## Holding on to Your Shorts: When Do Short Sellers Retreat?

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#### Abstract

This paper studies the response of arbitrageurs to adverse price shocks. We focus on short sellers and find that they cover their positions after suffering losses and increase them after experiencing gains. While this relationship is very strong for positions established due to perceived overvaluation, it does not hold for arbitrage trades, where the investor is hedged against stock price movements. Finally, expected returns do not explain the documented behavior, with short sellers actually losing money by closing their positions in response to losses. We interpret these results as evidence that even sophisticated investors cannot or are not willing to maintain positions after adverse market movements, making arbitrage less effective in moving prices towards their fundamental value.

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The efficient market hypothesis depends crucially on the stabilizing influence of rational, sophisticated investors, commonly referred to as arbitrageurs. Friedman (1953) and Fama (1965) in their seminal works argue that these investors counter the influence of any non-rational market participants, ensuring that market prices correctly reflect fundamental security value. In contrast, the literature on limits to arbitrage proposes that real-world arbitrage is considerably less effective than envisioned by Friedman and Fama, allowing mispricing to arise and persist. The potential impediments facing arbitrageurs include their short investment horizons (DeLong, Shleifer, Summers and Waldmann (1990)), their agency relationship with capital providers (Shleifer and Vishny (1997)), or their inability to coordinate trades with other arbitrageurs (Abreu and Brunnermeier (2002)).

Whether arbitrage is significantly limited or not, is ultimately an empirical question. One approach that can help us better understand arbitrage and its limitations is to study the actual trades made by arbitrageurs. Do they position themselves in the right investments? How do they react to new circumstances? How efficient are they in bringing prices to fair value? Do they even always push prices in the right direction? In varying degrees, the constrained arbitrage proponents have different answers to these questions than efficient market advocates, providing us with an opportunity to test the two theories. In this paper, we focus on the trading activity of short sellers, with an emphasis on their response to losses incurred due to adverse price movements of the stocks they target.

We choose short sellers because, as a group, they represent good candidates for the role of arbitrageurs. Finance practitioners, the press, and even public firms describe short sellers as well-informed, smart and often feared investors. This perception is supported by facts, as a substantial body of empirical evidence shows that short sellers indeed posses the ability to identify overpriced securities, utilizing both firm-specific information and more general financial characteristics.<sup>1</sup> Theory also suggests that short sellers should mostly be

<sup>&</sup>lt;sup>1</sup>The findings in Senchack and Starks (1993), Asquith and Meulbroek (1996), Aitken, Frino, McCorry and Swan (1998), Dechow, Hutton, Meulbroek and Sloan (2001), Jones and Lamont (2002), Desai, Ramesh, Thiagarajan and Balachandran (2002), Cohen, Diether and Malloy (2007), Asquith, Pathak and Ritter (2005), Christophe, Ferri and Angel (2004), Boehmer, Jones and Zhang (2008), and Diether, Lee and Werner (2009)

informed investors, given that shorting is a relatively expensive trading activity (Diamond and Verrecchia (1987)). Accordingly, Boehmer et al. (2008) find that institutional investors account for 74% of short sales and individuals for only 2%.

Furthermore, short sellers may be especially exposed to the risk of their positions moving against them. An investor with a long position can simply choose to wait out a price decline (assuming no margin or redemption pressure). In contrast, a short one will eventually have to put in more capital to maintain his trade, since a short position effectively grows as prices rise. Finally, while in many instances it is not easy to observe the positions of supposed arbitrageurs, short interest is collected and reported regularly by all stock exchanges.

We start by exploring how short sellers react to changes in the value of their positions. We show that they both cover their positions after suffering losses and increase them after experiencing gains. The result is highly statistically significant and robust to the inclusion of various controls for possible short sale constraints. This relationship between short interest and stock price movements is not limited to only short-term changes. It holds for horizons of up to six months.

To explore further the hypothesis that the trading activity of short sellers is sensitive to incurred losses, we exploit the fact that not all short selling is done by investors who believe a stock is overvalued. Often shorting a stock represents just one component of a more complex trading strategy seeking to take advantage of relative mispricing of two (or more) securities. In those instances, we would expect the relationship between stock returns and short interest changes to be much weaker, as the short seller is presumably hedged against stock price movements. The negative correlation between stock returns and subsequent short positions changes should apply only to valuation-motivated trades, which we define as the ones made with the goal of profiting from any future stock price declines. While we cannot observe perfectly what motivated a particular short position, we can use certain proxies. We classify a short position as a valuation or an arbitrage trade based on whether a firm has

all find that stocks targeted by short sellers earn negative abnormal returns.

a significant amount of convertible securities outstanding. In support of our hypothesis, we find that short sellers retreat after losses only for valuation trades, with no corresponding relationship for arbitrage trades.

The interpretation of our results depends crucially on future stock returns. If stock prices rise after short sellers who suffered losses cover, their trades may simply represent a profit-maximizing trading strategy.<sup>2</sup> However, loss-induced covering is actually followed by low rather than high returns, suggesting that short sellers are forgoing future profits by closing out their positions in response to losses. We can thus propose with at least a degree of confidence that their actions reflect some constraint (or behavioral bias).

Together these results are consistent with a world of constrained arbitrage, where losses impact short seller trades beyond their influence on expected returns. Short sellers bet against the right stocks, but if the market temporarily moves against them, they respond by cutting their exposure. In other words, although they are a sophisticated investor group, short sellers sometimes trade in a manner that both hurts their returns and does not push prices towards fair value. To the extent that these trades move prices, short selling can even have a destabilizing influence. When an overvalued stock experiences positive returns, short sellers cover, pushing up its stock price and exacerbating or prolonging the mispricing. Among other things, our findings therefore suggest short squeezes are not just a theoretical concept or a Wall Street myth, but rather a market reality. Moreover, if short sellers truly are a sophisticated group, they will foresee the possibility that the mispricing of stocks they target could worsen. In anticipation of this, they will be less aggressive initially in taking positions in overvalued stocks. Shleifer and Vishny (1997) develop a formal model in which such a mechanism limits the effectiveness of arbitrage.

This logic can perhaps explain why short selling remains a relatively specialized activity.<sup>3</sup> Explanations offered for investor reluctance to engage in short selling include its cost, risk

 $<sup>^{2}</sup>$ Perhaps a combination of high short interest and positive (negative) past returns somehow predicts positive (negative) future returns.

<sup>&</sup>lt;sup>3</sup>E.g., Almazan, Brown, Carlson and Chapman (2004) find that two-thirds of mutual funds have charters that specifically prohibit short selling and only 3% actually do short sell.

of recall, perceived riskiness of a short position, unfavorable tax treatment, unwillingness to bet against companies, and public bias against short sellers. Our results provide another potential rationale: the danger of being squeezed out of positions by losses.

Our results appear related to those in Lamont and Stein (2004), who document a negative correlation between past index returns and the aggregate short interest ratio. In a sense, we extend their results to the individual stock level, with the major qualification that our negative correlation between past returns and changes in short interest applies only to heavily shorted stocks. Brunnermeier and Nagel (2004) adopt an approach similar to ours that analyzes trades made by supposed arbitrageurs. They look at the holdings of certain hedge funds during the Internet bubble and conclude they were heavily invested in technology stocks. Instead of trying to combat the mispricing, these funds "rode" the bubble.<sup>4</sup> Brunnermeier and Nagel's results resemble those in this paper in that arbitrageurs sometimes destabilize prices, but they differ in that in their case arbitrageurs earn abnormal returns by doing so. Hong, Kubik and Fishman (2011) also find evidence that short sellers can amplify stock price movements, with highly shorted stocks being more sensitive to earnings news. Very interestingly, stocks with high short interest experience low returns in the period after positive earnings news, which is consistent with the hypothesis that short covering pressure may push prices away from fundamental value.

Diether et al. (2009) use new data that enables them to study short selling at a daily frequency, and find that short sellers become more active after positive returns. At first glance, this would seem in contradiction to our results. One possible explanation is that short seller behavior changes over different horizons. A few days of positive returns may lead them to increase their positions, but if their losses continue growing, they reverse course and cover. It is also important to note that Diether et al. (2009) study volumes not positions. Daske, Richardson and Tuna (2005), Boehmer et al. (2008), and Diether et al. (2009) all show that daily short selling volumes represent a much higher fraction of total volume than

<sup>&</sup>lt;sup>4</sup>Gabaix, Krishnamurthy and Vigneron (2007) document evidence suggesting that limits to arbitrage are present in the mortgage-backed securities market.

monthly short interest reported by exchanges, with numbers ranging from 13 to 31%. This indicates that much of the shorting activity is intra-day (at least over the last decade), with positions being open and closed rapidly. These trades could stem from liquidity provision, hedging, or a variety of other motivations. Our dataset does not cover such high-frequency trades. This paper instead focuses on more traditional short sellers with longer horizons.

