' opinion on prices, as mentioned in previous sections.

According to Miller's theory, risk and uncertainty entail divergence of opinions. Consequently, the divergence in investors' opinion can lead to the overpricing of short sale securities subject to constraints. The author argues that because of the short sale constraints, and with different opinions regarding the security price, only the beliefs of the most optimistic investors are incorporated into the price movements (Miller, 1977). This means that the negative information is not reflected into prices, and thus the price is upwardly biased. Additionally, since short selling is a costly strategy, only well-informed investors with strong negative information about the stock will be willing to sell the stock and bear the associated cost (Miller, 1977).

Diamond and Verrecchia (1987) confronted Miller's theory by arguing that investors have rational expectations and are informed traders. Their rational expectation model is based on the theory that investors have rational expectations, and thus are aware of the existence of short selling constraints. Accordingly, investors will adjust their expectations and consequently, stock prices will not be upward biased (Diamond & Verrecchia, 1987).

In the same research, Diamond and Verrecchia (1987) argue that the short selling constraints reduce the informational efficiency, as it reduces the speed of the price's adjustment to new information, especially to negative information. They reported that informed investors have access to private information while uninformed investors only have access to the public information. As a result, when short selling costs are high, only well-informed short sellers are willing to bear the costs associated with short selling (Diamond & Verrecchia, 1987). Moreover, they mentioned that the existence of tradable options can reduce the cost of short selling and increase the informational efficiency (Diamond & Verrecchia, 1987).

A growing body of literature has examined and supported both theories discussed above.

The earlier empirical studies on the Overpricing Hypothesis were diverse and inconclusive. For instance, Senchack and Starks (1993) studied the relationship between the changes in short interest and stock returns. Their findings provide evidence that unexpected increases of short interest in stock lead to negative abnormal returns. They suggest that the larger the change in short selling, the more negative the effect on the price. Moreover, in line with the Diamond and Verrecchia theory, this research documented that tradable options reduce the negative impact of short selling. This research implies that options improve informational efficiency (Senchack & Starks, 1993). This is related to the Figlewksi and Webb (1993) research, which suggests that options reduce the negative impact short selling has on excess return.

On the other hand, Wooldridge and Dickinson (1994) did not find a negative relationship between monthly stock returns and monthly changes in short interest positions. In their paper, they analyzed the relationship between monthly changes in short positions and returns on NYSE, Amex and NASDAQ. They concluded that short selling does not lead to lower prices, and therefore short sales are not necessarily informed. However, this strategy provides liquidity to the market (Wooldridge & Dickinson, 1994).

Other empirical evidence supports the Overpricing Hypothesis by investigating the relation between short interest and subsequent abnormal stock returns. While Asquith and Meulbroek (1995) based their research on the monthly short interest positions for NYSE and AMEX stocks, Desai *et al. (*2002) focused on NASDAQ listed firms. Both studies showed that high Short Interest Ratio (SIR) stocks have abnormal negative returns. More recently, Asquith *et al. (*2005) reported negative abnormal returns on high SIR stocks as well.

Likewise, earlier, Aitken *et al. (*1998) performed their research on the Australian stock market and provided empirical evidence that short interest is a bearish signal. Additionally, Aitken *et al. (*1998:2221) refers that "*short sales are almost instantaneously bad news*". They argue that the impact of short selling is negative, and the information is incorporated quickly into stock prices.

Consistent with Diamon and Verrecchia's theory, Dechow *et al*. (2001) presented evidence that short sellers are rational investors and invest based on publicly available information. They stated that investors short stocks with low fundamental-to-price ratios, as well as short stocks for which the transaction costs for short selling are low (Dechow *et al*., 2001).

Similarly, Jones and Lamont (2002) provided evidence consistent with the Overpricing Hypothesis. They studied the cost of short selling equities and found out that stocks with high costs due to the short selling, have higher market book ratios and low subsequent returns (Jones & Lamont, 2002).

In later studies, Boehme *et al*. (2006) found strong support to Miller's (1977) theory. The authors provided empirical evidence that short selling constraints combined with divergence in opinion among investors have an impact on overpricing. (Boehme *et al*., 2006). Other researches also support this theory using different data. Chang, *et al. (*2007) documented that short sale constraints cause stock overvaluation. These authors conducted their research using data from the Hong Kong Stock Exchange (HKEx).

Other work focuses on daily short-selling proprietary order flow data from NYSE. For example, Boehmer *et al.* (2008) documented that short selling improves the efficiency of stock prices. On top of that, they reported that heavily shorted stocks underperform lightly shorted stocks.

Additionally, Diether *et al. (*2009b) using U.S. data of short selling executed in 2005, documented that short sale represented thirty-one percent of NASDAQ's volume and twenty-four of NYSE's volume, which indicates that there is a significant volume of short selling in the market. Furthermore, these findings appear to support that there are increases in short selling following positive returns. Boehmer and Wu (2012) analyzed how daily short selling flows affect the price discovery, by applying different empirical approaches. This research has significant implications due to the recent short selling constraints. They reach the conclusion that short selling has impacts on the price discovery, as it moves the price closer to its fundamental value.

More recent empirical evidence showed that short selling risk affects stock prices, and therefore stocks with more short selling risk have lower returns and less price efficiency (Reed *et al.,* 2017). These authors analyzed U.S equities from 2006 to 2011 and concluded that short selling risk reduces short selling level and decreases price efficiency (Reed *et al.,* 2017).

Finally, another paper investigated short selling profitability. Diether (2019) analyzed short selling contract data from 1999 to 2005 in order to investigate if short sellers are profitable. This author concluded that short sellers are profitable on average and suggests that short sellers are informed investor or have access to private information (Diether, 2019). These conclusions are consistent with Diamond and Verrecchia (1987) theory.

Given the above, several studies support different conclusions regarding the impact of short selling on the stock market.

Since previous literature shows contrasting relationships and does not reach a consensus, the main goal of this study is to analyze whether short interest is an indicator of stock performance.

Hence, hypotheses are the following:

$$H_1\text{: } Short\ selling\ has\ a\ negative\ effect\ on\ stock\ prices$$

This first hypothesis is based on the Wooldridge and Dickinson (1994) study, which aims to evaluate the relationship between stocks returns and changes in short selling.

$$H_2\text{: } The\ short\ interest\ ratio\ is\ negatively\ related\ to\ abnormal\ returns$$

The second hypothesis aims to analyze the impact of short interest ratio in abnormal stock returns.

2.3. Short Selling Regulation

In 1934, the Securities Exchange Act of 1934 established the Securities and Exchange Commission (SEC), giving the commission the authority to regulate various exchange securities, such as the NASDAQ Stock Market (SEC.gov | The Laws That Govern the Securities Industry, 2019). On top of that, the SEC has the authority to require reporting from the companies (SEC.gov | The Laws That Govern the Securities Industry, 2019).

It was only in 1938 that the regulation on the short selling was adopted ("Key Points about Regulation SHO", 2019). Since that time, there were various changes in the short sale regulation.

Finally, in February 2010, the SEC adopted a new rule to restrict the short selling activity: rule 201 of Regulation SHO (Key Points about Regulation SHO, 2019). The goal of this alternative Uptick Rule is to restrict the short selling from driving down prices when the stock price has already declined by more than 10 percent in one day (Key Points about Regulation SHO, 2019).

3. Methodology

In this section, the main methodology used to analyze the relationship between short selling and returns of NASDAQ-100 stocks is introduced.

3.1. Model

To analyze the data, a panel data approach was chosen. Panel data has several benefits relevant to the analysis at hand, as it provides a wider range of degrees of freedom and reduces collinearity, hence improving efficiency (Baltagi, 2005).

A monthly unbalanced panel for 101 stocks, with periods between the 30th of March 2010 and 31st of August of 2019, was constructed. The unbalanced panel data implies that the number of time periods *t* may be different for each individual variable *i*. In this case, our data includes time periods from *t*=20 to *t*=112.

Two distinct analyses were performed: the impact of changes in short selling interest on stock monthly returns and the impact of short interest ratio on abnormal stock returns.

First, the changes in short selling interests on monthly stock returns were estimated, based on the Woolridge and Dickinson (1994) method:

$$R_{it} = \alpha_i + \beta_1 SHORT_{it} + \mu_{it} \quad t = 1,2 \dots T \tag{1}$$

where:

R_{it} − the monthly stock return of stock *i* at time *t;*

α_i − the intercept regression coefficient;

β_1 − the regression coefficient associated with changes in short interest*;*

$SHORT_{it}$ − the change in short interest for stock *i* at time *t*;

μ_{it} − the regression error for stock *i* at time *t.*

In order to support the first hypothesis, the estimate for the regression coefficient associated with changes in short interest should be negative and statistically significant (Woolridge & Dickinson, 1994).

Secondly, the impact of short interest ratio on the abnormal stock return was estimated:

$$AR_{it} = \alpha_i + \beta_1 SIR_{it} + \beta_2 \log(MC)_{it} + \mu_{it} \quad t = 1,2 \dots T\ months \tag{2}$$

where:

AR_{it} − abnormal return of stock *i* at time *t;*

α_i − the intercept regression coefficient;

β_1 − the regression coefficient associated with the short interest ratio variable for stock *i* at time *t;*

SIR_{it} − the short interest ratio for stock *i* at time *t*;

β_2 − the regression coefficient associated with the natural logarithm of marketable capitalization for stock *i* at time *t;*

$\log(MC)_{it}$ − the natural logarithm of marketable capitalization for stock *i* at time *t;*

μ_{it} − the regression error for stock *i* at time *t.*

In the second regression, the natural logarithm of marketable capitalization for each stock was added as a control variable. This variable was also used by Ackert and Athanassokos (2005) in their analysis, in which the Canadian market is investigated and a positive relation between the market capitalization and abnormal return was discovered. Later, Schindler (2015) introduced this variable in analysis of the relationship between the short interest ratio and abnormal returns for NASDAQ-100 companies. This author concluded that the marketable capitalization has a positive and statistically significant impact on the abnormal return.

In this case, it is expected that the estimates for the regression coefficient associated with the short interest ratio would be significantly smaller than zero (Woolridge & Dickinson, 1994).

