Loss of capital and liquidity:
The role of short sales in return reversals

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Abstract

Short term reversal increases in short interest for winners. The effects of short interest are much larger for losers, with reversal decreasing in short interest. Insofar as short interest indicates the proportion of capital dedicated to short and long positions, these results are consistent with a higher price for liquidity as reflected in larger reversals when investors experience margin calls or capital constraints from unprofitable positions. These results are also consistent with improved liquidity from the presence of short sellers whenever investors with long positions have liquidity demands stemming from losses. Controlling for short interest, reversal is increasing in institutional ownership for losers, suggesting a possible source for additional liquidity risk.

1. Introduction

Long Term Capital Management (LTCM) was subject to margin calls stemming from declines in the value of convertible arbitrage positions. The unwinding of LTCM's trading positions to meet margin requirements led to further declines in the value of convertible arbitrage trades, which eventually reversed once demand for liquidity subsided.[1] Brunnermeier and Pedersen (2009) argue that capital can deteriorate because of an adverse change in security prices. Capital losses reduce capital available for providing liquidity and drive up the cost of liquidity. When trading is necessary to provide liquidity and meet capital requirements, price concessions are often required. Price concessions required by liquidity providers create a wedge between transaction prices and fundamental value, as noted by Grossman and Miller (1988). Once demand for liquidity subsides, the wedge between transaction prices and fundamental value disappears, resulting in return reversals that compensate those who provide liquidity.

Return reversals reflect a certain aspect of liquidity, as the price of liquidity depends on the dynamic interplay between liquidity suppliers' and demanders' capital conditions.[2] Consistent with return reversals reflecting a price for liquidity that fluctuates with market turmoil and tighter funding constraints, as predicted by Brunnermeier and Pedersen (2009), Nagel (2012) finds that reversal profits increase in market volatility. Hameed et al. (2010) show that reversals are greater after market declines when investors' overall capital weakens. Hameed and Mian (2012) find that reversals are mainly limited to stocks with large order imbalances and are related

[1] See Jorion (2000) regarding the margin calls of LTCM and its prime broker, Bear Stearns. See Mitchell, Pedersen, and Pulvino (2007), especially their Figure 3, regarding the reversal in the value of convertible bond arbitrage positions after the collapse of LTCM.

[2] For evidence on reversals as the cost of liquidity provision, see Grossman and Miller (1988), Campbell, Grossman, and Wang (1993), Wang (1994), Chacko, Jurek, and Stafford (2008), Vayanos and Wang (2009, 2011), Avramov, Chordia, and Goyal (2006), Hendershott and Seasholes (2014), and Hendershott and Seasholes (2007).

to non-informational shocks, indicating that return reversals are shocks in the market for liquidity.

Related to the above example of LTCM, we try to identify a set of stocks that are more likely to be margin constrained or capital constrained, and we ask whether capital constraints help explain cross-sectional variation in returns to providing liquidity. We specifically examine whether adverse price changes, which weaken liquidity providers' capital and their liquidity provision capacity, lead to a greater price for liquidity as reflected in short-term stock return reversals. We use the magnitude of return reversals to measure the cost of liquidity provision, per Grossman and Miller (1988). In order to capture the extent to which liquidity providers' capital allocated to a long or short position for a particular stock deteriorates, we use direction of price changes and pre-existing levels of short interest.

Short interest levels serve as a proxy for the relative amount of capital dedicated to short positions versus long positions. Capital dedicated to a short position in a stock will strengthen when prices decline; whereas capital dedicated to long positions will strengthen when prices increase. In contrast, capital dedicated to a long position in a stock deteriorates when prices decline, and investors shorting a stock may receive margin calls when prices increase. We hypothesize that short-term return reversals will be stronger after a negative price shock for stocks with no short interest and after a positive price shock for stocks with high short interest, due to weakened capital resulting from adverse valuation changes.

We define groups of stocks that are likely to be margin constrained based on the magnitude of capital loss for long or short positions due to adverse price changes. Over the 1988 to 2010 sample, we find that return reversals are significantly greater for stocks that are more

likely to be margin constrained. Our portfolio results show that weekly market adjusted excess return for stocks that experience high past returns with high short interest is -12 basis points (t-statistic is -2.49) and 28 basis points (t-statistic is 7.39) for stocks that experience low past returns with low short interest. We do not find significant reversals for stocks that experience positive price shocks without short positions or for stocks that experience negative price shocks with high levels of short interest. We also create zero-cost reversal portfolios among stocks that are classified as margin constrained or unconstrained. Our method maintains identical past return and short interest characteristics for these two portfolios. The margin constrained portfolio has an average weekly reversal return of 44 basis points (t-statistic is 8.13), and the unconstrained portfolio has a reversal return of 18 basis points (t-statistic is 2.72), a difference in reversal magnitudes of 26 basis points (t-statistic is 3.65).

When we group stocks based on short interest into ten portfolios instead of two and keep only top and bottom deciles for short interest levels, we find even greater reversals for margin constrained stocks. The margin constrained portfolio has an average weekly reversal return of 63 basis points (t-statistic is 6.25), and the unconstrained portfolio has a reversal return of 18 basis points (t-statistic is 1.64), a difference in reversal magnitudes of 49 basis points (t-statistic is 3.23).

We find that the larger reversals for margin constrained portfolios persist within high and low values for market capitalization, institutional ownership, and trading volume. We also consider a multivariate Fama-MacBeth regression that uses all of the data to control for these three characteristics simultaneously. Consistent with the capital weakening hypothesis, we find that higher short interest levels increase reversal for past week winners, and lower short interest levels increase reversal for past week losers. We find that the effect of capital constraints on

liquidity appears to be more important for long positions, as the effect of short interest on return reversal is much stronger for past losers than for past winners. A one standard deviation decrease in short interest for past losers increases reversals by about 70% relative to the average reversal in our sample; whereas a one standard deviation increase in short interest for past winners increases reversals by 20% relative to the average reversal.

The importance of short interest levels for return reversal implies that capital constrained investors bear significant costs from price concessions when demanding liquidity. Our paper provides a nuanced perspective to the question of whether short sellers improve liquidity and price efficiency. The presence of short sales, as seen by higher short interest levels, can significantly reduce liquidity risks for investors maintaining a long position in a stock. On the other hand we find that the liquidity cost imposed by short positions in the case of a positive price shock is rather small. Therefore, we provide evidence that the presence of short sellers can improve liquidity and efficiency.

A number of studies, such as Hameed et al. (2010), Nagel (2012), and Rosch and Kaserer (2014), examine the relationship between funding liquidity tightness and market-wide liquidity. While one might argue that intermediaries could diversify by providing liquidity for numerous stocks, extant literature provides evidence that the way immediacy demands are accommodated might be decided on individual stock basis. Naik and Yadav (2003) find that dealers' pricing behavior is better explained by inventory positions in individual stocks than by the overall position of the dealer firm. Therefore, Naik and Yadav (2003) conclude that dealer firms operate like a decentralized market maker. Moreover, Brunnermeier and Pedersen (2009) cite several reasons, in their Appendix A.1, why it could be beneficial to use position-by-position margins, as

opposed to jointly financing a portfolio[3]. As a result, it appears that adverse price movements weakening speculators' capital may impact the cost of supplying liquidity at the level of the individual security.

To our knowledge we are the first to show the positive effect of short interest levels, as a proxy for the relative amount of capital dedicated to short positions, on the cost of liquidity provision for a long time period. Earlier studies on short selling mainly focus on the informational content of short sales for future returns or price efficiency. For example, Boehmer and Wu (2013), Bris, Goetzman, and Zhu (2007), and Saffi and Sigurdsson (2011) demonstrate that short sales make prices more efficient. Boehmer, Jones, and Zhang (2013) and Beber and Pagano (2013) find that shorting bans lead to a decline in stock liquidity measures such as effective spreads, price impact, or intra-day volatility. We extend the literature by documenting that existing short positions reduce the cost of liquidity provision for immediacy demands, with general implications outside specific regulatory events. Benefits to demanding liquidity supplied by short sellers tend to be greatest after negative price shocks, in which the capital position of short sellers' improves.