In our analysis of determinants of short interest changes, we find that higher institutional ownership eases short sale constraints. This confirms the results in D'Avolio (2002), which are derived from a detailed, but relatively short, proprietary dataset obtained from a large (unidentified) institutional stock lending intermediary. It also validates a recent approach in the short selling literature, which uses institutional ownership as a proxy for short sale constraints.<sup>5</sup>

The remainder of the paper is organized as follows. Section I briefly describes our data sources, outlines how the final dataset is constructed, defines all the variables, and provides some summary statistics. Section II investigates what factors influence short interest changes and relates the results to expected returns. Section III discusses our findings, and Section IV presents our conclusions. The Appendix offers some basic information about short selling (major participants, institutional details, risks, etc.).

#### I. Data

#### I.A. Dataset Construction

The core of our dataset are short interest positions obtained from Bloomberg for the 1991-2007 period. U.S. stock exchanges instruct their member firms to report their short positions for all accounts on a monthly basis. This information is collected on the fifteenth calendar day (or the preceding business day if this is not a business day) of every month and refers to positions as of settlement on the fifteenth. Since the settlement period is 3 (or 5 before June 1995)

<sup>&</sup>lt;sup>5</sup>Chen, Hong and Stein (2002), who show that stocks with reductions in breadth of institutional ownership underperform, and Nagel (2005), who finds that certain cross-sectional return patterns, among them the book-to-market effect, are more pronounced for stocks with low institutional ownership, are examples of this literature.

business days, this means that reported short positions reflect transactions that took place 3 (or 5) business days before the fifteenth. The data is then aggregated for each security and released eight business days later.<sup>6</sup> Various information providers, including the *Wall Street Journal, Barron's, New York Times,* and Bloomberg, publish the short interest for selected stocks. The whole sequence from establishment of short positions to their publication has four key dates: trade date - the last day for which short sales are included in the month's reported numbers; reporting date - the day when market makers are required to report their positions; dissemination date - the day when the exchange sends out the data; and publication date - the day when the information is published by the financial press and websites. For example, in January 2000, the trade date was 1/11, the reporting date was 1/14, the dissemination date was 1/26, and the publication date was 1/27. As we will discuss below, for our analysis the relevant date will be the trade date.

We obtain data on daily stock returns, shares outstanding, firm size, and share type from the Center for Research in Security Prices (CRSP). Annual accounting data are obtained from the CRSP/COMPUSTAT merged database and institutional ownership data from Thomson Financial's CDA/Spectrum Institutional (13f) Holdings database.<sup>7</sup> We add this information to the short interest dataset. We restrict our sample to ordinary common shares with valid return and book equity numbers, which leaves us with 438,157 firm-trade date observations ("Full Dataset"). Closed-end funds, ADRs, warrants, and units are excluded from the analysis, but our results do not change if these securities are included in the sample.

The main goal of this paper is to identify circumstances in which short sellers choose to increase their positions and those in which they choose to cover. One issue complicating our analysis is the existence of short sale constraints. Some stocks may be very costly or even

<sup>&</sup>lt;sup>6</sup>Apparently exchanges sometimes fail to meet this deadline and releases the data a couple of days later. This complication in no way impacts our analysis.

<sup>&</sup>lt;sup>7</sup>The Institutional Holdings database reports positions above 10,000 shares or \$200,000 for all investment companies with more than \$100 million of funds under discretionary management. The ultimate source of this information is the SEC, which requires all qualifying investment companies to file their holdings in the so-called 13f form on a quarterly basis. Gompers and Metrick (2001) provide a more extensive description of this database.

impossible to borrow (because the supply of loanable shares is low or because the demand for borrowing is high), potentially preventing traders from carrying out their intended strategies.<sup>8</sup> If these constraints play a significant role in driving changes in short sellers' positions, there exists a danger that some variables that actually have no impact on what short sellers want to do end up being significant because they have an impact on short sale constraints. For example, if positive past returns somehow ease binding short sale constraints, we could get a result that returns predict increases in short interest, even if none of the short sellers' unconstrained strategies depend on or take into account past returns. To alleviate such problems, we attempt to limit our sample to stocks that are not especially likely to be affected by short sale constraints.

We thus exclude from our analysis all stocks whose price is less than \$5 and stocks with market capitalizations in the bottom decile (using New York Stock Exchange breakpoints obtained from Kenneth French's website). We arrive at these screens by utilizing some of the existing literature on short selling, which suggests that small, illiquid stocks are often hard to short. D'Avolio (2002) finds that about one third of stocks priced under \$5 appear unshortable. He defines unshortable shares as those that were not available for borrowing from a large custody bank. But the loan supply of custody banks reflects the holdings of its clients and is therefore biased towards large-cap, liquid stocks. This means that D'Avolio might have overestimated the proportion of small, illiquid stocks that cannot be borrowed, as some of them might still be available for shorting from other sources. For example, small stocks held mostly by individual investors might be more easily borrowed from retail brokerage houses. In order to be conservative, we nonetheless choose to eliminate all the affected stocks. All of our findings continue to hold if do not exclude these stocks from our analysis. The screens reduce the size of our dataset by little less than a half, leaving us with 251,452 firm-trade date observations ("Shortable Dataset").

The criteria we impose for inclusion in the Shortable Dataset should substantially reduce

<sup>&</sup>lt;sup>8</sup>For more information on short selling, please see the appendix.

the presence of shorting-constrained stocks. D'Avolio reports that 91% of stocks lent out have a loan fee that is lower than 1% per annum. The average fee for the remainder is 4.3% per annum, with less than 1% having negative rebate rates (i.e., loan fees higher than the risk-free rate). Furthermore, recall is a rare occurrence. The relatively low loan fees and low recall risk for the great majority of stocks analyzed by D'Avolio suggest that most of them can be easily shorted. And, since the composition of his sample is similar to that of the Shortable Dataset (in that small, illiquid stocks are under-represented), we believe this should also be the case for stocks in this dataset.<sup>9</sup> However, we also realize that our screens do not completely solve this problem and therefore always include controls for short sale constraints in our regressions.

#### I.B. Variable Definitions

Throughout this paper, we define short interest as the percentage of a firm's outstanding shares that is sold short. This is calculated as the number of shares shorted divided by the number of shares outstanding (times 100).<sup>10</sup> The financial press often reports another measure, the cover ratio, which equals the number of shares shorted divided by the average daily trading volume. While this number might better capture the effect of future covering of short sellers' positions (of obvious interest to practitioners), we are more interested in the relative size of short positions, and this is more accurately captured by the short interest ratio.

Book equity is computed as in Cohen, Polk and Vuolteenaho (2003). Convertible securities outstanding are set to equal the sum of the balance sheet amount of outstanding convertible debt and the carrying value of convertible preferred stock (data item 39 in the CRSP/COMPUSTAT merged database). We assume markets get access to financial state-

<sup>&</sup>lt;sup>9</sup>D'Avolio's sample includes some under-\$5 stocks (whereas we eliminate all of them), making it possible that the stocks in our sample are on average cheaper to short.

<sup>&</sup>lt;sup>10</sup>We have to be careful here, as exchanges adjust the reported short interest only for those stocks that split on or before the settlement date (not the dissemination date). We thus use the outstanding shares number as of the settlement date (which varies from month to month).

ment information 4 months after the fiscal year ends.<sup>11</sup> All accounting values used always reflect the latest data available to the public. Firm size and market-to-book ratio are calculated using current month's closing market prices.

Institutional ownership is defined as the percentage of a firm's outstanding shares that is owned by institutional investors. We get this number by summing the stock holdings of all reporting institutions at the end of each quarter. Beforehand, we correct individual institutional holdings for the late-filer problem outlined in Gompers and Metrick (2001). For stocks without any institutional holders, we assume institutional ownership equals zero.

Since our analysis focuses on factors driving changes in short sellers' positions, we want to match our explanatory variables as closely as possible to the dates at which these positions were established. As described above, exchanges report short interest not as of month-end, but as of the trade day (which varies from month to month). Consequently, we make the trade date our key reference date. We define the return in month t as buy-and-hold return for the period between the trade day+1 in month t - 1 and the trade day in month t. For example, the return in January 2000 is the buy-and-hold return for the period between 12/11/1999 and 1/11/2000. The returns include delisting returns where appropriate and available. Momentum is computed as the buy-and-hold return over the corresponding months.