As mentioned above, in order to analyze the impact of short selling, a panel data approach will be used. For the analysis at hand, there are two alternative ways to deal with differences among cross section units: the fixed effect model or the random effect model. The fixed effect model permits correlation between the individual effect and the explanatory variables, whilst the random effect model does not allow this correlation (Wooldridge, 2014).

In order to decide between the fixed and random effect models, the Hausman (1978) test was performed. The null hypothesis of this test is that the preferred model is random effect over the alternative fixed effect (Wooldridge, 2014). In addition to this test, the F-test and the Breusch-Pagan Lagrange multiplier (LM) will be performed in order to test for individual effects and random effects.

3.2. Estimators' Efficiency

In order to estimate equations 1 and 2, it is crucial to ensure that the estimators for regression parameters are unbiased and the most efficient (Wooldridge, 2014).

Therefore, it is necessary to specify which hypothesis need to hold in the Fixed Effect and Random Effect Regressions, in order to adequately test them for the model formulated as follows:

$$y_{it} = \alpha_i + \beta_1 x_{it1} + \cdots + \beta_k \mathrm{x}_{itk} + \mu_{it} \qquad t = 1,2 \ldots T \tag{3}$$

where:

β_j − are the unknown parameters and;

a_i − is the unobserved effect

According to Wooldridge (2014), the assumptions that need to hold for Fixed Effect estimation are:

1. Random Sampling of the cross-sectional observations;

2. Zero Conditional Mean, which means that for each *t*, the expected value of the error term u_{it} is zero for all the independent variables and the unobserved effect, such that:

$$E(u_{it} \,|X_i \,, a_i) = 0 \tag{4}$$

3. There is no perfect collinearity among the independent variables and each variable changes over time;

4. Homoscedasticity, which implies that the error term u_{it} has the same variance for any values the independent variables and the unobserved effect in all time periods, such that:

$$Var(u_{it}|X_i \,, a_i) = \sigma_\mu^2 \tag{5}$$

5. The idiosyncratic errors are serially uncorrelated, such that:

$$Cov(u_{it}|X_i, a_i) = 0 \quad (6)$$

6. The normality of errors, which mean that the u_{it} are independent of the independent variables and unobserved effect and identically distributed, such that:

$$\mu_{it} \sim Normal\ (0, \sigma^2) \quad (7)$$

In this case, if hypotheses 1 to 3 are verified, the fixed effect estimator is considered unbiased. Additionally, in case of validity of hypotheses 1 through 5, the fixed effects estimator is considered the best linear unbiased estimator (BLUE) (Wooldridge, 2014). Finally, the last hypothesis (6) is also referred by this author. This hypothesis assumes a normal distribution for the idiosyncratic errors (Wooldridge, 2014).

For the Random Effect estimation, the assumption 1 and 5 are also applicable. In addition to 1 and 5 there are other assumptions that need to hold:

7. There is no perfect collinearity among the independent variables;

8. Zero Conditional Mean and the expected value of α_i given all independent variables is constant as follows:

$$E(\alpha_i\ |X_i) = \beta_0 \quad (8)$$

9. In addition to Homoscedasticity, the variance of α_i given all independent variables is constant as follows:

$$Var(\alpha_i\ |X_i) = \sigma_\alpha^2 \quad (9)$$

Regarding the first two hypotheses, they can be assumed as verified and hence not violated. Despite this, the remaining hypotheses need to be tested. To test the validity of the hypothesis several tests were performed.

For the 3rd and 7th hypotheses, a Pearson Correlation Matrix was computed and analyzed. Furthermore, for the remaining hypotheses the following tests were considered: the Breusch -

Pagan (1979) test, the Pasaran CD (2004) test, the Breusch-Godfrey (1978) test, and the Jarque - Bera (1980) test.

The Breusch - Pagan (1979) is used to test for heteroskedasticity. This test is a Lagrange Multiplier test which verifies whether the square of the error term is related to one of the independent variables (Wooldridge, 2014). Therefore, the null hypothesis is homoskedastic errors, and if it is rejected the error conditional variance is not constant (Wooldridge, 2014).

The Pasaran CD (2004) test is used to test the residuals correlation across entities (cross-sectional dependence in panels). The null hypothesis in this case is that errors across entities are not correlated.

The Breusch-Godfrey (1978) test is used to test for serial correlation in panel models. In this case the null hypothesis is that there is no serial correlation.

The Jarque - Bera (1980) test is used to test the error's normality. It compares the skewness and kurtosis of the error's distribution with normal distributions. In this case, the skewness should be close to zero and kurtosis should tend to three. The null hypothesis is that the testing residuals are normally distributed (Jarque & Bera, 1980).

Finally, the Im, Pesaran and Shin (2003) proposed a test for the presence of unit root in panels. The null hypothesis of this test is that panels contain a unit root.

4. Data

In this section, the source of the data and the sample construction are described. Additionally, the summary statistics of the data will be provided.

4.1. Data Source and Sample Construction

To study the impact of the short selling on the stock market, it was necessary to collect short selling and stock data.

The data used in this analysis was gathered mainly from Bloomberg and represents monthly observations of the NASDAQ-100 from April 2010 to August 2019. The chosen timeline was based on the changes in the short sale regulation, so that the same short selling regulation would apply across the whole sample. For that reason, April 2010 was set as the initial date of the sample.

The data related with the short sale information was retrieved from Bloomberg and represents monthly short interest observations and monthly short interest ratios (SIR). The short interest data refers to the total short interest positions, which are reported twice a month, around the 15th business day of each month, and on the last business day of the month. The data obtained for this study corresponds to the observation from the last business day of the month. The short interest ratio, also known as "days-to-cover-ratio", represents how many days it will take short sellers to cover their positions. Bloomberg computes this ratio as follows:

$$SIR_{it} = \frac{Short\ Interest_{it}}{Average\ daily\ trading\ volume_{it}} \tag{10}$$

where:

SIR_{it} − the short interest ratio for stock *i* in time *t;*

$Short\ Interest_{it}$ − the total short interest position for stock *i* in time *t*;

$Average\ daily\ trading\ volume_{it}$ − the average number of shares traded in a day for stock *i* in time *t.*

Several studies, such as Asquith *et al. (*2005) and Desai *et al. (*2002), used the short interest ratio in their analysis; however, they used the total number of outstanding shares as their divider. This stabilization is important to compare shorting across stocks with different trading volumes. In this analysis, the divisor used is average daily trading volume, in order to capture short-term strategies (Boehmer & Wu, 2012).

Regarding the stock data, daily and monthly stock prices for NASDAQ-100 from April 2010 to August 2019 were used, as well as monthly current marketable capitalization. In addition, daily and monthly market prices of the S&P500 from April 2010 to August 2019 were used for return computations.

Finally, data on the monthly Treasury Bills was gathered from the Federal Reserve Economic Data from April 2010 to August 2019.

Prior literature examines the relationship between the short interest and the stock performance. Therefore, in order to investigate the short selling impact on the stock market several variables were constructed.

Firstly, it is necessary to compute the abnormal returns of stock *i* in time *t* compared to the benchmark S&P500. The abnormal return is obtained as the difference between each actual stock rate of return and the respective expected stock rate of return. This variable was used in several researches in order to assess the impact of short selling on the stock market (Asquith *et al.,* 2005). This variable is computed using the following formula:

$$AR_{it} = R_{it} - E(R)_{it} \tag{11}$$

where:

AR_{it} − the abnormal returns of stock *i* in time *t*;

R_{it} − the actual return of stock *i* in time *t*;

$E(R)_{it}$ − the expected stock return for stock *i* in time *t*.

In order to compute the abnormal return, two variables had to be constructed: the monthly stock rate of return and the monthly expected stock rate of return.

The monthly stock rates of return were computed using the monthly stock price data as follows:

$$R_{it} = \frac{P_{it}}{P_{it-1}} - 1 \tag{12}$$

where:

R_{it} – the actual return of stock *i* in time *t;*

P_{it} – the price for stock *i* in time *t*;

P_{it-1} – the price for stock *i* in time *t-1*.

The expected monthly return was computed based on the capital asset pricing model (CAPM) in order to account not only for market return, but also for underlying market conditions. The CAPM measures the relationships between the systematic risk and expected return:

$$E(R)_{it} = R_{ft} + \beta_{it}(R_{mt} - R_{ft}) \quad (13)$$

with:

$E(R)_{it}$ – the expected stock return for stock *i* in time *t;*

R_{ft} – the risk-free rate of return on the market at time *t;*

β_{it} – the beta of the stock *i* in month *t*;

R_{mt} – the monthly market rate of return, i.e. the S&P500 in month *t.*

The market rate of return was computed using a similar method as for the stock rate of return:

$$R_{mt} = \frac{P_{mt}}{P_{mt-1}} - 1 \quad (14)$$

where:

R_{mt} – the actual monthly market rate of return in time *t;*

P_{mt} – the market price in time *t*;

P_{mt-1} – the market price in time *t-1*.

To estimate the CAPM, the monthly United States' Treasury Bills were used as proxy for the risk-free interest rate. The beta for each stock on a monthly basis was calculated against the S&P500 benchmark using daily changes in closing prices. In order to calculate the beta of a stock, the covariance between the stock rate of return and the market rate of return was computed, as well as the variance of the market rate of return, according to the following formula:

$$\beta_{it} = \frac{cov(R_{it}, R_{mt})}{var(R_{mt})} \tag{15}$$

where:

β_{it} − the beta of the stock *i* in month *t*;

$cov(R_{it}, R_{mt})$ − the covariance of stock rate of return of the stock i and market rate of return in time *t*;

$var(R_{mt})$ − the variance of market rate of return in time *t*.

In this case, R_{mt} and R_{it} correspond to the daily market return and the stock rate of return, respectively. Since the goal is to compute the monthly stock beta, the data used to compute the covariance and variance shall be daily.

4.2. Summary statistics

The dataset used in this study includes information for 103 stocks of NASDAQ-100 from April 2010 to August 2019 (including time periods from *t*=5 to *t*=112).