In our full regression model we also find greater return reversals for past week losers that have more institutional ownership. This result is the second largest in economic magnitude, with the largest being greater reversals for past week losers having lower short interest. We consider institutional ownership as a control variable because Nagel (2005) uses institutional ownership as a proxy for short sale constraints, and he finds that a number of cross-sectional characteristics have a more pronounced relation to returns when institutional ownership is low. Combined with

[3] The following article on WSJ highlights the significance of capital constraints at the individual stock level regarding intermediaries' immediacy demands after a positive price shock for highly shorted Tesla Motors. http://blogs.wsj.com/moneybeat/2013/05/14/tesla-no-joyride-for-short-sellers/

the evidence in Nagel (2005), our paper provides a nuanced perspective to the question of whether institutions improve liquidity and price efficiency. While institutional ownership may reduce short sale constraints and improve efficiency, as found in Nagel (2005), large institutional ownership may also pose a liquidity risk. If most institutions are getting out of a long position at the same time, there may be few market participants that can supply the amount of liquidity being demanded. The results are also consistent with those in Barber, Odean, and Zhu (2009) and Kaniel, Saar, and Titman (2008) who posit that individuals meet institutional demand for immediacy. In this regard, the relation between institutional ownership and return reversal is consistent with the relation between short interest and return reversal. Trading positions that are highly correlated across multiple market participants can present a liquidity risk.

The rest of the paper proceeds as follows. In Section 2, we empirically test the hypothesis regarding the importance of margin constraints for return reversal using short interest levels and past returns. Section 3 examines the robustness of results in a multivariate setting. Section 4 concludes the paper.

2. The Importance of Capital Constraints for Return Reversals using Short Interest and Past Returns

Because trading volume is an important control variable in our regressions, we include only common stocks (CRSP share codes 10 and 11) listed on the NYSE and the Amex.[4] To be included, stocks must also have a market price exceeding $5 per share at the end of the formation period, which would exclude penny stocks. We skip a day between the formation and holding periods. Using a skipped day between formation and holding periods and requiring a $5 price

[4] Variables containing trade volume are not comparable to Nasdaq stocks. Since Nasdaq trades often go through dealers, trades are double counted. For more information related to interpreting volume as reported by Nasdaq, see Atkins and Dyl (1997).

cut-off mitigates the influence of microstructure effects, such as bid-ask bounce, as documented in Kaul and Nimalendran (1990) and Conrad, Gultekin, and Kaul (1997). All returns include a stock's delisting return by selecting the Default Missing option for delisting returns in CRSP Sift. Our sample period is between 1988 and 2010, which is when short interest data is available. We use weekly returns, since we find in untabulated results that most return reversal occurs within the first week of the holding period regardless of the length of the formation period.

2.1. Which Stocks are Likely to be Margin Constrained?

Figure 1 illustrates the logic of our empirical strategy. We attempt to identify a zero-cost portfolio of stocks likely to be margin constrained and another zero-cost portfolio of stocks unlikely to be margin constrained. In order to determine weakening of capital for an individual stock, we consider capital allocated to short and long positions combined. We use short interest levels as a proxy for the relative amount of capital dedicated to short and long positions. If short interest for a stock is zero, there would be no capital allocated to short positions, and all capital would be allocated to long positions. The relative amount of capital committed to a short position on a stock would be increasing in short interest. We recognize that while establishing a short position requires setting up a margin account, not all long positions need to be established on margin. Although stocks with low short interest levels may not in fact be bought on margin, low short interest indicates a larger proportion of capital allocated to long positions in a stock, assuming an equal percentage of long positions are established on margin across stocks.

Stocks likely to be margin constrained will be stocks for which investors experience losses on their positions leading to deterioration of their capital. For investors buying on margin, stocks with lower returns are more likely to be margin constrained. For investors short selling,

stocks with higher returns are more likely to be margin constrained. Therefore, the margin constrained portfolio consists of stocks with both low short interest levels and low past returns and stocks with both high short interest levels and high past returns. For all other stocks, margin calls or margin constraints are less likely.

2.2. Differences in Short Interest Levels and Formation Week Returns between the Margin Constrained Portfolio and the Unconstrained Portfolio

In Table 1, we show descriptive statistics of the prior month's short interest and the prior week's absolute return for the margin constrained portfolio and the unconstrained portfolio. Because of the way the portfolios are constructed, we expect similar short interest and past week return characteristics. In Panel A, we verify that the two portfolios have almost identical short interest in the prior month and absolute returns in the prior week. For each portfolio, the panel shows time series means and standard deviations of cross-sectional statistics (mean, standard deviation, skewness, and kurtosis) for prior month short interest and prior week absolute returns. Based only on the extremity of past week returns, as measured by the prior week's absolute return, we would not expect a significant difference in the return reversal of the two portfolios. Therefore, our method of portfolio formation is biased toward finding no significant differences in return reversal between the margin constrained portfolio and the unconstrained portfolio.

2.3. Reversal Portfolio Returns for the Margin Constrained Portfolio and the Unconstrained Portfolio

In Panel B of Table 1, we test whether there is a significant difference in next week's return reversal between the margin constrained and unconstrained portfolios. We follow Lehmann (1990) and Nagel (2012) in forming return reversal portfolios.

In particular, the return on any portfolio, $r_{p,t}$, is

$$r_{p,t} = \sum_{i=1}^{N} \left[-\left(\frac{1}{2} \sum_{i=1}^{N} \left| r_{i,t-1} - r_{ew,t-1} \right| \right)^{-1} \left(r_{i,t-1} - r_{ew,t-1} \right) \right] r_{i,t} \ ,$$

where $r_{ew,t-1} \equiv \frac{1}{N} \sum_{i=1}^{N} r_{i,t-1}$ is the return on an equal weighted portfolio of the stocks considered. Enclosed in brackets are the portfolio weights. From Panel B, we find that the margin constrained portfolio in the top row has a reversal more than twice as large as the reversal on the unconstrained portfolio. The average difference of 26 basis points per week (t-statistic is 3.65) is statistically significant at conventional levels. The reversal return difference in Panel B is consistent with a larger demand for liquidity in margin constrained portfolios brought about by adverse price changes, which eventually subsides once liquidity is supplied. Because reversal also exists in the unconstrained portfolio, margin constraints, as defined by the interaction of short interest levels and formation week returns, may not entirely explain the liquidity dynamics observed in return reversal.

2.3. Varying the Level of Short Interest

By placing all stocks into only two groups based on short interest and past week returns, the division between margin constrained stocks and unconstrained stocks is coarse. Holding the level of the prior week's return constant, margin constraints should be more likely for more extreme short interest levels. Since it is well documented that more extreme formation week returns produce larger reversals, we focus on the effect of varying the level of short interest. In Table 2, we increase the number of short interest groups that stocks can be placed into. Instead

of only two ranks for short interest, we increase the number of ranks to ten by increments of two. We still maintain only a high and low group for the prior week's return.

The first column in Panel A of Table 2 is identical to Panel B of Table 1. The remaining columns show results for increasing the number of short interest groups and keeping only the stocks that fall into the groups with the highest and lowest short interest levels. , Reversals increase for the margin constrained portfolio as the number of short interest groups increases, as shown in the top row of Panel A. With two short interest groups, the margin constrained portfolio has a reversal return of 44 basis points per week (t-statistic is 8.13). Increasing to ten short interest groups increases the reversal on the margin constrained portfolio to 63 basis points per week (t-statistics is 6.25).

Increasing the number of short interest rankings has less of an effect on the reversal of the unconstrained portfolio. With two short interest groups, the unconstrained portfolio has a reversal return of 18 basis points per week (t-statistic is 2.72). Increasing to ten short interest groups decreases the reversal on the unconstrained portfolio to 16 basis points per week (t-statistic is 1.41). Examining groups of stocks with a greater difference in the proportion of capital allocated to short and long positions, by increasing the number of short interest groups from two to ten, increases the difference in weekly reversal returns between the margin constrained and unconstrained portfolios by more than 20 basis points per week. The difference in weekly reversal between the margin constrained and unconstrained portfolios increases from 26 basis points per week (t-statistic is 3.65) with two short interest rankings to 47 basis points per week (t-statistic is 2.9) with ten short interest rankings.

One concern with increasing the number of short interest groups could be that short interest and past return characteristics may become very different between the margin constrained and unconstrained portfolios. If the range of returns for the formation week becomes larger for the margin constrained portfolio after using more short interest groups, then larger reversal differences are expected. To assuage these concerns we present time series averages of cross-sectional descriptive statistics for the margin constrained and unconstrained portfolios in Panel B of Table 2. The first row in Panel B of Table 2 is identical to the first row in Panel A of Table 1. As the number of short interest groups increases, moving down the rows in Panel B of Table 1, there is little difference in either the prior month's short interest or in the prior week's absolute returns between the margin constrained and unconstrained stocks. Therefore, we cannot conclude that the larger reversal return differences between margin constrained and unconstrained portfolios can be attributed to either different short interest levels or more extreme formation week returns for one of the two portfolios.

