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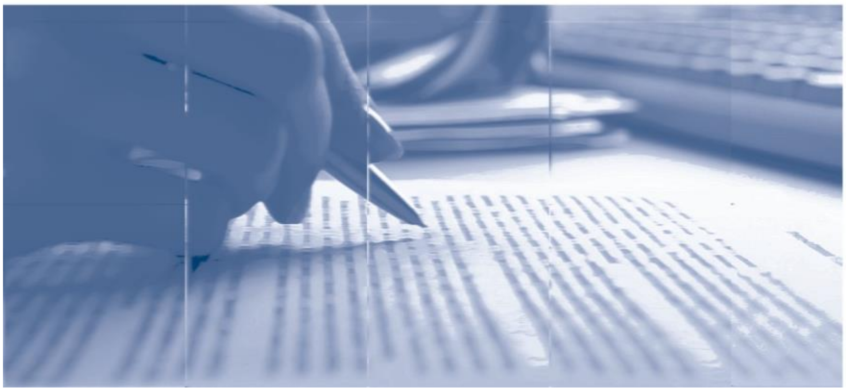

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The Cost of Shorting, Asymmetric Performance Reaction and the Price Response to Economic Shocks

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Abstract

The Working Papers should not be reported as representing the views of the Banco Central do Brasil. The views expressed in the papers are those of the author(s) and do not necessarily reflect those of the Banco Central do Brasil.

We propose and test a model of asymmetric performance-based arbitrage. While short arbitrageurs are forced to reduce their positions after a negative return, positive returns have no immediate effect on their managed funds. This price reaction is bounded by short-selling costs, because while short selling activity may generate overshooting, transaction costs may keep it limited. This paper empirically tests model predictions using Brazilian short-selling data. We show that there is an overshooting after good news for highly shorted stocks, but it is offset by trading and shorting costs indicating that short selling bans may be unnecessary to smooth market conditions. We also find support to the behavioral feature of our model that suggests that arbitrageurs behave asymmetrically to the types of news.

Keywords: Short-selling, performance-based arbitrage, price overshooting, short covering.
JEL Classification: G11, G12, G14

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1 Introduction

Regulators and the general public frequently associate short selling to increasing market volatility and amplifying panic. As noted by the preamble of European Union Regulation (No 236/2012): "*At the height of the financial crisis in September 2008, competent authorities in several Member States and supervisory authorities in third countries such as the United States of America and Japan adopted emergency measures to restrict or ban short selling in some or all securities. They acted due to concerns that at a time of considerable financial instability, short selling could aggravate the downward spiral in the prices of shares, notably in financial institutions, in a way which could ultimately threaten their viability and create systemic risks*." On the other hand, theoretical papers highlight the importance of short sales for a well-functioning market (Bris et al., 2007).

In this paper, we examine the impact of short selling in the stock market focusing on how the presence of arbitrageurs and the costs associated to short-selling impact the price sensitivity to news on the fundamentals of an asset. We propose a model combining features of two well-known models of the arbitrage[1] literature. As in Diamond and Verrechia (1987), we acknowledge the effect of short-sale constraints in the price adjustment; and we build on the Shleifer and Vishny (1997) model, by taking into consideration that arbitrageurs might have to close out their positions when faced with risk management issues. We also test empirically the propositions of the model using a data set of daily data from the Brazilian stock market.

Short sellers can be arbitrageurs, market makers, risk managers, inside traders, or mere speculators (D'Avolio, 2002) who borrow a security at a cost and later return the same number of shares to the lender. Rational investors sell a security at a price hoping to later repurchase it at a lower price.

When short volumes are high, future abnormal returns are negative indicating that short sellers are informed traders (Asquith et al., 2005 and Boehmer et al., 2008). Additionally, previous studies suggest that short sellers trade in anticipation of public information such as earning announcements (Cristophe et al, 2004) or revelation of

[1] In this literature, arbitrage is not risk-free, but means prices have some kind of distortion.

financial misrepresentation (Karpoff and Lou, 2010). The information advantage also manifests in the form of superior ability to process information (Engelberg et al., 2012).

Arbitrageurs can signal the equilibrium price of a stock by providing liquidity (Grossman and Miller, 1988). Diamond and Verrechia (1987) propose a model where informed traders observe identical private information and uniformed traders observe only public information. In this model, the market maker observes all trades that take place. Changing the constraints on short selling affects the information available to the market maker and reduces the number of trades because only those with the greatest anticipated benefits will pay to short sell.

Market frictions may prevent short sellers from driving prices to equilibrium. For example, if informed rational speculators receive good news about a stock, their trade will induce positive feedback trades and impact the price of the stock overshooting the effect of the news (de Long et al, 1990). Additionally, when investors have different access to new information, the amount of overreaction will be inversely related to the speed that information is processed. This allows arbitrageurs to take momentum strategies exploring short-term underreaction and leads the price to overreact in the longer horizon (Hong and Stein, 1999). In this paper, we are particularly interested in two aspects that may prevent the arbitrageur to implement optimal strategies: the resolution of information about the strategy of other speculators and the constraints on the short-selling activity.

Most of the times, arbitrage positions are externally funded, being financed by investors, and not risk free. Arbitrage can be limited when there are leverage constraints and/or agency problems arising from delegated portfolio management. Shleifer and Vishny (1997) proposes the so-called performance-based arbitrage (PBA) where capital is allocated based on past returns, in opposition to conventional arbitrage where capital is allocated according to expected returns, which in this case is related to the magnitude of the arbitrage opportunity. In this case, when the price temporarily deviates from the bet that arbitrageurs have taken, risk management or financial constraints possibly impose their exit of the market, and when they are forced to liquidate the position, prices are driven further away from equilibrium, triggering extreme variations (Kyle and Xiong, 2001).

The effects of a complete ban on short selling are discussed by Miller (1977). The author notes that uncertainty implies heterogeneous beliefs from investors and points that banning short selling removes pessimists from the market, generating an asymmetry between pessimists and optimists, leaving space for a positive bias on prices. In fact, recent work has suggested that short sale constraints can be a direct cause of bubbles and extreme volatility (Abreu and Brunnermeier, 2003). The theoretical model of Diamond and Verrecchia (1987) shows that short selling constraints may slow down price adjustments to information. Using short-selling costs as a proxy for constraints, Reed (2002) finds that larger price reactions occur when short selling is more expensive and that the adjustment of price to private information takes longer. Additionally, increased risks to the short selling activity are associated to less price efficiency (Engelberg et al., 2013). These findings are contradictory to the belief among regulators that short sales constraints can stabilize the market.

Additional empirical papers also find short sales constraints lead to greater overvaluation in stocks (Pontiff, 1996, Danielsen and Sorescu 2001, Jones and Lamont, 2002). Hirshleifer et al., 2011) found empirical evidence of a relationship between short arbitrage and accruals anomaly, and conclude that short-sale constraints limit arbitrage effectiveness. Alternatively, few studies diverge about the effect of short-selling constraints on the returns of stocks. Bris et al. (2007) use data from 46 equity markets, and country specific data on policies regarding short selling to study the impact of short sales restrictions on the efficiency of the market and find that the returns of stocks become more negatively skewed when short selling constrains are relaxed. Hurtado-Sanchez (1978) did not find any influence of borrowing costs in future returns, however, the author finds that the performance of the stocks was directly related to the borrowing rates on the following month.

This paper adds to the literature that focuses on the effects of arbitrageurs in transmitting fundamental shocks. Earnings announcements reveal information on the cash flow of the firm that was previously unavailable. Analysts covering specific stocks try to anticipate this news, providing forecasts on the earnings. After earning announcements, abnormal returns are positively correlated to the difference between actual and forecasted earnings. However, this reaction is not instantaneous. Ball and Brown (1968) and several other papers show that there is a post-earnings abnormal drift anomaly persists for periods of up to one year.

Accounting for the possibility of short-covering increasing price movements, Hong et al (2012) extend the model proposed by Shleifer and Vishny (1997). In their model, arbitrageurs could amplify mispricing induced by noise traders because their ability to hold short positions depend on stock prices and good news might generate short covering trades causing an overshooting on prices. Using data from the United States, they show that the price sensitivity to earnings surprises is higher for stocks that are relatively more shorted. Additionally, they show that after positive earnings surprises, highly shorted stocks experience a subsequent negative excess return when compared to stocks with a low short interest ratio. Data collection issues limit their study, as there is no readily available US data for the short interest ratio on a daily basis. Without access to these elements, one of their predictions cannot be directly tested.