#### I.C. Summary Statistics

In Figure 1, we plot the time-series evolution of the cross-sectional distribution of short interest for the Full Dataset.<sup>12</sup> The distribution is very skewed, with most stocks being very lightly-shorted and only a few having substantial short interest. This is especially true

<sup>&</sup>lt;sup>11</sup>The Securities and Exchange Commission used to require that firms under its jurisdiction file their 10-K reports within 90 days of fiscal year-end. This rule changed recently (deadlines were shortened for most firms), but was in effect during most of the period under consideration. We add an extra month to account for late filers.

 $<sup>^{12}</sup>$ The plots in Figures 1 and 2 closely resemble those in Asquith et al. (2005). In that paper, the authors attempt to manually correct suspicious short interest observations by cross-checking them against data published in *Barron's* and listed on Bloomberg. We make no such endeavour, but hope that the similarity between their summary statistics and those in this paper indicates that any errors we miss are not numerous enough to affect our findings.

early on in the sample. Over time, short interest tends to rise, with the increase being more pronounced for low-short interest stocks, which somewhat ameliorates the skewness. Between 1991 and 2007, short interest for the median stock jumps about thirty-fold and that for the 99<sup>th.</sup> percentile stock only triples. The increase in short interest could reflect either greater demand for shorting or greater supply of loanable shares. The former could stem from the rise of hedge fund investing or greater investor sophistication, while the latter can perhaps be attributed to the increase in the number or relative importance of institutions participating in the share lending market. We speculate that both supply and demand factors play a role, but leave this question for future investigation.

#### [FIGURES 1 AND 2 ABOUT HERE]

Figure 2 plots the same graphs for the Shortable Dataset. The main patterns are almost the same as those in Figure 1. The two principal differences are that the short interest distribution is shifted to the right and that it exhibits less skewness. Throughout the entire period, the median short interest is typically at least twice as high in the Shortable Dataset compared to the Full Dataset, which indicates that the screens we apply perform as intended in keeping out at least some unshortable stocks.<sup>13</sup>

Panel A of Table II presents the average number of stocks, average market capitalization, and total market capitalization for five short-interest-based subsamples of the Full Dataset. About 30% of stocks have short interest ratios that are above 2.5%, which we consider to be a reasonable threshold for classifying a stock as actively-shorted. When total market capitalization is used instead, that number falls to 22%, partly because the very largest stocks do not have very high short interest levels. While not overwhelmingly high, these percentages show that, on average, short sellers take positions in a respectable proportion of stocks in our sample.

#### [TABLE II ABOUT HERE]

Panel B of Table II reports the same information for the Shortable Dataset. The per-

<sup>&</sup>lt;sup>13</sup>The implicit assumption here is that at least some stocks have negligible short interest due to short sale constraints.

centage of actively-shorted stocks is higher than in Panel A, with 42% by number and 22% by market capitalization exceeding the 2.5% cut-off point. This further confirms that our screens do a reasonable job in restricting the sample under analysis to stocks that can be shorted.

Finally, in Panel C of Table II, we calculate for every subsample the proportion of stocks and total market capitalization that is included in the Shortable Dataset. We find that most of the stocks excluded from subsequent analysis are low short interest stocks. Only 35% of stocks with short interest below 1% are present in the Shortable Dataset, compared to at least 72% of stocks with short interest above 1%. Measured by total market capitalization, about 95% of stocks with short interest above 1% are represented in the Shortable Dataset. These findings give us confidence that the sample we analyze very adequately captures the positions of short sellers.

#### II. Empirical Analysis

Our primary goal here is to identify short seller responses to price movements in the stocks they target. These price movements can reflect real changes in the fundamental value of a firm, or they might reflect trades of liquidity-constrained or unsophisticated investors. Short sellers thus do not face just the risk that they wrongly picked a stock as overvalued, but also the risk that other investors continue to buy the already-overvalued security.<sup>14</sup> Moreover, short sellers could themselves become the target of other sophisticated investors, who push up the stock price in an attempt to "squeeze" short sellers out of their positions, either directly by buying up all the shares and demanding their return or, more plausibly, indirectly by inflicting losses until they become too much to bear. In order to shed more light on which of these forces influences short sellers' trading activity, we also explore the link between their past losses and future returns.

<sup>&</sup>lt;sup>14</sup>The latter is commonly referred to as "noise-trader risk" following DeLong et al. (1990).

#### **II.A.** Determinants of Short Interest Changes

We start by examining what factors play a role in determining short interest changes. Our dependent variable is the monthly change in short interest ( $\Delta SI_t = SI_t - SI_{t-1}$ ). The main focus of our analysis is past returns, but we also include a set of control variables, giving us the following specification:

$$\Delta SI_t = \alpha + \beta r_{t-1} + \gamma' X_{t-1} + u_t \tag{1}$$

X is a set of explanatory variables other than past month's return (r), which includes the book-to-market ratio (BE/ME), log size  $(\log(ME))$ , institutional ownership (IO), and lagged short interest (SI). Book-to-market is a very standard price-to-fundamentals ratio, which we use to determine whether short sellers have a preference for value or growth stocks. The log size variable is meant to capture a potential short seller preference for small or large stocks. Institutional ownership and lagged short interest are intended to control for potential short sale constraints. Institutional ownership proxies for supply of shortable shares, while previous month's short interest proxies for shorting demand. Presumably, stocks with high institutional ownership can be cheaply and reliably shorted, as lots of shares are available for borrowing from custody banks and broker-dealers acting as intermediaries for their institutional clients. D'Avolio (2002) finds that institutional ownership is the best predictor of stock loan supply. Conversely, short sellers might experience difficulties trying to increase positions in highly shorted stocks, because the supply of shortable shares is already exhausted by strong demand.

We estimate equation (1) by an ordinary least squares (OLS) panel regression, where our standard errors are clustered by trade date to reflect potential cross-sectional correlation of residuals across stocks. We also add fixed effects for each year in our sample. We utilize the same approach for all regressions in this paper.

#### [TABLE III ABOUT HERE]

The first column of Table III reports results from estimating equation (1) for the whole Shortable Dataset. The coefficient on  $r_{t-1}$  is strongly negative (t-stat=-7.02), showing that short sellers decrease their positions in stocks which recently increased in value. The coefficients on short sale constraints controls come out as theory would predict. Short sellers can more easily increase positions in stocks with a greater supply of shortable shares, so we expect the relevant coefficients to have a positive sign if our proxy variables indeed are correlated with supply. This expectation is corroborated by the data. The  $IO_{t-1}$  coefficients is both positive and statistically significant (t-stat=5.54). The expected sign of the demand proxy coefficient is negative, and this also is confirmed in the data, where we get a significantly negative coefficient on  $SI_{t-1}$  (t-stat=-8.15).

If short sellers cover their positions in response to incurred losses, it is reasonable to assume that the negative linkage between past returns and changes in short interest will be stronger for highly shorted stocks. Positive returns hurt short sellers more if their exposure is large, so they should respond by greater cuts in their positions.<sup>15</sup> To test this hypothesis, we restrict our sample to highly shorted stocks and re-run our regression.

Columns 2 through 6 of Table III present our findings, which are quite striking. When only stocks in the top quintile by short interest are included, the  $r_{t-1}$  coefficient is almost two times more negative than the coefficient for the entire sample (-0.616 vs. -0.374). For top decile stocks and those in the 95<sup>th.</sup> percentile, the magnitude of the  $r_{t-1}$  coefficient becomes even greater (-0.791 and -0.994 respectively). At the same time, the R<sup>2</sup>'s rise substantially as the sample becomes more restricted, almost tripling for the highest short interest one. This indicates that past returns are more important in determining short interest changes for highly shorted stocks. The results hold true even when past returns are the only right-hand side variable (we do not report those regressions for brevity), so we can conclude that at least a part of the increased explanatory power stems from the  $r_{t-1}$  variable. Our results are very similar when we use absolute short interest level screens instead of percentiles. For the

 $<sup>^{15}</sup>$  The implicit assumption here is that high aggregate short interest translates into larger average individual short positions.

samples consisting only of stocks with short interest above 2.5% and 5%, the  $r_{t-1}$  coefficient is again much more negative (-0.600 and -0.777 respectively) and R<sup>2</sup>s are significantly higher.

The other notable difference in the highly shorted samples involves the institutional ownership coefficient, which is no longer significant and has significantly lower point estimates. We interpret this result as evidence that, controlling for demand pressures, traders of high short interest stocks do not face considerable supply constraints, at least in the short-term.

