Understanding the Information Content of Short Interests

Yexiao Xu Harold H. Zhang Xin Zhou

This Version: June 2009

Abstract

Existing studies have debated on the information content of the short interest and its predictive power for future stock returns. We explore a unique institutional feature on the time lag between monthly recording of short interests and their public release to draw inference on the information content of short interests. Using a matching approach, we find that the impact of the negative information content of short interests is more pronounced than previously documented, but only exists in the period before the public release of short interest data. There is no significant predictive power of short interests for future stock returns once the information is released. Moreover, much of the previously documented negative abnormal return of the most heavily shorted portfolio formed on published short interests is largely associated with the liquidity risk. In order to better reveal the potential negative information in short sale activities while considering the short sale constraints, we propose a *binding ratio* between the short interest and the institutional ownership. We show that both short interest and binding ratio are closely related to forthcoming negative earnings surprises in the month. However, only binding ratio reflect other potential negative information.

JEL Classification: G12, G14

Keywords: Binding ratio, Earning surprise, Market efficiency, Return predictability, Short interests

We would like to thank Ted Day, Alexander Butler, Robert Kieschnick, Michael Rebello, Marius Popescu, and seminar participants at the University of Texas at Dallas, the Financial Management Association Annual Meetings, the Midwest Financial Association Annual Meetings for their useful comments and suggestions. Yexiao Xu and Harold H. Zhang are from the School of Management, University of Texas at Dallas, Richardson, TX 75080, and Xin Zhou is from the School of Management, Fudan University.

1. Introduction

This paper examines the information content in short interests—total number of shares of stocks sold short—and its predictability on future stock returns by exploring a unique institutional feature of the time lag between the recording of monthly cumulative short positions of stocks and the public release of the information. Because most investors cannot trade on this private information before public announcement, it offers a natural setting to analyze the information content associated with short interests and its effect on stock prices in a rational framework without the confounding effect from market participants' trading activities. A large number of studies have used short interests to investigate the information content of short selling and the effect on future stock returns. The empirical findings are, however, mixed. While some studies (for example, Figlewski, 1981, Brent, Morse, and Stice, 1990, Figlewski and Webb, 1993, and Boehme, Danielsen, and Sorescu, 2006) find little or no relation between short interests and subsequent stock returns, other studies (e.g., Asquith and Meulbroek, 1995, Asquith, Pathak, and Ritter, 2005, and Desai, Ramesh, Thiagarajan, and Balachandran, 2002) document that heavily shorted stocks measured by the short interest ratio (short interests divided by total number of shares outstanding) experience lower subsequent stock returns.

Short interests may reflect many facets depending upon different motivations of short sellers. First, investors sell short because they have negative private information on a firm. In this case, short interests should reflect the negative information of short sellers. Diamond and Verrecchia (1987) argue that short interests contain adverse information and are unlikely to be caused by liquidity trading due to high short selling costs. Second, short selling could be a result of exploiting overpricing. Many studies have suggested that, in the presence of short sale constraints and heterogeneous beliefs, security prices tend to be overpriced because pessimistic investors are restricted from short selling (see for example, Miller, 1977, Diamond and Verrecchia, 1987, Chen, Hong and Stein, 2002, Bai, Chang, and Wang, 2006, and Cao, Zhang and Zhou, 2007). In addition, overpricing could simply be a result of overreaction by investors. Third, short selling is an integral part of a hedging strategy. Finally, investors may short "against the box" for tax timing purpose. The different perspectives of short sales have distinct consequences on future price movements.