Our model blends costly arbitrage and an asymmetric performance-based arbitrage. Our costly arbitrage argument comes from Pontiff (1996), which extends the idea of conventional arbitrage, and proposes that some mispricing may remain due to the transactions costs incurred on arbitrage operations. We argue that the performance-based arbitrage proposed by Shleifer and Vishny (1997) is asymmetric in the short-run. Negative returns may trigger margin calls, stop-loss or other risk-management mechanisms, which will force or induce a reduction (or even closing) of the position in the short-run. However, it is not clear whether positive returns would bring new money to the same position in the short-run. We could even imagine investors bringing new money later, but the manager would not necessarily invest in the same trade. For this reason, we consider an asymmetric performance-based arbitrage.

Although we are dealing with the assumption of asymmetric PBA, that usually takes into consideration past returns, we also believe that the expected return (or the size of the arbitrage opportunity) is an important element. In fact, we note that what is truly relevant is the expected net return, or the size of the arbitrage after discounting transaction costs. This is the essence of the costly arbitrage argument. Therefore, our model put together costly arbitrage and asymmetric PBA to describe the dynamics of arbitrageur positions.

With these assumptions, we follow Hong et al (2012) and consider the case of over-optimistic noise traders pushing prices above the fundamental expected value of the asset, and arbitrageurs engaging in short selling. When the true asset value reveals good news, some arbitrageurs may be forced to close short positions (short covering), pushing prices even further from fundamental value. As in Hong et al (2012), our model predicts a price overshooting following good news for highly shorted stocks. However, we consider those arbitrageurs that are not forced to close out their positions will limit deviation of prices from fundamentals. Short selling costs are negatively correlated to the returns of the underlying stock (Engelberg et al., 2013). If the gap between price and fundamental is higher than arbitrage costs, arbitrage will become profitable even after trading costs and so price goes back until the gap reverts to arbitrage cost value. Thus, in our model the extent of overshooting is bounded by costs of arbitrage, which is not present in Hong et al (2012) model. We show some empirical evidence that costly arbitrage fits not only our data, but also the results from Hong et al (2012).

Another distinctive aspect of our model is the relative power of arbitrageurs and noise traders. We assume that, after uncertainty is resolved with a bad news, arbitrageurs keep their positions, while noise traders mostly retreat from the market. This means that the relative power of noise traders against arbitrageurs disappear after a bad news is released. This feature of the model is especially suitable to emerging markets, where fundamental uncertainty is high, and the percentage of individual investors is low compared to developed markets.

Our paper also adds to the empirical literature by interacting the short selling activity and short selling costs, or constraints. We consider that if on one hand short selling activity generates the overshooting, on the other hand it may limit it. If investors could short stocks without costs, our model would not predict any overshooting. In fact, short-sellers would offset the optimistic sentiment after fundamental uncertainty is resolved. However, in the presence of costs, the amount that they are willing to short is lesser and the returns from shorting are smoothed by the costs that they have to incur.

In the United States short selling is usually conducted over-the-counter and data about the short interest is published by exchanges on a biweekly basis only[2]. Some proprietary databases were also used, but with data from specific custodians. Recently, it became available a database with short-selling information coming from a pool of

[2] For instance, Proposition 2 of Hong et al. (2012) could not be tested exactly because the authors only had access to monthly data.

contributors. In any case, daily and precise data from the whole market is still an issue.

We test our model using a daily database of short selling activity and fees published by the Brazilian exchange BM&F Bovespa[3]. In Brazil, regulation requires that all lending contracts are registered and centrally cleared. This data accounts for the whole domestic Brazilian stock lending market. Since 2011, the Brazilian Exchange releases the number of stocks lent and lending fees on a daily basis for each stock. Taking into consideration aspects such as daily volume traded and using only one stock for each company, we have approximately 200 stocks in our universe of analysis. Using this data, we are able to directly test all of our predictions and, as such, we are finally able to directly test the proposition from Hong et al. (2012) that the change in the shorted interest ratio is negatively associated to the earnings surprises. The Brazilian short-selling data was used before in papers that evaluate if short sellers are informed as in Chague et al. (2013, 2014).

This paper also contributes to the current asset pricing literature by empirically testing how frictions in the arbitrage affect the prices of stocks and suggesting a channel through which highly shorted stocks generate future negative returns. We show that, after good news, there is an overshooting for highly shorted stocks, as in Hong et al. (2012). Nevertheless, this overshooting is offset by trading and shorting costs, providing empirical evidence that costly arbitrage limits overshooting. We also find support to a unique behavioral feature of our model that suggests that arbitrageurs behave asymmetrically according to the type of news. While good news trigger short covering, short selling is not increased by bad news.

The paper proceeds as follows: on section 2, we present our model of short selling activity in the presence of constraints. The dataset of daily data from the Brazilian stock market is presented on section 3 and the empirical findings are presented on section 4. We conclude on section 5.

2 A model with costly arbitrage and asymmetric reaction to performance

This paper presents a simple three-period model based on Hong et al. (2012) and Shleifer and Vishny (1997). We also consider the case of arbitrageurs shorting a stock overpriced by noise traders demand. As in Hong et al (2012) and Shleifer and Vishny

[3] *Bolsa de Valores, Mercadorias & Futuros de São Paulo*: Brazilian stock exchange.

(1997), our model represent arbitrageurs being forced to cut back on positions due to risk management constraints or margin calls, and thus leading to amplification of the price reaction to positive earnings shock. However, this price reaction is bounded by short arbitrage trading costs.

A single risky asset is available in unit net supply. Three dates are numbered 0, 1, and 2. At date 2, the asset is liquidated with payoff *v*, which could take on the value v_L or v_H with equal chance. At date 1, the value of *v* is announced to all. We denote the price at time *t* by p_t. A risk-free asset, with fully elastic supply, pays a zero interest rate.

We have three types of agents: noise traders, arbitrageurs and long-term investors, who will be the stock lending suppliers. The noise traders are optimistic and overestimate the fundamental payoff *v* by an amount $S > 0$ at time 0. Depending on the nature of the earnings announcement, this optimism could widen to a $S(v_H) > S$ or narrow to $S(v_L)<S$ at time 1, but disappears completely by time 2.

The aggregate noise trader demands, in number of shares, at time 0 and 1 are given by, respectively:

$$\boldsymbol{Q_0^N = \frac{E_0[v] + S}{p_0} = \frac{(1/2)v_L + (1/2)v_H + S}{p_0}} \qquad 2.1$$

$$\boldsymbol{Q_1^N = \frac{E_1[v] + S}{p_1} = \frac{v + S(v)}{p_1}} \qquad 2.2$$

Arbitrageurs undertake short positions that partially offset noise traders demand, and we consider the case in which their resources in the first period, given by F_0, are insufficient to bring prices to fundamental value. However, resources on the second period, F_1 (v), will be enough to bring prices almost to fundamental value, except for trading costs. This is an important difference from our model and the one in Hong et al (2012).

Arbitrageurs determine how much they will invest at time 0 ($D_0 < F_0$) and the remainder is invested in cash, as a precaution against running out of funds at time 1, and yields a zero net return. The initial aggregate arbitrageurs demand is given by:

$$\boldsymbol{Q_0^A = -\frac{D_0}{p_0}} \qquad 2.3$$

With $D_0 < F_0 < S$

At time 1, all uncertainty regarding *v* has been resolved and arbitrageurs take the maximum possible short position, so that their demand is:

$$\boldsymbol{Q_1^A = -\frac{F_1}{p_1}} \qquad 2.4$$

with $F_1 < S(v)$.

Due to the unit net supply assumption; the short demand of speculators in this model is also the short ratio or the ratio of shares shorted to total shares outstanding.

Long-term investors are supposed to hold stocks in the long-run so that their stock holdings is constant in all periods regardless of the outcome of *v*, therefore, their demand is zero for each period. However, they will act as lenders of the stocks for the arbitrageurs, who must borrow the stock before selling[4]. The short selling cost is exogenous, and defined as a percentage C_t of the number of stocks borrowed, where *t* is the initial period of the leasing.

The dynamics of arbitrageurs resources will asymmetric depend on past performance. If past returns are negative, arbitrageurs will be forced to reduce their positions on the short arbitrage. However, if past returns are positive, position on the short arbitrage will remain stable. Arbitrageurs position at time t = 1 is given by:

$$\boldsymbol{F_1 = F_0 + 1_{v_H} a D_0 R_0 + \gamma(p_1 - v - C_1 p_1) 1_{p_1 - v > C_1 p_1}} \qquad 2.5$$

Where R_0 is the percentage total return of arbitrageurs from time 0 to time 1; a > 1 is the sensitivity of flows to past positive returns, and 1_{v_H} is one for good news and zero for bad news.