The initial dataset was composed by N=11,097 observations, however the abnormal return showed extreme values for maximum and minimum statistics. Therefore, the data was corrected for outliers and another dataset was created, where outliers for the 1st and 99th percentile were removed. Additionally, stocks with time periods *t*<20 were removed from the sample, which included two stocks: FOX Class A common stock and FOX Class B common stock.

The descriptive statistics for the dataset after removing the outliers are presented in Table 4-1. This table contains information related to the number of observations (N), mean, standard deviation, and minimum and maximum values for each variable.

Table 4-1. *Descriptive Statistics (after removing outliers) for all the variables in dataset from April 2010 to August 2019*

Statistic	***N***	***Mean***	***St. Dev.***	***Min***	***Max***	***Kurtosis***	***Skewness***
$\boldsymbol{Market\_Cap_{it}}$	10,128	55,809.2	118,405.3	705.2	1,099,436	28.138	4.724
$\boldsymbol{SI_{it}}$	10,128	19,503,163	33,990,772	108,259	414,016,386	36.114	5.055
$\boldsymbol{SIR_{it}}$	10,128	4.2	3.7	0.2	44.1	13.783	2.682
$\boldsymbol{Rstock_{it}}$	10,128	1.7	7.8	-37.8	35.42	3.672	0.098
$\boldsymbol{Beta_{it}}$	10,128	1.1	0.7	-3.9	9.4	9.796	0.629
$\boldsymbol{ER_{it}}$	10,128	0.8	4.5	-30.8	28.9	6.007	-0.198
$\boldsymbol{AR_{it}}$	10,128	0.8	6.7	-18.6	23.9	3.544	0.17

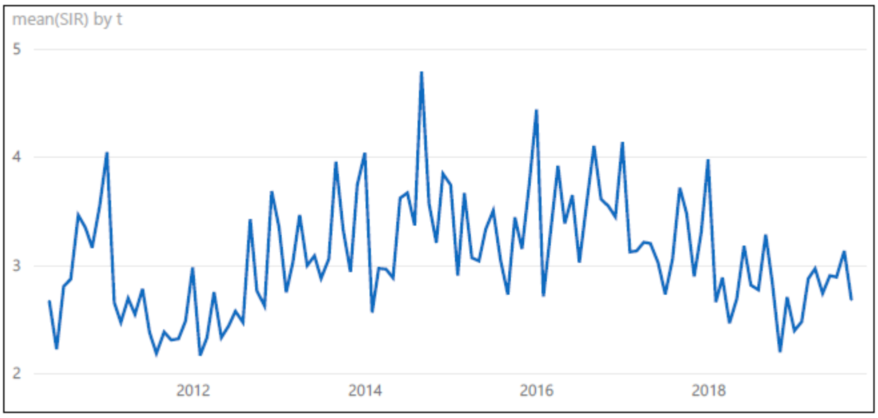
The final sample includes N=10,128 observations, with 101 stocks that includes time periods from *t*=20 to *t*=112 months.

The table shows that Abnormal Returns (AR_{it}) presents minimum and maximum values of – 18.6 percent and + 23.9 percent, respectively. The mean of this variable is of 0.8 percent and the standard deviation is 6.7 percent. The Rate Return of Stock ($Rstock_{it}$) has a minimum value of -37.8 and maximum 35.42 percent. The mean for this variable is 1.7 percent which is higher than the mean of abnormal rate of return (AR_{it}), implying that stocks between 2010 and 2019 have positive returns, on average. Additionally, the standard deviation, measure of volatility, is 7.8 percent. Furthermore, the skewness is positive for abnormal rate of return and stock rate of return and close to zero. Both empirical distributions show a high value of kurtosis, close but higher than 3, which indicates that the distribution is leptokurtic, a common stylized fact in empirical finance. Leptokurtic distributions are longer and have fatter tails when compared to the Normal distribution. Hence, we can reject the null hypothesis of normal distributed stock returns or abnormal returns (based on Jarque-Bera test presented in the following sections).

Regarding the independent variable, Table 4-1 reports that the Short Interest Ratio (SIR_{it}) ranges from +0.2 percent up to +44.1 percent. This variable shows positive skewness and high kurtosis of 13.794, which indicates that the distribution is highly leptokurtic, indicating that the data is not normally distributed. The standard deviation is 3.7 percent and the mean is 4.2 percent. These values are consistent with the values reported in previous literature. Desai *et al.* *(*2002), which focus their study in NASDAQ market from June 1988 to December 1994, concluded that the mean is increasing over time. This is consistent with the conclusion made by Angel et al. (2003), which examined the frequency of short selling on stocks from NASDAQ between September 2000 and December 2000, and showed that the mean of the percentage of short trades is of 2.36 percent, which is higher (1.14 percent) than the value presented by Desai *et al. (*2002). More recently, Schindler (2015) who also investigated NASDAQ-100 companies, reported a mean for SIR of 3.78 percent which is higher than the one reported previously. Therefore, it can be concluded that the mean is increasing over time.

The evolution of the short interest ratio's mean is presented in the Figure 4-1. It is observable in the graph that the mean of the SIR was increasing until the 2017, which is consistent with the information reported in the previous literature. Notwithstanding, it is possible to analyze that in the last two years the mean of SIR is decreasing.

Figure 4-1 *- The level of Short Interest Ratio (SIR) mean in period 2010-2019*

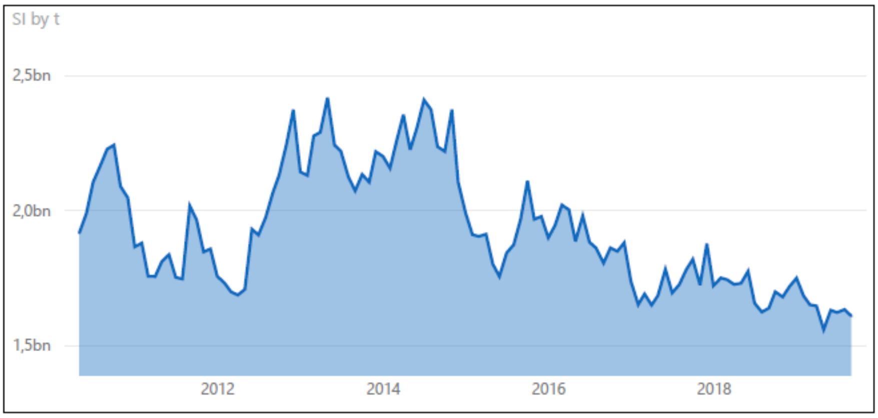


Finally, the maximum and the minimum values of the Marketable Capitalization ($Market\_Cap_{it}$) variable are of 1,099,436 million dollars and 705.2 million dollars, respectively. The mean for this variable is of 55,809.2 million dollars and the standard deviation is of 118,405.3 million dollars. This variable shows positive skewness and high kurtosis of 28.167, which indicates that the distribution is highly leptokurtic, thus indicating that the data is not normally distributed.

Furthermore, it is possible to take some conclusions from the descriptive statistics of other variables presented in the table. The beta's ($Beta_{it}$) mean is 1.1, which is higher than 1, suggesting that stocks' prices are more volatile than the market is. Additionally, the Short Interest (SI_{it}) variable shows a maximum and a minimum of 414,016,386 and 108,259 dollars, respectively. The mean of this variable is 19,503,163 and the standard deviation is 33,990,772 dollars.

The evolution of short selling activity, measured by short interest, is presented in Figure 4-2. The figure describes the evolution of aggregated short interest for stocks from NASDAQ - 100.

Figure 4-2 *- The short interest (SI) aggregated evolution of NASDAQ 100 from April 2010 to August 2019*



The analysis of this figure shows that short interest has been decreasing in past years. The maximum value of the short interest in NASDAQ 100 occurred on the 30th of April 2013, reaching 2,418 million dollars. This value is explained by the increase of Apple, since this stock accounted for the majority of the increase among the stocks. This analysis can be observed in the Annex 1. The minimum value was observed on 30th April 2019, reaching 1,561 million dollars. Apple, Micron Technology and Starbucks stocks had the largest decrease among stocks. This analysis can be observed in Annex 2.

The analysis of the correlation between the relevant variables for the model was conducted according to the Pearson correlation coefficient, presented in Table 4-2. This correlation was computed using the Pearson-method with pairwise-deletion.

Table 4-2 *- Pearson Correlation Matrix*

	AR_{it}	SIR_{it}	$Market\_Cap_{it}$	SI_{it}	$Rstock_{it}$
AR_{it}		0.022*	0.026**	0.013	0.816***
SIR_{it}	0.022*		-0.213***	0.131***	0.041***
$Market\_Cap_{it}$	0.026**	-0.213***		0.139***	0.015
SI_{it}	0.013	0.131***	0.139***		0.009
$Rstock_{it}$	0.816***	0.041***	0.015	0.009	

Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Computed correlation used Pearson-method with listwise-deletion.

According to the statistics, Abnormal Return (AR_{it}) is positively correlated to the Short Interest Ratio (SIR_{it}), with a correlation of 0.022; to the Marketable Capitalization ($Market\_Cap_{it}$), with a correlation of 0.026; to Short Interest (SI_{it}), with a correlation of 0.013; and to the Stock Return ($Rstock_{it}$), with a correlation of 0.816. Additionally, it is possible to conclude that correlation to the Short Interest Ratio (SIR_{it}), to the Marketable Capitalization ($Market\_Cap_{it}$) and to Stock Return ($Rstock_{it}$) are statistically significant since their p-value are lower than the 5% of significance level. In contrast, the correlation between the Abnormal Return (AR_{it}) and Short Interest Ratio (SIR_{it}) is not statistically significant, since its p-value is higher than the 5% of significance level. These results are conflicting with the previous literature, since it was expected that the correlation between the Short interest Ratio and Abnormal return would be negative.