For information motivated short selling, future security prices will be lower. However, such negative information should be quickly impounded into security prices once it becomes public. Different from existing studies on information motivated short selling, we explore a unique institutional feature on the time lag between the monthly recording of cumulative short positions on each stock (the Trade Date) and the release of the information to the public (the Publication Date). In general, the short interest data is published on the 11th business day each month after it is recorded. If short interests contain negative information, we are less likely to observe abnormal returns during the announcement period (from the publication date to the next trade date) when investors trade to exploit the announced information. In contrast, there should be abnormal returns during the information period (from the trade date to the publication date) since most investors cannot trade on this yet to be released information.[1]

In the presence of short sale constraints, however, the level of short interests may under reflect the amount of negative information. Therefore, simply examining short interests is unable to uncover the effect due to lower supply of shares under the short sale constraints. In order to better capture the information effect of short selling on future returns, we introduce the binding ratio—defined as the short interest ratio divided by institutional ownership. Since institutional investors are the primary source for short sellers to borrow shares for short selling, a low institutional ownership means that it is difficult to locate shares for selling short, which reflects a tight short sale constraint. In this case, if investors are still actively selling short, a high binding ratio is more likely to indicate an information driven short sale. Thus, the proposed binding ratio could be a better measure enabling us to capture the effect on stock returns associated with the negative information content of short sale activities. Our measure is also consistent with the recent empirical finding by Asquith, et al. (2005) suggesting that institutional ownership is a good proxy for supply of shares for short sales.

When short selling is related to overpricing, the relation between short interests and future returns depends on the nature of overpricing. If overpricing is caused by the inability of security prices to fully discount heterogeneous beliefs due to short sale

[1] In the presence of liquidity traders, uninformed investors cannot infer the negative information from the trading activities of short sellers.

constraints, future returns is unlikely to be related to short interests since constrains will likely remain and overpricing continues. If overpricing is due to overreaction to good news, a potential relationship between short sale activities and future returns will be stronger using short interest ratio than using the binding ratio.[2] When short selling is motivated by implementing hedging strategies and tax timing strategies, short interests will have small effect on future stock prices other things being equal. This is particularly true after passing the tax law that disallows the "shorting against the box" practice for tax avoidance purposes in 1996.

Since our focus here is on the information content of short interests and its effect on future stock returns, a nature experiment is to see if short interests corroborate negative news announced later, and how future stock return reacts differently. One major source of the negative information is negative earning surprises. Therefore, we divide the most heavily shorted stocks into two groups by their earning surprises reported in the month after the Trade Date. If short interests mainly reflect negative private information about earnings, we are more likely to find persistent underperformances in the group of stocks reported negative earning surprises than the group of stocks with no earnings or non-negative earnings announcements. At the same time, the group with negative earnings surprises should dominate the group with non-negative earnings surprises in terms of the number of firms. Otherwise, the predictive power of short interests will be mechanical since we are always able to find some stocks with negative earning surprises in the most heavily shorted group.

Desai, et al (2002) investigate the stock return predictability by forming portfolios according to short interest ratio to avoid the clustering problems in long horizon event studies. We extend the portfolio approach by further controlling for the sample selection bias that may adversely affect the estimation and statistical inference of using short interests data pertaining to stocks traded in certain market, say NASDAQ, and a particular sampling period. Specifically, we utilize a matching method to form matching portfolios based on firm size, book-to-market ratio, and liquidity but allowing the short interests to

[2] In the presence of overreaction to good news, the degree of price correction should be proportional to the amount of short sale activities. In other words, given the relationship between short interest and the future price decline, the relationship between the binding ratio and the future price will be weaker since the binding ratio will be much larger for the same amount of price decline when constraints are tight.

vary freely. We then analyze the abnormal return of a zero-investment portfolio which takes a long position in the portfolio of the most heavily shorted stocks and a short position in the matching portfolio.[3]

We contribute to the literature in the following aspects. First, we identify and exploit an important institutional feature of the time lag between the recording of short interests (the trade day) and the public release of the information (the announcement day). This time lag allows us to study how markets react with respect to the negative private information in short interests. Second, we propose a new measure—the binding ratio to better capture the information content of the short interests. Third, we investigate the significance of one possible source of negative information contained in the short interests—negative earning surprises. Finally, we use a matching approach to better control for sample selection bias and to show the importance of the liquidity factor.