The effect of varying the level of short interest can also be viewed in comparing Panels A and B of Figure 2. We build 16 equal-weighted portfolios from two-way sorts on short interest and past returns. We present market adjusted returns in the formation week and the holding week. Panel A shows that formation week returns are similar across different levels of short interest. In viewing Panel B, past week losers experience the most reversal for the lowest level of short interest, and past week winners have the most reversal for the highest level of short interest. A concern that comes from viewing Figure 2 is that we may be detecting lower returns to stocks with higher short interest, rather than larger reversal stemming from capital constraints. In the next section, we use multivariate regressions to control for the effect of short interest on returns that is unrelated to return reversal.

3. Alternative Explanations and Multivariate Tests

3.1 Portfolios from Two-way Sorts on Characteristics and Past Returns

The previous section helps to establish that loss of capital can impact return reversals. As margin calls become more eminent, it becomes more likely that liquidity is demanded through trading. The resulting price pressure eventually subsides as liquidity is supplied, resulting in a return reversal. There may be concerns that a number of variables are related to either return reversals or short interest, one of the main variables used to define stocks that are likely to be margin constrained due to deterioration of capital after adverse price movements. As such, the influence of these other variables may confound such an interpretation and render it premature.

We consider three control variables, all of which may be related to either short interest levels or short sale constraints and two of which have been found to be related to return reversals. In Table 3 we repeat the analysis conducted in Panel A of Table 2, substituting each control variable for the level of short interest. In Panel A of Table 3, we form portfolios based on size and prior week returns. We use the market capitalization at the beginning of the prior week for firm size, since Lehmann (1990) and Conrad, Hameed, and Niden (1994) find that reversal is greater among small firms. Also, short sale constraints are likely to be greater for small firms, as Gompers and Metrick (2001) and Nagel (2005) find that smaller firms have less institutional ownership, a plausible measure of short sale constraints. Reversal differences between portfolios formed on size and past returns are never significantly different. Therefore, it appears unlikely that the relation between short interest and return reversals can be attributed to size.

In Panel B of Table 3, we form portfolios based on institutional ownership and prior week returns. Institutional ownership is measured at the end of the previous quarter. Nagel (2005) uses institutional ownership as a proxy for short sale constraints. When institutional ownership tends to be low, the stock loan supply is smaller and short selling is more expensive and less frequent. Nagel (2005) also finds that a number of cross-sectional characteristics have a more pronounced relation to returns when institutional ownership is low. There is some evidence that institutional trading may be related to return reversal; however, most studies consider changes in institutional ownership or institutional trades rather than the level of institutional ownership considered here.[5] In order to find out whether we obtained the previous results only because short interest is positively correlated with institutional ownership, we replace the short interest variable with institutional ownership in our analysis. Reversal differences between portfolios formed on institutional ownership and past returns are statistically significant with two institutional ownership groups but not with more institutional ownership groups. Moreover, the sign of the reversal return difference between the two portfolios based on institutional ownership is the opposite of portfolios formed on short interest. Overall, it seems unlikely that the relation between short interest and return reversals can be attributed to institutional ownership.

In Panel C of Table 3, we form portfolios based on volume and prior week returns. As in Cooper (1999) and Avramov, Chordia, and Goyal (2006), volume is defined as turnover, which is the number of shares traded divided by the number of shares outstanding. Specifically, we use formation week turnover for the volume level, which Avramov, Chordia, and Goyal (2006) find

[5] See Griffin, Harris, and Topaloglu (2003), Sias, Starks, and Titman (2006), Coval and Stafford (2007), Kaniel, Saar, and Titman (2008), Barber, Odean, and Zhu (2008), Campbell, Ramadorai, and Schwartz (2009), and Jylha, Rinne, and Suominen (2013).

is positively related to next week's reversal. Also, short-sale constraints are likely to be greater for low volume firms, as Gompers and Metrick (2001) and Nagel (2005) find that stocks with less trading volume have less institutional ownership, a plausible measure of short sale constraints. From Panel C, volume appears to have a large impact on return reversal, consistent with Avramov, Chordia, and Goyal (2006). The high volume/high past return and low volume/low past return portfolio experiences return momentum in the next week, as seen by the negative but insignificant returns for the portfolios in the top row. The other portfolio experiences reversal, resulting in a statistically significant difference in the reversal of the two portfolios. However, the reversal difference has the opposite sign compared to the reversal difference when short interest is used. Considering that volume and short interest are positively correlated, as we later show in the paper, the strong relation between volume and reversal will not be of concern for the conclusion of our results.

3.2 Portfolios from Three-way Sorts on Characteristics, Short Interest, and Past Returns

We now consider whether the larger reversals for margin constrained portfolios only exist among a subset of stocks. It is possible that margin constraints only result in reversal for more thinly traded stocks, such as smaller, low volume stocks with low institutional ownership. Skipping a day between the formation and holding periods and requiring stocks to have a market price exceeding $5 per share at the end of the formation period should alleviate some of these concerns. In Table 4, this issue is examined more closely. In Table 4, all stocks are placed into two groups for the following characteristics: past returns, short interest, size, institutional ownership, and volume. Within each of the two groups based on size, institutional ownership, or volume, we form margin constrained and unconstrained portfolios. We report average weekly

reversal returns for the margin constrained and unconstrained portfolios and the average difference in weekly reversal returns between the two portfolios.

Margin constrained portfolios have significantly greater reversal than unconstrained portfolios. The difference in reversal returns ranges from 14 basis points per week (t-statistic is 2.43) to 47 basis points per week (t-statistic is 4.49). Consistent with margin constraints being more important for less liquid stocks, there is a greater difference between the reversals of margin constrained and unconstrained portfolios among small stocks and stocks with lower institutional ownership. Yet the largest difference in reversals between margin constrained and unconstrained portfolios occurs in stocks with high trading volume. Across Table 4, the largest reversal is for margin constrained stocks with high past volume (55 basis points, t-statistic is 8.28), and the smallest reversal is for unconstrained stocks with low past volume (7 basis points, t-statistic is 0.86).

3.3 Multivariate Fama-MacBeth Regressions

Next, we seek to observe the effect of margin constraints on reversals in a multivariate setting, allowing us to implement all control variables simultaneously. We first examine time-series averages of cross-sectional distributions for short interest, size, institutional ownership, and volume – our set of interaction characteristics. In Panel A of Table 5, we find that most variables exhibit rather large skewness and kurtosis, which could be problematic in Gaussian regression. Also, means and standard deviations greatly differ across variables, making regression inferences difficult.

In order to mitigate problems from non-normal distributions of variables and to make regression inferences comparable across variables, we transform each variable as follows. First,

all stocks are given a rank value each week, ranging from one to the total number of stocks included in the formation week. Transforming continuous variables to ranked values eliminates skewness and kurtosis, while preserving how stocks are ordered by the different variables. Second, all variables are standardized each week to have a mean of zero and a standard deviation of one, which helps to provide a clear interpretation of regression coefficients. From Panel B of Table 5, we see that the cross-sectional means and skewness are now zero, standard deviations are 1, and kurtosis is -1.2 for all variables after the rank standardization.

In Panel C of Table 5, we examine time series averages of the cross-sectional correlations among variables. Because variables were transformed with rank values, Pearson and Spearman correlations are equivalent. In scanning Panel C, all correlations are positive and no correlation is above 0.50 in absolute value. Of note, volume is positively correlated with short interest, suggesting that large reversals for volume based portfolios in Panel C of Table 3 are unlikely to be related to a set of margin constrained stocks. The largest correlation is 0.453, between institutional ownership and volume. The need for multivariate regressions is confirmed by the positive correlation all variables have with the level of short interest.

