Biased Shorts:

Short Sellers' Disposition Effect and Limits to Arbitrage

Bastian von Beschwitz*
Federal Reserve Board

Massimo Massa**
INSEAD

July 15, 2019

Abstract

We investigate whether short sellers are subject to the disposition effect. Consistent with the disposition effect, short sellers are less likely to close a position after experiencing capital losses. This tendency is associated with lower profitability, suggesting a behavioral bias. Furthermore, this tendency is weaker when short sells are likely part of a long-short strategy. In addition, the closing pattern of short sellers exhibits a hump shape relative to capital gains, the opposite of what has been established for individual long-only investors. Overall, short sellers' behavioral biases limit their ability to arbitrage away mispricing caused by other traders' disposition effect.

JEL classification: G10, G12, G14

Keywords: Disposition effect, Behavioral finance, Short selling

* Bastian von Beschwitz, Federal Reserve Board, International Finance Division, 20th Street and Constitution Avenue N.W., Washington, D.C. 20551, tel. +1 202 475 6330, e-mail: bastian.vonbeschwitz@gmail.com (corresponding author).
** Massimo Massa, INSEAD, Finance Department, Bd de Constance, 77305 Fontainebleau Cedex, France, tel. + 33-(0)160-724-481, email: massimo.massa@insead.edu.
We thank the UniCredit & Universities Knight of Labor Ugo Foscolo Foundation for a research grant that made this study possible. We thank Itzhak Ben-David, Bing Han, Matthew Ringgenberg, Anna Scherbina, Noah Stoffman and seminar participants at WFA, EFA, SFS Cavalcade, INSEAD, the Whitebox Advisors Graduate Student Conference and the German Economists Abroad Christmas Conference for helpful comments. The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

Introduction

The finance literature has devoted considerable attention to the effects of behavioral biases on the stock market. However, the majority of this research focuses either on individual household investors who are neither qualified nor informed enough to trade profitably (e.g., Odean (1998), Odean (1999), Barber and Odean (2000), Huberman (2001), Genesove and Mayer (2001)) or on mutual fund managers who are in general assumed to be uninformed (Coval and Moskowitz (1999), Frazzini (2006), Jin and Scherbina (2011)). It is less known whether financial professionals possessing both sophistication *and* information also succumb to psychological biases. The evidence on financial professionals is limited and mixed. Coval and Shumway (2005) document loss aversion for the intraday trades of proprietary futures traders, while Locke and Mann (2005) show that futures traders are able to discipline themselves and escape the negative performance implications of behavioral biases. In both cases, the focus is on intra-day trading and market making.

In contrast, the goal of this study is to investigate the existence and market impact of behavioral biases among investors believed to be rational, sophisticated, *and* trading on long-term information. We explore this subject by focusing on short sellers. Several studies show that the amount of short-selling predicts future stock returns for several weeks (Boehmer, Jones, and Zhang (2008); Engelberg, Reed, and Ringgenberg (2012); Cohen, Diether, and Malloy (2007); Diether, Lee, and Werner (2009); Boehmer, Huszar, and Jordan (2010)), implying that short sellers are informed. Indeed, most short-selling is undertaken by sophisticated traders such as hedge funds, which are structurally very different from the traditional focus group of behavioral finance—i.e., unsophisticated and/or less informed traders.

More importantly, this sophistication, in combination with the fact that short sellers are thought of as arbitraging away mispricing, suggests that behavioral constraints on their actions have direct implications for the stock market, effectively increasing the "limits to arbitrage." Thus, any evidence of behavioral biases among these traders should have more relevant equilibrium, practical, and normative implications than the previous evidence on retail investors, long-only managers, or even professional futures traders.

While short-selling has been extensively researched in the finance literature, it has never been studied in the behavioral context. Rather, short sellers are perceived as rational speculators, and the debate has centered on whether they are detrimental or beneficial to the overall investment community, or whether regulatory short-sale constraints have a tangible effect on stock prices. In contrast, we investigate whether the trades of short sellers are indicative of a behavioral influence and how "irrational" short-selling activity affects the stock market.

We focus on the disposition effect—i.e. the tendency of traders to hold on to their losing stocks too long while selling their winning stocks too early (Shefrin and Statman (1985)). This behavioral bias is

"one of the most robust facts about the trading of individual investors" (Barberis and Xiong (2009)). If traders are subject to the disposition effect, they should have higher demand for losing stocks than for winning stocks. Therefore, our first hypothesis is that short sellers close more positions after positive capital gains (following negative stock returns).

However, closing the winners and holding on to the losers might potentially be explained by trading on private information. To distinguish this explanation from the disposition effect, we study the profitability of the closing of short positions. If this trading pattern is indeed a behavioral bias, we would expect it to be related to trades that are less profitable. Thus, our second hypothesis is that the closing of short positions is less profitable if it is more positively correlated with capital gains.

We test our two hypotheses by focusing on weekly short-selling behavior over the period from August 2004 to June 2010 on all U.S. stocks. We use a dataset on equity lending provided by Markit (previously Data Explorers). This dataset has already been used by Saffi and Sigurdsson (2011) and Engelberg, Reed, and Ringgenberg (2017) and has become the main source of information on short-selling. As in von Beschwitz, Chuprinin, and Massa (2017), we use this data to back out the closing of short positions, which is crucial information when testing for the presence of the disposition effect.

We start by investigating whether short sellers are more likely to close positions with higher capital gains (*hypothesis 1*). We define a measure of *Short-Sale Capital Gains Overhang (SCGO)* as the average percentage gains of short sellers relative to the price at which they entered their positions. While we do not have individual trading records of short sellers, we can estimate the average price at which positions were entered from aggregate trading behavior by adopting a methodology used in Grinblatt and Han (2005). We find a strong positive and statistically significant link between the closing of short positions and *SCGO*. A one standard deviation increase in *SCGO* increases the share of open positions that are closed by 0.6 percentage point, which is 5% relative to the unconditional median. If we compare this finding with the results reported in Odean (1998), we find that the average retail investor in Odean's data exhibits a disposition effect that is approximately 6-11 times as strong as that of the average short seller. It makes sense that the disposition effect is less pronounced for short sellers, as they are generally professional investors and some short sells are undertaken as part of a long-short strategy, which makes it unlikely that they are affected by the disposition effect.

Next, we study whether this trading behavior is related to lower profitability in the closing of short positions (*hypothesis 2*). For this purpose we compute rolling correlations between the closing of short positions and *SCGO* for each stocks. In stocks with a more positive correlation, short sellers are more affected by the disposition effect. We find that the profitability of the closing of short positions is lower in these stocks. A one-standard deviation increase in the correlation between *Closing* and SGCO reduces how well *Closing* predicts future returns by 68-90% depending on the specification. This

finding suggests that short sellers condition their closing on capital gains because of the disposition effect rather than some rational motivation.

It is worth noting that being subject to the disposition effect does not mean that short sellers act as uniformed traders. Indeed, consistent with Boehmer, Duong, and Huszar (2016), we document that the closing of short positions is profitable on average. A one standard deviation increase in *Closing* increases future returns by 0.036% per week (1.87% annualized). By conditioning their trades on their capital gains, short sellers just reduce this profitability. Put differently, the short sellers are both biased and informed.

Next, we conduct interaction analyses that further support this interpretation. First, we focus on long-short strategies around mergers and acquisitions (M&As). We expect the closing of short positions in long-short strategies not to depend on *SCGO* because long-short traders most likely estimate their gains and losses over the combined long-short position. During M&As, most short-selling is done as part of a long-short strategy betting on the convergence (or divergence) of the target's and bidder's stock prices. Therefore, we expect the disposition effect on just the short-selling position not to play a significant role. And indeed, we find that the positive relationship between *SCGO* and the closing of short positions decreases during the time of a merger when a large part of short-selling activity is done to engage in the long-short strategy of merger arbitrage.

Next, we focus on transaction costs. We expect short sellers to give in less to the disposition effect when it is more costly to hold on to stocks for too long. In line with this idea, we find that the relationship between the closing of short positions and *SCGO* is attenuated for stocks that are expensive/difficult to borrow— i.e., small, illiquid stocks, stocks with low institutional ownership or stocks with a high lending fee. This result not only supports our working hypothesis, but it also implies that our results are driven by large and liquid stocks – i.e., the ones in which it is cheap to hold a position open (too) long. Thus, it is unlikely that our results are driven by the forced closure of short positions.

Finally, we take a deep dive into how the closure of short positions depends on capital gains. Ben-David and Hirshleifer (2012) find that individual (long-only) investors exhibit a V-shaped position closing pattern with respect to capital gains. Thus, they are more likely to close positions with very positive or very negative capital gains and are less likely to close positions that are little changed. We examine the same idea for short sellers. Interestingly, we find that short sellers exhibit the exact opposite behavior. They are most likely to close positions that are little changed while they are less likely to close positions with extremely positive or negative capital gains, i.e. they exhibit an inverted V-shaped or hump-shaped pattern. We also confirm that this result is statistically significant.

What explains the different closing behavior of short sellers? Ben-David and Hirshleifer (2012) argue that the V-shape results from the speculative trades of overconfident investors with limited attention. When a large price move occurs, investors are more likely to pay attention to the stock and

more likely to revise their opinion leading to a closure of the position. This effect is likely less prominent for short sellers, who are mostly professional traders and thus more attentive to all of their positions. While this argument explains why we might see less V-shaped pattern, it does not explain the hump shape that we observe.

We consider two potential explanations for the hump shape in the closure of short positions. The first is that short positions are more expensive to keep open as the short seller has to pay a lending fee to borrow the stock. These costs may incentivize short sellers that expected a drop in prices to close their position when the price drop does not materialize, leading to more closings of positions that are little changed. However, if this were the case, we would expect the hump shape to be more pronounced for stocks with higher lending fees. We find that this is not the case. If anything, stocks with high lending fees exhibit less of a hump shape.

The second explanation is that short sellers close stocks with little capital gains in either direction to take advantage of favourable liquidity conditions. The underlying assumption is that stocks are more liquid in quiet times when little news is hitting the market. In these quiet times, stock prices have changed little and short sellers' capital gains are close to zero. We find results consistent with this liquidity explanation. First, we show that stocks exhibit a hump-shaped pattern in *liquidity* relative to short seller's capital gains, which suggests that short sellers indeed close positions in times of higher liquidity. Second, we show that the hump-shaped pattern in the closing of short positions is more pronounced for less liquid stocks, using both direct liquidity measures and other liquidity proxies such as size or institutional ownership. Taken together, our results are consistent with short sellers being more likely to close positions with little capital gains to take advantage of favourable liquidity conditions and these considerations being more important for generally less liquid stocks. It also makes sense that this effect would be irrelevant to the individual investors studied by Ben-David and Hirshleifer (2012), as their orders are generally too small to have material price impact. However, these results are only indicative and we cannot rule out a behavioral explanation for the hump shape.

All of our results are robust to the inclusion of firm and week fixed effects, various control variables, and double clustering at the firm and week level. In particular, we show robustness to the inclusion of lagged return and turnover at different horizons. In robustness checks, we show that our results are not driven by borrowed stocks being recalled or by supply shocks in the equity lending market.

By showing that short sellers are subject to the disposition effect, we document that even sophisticated and informed investors that are generally making a profit can be affected by behavioral biases. This finding has important normative implications. Indeed, there is an active debate on whether short sellers are beneficial or detrimental to the market and whether regulatory short-sale constraints have a tangible effect on stock prices. However, if short sellers themselves are irrational, this will reduce their ability to arbitrage away mispricing. Our results help explain why certain market anomalies persist

despite the apparent availability of arbitrage capital. The fact that behavioral biases reduce the ability of short sellers to react, while negative in general, may in fact help to slow down and smooth market reaction during a crisis. This effect would reduce the need to curb short selling-activity, as the very behavioral bias acts like a self-regulatory device for short sellers.

We contribute to several strands of literature. First, we contribute to the literature on short selling. Several studies make a connection between short sellers' activity and stock returns (Senchack and Starks (1993), Asquith and Meulbroek (1995), Aitken et al. (1998)). It has been shown that the impact takes the form of improving liquidity and market efficiency (Bris, Goetzmann, and Zhu (2007); Boehmer, Jones, and Zhang (2008); Boehmer and Wu (2013); Saffi and Sigurdsson (2011)). Alternatively, their impact has been linked to numerous *constraints* to which short sellers are subject (Miller (1977); Jones and Lamont (2002); Diether, Malloy, and Scherbina (2002)). In both cases, stock characteristics are linked to rational short-selling behavior. In contrast, we link mispricing to the unconstrained but *suboptimal decisions* undertaken by the apparently rational and sophisticated traders. The prevalence of the disposition effect among short sellers can help explain why mispricing can persist even when short selling is unconstrained.

Second, we contribute in particular to the literature on short seller behavior. Short sellers have been traditionally identified as rational traders either endowed with superior private information (e.g., Cohen, Diether, and Malloy (2007)) or better able to process public information (e.g., Engelberg, Reed and Ringgenberg (2012)). We contribute to this literature by showing that while being informed traders in general, there is also a behavioral and irrational side to short-selling behavior.

Third, we contribute to the literature on behavioral biases and, in particular, on the disposition effect. This literature is both empirical/experimental (e.g., Weber and Camerer (1998); Odean (1998); Locke and Mann (2005); Heath, Huddart, and Lang (1999); Grinblatt and Keloharju (2000, 2001); Grinblatt and Han (2005); Ben-David and Hirshleifer (2012); Choi, Laibson, and Madrian(2009)) and theoretical (Shumway (1998); Gomes (2005); Berkelaar and Kouwenberg (2000); Barberis and Huang (2001); Barberis, Huang and Santos (2001); Ang, Berkaert, and Liu, (2001)). We contribute to it by providing evidence that supposedly rational and well-informed traders such as the short sellers are also prone to the disposition effect.

2. Main Hypotheses

The disposition effect is the *irrational* tendency to hold on to losing positions too long and to close winning positions too early (e.g., Shefrin and Statman (1985)). For short sellers, this bias should induce them to condition their closing of short positions on their capital gains. Specifically, they are more likely to close a position the higher the capital gains (and more likely to hold on to a position the higher the capital loss).

H1: The closing of short positions is positively related to the amount of capital gains.

However, such behavior could also be explained by rational trading based on private information. Indeed, finding only support of H1 is not sufficient to show that short sellers are subject to a behavioral bias because H1 is also consistent with the following explanation: Short sellers enter a short position if they have private information that the stock is overvalued. If the stock price moves higher and short sellers make a capital loss, they might hold on to their position, as they know that the stock is now even more overvalued. Similarly, short sellers might close their position after the share price decreases because the share price has fallen below the short sellers' private valuation.

We can distinguish disposition effect behavior from this rational information-based behavior by examining whether short sellers make higher profits by holding on to their losing positions and closing their winning positions. If the tendency is behavioral, we expect the closing of short positions to be less profitable when short sellers condition their trades more on their capital gains. On the contrary, if the behavior is driven by informed trading, we expect the closing of short positions to be more profitable when conditioned more on capital gains. Thus, we posit our second hypothesis:

H2: The closing of short positions is less profitable when it is more positively related to capital gains.

Before moving on to the main results, we describe the data we use and the main variables.

3. The Data and the Main Variables

We employ equity lending data provided by Markit (previously Data Explorers) as well as the standard datasets on stock returns (CRSP), balance sheet data (Compustat), analyst coverage (I/B/E/S), and institutional ownership (Thompson Reuters 13F filings).