The first term of equation (2.5) is simply the initial stock of resources. The second term of equation (2.5) assumes an asymmetric reaction behavior to good and bad news. If news are good arbitrageurs will suffer losses and then due to leverage their resources will be reduced. On the other hand, if news are bad, arbitrageurs will experience gains, and in this case their resources will remain stable from time 0 to time 1. This asymmetric reaction is in contrast with traditional papers like Shleifer and Vishiny (1997) and Hong et al.

[4] Thus, naked short–selling is not considered.

(2012) that consider the symmetric case where arbitrageurs invest more money after a past good return and withdraw money from the strategy after past negative returns. This behavior can be justified by two types of argument: a) leverage constrains and automatic risk management rules; or b) positive feedback behavior by outside investors and overconfidence by the manager. This first is typically a short-term process, and mainly mandatory, forced and immediate. Obviously this only happen after past negative returns, and this is the reason of our asymmetric response. The second type of argument is that outside investors withdraw resources after bad news and invest more after good news. We believe this is not a short-term behavior. And even if this happens, arbitrageurs and managers will not necessarily invest new money in the same strategy[5]. On the contrary, they may engage in profit taking on that strategy, and then initiate position in another asset with new money. Therefore, again asymmetric behavior can be justified.

The third term of equation (2.5) represents the fact that arbitrage strategies usually start with the identification of an arbitrage opportunity, and that the higher is the price-fundamental gap, the larger is the flow. This is also a novel feature of our model. The arbitrage opportunity exists if the price-fundamental gap is higher than the trading costs, i.e., if $(p_1 - v) > C_1 p_1$. And the inflow associated to this opportunity is proportional to the size of the opportunity$\big((p_1 - v) - C_1 p_1\big)$, being γ the proportionality constant.

The arbitrageurs percentage net return R_0 is the raw return arising from the change in price return from time 0 to time 1 minus the cost of short selling C_t at time t = 0, expressed as a percentage of the stock price. Since C_0 is expressed as a percentage of the quantity, we need to convert it to percentage of price by multiplying by (p_1/p_0). Therefore the net return of short selling is:

$$\boldsymbol{R_0} = \left(\mathbf{1} - \frac{\boldsymbol{p_1}}{\boldsymbol{p_0}}\right) - \left(\boldsymbol{C_0}\frac{\boldsymbol{p_1}}{\boldsymbol{p_0}}\right) = \mathbf{1} - \frac{\boldsymbol{p_1}}{\boldsymbol{p_0}}(\mathbf{1} + \boldsymbol{C_0}) \qquad 2.6$$

Note that this is different from Hong et al. (2012) as they do not consider cost of short selling and thus in their model C_0 is equal to zero.

At time t = 2, price comes back to its fundamental value *v*. Market clearing conditions for each time t ensure that aggregate demand is equal to unit supply:

[5] This would be consistent with an arbitrageur that had his esteem elevated after a good return, become overconfident on that strategy, and so increase the bet.

$$\boldsymbol{Q_t^N + Q_t^A = 1} \qquad 2.7$$

Now we can solve for the asset prices at time t = 0 and t = 1. Price at time zero is given by the expected value of *v* plus noise traders optimism, minus arbitrageurs' counteracting:

$$\boldsymbol{p_0 = (1/2)v_L + (1/2)v_H + S - D_0} \qquad 2.8$$

The equilibrium price at time one can be found by equating supply and demand at time one.

Thus, substituting equations (2.2) and (2.4) in equation (2.7) for time t = 1, and then solving for p_1:

$$\boldsymbol{p_1 = v + S(v) - F_1} \qquad 2.9$$

Substituting the formula for F_1 on equation (2.5) into equation (2.9) above will give us the equilibrium price at time t = 1:

$$\boldsymbol{p_1 = \frac{v\left(1 + \gamma \times 1_{p_1 - v > C_1 p_1}\right) + S(v) - F_0 - 1_{v_H} a D_0}{\left[1 - \left(1_{v_H} \frac{a D_0}{p_0}(1 + C_0) - (1 - C_1)\gamma 1_{p_1 - v > C_1 p_1}\right)\right]}} \qquad 2.10$$

Note that if we have bad news equation 10 would be the following:

$$\boldsymbol{p_1 = \frac{v_L + S(v_L) - F_0}{1}} \qquad 2.11$$

Note that the amount of noise traders resources will decrease from *S* to some $S(v_L) < S$. Assuming that $S(v_L) < F$, i.e., that noise traders dramatically reduce their position after a negative return, we will have a price p_1 on time 1 that is below the fundamental value *v*. As the price on time 2 converges to the fundamental value, we will have a positive return from time 1 to time 2 in the case of bad news and shorted stocks. Note that the short covering will happens from time 1 to time 2 as arbitrageurs engage in profit taking.

We have the following four propositions coming from our theoretical model.

Proposition 1: the short ratio will decrease immediately after a positive earnings surprise (short covering process), but will remain stable after a negative earnings surprise.

This proposition is equivalent for our model to proposition 2 of Hong et al. (2012). The difference is that we are considering an asymmetric behavior where the short ratio decreases after good news, with arbitrageurs being forced to close their short positions in the short run, but they do not change their position after bad news. So we keep the amplifying mechanism caused by short covering.

Proposition 2: If sentiment increases proportionally with unexpected positive earnings news, then, for highly shorted stocks, the buying pressure from short covering could push the price to above fundamental value in the short run, and the expected raw return to shorting is higher after a good earnings surprise, but the net return depends on the cost of shorting fees.

This proposition is equivalent to proposition 3 of Hong et al. (2012). The difference is that we make a distinction between the raw return (price return plus dividends) and the net return, which would be the raw return minus the short selling fee. So it may be the case that short selling costs will offset the (positive) price return.

Proposition 3: If sentiment increases proportionally with unexpected positive earnings news, then, for highly shorted stocks, the expected raw return to shorting is bounded by shorting costs.

This proposition comes from the costly arbitrage feature of our model. The raw return cannot be larger than short selling costs, otherwise arbitrageurs would have a positive net return. Therefore, price mismatch will survive as long as shorting fees and other trading costs make the **net** profit of arbitrage negative.

Proposition 4: If sentiment decreases (or ceases) with unexpected bad earnings news, the price could fall to a value under the fundamental value in the short run, and the expected raw return to buying is higher after a bad earnings surprise, since the profit taking behavior will bring prices back to fundamentals in the long run.

3 Short selling data from Brazil

The Brazilian market has some distinctive differences from mature markets. First, as an emerging market, it has more uncertainty and consequently higher volatility. Also, it has a lower participation of individual investors. So, on one hand arbitrageurs are threatened by higher uncertainty, but on the other hand the relative participation of noise traders is lower. We are not concerned with this feature of the Brazilian market because we are considering the relative reaction of shorted stocks. Another key difference on Brazilian market is that short selling is based on exchange-based contracts, which cannot be early terminated by lenders. Therefore, unlike US markets, there is no risk that short-selling fee will increase during the contract. Engelberg et al. (2013) discuss the nature of this short-selling risk. In Brazil, when early termination is possible, only the borrower has this right. This makes the contract less risky for the short-seller and gives more relevance for our results.

Our sample includes quarterly observations of stocks listed on the BM&F Bovespa exchange from 2011 to 2013. For liquidity purposes, we consider only stocks that are present in two indices: BM&F Bovespa small caps or BM&F mid large caps. These indices combine stocks that represent roughly 99% of the market cap and at least 95% of the volume traded of the Brazilian stock market on the 12 previous months. The liquidity constraint is important because short-selling activity is usually taken in stocks that are liquid enough for positions to be covered (Chague et al., 2013). We collect our earning estimate data from Bloomberg and drop from our samples stock quarters in which the short interest data, lending rate or estimate forecast data are missing. Also, when there is more than one type of stock traded for the same firm, we select only the most liquid one. After this sample selection process, for each quarter, the number of stocks varies between 136 and 148 stocks.

Our data on the daily short interest ratio and shorting costs is published by BM&F

Bovespa, and can be gathered from data providers. Our sample period is constrained by the availability of short selling costs data. The Brazilian lending market is centralized and all lending deals must be registered on the BTC securities lending system. Since 2011, the BM&F Bovespa releases the daily closing value for these two variables.

The short interest ratio is the total number of shares investors have sold short divided by the total number of stocks available for trading. The shorting costs are represented by the average borrowing rate, in an annual basis, calculated for the last 3 days as made public by the Brazilian stock exchange. As in Hong et al (2012), we focus on the 33% highly shorted stocks. We identify this subset of stocks using the dummy variables HISR that takes the value of 1 for highly shorted stocks.