3.3.1 Regression Methodology for All Stocks

In Table 6, we run regressions of the following form:

$$ret_{i,t+1} = \alpha_t + \beta_t ret_{i,t} + \boldsymbol{\gamma_t}^{\top}\left(ret_{i,t}\boldsymbol{Z_{i,t}}\right) + \boldsymbol{\delta_t}^{\top}\boldsymbol{Z_{it}} + \varepsilon_{i,t}$$

where $ret_{i,t+1}$ and $ret_{i,t}$ are returns in week *t+1* and week *t*, respectively. $\boldsymbol{Z_{i,t}}$ is a vector of *N* ranked and standardized characteristics computed in week *t* or earlier. Since characteristics are standardized to have a mean of zero, the coefficient β_t is interpreted as the fraction of the

formation week return that reverses for an average value of all interaction characteristics included in vector $\boldsymbol{Z_{i,t}}$. $\boldsymbol{\gamma_t}$ is a vector of coefficients for *N* characteristics. Since characteristics are transformed to ranked values, the coefficient for each element in the vector is the additional reversal in past week returns from the same one standard deviation increase in the ranked value of the corresponding characteristic. The coefficient on the interaction term, or each element of $\boldsymbol{\gamma_t}$, is the focus of our analysis.

In Model 1 of Table 6, we run the following regression, which excludes any characteristics and their interaction terms from the model,

$$ret_{i,t+1} = \alpha_t + \beta_t ret_{i,t} + \varepsilon_{i,t} \ .$$

The regression coefficient on past week returns is -1.859, indicating that 1.86% of formation week returns reverse. The next regression specification, Model 2, includes the full model. Here, the characteristic vector, $\boldsymbol{Z_{i,t}}$, includes only the prior month's level of short interest. By including short interest as an independent variable that is not interacted with past returns, we are able to control for the effect of short interest on returns that is independent of return reversal. The coefficient on short interest as a standalone variable is -0.035 (t-statistic is -2.37), indicating that a one standard deviation increase in short interest reduces returns by 3.5 basis points per week.

In Model 2 of Table 4, the regression coefficient for the interaction of short interest and prior week returns is 0.663 (t-statistic is 4.89). There is 0.66% less reversal for a one standard deviation increase in short interest, which is equivalent to reducing average reversal by about 35%. Therefore, if we disregard the sign of the past week return, a greater short interest or proportion of capital dedicated to short positions reduces return reversal. This result is also

consistent with Figure 2, which shows that there is less reversal among high short interest stocks. Depending on one's view of return reversal, it appears that a larger presence of short sellers improves liquidity or market efficiency. Conversely, the absence of short sellers may pose a liquidity risk for those seeking to exit a position. Without short sellers to take the other side of a trade, it appears that liquidity demanders must resort to greater price concessions.

In Models 3, 4, and 5, the characteristic vector now includes only size, institutional ownership, or volume, respectively. The regression coefficient for the interaction of size and prior week returns in Model 3 is -0.278 (t-statistic is -1.74), indicating 0.28% more reversal for a one standard deviation increase in firm size. In Model 4, there is no statistically significant relation between the level of institutional ownership and return reversal. For Model 5, the regression coefficient for the interaction of volume and prior week returns is 0.804 (t-statistic is 6.39), indicating 0.80% less reversal for a one standard deviation increase in volume.

Because the regression coefficient for the interaction with volume has the same sign as the interaction with short interest and because both characteristics are positively correlated, we include both interaction terms in Model 6, along with interaction terms for size and institutional ownership. For the most part, regression coefficients on interaction terms are similar to Models 2, 3, 4, and 5. In particular, the interaction between short interest and past returns remains positive and significant at 0.602 (t-statistic is 4.31). The main difference in Model 6 is that the interaction between institutional ownership and past returns is now larger in magnitude and it becomes statistically significant. The coefficient of -0.503 (t-statistic is -3.64) indicates 0.50% more reversal for a one standard deviation increase in institutional ownership. The insignificant relation between institutional ownership and return reversal in Model 4 may have been confounded by the positive correlation of institutional ownership with short interest and volume,

both of which reduce return reversal. Finding that institutional ownership increases return reversal suggests that large institutional ownership for a stock may present a liquidity risk. Since institutional ownership indicates that institutions have a long position in a stock, negative returns on a widely held stock may result in multiple market participants attempting to exit the stock simultaneously. We explore this hypothesis further in the next section.

3.3.2 Regression Methodology with Winners and Losers Separated

In Table 7 we run regressions of a similar form to those presented in Table 6, except we now observe return reversal separately for stocks with high and low past returns. Separating high and low past returns allows us to better identify deterioration of capital for investors with long or short positions separately and thus observe the importance of margin constraints for return reversal. Our regressions take the following form:

$$ret_{i,t+1} = \alpha_t + \beta_t ret_{i,t} + \boldsymbol{\delta_t}^{\top}\boldsymbol{Z_{it}} + \boldsymbol{\xi_t}^{\top}\left(winner_{i,t} ret_{i,t}\boldsymbol{Z_{i,t}}\right) + \boldsymbol{\varphi_t}^{\top}\left(loser_{i,t} ret_{i,t}\boldsymbol{Z_{i,t}}\right) + \varepsilon_{i,t} \quad ,$$

where $winner_{i,t}$ is an interaction dummy variable that takes a value of 1 if $ret_{i,t}$ is in the top half of returns and is 0 otherwise. $loser_{i,t}$ is an interaction dummy variable that takes a value of 1 if $ret_{i,t}$ is in the bottom half of returns and is 0 otherwise.

The coefficient for each element in the vector $\boldsymbol{\xi_t}$ indicates the additional reversal in past week returns from a one standard deviation increase in the ranked value of the corresponding characteristic in vector $\boldsymbol{Z_{i,t}}$ for past winners. The coefficient for each element in the vector $\boldsymbol{\varphi_t}$ indicates the additional reversal in past week returns from a one standard deviation increase in the ranked value of the corresponding characteristic in vector $\boldsymbol{Z_{i,t}}$ for past losers. The coefficients in vectors $\boldsymbol{\xi_t}$ and $\boldsymbol{\varphi_t}$ are the focus of the analysis in Table 7.

Model 1 of Table 7 provides a test of our margin constrained stocks hypothesis. Return reversal is increasing with short interest levels for past winners and decreasing in short interest levels for past losers. Viewed from the perspective of a margin constrained investor, a one standard deviation decrease in short interest for loser stocks results in twice as much return reversal as what occurs on average, as seen by comparing the coefficient for past returns alone with the interaction coefficient of short interest and past returns for past week losers. Stocks with larger short positions, as observed by greater short interest levels, experience larger reversals after a positive price shock. The opposing signs of the interaction terms for short interest with past returns are consistent with the margin constrained stocks hypothesis. In related literature, Boehmer and Wu (2012) find a decline in short selling around an extreme negative price event. Given that we find evidence of short sellers reducing return reversal for past losers, it is possible that negative price events allow short sellers to cover their positions while providing liquidity to the market, which would in turn reduce the cost of liquidity demanded by long investors with weakened capital.

In Models 2, 3, and 4, the signs for the interaction of past returns with the other characteristics are the same for winners and losers. When size is interacted with past returns, an increase in firm size results in significantly more reversal only for past winners, as seen in Model 2. In Model 3, institutional ownership has no statistically significant relation to return reversal. In Model 4, reversal is significantly decreasing in stock trading volume, with the decrease in reversal being larger for past losers.

Because interaction characteristics are positively correlated with each other, results could be confounded without the use of control variables. In Model 5, short interest, size, institutional ownership, and volume are all included in the characteristic vector. With controls, coefficients

on the interaction of short interest and past returns diverge more between winners and losers. A one standard deviation increase in short interest results in 0.57% more reversal for winner stocks, with a t-statistic of -2.65. A one standard deviation decrease in short interest results in 2.04% more reversal for loser stocks, with a t-statistic of 7.24. Therefore, the effect of capital deterioration on reversal becomes more important with the use of control variables. The evidence presented in Table 7 lends strong support to the margin constraints hypothesis.

Interaction coefficients for all other characteristics maintain the same sign for the winners and the losers in Model 5. Perhaps unexpectedly, size and volume have opposite effects on return reversal. Reversal is increasing in firm size and decreasing in trading volume, with the effect being larger for past winners in both cases. Controlling for other variables, institutional ownership increases reversal mainly for past loser stocks. The coefficient on the interaction of institutional ownership and past returns for past losers is the second largest of all interaction terms, with the coefficient on the interaction of short interest and past returns for past losers being the largest. A one standard deviation increase in institutional ownership results in 1.15% more return reversal for past losers. Institutional ownership has no effect on reversal among past winners. This evidence is consistent with institutions as a destabilizing force, as argued in Sias, Starks, and Titman (2006), but our evidence suggests that this occurs mainly when institutions need to sell stocks.