Our empirical results suggest that the negative information contained in short interests is much larger than previously documented. For example, the top decile portfolio of stocks with the largest binding ratio generates a negative average annual abnormal return of -35 percent. However, such a significant negative return only exists before the "Publication Date" of short interests. Upon the release of short interest data to the public, there is no more significant abnormal return. This finding is consistent with the efficient market hypothesis. Moreover, our analysis indicates that previously documented underperformance of the most heavily shorted stock portfolio constructed according to the short interest ratio is largely due to differences in liquidity. After controlling for firm characteristics including liquidity in a matching procedure, the most heavily shorted stock portfolio formed using the short interest ratio announced last month does not significantly underperform other stocks.

We also find that the negative information in short interests is related to negative earnings surprises. In particular, stocks with negative earnings surprises announced before the public release of short interests experienced a much larger price decline than those announced after the release of short interests data. This indicates that investors may have learned the negative news from the short interest data leading to a smaller reaction to

[3] Desai, et al (2002) have also applied a matching approach as a robust check. However, they did not match on liquidity and found weak evidence after matching.

negative earnings surprises announced after the release of the short interests. Moreover, we document that, while both short interest and binding ratio are closely related to forthcoming negative earnings surprises in the following month, only binding ratio reflect other potential negative information.

Finally, we use an alternative event study approach to perform the robustness analysis of our findings. The event date is chose to be the "Trade Date". We examine the cumulative abnormal return (CAR) for the next twenty-two trading days (one month in calendar time) which covers the "Publication Date". The results from the event study strongly support our findings above. Based on the short interest ratio, the CAR of the most heavily shorted portfolio is statistically insignificant for the full month, the information period, and the announcement period, using the matching portfolio as the benchmark. Based on the binding ratio, the CAR of the most heavily shorted portfolio steadily decreases during the information period, and levels off after the release of the short interest data. Therefore, the negative information emerged in the information period. The results also reinforce our findings that the binding ratio is a more accurate measure in capturing the negative information of the most heavily shorted stocks, and that the published short interest data alone does not help forecast future returns.

Our focus on the information content of short interests and its effect on subsequent returns of portfolios constructed using the short interest ratio is closely related to that of Desai, et al. (2002) and Asquith, et al. (2005). Using portfolios that consist of stocks with the short interest ratio greater than 2.5 percent, they find that the monthly abnormal return is in the magnitude of -1.13 percent after controlling for the market, size, book-to-market (B/M), and momentum factors. Asquith, et al. (2005) also examine the performances of stocks with the short interest ratio greater than certain percent or stocks with short interest ratios in the top percentiles and find that monthly abnormal returns of equally weighted portfolios of these stocks range from -0.28 percent to -1.25 percent. Further, they document an increasingly larger negative abnormal return among the highly shorted stocks as the institutional holdings decrease. In contrast, we show that some of the documented abnormal returns can be attributed to firm characteristics such as liquidity. At the same time, we provide evidence supporting that the binding ratio is a better measure in capturing the negative information in short interests than the commonly used short interest ratio.

The rest of our paper is organized as follows. Section 2 reviews related literature and discusses the relevance of our study. We describe our data and empirical methodology in section 3. Our empirical findings and implications based on portfolios of most heavily shorted stocks are discussed in section 4. In addition, we present event study results in section 5. Section 6 provides concluding comments.

2. Related Literature

Theoretical studies on short sales have focused on how short sale constraint affects stock prices and informational efficiency. Miller (1977) argues that a stock can be overpriced with the existence of short sale constraints and heterogeneous investor beliefs because pessimistic investors are restricted from fully revealing their sentiments. Diamond and Verrecchia (1987) provide a rational expectation model in which they show that the informational efficiency will be reduced in the presence of short sale constraints, but the stock price is unbiased when market participants are risk neutral. Cao, Zhang and Zhou (2007) suggest that short sale constraints can affect the informational efficiency. Stock price can move in both directions in Diamond and Verrecchia's (1987) framework when allowing for risk averse and differences in trading sizes (also see Bai, Chang, and Wang, 2006). Recently, Duffie, Garleanu, and Pedersen (2002) present a continuous time model with short-selling fees. The prospect of lending fees may push the initial stock price above the most optimistic buyer's valuation and lead to a higher stock price. Scheinkman and Xiong (2003) also demonstrate that with short sale constraints an asset buyer acquires an option to sell the asset to other agents with more optimistic beliefs. As a result, agents are willing to pay prices that exceed their own valuation, which ultimately may cause bubble component in asset prices.