We also focus on comparatively large earning surprises. We collect earning estimates from Bloomberg, as the earnings per share estimate returns, which may exclude the effects of one-time and extraordinary gains/losses, at the date day prior to the announcement date. In this paper, we define earning surprise as the difference between the earning per share announced and the earning estimates. We then select the 33% highest surprises to analyze the impact of a high earning surprise on the abnormal returns. If there is a lot of uncertainty about the earnings per share estimate, deviations from the central estimate of earnings per share may not cause surprise. We account for this uncertainty in the measure and by adding a disagreement measure, DISAG, measured as the firm's relative cross-sectional standard deviation of analyst's forecast in each quarter.

The variation of the short interest ratio around the earning per share announcements is important to validate the dynamics of short selling activities proposed by our model. We focus in changes in the short ratio from the day before to the day after the announcement, ΔSR, and from twenty one days before and until twenty one days after the announcement, $\Delta SR21_{i,Q}$. These two variables capture short selling and covering that happens around the announcement date and the extent to which short selling positions build up in the month before earnings announcement and the unwinding that happens after that.

The impact of short selling economics on prices around the announcements of earnings per share for each stock i in each quarter Q is captured using the cumulative abnormal returns, $CAR_{i,Q}$, from the day before the earnings announcement to the day after the announcement, and the $POSTCAR_{i,Q}$, from the second trading day after the announcement to twenty-one days after the announcement. The abnormal returns are measured against a double-sorted portfolio on size and volatility. These double-sorted portfolios have each between 15 to 16 stocks.

4 Empirical Findings

4.1 Building and unwinding the short position

Our model assumes that arbitrageurs build up their position before earnings announcements, and then unwind after that. Before starting with the proposition testing, we show the general shorting dynamics surrounding the earnings announcements. We run the following regression in order to have an idea of the magnitude of the shorting position changes around announcements:

$$\begin{aligned} \Delta SR21_{i,Q} &= \alpha + \beta_1 HISR_{i,Q} + SIZE\ Dummies_{i,Q} + \\ &+ P/E\ Dummies_{i,Q} + VOLA\ Dummies_{i,Q} + MOM\ Dummies_{i,Q} \\ &+ DISAG\ Dummies_{i,Q} + \varepsilon_{i,Q} \end{aligned} \quad 4.1$$

Where

i refers to each stock

Q refers to each quarter

$\boldsymbol{\Delta SR21_{i,Q}}$ is the variation on short ratio for stock *i* twenty one trading days before and after the earnings announcement of quarter *Q*. The short ratio is defined as the number of lent stocks divided by the total number of stocks available for trading (stock float).

$\boldsymbol{HISR_{i,Q}}$ is a dummy equal to one if the stock *i*'s is in the top one third of the short ratio distribution for stocks in our sample for quarter *Q* and zero otherwise.

$\boldsymbol{SIZE_{i,Q}}$ are dummies variables that measures where a stock's relative market capitalization is each quarter. We have a dummy that is equal to one for stocks on the top one third of the market capitalization distribution on quarter *Q*, and another dummy for stocks on the bottom one third of the market capitalization distribution on quarter *Q*.

$\boldsymbol{P/E_{i,Q}}$ are dummies variables that measures where a stock's relative *P/E* is each quarter. We have a dummy that is equal to one for stocks on the top one third of the *P/E* distribution on quarter *Q*, and another dummy for stocks on the bottom one third of the *P/E* distribution on quarter *Q*.

$\boldsymbol{VOLA_{i,Q}}$ are dummies variables that measures where a stock's relative 90-days volatility is each quarter. We have a dummy that is equal to one for stocks on the top one third of 90-days volatility distribution at the end of quarter *Q* -1, and another dummy for stocks on the bottom one third of 90-days volatility distribution at the end of quarter *Q* -1.

$\boldsymbol{MOM_{i,Q}}$ are dummies variables that measures where a stock's relative momentum is each quarter. We have a dummy that is equal to one for stocks on the top one third of the one-year return distribution at the end of quarter *Q* -1, and another dummy for stocks on the bottom one third of the one-year return distribution at the end of quarter *Q* -1.

$\boldsymbol{DISAG_{i,Q}}$ are dummies variables that measure where a firms' relative analyst forecasts cross-section standard deviation (analyst's disagreement about firm's earnings) is on quarter *Q*. We have a dummy that is equal to one for stocks on the top one third of the forecast standard deviation distribution on the announcement day on quarter *Q*, and another dummy for stocks on the bottom top one third of the forecast standard deviation distribution on the announcement day on quarter *Q*.

Table I – Short Ratio changes before earnings announcements

This table shows OLS estimates of the evolution of the short ratio before and after earnings announcements. The dependent variable is $\Delta \boldsymbol{SR21}$*, which is the variation of the short ratio 21 days before and 21 days after the announcement. The independent variables are HISR (a dummy equal to one if the stock is in the top 33,3% of the sample short ratio distribution for the quarter of the observation), SIZE (dummy variables measuring where a stock's relative market capitalization is each quarter), P/E (dummy variables measuring where a stock's relative P/E ratio is each quarter), VOLA (dummy variables measuring where a stock's past volatility is each quarter), MOM (dummy variables measuring stock's relative momentum is each quarter), DISAG (analyst disagreement dummy variables measuring where a firm's relative cross-section standard deviation of analysts' earnings forecast is each quarter). The t-statistics in parentheses are adjusted by allowing for the errors to be correlated across observations of the same stock, i.e., the standard errors are clustered by stock. There are 1,656 observations.*

Dependent Variable: $\Delta \boldsymbol{SR}21$	**21 days before announcement**	**21 days after announcement**
Indicator for high short ratio (HISR)	0.79 (4.02)	-0.84 (-4.72)
R^2	1.76	0.29

Results on table I show that highly shorted stocks at the time of the announcement had an increase of 0.79% in their short ratio in the month before the announcement. This increase is almost all reversed in the month after the announcement. A typical stock in

Brazil had a trading volume equal to 0.3% of their market capitalization on average in 2013. Therefore, this change is equivalent to 2 or 3 days in terms of trading volume.

4.2 Short Covering

In this section, we evaluate proposition 1, which states that short ratio decreases after good news, and remains stable after bad news. First, we test if short arbitrageurs are forced to close their positions after unexpected good news about the firm's earnings, i.e., if there is a short covering process. Therefore, we compare daily changes in the short interest ratio after our earnings announcements with unexpected good news. Note that Hong et al. (2012) was not able to directly test this proposition and uses turnover changes as a proxy because US data short data has monthly frequency.

We use the following specification to test the short covering regardless of the short interest level:

$$\begin{aligned}\Delta SR_{i,Q} = \alpha + \beta_1 UEHIGH_{i,Q} + \beta_2 HISR_{i,Q} + SIZE\ Dummies_{i,Q} \\ + P/E\ Dummies_{i,Q} + VOLA\ Dummies_{i,Q} + MOM\ Dummies_{i,Q} \\ + DISAG\ Dummies_{i,Q} + \varepsilon_{i,Q}\end{aligned} \quad 4.2$$

Where:

$\boldsymbol{\Delta SR_{i,Q}}$ is the variation on short ratio for stock i on the first trading day after the earnings announcement of quarter Q. The short ratio is defined as the number of lent stocks divided by the total number of stocks available for trading (stock float);

$\boldsymbol{UEHIGH_{i,Q}}$ is equal to one if firm i's earnings surprise is in the top one third of the earnings surprises distribution on quarter Q, and zero otherwise.

Results are on column (1) of table II. We see that unexpected good news trigger short covering as coefficient $\boldsymbol{\beta_1}$ is negative and significant. We see also that high short ratios have a reversal trend, as $\boldsymbol{\beta_2}$ coefficient is also negative and significant. Having an unexpected good news leads to a decrease of 0.14 percentage point to the short ratio, while having a high short ratio leads to a decrease of 0.27 percentage point.

We now test if for highly shorted stocks, the short covering process is stronger, by adding the interaction of UEHIGH and HISR on equation (4.2), yielding the following regression specification:

$$\Delta SR_{i,Q} = \alpha + \beta_1 UEHIGH_{i,Q} + \beta_2 HISR_{i,Q} + \beta_3 UEHIGH_{i,Q} \times HISR_{i,Q} \\ + SIZE\ Dummies_{i,Q} + P/E\ Dummies_{i,Q} + VOLA\ Dummies_{i,Q} + \\ + MOM\ Dummies_{i,Q} + DISAG\ Dummies_{i,Q} + \varepsilon_{i,Q} \tag{4.3}$$

Results are on column (2) of table II. Coefficient $\boldsymbol{\beta_3}$ is negative and significant, corroborating our short covering dynamics. Stocks with high short ratio and good unexpected news have their short ratio decreased by approximately 0.3 percentage points more than other stocks. Note that this is a variation of 0.3 percentage point of the stock's market capitalization in a single day, which seems to be a quite strong movement. The average turnover of BM&FBovespa is around 0.3% of market capitalization per day.