3.1 Equity lending data

We estimate short-selling with data from the equity lending market. Short-selling is the main purpose for which market participants borrow shares. Short sellers only need to borrow shares if they keep a short position open overnight. Thus, equity lending data excludes information on intraday short-selling. This feature of the data is actually an advantage for studying a behavioral bias because most intraday trading is conducted by computer algorithms (that are not subject to behavioral biases).

We use equity lending data from Markit (formerly DataExplorers). Markit collects its data from custodians and prime brokers that lend and borrow securities and is the leading provider of such data. For each stock, it reports the following variables at daily or weekly frequency: lendable value in dollars, active lendable value in dollars, total balance value on loan in dollars, and weighted average loan fee (across active contracts) in basis points.

We limit our attention to U.S. common stocks (share codes of 10 or 11 in CRSP). In addition, we exclude all companies with a market capitalization of less than $10 million or a share price of less than

$1. The data span the period from August 2004 to June 2010. Until July 2006, the data are only available at a weekly frequency, while from then on, data are available at a daily frequency. Since all of our analyses are conducted at the weekly frequency, we will use the full sample from 2004 to 2010. We exclude from all our analyses any week that included the time period of the short-selling ban following the financial crisis—i.e., we exclude September 15, 2008, to October 10, 2008.[1]

As is commonly done in the literature (e.g., Boehmer et al. (2015)), we use shares on loan reported by Markit as an estimate for open short positions (short interest). In the United States, equity transactions are settled after three trading days, while equity loans are settled immediately. Accordingly, a short seller does not need to borrow the shares until three days after taking his or her short position. Therefore, we make the standard adjustment to compute the amount of shorted shares on a day using the shares on loan at t+3 following Geczy, Musto, and Reed (2002) and Thornock (2013).

The Markit dataset has the unique feature that it contains information on the number of shares that are on loan as well as the number of shares that have been newly borrowed during the past week. This feature allows us to compute the number of shares that have been returned to lenders during the week as follows:[2]

$$Shares\ returned_t = Shares\ newly\ borrowed_t - Shares\ on\ loan_t + Shares\ on\ loan_{t-1}$$

As in von Beschwitz, Chuprinin, and Massa (2015), we use *Shares Newly Borrowed* as a proxy for newly opened short positions and *Shares Returned* as a proxy for the closing of short positions. Having access to information on the closing of the positions is very important for this study, as the disposition effect affects the closing of positions. Our main variable of interest is *Closing*, which is defined as the percentage of shares at the beginning of the week that were returned to lenders during the week:

$$Closing_t = \frac{Shares\ returned_t}{Shares\ on\ loan_{t-1}}.$$

This variable captures the percentage of positions that are closed, thereby being our analog to the percentage of gains realized (PGR) and percentage of losses realized (PLR) variables employed in Odean (1998) and Frazzini (2006). As control variables, we use, among others, the average fee (value-weighted) that short sellers have to pay to borrow the shares and the average number of days (value-weighted) that an equity loan is open (we refer to this variable as *Short-Sale Duration*).

Our variable *Closing* is only a proxy for the closing of short positions and does not measure it perfectly for the following reasons. First, in some cases investors may borrow shares for tax arbitrage rather than for short-selling. Second, sometimes equity loans get recalled before the short seller wants to close the short position. Third, some short sellers access the equity lending market through their

[1] Results are little changed if we include the time of the short-sale ban (unreported, available on request).

[2] More detailed information on variable construction is provided in Appendix 1.

broker, and some brokers may have the shares available without having to borrow them on the lending market.

We believe these concerns to be limited due to several reasons. First, Markit equity lending data are commonly used in the literature to study short-selling (e.g. Boehmer et al. (2015); Saffi and Sigurdsson (2011); Engelberg, Reed and Ringgenberg (2017)). Second, borrowing for non-shorting reasons and the recall of shares are fairly rare. For example, D'Avolio (2002) reports that recall only affects 2% of stocks in a given month. Furthermore, we show in a robustness check reported in IA-Table 3 in the internet appendix that our results actually become larger when we exclude shares with high utilization that are more likely affected by recall. Third, and more generally, these concerns should only add measurement error but should not bias our findings.

To further alleviate concerns about our measure, we show that it behaves like we would expect. As measures of turnover, we expect *Closing* and *Shorting* to be correlated with overall turnover in a stock. And indeed, we provide strong evidence of this relation in IA-Figure 1 in the internet appendix. In Panel A, we split stocks each week into quintiles by their turnover. The stocks with the most turnover also have the highest measures of *Closing* and *Shorting*, and the relationship is very monotonic. The same result holds when sorting all weeks of a single stock by turnover into quintiles, as we do in Panel B.

In Table 1, we show that the median of Short-Sale Duration computed from the equity lending data is 62 days. This value is very close to the 51-day average holding period that Jones, Reed, and Waller (2015) compute from disclosure data of large short positions in Europe. These results give us confidence that we measure the closing and shorting of positions fairly accurately.

3.2 Constructing capital gains variables

The disposition effect is the irrational tendency of traders to sell stocks with high capital gains and to hold on to stocks with low capital gains. Capital gains are defined relative to the trader's reference point—i.e., the price at which traders entered their position (e.g., Thaler (1980), Shefrin and Statman (1985), Odean (1998), Frazzini (2006)). In our context, this corresponds to the price at which the short sellers have sold the stock short. Since we do not have access to individual short sellers' portfolios, we have to estimate the average price at which the short sellers entered their current position. To do this, we follow the methodology of Grinblatt and Han (2005). We apply it to short sellers weekly trading. More specifically, we estimate:

$$R_t = R_{t-1} * \left(1 - \frac{Shares\ newly\ borrowed_t}{Shares\ on\ loan_t}\right) + \frac{Shares\ newly\ borrowed_t}{Shares\ on\ loan_t} * P_t,$$

where R_t is the reference price and P_t is the market price.[3] This recursive method computes the new reference price as a weighted average between last week's reference price and today's price.[4] The weight on today's price equals the percentage of total open short positions that were opened in the past week. Basically, this approach assumes that all short positions have the same probability of being closed independent of when they were opened.

As an alternative measure, we construct the reference price using information from the equity lending data on how long shares have been lent out. Markit only provides relatively coarse information. It provides the percentage of shares lent out 1 day ago, in the past 3 days, in the past 7 days, in the past 30 days, and longer than 30 days ago. We use this information to estimate the reference price as follows:

$$R_\tau^{alt.} = S_{\tau-1} * P_{\tau-1} + S_{\tau-3,\tau-2} * P_{\tau-2} + S_{\tau-7,\tau-4} * P_{\tau-4} + S_{\tau-30,\tau-8} * P_{\tau-8} + S_{\tau-\infty,\tau-31} * P_{\tau-31},$$

where $R_\tau^{alt.}$ is the alternative definition of the reference price at date τ[5], P_τ is the price at date τ, and $S_{\tau,s}$ is the fraction of shares that were shorted between dates τ and s. For each window of the short-selling horizon, we use the prices closest to the current market price. This approach leads to an underestimation of the difference between the current price and the reference price but should not introduce any bias.

Because short sellers profit when the stock price decreases, we compute the capital gains overhang of the short seller for both our reference prices as

$$SCGO_t = \frac{R_t - P_t}{R_t}.$$

We define *Short-Sale Capital Gains Overhang I (SCGO I)* as the capital gains overhang constructed using the reference price of the recursive methodology (R_t) and define *Short Sale Capital Gains Overhang II (SCGO II)* as the capital gains overhang constructed using the reference price computed from short seller horizon ($R_\tau^{alt.}$). Both variables are an estimate of the average capital gains with which short sellers hold the specific stock. They generally increase as stock prices fall and decrease as stock prices appreciate.

As a comparison, we also estimate the capital gains of long traders in the market. Following Grinblatt and Han (2005), we compute the reference price of long traders at a weekly frequency recursively as

$$R_t = R_{t-1} * \left(1 - \frac{Shares\ Traded_t}{Shares\ Outstanding_t}\right) + \frac{Shares\ Traded_t}{Shares\ Outstanding_t} * P_t$$

Then, we compute the capital gains of long traders as

[3] Both market price and reference price include dividend payments, i.e. they are computed from total returns.
[4] Differently from Grinblatt and Han (2005), we do not truncate this calculation after 5 years, i.e. we use whatever length of data we have available.
[5] We use τ to illustrate the daily frequency, while t refers to the weekly frequency.

$$LCGO_t = \frac{P_t - R_t}{R_t}$$

Long Capital Gains Overhang (LCGO) is an estimate of the average capital gains with which long traders hold the specific stock. It is the same variable as constructed in Grinblatt and Han (2005). It generally decreases as stock prices fall and increases as stock prices appreciate.

Following Grinblatt and Han (2005), we run all our tests at the weekly frequency, as it provides a good balance between a high enough frequency that allows us to have an accurate estimation of computed capital gains and a low enough frequency that reduces the influence of market microstructure effects. Also, it allows us to use the longer time period from August 2004 to June 2010 in our short selling data.

3.3 Example of references prices and capital gains for a specific stock

To illustrate the construction of the various measures, we display them for a specific stock in Figure 1. We picked Microsoft because it is a large, representative company. In Panel A of Figure 1, we display the stock price index, which is based on total returns and thus includes dividends, as well as the three references prices for *SCGO I*, *SCGO II*, and *LCGO*. All three references prices are essentially moving averages of the indexed stock price. As discussed above, they vary in how much weight they put onto more recent observations depending on which fraction of short or long positions is closed in a specific week. Long positions are generally kept open much longer (see Section 3.5 below). Thus, unsurprisingly, the reference price for *LCGO* is moving much slower and is thus smoother than the references prices for *SCGO*. Of the two *SCGO* measures, the reference price for *SCGO I* is somewhat smoother, but otherwise they are very close to each other.

In Panel B, we display *SCGO I*, *SCGO II*, and *LCGO*. *LCGO* and *SCGO* are clearly negatively correlated, which is not surprising, given that *SCGO* increase as the stock price falls, while the opposite is true for *LCGO*. *LCGO* are less mean-reverting because the underlying references price updates slower. Thus, *LCGO* cross the zero line less often and can be further away from zero than *SCGO*.

3.4 Control variables

For each of the firms covered in the short-selling data, we retrieve stock market data from CRSP and balance sheet data from Compustat to compute market capitalization and book-to-market ratios. In addition, we use the I/B/E/S database to construct a measure of analysts following the stock. We define *Number of Analysts* as the logarithm of one plus the number of analysts that issued earnings forecasts for the stock in the observation period. We obtain data on institutional ownership from Thomson Reuters 13F filings. *Institutional Ownership* is computed as the aggregate number of shares held by institutional investors divided by the total number of shares outstanding. *Breadth of Ownership* is defined as the number of institutions holding the stock divided by the number of all reporting institutions

in the period (similar to the definition used by Chen, Hong and Stein (2002)). *Amihud Illiquity* is defined as the following: $\text{Amihud Illiqudity} = \text{mean}_{\text{over quarter}}\left(\frac{|\text{ret}_{\text{daily}}|}{\text{dollar volume}_{\text{daily}}}\right)$. Given that this measure often has large outliers, we use 100 percentiles rather than the continuous variable. Companies with the highest Amihud illiquidity are assigned a value of 100, and companies with the lowest Amihud illiquidity are assigned a value of 1. To reduce the effect of outliers, all variables are winsorized at the 1% cutoff, but we show in IA-Table 1 in the internet appendix that we find very similar results without winsorization. All variable definitions can also be found in Appendix 1.

3.5 Summary statistics

We report summary statistics in Table 1. In our sample, we have stocks of 6,134 U.S. companies and roughly 1 million company-week observations. In Panel A, we report the average of company variables over company-year observations. The mean market capitalization is $2.5 billion (median $350 million). The mean market-to-book ratio is 2.78 (median 1.94). The companies are covered, on average, by five analysts (median 3), but more than 25% of the sample firms have no analyst coverage. Institutional ownership is, on average, 50.7% (median 52.8%).

In Panel B, we report summary statistics of the market variables. On average, 3.9% (median 1.7%) of shares outstanding are on loan. Every week, on average, 0.57% (median 0.24%) of the shares outstanding are newly borrowed (i.e., newly shorted), and a very similar fraction is returned to lenders (i.e., closed short positions). Of all open short positions, on average, 19% (median 13%) are closed every week. The median of *Average Lending Fee* is 14 basis points, so most stocks are very cheap to short sell. The average of *Short Sale Duration* is 77 days (median 62). The mean turnover is 4.2% per week (median 2.5%). Thus, the average long trader has a longer investment horizon of 24 to 40 weeks. The average weekly return is 0.2% (median 0%). The average S*hort-Sale Capital Gains Overhang I (SCGO I)* is slightly positive with 0.9% (median 0%), while the alternative specification (*SCGO II)* is, on average, slightly negative with -0.1% (median -0.3%). *Long Capital Gains Overhang (LCGO)* is positive, on average, with 1% (median 1.8%), probably due to the positive average return of stocks over the sample period. The higher standard deviation of *LCGO* (28%) compared with *SCGO* (11%) is due to the longer investment horizon of long traders. Since long traders hold on to stocks longer than short sellers, they can accumulate more extreme levels of capital gains overhang. This fact is also illustrated in the example in Figure 1. The standard deviation of *LCGO* is very close to the value reported in the study of Grinblatt and Han (2005) (27.6% compared with 25.1%).

4. Do Short Sellers Exhibit the Disposition Effect?

In this section and in Section 5, we present the empirical results of our paper. In this section, we examine whether short sellers are subject to the disposition effect by testing hypothesis 1—that short sellers are more likely to close positions with positive capital gains—and hypothesis 2—that short sellers' closing

of positions is less profitable if they condition it more on their capital gains. In Section 5, we study whether short sellers exhibit a V-shape pattern in closing with respect to their capital gains, as has been found for retail (long-only) investors by Ben-David and Hirshleifer (2012).

4.1 Are short sellers more likely to close positions with positive capital gains?

The disposition effect is the irrational tendency to realize gains too early and hold on to losing stocks for too long. Therefore, it should mainly affect the *closing* of short positions. As previously pointed out, our dataset allows us to estimate the amount of short positions that have been closed, rather than just observing differences in short interest. Therefore, as a first step, we study whether the way in which short sellers close their positions is influenced by their capital gains on these positions. If short sellers are prone to the disposition effect, we would expect them to close a larger fraction of their positions if they hold it at higher (more positive) capital gains overhang (hypothesis 1).

We report our results in Table 2. The dependent variable is *Closing*— i.e., the percentage of shares on loan that is returned to lenders during the week. We conduct weekly panel regressions with week and firm fixed effects. Intuitively, one can think of this regression as a way of investigating the change in the closing of short positions in stock A compared with the change in the closing of short positions in stock B.