Several empirical studies have focused on the effect of short sale constraints on asset prices. For instance, using the breadth of ownership as a proxy for the short sale constraint, Chen, Hong and Stein (2002) find that more restrictive short-sale constraint can forecast lower subsequent return. By analyzing the price effects following the addition of individual stocks to a list of designated securities that can be sold short in the Hong Kong stock market, Chang, Cheng, and Yu (2007) find that short-sales constraints cause stock overvaluation and the effect is more dramatic for individual stocks with more diverse

dispersion of opinions. There are also a large number of empirical studies devoted to understand the motivation for short sales and their effect on asset prices. Brent, Morse and Stice (1990) examine three possible explanations of short sales: tax purpose, arbitrage and hedging, and speculation. They find that arbitrage and hedging account for a large proportion of short selling. Chen and Singal (2003) further document that speculative short sellers' activities can explain a significant proportion of the weekend effect—stock returns are higher on Fridays than on Mondays.[4]

Recent empirical studies have also utilized data on the equity lending market to assess the cost of selling short and its effect on stock prices. For example, D'Avolio (2002) examines a special database on lenders and finds that the number of stocks with high loan fees and steep costs to sell short is very small on average, and that monthly short interest ratio alone can not correctly approximate for the short sale constraints. Geczy, Musto, and Reed (2002) document that regular investors cannot obtain shares to short in more than seven percent cases. In addition, Jones and Lamont (2002) find that stocks that are expensive to short have high valuation and low subsequent returns. Although the equity loan market data offers a direct measure of the cost of short selling, they are not publicly available. Further, lack of a centralized equity loan market may introduce sample selection bias.

In addition, several studies link short sale orders to negative information about a firm. Aitken, Frino, McCorry, and Swan (1998) examine Australian stocks where investors can directly observe if a trade is a short sale or not. They find an immediate negative price reaction when information about a short position is revealed. Boehmer, Jones and Zhang (2005) examine a panel data that consists of electronically submitted short sale orders in NYSE from January 2000 through April 2004. They find that institutional non-program short sales are the most informative. Diether, Lee and Werner (2007) investigate the daily short sale activities of stocks listed in NYSE and NASDAQ from January 2005 to December 2005. They find that short sellers increase their trading following positive returns and can correctly predict future negative abnormal returns.

[4] They claim that because of the inability to continuously monitor and to adjust positions, speculative short sellers will cover their positions on Friday and re-establish short positions on Monday, which generates the weekend effect.

Our paper is directly related to empirical studies on how short interests is relate to subsequent stock returns. Figlewski (1981) uses short interests as a proxy for short sale constraint and finds that more heavily shorted stocks under-perform less heavily shorted stocks when using a limited sample from 1973 to 1979, but he also finds that the most heavily shorted stocks alone fail to generate statistically significant negative abnormal return. Brent, et al. (1990) and Figlewski and Webb (1993) also find little or no relation between short interests and subsequent returns. Boehme, et al.(2006) find that the stocks with high short interests and dispersed investor opinions are overvalued. But stocks are not overvalued when either the short interests or the dispersion of investor opinions are low. Asquith and Meulbroek (1995) use monthly short interest data for all NYSE and ASE stocks from 1976 to1993 and find a strong negative relation between short interest and subsequent abnormal returns. Asquith et al. (2005) use short interest as a proxy for short sale demand and institutional holding to approximate for supply of shares to short and find that the short sale constrained stocks underperform significantly for equally weighted portfolios between 1988 to 2002. Desai et al. (2002) use NASDAQ monthly short interest data from 1988 to 1994 and find that heavily shorted stocks experience significant negative abnormal return.