Stocks with good unexpected news but that are not highly shorted have no evidence of short covering. And highly shorted stocks that do not have good news also show some short covering evidence, but with intensity approximately three times lower than stocks with god news.

We also estimate a specification that adds interactions of unexpected earnings (UEHIGH) with risk factors to the equation (4.3),

$$\Delta SR_{i,Q} = \alpha + \beta_1 UEHIGH_{i,Q} + \beta_2 HISR_{i,Q} + \beta_3 UEHIGH_{i,Q} \times HISR_{i,Q} + \\ SIZE\ Dummies_{i,Q} + P/E\ Dummies_{i,Q} + VOLA\ Dummies_{i,Q} + \\ MOM\ Dummies_{i,Q} + DISAG\ Dummies_{i,Q} + \\ SIZE\ Dummies_{i,Q} \times UEHIGH_{i,Q} + P/E\ Dummies_{i,Q} \times UEHIGH_{i,Q} + \\ VOLA\ Dummies_{i,Q} \times UEHIGH_{i,Q} + MOM\ Dummies_{i,Q} \times UEHIGH_{i,Q} + \\ DISAG\ Dummies_{i,Q} \times UEHIGH_{i,Q} + \varepsilon_{i,Q} \tag{4.4}$$

Results are on column (3) of table II. This specification show slightly weaker results to our proposition. Highly shorted stocks that do not have good news also show short covering intensity that is half of the good news stocks. The $\boldsymbol{\beta_3}$ coefficient has now a t statistic of only 1.45 (15% p-value).

Finally, columns 4 to 6 show the specifications from columns 1 to 3 estimated using random effects. Results are approximately the same. $\boldsymbol{\beta_3}$ coefficients are higher with slightly better t statistics. Overall, empirical evidence on table II support the short covering story of proposition 2.

Table II – Short Ratio changes and Positive Earnings Surprises

This table shows OLS estimates of the sensitive of short ratio to unexpected good earnings. The dependent variable is $\Delta \boldsymbol{SR}$ (variation of the short ratio on the first trading day after the announcement). The independent variables are UEHIGH (indicator that a stock's earnings surprise for the quarter is in the top 33,3% of the sample distribution that quarter), HISR (a dummy equal to one if the stock is in the top 33,3% of the sample short ratio distribution for the quarter of the observation), SIZE (dummy variables measuring where a stock's relative market capitalization is each quarter), P/E (dummy variables measuring where a stock's relative P/E ratio is each quarter), VOLA (dummy variables measuring where a stock's past volatility is each quarter), MOM (dummy variables measuring stock's relative momentum is each quarter), DISAG (analyst disagreement dummy variables measuring where a firm's relative cross-section standard deviation of analysts' earnings forecast is each quarter). In Column 3, interactions of UEHIGH and all of the other controls are included in the specification. The t-statistics in parentheses are adjusted by allowing for the errors to be correlated across observations of the same stock; i.e., the standard errors are clustered by stock. There are 1,656 observations.

Dependent Variable: $\Delta \boldsymbol{SR}$	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Indicator for high unexpected earnings (UEHIGH)	-0.14 (-2.18)	-0.04 (-1.37)		-0.13 (-1.76)	0.01 (-0.39)	
Indicator for high short ratio (HISR)	-0.27 (-2.79)	-0.18 (-1.57)	-0.20 (-1.83)	-0.21 (-3.21)	-0.09 (-1.09)	-0.14 (-1.91)
High unexpected earnings x High short ratio (UEHIGH x HISR)		-0.30 (1.67)	-0.21 (-1.45)		-0.37 (-1.70)	-0.23 (-1.41)
Stock Fixed Effects/Random Effects	FE	FE	FE	RE	RE	RE
R^2	1.91	2.42	3.10	1.99	2.56	3.34

We also test the second part of the proposition, that bad news do not immediately change the short ratio. We do that by replacing UEHIGH on the above regressions by UELOW, which is a dummy equal to one if the surprise is in the most negative tercile.

Table III shows the same six specifications of table II, with UELOW replacing UEHIGH. In contrast to table II, now coefficient $\boldsymbol{\beta_3}$ is not significant, having point estimates positive or negative depending on the specification. This confirms the asymmetric behavior of short sellers after an unexpected new. While they run to cover after good news, after bad news they hold their position in the short run.

Table III – Short Ratio changes and Negative Earnings Surprises

This table shows OLS estimates of the sensitive of short ratio to unexpected bad earnings. The dependent variable is ΔSR (variation of the short ratio on the first trading day after the announcement). The independent variables are UELOW (indicator that a stock's earnings surprise for the quarter is in the bottom 33,3% of the sample distribution that quarter), HISR (a dummy equal to one if the stock is in the top 33,3% of the sample short ratio distribution for the quarter of the observation), SIZE (dummy variables measuring where a stock's relative market capitalization is each quarter), P/E (dummy variables measuring where a stock's relative P/E ratio is each quarter), VOLA (dummy variables measuring where a stock's past volatility is each quarter), MOM (dummy variables measuring stock's relative momentum is each quarter), DISAG (analyst disagreement dummy variables measuring where a firm's relative cross-section standard deviation of analysts' earnings forecast is each quarter). In Column 3, interactions of UELOW and all of the other controls are included in the specification. The t-statistics in parentheses are adjusted by allowing for the errors to be correlated across observations of the same stock; i.e., the standard errors are clustered by stock. There are 1,656 observations.

Dependent Variable: ΔSR	(1)	(2)	(3)	(4)	(5)	(6)
Indicator for low unexpected earnings (UELOW)	0.07 (0.85)	0.04 (0.89)		0.06 (0.77)	0.02 (0.66)	
Indicator for high short ratio (HISR)	-0.27 (-2.74)	-0.29 (-2.57)	-0.29 (-2.69)	-0.20 (-3.19)	-0.24 (-2.44)	-0.23 (-2.64)
Low unexpected earnings x High short ratio (UELOW x HISR)		-0.09 (-0.48)	0.06 (0.41)		0.11 (0.58)	0.08 (0.54)
Stock Fixed Effects/Random Effects	FE	FE	FE	RE	RE	RE
R^2	1.63	1.67	2.11	1.73	1.78	2.25

4.3 Arbitrageur Amplification, Price Overshooting and Reversal

On this section, we evaluate our second prediction: there is a price overshooting and subsequent reversal for highly shorted stocks with good unexpected news. This is caused by the arbitrageur amplification mechanism. Right after the positive earning surprises, we expect a price increase above the fundamental for highly shorted stocks. In the next time period, we expect a reversal to fundamental value so that the price return to shorting after a good earnings surprise for a previously highly shorted stock is higher than for other stocks. It is important to highlight that we are talking about expected price return, without considering shorting costs. Next section will deal with shorting and other transaction costs.

Our research design divides the time period into the days around the announcement (one day before to one day after as in Hong) and the following 20 days after the announcement. We expect that the abnormal return near the good new announcement to be positive (positive CAR), and then followed by negative abnormal returns (negative POSTCAR).

We first estimate a baseline regression that measures the overall effect of unexpected earnings shocks on returns following the announcement, i.e., the price to earnings sensitivity for the typical firm in our sample. Thus, we estimate the following regression:

$$CAR_{i,Q} = \alpha + \beta_1 UEHIGH_{i,Q} + \beta_2 HISR_{i,Q} + SIZE\ Dummies_{i,Q} + P/E\ Dummies_{i,Q} + VOLA\ Dummies_{i,Q} + MOM\ Dummies_{i,Q} + DISAG\ Dummies_{i,Q} + \varepsilon_{i,Q} \quad 4.5$$

Where

$\boldsymbol{CAR_{i,Q}}$ is the cumulative abnormal return from the last trading before quarter *Q*'s earnings announcement to the first trading day after the announcement. Abnormal returns are measured against double-sorted portfolios on size and volatility.

The dummy variables for size, P/E, volatility, momentum are controls for risk factors. The dummy variable for the disagreement is used to rule out alternative explanation that short interest is a proxy for analysts having different forecasts for the earnings, and so the good news would induce price discovery.

The result for this specification is reported in column 1 of table IV. As expected, the coefficient $\boldsymbol{\beta_1}$ for UEHIGH is positive and statistically different from zero. The coefficient implies that being in the high unexpected earnings group is associated with a 1.82% abnormal return of the stock. This number is lower than international evidence of the sensitivity of stock price to earnings surprises.