Another conclusion that can be retrieved from Table 4-2 is that the correlation between the Short Interest Ratio (SIR_{it}) and Marketable Capitalization ($Market\_Cap_{it}$) is negative (-0.213) and statistically significant since its p-value is lower than the 5% of significance level. However, the correlation between Short Interest Ratio (SIR_{it}) and Stock Return ($Rstock_{it}$) is positive (0.041) and statistically significant. Additionally, the Marketable Capitalization ($Market\_Cap_{it}$) is positively correlated with Short Interest (SI_{it}), with a correlation of 0.139, which is statistically significant since its p-value is lower than the 5% of significance level. Regarding the Stock Rate of Return ($Rstock_{it}$), this variable is positively correlated with Marketable Capitalization ($Market\_Cap_{it}$), with a correlation of 0.015 and with Short Interest (SI_{it}), with a correlation of 0.009. Both of the mentioned correlations are not statistically significant since their p-value is higher than the 5% of significance level.

As the scale of the variables is so different, we decided to compute also the Spearman correlation coefficient, presented in Table 4-3. The results point for a weaker statistical significance of the correlation between the Abnormal Return (AR_{it}) and Marketable Capitalization ($Market\_Cap_{it}$). Additionally, several correlation coefficient changed but, the change is not substantial.

Table 4-3- *Spearman Correlation Matrix*

	AR_{it}	SIR_{it}	$Market\_Cap_{it}$	SI_{it}	$Rstock_{it}$
AR_{it}		0.024*	0.018 .	-0.013	0.803***
SIR_{it}	0.024*		-0.368***	0.244***	0.054***
$Market\_Cap_{it}$	0.018 .	-0.368***		0.154***	0.014
SI_{it}	-0.013	0.244***	0.154***		-0.011
$Rstock_{it}$	0.803***	0.054***	0.014	-0.011	

Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Computed correlation used Spearman-method with listwise-deletion.

5. Empirical results

In this section, the focus is on the analysis of the results of the estimated equations by interpreting the statistical model. Furthermore, the estimators' efficiency analysis is presented, in order to ensure that the data is suitable to be analyzed in the regression model.

5.1. Short Selling impact on Stock Returns

Firstly, in order to test the first hypothesis, it is necessary to estimate the equations (1) for the Pooled Model, the Fixed Effect Model and for the Random Effect Model. Afterwards, in order to decide between pooled, fixed or random effects, the Hausman (1978) test, the F-test and BP test were performed.

The results obtained are presented in Table 5-1:

Table 5-1*- Hausman Test (1978), F-test and BP test results for equation (1)*

	Test Statistic	**P-value**
Hausman Test (1978)	0.67827	0.4102
F - Test	0.84593	0.8641
BP - Test	2.1382	0.1437
Significance levels: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

From the result analysis, it is possible to conclude that the p-value associated to the Hausman (1978) test is higher than the significance level of 5% (Chiq=0.67827), which leads us to do not reject the null hypothesis. Hence, it can be concluded that the preferred model is the Random Effect Model based on the considered sample.

Regarding the F-test, its p-value is higher than the significance level of 5% (F=0.84593) and therefore we do not reject the null hypothesis. This leads us to conclude that the pooled effect is the preferred model.

Finally, regarding the BP-test, its p-value is higher than the significance level of 5% (Chiq=2.1382) and therefore we do not reject the null hypothesis. Here we conclude that random effect is not appropriate.

Based on the results presented above, it is possible to conclude that the chosen model is the Pooling Model for this regression.

In order to test our first hypothesis, the relation between the stock returns and changes in short position was analyzed, based on the Woolridge and Dickinson (1994) research. Therefore, it is expected that changes in short position are statistically significant with a negative impact on stock returns.

Since the chosen model is the Pooling Model, its results are presented in the table 5-2:

Table 5-2 – *Pooling Model estimation of the equation (1)*

Variable	**Coefficients**	**Std. Error**	**t-value**	**p-value**
(Intercept)	1.7044310	0.0774924	21. 9948	<2e-16 ***
SHORT	-0.0028158	0.0016998	-1.6565	0.09765 .
N			10128	
R-Squared			0.00027091	
Adj. R-Squared			0.00017218	
F-statistic(1,10126)	2.74401	**P-value**	0.097651 .	
Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

From the results displayed in table 5-2, it is possible to discern the major conclusion of this study. The p-value associated to the F- statistic is lower than the significance level of 10%, therefore we can reject the null hypothesis. So, the model in general is statistically significant. From the t-test, we can conclude that the estimate for the coefficient of SHORT variable is statistically significant.

The coefficient associated with SHORT variable has a p-value higher than the significance level of 10% (t-value=-1.6565), which leads us to reject the null hypothesis; it can thus be concluded that SHORT has an impact on the stock returns. Additionally, we can conclude that the coefficient value is - 0. 0028158; while this is not a very high value, it reveals that SHORT impacts the stock return negatively, since the coefficient is negative. Therefore, the model predicts that an increase in the SHORT would lead to an expected decrease in stock return of 0.0028158, *ceteris paribus*

This observation leads to the conclusion that our hypothesis does hold, since the variable has negative statistically significant impact.

Notwithstanding, the R-squared for this model is 0.027091%, which leads to the conclusion that the total variation in stock returns can only be explained by 0.027091% by the independent variable (short interest change).

Our findings are not consistent with the Woolridge and Dickinson (1994) research since they found a positive relation between the changes in short position and stock return. The difference in results compared to Woolridge and Dickinson (1994) may be caused by the different sample of companies but also by different short selling regulations. These authors based their analysis on a random sample of 50 companies from NASDAQ.

Note that the outputs extracted from R© for all the tests presented in this section are listed in the Annexes.

5.2. SIR impact on Abnormal Return

Concerning the second hypothesis, it was also required to estimate equation (2) for the Pooled Model, Fixed Effect Model and for the Random Effect Model. Afterwards, in order to decide between pooled, fixed or random effects, the Hausman (1978) test, the F-test and BP test were performed.

The results obtained are presented in Table 5-3:

Table 5-3- *Hausman Test (1978), F-test and BP test results for equation (2)*

	Test Statistic	**P-value**
Hausman Test (1978)	25.045	3.643e-06 ***
F - Test	1.5582	0.0003272***
BP Test	4.4046	0.03584*
Significance levels: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

From the results presented above, it can be concluded that the p-value associated to the Hausman (1978) test is below the 5% significance level, which leads us to reject the null hypothesis. Hence, we can conclude that the preferred model is the Fixed Effect Model based on the considered sample.

Regarding the F-test, its p-value is lower than the significance level of 5% (F=1.5582) and therefore we reject the null hypothesis. This leads us to conclude that the Fixed Effect is the preferred model.

Finally, regarding the BP-test, its p-value is lower than the significance level of 5% (Chiq=4.4046) and therefore we reject the null hypothesis. Here we conclude that Random Effect is the appropriate model.

Based on the results presented above, it is possible to conclude that the chosen model is the Fixed Effect Model for this regression.

In order to test our hypothesis, the short interest ratio is expected to be negatively related with abnormal return.

Regarding the market capitalization, it is expected to have a positive effect on abnormal returns, based on the Schindler (2015) conclusions. This author studied the short interest ratio impact on the abnormal returns, using companies from NASDAQ-100.

Since the chosen model is the Fixed Effect Model, the obtained results are presented in Table 5-4:

Table 5-4 *- Fixed Effect Model estimation of the equation (2)*

Variable	**Coefficients**	**Std. Error**	**t-value**	**p-value**
SIR	0.074335	0.024148	3.0783	0.002088 **
lm_MC	0.698077	0.118557	5.8881	4.031e-09 ***
N			10128	
R-Squared			0. 0038732	
Adj. R-Squared			-0. 006262	
F-statistic (2,10025)	19. 4899	**P-value**	3.5651e-09***	
Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

From the results shown in Table 5-4, it is possible to observe the major conclusion of this study. The p-value associated to the F-statistic is lower than the 5% significance level, therefore we can conclude that the null hypothesis is rejected. So, the model has at least one relevant explanatory variable. From the t-test, we can conclude that the estimates for both variables are statistically significant.

The coefficient associated with SIR variable has a p-value lower than the 5% significance level (t=3.0783), which leads us to reject the null hypothesis; it can thus be concluded that SIR has an impact on abnormal returns. Additionally, since the coefficient value is 0.074335, we can conclude that despite not being very impactful in terms of magnitude, SIR impacts the abnormal return positively, since the coefficient is positive. This observation leads to the conclusion that our hypothesis does not hold and therefore the SIR is not negatively related to abnormal return. Therefore, the model predicts that an increase in the SIR would lead to an expected increase in abnormal return of 0.074335, *ceteris paribus.*

The coefficient associated with the ln_MC variable has a p-value lower than the 5% significance level (t=5.8881), which leads us to reject the null hypothesis; it can thus be concluded that market capitalization has an impact on abnormal returns. Additionally, since the estimate for the coefficient is 0.698077, we can conclude that marketable capitalization impacts the abnormal return positively, since the coefficient is positive. Therefore, the model predicts that a one percent increase in the marketable capitalization would lead to an expected increase in abnormal return of 0.00698077 points, *ceteris paribus*. This conclusion is consistent with the Schindler (2015) study, who investigated the NASDAQ 100 companies. Moreover, Ackert and Athanassokos (2005) examined this relation in the Canadian Market and also found a positive statistically significant impact of marketable capitalization on abnormal returns.

Notwithstanding, the R-squared for this model is 0.38732%, which leads to the conclusion that the total variation in abnormal returns can only be explained by 0.3873% by the independent variables (short interest ratio and market capitalization).

Our findings are not consistent with the previous literature, considering that Desai *et al. (*2002) and Asquith *et al. (*2005) showed that high SIR stocks have abnormal negative returns. However, both studies were performed with data subject to different regulations and before the financial crisis.

In contrast, when comparing these results with more recent empirical evidence, it is possible to conclude that our findings are consistent with the conclusions presented by the Schindler (2015). They found a positive relationship between short interest ratio and abnormal returns for NASDAQ 100 companies.

Note that the outputs extracted from R© for all the tests displayed in this section are listed in the Annexes.

5.2.1. Evaluation of conditions under econometric models

As discussed previously, in order to estimate equation (1) and (2) it is important to ensure that the parameters are unbiased and the most efficient (Wooldridge, 2014). To prove that, it is necessary to test hypotheses 3 to 9, discussed in the section above.