Since short sellers' trades might be driven by past returns (Diether, Lee, and Werner (2009)) and turnover, we control for past stock returns and turnover. In Regressions 1 and 4, we employ exactly the same controls as Grinblatt and Han (2005), which are stock turnover in the past year and past returns over the non-overlapping one-month, one-year and three-year horizons. In Regressions 2, 3, 5, and 6, we add additional controls that are standard in the literature: *Market to Book*, *Size*, *Amihud Illiquidity*, *Breadth of Ownership*, *Institutional Ownership* and *Number of Analysts*. In addition, we also employ short-selling specific controls: We include *Average Lending Fee* to control for a potential correlation between lower stock prices and higher borrowing costs. We also control for *Average Short-Sale Duration*—i.e., the average time that short positions are open, as older positions may be more likely to be closed and control for the number of shares on loan as a percentage of shares outstanding because larger short positions may be closed faster. Furthermore, to control for the risk that shares on loan are recalled forcing short sellers to close their position, we add *Volatility* and *P (return > 5%)*, which is the fraction of above positive 5% stock return spikes in the prior quarter for the stock. Finally, in regressions 3 and 6, we break up returns and turnover into weekly windows for the prior four weeks to account for the autocovariances documented in Conrad, Hameed, and Niden (1994).

We find a positive effect of both definitions of short-sale capital gains overhang (*SCGO I* and *SCGO II*) on the closing of short positions, significant at the 1% level. The findings are also economically sizable, as a one standard deviation (10.8%) increase in *SCGO I* raises *Closing* 0.6 percentage points

($10.8\% * 0.058 \approx 0.6\%$), or approximately 5% relative to its median ($\frac{0.6\%}{13\%} \approx 5\%$).[6] Overall, our results indicate that short sellers are more likely to close positions in which they hold positive capital gains, consistent with the disposition effect.

We now study the importance of the disposition effect for short sellers relative to the disposition effect of retail investors covered in Odean (1998). Since Odean (1998) has individual positions, our measures are not directly comparable, but we nonetheless try a rough approximation. We detail our calculations in Table 3. Odean (1998) reports PGR and PLR, where *PGR* (*PLR*) is defined as the percentage of open positions with positive (negative) capital gains that are sold (Odean (1998) only studies long positions). The fact that PGR is significantly greater than PLR shows the existence of the disposition effect. Our variable *Closing* captures the percentage of positions that have been closed. The fact that more positions are closed the higher the capital gains implies that PGR is also larger than PLR for short sellers.

Therefore, we estimate the values of PGR and PLR in our sample. We do this by measuring the average short sale capital gains both in the case where they are positive and in the case where they are negative. We then take the difference between these values and multiply it with our regression coefficient from Table 2. We estimate a difference between PGR and PLR that is 0.86% for *SCGO I* and 0.47% for *SCGO II*. In Odean (1998) this difference is 5%. Thus, our short sellers exhibit a disposition effect of a magnitude between 9% and 17% of the magnitude measured by Odean (1998). This suggests that individual traders experience a disposition effect that is roughly 6-11 times stronger than the disposition effect of short sellers.[7] However, this is only a rough estimate, as the underlying data are very different. It is not surprising that the average short seller is less affected by the disposition effect than the average retail investor, given that short sellers are more sophisticated and a subset of them trades algorithmically or uses long-short strategies and therefore is not affected by the disposition effect.

4.2 Is the closing of positions less profitable if it is more based on capital gains?

We have shown that short sellers are more likely to close their winning positions than their losing positions. Now, we examine if this trading pattern is due to the disposition effect bias or some rational explanation such as trading on private information. If the trading pattern is due to the disposition effect, we would expect the closing of short positions to be less profitable when short sellers base their trades more on their capital gains (*hypothesis 2*)—i.e., when they exhibit more "closing the winner and holding

[6] As a comparison, a one standard deviation in the 1 week lagged return has an effect of 0.5 percentage points (6.6%*0.07≈0.5%).

[7] The average PLR in Odean (1998) is 9.8%, and the average PGR is 14.8%; therefore, they are comparable in size to our *Closing* variable, which has a median of 13%.

the loser"- behavior. On the contrary, if it was due to private information, we would expect the closing of short positions to be more profitable in this case.

Because we do not have portfolio-level data, we cannot compute how much individual short sellers base their trades on their capital gains. Instead, we compute the degree to which short sellers who trade a specific stock base their trades on their capital gains. For this purpose, we compute rolling correlations between *Closing* and *SCGO* at the stock level. A higher correlation means more "closing the winner and holding the loser"-behavior. We then study whether such behavior is associated with more or less profitable closing of positions.[8]

To study the profitability of short sellers' closing of positions, we measure how *Closing* predicts future returns. The shorting of a stock is profitable if it is followed by a negative stock return, while the closing of a short position is profitable if followed by a positive return, as the closing prevents the losses that the short seller would have incurred from the positive return. On the other hand, a negative return after the closing of a short position implies that it was closed too early and that the short seller foregoes a potential profit.

Therefore, we study how the closing of short positions predicts future returns depending on how much disposition effect short sellers in that stock exhibited in the past. We present our results in Table 4. We regress weekly returns on an interaction between *Closing* and *Correlation (Closing, SCGO).* Following Grinblatt and Han (2005), we employ Fama-MacBeth regressions estimated at a weekly frequency. This regression set-up is adequate for dependent variables such as returns that have a large time fixed effect and cross-sectional correlation, but little autocorrelation (Petersen (2009)). We adjust standard errors for autocorrelation at eight lags (about two months) using the methodology of Newey-West (1987). We show in the internet appendix in IA-Table 2 that our results are robust if we use a panel set-up with firm and week fixed effects instead of Fama-MacBeth. We include the full set of control variables but do not report them for brevity. The full specification reporting all control variables is available in the internet appendix.

We compute four measures of correlation using one and two years of prior data and using the two definitions of short-sale capital gains overhang (*SCGO I* or *SCGO II*). In all four specifications, we find that the closing of short positions is less profitable in stocks where short sellers exhibit more disposition effect behavior in the past. This result is significant at the 5% level.

However, it is worth noting that being subject to the disposition effect does not mean that short sellers are uninformed. Indeed, in Regression 5, we document that, on average, *Closing* predicts future returns positively. Thus, short sellers, on average, are informed in closing their short positions,

[8] It may seem intuitive to regress returns on an interaction of *SCGO* and *Closing* instead. However, as discussed in Internet Appendix 2, we would not expect such an interaction to be significant even if short sellers are subject to the disposition effect.

consistent with the prior evidence that they are informed when shorting (e.g. Boehmer, Jones, and Zhang (2008)). Being subject to the disposition effect just reduces the ability of short sellers to act as informed traders. See Internet Appendix 1 for a numerical example illustrating how short sellers can be biased and informed at the same time.

In Panels B and C, we estimate the economic magnitude of the respective effects. We start with the base effect of how well *Closing* predicts future returns in Panel B. A one-standard deviation increase in *Closing* increases future returns by 0.036% per week (1.87% annualized). This suggests that short sellers are fairly informed in closing their short positions.

In Panel C, we estimate how much this effect is moderated by the amount of disposition effect behavior (measured by the correlation between *Closing* and *SCGO*). The effect is economically large. A one-standard deviation increase in the correlation between *Closing* and *SCGO* reduces how well *Closing* predicts future returns by 68-90% depending on the specification. This result is similar between the different specifications, suggesting that it does not depend much on which window length or capital gains definition we use. Furthermore, we calculate that a one standard deviation change in the correlation lowers the one standard deviation effect of *Closing* on returns by 0.025% to 0.033% per week (1.3%-1.72% annualized).

These results suggest that while short sellers, on average, exhibit skill in closing their positions, this skill is significantly lower in stocks where they base their trades more on their capital gains. This finding confirms hypothesis 2 and suggests that short sellers base their closing on their capital gains due to the disposition effect rather than some rational trading strategy.

4.3 In which situations is the bias the strongest?

In this section, we further refine our analysis by focusing on the subsamples in which we expect the relationship between the closing of short position and short sellers' capital gains to be stronger. This analysis has two goals. First, it provides further evidence that this behavior is indeed driven by the disposition effect. Second, it further qualifies the range of impact of such a bias on professional and informed investors.

We consider different subsamples. First, we focus on mergers and acquisitions (M&As). Around M&As, short sales are not only used for directional bets, but also for long-short strategies. Indeed, when a company is engaged in a merger, a common long-short strategy is merger arbitrage, in which the arbitrageur bets on convergence between the stock prices of the target and the acquirer. In this case, the disposition effect works differently as short sellers likely combine the profits and losses of the long and short leg of the strategy in their mind. Thus, our short-sell capital gains variable will not be informative for the disposition effect related to the combined long-short position. Accordingly, we would expect the positive relationship between *SCGO* and the closing of short positions to drop during a merger.

We test this idea by regressing *Closing* on an interaction between *SCGO* and *Merger*, a dummy variable which is equal to one between the announcement and the completion of a merger or acquisition in which the company is either the acquirer or the target. We report the results in Regressions 1 and 2 of Table 5, Panel A. We report results for both *SCGO I* and *SCGO II*, but only use our main specification (full controls with week and firm fixed effects). In both cases, we find a negative coefficient on the interaction between *Merger* and *SCGO*, suggesting that short sellers condition their closing of positions less on their capital gains during times of a merger. The decrease in the effect of *SCGO* on *Closing* is approximately 50% to 100%, depending on the measure. This finding has two implications. First, it is consistent with our results being driven by the disposition effect. Second, it suggests that our results are not caused by short sellers engaging in long-short strategies, but rather that long-short strategies work against us finding an effect of *SCGO* on the closing of short positions.

The next set of analysis is based on the cost of keeping the short position open. The disposition effect predicts that a trader keeps a losing position open for too long. Holding open a short position is costly, as the short seller must pay the lending fee to the security owner and faces the funding risk to roll over the position. Thus, we expect short sellers facing higher costs to be less affected by the disposition effect, as being biased is more costly for them. We examine this idea by interacting *SCGO* with a dummy variable equal to one when a stock is "special"— i.e., it has a lending fee of over 100 basis points per year. This interaction comes in (insignificantly) negative, showing that we observe somewhat less "disposition effect behavior" in stocks with high lending fees.

In Panel B, we extend this analysis by studying other firm characteristics that are generally associated with short-selling being more costly or difficult. Indeed, we find a significantly weaker effect of *SCGO* on *Closing* for smaller firms, more illiquid stocks, and stocks with lower institutional ownership. These are exactly the stocks for which short-selling is more expensive /difficult.

These findings not only support our working hypothesis, but they also rule out the following alternative explanation for the positive relationship between *Closing* and *SCGO*: Management or long investors might try to force short sellers to close their positions (Lamont (2012)). If they are more likely to do so after stock prices have fallen, it might provide an alternative explanation because *SCGO* is negatively correlated with returns. However, this behavior is much more likely to work for stocks that are hard to borrow— i.e., small, illiquid, and low institutional ownership stocks— but these are the very stocks in which our results are actually the weakest. This suggests that this alternative explanation of our findings is not true.

Taken together, the results in this section are consistent with the positive relationship between *SCGO* and Closing being driven by the disposition effect rather than some alternative explanations.

5. Do Short Sellers exhibit a V-shaped pattern in closing their positions?

Ben-David and Hirshleifer (2012) find that (long-only) retail investors exhibit a V-shaped pattern in closing their positions (in addition to the disposition effect). This means that retail investors are most likely to close positions that they hold with either very positive or very negative capital gains. In this section, we examine if short sellers behave in a similar way.

5.1 Graphical analysis

We start with a simple graphical analysis. Because we do not have access to individual-level data, we cannot exactly replicate the figures in Ben-David and Hirshleifer (2012). However, we can do something very similar. We group stocks into 10 deciles by the level of short sale capital gains and compute the average level of *Closing* for each decile.

We report the results in Figure 2. In Panel A, we form deciles based on *SCGO I* and in Panel B, we form deciles based on *SCGO II*. In both cases, we find the exact opposite pattern of Ben-David and Hirshleifer (2012): short sellers are more likely to close positions that they hold with short sale capital gains close to zero. In other words, we find an inverted V-Shape or hump-shape rather than the V-shape documented by Ben-David and Hirshleifer (2012) for long investors.[9]

We also report the average SCGO by decile on the x-axis. As you would expect, the deciles 1 to 5 have negative SCGO and the deciles 6 to 10 have positive SCGO. There also does not seem to be that much skewness. SCGO I has larger absolute values for deciles 5 to 10 than for deciles 1 to 5, suggesting that SCGO I is skewed positively. In contrast, SCGO II is slightly negatively skewed.

5.2 Regression analysis

Next, we use a regression framework to determine if this pattern is statistically significant. We examine the effect of *SCGO* on *Closing* separately for positive and negative values of *SCGO*. For this purpose, we follow Ben-David and Hirshleifer (2012) and define two new variables. *SCGO (negative)* is equal to *SCGO* for negative values and equal to zero for positive values, while *SCGO (positive)* is equal to *SCGO* for positive value and equal to zero for negative values. Or, expressed mathematically:

$$SCGO\ (negative) = \min(SCGO, 0)$$

$$SCGO\ (positive) = \max(SCGO, 0)$$

We regress *Closing* on both *SCGO (negative)* and *SCGO (positive)*. By including both variables in one regression, we isolate the effect of *SCGO* for positive and negative values, respectively. We include the same control variables as before and report results using both definitions of short sale capital gains, i.e. *SCGO I* and *SCGO II*.

[9] We find the same result if we use form averages based on the residuals of *Closing* regressed on all control variables and fixed effects (but not *SCGO*) of Regression 2 in Table 2 (unreported).

We report the results in Table 6. We obtain positive coefficients for *SCGO (negative)* and negative coefficients for *SCGO (positive)*, irrespective of whether we use *SCGO I* or *SCGO II*. Thus *SCGO* has a positive effect on *Closing* if it is negative but a negative effect of *Closing* if it is positive. Thus, closing exhibits a hump shape relative to *SCGO*. Short sellers are most likely to close positions where capital gains are close to zero. This result is generally significant at the 1% level, except for the negative coefficient of *SCGO II (positive)*, which is only significant at the 10% level. Furthermore, the positive coefficient on *SCGO (negative)* is of larger magnitude than the negative coefficient of *SCGO (positive)*, explaining why we observe a positive effect of *SCGO* on *Closing* in general.

Finally, we examine another option to test for a V-shape by regressing *Closing* on *Abs(SCGO)*, which is the absolute value of *SCGO*. If *Closing* exhibits a hump shape relative *SCGO*, the coefficient on *Abs(SCGO)* should be significantly negative, which is exactly what we find. This finding is significant at the 1% level.

5.3 Why do we observe a hump shape?

Our results clearly indicate that *Closing* has a hump shape relative to *SCGO*, which is the exact opposite of the result that Ben-David and Hirshleifer (2012) find for long-only retail investors. What might explain this difference in finding? Ben-David and Hirshleifer (2012) argue that the V-shape pattern results from speculative trades of overconfident retail investors. After a large capital gain, an investor might think that the perceived trading opportunity has run its course and it is time to close the position. Similarly, after a large capital loss, the investor might get discouraged and decide to give up on the trading strategy and close the position. Such behavior would lead to a V-shape pattern in capital gains when closing positions. A related explanation is limited attention. Investors may focus more on stocks that exhibited large gains or losses and thus are more likely to close them. Especially, the second effect should be less important for short sellers, who are mostly professional traders and thus likely pay a lot of attention to all their positions. While this argument explains why we might see less of a V-shape pattern for short sellers, it cannot explain why we observe a hump shape.