3. Data and Empirical Methodology

Our sample consists of NASDAQ monthly short interest data obtained from NASDAQ and covers the sample period from 1995 to 2000, which is comparable to that of Desai, et al. (2002) with more recent sample. As a convention, only stocks with short interests in excess of $10,000 or 0.01% of total market value of equity are included in the sample. The number of firms in our sample has increased over time due to an increase in the total number of listed firms. On average, our sample accounts about 70% of the total number of listed NASDAQ firms. Daily stock return data is from the Center for Research in Security Prices (CRSP). Only common stocks with share code of 10 or 11 in the CRSP are included in our sample. The institutional holding data is from Thomson Financial 13F. Since the institutional holding data only appears on a quarterly basis, we assume the institutional holding will not change in the same quarter. Our final sample consists of

147,053 firm-month observations. We obtain the daily common factor data and risk free interest rate from the Fama-French database in WRDS.

In the presence of market frictions, security prices may not fully incorporate information of all market participants. For instance, when short sale is restricted, market price of a financial asset may not fully impound the negative information of some investors. While short sales are allowed in the U.S. stock market, there are several restrictions on short sales which make selling short costly (see Shleifer and Vishny, 1997). For example, the collateralized proceeds of short sales, the difficulty to locate equity lenders, the possible earlier recall by lenders, and the forced covering of short positions by margin requirements all pose obstacles on short sellers. In addition, up until July 5, 2007, the NASDAQ short sale rule prohibits NASD members from selling short a NASDAQ-listed stock at or below the inside best bid when that price is lower than the previous inside best bid in that stock.[5] These features make short selling much more costly than buying stocks. Consequently, stock prices are more likely skewed towards reflecting good news than bad news leading to upward bias in stock prices (Miller, 1977).

Precisely because of the high cost of selling short, short interest ratio alone may not fully reflect the negative information content of short sales because it does not allow us to disentangle the cost of selling short from information. Since institutional holdings are the primary source of equity loan for short sellers, we propose an alternative measure of binding ratio—the short interest ratio divided by percentage institutional ownership to better capture the information content of short interests. The rationale for the new measure is that if investors are willing to incur a high cost to engaging in short selling, these short sales are more likely to be information driven. As we demonstrate later, the short interest ratio and the binding ratio are imperfectly correlated with their unique characteristics. Thus, we hypothesize that stocks with high binding ratios will be associated with low returns because of the negative information content.

From the summary statistics in Table 1, we see that our sample is representative and accounts for between 80% to 90% of the market capitalization of all NASDAQ stocks. Although the average return fluctuation over time echoes that of the NASDAQ and NYSE

[5] As on July 5, 2007, SEC lifted the up-tick rule on short sales. Since our data are for the period from 1995 to 2000, short sales in our analysis are subject to the up-tick requirement.

indices, the average returns of our sample are lower that those of indices. This is consistent with the fact that all the stocks in our sample have been shorted to certain degree. The lower return could thus reflect investors' negative information. On average, short interest accounts for one to two percent of the total shares outstanding. Both short interest and binding ratio exhibit an increasing trend over time. However, bind ratio fluctuates much more than short interest. During our sample period, NASDAQ stocks have experienced much higher returns than the NYSE stocks. This return difference is also coincident with the rising in short interest, which suggests a simple controlling for the Fama and French factors could be insufficient.

There are substantial differences in the short interest between the least shorted versus the most shorted stocks. Both the short interest and binding ratio are close to zero for the least shorted group. However, for the most shorted group, the short interest has increased from 8% to 12% over time. The increase is even more dramatic for binding ratio. To a large extend, these trend may simply reflect market speculation during the internet boom of the late 90s. Since we use these measures to sort stocks into portfolio, a common trend is not necessarily an issue. When comparing the characteristics of most heavily shorted portfolio to those least shorted portfolio, it is interesting to see that investors are more likely to short median size growth firms than small value firms. This is reasonable since it is difficult to borrow small firm shares to short, and growth firm are more likely to be overvalued than value firms. For binding ratio shorted portfolios, the book-to-market characteristics are very similar to those short interest shorted portfolios. However, the portfolio with largest binding ratio also contains small stocks since these stocks subject to large short sale costs. Despite their small market capitalizations, these stocks have similar liquidity to those median size stocks of the most heavily shorted stock portfolio. The portfolio with largest binding ratio tends to have smaller returns than the corresponding short interest shorted portfolio, indicating a better measure to capture the negative information over time.