To test the hypothesis of no perfect collinearity, the Pearson Correlation Matrix was computed; it is presented in Table 5-2. The matrix reveals that correlations between the variables are lower than 0.8 in absolute value, therefore it can be concluded that the variables do not suffer from multicollinearity. The only exception is the correlation between abnormal return and stock rate of return, which is not unexpected considering that these variables are closely related. Therefore, it can be concluded that there is no perfect collinearity among the independent variables.

To test if the errors are heteroskedastic and if they follow a normal distribution, the Breusch -Pagan (1979) and the Jarque-Bera (1980) tests were computed; the results obtained are presented in Table 5-5. Additionally, the Pesaran's CD and Breusch–Pagan's LM tests were performed in order to test whether residuals are correlated across entities in panel.

Finally, in order to test if there is serial correlation and unit root, the Breusch-Godfrey (1978) and Im, Pesaran and Shin (2003) tests were performed.

The obtained tests results for the equation (1) are presented in Table 5-5:

Table 5-5 *- Breusch - Pagan (1979), Jarque - Bera (1980), Pasaran CD (2004), Breusch–Pagan's LM ,Breusch-Godfrey (1978) and Im, Pesaran and Shin (2003) tests results for equation (1)*

	Test Statistic	**P-value**
Breusch-Pagan test (1979)	5.1029	0.02389*
Jarque - Bera (1980) – Rstock	207.01	2.2e-16***
Jarque - Bera (1980) – SHORT	895	2.2e-16***
Pesaran CD test (2004)	208.59	2.2e-16***
Breusch–Pagan's LM test (1979)	52465	2.2e-16***
Breusch-Godfrey test (1978)	73.596	2.2e-16***
Im, Pesaran and Shin test (2003) – Rstock	-5.5035	0.01**
Im, Pesaran and Shin test (2003) – SHORT	-5.9849	0.01**
Significance levels: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

From the results shown in Table 5-5, it is observable that the p-value associated to the Breusch-Pagan test is lower than the 5% significance level (t=5.1029), which leads us to reject the null hypothesis. Therefore, we can reject the hypothesis that the regression's errors are homoscedastic. Notwithstanding, violation of this hypothesis does not imply that the estimated parameters are inconsistent or biased. In this case, it is important to use robust standard error; still, it is necessary to compute other tests beforehand in order to decide which method to use.

Regarding the Jarque-Bera test, its p-value is below the 5% of significance level and therefore we can reject the null hypothesis of normally distributed errors. This test result was expected since the skewness and kurtosis previously computed are considerably high for each variable. Albeit we rejected this hypothesis, we can proceed with statistical inference, since we have a very large sample (N=10,128 observations). The assumption that the estimators can be considered as asymptotically normally distributed can be made under the Central Limit Theorem.

Regarding the Pesaran CD (2004) test, its p-value is lower than the 5% of significance level (t=208.59) and therefore we can reject the null hypothesis that errors across entities are not correlated. The p-value associated to the Breusch–Pagan's LM test (1979) is lower than 5% of significance level (t=52465), and therefore this leads us to also reject the null hypothesis. This can lead to the conclusion that we have contemporaneous correlation and therefore, it is important to use robust standard error.

The p-value associated to the Breusch-Godfrey (1978) test is lower than 5% of significance level (t=159.9), and therefore this leads us to reject the null hypothesis. We can conclude that there is serial correlation in the panel model.

Finally, regarding the Im, Pesaran and Shin test (2003), its p-value is lower than the 5% of significance level and therefore we can reject the null hypothesis of a unit root. Therefore, it is possible to conclude that $Rstock_{it}$ and $SHORT_{it}$ are stationary.

It is possible to conclude that there is heteroscedasticity, contemporaneous correlation and serial correlation in the panel model, therefore it is necessary to use robust standard errors to correct these problems.

To do that, the Beck and Katz Robust Covariance Matrix Estimators, as proposed by Beck and Katz (1995), were used. This correction is known as Panel Corrected Standard Errors (PCSE) and corrects these problems, while also enabling the calculation of the standard errors suitable for statistical inference.

Table 5-6 *- Pooled Model estimation with robust standard errors for equation (1).*

Variable	**Coefficients**	**Std. Error**	**t-value**	**p-value**
(Intercept)	1.7044310	0.0688344	24.761	<2e-16 ***
SHORT	-0.0028158	0.0017620	-1.598	0.1101

Significance levels: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

After correcting the heteroscedasticity and residual correlation, the results obtained are presented in Table 5-6. The first conclusion to be inferred from these results is that the estimate for the parameter is exactly the same as the one obtained without robust standard errors. However, its standard error is now higher, reaching values of 0.0017620. However, it can also be concluded that estimate for the variable is no longer statistically significant, as the p-values associated to the tests is higher than 10% significance level. Therefore, the null hypothesis is not rejected.

To summarize, the parameters are unbiased and consistent, and their standard errors are consistent.

The same tests were applied to our second equation and the obtained tests results for the equation (2) are presented in Table 5-7:

Table 5-7 *- Breusch - Pagan (1979), Jarque - Bera (1980), Pasaran CD (2004), Breusch–Pagan's LM, Breusch-Godfrey (1978) and Im, Pesaran and Shin (2003) tests results for equation (2)*

	Test Statistic	**P-value**
Breusch-Pagan test (1979)	218.89	2.2e-16***
Jarque - Bera (1980) – AR	173.66	2.2e-16***
Jarque - Bera (1980) – SIR	61212	2.2e-16***
Jarque - Bera (1980) – ln_MC	780.79	2.2e-16***
Pesaran CD test (2004)	25.696	2.2e-16***
Breusch–Pagan's LM test (1979)	8400.7	2.2e-16***
Breusch-Godfrey test (1978)	3.974	0.1371
Im, Pesaran and Shin test (2003) – AR	-5.5319	0.01*
Im, Pesaran and Shin test (2003) – SIR	-2.8626	0.01*
Significance levels: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

From the results shown in Table 5-7, it is observable that the p-value associated to the Breusch-Pagan test is lower than the 5% significance level (t=218.89), which leads us to reject the null hypothesis. Therefore, we can reject the hypothesis that the regression's errors are homoscedastic. Notwithstanding, violation of this hypothesis does not imply that the estimated parameters are inconsistent or biased. In this case, it is important to use robust standard error; still, it is necessary to compute other tests beforehand in order to decide which method to use.

Regarding the Jarque-Bera test, its p-value is below the 5% significance level and therefore we can reject the null hypothesis of normally distributed errors. This test result was expected since the skewness and kurtosis previously computed are considerably high for each variable. Albeit we rejected this hypothesis, we can proceed with statistical inference, since we have a very large sample (N=10,128 observations). The assumption that the estimators can be considered as asymptotically normally distributed can be made under the Central Limit Theorem.

Regarding the Pesaran CD (2004) test, its p-value is lower than the 5% significance level (t=25.696) and therefore we can reject the null hypothesis that errors across entities are not correlated. The p-value associated to the Breusch–Pagan's LM test (1979) is lower than 5% of significance level (t=8400.7), and therefore this leads us to also reject the null hypothesis This can lead the conclusion that we have contemporaneous correlation and therefore, it is important to use robust standard error.

The p-value associated to the Breusch-Godfrey (1978) test is higher than 5% of significance level (t=3.974), and therefore we cannot reject the null hypothesis. We can conclude that there is no serial correlation in the panel model.

Finally, regarding the Im, Pesaran and Shin test (2003), its p-value is lower than the 5% of significance level and therefore we can reject the null hypothesis of a unit root. Therefore, it is possible to conclude that AR_{it} and SIR_{it} are stationary.

Since the hypotheses 1 to 3 are verified, the fixed effect estimator is considered unbiased. However, since there is heteroscedasticity and contemporaneous correlation, it is necessary to use robust standard errors to correct both problems.

To do that, the Beck and Katz Robust Covariance Matrix Estimators, as proposed by Beck and Katz (1995), were used. This correction is known as Panel Corrected Standard Errors (PCSE) and corrects both problems, while also enabling the calculation of the standard errors suitable for statistical inference.

Table 5-8 *- Fixed Effect Model estimation with robust standard errors for equation (2).*

Variable	Coefficients	Std. Error	t-value	p-value
SIR	0.074335	0.025591	2.9047	0.003684 **
lm_MC	0.698077	0.151475	4.6085	4.105e-06 ***

Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

After correcting the heteroscedasticity and residual correlation, the results obtained are presented in Table 5-8. The first conclusion to be inferred from these results is that the estimates for the parameters are exactly the same as the ones obtained without robust standard errors. However, their standard errors are now higher, reaching values of 0.025591 and 0.151475 for SIR and ln_MC, respectively. However, it can also be concluded that estimates for both variables are still statistically significant, as the p-values associated to both tests are lower than 5% significance level. Therefore, the null hypothesis is rejected for both the parameters.

To summarize, the parameters are unbiased and consistent, and their standard errors are consistent.

Note that the outputs extracted from R© for all the tests presented in this section are listed in the Annexes.

5.3. Short Interest Ratio during 2018-2019

It was also deemed useful to analyze a sub-period of our data, specifically for the dates between January 2018 and August 2019. The US stock market has been exceptionally volatile in the past two years. Therefore, the analysis for this sub-period can lead us to reach different conclusions regarding the relation between the short interest ratio and abnormal return.

The equation to estimate is the following:

$$AR_{it} = \alpha_i + \beta_1 SIR_{it} + \beta_2 \log(MC)_{it} + \mu_{it} \qquad t = 1,2 \ldots T \qquad (16)$$

where:

AR_{it} − the abnormal return of stock i at time t;

α_i − the intercept regression coefficient;

β_1 − the regression coefficient associated with the short interest ratio variable for stock i at time t;

SIR_{it} − the short interest ratio for stock i at time t;

β_2 − the regression coefficient associated with the natural logarithm of marketable capitalization for stock i at time t;

$\log(MC)_{it}$ − the natural logarithm of marketable capitalization for stock i at time t;

μ_{it} − the regression error for stock i at time t.