We propose and then test two explanations of the hump shape. The first is the shorting cost explanation. Different from long positions, short positions are expensive to keep open as the short seller needs to borrow the shares while they are sold short. For this time period, the short seller needs to pay a lending fee to the owner of the shares. These costs might incentivize short sellers to sell a position if it has not moved much (and they do not expect much movement in the future). In such a quiet market, where potential gains are small, it may not be worth to keep open a position that costs a lending fees. This effect might lead to a hump shape in *Closing* relative to *SCGO*

If shorting costs would explain the hump shape, we would expect the hump shape to be more pronounced for stocks that exhibit a large lending fee. To examine this proposition, we regress *Closing* on an interaction between *Abs(SCGO)* and measures of shorting costs. To make sure that our firm-

specific characteristics can also be affected by variation between firms, we run this regression without firm and week fixed effects. However, we show in the internet appendix in IA-Table 5 that the results are very similar when we run our usual specification that includes firm and week fixed effects.

We present the results of this regression in Table 7 Panel A. We use two measures of shorting costs: the average lending fee and *Specialness*, which is a dummy variable equal to one if the lending fee is above 100 basis points per year. For both interactions we generally obtain positive coefficients. This means that the negative effect of *Abs(SCGO)* on *Closing* is lower when shorting costs are high. Thus, we observe less hump shape when shorting costs are high, the exact opposite of what we would expect if shorting costs were to explain the hump shape. This finding suggests that the shorting cost explanation cannot explain the hump shape.[10]

Our second potential explanation for the hump shape is the *liquidity explanation*. Different from retail investors studied by Ben-David and Hirshleifer (2012), short sells are mainly undertaken by large institutional investors such as hedge funds. These large investors are concerned about price impact leading to high transaction costs. Thus, they have an incentive to close positions when the market is most liquid. Times when prices are volatile and much new information is incorporated into prices are times when markets should be less liquid (e.g. Kim and Verrechia (1994)). These are also the times when short sellers are likely to exhibit large absolute capital gains. Thus, the *liquidity explanation* proposes that short sellers are less likely to close positions when they hold stocks with large positive or negative capital gains because these are the times where stocks are less liquid.

We start to examine this explanation by first studying the underlying assumption that stocks are less liquid at times when short sellers hold them with high absolute capital gains. For this purpose, we compute the average liquidity for each decile of short sale capital gains.

The results are displayed in Figure 3. We examine two measures of illiquidity. *Amihud Illiquidity* (as defined above) and the intraday bid-ask spread. The intraday bid-ask spread is the average bid-ask spread on the given week taken every 5 minutes from TAQ data. Due to data limitations, we have the intraday bid-ask spread available only for a subset of our sample. However, we show a similar result using average end-of-day bid-ask spreads taken from CRSP in IA-Figure 2 in the internet appendix. For both measures of illiquidity and both measures of *SCGO*, we observe a V-shape (or U-shape) of illiquidity with respect to *SCGO*, i.e. we observe a hump shape of liquidity with respect to SCGO. This means that indeed stocks are most illiquid when they exhibit large absolute values of *SCGO*. This confirms the premise of the liquidity explanation.

[10] The fact that we observe less of a hump shape for stock with larger shorting costs may be explained by the forced closure of short positions due to the stocks becoming unavailable or expensive to borrow in the equity lending market. Indeed, high volatility may lead to both higher *Abs(SCGO)* and higher lending fees (we confirm this relation in unreported results), which may force short sellers to close their positions. This channel would work against the hump-shape pattern that we observe, making it less pronounced. For stocks that are already expensive to borrow ex-ante, this relationship is likely stronger, explaining why we observe a less pronounced hump shape for these stocks.

If liquidity considerations explain the hump-shaped closing pattern of short sales, we would expect this pattern to be stronger for stocks that are generally more illiquid. Thus, we regress *Closing* on an interaction between *Abs(SCGO)* and different measures of stock liquidity.

In Panel B of Table 7, we focus on three measures of liquidity. *Small Firm*, which is a dummy variable equal to one if *Size* is below the sample median; *Illiquidity*, which is a dummy variable equal to one if *Amihud Illiquidity* is above the sample median; and *Low Institutional Ownership*, which is a dummy variable equal to one if *Institutional Ownership* is below the sample median. All interactions are negative and significant at the 1% level. This means that the hump shape pattern is stronger for smaller stocks, more illiquid stocks, and stocks with low institutional ownership.

In Panel C, we focus on other illiquidity measures. For this purpose, we examine the average of intra-day illiquidity measures computed over the previous quarter. We take these indicators from WRDS Intraday Indicator Database (IID), which uses the methodology specified in Holden and Jacobsen (2014). Specifically, we define *High Effect Spread* as a dummy variable equal to one if the average effective spread over the prior quarter is above the sample median. The effective spread measures how much a buy (sell) order's trade price is higher (lower) than the bid-ask midpoint that prevailed prior to the trade. The effective spread can be decomposed into its temporary component, which is called the realized spread and its permanent component, which is called price impact. Thus, we also include *High Realized Spread*, which is a dummy variable equal to one if the realized spread over the prior quarter is above the sample median, and *High Price Impact*, which is a dummy variable equal to one if the realized spread over the prior quarter is above the sample median.

In analyses presented in Panel C of Table 7, we interact these illiquidity measures with *Abs(SCGO).* As before, we find negative coefficients, which suggest that the hump shape is more pronounced in stocks that are more illiquid. Taken together, our results are consistent with the idea that the hump shape pattern is related to short sellers closing positions at times when stocks are more liquid. It also makes sense that such liquidity considerations are less important for retail investors studied by Ben-David and Hirshleifer (2012).

While this evidence is consistent with this behavior being driven by liquidity considerations and we believe this to be the most likely explanation for the hump shape, we cannot rule out other explanations that may be related to behavioral biases.

6. Robustness Checks

Our short-sale capital gains variables are inevitably correlated with past returns. Therefore, we control for past returns in all our regressions. We choose the same controls as Grinblatt and Han (2005) and control for non-overlapping returns at the one-month, one-year and three-year horizons. However, one may be worried that these returns are not detailed enough and our short-sale capital gains variables simply proxy for past returns at a different horizon.

To address this issue, we report robustness checks in which we replace the one-year return variable with return variables for each individual quarter in Table 8. More specifically, we include returns for weeks t-4 to t-1, t-12 to t-5, t-26 to t-13, t-39 to t-27, t-52 to t-40, and t-156 to t-52. In Panel A, we repeat the main regressions of Tables 2, 5 and 6, which are specifications with *Closing* as the dependent variable. In Panel B, we repeat Table 4 where stock return is the dependent variable. In all these cases, our results stay significant and the size of our effects actually increases in most cases. This finding suggests that our results are not driven by inappropriate controls for past returns.

For all regressions in the paper, we winsorize the return variables at the 1% threshold to remove outliers. In IA-Table 1 in the internet appendix, we show that our results are robust to not winsorizing variables at all. Without winsorization, the results remain statistically significant and of similar economic magnitude. This finding suggests that the fact that we winsorize returns does not drive our results.

Following Grinblatt and Han (2005), we use Fama-MacBeth regressions for all specifications in which stock return is the dependent variable. In IA-Table 2 in the internet appendix, we show that our results remain generally significant and of similar economic magnitude when we use panel regressions with firm and week fixed effects instead. In this case, we two-way cluster standard errors by firm and week.

Throughout this paper, we estimate short-selling activity using equity lending data. Thus, the closing of short positions is measured using the termination of equity loans. The closure of a short position is the main reason why equity loans are terminated. However, in rare cases (about 2%, according to D'Avolio (2002)) equity loans are terminated because the lender recalls the shares. Recall will be more prominent in stocks that have a higher utilization—i.e., in which a larger fraction of lendable shares is lent out. In IA-Table 3 in the internet appendix, we rerun Table 2 in the paper but exclude all stock-weeks with active utilization above 90%. If there are any issues with recall, they should show up in these stocks. However, our results not only remain statistically significant when we exclude these stock-weeks, but they actually increase in magnitude. These results are consistent with results in Table 5 showing a larger effect in stocks with high loan fee and low institutional ownership (other stock characteristics associated with more recalls). Taken together, these results suggest that any measurement error related to recall actually works against us confirming our hypotheses (rather than causing our results).

The equity lending market is affected by both the demand for borrowing securities (mainly for short selling) and the supply of securities. The disposition effect of short sellers should only affect the demand for borrowing securities. To confirm that our results are not driven by supply effects, we conduct the following robustness check. Following Cohen, Diether, and Malloy (2007), we define a supply shock as a week in which the number shares on loan increase while the lending fee decreases (outward shift

of the supply curve (SOUT)) or where the number shares on loan increase while the lending fee decreases (inward shift of supply curve (SIN)). In IA-Table 4 in the internet appendix, we report a robustness check where we rerun the test of Table 2 but exclude weeks with a supply shock. Our results remain significant, suggesting that they are not driven by supply shocks.

7. Conclusion

We study whether short sellers (usually seen as rational, sophisticated, and well-informed traders) suffer from behavioral biases. We focus on the disposition effect (Shefrin and Statman (1985)). Using a dataset on stock lending for all U.S. stocks from 2004 to 2010, we are able to examine the closing of short positions. We show that short sellers exhibit the disposition effect— i.e., they hold on to their losing positions too long and close their winning positions too early. We establish this by demonstrating two facts. First, the closing of short-sale positions is strongly related to a proxy of short-sale capital gains overhang (*SCGO*). Second, the closing decisions of short sellers are less profitable the more they base them on *SCGO*. Taken together, these findings suggest that short sellers are subject to the disposition effect.

Furthermore, we examine the exact pattern of closing relative to capital gains and find that it has a hump shape. Interestingly, this is the exact opposite result of the V-shape that Ben-David and Hirshleifer (2012) find for long-only retail investors. Further evidence suggests that the hump shape may be related to market liquidity. Liquidity also exhibits a hump shape relative to *SCGO* and the hump-shaped pattern is stronger for illiquid stocks. These findings are consistent with the idea that short sellers prefer to liquidate positions that have little changed because they are more liquid. However, our results are only indicative on this issue and further research may shed further light on this issue.

Our findings have important normative implications. Indeed, short sellers are generally seen as informed arbitrageurs that improve market efficiency. While we generally agree with this description, our findings suggest that even this sophisticated group of investors is subject to behavioral biases. This finding is important, because these biases limit short sellers' ability to arbitrage away mispricing, which helps to explain why market anomalies can persist despite the apparent availability of arbitrage capital.

References

Aitken, Michael J., Alex Frino, Michael S. McCorry, and Peter L. Swan, 1998, Short Sales Are Almost Instantaneously Bad News: Evidence from the Australian Stock Exchange, *The Journal of Finance* 53, 2205-2223.

Asquith, Paul, and Lisa K. Meulbroek, 1995, An empirical investigation of short interest, *Working Paper* .

Barber, Brad M., and Terrance Odean, 2000, Trading Is Hazardous to Your Wealth: The Common Stock Investment Performance of Individual Investors, *The Journal of Finance* 55, 773-806.

Barberis, Nicholas, Ming Huang, and Tano Santos, 2001, Prospect Theory and Asset Prices, *The Quarterly Journal of Economics* 116, 1-53.

Barberis, Nicholas, and Ming Huang, 2001, Mental Accounting, Loss Aversion, and Individual Stock Returns, *The Journal of Finance* 56, 1247-1292.

Barberis, Nicholas, and Wei Xiong, 2009, What Drives the Disposition Effect? An Analysis of a Long-Standing Preference-Based Explanation, *The Journal of Finance* 64, 751-784.

Ben-David, Itzhak and David Hirshleifer, 2012, Are Investors Really Reluctant to Realize Their Losses? Trading Responses to Past Returns and the Disposition Effect, *Review of Financial Studies 25*, 2485-2532.

Berkelaar, Arjan B., and Roy R. P. Kouwenberg, 2000, Dynamic Asset Allocation and Downside-Risk Aversion, *Econometric Institute Report No. EI 2000-12/A.*

Boehmer, Ekkehart, Truong X. Duong, and Zsuzsa R. Huszar, 2018, Short Covering Trades, *Journal of Financial and Quantitative Analysis* 53, 723-748.

Boehmer, Ekkehart, Zsuzsa R. Huszar, and Bradford. Jordan, 2010, The Good News in Short Interest, *Journal of Financial Economics* 96, 80-97.

Boehmer Ekkehart, Zsuzsa R. Huszar, Yanchu Wang, and Xiaoyan Zhang, 2015, Are Shorts Equally Informed? A Global Perspective, Working Paper.

Boehmer, Ekkehart, Charles M. Jones, and Xiaoyan Zhang, 2008, Which Shorts Are Informed? The Journal of Finance 63, 491-527.

Boehmer, Ekkehart, and Juan Wu, 2013, Short Sellling and the Price Discovery Process, *Review of Financial Studies* 26, 287-322.

Bris, Arturo, William N. Goetzmann, and Ning Zhu, 2007, Efficiency and the Bear: Short Sales and Markets Around the World, *The Journal of Finance* 62, 1029-1079.

Carhart, Mark M., 1997, On Persistence in Mutual Fund Performance, *The Journal of Finance* 52, 57-82.

Chen, Joseph, Harrison Hong, and Jeremy C. Stein, 2002, Breadth of ownership and stock returns, *Journal of Financial Economics* 66, 171-205.

Choi, James J., David Laibson, and Brigitte C. Madrian, 2009, Mental Accounting in Portfolio Choice: Evidence from a Flypaper Effect, *Amercian Economic Review* 99, 2085-2095.

Cohen, Lauren, Karl B. Diether, and Christopher J. Malloy, 2007, Supply and Demand Shifts in the Shorting Market, *The Journal of Finance* 62, 2061-2096.

Conrad, Jennifer S., Allaudeen Hameed, and Cathy Niden, Volume and Autocovariances in Short-Horizon Individual Security Returns, *The Journal of Finance* 46, 1305-1329.

Coval, Joshua D., and Tobias J. Moskowitz, 1999, Home Bias at Home: Local Equity Preference in Domestic Portfolios, *The Journal of Finance* 54, 2045-2073.

Coval, Joshua D., and Tyler Shumway, 2005, Do Behavioral Biases Affect Prices?, *The Journal of Finance* 34, 1-34.

Diether, Karl B., Kuan-Hui Lee, and Ingrid M. Werner, 2009, Short-Sale Strategies and Return Predictability, *Review of Financial Studies* 22, 575-607.

Diether, Karl B., Christopher J. Malloy, and Anna Scherbina, 2002, Differences of Opinion and the Cross Section of Stock Returns, *The Journal of Finance* 57, 2113-2141.

Engelberg, Joseph E., Adam V. Reed, and Matthew C. Ringgenberg, 2012, How are shorts informed?: Short sellers, news, and information processing, *Journal of Financial Economics* 105, 260-278.

Engelberg, Joseph E., Adam V. Reed, and Matthew C. Ringgenberg, 2017, Short Selling Risk, *Journal of Finance* 73, 755-786 .

Fama, Eugene F., and Kenneth R. French, 1993, Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics* 33, 3-56.

Frazzini, Andrea, 2006, The Disposition Effect and Underreaction to News, *The Journal of Finance* 61, 2017-2046.

Geczy, Christopher C., David K. Musto, and Adam V. Reed, 2002, Stocks are special too: an analysis of the equity lending market, *Journal of Financial Economics* 66, 241-269.

Genesove, David, and Christopher Mayer, 2001, Loss Aversion and Seller Behavior: Evidence from the Housing Market, *The Quarterly Journal of Economics* 116, 1233-1260.

Gomes, Francisco J., 2005, Portfolio Choice and Trading Volume with Loss-Averse Investors, *The Journal of Business* 78, 675-706.