The results suggest that long-only investors have less risk of a price concession when demanding liquidity if they hold stocks with high short interest. In contrast, high institutional ownership increases the risk of a price concession when trying to exit a stock. Therefore, although institutional ownership would appear to improve efficiency from making short sales cheaper, as found by Nagel (2005), institutional ownership may also have a cost in efficiency or

liquidity, as seen by greater reversals. An extreme example of this can be found in Coval and Stafford (2007), in which institutions susceptible to capital outflows requiring asset fire sales can experience large price declines that eventually reverse. On the other hand, the presence of short selling reduces reversal for past losers, improving efficiency and liquidity. The improvement in efficiency and liquidity from the presence of short sellers is consistent with evidence presented in Diether, Lee, and Werner (2009), Saffi and Sigurdsson (2010), Beber and Pagano (2013), Boehmer, Jones, and Zhang (2013), and Boehmer and Wu (2012). To this observation, we add the caveat that these liquidity benefits occur mainly from being on the opposite side of the trade from short sellers – rather than on the same side of the trade.

4. Conclusion

We employ a novel approach to identify the relative loss of capital dedicated to a certain stock and its effect on liquidity provision. Short interest is used to measure the relative amount of capital dedicated to a short position versus a long position. We posit that stocks with the greatest loss of capital are the ones that experience significant price declines and have no short interest and those that experience significant price jumps and have the highest short interest levels. We note that while we do not measure margin calls on intermediaries directly, any significant capital weakening due to adverse price changes could be sufficient to increase their liquidity demand or reduce their willingness and capacity to provide liquidity, as described by Hameed, Kang, and Viswanathan (2010). Consistent with expectations, larger positive price changes result in larger reversals for stocks with high short-interest, and larger negative price changes result in larger reversals for stocks with low short-interest. Deterioration of total capital dedicated to short and long positions for a stock seems to be a significant driver of liquidity for that stock when short-term return reversals are used as a proxy for the price of liquidity provision.

We contribute to a prior literature that focuses mainly on the cost of liquidity provision at the aggregate level. For example, Hameed, Kang, and Viswanathan (2010) provide time-series evidence that reversals are much larger when markets are declining, and Comerton-Forde et al. (2010) demonstrate that market-wide spreads widen when market makers' balance sheet positions deteriorate. Nagel (2012) documents that reversals correlate with the VIX index positively over time. Different from these studies, we find that capital deterioration from adverse price changes at the individual stock level is also important for the cost of liquidity provision, consistent with evidence on dealer pricing behavior in Naik and Yadav (2003) and with arguments made by Brunnermeier and Pedersen (2009) about portfolio financing.

The overall effect of short interest on the cost of liquidity provision is positive. On average, stocks with higher short interest seem to have lower short-term return reversals, suggesting that short sellers ease liquidity dry-ups in the market. Short sellers' positive contribution to providing liquidity after price declines is greater than their immediacy demands after price increases. This result is likely to stem from the fact that capital dedicated to short positions is far less than capital dedicated to long positions, as observed by low short interest levels in the market on average. After a significant negative price shock, a greater percentage of capital (which is dedicated to long positions) would be weakened and thus decrease the supply of liquidity and increase demands for immediacy, making liquidity provision more valuable. On the other hand, after a positive price shock, only a small percentage of capital (which is dedicated to short positions) would demand immediacy, which could be met at a relatively lower cost. Therefore, our results suggest that the dynamic interplay between the relative amount of capital committed to long and short positions has implications for the cost of liquidity provision.

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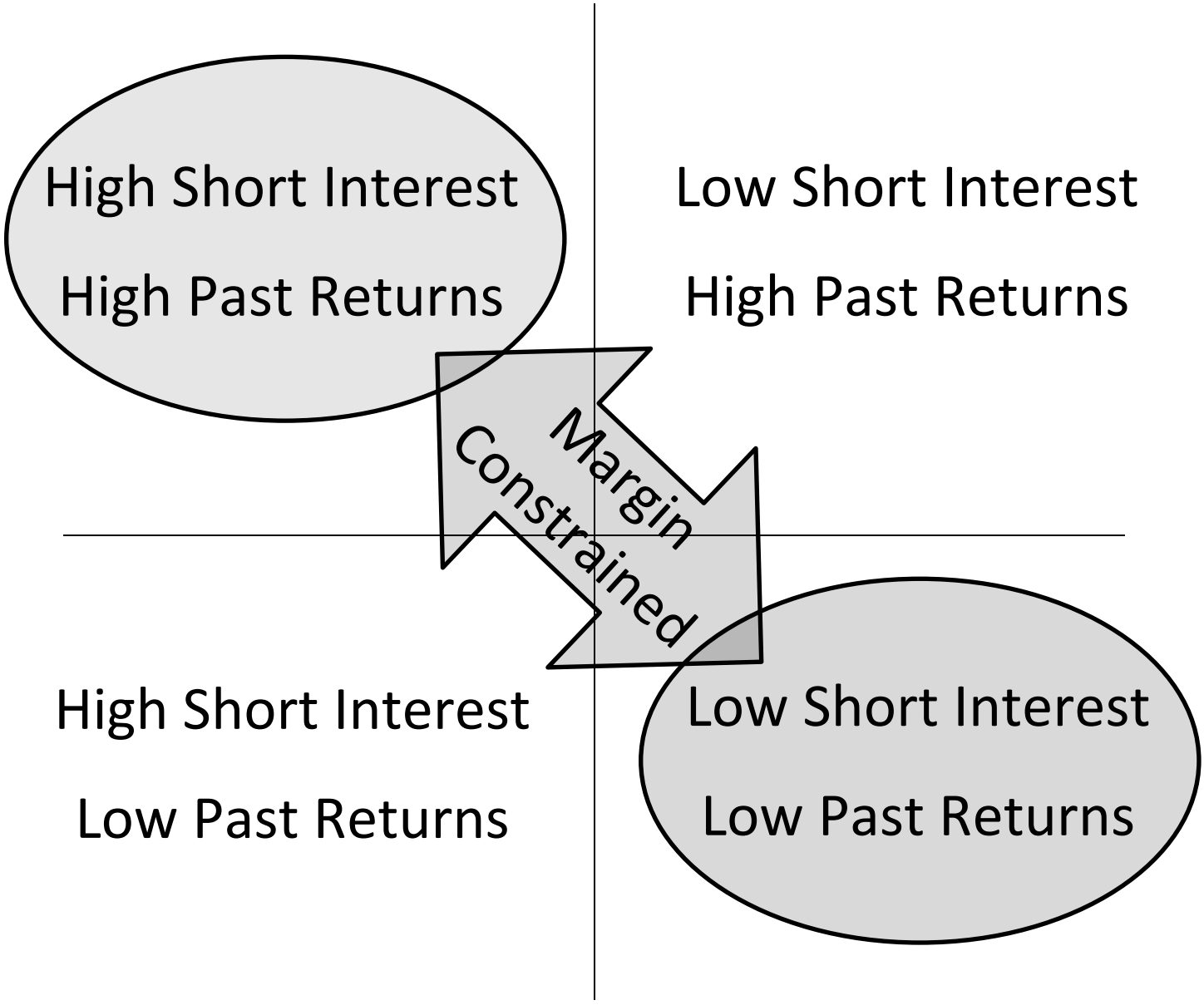
Figure 1: Illustration of stocks likely to be margin constrained