However, the negative information reflected in the binding ratio may not help to predict future stock returns if markets are efficient in impounding negative information of investors. Therefore, it is important to examine price movement before and after the release of short interest data. It is exactly the institutional feature of recording and

releasing of the short interest data that helps us to test the information content of short sales. In practice, the cumulative short interest on each stock for previous month is recorded by the SEC around the 10^{th} of the current month, but the information is not released until about two weeks later. We refer the recording date as the "Trade Date" and the public releasing date as the "Publication Date" as illustrated in Figure 1 for NASDAQ stocks. To better isolate the information effect in the short interest data, we divide the time interval between two Trade Dates into two sub-periods. We define the "information effect period" ("information period" for brevity) as the period from the "Trade Date" in month *t* to the "Publication Date" in the same month, which covers 11 working days, and the "announcement effect period" ("announcement period" for brevity) as the period from the "Publication Date" of month *t* to the "Trade Date" of month *t*+1. Although the net cumulative short positions are recorded at the beginning of the information period, such information is not observable by the general public. It is possible, however, some of the negative information that short sellers possess may become public during the information period. Consequently stock prices may gradually drop during the period. However, when markets are efficient, security prices should quickly reflect all information in short interests, which leaves no subsequent price movement during the announcement period.

Most studies on the information content of short seles use the even study approach. There are many issues, however, related to event studies, including the clustering problem pertained to the long-horizon event study. One common solution to the clustering problem in this case is to form portfolios. We applied the same approach. In particular, in each month ten decile portfolios are constructed based on the short interest ratio (or the binding ratio) one day after the "Trade Date". This is different from many existing studies that form portfolios one month after the public release of the short interest data, where the possible information pertained to cumulative short positions formed almost six weeks ago. The low portfolio returns during the holding period found in these studies could mean that either investors are slow in understanding and trading on the information of the public release of short interest, or it is related to some other characteristics based factors, such as the liquidity factor that we will investigate further. Although both our study and the existing studies use the portfolio approach and sort on the same information, the return periods are very different. By focusing on the return performance differences during the

information period versus the announcement period, we are able to make a better case for the relevance of information in a reasonably unfettered environment.

In addition to the clustering issue, benchmarking is another important issue in an event study. During our sample period from 1995 to 2000, the NASDAQ stocks have witnessed a run-up of the 90s'. Consequently, NASDAQ stock portfolios tend to have positive alphas relative to the Fama and French factors, suggesting insufficient controls for the characteristics related factors. To mitigating the problem, we utilize a "matching method". Specifically, we compare the performance of the most heavily shorted stocks, measured either by the binding ratio or the short interest ratio, with the performance of their matching stocks. The matching stocks are randomly chosen in terms of the binding ratio or the short interest ratio but have similar other characteristics commonly believed to affect stock returns, such as size, book-to-market ratio, and liquidity.[6] This is in contrast to most existing studies in this literature that only control for the Fama and French factors.

The following procedure illustrates the steps to implement the matching method, controlling for firm size and book-to-market. But the same approach also applies to match the additional dimension of liquidity.

1. We divide stocks in our sample into ten portfolios using the short interest ratio (or the binding ratio), at the closing of the "trade date" of each month. We call these portfolios as the "original portfolios".

2. Using information at the closing of the "Trade Date" of each month, we form one hundred portfolios by first dividing the NASDAQ stocks that is not in the most heavily shorted decile into ten portfolios based on firm size, and then dividing each portfolio further into ten sub-portfolios based on firm's book-to-market ratio. These portfolios are used to construct matching portfolios.