Grinblatt, Mark, and Bing Han, 2005, Prospect theory, mental accounting, and momentum, *Journal of Financial Economics* 78, 311-339.

Grinblatt, Mark, and Matti Keloharju, 2001, What Makes Investors Trade? *The Journal of Finance* 56, 589-616.

---. 2000, The Investment Behavior and Performance of Various Investor-Types: A Study of Finland's Unique Data Set. *Journal of Financial Economics 55*, 43-67.

Heath, Chip, Steven Huddart, and Mark Lang, 1999, Psychological Factors and Stock Option Exercise, *The Quarterly Journal of Economics* 114, 601-627.

Holden, Craig, and Stacey Jacobsen, 2014, Liquidity Measurement Problems in Fast, Competitive Markets: Expensive and Cheap Solutions, The Journal of Finance 69, 1747-1785.

Huberman, Gur, 2001, Familiarity Breeds Investment, *Review of Financial Studies* 14, 659-680.

Jegadeesh, Narasimhan and Sheridan Titman, 1993, Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency, *The Journal of Finance* 48, 65-91.

Jin, Li, and Anna Scherbina, 2011, Inheriting Losers, *Review of Financial Studies* 24, 786-820.

Jones, Charles M., and Owen A. Lamont, 2002, Short-sale constraints and stock returns, *Journal of Financial Economics* 66, 207-239.

Kim, Oliver, and Robert E. Verrecchia, 1994, Market liquidity and volume around earnings announcements, *Journal of Acccounting and Economics* 17, 41-67.

Lamont, Owen A., 2012, Go Down Fighting: Short Sellers vs. Firms, *Review of Asset Pricing Studies* 2, 1-30.

Locke, Peter R., and Steven C. Mann, 2005, Professional trader discipline and trade disposition, *Journal of Financial Economics* 76, 401-444.

Miller, Edward M., 1977, Risk, Uncertainty, and Divergence of Opinion, *The Journal of Finance* 32, 1151-1168.

Odean, Terrance, 1998, Are Investors Reluctant to Realize Their Losses? *The Journal of Finance* 53, 1775-1798.

---. 1999, Do Investors Trade Too Much? *American Economic Review* 89, 1279-1298.

Petersen, Mitchell A., 2009, Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches, *Review of Financial Studies* 22, 435-480.

Saffi, Pedro A. C., and Kari Sigurdsson, 2011, Price Efficiency and Short Selling, *Review of Financial Studies* 24, 821-852.

Senchack, A. J.,Jr., and Laura T. Starks, 1993, Short-Sale Restrictions and Market Reaction to Short-Interest Announcements, *The Journal of Financial and Quantitative Analysis* 28, pp. 177-194.

Shefrin, Hersh, and Meir Statman, 1985, The Disposition to Sell Winners Too Early and Ride Losers Too Long: Theory and Evidence, *The Journal of Finance* 40, 777-790.

Shumway, Tyler, 1998, Explaining Returns with Loss Aversion, *Working Paper*.

Shleifer, Andrei and Robert W. Vishny, 1997, The Limits of Arbitrage, *The Journal of Finance* 52, 35-55.

Thaler, Richard, 1980, Toward a positive theory of consumer choice, *Journal of Economic Behavior & Organization* 1, 39-60.

Thornock, Jacob R., 2013, The Effects of Dividend Taxation on Short Selling and Market Quality, *Accounting Review* 88, 1833-1856.

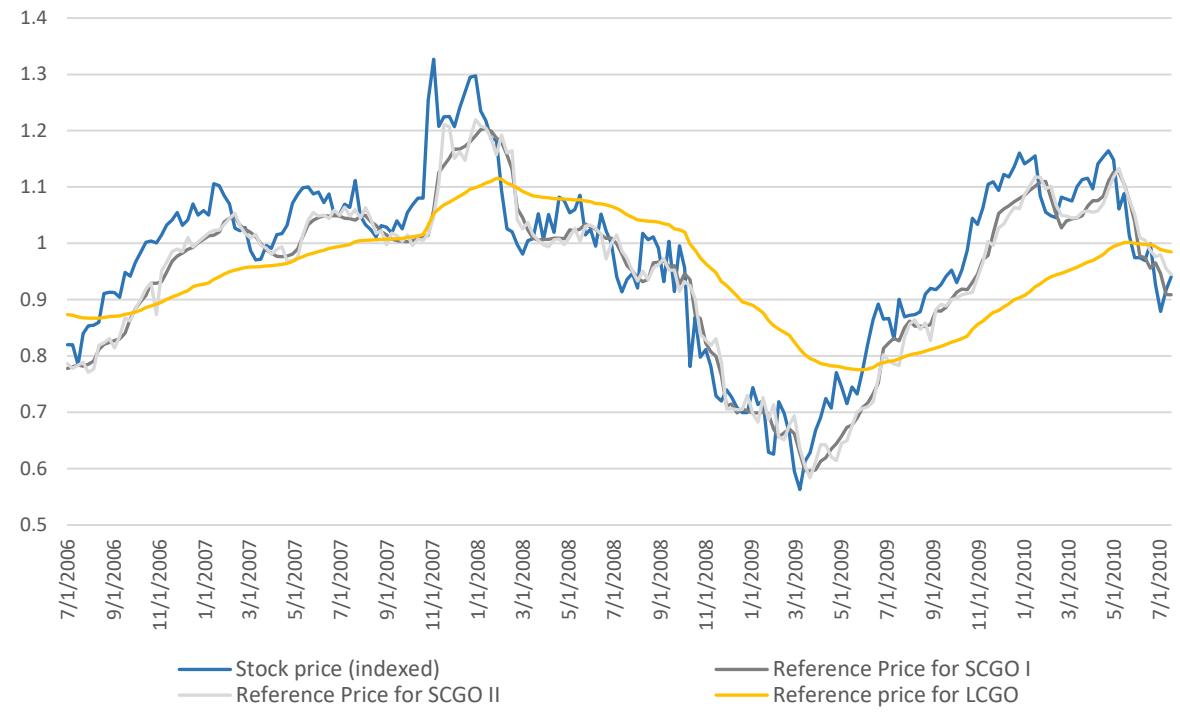
von Beschwitz, Bastian, Oleg Chuprinin and Massimo Massa, 2017, Why Do Short Sellers Like Qualitative News?, *Journal of Quantitative and Financial Analysis 52*, 645-675.

Weber, Martin, and Colin F. Camerer, 1998, The disposition effect in securities trading: an experimental analysis, *Journal of Economic Behavior & Organization* 33, 167-184.

Figure 1: Example of references prices and capital gains

In this figure, we illustrate the construction of short sale capital gains overhang (*SCGO*) and long capital gains overhang (*LCGO*) for the example of one stock (Microsoft). In Panel A, we display the stock price (indexed and including dividends), as well as the three references prices for *SCGO I*, *SCGO II*, and *LCGO*. In Panel B, we display *SCGO I*, *SCGO II*, and *LCGO*.

Panel A: References prices



Panel B: Capital gains

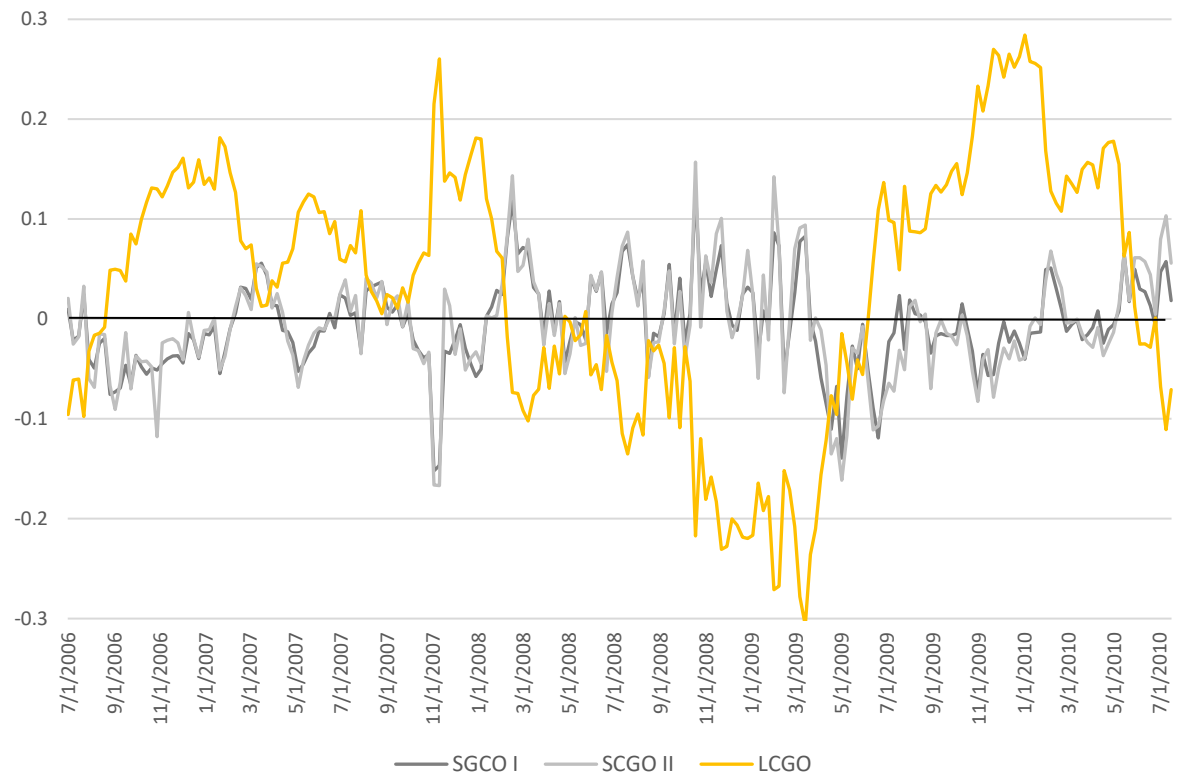
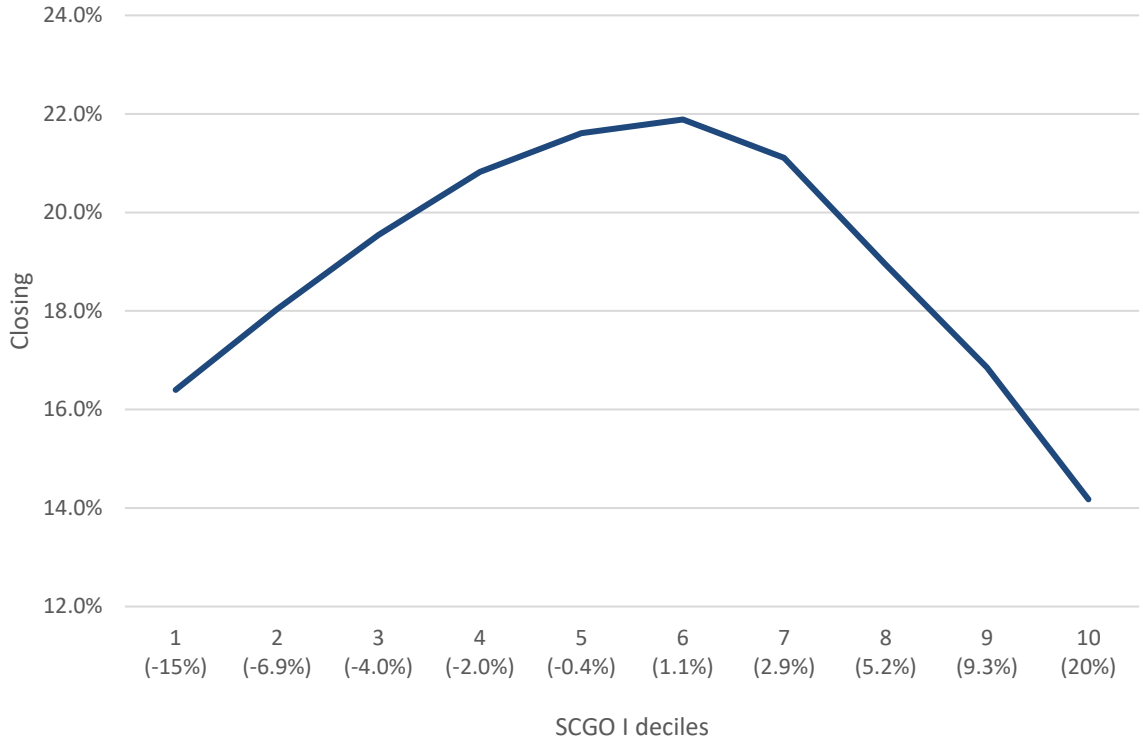


Figure 2: Closing as a function of capital gains by deciles

In this figure, we show the average of *Closing* for each decile of *Short Sale Capital Gains Overhang (SCGO)*. We show on the x-axis the average of SCGO within the decile in parenthesis. In Panel A, deciles are formed based on *SCGO I*. In Panel B, deciles are formed based on *SCGO II*.

Panel A: SCGO I



Panel B: SCGO II

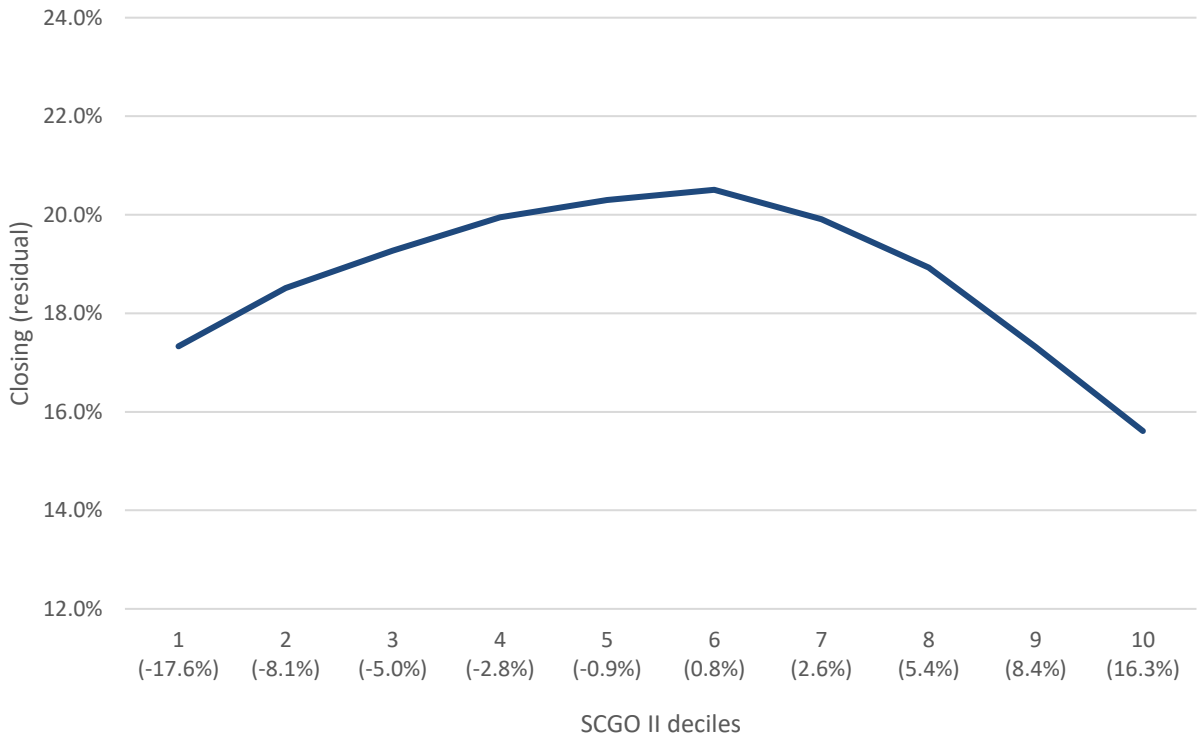
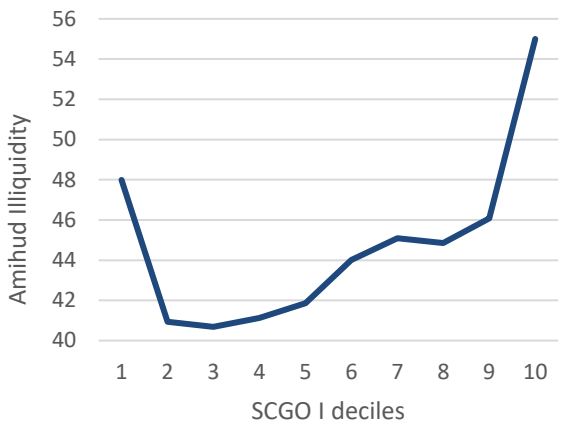
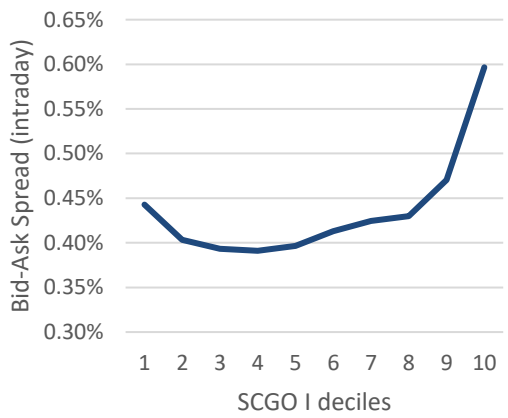