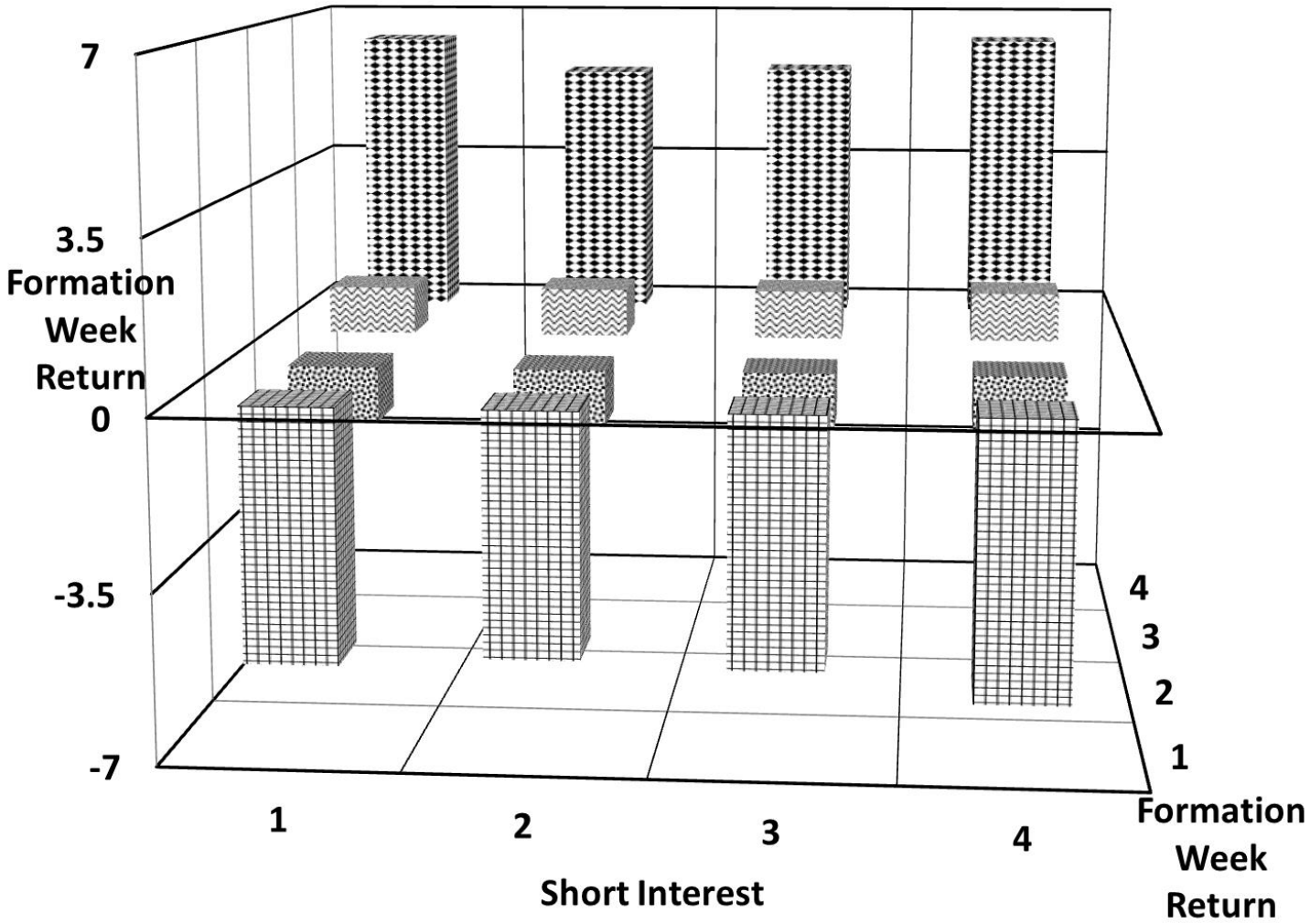


Gray shading indicates securities that are likely to receive margin calls or to be margin constrained. Assuming that taking a long or short position requires borrowing on margin, the amount of short interest is used to indicate the direction of trade for a particular stock. Therefore, high short interest indicates a short position, and margin calls would occur when the price of those stocks increases, as observed by high past returns. Low short interest indicates a long position, and margin calls would occur when the price of those stocks decreases, as observed by low past returns. Based on the direction of trade as indicated by the amount of short interest, quadrants that are not shaded gray are unlikely to receive margin calls since the trade positions are profitable.

Figure 2: Two-way portfolio sorts: Formation week and holding week returns

This figure shows the average market adjusted weekly return for the formation period and the holding period reported as a percent. Equal-weighted portfolios are formed every week, with a day skipped between the formation week and the holding week. The sorts are based on returns in the formation week and the level of short interest in the month prior to portfolio formation. Short interest portfolio 1 has the lowest short interest, and portfolio 4 has the highest short interest. Formation week return portfolio 1 has the lowest formation week return, and portfolio 4 has the highest formation week return. The sample period from 1988 to 2010 includes all NYSE and AMEX stocks with a price above $5 at the end of the formation week and with data on short interest and returns.

Panel A: Formation week returns



Panel B: Holding week returns

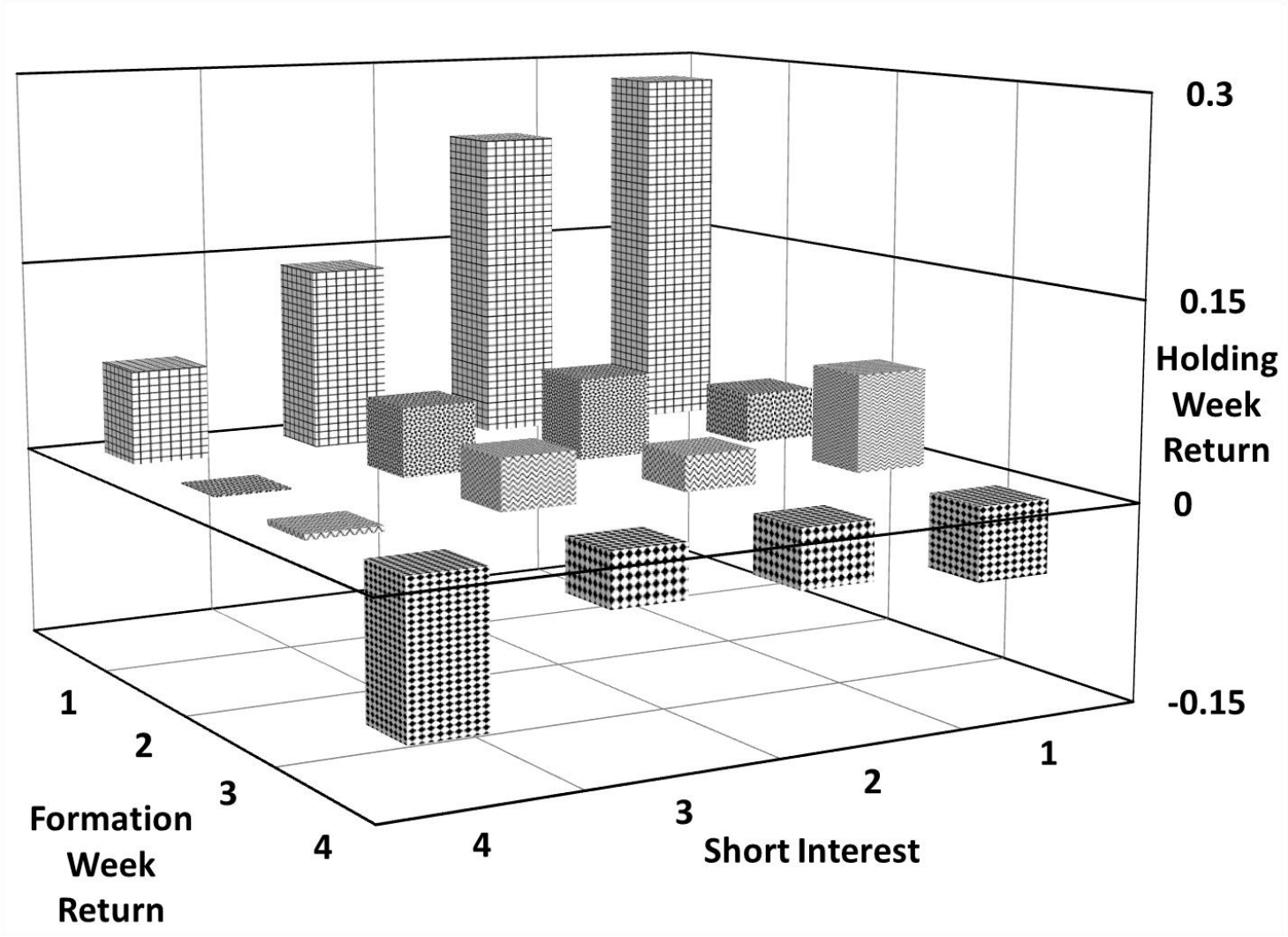


Table 1 – Reversal portfolios in past return and short interest groups

All stocks are placed into one of two reversal portfolios based on the prior month's short interest and the prior week's returns. One portfolio includes stocks in the top half of both past week returns (p.r.=high) and short interest (s.i.=high) or in the bottom half of both past week returns (p.r.=low) and short interest (s.i.=low). The other portfolio consists of all other stocks. For each portfolio, Panel A reports the time series mean and standard deviation of cross-sectional means, standard deviations, skewness, and kurtosis for short interest and past week absolute returns. In Panel B, weekly zero-cost portfolio returns are reported as a percentage. Portfolio weights are inversely proportional to the return in the prior week. HAC t-statistics are reported in parentheses based on the quadratic spectral kernel using the automatic bandwidth selection method of Andrews (1991). ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. The sample consists of NYSE/Amex stocks for the period from 1988 to 2010.