Having our baseline case, we now estimate a regression that includes the interaction of UEHIGH and HISR on equation (4.5):

$$CAR_{i,Q} = \alpha + \beta_1 UEHIGH_{i,Q} + \beta_2 HISR_{i,Q} + \beta_3 UEHIGH_{i,Q} \times HISR_{i,Q} + SIZE\ Dummies_{i,Q} + P/E\ Dummies_{i,Q} + VOLA\ Dummies_{i,Q} + MOM\ Dummies_{i,Q} + DISAG\ Dummies_{i,Q} + \varepsilon_{i,Q} \quad 4.6$$

Our focus on this regression is on the added coefficient $\boldsymbol{\beta_3}$, which measures the additional sensitivity of highly shorted stocks to unexpected earnings when compared with other stocks. Results are reported on the second column of table IV. The estimates show that the sensitivity to high unexpected earnings shocks is greater for high short ratio stocks. The coefficient $\boldsymbol{\beta_1}$ refers to stocks in the high unexpected earnings and low short ratio group. Being in this group means a statistically significant 1.76 percentage point increase in CAR. However, stocks with a high short ratio will have 1.03 percentage point more CAR than stocks with low short ratio, as we can see on coefficient $\boldsymbol{\beta_3}$**.** This coefficient is significantly different from zero with a p-value around 10%. The sensitivity of high short ratio stocks to unexpected earnings is about 58% (1.02/1.76) greater than for low short ratio stocks. This addition sensitivity is much bigger than the 17% estimated by Hong et al. (2012).

Although this specification controls for a number of risk factors, it is not allowing the news' effect to vary for each risk factor. For instance, the price of large stocks might respond faster to earnings news than the price of small stocks if large stocks are held by institutional investors or traded by professional asset managers, and they react more promptly to news than individuals. Therefore, we also estimate the following regression, which is equation (4.6) with the addition of the interactions of unexpected earnings (UEHIGH) with risk factors:

$$\begin{aligned} CAR_{i,Q} = \alpha + \beta_1 UEHIGH_{i,Q} + \beta_2 HISR_{i,Q} + \beta_3 UEHIGH_{i,Q} \times HISR_{i,Q} + \\ SIZE\ Dummies_{i,Q} + P/E\ Dummies_{i,Q} + VOLA\ Dummies_{i,Q} + \\ MOM\ Dummies_{i,Q} + DISAG\ Dummies_{i,Q} + \\ SIZE\ Dummies_{i,Q} \times UEHIGH_{i,Q} + P/E\ Dummies_{i,Q} \times UEHIGH_{i,Q} + \\ VOLA\ Dummies_{i,Q} \times UEHIGH_{i,Q} + MOM\ Dummies_{i,Q} \times UEHIGH_{i,Q} + \\ DISAG\ Dummies_{i,Q} \times UEHIGH_{i,Q} + \varepsilon_{i,Q} \end{aligned} \qquad 4.7$$

Our focus on this regression is again $\boldsymbol{\beta_3}$, which measures the differential sensitivity of high short ratio shocks to unexpected earnings shocks. Results are presented on column 3 of Table IV. $\boldsymbol{\beta_3}$ is now statistically significant at around 6%, so that we may say the sensitivity to unexpected earnings is greater for high short ratio stocks. The point estimate and t-statistics are higher if compared with results of column 2. Having a high unexpected earnings surprise now add more than one percentage point to the CAR. We should have cautious to interpret the meaning of $\boldsymbol{\beta_1}$ in this specification because there are several interactions with UEHIGH, so that we cannot evaluate the economic significance as we did on equation (4.6).

In columns 4–6 of table IV, we reestimate the specifications in columns 1–3 without using stock fixed effects. This is a more parsimonious approach. Results have similar magnitudes, although they are slightly weaker.

Overall, findings in table IV help confirm the arbitrageur amplification hypothesis. Results here are similar to those of Hong et al. (2012).

Table IV – Sensitivity of stock returns to unexpected earnings

This table shows OLS estimates of the sensitive of stock returns to unexpected earnings. The dependent variable is CAR (cumulative abnormal return from one trading day before the announcement to one trading day after the announcement). The independent variables are UEHIGH (indicator that a stock's earnings surprise for the quarter is in the top 33,3% of the sample distribution that quarter), HISR (a dummy equal to one if the stock is in the top 33,3% of the sample short ratio distribution for the quarter of the observation), SIZE (dummy variables measuring where a stock's relative market capitalization is each quarter), P/E (dummy variables measuring where a stock's relative P/E ratio is each quarter), VOLA (dummy variables measuring where a stock's past volatility is each quarter), MOM (dummy variables measuring stock's relative momentum is each quarter), DISAG (analyst disagreement dummy variables measuring where a firm's relative cross-section standard deviation of analysts' earnings forecast is each quarter). In Column 3, interactions of UEHIGH and all of the other controls are included in the specification. The t-statistics in parentheses are adjusted by allowing for the errors to be correlated across observations of the same stock; i.e., the standard errors are clustered by stock. There are 1,656 observations.

Dependent Variable: CAR	(1)	(2)	(3)	(4)	(5)	(6)
Indicator for high unexpected earnings (UEHIGH)	1.82 (6.94)	1.76 (2.32)		1.62 (6.38)	1.35 (4.46)	
Indicator for high short ratio (HISR)	0.06 (0.18)	-0.26 (-0.70)	-0.33 (-0.88)	-0.22 (-0.84)	-0.50 (-1.64)	-0.56 (-1.77)
High unexpected earnings x High short ratio (UEHIGH x HISR)		1.03 (1.64)	1.22 (1.90)		0.87 (1.43)	1.04 (1.66)
Stock Fixed Effects/Random Effects	FE	FE	FE	RE	RE	RE
R^2	2.37	2.52	3.35	3.17	3.32	4.23

If the CAR results of highly shorted stocks are due to the short covering process of the model, then we should see expected returns to shorting being higher after a good earnings announcement. In this way, after the abnormal returns documented on table IV, one would expect negative subsequent returns. We basically repeat specifications of table IV changing the dependent variable from CAR to a POSTCAR, which is the abnormal return from the second trading days after announcement to 21 trading days after the announcement.

Results are on table V. Column 1 shows that having high unexpected earnings is associated with a largely insignificant effect on POSTCAR. So there is no evidence of post-earnings announcement drift. Coefficient $\boldsymbol{\beta_1}$ on column 2 shows that for little shorted stocks, the effect of having high unexpected earnings is an increase of 0.57 percentage points on POSTCAR, and so now we have some weak evidence of post-earnings announcement drift.

On the other hand, for highly shorted stocks, the effect of having high unexpected earnings is a decrease on POSTCAR, as the positive estimate on $\boldsymbol{\beta_1}$ is more than offset by the negative estimate of $\boldsymbol{\beta_3}$, which is -1.94 with a 10% p-value. The sum $\boldsymbol{\beta_1} + \boldsymbol{\beta_3}$ is therefore 1.37 percentage point negative. However, it is not statistically significant (p-value of 20%). So stocks with high short ratio have a slightly significant negative subsequent expected price returns. The magnitude of this number is similar of the 1.1 percentage points of POSTCAR found by Hong et al. (2012) for the US market. It is worth noting, however, that they consider a POSTCAR with six months instead of three months, which generate overlapping earnings announcements.

The result in column 3 using more controls confirms those of column 2. The coefficient $\boldsymbol{\beta_3}$ has even a higher absolute value with a stronger significance. On the other hand, the use of random effects, shown on columns 4 to 6, provides a weaker evidence of the overshooting reversal.

Overall, results on table V provide evidence of overshooting and reversal on prices of highly shorted stocks with good earnings news.

Table V – Unexpected earnings and subsequent stock returns

This table shows OLS estimates of the sensitive of stock returns to unexpected earnings. The dependent variable is POSTCAR (cumulative abnormal return from the second trading day after the announcement to 21 trading days after the announcement). The independent variables are UEHIGH (indicator that a stock's earnings surprise for the quarter is in the top 33,3% of the sample distribution that quarter), HISR (a dummy equal to one if the stock is in the top 33,3% of the sample short ratio distribution for the quarter of the observation), SIZE (dummy variables measuring where a stock's relative market capitalization is each quarter), P/E (dummy variables measuring where a stock's relative P/E ratio is each quarter), VOLA (dummy variables measuring where a stock's past volatility is each quarter), MOM (dummy variables measuring stock's relative momentum is each quarter), DISAG (analyst disagreement dummy variables measuring where a firm's relative cross-section standard deviation of analysts' earnings forecast is each quarter). In Column 3, interactions of UEHIGH and all of the other controls are included in the specification. The t-statistics in parentheses are adjusted by allowing for the errors to be correlated across observations of the same stock, i.e., the standard errors are clustered by stock. There are 1,656 observations.