Figure 3: Liquidity as a function of capital gains by deciles

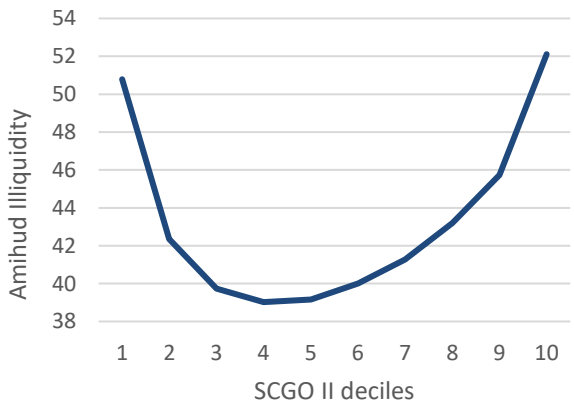
In this figure, we show the average of *Amihud Illiquidity and Bid-Ask Spread* for each decile of *Short Sale Capital Gains Overhang (SCGO)*. *Amihud Illiquidity* is a percentage rank where companies with the highest Amihud illiquidity are assigned a value of 100, companies with the lowest Amihud illiquidity are assigned a value of 0. *Bid-Ask Spread (intraday)* is the weekly average of bid-ask spreads measured at the end of each 5-minute interval from TAQ data. In Panel A, deciles are formed based on *SCGO I*. In Panel B, deciles are formed based on *SCGO II*.

Panel A: SCGO I





Panel B: SCGO II



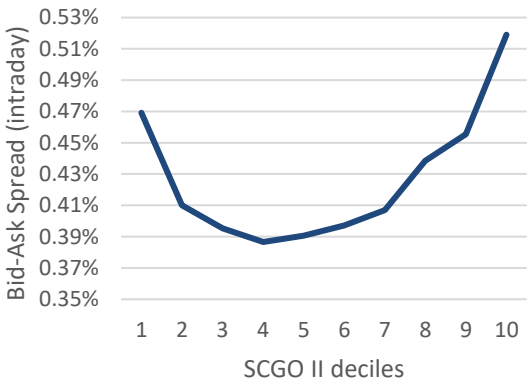


Table 1: Summary statistics

In Panel A, we list the company specific variables for the 6,134 companies in our sample. We compute those variables at the company-year level. *Breadth of Ownership* is defined as the number of institutions holding the stock divided by total number of reporting institutions. *Number of Analysts* is the number of analysts on IBES that issue an earnings forecast for the stock. *Institutional Ownership* is the percentage of shares held by institutions. In Panel B, we list summary statistics of market variables for the 1,231,405 company-weeks in the period of August 2004 to June 2010. *Loaned Shares* is the number of stocks on loan at the end of the week divided by shares outstanding. *Closing* is the number of shares returned to lenders during the week divided by shares on loan at the beginning of the week. *Closing as a Fraction of Shares Outstanding* is the number of shares returned to lenders during the week divided by shares outstanding. *Shorting as Fraction of Shares Outstanding* is the number of shares newly borrowed during the week divided by shares outstanding. *Average Short-Sale Duration* is the average number of days that the short positions are open. *Average Lending Fee* is the average cost to borrow that stock in basis points per year. *SCGO I* and *SCGO II* (short-sale capital gains overhang variables) are both defined as $\frac{\text{Reference Price}-\text{Price}}{\text{Reference Price}}$, but with different proxies for the reference price (see Section 3.2 and Appendix 1 for a more detailed description). They proxy the average capital gains with which short sellers hold their position in the stock. *LCGO* (Long Capital Gains Overhang) is defined as $\frac{\text{Price}-\text{Reference Price}}{\text{Reference Price}}$, where the reference price is defined recursively as $\text{Reference price}_t = \frac{\text{Trading volume}_t}{\text{Shares Outstanding}_t} * \text{Price}_t + \left(1 - \frac{\text{Trading volume}_t}{\text{Shares Outstanding}_t}\right) * \text{Reference Price}_{t-1}$. This variable measures the average capital gains of traders that are long. We remove weeks that include the period of the short-sale ban (September 15, 2008, to October 10, 2008).

Panel A: Company Variables

	Median	Mean	25th Percentile	75th Percentile	Standard Deviation
Market capitalization in m $	350	2507	102	1328	7614
Market to Book	1.94	2.78	1.25	3.22	2.75
Breadth of Ownership (%)	2.98	4.81	0.92	6.13	5.87
Number of Analysts	3	5	0	7	6.1
Institutional Ownership (%)	52.8	50.7	23.2	78.2	30.2

Panel B: Market Variables

	Median	Mean	25th Percentile	75th Percentile	Standard Deviation
Loaned Shares (%)	1.70	3.89	0.20	5.31	5.39
Closing (%)	12.95	18.96	5.39	25.00	20.19
Closing as a Fraction of Shares Outstanding (%)	0.23	0.57	0.02	0.74	0.86
Shorting as Fraction of Shares Outstanding (%)	0.24	0.57	0.03	0.76	0.84
Average Lending Fee (bp)	14.32	71.30	9.41	26.96	173.87
Average Short-Sale Duration (days)	62	77	34	99	66
Weekly Turnover (%)	2.52	4.20	0.99	5.09	8.14
Weekly Return (%)	0.00	0.19	-2.96	3.09	6.55
SCGO I (%)	0.00	0.93	-4.03	4.61	10.82
SCGO II (%)	-0.30	-0.12	-5.19	4.86	10.75
LCGO (%)	1.81	1.00	-13.45	15.02	27.61

Table 2: Do short sellers close winning and hold on to losing positions?

This table contains the results of weekly panel regressions that examine the effect of *Short-Sale Capital Gains Overhang* (*SCGO*) on the closing of short-sale positions from August 2004 to June 2010, excluding the period of the short-sale ban (September 15, 2008, to October 10, 2008). The dependent variable is *Closing* (percentage of loaned shares that are returned to lenders during the week). The explanatory variable of interest is *SCGO* at the beginning of the week. We show results of *SCGO I* and *SCGO II*, respectively. *Return* t-k to t-j is the average weekly return in the specified weeks. *Turnover* t-k to t-j is the weekly average of number of shares traded divided by shares outstanding in the specified week. *P(return>5%)* measures the fraction of daily returns in the prior quarter for that stock that are above 5%. *Volatility* is the standard deviation of the stock's daily returns in the prior quarter. Other control variables are defined in Appendix 1. Standard errors are two-way clustered at the firm and week levels. T-statistics are below the parameter estimates in parenthesis. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

	Closing					
	(1)	(2)	(3)	(4)	(5)	(6)
SCGO I	0.0318***	0.0589***	0.0583***			
	(2.83)	(5.91)	(5.56)			
SCGO II				0.0337***	0.0316***	0.0312***
				(2.93)	(3.25)	(3.02)
Return t-4 to t	0.2703***	0.2995***		0.2759***	0.2514***	
	(7.61)	(9.86)		(7.14)	(7.54)	
Return t-52 to t-5	1.2570***	1.1633***	0.9716***	1.2291***	1.1003***	0.9103***
	(13.29)	(9.84)	(8.38)	(14.57)	(9.27)	(7.83)
Return t-156 to t-53	0.4013***	0.5422***	0.4914***	0.4347***	0.5437***	0.4890***
	(2.89)	(3.36)	(3.08)	(3.13)	(3.32)	(3.03)
Turnover t-52 to t-1	-0.1144***	0.1080***		-0.1006***	0.1140***	
	(-3.90)	(2.89)		(-3.40)	(2.99)	
Market to Book		-0.0002	-0.0003		-0.0002	-0.0003
		(-0.58)	(-0.85)		(-0.40)	(-0.74)
Size		-0.0013	-0.0025		-0.0025	-0.0037
		(-0.41)	(-0.82)		(-0.82)	(-1.24)
Amihud Illiqudity		0.0006***	0.0007***		0.0005***	0.0006***
		(4.55)	(5.11)		(3.95)	(4.54)
Breadth of Ownership		0.1372**	0.1766***		0.1483**	0.1894***
		(2.05)	(2.68)		(2.21)	(2.88)
Inst. Ownership		0.0317***	0.0325***		0.0264***	0.0271***
		(4.79)	(5.05)		(3.94)	(4.17)
Number of Analysts		-0.0063***	-0.0051***		-0.0066***	-0.0054***
		(-4.87)	(-4.12)		(-5.07)	(-4.34)
Average Short-Sale Duration		-0.0006***	-0.0006***		-0.0006***	-0.0006***
		(-34.30)	(-33.90)		(-33.31)	(-32.92)
Average Lending Fee		0.0033***	0.0034***		0.0038***	0.0039***
		(5.26)	(5.38)		(5.99)	(6.14)
Loaned Shares		-0.0059***	-0.0067***		-0.0060***	-0.0067***
		(-26.97)	(-29.65)		(-26.93)	(-29.64)
P (return>5%)		0.0302*	0.0161		0.0214	0.0064
		(1.75)	(0.94)		(1.23)	(0.37)
Volatility		0.0144	-0.1196*		0.0524	-0.0854
		(0.23)	(-1.96)		(0.83)	(-1.36)
Return t-1			0.0811***			0.0607***
			(7.43)			(5.02)
Return t-2			0.0814***			0.0693***
			(9.10)			(7.04)
Return t-3			0.0617***			0.0515***
			(7.72)			(6.28)
Return t-4			0.0482***			0.0422***
			(6.45)			(5.18)
Turnover t-1			0.5899***			0.5913***
			(21.38)			(22.07)
Turnover t-2			0.0249			0.0263
			(1.47)			(1.61)
Turnover t-3			-0.0209*			-0.0158
			(-1.67)			(-1.25)
Turnover t-4			-0.0202			-0.0222*
			(-1.63)			(-1.79)
Turnover t-52 to t-5			-0.2431***			-0.2415***
			(-6.80)			(-6.65)
Observations	951467	766333	766326	912386	734832	734832
Adjusted R^2	0.17	0.21	0.21	0.17	0.21	0.22
Firm and Week F. E.	Yes	Yes	Yes	Yes	Yes	Yes

Table 3: Comparing the magnitude of our results to Odean (1998)

In this table, we compare the magnitude of our results to those of Odean (1998). In Panel A, we display the result of Odean (1998), taken from Table 1 of his paper. In Panel B, we display our own results both using *SCGO I* in column 1 and *SCGO II* in column 2. We display the average of *SCGO* when it is positive and the average of SCGO when it is negative. Then we take the difference between these values and multiply it with our regression coefficient to estimate the difference between percentage of gains realized and percentage of loss realized in our sample. Finally, we express this value as a fraction of the Odean (1998) result.

Panel A: Results from Odean (1998)

	Value
Percentage of Gains Realized (PGR)	14.8%
Percentage of Losses Realized (PLR)	9.8%
Difference	5%
T-statistic	-35

Panel B: Our results

	Using SCGO I (1)	Using SCGO II (2)
Average Positive SCGO	8.5%	7.7%
Average Negative SCGO	-6.4%	-7.4%
Difference	14.9%	15.1%
Regression Coefficient	0.058	0.031
Percentage of Gains Realized – Percentage of Losses Realized	0.86%	0.47%
As a fraction of the effect from Odean (1998)	17.2%	9.4%

Table 4: Profitability of closing of short positions and disposition effect

This table contains the results of weekly Fama-MacBeth regressions (1973) with Newey-West (1987) correction at eight lags that examine how the closing of short positions predicts future returns depending on how prevalent the disposition effect is amongst short sellers in that stock. The time period ranges from August 2004 to June 2010, excluding the period of the short-sale ban (September 15, 2008, to October 10, 2008). The dependent variable is the weekly stock return. The explanatory variable of interest is an interaction between *Closing* and *Correlation (Closing, SCGO)*, which is the rolling correlation between *Closing* and *SCGO* (either *SCGO I* or *SCGO II*) over either the prior year or the prior two years. In Regression 5, we show the base effect of *Closing* on future Returns. All regressions include the following control variables that are omitted for brevity: *Return t-4 to t-1, Return t-52 to t-5, Return t-156 to t-53, Turnover t-52 to t-1, Market to Book, Size, Amihud Illiqudity, Breadth of Ownership, Institutional Ownership, Number of Analysts, Average Short-Sale Duration, Average Lending Fee, Loaned Shares, P(return>5%), Volatility*. T-statistics are below the parameter estimates in parentheses and are based on Newey-West (1987) correction with eight lags (2 month). *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level. In Panel B, we estimate the economic magnitude of the base effect by multiplying the coefficient of Regression 5 with the standard deviation on *Closing*. In Panel C, we estimate how much this base effect is changed when the respective correlation measure changes by one standard deviation. We also compute how large this effect is as a fraction of the base effect.