The data set used in this study includes information for 101 stocks of NASDAQ-100 from January 2018 to August 2019 (including time periods from t=16 to t=20). In this case, the number of observations is N= 1,978.

Concerning this hypothesis, it was required to estimate equation (16) for the Pooled Model, Fixed Effect Model and for the Random Effect Model. Afterwards, in order to decide between pooled, fixed or random effects, the Hausman (1978) test, the F-test and BP test were performed.

The results obtained are presented in Table 5-9:

Table 5-9 *- Hausman Test (1978), F-test and BP-test results for equation (16)*

	Test Statistic	**P-value**
Hausman Test (1978)	50.021	1.374e-11***
F - Test	1.6286	0.0001253***
BP-Test	0.50229	0.4785
Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1		

From the results presented above, it can be concluded that the p-value associated to the Hausman (1978) test is below the 5% significance level, which leads us to reject the null hypothesis. Hence, we can conclude that the preferred model is the Fixed Effect Model based on the considered sample.

Regarding the F-test, its p-value is lower than the significance level of 5% (F=1.6286) and therefore we reject the null hypothesis. This leads us to conclude that the Fixed Effect is the preferred model.

Finally, regarding the BP-test, its p-value is higher than the significance level of 5% (Chiq=0.50229) and therefore we do not reject the null hypothesis. Here we conclude that Random Effect is not appropriate model.

Based on the results presented above, it is possible to conclude that the chosen model is the Fixed Effect Model for this regression.

The sub-period analysis is shown in Table 5-10:

Table 5-10 *- Fixed Effect Model estimation of the equation (16)*

Variable	**Coefficients**	**Std. Error**	**t-value**	**p-value**
SIR	0.32359	0.10707	3.0224	0.002542 **
lm_MC	6.19489	0.90906	6.8146	1.27e-11 ***
N			1978	
R-Squared			0.029099	
Adj. R-Squared			-0.023718	
F-statistic (2, 1875)	28.0982	**P-value**	9.4714e-13***	
Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1				

From the results shown in Table 5-10 it is possible to observe that p-value associated to the F statistic is lower than the 5% significance level, therefore the model has at least one estimated coefficient that is statistically significant.

The coefficient associated with SIR variable has a p-value lower than the 5% significance level (t=3.0224), which leads us to conclude that SIR has an impact on the abnormal returns. Additionally, we can observe that the estimated value for the coefficient value 0.32359, which is higher comparing with the estimation made for the full sample. This coefficient reveals that SIR impacts the abnormal return positively. Therefore, our hypothesis also does not hold for the subsample.

The coefficient associated with ln_MC variable has a p-value lower than the 5% significance level (t=6.8149), which leads us to conclude that market capitalization has an impact on the abnormal returns. Additionally, we can observe that the estimated value for the coefficient is 6.19489, thus revealing that marketable capitalization impacts the abnormal return positively. This value is higher in comparison with the coefficient estimated for the whole sample.

The R-squared for this model is 2.9099%, which is higher than the one estimated for the whole sample.

When analyzing a subsample from January 2018 to August 2019 it can be observed that in the last two years, the SIR has had a positive and higher impact when compared with the estimation for the full sample.

The sub-period was also tested for the hypotheses described in the previous section. The obtained results are presented in the Table 5-11.

Table 5-11 *- Breusch - Pagan (1979), Jarque - Bera (1980), Pasaran CD (2004), Breusch–Pagan's LM, and Wooldridge's tests results for equation (16).*

	Test Statistic	**P-value**
Breusch-Pagan test (1979)	39.784	2.296e-09***
Jarque - Bera (1980) – AR	9.4897	0.008696**
Jarque - Bera (1980) – SIR	8019.4	2.2e-16***
Jarque - Bera (1980) – lm_MC	595.17	2.2e-16***
Pesaran CD test (2004)	3.7961	0.000147***
Breusch–Pagan's LM test (1979)	6280.3	2.2e-16***
Wooldridge's test	0.93073	0.3348
Significance levels: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

From the table above, two problems can be pinpointed in the subsample: the regression's residuals are heteroscedastic and there is contemporaneous correlation. The conclusions obtained for the model for the full sample remain applicable to the sub-period analysis.

To correct heteroscedasticity and contemporaneous correlation, the Beck and Katz Robust Covariance Matrix Estimators, as proposed by Beck and Katz (1995), were used. The obtained results are presented below:

Table 5-12 *- Fixed Effect Model estimation with robust standard errors for equation (16).*

Variable	Coefficients	Std. Error	t-value	p-value
SIR	0.32359	0.10829	2.9883	0.002842 **
lm_MC	6.19489	1.01367	6.1114	1.198e-09***

Significance levels: ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

After the correction presented in Table 5-12, it can be concluded that the coefficients remain unchanged, and standard errors are now higher.

Note that the outputs extracted from R© for all the tests presented in this section are listed in the Annexes.

6. Conclusion

Short selling is an important mechanism in the financial markets which activity has been increasing over the past years. Despites the popularity this strategy has as high borrowing costs and other risks associated. Therefore, there is a considerable amount of literature that discuss the impact of short selling on the financial markets. Most of the empirical evidence has controversial conclusions. The main criticism of short selling is that it is responsible for declines in market as well as in individual security prices. In this sense, this study aims to empirically investigate the impact of short selling in the financial markets, more specifically the impact of short selling on stock returns.

For instance, Senchack and Starks (1993) and Wooldridge and Dickinson (1994) studied the relation between the changes in short interest and stock returns. Senchack and Starks (1993) found that a change in short selling has a negative impact on the stock prices. Contrary, Wooldridge and Dickinson (1994) did not find a negative relationship between monthly stock returns and monthly changes in short interest. Other empirical evidence investigated the relation between short interest and abnormal stock returns in NASDAQ (Desai *et al.*, 2002, Schindler, 2015). In this case, there is also controversial results. Desai et al. (2002) showed that SIR has a negative abnormal return, while Schindler (2015) point for a positive relationship between the short interest ratio and abnormal return.

Hence, our analysis includes the estimation of both methods. To do this, we used a monthly unbalanced panel for 101 stocks listed in NASDAQ-100 from March 2010 to August 2019.

Firstly, we investigated the relationship between the changes in short interest and stock returns following Wooldridge and Dickinson (1994) approach. In this case, we applied a pooled model regression.

The results obtained from this analysis point for a negative relationship between the short interest changes and the stock returns. However, we did not find a statistically significant effect of changes in short interest position in stock returns. It can be concluded that the hypothesis that states that short selling has a negative effect on stock prices does not hold.

Our findings are not consistent with the Woolridge and Dickinson (1994) research since they found a positive relation between the changes in short position and stock return. However, this study was performed with data subject to different regulation and for a different sample of companies. These authors based their analysis on a random sample of 50 companies from NASDAQ.

Afterwards, we analyzed the short interest ratio impact on the abnormal returns. In this case, the Fixed Effect Model was applied and a control variable vas introduced – natural logarithm of Marketable Capitalization.

From the obtained results it was possible to retrieve two different conclusions. Firstly, we observed a statistically significant impact of short interest ratio on the abnormal returns. Nevertheless, our findings suggest that short interest ratio impacts abnormal returns positively. Secondly, the marketable capitalization impacts the abnormal return positively.

From this, it can be assumed that the hypothesis which states that short selling negatively influences abnormal stock returns does not hold.

Our findings are not consistent with the recent previous literature, considering that Desai et al. (2002) and Asquith et al. (2005) showed that high SIR stocks have abnormal negative returns. However, both studies were performed with data subject to different regulations, before the financial crisis and using different sample of companies. Conversely, these findings are consistent with the results indicated by the Schindler (2015), who investigated the relation between the short interest ratio and abnormal return for NASDAQ-100 companies. This author reported a statistically significant positive relation. Regarding the marketable capitalization, the positive statistically significant relation is consistent with previous literature. This conclusion is consistent with the Schindler (2015) and Ackert and Athanassokos (2005) who studied this relation in the Canadian Market and also found a positive statistically significant impact of marketable capitalization on abnormal returns.

Finally, since the US stock market has been exceptionally volatile in the past two years, we analyzed the last estimation for sub-period of our data, specifically for the dates between January 2018 and August 2019. The obtained results support the conclusion from previous estimation. In this case, it can be observed that in the last two years, the SIR has had a positive and higher impact when compared with the estimation for the full sample.

By analyzing all the results it is possible to conclude that short selling interest do not have a negative impact on the stock returns. This study provides a relevant contribution to the finance literature, since it allows to clarify empirical results and provides recent data analysis. This is important in order to take into account recent short selling regulations that can have impact on the obtained results.

Accordingly, there are several limitations that can be highlighted in this study. Firstly, it is important to note that the R-Squared statistics for all the models are very low. This is consistent with the previous literature (Woolridge and Dickinson, 1994 and Schindler, 2015), but it can be concluded that significance of these models is minor. Second limitation of this study is the short interest monthly data. Since, short interest data is published twice a month, on the 15^{th} of the month and at the end of the month, it can impact the results. Finally, this analysis was performed taking into account the short selling regulation that may impact the obtained results. Therefore, it is advised to future research analyze the short selling impact under different short selling regulations. For that it would be necessary to estimate the regression for different periods, to have an overview of the impacts of these regulations.