Dependent Variable: POSTCAR	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Indicator for high unexpected earnings (UEHIGH)	-0.05 (-0.11)	0.57 (1.04)		-0.14 (-0.29)	0.38 (0.71)	
Indicator for high short ratio (HISR)	0.85 (1.18)	1.48 (1.66)	1.57 (1.73)	1.17 (2.05)	1.69 (2.37)	1.69 (1.84)
High unexpected earnings x High short ratio (UEHIGH x HISR)		-1.94 (-1.62)	-2.77 (-2.37)		-1.62 (-1.52)	-2.67 (-2.16)
Stock Fixed Effects/Random Effects	FE	FE	FE	RE	RE	RE
R^2	0.14	0.24	0.34	1.31	1.46	0.53

4.4 Shorting Costs and Overshooting

Last section provided evidence that evidence that the expected price return of highly shorted stocks is negative some days after good unexpected earnings news. But the main question is: does it mean that it is profitable for arbitrageurs to sell short these stocks? To answer this question, we need to consider not only price variations, but also other transaction costs. Specifically in our case, we need to take into consideration the costs of borrowing a stock. The price variation return may be offset by shorting costs. And recall that we are considering stocks with high short ratio, which theoretically should have higher shorting fees.

Table VI gives a general idea of the shorting costs of stocks on the first day after the announcement, which would be the date where arbitrageurs would borrow the stock. We see that, as expected, stocks with high unexpected earnings and high short ratio have a higher borrowing rate. More than that, the magnitude of the borrowing rate is similar or even higher than the subsequent negative price returns documented on table V. If we convert the 4.9% annual borrowing rate to a monthly rate (equivalent to 21 trading days), we would have 0.4% against price returns around 1.3% of table V. If we consider other trading costs such as bid-ask spread and broker fees, this difference will lower. So we have evidence that a trading strategy of short selling these stocks may be profitable looking only to prices, but this arbitrage opportunity may not survive to trading costs.

We may compare our results with those of Hong et al. (2012). Although their paper completely ignored the bowing costs, we may try to infer if this phenomenon happens also in the US market. D'Avolio (2002) used data from early 2000's and shows that stocks in the highest decile when sorted by short interest had a shorting fee above 0.6%. Simple calculations based on their Figure 3 suggests that the shorting fee for the 1/3 highest shorted stocks have a shorting fee around 1%, which would vanish half of the 1.1% semi-annual POSTCAR found by Hong at al. (2012). Also Saffi and Sigurdsson (2011) using more recent data (2004-2008), show that borrowing cost raises on the ex-dividend week to an average of 1%. Therefore, stocks with a higher short ratio should have a cost above 1%, which again would take away most of the POSTCAR found in the US study of Hong et al. (2012). It is worth noting that we are considering just one element of transaction costs: the shorting fee. Again, other transaction costs such as bid-ask spread, broker and exchange fees could be added, and this would even strengthen our argument.

These results are consistent with our costly arbitrage argument of proposition 3. The price overshooting and reversal should not be (much) higher than arbitrage costs, otherwise arbitrageurs would engage in trading. As long as the price overshooting is lower than transaction costs, it can survive.

Table VI – Borrowing Costs

This table shows the mean borrowing rate on the first day after the announcement for two groups of stocks: with high unexpected earnings and high short ratio and all other stocks. Borrowing rate is expressed on annual basis.

	Borrowing Rate
Stocks with high unexpected earnings and high short ratio (UEHIGH x HISR =1)	4.90
All other stocks (UEHIGH x HISR =0)	4.27

4.5 Bad news and Profit Taking

On this section, we look at negative surprises in order to test proposition 4. According to this proposition, stock price falls under fundamental value just after the release of bad earnings news, but profit-taking behavior by arbitrageurs will bring prices back to fundamentals in the mid/long run. We follow a research design similar to section 4.3 in order to test this proposition, but using negative earnings surprises instead of positive surprises.

First, we analyze the behavior of the CAR after bad news. Regression specifications of table VII are equivalent to those of table IV, but replacing UEHIGH by UELOW. As expected, a negative surprise triggers a price fall, as we can see on negative and statistically significant coefficients for UELOW from all specifications. A high short ratio per se does not influence CAR, as their coefficients are statically equal to zero, and vary from positive to negative depending on the use of fixed or random effects.

Our main concern is on the interaction of UELOW with HISR, which is negative, but statistically different from zero only on specification (3) from table IV. So there is very weak evidence that a high short ratio magnify the downward price reaction to bad news. And as we saw on table III, there is no evidence that arbitrageurs increase short positions after bad news. Therefore, we may conclude that price adjustments after bad news are driven by new information updating and noise traders reducing their demand, supporting our core model. Note, however, that results of section 4.4 of Hong et al. (2012) suggest that in the US market the price reaction is magnified for stocks with a high short ratio. However, the lack of short ratio US data avoids a clear conclusion whether arbitrageurs increase short positions after bad news.

Table VII – Sensitivity of stock returns to negative unexpected earnings

This table shows Pooled OLS estimates of the sensitive of stock returns to negative unexpected earnings. The dependent variable is CAR (cumulative abnormal return from one trading day before the announcement to one trading day after the announcement). The independent variables are UEHIGH (indicator that a stock's earnings surprise for the quarter is in the top 33,3% of the sample distribution that quarter), HISR (a dummy equal to one if the stock is in the top 33,3% of the sample short ratio distribution for the quarter of the observation), SIZE (dummy variables measuring where a stock's relative market capitalization is each quarter), P/E (dummy variables measuring where a stock's relative P/E ratio is each quarter), VOLA (dummy variables measuring where a stock's past volatility is each quarter), MOM (dummy variables measuring stock's relative momentum is each quarter), DISAG (analyst disagreement dummy variables measuring where a firm's relative cross-section standard deviation of analysts' earnings forecast is each quarter). In Column 3, interactions of UEHIGH and all of the other controls are included in the specification. The t-statistics in parentheses are adjusted by allowing for the errors to be correlated across observations of the same stock; i.e., the standard errors are clustered by stock. There are 1,656 observations.

Dependent Variable: CAR	(1)	(2)	(3)	(4)	(5)	(6)
Indicator for low unexpected earnings (UELOW)	-1.63 (-5.11)	-1.30 (-3.83)		-1.30 (-4.41)	-1.11 (-3.51)	
Indicator for high short ratio (HISR)	0.01 (0.03)	0.29 (0.65)	0.34 (0.76)	-0.22 (-0.82)	-0.05 (-0.14)	-0.03 (-0.07)
Low unexpected earnings x High short ratio (UELOW x HISR)		-0.97 (-1.37)	-1.19 (-1.65)		-0.53 (-0.85)	-0.58 (-0.90)
Stock Fixed Effects/Random Effects	FE	FE	FE	RE	RE	RE
R^2	1.80	1.87	2.47	2.18	2.24	2.91

While results from table VII shows prices going down after the bad news, results from table VIII suggests this movement was more intense than necessary to bring prices to fundamentals. Table VIII is the equivalent to table V, with UELOW replacing UEHIGH. Our main interest in this regression is the coefficient of the interaction of UELOW and HISR. We see on specifications (2) and (4) that this coefficient is positive and with an absolute value higher than the UELOW coefficient. More than that, this interaction coefficient is statistically greater than zero, suggesting that price drop just after the news is subsequently reverted back to fundamental value. This result gives empirical support our proposition 4 with Brazilian data. Out POSTCAR is calculated with 21 business days. Increasing this time period to 42 (or more) business days eliminates the statistical significance of our results. So this price undershooting and reversal is a phenomenon with a one-month duration approximately.

It is difficult to compare our results with those present in specification (3) of section

4.4 of Hong et al. (2012), as they use a holding period of six months for the POSTCAR. See that this holding period encompasses two quarters, and this overlapping data may add noise in the results. Thus, although they found no evidence of price undershooting and reversal with a two quarters period, a further analysis with a shorter term would be necessary to clarify this point.

Table VIII – Unexpected negative earnings and subsequent stock returns

This table shows Pooled OLS estimates of the sensitivity of stock returns to negative unexpected earnings. The dependent variable is POSTCAR (cumulative abnormal return from the second trading day after the announcement to 21 trading days after the announcement). The independent variables are UEHIGH (indicator that a stock's earnings surprise for the quarter is in the top 33,3% of the sample distribution that quarter), HISR (a dummy equal to one if the stock is in the top 33,3% of the sample short ratio distribution for the quarter of the observation), SIZE (dummy variables measuring where a stock's relative market capitalization is each quarter), P/E (dummy variables measuring where a stock's relative P/E ratio is each quarter), VOLA (dummy variables measuring where a stock's past volatility is each quarter), MOM (dummy variables measuring stock's relative momentum is each quarter), DISAG (analyst disagreement dummy variables measuring where a firm's relative cross-section standard deviation of analysts' earnings forecast is each quarter). In Column 3, interactions of UEHIGH and all of the other controls are included in the specification. The t-statistics in parentheses are adjusted by allowing for the errors to be correlated across observations of the same stock; i.e., the standard errors are clustered by stock. There are 1,656 observations.