In the context of this paper, the most important result is that the past returns coefficient becomes more negative as the sample is more tightly restricted to highly shorted stocks. This relationship is consistent with the hypothesis that short sellers are sensitive to losses. An alternative, and probably more precise, test of this proposition would involve a direct measure of the aggregate loss (gain) incurred by short sellers of a given stock. We compute this variable (*Short\_ret*) as the interaction term between the short interest ratio and the monthly return. More specifically, aggregate short seller loss (gain) in month t is calculated as the product of the short interest ratio in month t and the return in month t. This value represents the loss (as a percentage of the firm's market capitalization) that short sellers would have suffered in the period between trade day + 1 in month t - 1 and trade day in month t if their positions equaled the reported short interest throughout this period.<sup>16</sup> Obviously, the actual short sellers' losses could be higher or lower, depending on their trading activity in the period. With the addition of the loss variable, we get this specification:

$$\Delta SI_t = \alpha + \beta r_{t-1} + \gamma' X_{t-1} + \delta Short \quad ret_{t-1} + u_t \tag{2}$$

We estimate equation (2) by using the same approach as before and report the results in column 1 of Table IV. The crucial finding is that the coefficient on  $Short\_ret_{t-1}$  is negative and highly statistically significant (t-stat=-3.46). This indicates that short sellers indeed do cover their positions after suffering losses (and increase them after experiencing gains) and

<sup>&</sup>lt;sup>16</sup>We implicitly assume here that short sellers earn a rebate rate of zero on short sale proceeds. This is the rate retail investors get when they borrow stock. Our results do not change if we instead set the rebate rate equal to the riskfree rate.

thus offers strong support for our hypothesis. Furthermore, when we add the  $Short\_ret_{t-1}$  variable, the  $r_{t-1}$  coefficient is no longer significant (and actually has a positive sign), implying that short sellers are motivated by losses rather than past returns.

As a robustness check, we split our sample in two parts: the period from 1991 to 1998 and the period from 1999 to 2007. The results continue to hold in both subsamples, with the  $Short\_ret_{t-1}$  coefficient being negative and statistically significant at the 1% level. Consequently, we are reassured our results are not just an artifact of extraordinary market conditions at a particular point in time. The findings are also robust to different regression specifications and to different methodologies for calculating short seller loss (such as replacing raw returns with various measures of abnormal returns).<sup>17</sup>

#### [TABLE IV ABOUT HERE]

One problem with our interpretation of the negative sign on the  $Short\_ret_{t-1}$  coefficient is the possibility that losses and gains have a fundamentally different impact on short sellers. For example, it could be the case that short sellers respond only to losses, while gains do not at all influence their trades. Or it could be the case that only gains matter. To examine this issue in more detail, we create two variables, one measuring only losses and the other only gains:

$$Loss_{t-1} = \max(SI_{t-1}r_{t-1}, 0) \tag{3}$$

$$Gain_{t-1} = \max(-SI_{t-1}r_{t-1}, 0) \tag{4}$$

We then replace the  $Short\_ret_{t-1}$  variable with these two variables, giving us the following regression equation:

$$\Delta SI_t = \alpha + \beta r_{t-1} + \gamma' X_{t-1} + \delta Loss_{t-1} + \varepsilon Gain_{t-1} + u_t \tag{5}$$

The results from estimating equation (5) are presented in column 2 of Table IV. They show that both past gains and past losses impact short seller trades. The coefficient on

<sup>&</sup>lt;sup>17</sup>For brevity, we do not report those results here. They are available on request.

 $Loss_{t-1}$  is negative and statistically significant (t-stat=-2.98), and the coefficient on  $Gain_{t-1}$  is positive and statistically significant (t-stat=2.30). In accordance with our predictions, short sellers cover their positions after suffering losses and increase them after experiencing gains.<sup>18</sup> Coefficient magnitudes are relatively similar, indicating that, for a given loss or gain, short sellers adjust their positions by roughly the same proportion. This last result validates our use of a single variable as our proxy for short seller losses and gains.

Finally, we explore whether short sellers react only to recent losses (those suffered during the last month) or whether they also decrease their positions in response to more longterm losses. Our measure of these long-term losses (gains if negative) is very similar to the  $Short\_ret$  variable: it is the product of a stock's cumulative return in months t-6 through t-2 and its level of short interest, and we label it  $Long\_Short\_ret$ . We add this term to equation (2) and report the findings in column 3 of Table IV. The coefficient on long-term short seller losses is negative and significant (t-stat=-4.32), indicating that short sellers cut down their positions when faced with such losses. The presence of  $Long\_Short\_ret$  does not affect the impact of recent losses: the coefficient on  $Short\_ret$  is still negative and significant (t-stat=-3.54), with an almost unchanged point estimate. These results suggest that short sellers are affected by both recent and more long-term losses. In column 4, we repeat the same analysis, but define separately long-term short seller losses and gains (as in equations (3) and (4)). We find that both have the predicted impact on short seller positions, although long-term losses seem more important than gains (t-stat of the former is -3.38 versus 1.90 for the latter, with the corresponding difference in point estimates).

In our analysis in this section, we implicitly treat short sellers of a particular stock as one uniform group, whose membership does not change over time. Although this is obviously not a completely realistic assumption, we believe it does not significantly affect any of our results. First, it probably does not misrepresent the actual state of affairs too much. Major short sellers, such as hedge funds, are usually specialized and relatively few in number. Whereas

<sup>&</sup>lt;sup>18</sup>As before, this finding holds even when we split the sample into two subperiods.

with long positions one class of investors can be replaced by another as circumstances change, this is much less likely to occur with short positions. Second, to the extent that for some stocks new short sellers do replace those who exit, this only serves to weaken our results, as we wrongly classify such stocks as being unaffected by covering.<sup>19</sup>

#### II.B. Valuation-Motivated Shorting vs. Arbitrage Trades

Not all short positions are established by investors who believe a stock is overvalued. Often shorting a stock represents just one component of a more complex trading strategy seeking to take advantage of relative mispricing of two (or more) securities. We call these trades "arbitrage," because, unlike naked short selling, in theory they should make money regardless of whether the stock price moves up or down. Therefore, as investors engaging in arbitrage are hedged against stock price movements, we expect them to be insensitive to losses incurred on their short positions. This difference between valuation-motivated short selling and arbitrage trades presents us with an opportunity to further refine our analysis. If the documented negative correlation between our measure of short seller losses and short interest changes really is caused by sensitivity to incurred losses, this relationship should hold only for valuation-motivated short sales and not for arbitrage ones.

The problem now is that we cannot directly or accurately determine what reasons prompted the establishment of short positions in our dataset. However, we can find proxies that enable us to make reasonable guesses. One prominent example of arbitrage is convertible security arbitrage, a strategy popular at many hedge funds and investment bank trading desks. It usually involves buying a convertible security whose imbedded call option appears undervalued and shorting the underlying stock to hedge the risk associated with stock price movements.<sup>20</sup>

<sup>&</sup>lt;sup>19</sup>Another source of noise in our sample is the aggregation of short positions of market makers and customers. Ideally, we would want to distinguish between those two types of market participants and apply our tests only to the latter.

<sup>&</sup>lt;sup>20</sup>One complication with convertible security arbitrage is that, as the stock price moves, short positions have to be adjusted to keep the net position fully hedged. In general, this dynamic hedging requires increases (decreases) in short positions after increases (decreases) in the stock price, creating a positive correlation between the two. We ignore this bias in our analysis, believing it to be only of second-order importance. To the extent it is not, we should expect the difference between valuation and arbitrage trades to be even more

By utilizing the CRSP/COMPUSTAT merged database, we identify firms with a significant amount of convertible bonds or convertible preferred stock outstanding and classify short positions in their stock as arbitrage trades.<sup>21</sup>

More specifically, we create three subsamples using different cut-off points. The Non-Convertible Dataset consists of all firm-trade date observations with no convertible securities outstanding (205,554 observations). We assume this sample is made up mostly of valuationmotivated short positions. The Convertible Dataset consists of all firm-trade date observations with convertible securities outstanding (45,908 observations). This sample is supposed to include arbitrage trades, but probably also includes many valuation ones. We focus more exclusively on arbitrage trades in the High Convertible Dataset, which consists of all firmtrade date observations for which the convertible securities outstanding exceed \$10M and 10% of book equity (27,314 observations).

We re-run regression (2) for each of these three samples and present the results in Table V. For the Non-Convertible Dataset, the results are very similar to those for the Shortable Dataset. But the Convertible Dataset results are quite different. Most importantly for our purposes, the coefficient on  $Short\_ret_{t-1}$  is no longer statistically significant (t-stat=-0.75), and the point estimate is cut three-fold. For the High Convertible Dataset, the  $Short\_ret_{t-1}$  coefficient is still statistically insignificant and now has a point estimate that is barely one fifth of its level in the Non-Convertible Dataset.

#### [TABLE V ABOUT HERE]

One potential complication with direct comparisons of coefficients across the three samples is their different sizes. The Convertible Dataset and High Convertible Dataset are much smaller than the Non-Convertible Dataset, possibly making statistical significance harder to attain. To address this issue, we conduct a simple simulation. We randomly sample 45,908

pronounced (in terms of how positions change in response to moves in stock prices).