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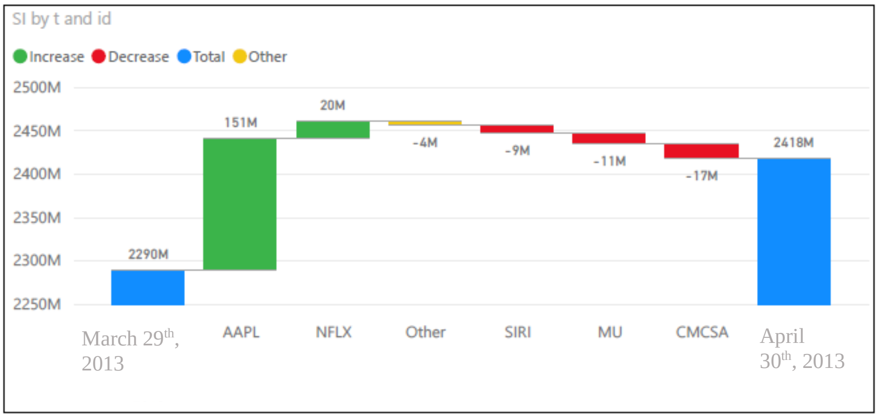
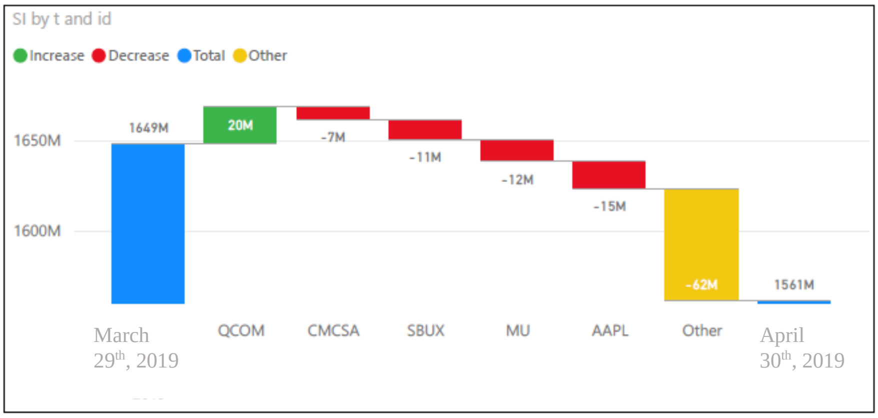
7. Annexes

Annex 1 - Impact of stocks in the global increase of SI (April 30th, 2013)



Annex 2- Impact of stocks in the global decrease of SI (April 30th, 2019)



Annex 3 – Pearson Correlation Matrix - Output from R

	AR	*SIR*	*Current_M*	*SI*	*Rstock*
AR		0.022 *(.026)*	0.026 *(.009)*	0.013 *(.193)*	0.816 *(<.001)*
SIR	0.022 *(.026)*		-0.213 *(<.001)*	0.131 *(<.001)*	0.041 *(<.001)*
Current_M	0.026 *(.009)*	-0.213 *(<.001)*		0.139 *(<.001)*	0.015 *(.135)*
SI	0.013 *(.193)*	0.131 *(<.001)*	0.139 *(<.001)*		0.009 *(.348)*
Rstock	0.816 *(<.001)*	0.041 *(<.001)*	0.015 *(.135)*	0.009 *(.348)*	

Computed correlation used Pearson-method with listwise-deletion.

Annex 4 – Spearman Correlation Matrix - Output from R

	AR	*SIR*	*Current_M*	*SI*	*Rstock*
AR		0.024 *(.016)*	0.018 *(.077)*	-0.013 *(.184)*	0.803 *(<.001)*
SIR	0.024 *(.016)*		-0.368 *(<.001)*	0.244 *(<.001)*	0.054 *(<.001)*
Current_M	0.018 *(.077)*	-0.368 *(<.001)*		0.154 *(<.001)*	0.014 *(.147)*
SI	-0.013 *(.184)*	0.244 *(<.001)*	0.154 *(<.001)*		-0.011 *(.255)*
Rstock	0.803 *(<.001)*	0.054 *(<.001)*	0.014 *(.147)*	-0.011 *(.255)*	

Computed correlation used Spearman-method with listwise-deletion.

Annex 5 - Pooling Model Estimation for equation (1) - Output from R

```
Pooling Model

Call:
plm(formula = Rstock ~ SHORT, data = pdatana, model = "pooling",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 20-112, N = 10128

Residuals:
    Min.  1st Qu.   Median  3rd Qu.     Max.
-39.3583  -4.8505  -0.1829   4.8303  33.7193

Coefficients:
              Estimate Std. Error t-value Pr(>|t|)
(Intercept)  1.7044310  0.0774924 21.9948  < 2e-16 ***
SHORT       -0.0028158  0.0016998 -1.6565  0.09765 .
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares:    614330
Residual Sum of Squares: 614160
R-Squared:      0.00027091
Adj. R-Squared: 0.00017218
F-statistic: 2.74401 on 1 and 10126 DF, p-value: 0.097651
```

Annex 6 - Fixed Effect Model Estimation for equation (1) - Output from R

```
Oneway (individual) effect Within Model

Call:
plm(formula = Rstock ~ SHORT, data = pdatana, model = "within",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 20-112, N = 10128

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-38.357821  -4.861453  -0.041704   4.784689  32.767881

Coefficients:
        Estimate Std. Error t-value Pr(>|t|)
SHORT -0.0026589  0.0017105 -1.5545   0.1201

Total Sum of Squares:    609170
Residual Sum of Squares: 609020
R-Squared:      0.00024095
Adj. R-Squared: -0.0098304
F-statistic: 2.41639 on 1 and 10026 DF, p-value: 0.1201
```

Annex 7- Random Effect Model Estimation for equation (1) - Output from R

```
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = Rstock ~ SHORT, data = pdatana, model = "random",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 20-112, N = 10128

Effects:
                 var std.dev share
idiosyncratic 60.744   7.794     1
individual     0.000   0.000     0
theta:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
      0       0       0       0       0       0

Residuals:
    Min.  1st Qu.   Median  3rd Qu.     Max.
-39.3583  -4.8505  -0.1829   4.8303  33.7193

Coefficients:
              Estimate Std. Error z-value Pr(>|z|)
(Intercept)  1.7044310  0.0774924 21.9948  < 2e-16 ***
SHORT       -0.0028158  0.0016998 -1.6565  0.09762 .
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    614330
Residual Sum of Squares: 614160
R-Squared:      0.00027091
Adj. R-Squared: 0.00017218
Chisq: 2.74401 on 1 DF, p-value: 0.09762
```

Annex 8- Hausman Test (1978) for equation (1) - Output from R

```
Hausman Test

data:  Rstock ~ SHORT
chisq = 0.67827, df = 1, p-value = 0.4102
alternative hypothesis: one model is inconsistent
```

Annex 9- F-test for equation (1) - Output from R

```
F test for individual effects

data:  Rstock ~ SHORT
F = 0.84593, df1 = 100, df2 = 10026, p-value = 0.8641
alternative hypothesis: significant effects
```

Annex 10 - Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels for equation (1) - Output from R

```
Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels

data:  Rstock ~ SHORT
chisq = 2.1382, df = 1, p-value = 0.1437
alternative hypothesis: significant effects
```

Annex 11- Breusch-Pagan LM test for cross-sectional dependence in panels for equation (1) - Output from R

```
Breusch-Pagan LM test for cross-sectional dependence in panels

data:  Rstock ~ SHORT
chisq = 52465, df = 5050, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence
```

Annex 12- Pesaran CD test for cross-sectional dependence in panels for equation (1) - Output from R

```
Pesaran CD test for cross-sectional dependence in panels

data:  Rstock ~ SHORT
z = 208.59, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence
```

Annex 13- Breusch-Godfrey/Wooldridge test for serial correlation in panel models for equation (1) - Output from R

```
Breusch-Godfrey/Wooldridge test for serial correlation in panel
models

data:  Rstock ~ SHORT
chisq = 73.596, df = 2, p-value < 2.2e-16
alternative hypothesis: serial correlation in idiosyncratic errors
```

Annex 14- Jarque Bera Test for Rstock - Output from R

```
Jarque Bera Test

data:  pdatana$Rstock
X-squared = 207.01, df = 2, p-value < 2.2e-16
```

Annex 15- Jarque Bera Test for SHORT- Output from R

```
Jarque Bera Test

data:  pdatana$SHORT
X-squared = 8952836802, df = 2, p-value < 2.2e-16
```

Annex 16- Pesaran's CIPS test for unit roots for Rstock - Output from R

```
Pesaran's CIPS test for unit roots

data:  pdatana$Rstock
CIPS test = -5.5035, lag order = 2, p-value = 0.01
alternative hypothesis: Stationarity
```

Annex 17- Pesaran's CIPS test for unit roots for SHORT- Output from R

```
Pesaran's CIPS test for unit roots

data:  pdatana$SHORT
CIPS test = -5.9849, lag order = 2, p-value = 0.01
alternative hypothesis: Stationarity
```

Annex 18- Breusch-Pagan test for equation (1) - Output from R

```
Breusch-Pagan test

data:  pool1
BP = 5.1029, df = 1, p-value = 0.02389
```

Annex 19- Pooled Model estimation with robust standard errors for equation (1) - Output from R

```
t test of coefficients:

              Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.7044310  0.0688344  24.761   <2e-16 ***
SHORT       -0.0028158  0.0017620  -1.598   0.1101
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Annex 20 - Pooling Model Estimation for equation (2) - Output from R

```
Pooling Model

Call:
plm(formula = AR ~ SIR + lm_MC, data = pdatana, model = "pooling",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 20-112, N = 10128

Residuals:
    Min.  1st Qu.   Median  3rd Qu.     Max.
-19.2905  -4.1635  -0.1502   3.9198  23.3671

Coefficients:
             Estimate Std. Error t-value Pr(>|t|)
(Intercept) -1.133580   0.640037 -1.7711  0.07657 .
SIR          0.060072   0.019169  3.1338  0.00173 **
lm_MC        0.172650   0.059956  2.8796  0.00399 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    449150
Residual Sum of Squares: 448570
R-Squared:      0.0013075
Adj. R-Squared: 0.0011102
F-statistic: 6.6279 on 2 and 10125 DF, p-value: 0.0013287
```

Annex 21 - Fixed Effect Model Estimation for equation (2) - Output from R

```
Oneway (individual) effect Within Model

Call:
plm(formula = AR ~ SIR + lm_MC, data = pdatana, model = "within",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 20-112, N = 10128

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-21.361835  -4.115447  -0.093871   3.851466  24.365785

Coefficients:
      Estimate Std. Error t-value  Pr(>|t|)
SIR   0.074335   0.024148  3.0783  0.002088 **
lm_MC 0.698077   0.118557  5.8881 4.031e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    443420
Residual Sum of Squares: 441700
R-Squared:      0.0038732
Adj. R-Squared: -0.006262
F-statistic: 19.4899 on 2 and 10025 DF, p-value: 3.5651e-09
```

Annex 22 - Random Effect Model Estimation for equation (2) - Output from R