Panel A: Portfolio descriptive statistics

	short interest		past absolute return	
	p.r.=high and s.i.=high p.r.=low and s.i.=low	p.r.=high and s.i.=low p.r.=low and s.i.=high	p.r.=high and s.i.=high p.r.=low and s.i.=low	p.r.=high and s.i.=low p.r.=low and s.i.=high
	Mean			
mean :	0.027	0.028	0.037	0.038
std :	0.041	0.043	0.039	0.041
skew :	5.5	5.7	3.3	3.6
kurt :	56.2	62.4	24.5	28.8
	standard deviation			
mean :	0.017	0.017	0.014	0.013
std :	0.022	0.022	0.013	0.017
skew :	2.8	3.1	2.0	2.2
kurt :	71.7	80.2	43.0	49.7

Panel B: Portfolio returns

past return=high and short interest=high past return=low and short interest=low	0.440*** (8.13)
past return=high and short interest=low past return=low and short interest=high	0.179*** (2.72)
difference	0.261*** (3.65)

Table 2 – Effect of increasing short interest extremes on reversal portfolios

All stocks are placed into one of two portfolios based on the prior month's short interest and the prior week's returns. One portfolio includes stocks that are either in the top ranking of both past week returns (p.r.=high) and short interest (s.i.=high) or in the bottom ranking of both past week returns (p.r.=low) and short interest (s.i.=low). The other portfolio includes stocks that are either in the top ranking of past week returns (p.r.=high) and bottom ranking of short interest (s.i.=low) or in the bottom ranking of past week returns (p.r.=low) and top ranking of short interest (s.i.=high). There are only two rankings based on past returns, but the number of rankings based on short interest is varied from 2 to 10. In Panel A, weekly zero-cost portfolio returns are reported as a percentage. Portfolio weights are inversely proportional to the return in the prior week. HAC t-statistics are reported in parentheses based on the quadratic spectral kernel using the automatic bandwidth selection method of Andrews (1991). ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. For the two portfolios, Panel A reports the time series mean of cross-sectional means, standard deviations, skewness, and kurtosis for short interest and past week absolute returns. The sample consists of NYSE/Amex stocks for the period from 1988 to 2010.

Panel A: Portfolio returns

	number of short interest rankings				
	2	4	6	8	10
past return=high and short interest=high	0.44***	0.516***	0.58***	0.663***	0.63***
past return=low and short interest=low	(8.13)	(7.34)	(6.89)	(7.18)	(6.25)
past return=high and short interest=low	0.179***	0.162*	0.16*	0.177	0.162
past return=low and short interest=high	(2.72)	(1.9)	(1.64)	(1.64)	(1.41)
difference	0.261***	0.354***	0.419***	0.485***	0.468***
	(3.65)	(3.22)	(3.14)	(3.23)	(2.9)

Panel B: Portfolio descriptive statistics

	short interest		past absolute return	
	p.r.=high and s.i.=high p.r.=low and s.i.=low	p.r.=high and s.i.=low p.r.=low and s.i.=high	p.r.=high and s.i.=high p.r.=low and s.i.=low	p.r.=high and s.i.=low p.r.=low and s.i.=high
	2 short interest rankings			
mean :	0.027	0.028	0.037	0.038
std :	0.041	0.043	0.039	0.041
skew :	5.5	5.7	3.3	3.6
kurt :	56.2	62.4	24.5	28.8
	4 short interest rankings			
mean :	0.037	0.039	0.038	0.040
std :	0.056	0.059	0.041	0.045
skew :	3.8	4.0	3.0	3.3
kurt :	28.0	31.4	17.7	21.8
	6 short interest rankings			
mean :	0.046	0.047	0.039	0.041
std :	0.066	0.069	0.043	0.046
skew :	3.1	3.3	2.8	3.0
kurt :	18.9	21.4	14.7	17.2
	8 short interest rankings			
mean :	0.052	0.054	0.040	0.042
std :	0.074	0.077	0.044	0.048
skew :	2.7	2.8	2.6	2.9
kurt :	14.5	16.6	12.6	15.2
	10 short interest rankings			
mean :	0.057	0.059	0.040	0.042
std :	0.080	0.083	0.045	0.049
skew :	2.4	2.6	2.6	2.8
kurt :	12.0	13.7	11.4	13.7

Table 3 – Effect of increasing the extremes of size, institutional ownership, and volume on reversal portfolios

All stocks are placed into one of two portfolios based the prior week's returns and either size at the beginning of the previous week, institutional ownership at the end of the previous quarter, or volume over the prior week. In Panel A, one portfolio includes stocks that are either in the top ranking of both past week returns (past return=high) and size (size=high) or in the bottom ranking of both past week returns (past return=low) and size (size=low). The other portfolio includes stocks that are either in the top ranking of past week returns (past return=high) and bottom ranking of size (size=low) or in the bottom ranking of past week returns (past return=low) and top ranking of size (size=high). Similar portfolios are formed with institutional ownership and volume instead of size in Panels B and C, respectively. There are only two rankings based on past returns, but the number of rankings based on size, institutional ownership, and volume is varied from 2 to 10. Weekly zero-cost portfolio returns are reported as a percentage. Portfolio weights are inversely proportional to the return in the prior week. HAC t-statistics are reported in parentheses based on the quadratic spectral kernel using the automatic bandwidth selection method of Andrews (1991). ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. The sample consists of NYSE/Amex stocks for the period from 1988 to 2010.

Panel A: Returns from portfolios based on size and past returns

	number of size rankings				
	2	4	6	8	10
past return=high and size=high	0.328***	0.37***	0.38***	0.427***	0.417***
past return=low and size=low	(5.97)	(5.88)	(5.55)	(5.98)	(5.46)
past return=high and size=low	0.31***	0.428***	0.474***	0.513***	0.566***
past return=low and size=high	(4.69)	(4.91)	(4.82)	(4.77)	(4.86)
difference	0.018	-0.057	-0.094	-0.085	-0.148
	(0.25)	(-0.55)	(-0.77)	(-0.64)	(-1.03)

Panel B: Returns from portfolios based on institutional ownership and past returns

	number of institutional ownership rankings				
	2	4	6	8	10
past return=high and institutional ownership=high	0.271***	0.302***	0.294***	0.325***	0.32***
past return=low and institutional ownership=low	(5.72)	(5.32)	(4.45)	(4.45)	(4.01)
past return=high and institutional ownership=low	0.377***	0.443***	0.458***	0.441***	0.494***
past return=low and institutional ownership=high	(5.68)	(5.11)	(4.59)	(4.12)	(4.57)
difference	-0.105*	-0.14	-0.164	-0.115	-0.173
	(-1.66)	(-1.46)	(-1.42)	(-0.9)	(-1.33)

Panel C: Returns from portfolios based on volume and past returns

	number of volume rankings				
	2	4	6	8	10
past return=high and volume=high	0.089	-0.021	-0.089	-0.102	-0.124
past return=low and volume=low	(1.45)	(-0.3)	(-1.11)	(-1.09)	(-1.25)
past return=high and volume=low	0.528***	0.585***	0.593***	0.632***	0.612***
past return=low and volume=high	(8.91)	(7.58)	(6.72)	(6.47)	(6.08)
difference	-0.439***	-0.607***	-0.683***	-0.735***	-0.737***
	(-5.89)	(-6.03)	(-5.82)	(-5.48)	(-5.04)

Table 4 – Reversal portfolios formed on past returns and short interest within size, institutional ownership, and volume groups

Stocks are placed into one of four portfolios based on the intersection of past return and short interest rankings with rankings by size, institutional ownership, or volume. Two portfolios include stocks that are either in the top ranking of both past week returns (past return=high) and short interest (short interest=high) or in the bottom ranking of both past week returns (past return=low) and short interest (short interest=low). The other two portfolios include stocks that are either in the top ranking of past week returns (past return=high) and bottom ranking of short interest (short interest=low) or in the bottom ranking of past week returns (past return=low) and top ranking of short interest (short interest=high). To form four portfolios, each of set of past return and short interest ranking intersections is further subdivided according to whether stocks are in the top or bottom ranking of size, institutional ownership, or volume. Weekly zero-cost portfolio returns are reported as a percentage, and portfolio weights are inversely proportional to the return in the prior week. HAC t-statistics are reported in parentheses based on the quadratic spectral kernel using the automatic bandwidth selection method of Andrews (1991). ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. The sample consists of NYSE/Amex stocks for the period from 1988 to 2010.