<sup>&</sup>lt;sup>21</sup>Of course, there are other arbitrage strategies that do not involve convertible securities, such as index arbitrage, merger arbitrage, or pairs trading. We make no attempt to identify short positions established by investors pursuing these strategies. Their inclusion in the valuation-motivated short position sample should only weaken our results, so we do not believe this represents a problem.

observations (their number in the Convertible Dataset) from the Non-Convertible Dataset and then estimate our equation using these observations. We repeat the procedure 10,000 times. The  $Short\_ret_{t-1}$  coefficient is negative 98.4% of the time and negative and statistically significant at the 10% level 88.1% of the time. We perform the same simulation for randomly sampled datasets with 27,314 observations (their number in the High Convertible Dataset). The  $Short\_ret_{t-1}$  coefficient is negative 92.9% of the time and is negative and statistically significant at the 10% level 60.7% of the time. These results suggest that the difference in  $Short\_ret_{t-1}$  coefficients across samples is unlikely to be just a product of their size disparity.

We repeat this same analysis for equation (5), where we distinguish between short seller gains and losses. Again the results show there exists a difference between valuation-motivated and arbitrage trades. For valuation-motivated trades in the Non-Convertible Dataset, the coefficient on  $Loss_{t-1}$  is negative and statistically significant (t-stat=-2.89), and the coefficient on  $Gain_{t-1}$  is positive and statistically significant (t-stat=2.57). These coefficients are no longer significant in the Convertible and High Convertible Datasets. Simulation results confirm these findings.<sup>22</sup>

There are two principal inferences we draw from the results in this section. First, short sellers motivated by perceived overvaluation decrease their positions after suffering losses, whereas those engaging in arbitrage trades, whose losses are presumably offset by their other positions, do not. Second, the similarity of regression results for the Shortable Dataset and the Non-Convertible Dataset means that the majority of short positions we analyze stem from valuation trades.

#### II.C. Loss-based Portfolio Returns

We have documented that valuation-motivated short sellers respond to losses (gains) by cutting (increasing) their positions. The interpretation of this result depends crucially on future stock returns. If the stock increases in value after short sellers who suffered losses cover, we cannot conclusively attribute their trades to any other motive than portfolio return

 $<sup>^{22}\</sup>mathrm{For}$  brevity, we do not report those results here. They are available on request.

maximization. Perhaps a combination of high short interest and positive (negative) past returns somehow predicts positive (negative) future returns, and short sellers act with this in mind.<sup>23</sup> However, if the stock experiences negative returns after losing short sellers close their positions, we can propose with at least a degree of confidence that their actions reflect some constraint or behavioral bias. By covering in this situation, short sellers are forgoing gains they would otherwise capture when the stock price falls in the future.

To help determine what drives short sellers' response to losses, we explore whether these losses help forecast future returns. For a stock j, we measure the raw buy-and-hold return over N months starting on trade day+1 in month t  $(BHR_{j,t}^N)$ .<sup>24</sup> This return measures the stock's performance after short sellers report their positions in month t. The return horizon ranges from 1 to 6 months, which, given the costs associated with maintaining positions, covers the plausible holding periods for most short sellers, retail and institutional alike.

We start by studying the direct impact of short seller losses in a particular stock on its subsequent performance through the following regression:

$$BHR_t^N = \alpha + \beta Short \quad ret_{t-1} + \gamma Y_{t-1} + \delta \Delta SI_{t-1} + u_t \tag{6}$$

Y is a set of explanatory variables other than short seller losses  $(Short\_ret)$ , which includes the book-to-market ratio (BE/ME), log size  $(\log(ME))$ , and institutional ownership (IO). To estimate equation (6), we adopt the same approach as before, but now have fixed effects for each trade date (rather than each year).

Column 1 of Table VI presents our results for various return horizons. We only report the coefficient on short seller losses, as we are primarily interested in their impact on future returns. This coefficient is not significant at any horizon, with t-statistics ranging from -0.88 for 1-month returns to 0.04 for 6-month returns, which seems to suggest that short sellers

 $<sup>^{23}</sup>$ One potential explanation for this relationship is that the true value of a highly-shorted stock is subject to significant uncertainty, with past returns partly or completely resolving this uncertainty and the market underreacting to this information.

<sup>&</sup>lt;sup>24</sup>Our results are very similar if we use cumulative and/or abnormal returns instead.

losses by themselves have no impact on future returns.

The next step in our analysis is to directly test whether short sellers who cover their positions after suffering losses are making the right decision. We do so by utilizing the following specification:

$$BHR_t^N = \alpha + \beta Short\_ret_{t-1} + \gamma Y_{t-1} + \delta \Delta SI_{t-1} + \varepsilon (Short\_ret_{t-1} * \Delta SI_{t-1}) + u_t \quad (7)$$

The focus of our interest is the interaction term between changes in short seller positions and past short seller losses. A negative coefficient here indicates that decreases in short interest combined with high short seller losses forecast positive returns. This would imply that short sellers are avoiding future losses when they cover their positions in response to past losses and would provide a purely rational explanation for our previously documented findings. However, as we report in column 2 of Table VI, the interaction coefficient is always positive and significant for all return horizons considered. Not only are short sellers not avoiding losses by covering when they do, they are actually forgoing future profits. Thus, at least in some circumstances, the trading activity of short sellers is actually pushing stock prices away from their intrinsic values.

In our analysis above, we use information known on trade day in month t - 1 to forecast stock returns starting on trade day+1 in month t. There therefore exists a one-month gap between the dating of our explanatory variables and the beginning of the return window. We adopt this approach because the objective of our exercise is to determine whether lossinduced covering (gain-induced increases) benefit short sellers. The complication here is the frequency of short position reports, which are collected once a month. This makes it impossible to accurately determine the performance of short seller trades during the month when they take place, as we do not know at which prices they were executed. To get around this problem, we are required to make assumptions about when short sellers do their trading. The analysis so far effectively assumes their trades all happen at market-close prices on trade day in month t. One advantage of this approach is that we do not include in our analysis returns in month t, which could be contaminated by price pressure stemming from short seller trading activity. The one-month lag also alleviates any bid-ask bounce problems that might affect our results.

An obvious alternative assumption is to suppose that short seller trades occur at the beginning of the reporting period, i.e. on trade day in month t - 1. When we use this assumption, our results remain basically the same. The fact that they do not change much when we replace return windows starting in month t with those starting in month t - 1 reassures us about the robustness of our findings. Although we do not know at what exact prices short sellers execute their trades, it seems this issue is not of crucial importance to our analysis. What is important and represents the main contribution of this section, is that loss-induced covering does not appear to be motivated purely by expected returns, potentially suggesting that short sellers are subject to certain constraints or behavioral biases that force them to sometimes trade in such a manner that actually hurts their bottom line.

#### III. Discussion

We have shown that short sellers decrease their positions after incurring losses and increase them after experiencing gains. Now we explore the possible motivations behind the observed short seller response to stock price movements. More specifically, we propose two very general models governing short seller reactions to price fluctuations and try to determine which one better fits our results.

One hypothesis is that short sellers are fully rational and face no capital constraints, as in Friedman (1953) or Fama (1965). In this case, the only influence past losses exert on short sellers' trades is through their impact on expected future risk-adjusted returns. If high losses forecast positive (negative) future returns, the correlation between losses and changes in short interest will be negative (positive). In other words, short sellers close their positions only if fundamentals of the targeted company improve, but do not cover (and may even increase) positions if the price run-up is caused by noise-traders or strategic investors trying to cause a short squeeze.<sup>25</sup> For example, if a positive (negative) return in the previous month makes a high short interest stock more (less) overvalued, short sellers will increase (decrease) their positions. As a result, we would get a positive correlation between losses and changes in short interest. We call this model the "unconstrained arbitrage hypothesis."

The evidence suggests that expected returns are not the explanation for why short sellers cover their positions after losses (and increase them after gains). When short sellers cover in response to losses, the affected stocks exhibit low rather than high future returns. This makes short seller covering truly puzzling from the unconstrained arbitrage perspective, as these loss-induced trades actually lose money for short sellers.

The alternative hypothesis is that past returns influence short seller actions beyond what impact they have on expected future returns. We call this model the "constrained arbitrage hypothesis." While we are agnostic about the exact origins of this relationship, we put forward two theories we consider as the most likely explanations. The first one is that short sellers have limited capital at their disposal. These capital constraints arise either because their own funds are limited or, if they are acting as investment managers for others, because of problems stemming from their agency relationship with outside investors.