```
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = AR ~ SIR + lm_MC, data = pdatana, model = "random",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 20-112, N = 10128

Effects:
                  var std.dev share
idiosyncratic 44.0601  6.6378 0.997
individual     0.1392  0.3731 0.003
theta:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.03017 0.13448 0.13956 0.13285 0.14056 0.14056

Residuals:
    Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
-19.3480  -4.1649  -0.1354   0.0015   3.9206  23.5303

Coefficients:
             Estimate Std. Error z-value Pr(>|z|)
(Intercept) -1.514461   0.700069 -2.1633 0.030518 *
SIR          0.063463   0.020110  3.1558 0.001600 **
lm_MC        0.208792   0.065855  3.1705 0.001522 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    447800
Residual Sum of Squares: 447160
R-Squared:      0.0014378
Adj. R-Squared: 0.0012405
Chisq: 14.5734 on 2 DF, p-value: 0.00068457
```

Annex 23 - Hausman Test (1978) for equation (2) - Output from R

```
Hausman Test

data:  AR ~ SIR + lm_MC
chisq = 25.045, df = 2, p-value = 3.643e-06
alternative hypothesis: one model is inconsistent
```

Annex 24- F-test for equation (2) - Output from R

```
F test for individual effects

data:  AR ~ SIR + lm_MC
F = 1.5582, df1 = 100, df2 = 10025, p-value = 0.0003272
alternative hypothesis: significant effects
```

Annex 25- Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels for equation (2) - Output from R

```
Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels

data:  AR ~ SIR + lm_MC
chisq = 4.4046, df = 1, p-value = 0.03584
alternative hypothesis: significant effects
```

Annex 26 - The Breusch-Pagan LM test for cross-sectional dependence in panels for equation (2) - Output from R

```
Breusch-Pagan LM test for cross-sectional dependence in panels

data:  AR ~ SIR + lm_MC
chisq = 8400.7, df = 5050, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence
```

Annex 27 - Pesaran CD test for cross-sectional dependence in panels for equation (2) - Output from R

```
Pesaran CD test for cross-sectional dependence in panels

data:  AR ~ SIR + lm_MC
z = 25.696, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence
```

Annex 28 - The Breusch-Godfrey/Wooldridge test for serial correlation in panel models for equation (2) - Output from R

```
Breusch-Godfrey/Wooldridge test for serial correlation in panel
models

data:  AR ~ SIR + lm_MC
chisq = 3.974, df = 2, p-value = 0.1371
alternative hypothesis: serial correlation in idiosyncratic errors
```

Annex 29 - The Jarque Bera Test for AR - Output from R

```
Jarque Bera Test

data:  pdatana$AR
X-squared = 173.66, df = 2, p-value < 2.2e-16
```

Annex 30 - The Jarque Bera Test for SIR - Output from R

```
Jarque Bera Test

data:  pdatana$SIR
X-squared = 61212, df = 2, p-value < 2.2e-16
```

Annex 31 - The Jarque Bera Test for ln_MC - Output from R

```
Jarque Bera Test

data:  pdatana$lm_MC
X-squared = 780.79, df = 2, p-value < 2.2e-16
```

Annex 32 - The Pesaran's CIPS test for unit roots for AR - Output from R

```
Pesaran's CIPS test for unit roots

data:  pdatana$AR
CIPS test = -5.5319, lag order = 2, p-value = 0.01
alternative hypothesis: Stationarity
```

Annex 33 - The Pesaran's CIPS test for unit roots for SIR - Output from R

```
Pesaran's CIPS test for unit roots

data:  pdatana$SIR
CIPS test = -2.8626, lag order = 2, p-value = 0.01
alternative hypothesis: Stationarity
```

Annex 34 - The Breusch-Pagan test for equation (2) - Output from R

```
Breusch-Pagan test

data:  FE
BP = 218.89, df = 2, p-value < 2.2e-16
```

Annex 35 - Fixed Effect Model estimation with robust standard errors for equation (2) - Output from R

```
t test of coefficients:

      Estimate Std. Error t value  Pr(>|t|)
SIR   0.074100   0.025583  2.8965  0.003782 **
lm_MC 0.698823   0.151460  4.6139 4.001e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Annex 36- Pooling Model Estimation for equation (16) - Output from R

```
Pooling Model

Call:
plm(formula = AR ~ SIR + lm_MC, data = pdatana1, model = "pooling",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 16-20, N = 1978

Residuals:
     Min.   1st Qu.    Median   3rd Qu.      Max.
-20.70148  -4.08006   0.16656   4.15813  21.45449

Coefficients:
             Estimate Std. Error t-value Pr(>|t|)
(Intercept) -4.842655   1.698793 -2.8506 0.004408 **
SIR          0.076970   0.061643  1.2486 0.211946
lm_MC        0.491967   0.150971  3.2587 0.001138 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    86554
Residual Sum of Squares: 86090
R-Squared:      0.0053541
Adj. R-Squared: 0.0043468
F-statistic: 5.3156 on 2 and 1975 DF, p-value: 0.0049849
```

Annex 37- Fixed Effect Model Estimation for equation (16) - Output from R

```
Oneway (individual) effect Within Model

Call:
plm(formula = AR ~ SIR + lm_MC, data = pdatana1, model = "within",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 16-20, N = 1978

Residuals:
      Min.    1st Qu.     Median    3rd Qu.       Max.
-21.300250  -3.936222  -0.041321   3.928887  21.386993

Coefficients:
      Estimate Std. Error t-value Pr(>|t|)
SIR    0.32359    0.10707  3.0224 0.002542 **
lm_MC  6.19489    0.90906  6.8146 1.27e-11 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    81584
Residual Sum of Squares: 79210
R-Squared:      0.029099
Adj. R-Squared: -0.023718
F-statistic: 28.0982 on 2 and 1875 DF, p-value: 9.4714e-13
```

Annex 38 - Random Effect Model Estimation for equation (16) - Output from R

```
Oneway (individual) effect Random Effect Model
   (Swamy-Arora's transformation)

Call:
plm(formula = AR ~ SIR + lm_MC, data = pdatana1, model = "random",
    index = c("id", "date"))

Unbalanced Panel: n = 101, T = 16-20, N = 1978

Effects:
                  var std.dev share
idiosyncratic 42.2453  6.4996 0.993
individual     0.3162  0.5624 0.007
theta:
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
0.05499 0.06738 0.06738 0.06621 0.06738 0.06738

Residuals:
    Min.  1st Qu.   Median     Mean  3rd Qu.     Max.
-20.6641  -4.0788   0.1723  -0.0006   4.1687  21.4103

Coefficients:
             Estimate Std. Error z-value Pr(>|z|)
(Intercept) -5.209878   1.800769 -2.8931 0.003814 **
SIR          0.090991   0.064279  1.4156 0.156901
lm_MC        0.522097   0.160357  3.2558 0.001131 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Total Sum of Squares:    85933
Residual Sum of Squares: 85469
R-Squared:      0.0054019
Adj. R-Squared: 0.0043948
Chisq: 10.7267 on 2 DF, p-value: 0.0046851
```

Annex 39 - Hausman Test (1978) for equation (16) - Output from R

```
Hausman Test

data:  AR ~ SIR + lm_MC
chisq = 50.021, df = 2, p-value = 1.374e-11
alternative hypothesis: one model is inconsistent
```

Annex 40- F-test for equation (16) - Output from R

```
F test for individual effects

data:  AR ~ SIR + lm_MC
F = 1.6286, df1 = 100, df2 = 1875, p-value = 0.0001253
alternative hypothesis: significant effects
```

Annex 41- Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced panels for equation (16) - Output from R

```
Lagrange Multiplier Test - (Breusch-Pagan) for unbalanced
      panels

data:  AR ~ SIR + lm_MC
chisq = 0.50229, df = 1, p-value = 0.4785
alternative hypothesis: significant effects
```

Annex 42 - The Breusch-Pagan LM test for cross-sectional dependence in panels for equation (16) - Output from R

```
Breusch-Pagan LM test for cross-sectional dependence in panels

data:  AR ~ SIR + lm_MC
chisq = 6280.3, df = 5050, p-value < 2.2e-16
alternative hypothesis: cross-sectional dependence
```

Annex 43 - Pesaran CD test for cross-sectional dependence in panels for equation (16) - Output from R

```
Pesaran CD test for cross-sectional dependence in panels

data:  AR ~ SIR + lm_MC
z = 3.7961, p-value = 0.000147
alternative hypothesis: cross-sectional dependence
```

Annex 44 - The Wooldridge's test for serial correlation in FE panels for equation (16) - Output from R

```
Wooldridge's test for serial correlation in FE panels


data:  FE2
F = 0.93073, df1 = 1, df2 = 1875, p-value = 0.3348
alternative hypothesis: serial correlation
```

Annex 45 - The Jarque Bera Test for AR - Output from R

```
Jarque Bera Test


data:  pdatana1$AR
X-squared = 9.4897, df = 2, p-value = 0.008696
```

Annex 46 - The Jarque Bera Test for SIR - Output from R

```
Jarque Bera Test


data:  pdatana1$SIR
X-squared = 8019.4, df = 2, p-value < 2.2e-16
```

Annex 47 - The Jarque Bera Test for ln_MC - Output from R

```
Jarque Bera Test


data:  pdatana1$lm_MC
X-squared = 595.17, df = 2, p-value < 2.2e-16
```

Annexe 48 - The Breusch-Pagan test for equation (16) - Output from R

```
Breusch-Pagan test


data:  FE2
BP = 39.784, df = 2, p-value = 2.296e-09
```

Annexe 49 - Fixed Effect Model estimation with robust standard errors for equation (16) - Output from R

```
t test of coefficients:


      Estimate Std. Error t value  Pr(>|t|)
SIR    0.32359    0.10829  2.9883  0.002842 **
lm_MC  6.19489    1.01367  6.1114 1.198e-09 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```