	size	institutional ownership	volume
past return=high and short interest=high	0.358***	0.368***	0.545***
past return=low and short interest=low	(6.74)	(7.46)	(8.28)
	size=high	institutional ownership=high	volume=high
past return=high and short interest=low	0.22***	0.211***	0.071
past return=low and short interest=high	(3.7)	(3.4)	(0.86)
difference	0.138**	0.157**	0.474***
	(2.43)	(2.55)	(5.43)
past return=high and short interest=high	0.51***	0.504***	0.47***
past return=low and short interest=low	(7.71)	(7.25)	(10.22)
	size=low	institutional ownership=low	volume=low
past return=high and short interest=low	0.183**	0.146*	0.207***
past return=low and short interest=high	(2.35)	(1.92)	(4.37)
difference	0.326***	0.357***	0.262***
	(3.39)	(3.84)	(4.49)

Table 5 – Descriptive statistics for short interest, size, institutional ownership, and volume

This table shows descriptive statistics for the following variables: short interest, market capitalization, institutional ownership, and volume. The mean and standard deviation for size is reported in millions of dollars. Panel A reports the time series average of the cross-sectional mean, standard deviation, skewness, and kurtosis of each variable before transforming each variable by ranking cross-sectionally and standardizing to have a cross-sectional mean of zero and standard deviation of one. Panel B reports the same statistics after the rank standardization. Panel C reports the time-series averages of cross-sectional correlations between each of the variables after rank standardization. The sample consists of NYSE/Amex stocks for the period from 1988 to 2010.

Panel A: Descriptive statistics before rank standardization

	short interest	size	institutional ownership	volume
mean :	0.03	4,868	0.59	0.04
std :	0.04	15,115	0.25	0.07
skew :	6.4	8.0	0.1	8.7
kurt :	87.7	90.0	7.2	140.8

Panel B: Descriptive statistics after rank standardization

	short interest	size	institutional ownership	volume
mean :	0	0	0	0
std :	1	1	1	1
skew :	0.0	0.0	0.0	0.0
kurt :	-1.2	-1.2	-1.2	-1.2

Panel B: Sample correlations after rank standardization

	short interest	size	institutional ownership	volume
short interest	1.000	0.208	0.347	0.428
size		1.000	0.337	0.305
institutional ownership			1.000	0.453
volume				1.000

Table 6 – Multivariate Fama and MacBeth (1973) regressions

Each week we run the following regression, $ret_{i,t+1} = \alpha_t + \beta_t ret_{i,t} + \boldsymbol{\delta_t}^{\top}\boldsymbol{Z_{it}} + \boldsymbol{\gamma_t}^{\top}(ret_{i,t}\boldsymbol{Z_{i,t}}) + \varepsilon_{i,t}$. $ret_{i,t+1}$ and $ret_{i,t}$ are returns in week *t+1* and week *t*, respectively. $\boldsymbol{Z_{i,t}}$ is a vector of ranked and standardized characteristics computed prior to week *t+1*. In the table, the return in week *t* is represented by ret. Characteristics interacted with prior week returns, which can be included in the vector $\boldsymbol{Z_{i,t}}$, include short interest in the month prior to week *t+1*, *short interest*, market capitalization at the end of the previous week, *size*, institutional ownership in the quarter prior to week *t+1*, *institutional ownership*, and volume over week *t*, *volume*. All characteristics are first ranked cross-sectionally and then standardized to have a mean of zero and a standard deviation of one. The time series average of weekly cross-sectional regression coefficients and adjusted R^2 values are reported. HAC t-statistics are reported in parentheses based on the quadratic spectral kernel using the automatic bandwidth selection method of Andrews (1991). ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. The sample consists of NYSE/Amex stocks for the period from 1988 to 2010.

	dependent variable: return in week *t+1*					
	model 1	model 2	model 3	model 4	model 5	model 6
intercept	0.281***	0.281***	0.286***	0.282***	0.285***	0.291***
	(4.26)	(4.24)	(4.33)	(4.26)	(4.28)	(4.35)
ret	-1.859***	-1.849***	-1.987***	-1.838***	-2.343***	-2.827***
	(-6.95)	(-7.24)	(-7.08)	(-6.91)	(-9.15)	(-10.64)
short interest		-0.035**				-0.105***
		(-2.37)				(-8.18)
size			-0.01			-0.04**
			(-0.66)			(-2.03)
institutional ownership				0.009		-0.038***
				(0.81)		(-3.34)
volume					0.131***	0.209***
					(8.6)	(12.91)
short interest*ret		0.663***				0.602***
		(4.89)				(4.31)
size*ret			-0.278*			-0.305*
			(-1.74)			(-1.93)
institutional ownership*ret				-0.165		-0.503***
				(-1.24)		(-3.64)
volume*ret					0.801***	0.71***
					(6.39)	(5.08)
adjusted R^2	0.786	1.713	1.765	1.422	1.858	3.654

Table 7 – Multivariate Fama and MacBeth (1973) regressions in past week winners and losers

Each week we run the following regression,
$ret_{i,t+1} = \alpha_t + \beta_t ret_{i,t} + \boldsymbol{\delta_t}^{\top}\boldsymbol{Z_{it}} + \boldsymbol{\xi_t}^{\top}(winner_{i,t} ret_{i,t}\boldsymbol{Z_{i,t}}) + \boldsymbol{\varphi_t}^{\top}(loser_{i,t} ret_{i,t}\boldsymbol{Z_{i,t}}) + \varepsilon_{i,t}. ret_{i,t+1}$
and $ret_{i,t}$ are returns in week *t+1* and week *t*, respectively. $winner_{i,t}$ is a dummy variable that takes a value of 1 if $ret_{i,t}$ is in the top half of returns and is 0 otherwise. $loser_{i,t}$ is a dummy variable that takes a value of 1 if $ret_{i,t}$ is in the bottom half of returns and is 0 otherwise. $\boldsymbol{Z_{i,t}}$ is a vector of ranked and standardized characteristics computed prior to week *t+1*. In the table, the return in week *t* is represented by ret. Characteristics interacted with prior week returns, which can be included in the vector $\boldsymbol{Z_{i,t}}$, include short interest in the month prior to week *t+1*, *short interest*, market capitalization at the end of the previous week, *size*, institutional ownership in the quarter prior to week *t+1*, *institutional ownership*, and volume over week *t*, *volume*. All characteristics are first ranked cross-sectionally and then standardized to have a mean of zero and a standard deviation of one. The time series average of weekly cross-sectional regression coefficients and adjusted R^2 values are reported. HAC t-statistics are reported in parentheses based on the quadratic spectral kernel using the automatic bandwidth selection method of Andrews (1991). ***, **, * denote significance at 1%, 5%, and 10% levels, respectively. The sample consists of NYSE/Amex stocks for the period from 1988 to 2010.

dependent variable: return in week *t+1*

	model 1	model 2	model 3	model 4	model 5
intercept	0.283***	0.285***	0.282***	0.287***	0.292***
	(4.28)	(4.35)	(4.28)	(4.32)	(4.39)
ret	-1.897***	-1.991***	-1.803***	-2.314***	-2.798***
	(-7.42)	(-7.01)	(-6.74)	(-9.03)	(-10.43)
short interest	-0.003				-0.07***
	(-0.25)				(-5.41)
size		-0.006			-0.043**
		(-0.43)			(-2.18)
institutional ownership			0.007		-0.055***
			(0.54)		(-4.51)
volume				0.138***	0.209***
				(8.86)	(12.64)
winner*short interest*ret	-0.383*				-0.569***
	(-1.86)				(-2.65)
loser*short interest*ret	1.866***				2.041***
	(7.52)				(7.24)
winner*size*ret		-0.598**			-0.542**
		(-2.5)			(-2.31)
loser*size*ret		-0.274			-0.495*
		(-1)			(-1.73)
winner*institutional ownership*ret			-0.197		-0.012
			(-0.89)		(-0.05)
loser*institutional ownership*ret			-0.173		-1.153***
			(-0.69)		(-4.07)
winner*volume*ret				0.705***	0.96***
				(3.74)	(4.55)
loser*volume*ret				1.092***	0.643**
				(4.38)	(2.22)
adjusted R^2	1.861	1.931	1.577	2.03	4.121