The latter option represents the Shleifer and Vishny (1997) model, where professional, specialized arbitrageurs manage money for outside investors, who evaluate them based on their performance. These arbitrageurs (in our case the short sellers) cannot easily raise new funds after suffering losses. In some circumstances, especially if they are leveraged, they might actually be forced to return already committed funds.<sup>26</sup> Thus, when markets move against short sellers in a substantial way, they, voluntarily or involuntarily, terminate their positions, even though these positions might now present better opportunities than when

 $<sup>^{25}</sup>$ The assumption here is that these strategic buyers cannot buy up the entire supply of loanable shares. Instead, they aim to induce short seller covering by inflicting losses. Given the high capital requirements of the former strategy and the scant evidence of it taking place, we feel confident that most short squeezing takes the form of the latter strategy. See Brunnermeier and Pedersen (2005) for a formal model of predatory trading.

<sup>&</sup>lt;sup>26</sup>The fact that investors withdraw money from funds with bad performance is a well-documented one. See, e.g., Chevalier and Ellison (1997).

they were established. After experiencing gains, short sellers have more capital to invest and use it to increase those positions with attractive payoff profiles.

Given that our results apply to individual stocks, an explanation involving capital constraints would require short sellers to hold imperfectly diversified positions. Unfortunately, short position data on an investor-by-investor basis is very hard to obtain, so the best we can do is conjecture. Perhaps the low number of highly shorted stocks indicates that at any point in time short sellers target a limited number of stocks. The impact of such imperfect diversification could be amplified by the different payoff profile of a short position. Shorting a stock is fundamentally different from buying it in that *ceteris paribus* an adverse price movement increases your portfolio's exposure to that stock. A simple numerical exercise might better illustrate this point. Let us consider a portfolio with a long position representing 20% of its net value. A price decline of 50% will reduce that long position to 11% of the portfolio's new net value. Now, let us consider a portfolio with a short position equal to 20% of its net value. If the price of the stock rises by 50%, the short position will grow to 33% of the portfolio's new net value. This example shows how a single short position can quickly become a substantial portion of a portfolio. Even in the absence of direct capital constraints (i.e., the prospect of going bankrupt), internal risk management tools such as position limits would then lead to covering of losing positions.

The second theory is that short sellers are loss-averse and that the degree of their loss aversion depends on prior gains and losses (the so-called "house money" effect), a combination referred to as myopic loss aversion (Barberis and Huang (2001)). If short sellers have such preferences, they will become more (less) loss-averse after losses (gains) and consequently cover (increase) their positions.<sup>27</sup> Even if most short selling is done by professional money managers acting on behalf of outside investors, myopic loss aversion could still affect their trades, as long as the managers' compensation depends on investment performance. Haigh and List (2005) describe experimental evidence that professional traders exhibit behavior

<sup>&</sup>lt;sup>27</sup>Since our analysis uses short positions in individual stocks, this theory would also require that short sellers measure losses and gains over each individual position, rather than their overall portfolio.

consistent with myopic loss aversion, suggesting the bias may be widespread enough to materially impact markets. In another paper, Coval and Shumway (2005) find that Chicago Board of Trade proprietary traders are highly loss-averse over a one-day holding period, taking above-average risks in the afternoon to try and recover from morning losses. These traders do not exhibit behavior consistent with the "house money" effect, but this could just be the function of the short holding period.

Capital constraints and myopic loss aversion both have the same prediction that short sellers, all else equal, cut their positions after suffering losses. Short sellers now cover even if the price increase reflects noise-trader actions rather than a change in the fundamental firm value. Thus, under the constrained arbitrage hypothesis, the correlation between short seller losses and short interest changes should be negative, which is exactly what we document in the data. The differential impact of losses on valuation-motivated and arbitrage trades is another, more subtle prediction that is confirmed by the data. Short of some unspecified systematic difference among the two groups of stocks, it is not obvious why the unconstrained arbitrage hypothesis would imply this. Finally, on balance the relationship between losses and future returns is more consistent with the constrained arbitrage interpretation. While it is certainly possible that short sellers always make "smart" trades and that they operate in a world of constrained arbitrage, the case for constrained arbitrage is made stronger when we find that at least some of their trades do not predict returns in the right direction.

One issue raised by our research is, if some short sellers close their positions due to losses, why are they not replaced by new investors? Perhaps the number of investors who short sell stocks is simply limited, and once those short sellers are all committed, there is no one left to replace them when they exit. We know that mutual funds, which as a group are the biggest holders of U.S. equities, very rarely engage in shorting, with many not even considering the activity as a possible trading strategy. Almazan et al. (2004) find that two-thirds of mutual funds have charters that specifically prohibit short selling and only 3% actually do short sell. The reasons often given for this reluctance include the cost of short selling, risk of recall, perceived riskiness of a short position (theoretically unlimited potential loss), unfavorable tax treatment, reluctance to bet against companies, and public bias against short sellers. Our results provide another potential rationale for why many investors abstain from short selling: maybe the danger of being squeezed out of positions by losses makes them uneasy about shorting.

#### IV. Conclusion

This paper investigates which factors play a role in influencing short sellers' trades. Our main result is that short sellers cover their positions after suffering losses and increase them after experiencing gains. Moreover, while this relationship is very strong for positions established due to perceived overvaluation, it does not hold for arbitrage trades, where the investor is less exposed to stock price movements. Subsequent returns do not explain the observed negative relationship between past returns and changes in short interest. By closing out positions in response to losses, short sellers actually lose out on future profits.

We interpret these findings as evidence that even sophisticated investors cannot or are not willing to maintain positions after adverse market movements, making arbitrage considerably less effective than envisioned by the efficient market hypothesis. Not only is the corrective pressure exerted by short sellers sometimes weakest, or even reversed in the case of short squeezes, when mispricing is most severe, but also short sellers who anticipate this eventuality will generally be less aggressive in attacking overvalued stocks in the first place.

Our analysis treats short sellers as one uniform group. This is the only available approach to us, as we do not observe individual short positions. This limitation should work against us finding that short sellers close out positions in response to losses, since some of the ones who do so can potentially be replaced by new entrants. Our measure of short interest will reflect the trading activity of both groups, so some of the loss-induced covering will be obscured. Consequently, our findings likely underestimate the effect.

However, by studying only aggregate short interest we are unable to determine what

characteristics make short sellers (and by extension other kinds of arbitrageurs) more or less susceptible to loss-induced covering. Some new datasets already distinguish between retail, institutional, and specialist short sellers (Boehmer et al. (2008)), and hopefully more disaggregated data will soon become available. Investor-level data would also enable us to much more precisely distinguish between valuation- and arbitrage-motivated trades. And more generally, it would fill a big gap in our understanding of short sellers. While a lot of short-selling takes places in U.S. markets, most of it seems to be very short-term in nature. Investors who are willing to hold short positions for prolonged periods of time appear to be reasonably rare. Recent years have seen a lot of research documenting various aspects of their behavior, but what remains to be learnt is who they are.

### Appendix I: Short Selling

The Securities and Exchange Commission (SEC) defines a short sale as "the sale of a security that the seller does not own or any sale that is consummated by the delivery of a security borrowed by, or for the account of, the seller." There are three main motives for short selling a stock. First, a short seller might be speculating that the stock price will fall in the future, enabling him to buy it back at a lower level and profit from the difference. Although there exist alternatives to short selling that can give arbitrageurs exactly the same exposure (options, return swaps), anecdotal evidence suggests that these markets are usually not liquid enough to accommodate large positions. Asquith et al. (2005) report interviews with hedge fund managers and other practitioners, where they assert that the options market is less liquid and more expensive than the short sales market for establishment of substantial positions. Short selling thus remains one of the most important tools for betting on future stock price decreases. Second, a short seller could be hedging certain risks associated with his existing positions. Traders of equity derivatives, for example, often use short sales as a means of hedging their positions. Finally, market makers and specialists rely on short sales to provide liquidity in response to unanticipated demand.

Short selling is generally harder than buying a stock. A short sale should not be completed before the prospective short seller locates shares available for borrowing, though this sometimes does happen in practice.<sup>28</sup> Most short sellers usually delegate this responsibility to broker-dealers, who are then the ones actually searching for stock lenders. Custody banks, acting as intermediaries for their institutional clients, are the largest providers of stock loans, especially for non-retail traders. D'Avolio (2002) cites interviews with professional short sellers that suggest custody banks are also considered to be the most reliable source of stock loans. The reason for this is probably that they have access to shares held by relatively pas-

<sup>&</sup>lt;sup>28</sup>There are some exceptions to this SEC rule, most notably market makers and specialists in the course of their regular activities and broker-dealers accepting short sale orders from other broker-dealers. Investors who are deemed to own a security, but do not have physical possession of it (for example, owners of convertible securities that have been tendered for conversion, who have not yet received the underlying security), have also recently been exempted from the locate requirement.

sive investors, such as index funds and pension funds. Broker-dealers with market-making or trading operations and retail brokerage houses are other potential lenders of stock. These institutions have access to stocks held in their customers' accounts in addition to their own, which provides them with a large supply of shares for lending. Institutional investors whose stock is lent out usually negotiate a split of any fees earned thereby, whereas retail investors are not compensated in any way. Over the recent years, institutions have become increasingly aggressive in lending out their shares as a way of earning additional income. The California Public Employees Retirement System, one of the biggest institutional stock holders in the world, has even set up an exclusive network for lending shares from its portfolio.