Panel A: Regression Results

	Return				
	(1)	(2)	(3)	(4)	(5)
One-Year Correlation (Closing, SCGO I)* Closing (t-1)	-0.0086***				
	(-3.29)				
One-Year Correlation (Closing, SCGO II)* Closing (t-1)		-0.0069**			
		(-2.29)			
Two-Year Correlation (Closing, SCGO I)* Closing (t-1)			-0.0083**		
			(-2.54)		
Two-Year Correlation (Closing, SCGO II)* Closing (t-1)				-0.0114***	
				(-3.13)	
One-Year Correlation (Closing, SCGO I)	0.0016*				
	(1.81)				
One-Year Correlation (Closing, SCGO II)		0.0015			
		(1.57)			
Two-Year Correlation (Closing, SCGO I)			0.0023**		
			(2.09)		
Two-Year Correlation (Closing, SCGO II)				0.0033***	
				(2.64)	
Closing (t-1)	0.0013**	0.0013**	0.0009	0.0009	0.0018***
	(2.40)	(2.26)	(1.58)	(1.45)	(3.06)
Observations	621803	598500	504605	485682	763261
Average R^2	0.07	0.08	0.08	0.08	0.07
Controls	Yes	Yes	Yes	Yes	Yes
Fama-MacBeth	Yes	Yes	Yes	Yes	Yes

Panel B: Estimating the economic magnitude of the base effect (regression 5)

	Effect of Closing
	(1)
Standard deviation of *Closing*	0.202
Coefficient (from Regression 5 Panel A)	0.0018
Effect of 1 standard deviation on return (weekly)	0.036%
Effect of 1 standard deviation on return (annualized)	1.87%

Panel C: Estimating the economic magnitude of the interaction effect (regression 1-4)

	One-Year SCGO I	One-Year SCGO II	Two-Year SCGO I	Two-Year SCGO II
	(1)	(2)	(3)	(4)
Standard deviation of correlation	0.189	0.179	0.148	0.131
Coefficient (from Panel A)	-0.0086	-0.0069	-0.0083	-0.0114
Effect of 1 standard deviation on base effect	-0.163%	-0.124%	-0.123%	-0.149%
As a fraction of base effect	90%	69%	68%	83%
Effect of 1 st. dev. change in correlation on the 1 st. dev. effect of *Closing* on return (weekly)	0.033%	0.025%	0.025%	0.03%
Effect of 1 st. dev. change in correlation on the 1 st. dev. effect of *Closing* on return (annualized)	1.72%	1.31%	1.30%	1.58%

Table 5: Interactions

This table contains the results of weekly panel regressions that examine how different factors mediate the effect of *Short-Sale Capital Gains Overhang* (*SCGO*) on the closing of short-sale positions. The sample period runs from August 2004 to June 2010, excluding the period of the short-sale ban (September 15, 2008, to October 10, 2008). The explanatory variables of interest are *SCGO I* and *SCGO II* at the beginning of the week interacted with different variables. We use the following dummy variables as interactions: *Merger* is equal to 1 in the weeks between the announcement and completion of a merger (for either acquirers or targets). *Specialness* is equal to 1 if the value weighted average lending fee is above 100 basis points. *Small Firm* is equal to 1 if the firm is below the median of market capitalization in that week. *Illiquidity* is equal to 1 if the firm is above the median by *Amihud Illiquidity*. *Low Institutional Ownership* is equal to 1 if the firm is below the median in institutional ownership. All regressions include the following control variables that are omitted for brevity: *Return t-4 to t-1, Return t-52 to t-5, Return t-156 to t-53, Turnover t-52 to t-1, Market to Book, Size, Amihud Illiqudity, Breadth of Ownership, Institutional Ownership, Number of Analysts, Average Short-Sale Duration, Average Lending Fee, Loaned Shares, P(return>5%), Volatility*. Standard errors are two-way clustered at the firm and week levels. T-statistics are below the parameter estimates in parentheses. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Panel A: Interactions with Merger and Specialness

	Closing			
	(1)	(2)	(3)	(4)
Merger * SCGO I	-0.0258**			
	(-1.98)			
Merger * SCGO II		-0.0435***		
		(-3.49)		
Specialness * SCGO I			-0.0130	
			(-1.37)	
Specialness * SCGO II				-0.0118
				(-1.42)
SCGO I	0.0598***		0.0625***	
	(5.99)		(5.84)	
SCGO II		0.0335***		0.0343***
		(3.45)		(3.32)
Merger	0.0122***	0.0123***		
	(7.30)	(7.47)		
Specialness			-0.0008	0.0011
			(-0.30)	(0.42)
Observations	766333	734832	766333	734832
Adjusted R^2	0.21	0.21	0.21	0.21
Controls	Yes	Yes	Yes	Yes
Week and Firm Fixed Effects	Yes	Yes	Yes	Yes

Panel B: Interactions with Size, Illiquidity, and Institutional Ownership

	Closing					
	(1)	(2)	(3)	(4)	(5)	(6)
Small Firm * SCGO I	-0.0610***					
	(-7.17)					
Small Firm * SCGO II		-0.0501***				
		(-6.05)				
Illiquidity * SCGO I			-0.0814***			
			(-9.63)			
Illiquidity * SCGO II				-0.0718***		
				(-8.46)		
Low Institutional Ownership * SCGO I					-0.0631***	
					(-8.97)	
Low Institutional Ownership * SCGO II						-0.0577***
						(-8.30)
SCGO I	0.1001***		0.1120***		0.0928***	
	(8.85)		(10.08)		(8.97)	
SCGO II		0.0647***		0.0780***		0.0623***
		(6.11)		(7.40)		(6.18)
Small Firm	0.0006	0.0018				
	(0.28)	(0.85)				
Illiquidity			-0.0035	-0.0033		
			(-1.50)	(-1.42)		
Low Institutional Ownership					0.0000	-0.0011
					(0.01)	(-0.44)
Observations	766333	734832	766333	734832	766333	734832
Adjusted R^2	0.21	0.21	0.21	0.21	0.21	0.21
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Week and Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: Is short sellers' selling pattern V-shaped?

This table contains the results of weekly panel regressions that examine the effect of *Short-Sale Capital Gains Overhang* (*SCGO*) on the closing of short-sale positions from August 2004 to June 2010, excluding the period of the short-sale ban (September 15, 2008, to October 10, 2008). The dependent variable is *Closing* (percentage of loaned shares that are returned to lenders during the week). In regressions 1 to 4, the explanatory variables of interest are *SCGO (negative)* and *SCGO (positive)*. *SCGO (negative)* if equal to the minimum of *SCGO* and zero. *SCGO positive* is equal to the maximum between *SCGO* and zero. In regressions 5 and 6, the variable of interest is *Abs(SCGO)*, which is the absolute value of *SCGO*. Other variables are defined in Appendix 1. Standard errors are two-way clustered at the firm and week levels. T-statistics are below the parameter estimates in parenthesis. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

	Closing					
	(1)	(2)	(3)	(4)	(5)	(6)
SCGO I (negative)	0.2337***	0.1690***				
	(15.94)	(13.96)				
SCGO I (positive)	-0.1181***	-0.0302***				
	(-12.13)	(-2.99)				
SCGO II (negative)			0.1220***	0.0745***		
			(10.92)	(7.60)		
SCGO II (positive)			-0.0698***	-0.0201*		
			(-5.88)	(-1.84)		
Abs(SCGO I)					-0.0915***	
					(-13.15)	
Abs(SCGO II)						-0.0525***
						(-8.45)
Return t-4 to t	0.2739***	0.3069***	0.2601***	0.2522***	0.1787***	0.1863***
	(7.65)	(10.04)	(7.21)	(8.25)	(8.66)	(9.00)
Return t-52 to t-5	1.0426***	1.1485***	1.0848***	1.0841***	1.0452***	1.0801***
	(11.16)	(9.75)	(12.75)	(9.28)	(9.04)	(9.13)
Return t-156 to t-53	0.1580	0.5563***	0.2488*	0.5338***	0.5352***	0.5394***
	(1.16)	(3.46)	(1.80)	(3.31)	(3.33)	(3.30)
Turnover t-52 to t-1	-0.0667**	0.1211***	-0.0867***	0.1115***	0.1136***	0.1176***
	(-2.34)	(3.28)	(-3.00)	(3.00)	(3.07)	(3.09)
Market to Book		-0.0002		-0.0001	-0.0001	-0.0001
		(-0.45)		(-0.25)	(-0.14)	(-0.18)
Size		-0.0040		-0.0052*	-0.0082***	-0.0051*
		(-1.28)		(-1.74)	(-2.78)	(-1.71)
Amihud Illiqudity		0.0006***		0.0005***	0.0004***	0.0005***
		(4.41)		(3.87)	(3.30)	(3.49)
Breadth of Ownership		0.1385**		0.1681**	0.1788***	0.1620**
		(2.09)		(2.52)	(2.70)	(2.42)
Inst. Ownership		0.0319***		0.0308***	0.0305***	0.0259***
		(4.87)		(4.67)	(4.66)	(3.88)
Number of Analysts		-0.0064***		-0.0064***	-0.0064***	-0.0066***
		(-4.98)		(-4.91)	(-4.98)	(-5.09)
Average Short-Sale Duration		-0.0006***		-0.0006***	-0.0006***	-0.0006***
		(-34.40)		(-34.23)	(-34.18)	(-33.43)
Average Lending Fee		0.0035***		0.0034***	0.0036***	0.0038***
		(5.63)		(5.48)	(5.85)	(6.03)
Loaned Shares		-0.0058***		-0.0059***	-0.0058***	-0.0059***
		(-26.47)		(-26.71)	(-26.43)	(-26.84)
P (return>5%)		0.0351**		0.0245	0.0248	0.0247
		(2.05)		(1.44)	(1.46)	(1.42)
Volatility		0.0514		0.0631	0.0674	0.0684
		(0.84)		(1.02)	(1.10)	(1.08)
Observations	951656	766380	951656	766380	766333	734832
Adjusted R^2	0.18	0.21	0.17	0.21	0.21	0.21
Firm and Week F. E.	Yes	Yes	Yes	Yes	Yes	Yes

Table 7: Where is the hump-shaped pattern strongest?

This table contains the results of weekly panel regressions that examine how different factors mediate the effect of *Abs(SCGO)* on the closing of short-sale positions. The sample period runs from August 2004 to June 2010, excluding the period of the short-sale ban (September 15, 2008, to October 10, 2008). The explanatory variables of interest are *Abs*(*SCGO I)* and *Abs(SCGO II)* at the beginning of the week interacted with different variables. We use the following dummy variables as interactions: *Average Lending Fee* is the average lending fee weighted by loan value. *Specialness* is equal to 1 if the value weighted average lending fee is above 100 basis points. *Small Firm* is equal to 1 if the firm is below the median of market capitalization in that week. *Illiquidity* is equal to 1 if the firm is above the median by *Amihud Illiquidity*. *Low Institutional Ownership* is equal to 1 if the firm is below the median in institutional ownership. *High Effective Spread* is equal to 1 if the stock had above median average effective spread over the previous quarter. *High Realized Spread* is equal to 1 if the stock had above median average realized spread over the previous quarter. *High Price Impact* is equal to 1 if the stock had above median average price impact over the previous quarter. All regressions include the following control variables that are omitted for brevity: *Return t-4 to t-1, Return t-52 to t-5, Return t-156 to t-53, Turnover t-52 to t-1, Market to Book, Size, Amihud Illiqudity, Breadth of Ownership, Institutional Ownership, Number of Analysts, Average Short-Sale Duration, Average Lending Fee, Loaned Shares, P(return>5%), Volatility*. Standard errors are two-way clustered at the firm and week levels. T-statistics are below the parameter estimates in parentheses. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Panel A: Interactions with Lending Fee and Specialness

	Closing			
	(1)	(2)	(3)	(4)
Average Lending Fee * Abs(SCGO I)	0.0218***			
	(6.64)			
Average Lending Fee * Abs(SCGO II)		0.0057*		
		(1.95)		
Specialness * Abs(SCGO I)			0.0858***	
			(4.49)	
Specialness * Abs(SCGO II)				-0.0022
				(-0.13)
Abs(SCGO I)	-0.1583***		-0.1523***	
	(-9.99)		(-9.40)	
Abs(SCGO II)		-0.0678***		-0.0619***
		(-4.41)		(-3.97)
Average Lending Fee	-0.0044***	-0.0022***	-0.0004	-0.0004
	(-5.88)	(-3.10)	(-0.62)	(-0.60)
Specialness			-0.0169***	-0.0075**
			(-4.78)	(-2.08)
Observations	766355	734851	766355	734851
Adjusted R^2	0.11	0.11	0.11	0.11
Controls	Yes	Yes	Yes	Yes

Panel B: Interactions with Size, Illiquidity, and Institutional Ownership

	Closing					
	(1)	(2)	(3)	(4)	(5)	(6)
Small Firm * Abs(SCGO I)	-0.1320***					
	(-7.04)					
Small Firm * Abs(SCGO II)		-0.1255***				
		(-7.41)				
Illiquidity * Abs(SCGO I)			-0.1422***			
			(-8.52)			
Illiquidity * Abs(SCGO II)				-0.1230***		
				(-7.68)		
Low Institutional Ownership * Abs(SCGO I)					-0.1156***	
					(-7.76)	
Low Institutional Ownership * Abs(SCGO II)						-0.0925***
						(-6.39)
Abs(SCGO I)	-0.0463**		-0.0414**		-0.0725***	
	(-2.24)		(-2.23)		(-4.36)	
Abs(SCGO II)		0.0135		0.0117		-0.0171
		(0.66)		(0.60)		(-0.97)
Small Firm	0.0117***	0.0121***				
	(3.63)	(3.84)				
Illiquidity			-0.0010	-0.0021		
			(-0.28)	(-0.63)		
Low Institutional Ownership					0.0008	-0.0005
					(0.25)	(-0.16)
Observations	766355	734851	766355	734851	766355	734851
Adjusted R^2	0.11	0.11	0.11	0.11	0.11	0.11
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Panel C: Interactions with intra-day liquidity measures (averaged over the previous quarter)

	Closing					
	(1)	(2)	(3)	(4)	(5)	(6)
High Effective Spread * Abs(SCGO I)	-0.1589***					
	(-9.28)					
High Effective Spread * Abs(SCGO II)		-0.1482***				
		(-9.22)				
High Realized Spread * Abs(SCGO I)			-0.1294***			
			(-8.73)			
High Realized Spread * Abs(SCGO II)				-0.1184***		
				(-8.36)		
High Price Impact * Abs(SCGO I)					-0.1114***	
					(-6.71)	
High Price Impact * Abs(SCGO II)						-0.1098***
						(-7.06)
Abs(SCGO I)	-0.0346*		-0.0556***		-0.0595***	
	(-1.84)		(-3.14)		(-3.11)	
Abs(SCGO II)		0.0237		0.0044		0.0061
		(1.22)		(0.24)		(0.31)
High Price Impact	0.0123***	0.0123***				
	(4.04)	(4.07)				
High Realized Spread			0.0096***	0.0090***		
			(4.27)	(4.06)		
High Price Impact					-0.0016	-0.0013
					(-0.63)	(-0.52)
Observations	759391	728219	759391	728219	759391	728219
Adjusted R^2	0.11	0.11	0.11	0.11	0.11	0.11
Controls	Yes	Yes	Yes	Yes	Yes	Yes

Table 8: Robustness Check: Different Return Controls

This table contains robustness checks for Tables 2 to 6. In this robustness check, we replace the prior year return control with individual controls for each quarter. Panel A contains regressions from Tables 2, 5, and 6. Panel B contains regressions from Table 4. Variables are defined in Appendix 1. Fama-MacBeth (1983) regressions are at a weekly frequency and include a Newey-West (1987) correction at eight lags. In the OLS regressions, standard errors are two-way clustered at the firm and week levels. We report average R^2 for the Fama-MacBeth regression and adjusted R^2 for the OLS regressions. T-statistics are below the parameter estimates in parentheses. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Panel A: Short-Sale Capital Gains and Closing of Short Positions (robustness to Table 2, 5, and 6)