Dependent Variable: POSTCAR	(1)	(2)	(3)	(4)	(5)	(6)
Indicator for low unexpected earnings (UELOW)	0.24 (0.42)	-0.80 (-1.23)		-0.21 (-0.39)	-1.13 (-1.89)	
Indicator for high short ratio (HISR)	0.86 (1.18)	-0.01 (-0.01)	-0.23 (-0.30)	1.19 (2.08)	0.30 (0.51)	0.22 (0.38)
Low unexpected earnings x High short ratio (UELOW x HISR)		3.03 (2.26)	3.62 (2.38)		2.67 (2.27)	2.88 (2.18)
Stock Fixed Effects/Random Effects	FE	FE	FE	RE	RE	RE
R^2	0.12	0.39	0.58	1.32	1.75	2.13

5 Conclusion

Our paper presents a model that combines Performance-Based Arbitrage (PBA) and short-selling costs to examine the impact of short selling in the price sensitivity to earning surprises. The key assumption of our model is that the performance-based arbitrage is asymmetric. While negative returns may trigger margin calls and sudden withdrawal of funds, positive returns do not generate immediate new income. Our model also considers that the amplification generated by PBA is bounded by the costs of selling a stock. Investors take into consideration the net expected return when bringing new money into the market. As a result, short selling costs will constrain the attractiveness of some of otherwise feasible strategies.

We provide empirical evidence that our model is consistent with data available from the Brazilian stock exchange. We find that unexpected good news indeed triggers short covering and that this is more pronounced for highly shorted stocks. However, we do not find that the release of bad news is associated to the increase of short selling activity, characterizing the asymmetric behavior of the performance-based arbitrage. We also provide evidence that although prices converge back to equilibrium after the initial overshooting, this strategy may not always be profitable for arbitrageurs as the profitability is bounded by the costs of shorting these stocks.

Our paper sheds light on how the market efficiently adjusts itself to mitigate amplifying effects of short selling activity. If on one hand, performance based arbitrage may exacerbate price movements, a costly arbitrage argument may be used to justify that these movements are limited. Moreover, the higher is the supply of stocks available to lend, the lower will be the shorting lending fee, and the lower will be the price overshooting or undershooting. In this way, regulators should provide conditions for the stock lending supply to be maximized, so that shorting costs are reduced.

Nevertheless, we agree that "naked" short selling, where a lending fee is not present and the trade is executed intraday, does not help much for financial stability in this context. Therefore, a regulatory framework where stock lending is stimulated and naked short selling is restricted seems adequate.

References

Abreu, D., & Brunnermeier, M. K. (2003). Bubbles and crashes. *Econometrica*, *71*(1), 173-204.

Asquith, P., Pathak, P. A., & Ritter, J. R. (2005). Short interest, institutional ownership, and stock returns. *Journal of Financial Economics*, *78*(2), 243-276.

Ball, R., & Brown, P. (1968). An empirical evaluation of accounting income numbers. *Journal of accounting research*, *6*(2), 159-178.

Boehmer, E., Jones, C. M., & Zhang, X. (2008). Which shorts are informed?.*The Journal of Finance*, *63*(2), 491-527.

Bris, A., Goetzmann, W. N., & Zhu, N. (2007). Efficiency and the bear: Short sales and markets around the world. *The Journal of Finance*, *62*(3), 1029-1079.

Campbell, J. Y., & Kyle, A. S. (1993). Smart money, noise trading and stock price behaviour. *The Review of Economic Studies*, *60*(1), 1-34.

Chague, F., De-Losso, R., Genaro, A. D., & Giovannetti, B. C. (2013). Short Selling and Inside Information. *Working Paper,* Universidade de São Paulo (FEA-USP).

Chague, F., Bueno, R., Genaro, A., Giovannetti, B. C. (2014) Short-Sellers: Informed but Restricted. *Journal of International Money and Finance* Volume 47, 56-70.

Christophe, S. E., Ferri, M. G., & Angel, J. J. (2004). Short−Selling Prior to Earnings Announcements. *The Journal of Finance*, *59*(4), 1845-1876.

D'avolio, G. (2002). The market for borrowing stock. *Journal of Financial Economics*, *66*(2), 271-306.

Danielsen, B. R., & Sorescu, S. M. (2001). Why do option introductions depress stock prices? A study of diminishing short sale constraints. *Journal of Financial and Quantitative Analysis*, *36*(04), 451-484.

de Long, J. B., Shleifer, A., Summers, L. H., & Waldmann, R. J. (1990). Positive Feedback Investment Strategies and Destabilizing Rational Speculation. *The Journal of Finance*, *45*(2), 379-395.

Diamond, D. W., & Verrecchia, R. E. (1987). Constraints on short-selling and asset price adjustment to private information. *Journal of Financial Economics*,*18*(2), 277-311.

Diether, K. B., Malloy, C. J., & Scherbina, A. (2002). Differences of opinion and the cross section of stock returns. *The Journal of Finance*, *57*(5), 2113-2141.

Engelberg, J. E., Reed, A. V., & Ringgenberg, M. C. (2012). How are shorts informed? Short sellers, news, and information processing. *Journal of Financial Economics*, *105*(2), 260-278.

Engelberg, J., Reed, A. V., & Ringgenberg, M. C. (2013). Short selling risk. *Available at SSRN*.

European Union (2012) Regulation (EU) No 236/2012 of The European Parliament and of The Council of 14 March 2012 on short selling and certain aspects of credit default swaps.

Friedman, M. (1953). The case for flexible exchange rates, in Milton Friedman, ed. Essays in Positive Economics (University of Chicago Press, Chicago, IL).

Grossman, S. J., & Miller, M. H. (1988). Liquidity and market structure. *the Journal of Finance*, *43*(3), 617-633.

Hirshleifer, D., Teoh, S. H., & Yu, J. J. (2011). Short arbitrage, return asymmetry, and the accrual anomaly. *Review of Financial Studies*, *24*(7), 2429-2461.

Hong, H., Kubik, J. D., & Fishman, T. (2012). Do arbitrageurs amplify economic shocks?. *Journal of Financial Economics*, *103*(3), 454-470.

Hong, H., & Stein, J. C. (1999). A unified theory of underreaction, momentum trading, and overreaction in asset markets. *The Journal of Finance*, *54*(6), 2143-2184.

Hurtado-Sanchez, L. (1978). Short interest: its influence as a stabilizer of stock returns. *Journal of Financial and Quantitative Analysis*, *13*(5), 965-985.

Jones, C. M., & Lamont, O. A. (2002). Short-sale constraints and stock returns. *Journal of Financial Economics*, *66*(2), 207-239.

Karpoff, J. M., & Lou, X. (2010). Short sellers and financial misconduct. *The Journal of Finance*, *65*(5), 1879-1913.

Khandani, A. E., & Lo, A. W. (2007). What happened to the quants in August 2007?. *Journal of Investment Management*, *5*(4), 5-54.

Kyle, A. S., & Xiong, W. (2001). Contagion as a wealth effect. *The Journal of Finance*, *56*(4), 1401-1440.

Lamont, O. A., & Stein, J. C. (2004). Aggregate Short Interest and Market Valuations. *American Economic Review*, *94*(2), 29-32.

Miller, E. M. (1977). Risk, uncertainty, and divergence of opinion. *The Journal of Finance*, *32*(4), 1151-1168.

Nagel, S. (2005). Short sales, institutional investors and the cross-section of stock returns.

Journal of Financial Economics, *78*(2), 277-309.

Pontiff, J. (1996). Costly arbitrage: Evidence from closed-end funds. *The Quarterly Journal of Economics*, *111*(4), 1135-1151.

Reed, A. V. (2002). Costly short-selling and stock price adjustment to earnings announcements. *Doctoral dissertation, University of Pennsylvania.*

Ross, Stephen A. (1976) The arbitrage theory of capital asset pricing. *Journal of Economic Theory 13*, 341–360.

Saffi, P. A., & Sigurdsson, K. (2011). Price efficiency and short selling. *Review of Financial Studies*, *24*(3), 821-852.

Shleifer, A., & Vishny, R. W. (1997). The limits of arbitrage. *The Journal of Finance*, *52*(1), 35-55.

Stein, J. C. (2009). Presidential address: Sophisticated investors and market efficiency. *The Journal of Finance*, *64*(4), 1517-1548.