Short sellers also used to face restrictions imposed by the SEC and stock exchanges on when a short sale can occur. NYSE and AMEX stocks could only be sold short at a price above the immediately preceding reported price ("plus tick") or at the last sale price if it was higher than the last different reported price ("zero-plus tick") (SEC Rule 10a-1). NASDAQ prohibited its members from short selling stocks at or below the current bid price when the current bid was below the previous bid (NASD Rule 3350). The SEC recently lifted these restrictions for all stocks, but they were in effect as described during most of the period we consider. The period in September and October 2008, when the SEC barred any short selling of financial stocks, occurred after our sample ended.

After the sale is completed, short sellers do not get access to the proceeds. Instead, they are required to post collateral equal to 102% of the shorted stock's value (marked to market daily). The collateral generally takes the form of cash, on which short sellers earn a rate of interest, referred to as the *rebate rate*. The loan fee is charged implicitly as the difference between the money market rate and the rebate rate. If the loan fee is higher than the money market rate, the rebate rate is negative, and short sellers have to pay interest in order to maintain their position. Federal Reserve Regulation T requires short sellers to deposit an additional 50% of the shorted stock's value as a margin requirement. Short sellers can offer any non-margined long securities to meet this requirement, which substantially mitigates its

impact on the cost of short selling. Short sellers are also responsible for compensating the stock lender for any distributions (such as dividends) made to stock holders during the period of the loan.<sup>29</sup> When the position is closed, any potential gains from selling short a stock are taxed at the short-term capital gains rate, even if the position was held for more than a year.

Short sellers have to contend with another problem that buyers of stock do not in the form of *recall risk*. Due to regulatory and tax reasons, most institutional investors structure stock loans as demand loans, reserving the right to recall lent out shares at their convenience.<sup>30</sup> Therefore, short sellers almost always deal with stock lenders who can terminate their loans at any point in time. If that happens, and the affected short seller wants to maintain his position, he has to find replacement lenders. Otherwise, the short seller has to buy back the shares on the open market and return them to the original lender (this chain of events is often referred to as a *short squeeze*).

Many institutional investors do not ever engage in short selling. One important reason for this is the riskier payoff profile of a short position. When the market moves against a short seller, his exposure to the stock grows, and his potential losses are in theory unlimited. Due to these risks associated with shorting, prudent investor regulations prohibit institutions under their purview, such as pension funds or insurance companies, to short sell stocks. Until 1998, mutual funds were also not allowed to engage in significant shorting.<sup>31</sup> Even now most mutual funds voluntarily abstain from the activity, because of its risks, difficulties (including potential negative publicity and lawsuits - see Lamont (2004) for a detailed description), and costs. However, the growth of hedge funds, many of which regularly employ short selling as an investment technique, has increased the amount of capital devoted to short selling. Indeed, many institutional investors not allowed to short sell indirectly do so through their

<sup>&</sup>lt;sup>29</sup>The tax treatment of these compensating payments sometimes differs from the treatment of regular distributions.

<sup>&</sup>lt;sup>30</sup>Geczy, Musto and Reed (2002) report that some stock lenders get around this by making loans that are nominally demand loans, but with the loan fee as a back-end charge. This makes it much more expensive for the lenders to recall their loans early.

<sup>&</sup>lt;sup>31</sup>The Taxpayer Relief Act of 1997 repealed the so-called short-short rule, which had prohibited mutual funds from deriving more than 30% of their income from short-term gains (in this case, securities owned for less than three months). Before the Act was passed, gains from short sales were considered short term.

investments in hedge funds.

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Figure 1. Distribution of Short Interest for the Full Dataset. The figure plots the distribution of short interest (expressed as a % of shares outstanding) for the Full Datset over the period starting in 1991 and ending in 2007.



Figure 2. Distribution of Short Interest for the Shortable Dataset. The figure plots the distribution of short interest (expressed as a % of shares outstanding) for the Shortable Datset over the period starting in 1991 and ending in 2007.

Table IVariable Definitions	
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Firm size is calculated as the market value of its equity at the of the preceding month (siven in millions).	Book equity is computed as in Cohen, Polk, and Vuolteenaho (2003) (given in millions). Book-to-market is calculated as the ratio of the company's book equity and its market	Capitalization (as of the end of the previous month). Short interest is calculated as the number of shares shorted as a percentage of the number of shares outstanding.	Return in month t is defined as the buy-and-hold return for the period between the trade dav+1 in month $t-1$ and the trade dav in month t.	Institutional ownership is defined as the percentage of shares outstanding that is owned by institutions. Institutional ownership data is obtained from Thomson Financial's CDA/Spectrum Institutional (13f) Holdings database.	Short seller losses (gains) are computed as the interaction term between past month's returns and short interest $(SI_{t-1}r_{t-1})$ .	$Gain_{t-1} = \max(-SI_{t-1}r_{t-1}, 0)$ represents just short seller gains (and is 0 otherwise). $Loss_{t-1} = \max(SI_{t-1}r_{t-1}, 0)$ represents just short seller losses (and is 0 otherwise).	et Long-term short seller losses (gains) $(Long\_Short\_ret\_lag_{t-1})$ are calculated as the interaction term between cumulative return from month $t - 6$ to month $t - 2$ and past month's short interest.	$Long\_Gain_{t-1} = \max(-Long\_Short\_ret, 0).$ $Long\_Loss_{t-1} = \max(Long\_Short\_ret, 0).$ Buy-and-hold returns for a period of N months after a trade date.
ME	BE BE/ME	IS	r	OI	$Short\_ret$	Gain Loss	$Long\_Short\_r$	$Long\_Gain \\ Long\_Loss \\ BHR^N$

# Table II Summary Statistics

Panel A reports the total market capitalization, mean market capitalization, and average number of stocks for five short interest subsamples of the Full Dataset. Market capitalization is calculated as month-end market price times the month-end number of shares outstanding. Total market capitalization is the sum of market capitalizations of all firms in a particular subsample. Mean market capitalization is the average market capitalization of all firms in a particular subsample. Reported numbers are time-series averages across the 1991 - 2007 period. Panel B reports the same information for the Shortable Dataset. Panel C reports the proportion of stocks and total market capitalization from the Full Dataset that is included in the Shortable Dataset.

	$SI \in [0, 1)$	Panel $SI \in [1, 2.5)$	A: Full Data $SI \in [2.5, 5)$	set $SI \in [5, 10)$	SI > 10
Total Market Capitalization (\$ mil) Mean Market Capitalization (\$ mil) Number of Stocks	3,189,091 2,387 1,227	$\begin{array}{c} 2,331,347\\ 3,836\\ 466\end{array}$	946,317 2,491 352	$\begin{array}{c} 444,988 \\ 1,666 \\ 238 \end{array}$	136,047 1,031 125
	$SI \in [0, 1)$	<b>Panel B:</b> $SI \in [1, 2.5)$	Shortable D $SI \in [2.5, 5)$	ataset $SI \in [5, 10)$	SI > 10
Total Market Capitalization (\$ mil) Mean Market Capitalization (\$ mil) Number of Stocks	3,029,497 7,610 432	$\begin{array}{c} 2,285,564\\ 5,139\\ 336\end{array}$	912,405 3,059 267	$\begin{array}{c} 423,990 \\ 1,973 \\ 187 \end{array}$	$126,858 \\ 1,201 \\ 98$
	$\mathbf{Par}$ $SI \in [0, 1)$	nel C: Propo $SI \in [1, 2.5)$	rtion in Shor $SI \in [2.5, 5)$	table Datase $SI \in [5, 10)$	t SI > 10
Total Market Capitalization(%) Number of Stocks (%)	95.0 35.2	98.0 72.0	96.4 75.8	95.3 78.6	93.2 78.1