	Closing					
	(1)	(2)	(3)	(4)	(5)	(6)
Merger * SCGO I			-0.0240*			
			(-1.84)			
Specialness * SCGO I				-0.0152		
				(-1.59)		
SCGO I	0.0849***		0.0851***	0.0892***		
	(7.05)		(7.07)	(6.95)		
SCGO II		0.0429***				
		(3.95)				
Merger			0.0116***			
			(6.99)			
Specialness				-0.0006		
				(-0.21)		
Abs(SCGO I)					-0.0905***	
					(-12.97)	
Abs(SCGO II)						-0.0529***
						(-8.44)
Return t-4 to t-1	0.3828***	0.3011***	0.3773***	0.3856***	0.1978***	0.2059***
	(10.28)	(7.84)	(10.13)	(10.24)	(9.07)	(9.40)
Return t-12 to t-5	0.4254***	0.3371***	0.4181***	0.4260***	0.2844***	0.2930***
	(11.16)	(9.70)	(10.95)	(11.15)	(9.41)	(9.37)
Return t-26 to t-13	0.4588***	0.4149***	0.4540***	0.4581***	0.4074***	0.4197***
	(10.77)	(9.81)	(10.66)	(10.74)	(9.79)	(9.89)
Return t-39 to t-27	0.2798***	0.2812***	0.2781***	0.2785***	0.2756***	0.2832***
	(7.52)	(7.40)	(7.47)	(7.48)	(7.40)	(7.43)
Return t-52 to t-40	0.1864***	0.1914***	0.1843***	0.1858***	0.1837***	0.1924***
	(5.70)	(5.80)	(5.64)	(5.69)	(5.61)	(5.83)
Return t-156 to t-53	0.4524***	0.4796***	0.4375***	0.4537***	0.4838***	0.4863***
	(2.85)	(2.98)	(2.76)	(2.86)	(3.05)	(3.02)
Turnover t-52 to t-1	0.1100***	0.1152***	0.1116***	0.1102***	0.1165***	0.1198***
	(2.94)	(3.00)	(2.99)	(2.95)	(3.13)	(3.14)
Loaned Shares	-0.0060***	-0.0060***	-0.0060***	-0.0060***	-0.0058***	-0.0060***
	(-27.19)	(-27.05)	(-27.08)	(-27.13)	(-26.49)	(-26.92)
Market to Book	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	(0.52)	(0.40)	(0.44)	(0.54)	(0.60)	(0.54)
Size	-0.0070**	-0.0073**	-0.0068**	-0.0070**	-0.0123***	-0.0094***
	(-2.24)	(-2.29)	(-2.18)	(-2.24)	(-3.94)	(-2.94)
Amihud Illiqudity	0.0004***	0.0003**	0.0004***	0.0004***	0.0003**	0.0003**
	(2.69)	(2.44)	(2.82)	(2.69)	(2.00)	(2.14)
Breadth of Ownership	0.2017***	0.2045***	0.1980***	0.2008***	0.2299***	0.2139***
	(2.96)	(2.98)	(2.90)	(2.95)	(3.39)	(3.12)
Inst. Ownership	0.0310***	0.0258***	0.0303***	0.0309***	0.0302***	0.0255***
	(4.71)	(3.87)	(4.60)	(4.72)	(4.61)	(3.84)
Number of Analysts	-0.0060***	-0.0064***	-0.0054***	-0.0060***	-0.0062***	-0.0064***
	(-4.65)	(-4.88)	(-4.26)	(-4.66)	(-4.82)	(-4.91)
Average Short-Sale Duration	-0.0006***	-0.0006***	-0.0006***	-0.0006***	-0.0006***	-0.0006***
	(-34.57)	(-33.45)	(-34.55)	(-34.53)	(-34.28)	(-33.53)
Average Lending Fee	0.0031***	0.0037***	0.0031***	0.0032***	0.0035***	0.0037***
	(4.96)	(5.86)	(4.97)	(5.27)	(5.74)	(5.90)
P (return>5%)	-0.0062	-0.0083	-0.0026	-0.0062	-0.0001	-0.0013
	(-0.37)	(-0.48)	(-0.15)	(-0.37)	(-0.01)	(-0.07)
Volatility	0.0377	0.0815	0.0268	0.0377	0.0910	0.0946
	(0.61)	(1.28)	(0.43)	(0.61)	(1.47)	(1.48)
Observations	766218	734832	766218	766218	766218	734832
Adjusted R^2	0.21	0.21	0.21	0.21	0.21	0.21
Firm and Week F.E.	Yes	Yes	Yes	Yes		

Panel A: Short-Sale Capital Gains and returns (robustness to Table 4)

	Return			
	(1)	(2)	(3)	(4)
One-Year Correlation (Closing, SCGO I)* Closing (t-1)	-0.0082***			
	(-3.18)			
One-Year Correlation (Closing, SCGO II)* Closing (t-1)		-0.0065**		
		(-2.26)		
Two-Year Correlation (Closing, SCGO I)* Closing (t-1)			-0.0075**	
			(-2.26)	
Two-Year Correlation (Closing, SCGO II)* Closing (t-1)				-0.0105***
				(-2.90)
One-Year Correlation (Closing, SCGO I)	0.0014			
	(1.56)			
One-Year Correlation (Closing, SCGO II)		0.0013		
		(1.49)		
Two-Year Correlation (Closing, SCGO I)			0.0019*	
			(1.66)	
Two-Year Correlation (Closing, SCGO II)				0.0029**
				(2.29)
Closing (t-1)	0.0014**	0.0013**	0.0010*	0.0009
	(2.55)	(2.33)	(1.70)	(1.51)
Return t-4 to t-1	-0.0544***	-0.0527***	-0.0549***	-0.0535***
	(-4.33)	(-4.25)	(-4.04)	(-3.98)
Return t-12 to t-5	-0.0045	-0.0044	-0.0077	-0.0072
	(-0.26)	(-0.25)	(-0.38)	(-0.36)
Return t-26 to t-13	0.0253	0.0233	0.0147	0.0129
	(1.19)	(1.06)	(0.59)	(0.50)
Return t-39 to t-27	0.0016	-0.0014	-0.0020	-0.0040
	(0.08)	(-0.07)	(-0.09)	(-0.18)
Return t-52 to t-40	-0.0035	-0.0023	-0.0164	-0.0159
	(-0.23)	(-0.14)	(-0.99)	(-0.92)
Return t-156 to t-53	0.0480	0.0473	0.0489	0.0482
	(1.00)	(0.95)	(0.84)	(0.81)
Turnover t-52 to t-1	0.0061	0.0065	-0.0018	-0.0014
	(0.67)	(0.71)	(-0.17)	(-0.13)
Loaned Shares	-0.0000	0.0000	0.0001	0.0001
	(-0.00)	(0.27)	(0.79)	(1.10)
Market to Book	-0.0003	-0.0003	-0.0006	-0.0006
	(-0.88)	(-0.89)	(-1.54)	(-1.60)
Size	-0.0000	-0.0000*	-0.0001**	-0.0001**
	(-1.65)	(-1.74)	(-2.09)	(-2.15)
Amihud Illiqudity	-0.0024	-0.0026	0.0001	-0.0001
	(-0.59)	(-0.65)	(0.02)	(-0.02)
Breadth of Ownership	0.0014	0.0009	0.0010	0.0003
	(0.95)	(0.63)	(0.59)	(0.17)
Inst. Ownership	-0.0004*	-0.0005**	-0.0006**	-0.0006**
	(-1.94)	(-1.99)	(-2.15)	(-2.14)
Number of Analysts	-0.0000	-0.0000	-0.0000	-0.0000
	(-0.52)	(-0.48)	(-0.98)	(-1.01)
Average Short-Sale Duration	-0.0004***	-0.0005***	-0.0004***	-0.0004***
	(-4.23)	(-4.58)	(-4.47)	(-4.80)
Average Lending Fee	-0.0001	-0.0001	-0.0001	-0.0001
	(-1.38)	(-1.43)	(-1.53)	(-1.61)
P (return>5%)	0.0050	0.0056	0.0050	0.0054
	(0.79)	(0.85)	(0.69)	(0.74)
Volatility	-0.0393*	-0.0407*	-0.0757***	-0.0754***
	(-1.81)	(-1.80)	(-3.31)	(-3.14)
Observations	621705	598500	504527	485682
Average R^2	0.08	0.08	0.09	0.09
Fama-MacBeth	Yes	Yes	Yes	Yes

Appendix 1: Variable Definitions

This table displays the variable definitions for all variables used in the regressions. All variables are stock-level variables on a weekly basis, unless explicitly stated differently. Stock and date indices are omitted for better readability. All continuous variables are winsorized at the 1% threshold.

Variable Name	Definition
Size	*Log (market capitalization) [at the beginning of the quarter]*
Market to Book	$\frac{Market\ capitalization}{Book\ value\ of\ equity}$ *[at the beginning of the fiscal year, from Compustat]*
Breadth of Ownership	$\frac{Number\ of\ institutions\ holding\ the\ stock}{Total\ number\ of\ reporting\ institutions}$ *[at the beginning of the year, from Thomson Reuters 13F filings]*
Institutional Ownership	*Percentage of shares held by institutions at the beginning of the year [from Thomson Reuters 13F filings]*
Number of Analysts	*Log (1+ number of analysts on IBES making an earnings forecasts for the stock at the beginning of the quarter). This variable is set to zero if the company is not covered in IBES.*
Amihud Illiquidity	*Amihud Illiquidity is a percentage rank at the beginning of the quarter, where companies are ranked by Amihud illiquidity defined as:* $Amihud\ Illiqudity = mean_{over\ quarter}\left(\frac{\lvert ret_{daily}\rvert}{dollar\ volume_{daily}}\right)$*. Companies with the highest Amihud illiquidity are assigned a value of 100, companies with the lowest Amihud illiquidity are assigned a value of 0.*
Turnover t-52 to t-1	$Mean_{t-52\ to\ t-1}\left(\frac{Volume}{Shares\ outstanding}\right)$ *[in weeks, from CRSP]*
Return t-k to t-j	$Mean_{t-k\ to\ t-j}(Total\ Return)$ *[in weeks, from CRSP]*
Loaned Shares	$\frac{Number\ of\ shares\ on\ loan\ (at\ the\ beginning\ of\ the\ week\ )}{Shares\ outstanding}$ *[using Markit variable "Total Balance Quantity"]*
P (return>5%)	*Fraction of days in the prior quarter where the stock experience a return larger than 5 percent.*
Volatility	*Standard deviation of the stock's daily returns over the prior quarter.*
Shorting as fraction of shares outstanding	$\frac{Shares\ newly\ borrowed\ during\ the\ week}{Shares\ outstanding}$ *[Number of shares borrowed is computed in the following way from Markit data:* $Shares\ newly\ borrowed\ during\ the\ week = \frac{Balance\ Value\ 7\ day}{Total\ Balance\ Value} * Total\ Balance\ Quantity$*]*
Shares Returned	$Shares\ newly\ borrowed\ _t - Loaned\ Shares_t + Loaned\ Shares_{t-1}$ *[this variable is set to zero if it is negative]*
Closing	$\frac{Shares\ Returned_t}{Shares\ on\ loan_{t-1}}$
Average Short-Sale Duration	*Weighted average duration of securities lending transactions measured in days, weighted by loan volume. ["SL tenure" variable from Markit]*
Average Lending Fee	*Average lending fee, weighted by loan value. ["Value Weighted Average Fee" from Markit]*
Short-Sale Capital Gains Overhang I (SCGO I)	$\frac{Reference\ Price - Price}{Reference\ Price}$*, where the Reference Price is computed recursively as:* $Reference\ price_t = \frac{Shorting_t}{Loaned\ Shares_t} * Price_t + \left(1 - \frac{Shorting_t}{Loaned\ Shares_t}\right) * Reference\ Price_{t-1}$
Short-Sale Capital Gains Overhang II (SCGO II)	$\frac{Reference\ Price\ (alternative) - Price}{Reference\ Price\ (alternative)}$*, where the Reference Price is computed as:* $Reference\ Price\ (alternative)_\tau = S_{\tau-1} * P_{\tau-1} + S_{\tau-3,\tau-2} * P_{\tau-2} + S_{\tau-7,\tau-4} * P_{\tau-4} + S_{\tau-30,\tau-8} * P_{\tau-8} + S_{\tau-\infty,\tau-31} * P_{\tau-31}$ *where* P_τ *is the price at date* τ *and* $S_{\tau,s}$ *is the fraction of shares that were borrowed between dates* τ *and s [computed using Markit data as follows:* $S_{\tau-1} = \frac{Balance\ Value\ 1\ day}{Total\ Balance\ Value}$*;* $S_{\tau-3,t-2} = \frac{Balance\ Value\ 3\ day - Balance\ Value\ 1\ day}{Total\ Balance\ Value}$*, etc.].*
Long Capital Gains Overhang (LCGO)	$\frac{\text{Price} - \text{Reference Price}}{\text{Reference Price}}$, where the reference price is defined recursively as: $\text{Reference price}_t = \frac{\text{Trading volume}_t}{\text{Shares Outstanding}_t} * \text{Price}_t + \left(1 - \frac{\text{Trading volume}_t}{\text{Shares Outstanding}_t}\right) * \text{Reference Price}_{t-1}$
Merger	*Dummy variable equal to 1 in the weeks between the announcement and completion of a merger (for either acquirers or targets) [data on mergers comes from SDC Platinum]*
Specialness	*Dummy variable equal to 1 if Average Lending Fee is above 100 basis points*
Small Firm	*Dummy variable equal to 1 if Size is below the sample median in that week.*
Illiquidity	*Dummy variable equal to 1 if Amihud Illiquidity is above the sample median in that week.*
Low Institutional Ownership	*Dummy variable equal to 1 if Institutional Ownership is below the sample median in that week.*

Variable Name	Definition
One-Year Correlation (Closing, SCGO I)	*Rolling correlation between Closing and SCGO I over the past year.*
One-Year Correlation (Closing, SCGO II)	*Rolling correlation between Closing and SCGO II over the past year.*
Two-Year Correlation (Closing, SCGO I)	*Rolling correlation between Closing and SCGO I over the past two years.*
Two-Year Correlation (Closing, SCGO II)	*Rolling correlation between Closing and SCGO I over the past two years.*
Active Utilization	*Shares on Loan / Active Lendable Shares*
P(return<-5%)	Fraction of daily returns in the prior quarter for that stock that are above 5%
Volatility	*Standard deviation of the stock's daily returns over the prior quarter.*
Skewness	*Skewness of the stock's daily returns over the prior quarter.*
SCGO I (negative)	$Min(SCGO\ I, 0)$
SCGO I (positive)	$Max(SCGO\ I, 0)$
SCGO II (negative)	$Min(SCGO\ II, 0)$
SCGO II (positive)	$Max(SCGO\ II, 0)$
Abs(SCGO I)	*Absolute value of SCGO I*
Abs(SCGO II)	*Absolute value of SCGO II*
High Effective Spread	*Dummy variable equal to 1 if the average effective spread over the prior quarter is above the sample median. Effective spread is the dollar-weighted percent effective spread taken from WRDS Intraday Indicator Database.*
High Realized Spread	*Dummy variable equal to 1 if the average realized spread over the prior quarter is above the sample median. Realized spread is the dollar-weighted percent realized spread taken from WRDS Intraday Indicator Database.*
High Price Impact	*Dummy variable equal to 1 if the average price impact over the prior quarter is above the sample median. Price impact is the dollar-weighted percent price impact taken from WRDS Intraday Indicator Database.*