1 dummy variables Dataset; results in is in the top decile > 2.5 reflect only est greater than 5				
rship $(IO)$ , and the Shortable I nly observation the short intervite short intervited the short intervited	SI > 5	-0.7770	[-5.46]-0.1017	[-7.53]
itutional owne servations in t 90 <i>th</i> reflect o short interest observations v	SI > 2.5	-0.6003	[-6.70]	[-7.99]
g(ME)), inst- using all obs ults in $SI \in$ percentile of reflect only	$SI \in 95th$	-0.9942	[-3.84]-0.1816	[-7.34]
), log size (log n regressions t interest; res s in the $95^{\text{th.}}$ lts in $SI > 5$ t in brackets.	$SI \in 90th$	-0.7909	[-5.49]-0.1256	[-7.50]
tio $(BE/ME)$ I All are from intile by shor- y observation percent; resu- und are shown	$SI \in 80th$	-0.6157	[-6.67]	[-7.83]
ook-to-market rat esults in column ons in the top qu 95th reflect only greater than $2.5$ I by trade date a	All	-0.3737	[-7.02]	[-8.15]
for tinterest $(SI)$ , be (not reported). Reflect only observatic est; results in $SI \in$ with short interest g atistics are clustered		$r_{t-1}$	$SI_{t-1}$	H
X includes sh for each year $SI \in 80th$ re of short inter- observations ' percent. T-st				

	All	$SI \in 80th$	$SI \in 90th$	$SI \in 95th$	SI > 2.5	SI > 5
$r_{t-1}$	-0.3737	-0.6157	-0.7909	-0.9942	-0.6003	-0.7770
	[-7.02]	[-6.67]	[-5.49]	[-3.84]	[-6.70]	[-5.46]
$SI_{t-1}$	-0.0571	-0.0916	-0.1256	-0.1816	-0.0784	-0.1017
	[-8.15]	[-7.83]	[-7.50]	[-7.34]	[-7.99]	[-7.53]
$BE/ME_{t-1}$	-0.0087	0.0296	0.1048	0.0481	0.0197	0.0751
	[-0.24]	[0.44]	[0.89]	[0.78]	[0.30]	[0.70]
$IO_{t-1}$	0.1409	0.0100	0.0518	0.1444	0.0308	-0.0355
	[5.54]	[0.22]	[0.69]	[1.10]	[0.81]	[-0.58]
$\log(ME_{t-1})$	-0.0347	-0.1159	-0.2055	-0.4082	-0.1139	-0.1868
	[-6.51]	[-9.07]	[-8.00]	[-7.73]	[-9.82]	[-8.46]
Intercept	0.5900	1.8529	3.2444	6.2437	1.4600	2.3830
	[6.17]	[8.26]	[8.17]	[8.61]	[8.23]	[8.13]
c						
$R^2$	0.029	0.044	0.059	0.084	0.039	0.050
N	251, 452	77,488	37, 369	17,251	104,003	53,570

This table presents coefficient estimates for the following OLS regression of changes in short interest on past returns and other

 $\Delta SI_t = \alpha + \beta r_{t-1} + \gamma' X_{t-1} + u_t$ 

explanatory variables:

Table IV Interest Changes -	Table IV of Short Interest Changes -		Alternative Specification
Ta Interest	Ta of Short Interest	ble IV	Changes -
	of Short	Ta	Interest
rminants			Dete

This table presents coefficient estimates for the following OLS regression of changes in short interest on past returns (r), short seller losses (gains)  $(Short\_ret)$ , long-term short seller losses (gains)  $(Long\_Short\_ret)$ , and other explanatory variables:

$$\Delta SI_t = \alpha + \beta r_{t-1} + \gamma' X_{t-1} + \delta Short\_ret_{t-1} + \varepsilon Long\_Short\_ret_{t-1} + u_t$$

X includes short interest (SI), book-to-market ratio (BE/ME), log size  $(\log(ME))$ , institutional ownership (IO), and dummy variables for each year (not reported). T-statistics are clustered by trade date and are shown in brackets.

Continued on next page.

	(1)	(2)	(3)	(4)
	0.2038	0.1997	0.0942	0.0899
	[1.37]	[1.36]	[0.74]	[0.72]
1	-0.0540	-0.0518	-0.0439	-0.0371
	[-8.29]	[-6.96]	[-10.26]	[-5.96]
$rt\_ret_{t-1}$	-0.1264 [-3,46]		-0.1115 [-3.54]	
$n_{t-1}$		0.1047		0.1092
		[2.30]		[2.41]
$S_{t-1}$		-0.1380		-0.1067
		[-2.98]		[-2.77]
$g\_Short\_ret_{t-1}$			-0.0654 [-4.32]	
$g\_Gain_{t-1}$			1	0.0304
				[1.90]
$g\_Loss_{t-1}$				-0.0815
				[-3.38]
$/ME_{t-1}$	-0.0095	-0.0098	-0.0253	-0.0256
	[-0.26]	[-0.26]	[-0.65]	[-0.66]
-1	0.1389	0.1372	0.1403	0.1333
	[5.59]	[5.56]	[6.13]	[6.11]
$ME_{t-1})$	-0.0334	-0.0335	-0.0362	-0.0364
	[-6.49]	[-6.47]	[-6.71]	[-6.71]
srcept	0.5649	0.5626	0.5484	0.5394
	[6.10]	[60.9]	[5.70]	[5.66]
	0.034	0.034	0.040	0.040
	251,452	251, 452	240,461	240,461

	Arbitrage Trades
Table $\mathbf{V}$	Shorting vs.
	Valuation-Motivated

This table presents coefficient estimates for the following OLS regression of changes in short interest on past returns (r), short seller losses (gains)  $(Short\_ret)$ , and other explanatory variables:

$$\Delta SI_t = \alpha + \beta r_{t-1} + \gamma' X_{t-1} + \delta Short\_ret_{t-1} + u_t$$

for each year (not reported). Results in column Non-Convertible are from regressions using only observations with no convertible securities X includes short interest (SI), book-to-market ratio (BE/ME), log size  $(\log(ME))$ , institutional ownership (IO), and dummy variables outstanding; results in Convertible reflect only observations with some convertible securities outstanding; results in High Convertible reflect only observations with convertible securities outstanding exceeding \$10 million and 10% of book equity. T-statistics are clustered by trade date and are shown in brackets.

Continued on next page.

Non- Jonvertible	Non- Convertible	Convertible	Convertible	High Convertible	High Convertible
0.2085	0.2028	0.1652	0.1711	0.0499	0.0448
[1.33]	[1.32]	[0.43]	[0.45]	[0.09]	[0.08]
-0.0488	-0.0450	-0.0757	-0.0772	-0.0756	-0.0747
[-7.34]	[-5.62]	[-6.57]	[-6.79]	[-5.54]	[-5.90]
-0.1512		-0.0543		-0.0333	
[-3.56]		[-0.75]		[-0.40]	
	0.1139		-0.0463		-0.0376
	[2.57]		[-0.58]		[-0.43]
	-0.1719		0.0705		0.0241
	[-2.89]		[0.78]		[0.20]
-0.0389	-0.0393	0.0735	0.0738	0.1137	0.1135
[-3.27]	[-3.29]	[0.60]	[0.60]	[0.72]	[0.72]
0.1461	0.1430	0.0876	0.0888	0.0309	0.0304
[6.01]	[6.01]	[1.83]	[1.88]	[0.50]	[0.50]
-0.0313	-0.0315	-0.0592	-0.0591	-0.0575	-0.0575
[-6.86]	[-6.82]	[-5.01]	[-4.94]	[-2.48]	[-2.47]
0.5188	0.5146	0.9539	0.9551	1.0341	1.0331
[6.03]	[6.00]	[5.24]	[5.27]	[3.56]	[3.58]
0.034	0.034	0.042	0.042	0.040	0.040
205,544	205,544	45,908	45,908	27,314	27,314

	Returns
VI	nd Future
Table	Losses a
	rt Sellers
	$\mathbf{Sho}$

This table presents coefficient estimates for the following OLS regression of N-month buy-and-hold stock returns  $(BHR^N)$  on short seller losses (gains) (Short\_ret), changes in short seller positions ( $\Delta SI$ ), and other explanatory variables:

$$BHR_t^N = \alpha + \beta Short\_ret_{t-1} + \gamma Y_{t-1} + \delta \Delta SI_{t-1} + \varepsilon (Short\_ret_{t-1} * \Delta SI_{t-1}) + u_t$$

(not reported). Column 1 presents the coefficient estimate for short seller losses ( $\beta$ ) when the last term (Short \_ret\_{t-1} \*  $\Delta SI_{t-1}$ ) in the above equation is excluded, and column 2 reports the coefficient estimates for short sellers losses ( $\beta$ ) and the interaction term ( $\varepsilon$ ) in the Y includes book-to-market ratio (BE/ME), log size  $(\log(ME))$ , institutional ownership (IO), and dummy variables for each trade date full specification. T-statistics are clustered by trade date and are shown in brackets.