3. For each stock in every original portfolio formed in step 1, we identify the corresponding portfolio constructed in step 2 by matching the size and the book-to-market of the stock with that of the portfolio. We then randomly choose one stock in

[6] See Amihud and Mendelson (1986), Brennan and Subrahmanyam (1996), Chalmers and Kadlec (1998), Chordia, Roll, and Subrahmanyam (2000), Pastor and Stambaugh (2003), and Amihud(2002), among others. They argue that investors demand a return premium on assets with low liquidity.

the identified portfolio as the matching stock. We use these matching stocks to construct our "matching portfolio".

4. We examine the performance difference between each original portfolio constructed in step 1 and its matching portfolio constructed in step 3.

The main advantage from the matching approach is better control for non-informational factors. When the data are from a particular time period or only consist of stocks from a particular market, examining the highly shorted stocks alone may lead to spurious results because of sample selection bias. For instance, if we only analyze the returns of the heavily shorted stocks traded on NASDAQ without using a control group, any characteristics specific to the NASDAQ market will likely show up in the highly shorted stocks as well. By comparing to a control group, any special characteristics pertaining to the sampling period and to the NASDAQ market will likely be eliminated. Therefore, the estimation bias will be reduced when we examine the performance differences between the two groups.

For comparison with existing studies, we also compute the abnormal returns by regressing the raw portfolio returns against Carhart (1996) four factors (see for example, Asquith, Pathak and Ritter, 2005, among others). In particular, we use daily portfolio returns to run the following time series regression:

$$r_{pt} - r_{ft} = \alpha + \beta_1 RMRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_t, \qquad (1)$$

where r_{pt} is the portfolio return in period *t*, r_{ft} is the risk free rate in period *t*, $RMRF_t$ is the market excess return in period t, SMB_t is the excess return of small size portfolio return over big size portfolio return in period *t*, HML_t is the excess return of high book-to-market portfolio return over low book-to-market portfolio return in period *t*, MOM_t is the portfolio return of the prior winner over that of the prior loser. The coefficient of intercept α measures the abnormal return.

4. Empirical Analysis on Portfolios

In this subsection, we study whether a portfolio formed based on either the widely used short interest ratio or our proposed binding ratio can generate abnormal returns with respect to a benchmark. We also investigate the possible source of abnormal returns by linking negative information of short sales to difference trading periods. In addition, we

show the importance of controlling for the liquidity factor in assessing the information content of short sales. For comparison, we also report the average returns of the portfolios formed based on the short interest ratio in the previous month. This is the approach used in Desai, et al. (2002).

4.1 Short interest ratio and binding ratio

Before studying the information content of short selling, it is important to understand the characteristics of different short sale related measures and their potential to reflect information. As discussed in the introduction, there are many reasons for short selling, such as hedging, speculation, among others. A large short interest alone may not reflect negative private information but rather as a result of differences of opinions. However, high cost of shorting due to short sale constraints will likely prevent non-information based shorting, which suggests that our proposed binding ratio may serve as a better measure in capturing the information motivated short sales than the short interest ratio. This is because the binding ratio accounts for the cost of shorting by incorporating the percentage of shares owned by institutional investors who are the primary source of equity loan for short sellers.

Table 2 shows the contemporaneous and lagged correlation between the average monthly short interest ratio and the binding ratio of NASDAQ stocks in our sample. The contemporaneous correlation between the two measures is only 0.61, indicating the significant difference between the two measures. If the binding ratio is capable of capturing the information content of short sales, the short interest ratio is likely to be a noisy measure of informative trading. Moreover, the autocorrelation of the short interest ratio is close to 0.7, implying that the short interest ratio is fairly persistent. At the same time, we also see that short interest does not change very much from month to month, suggesting persistence is largely due to the stable nature of the short interest. Therefore, short interest alone is less likely to convey new information from month to month. In contrast, the autocorrelation of the binding ratio is less than 0.3. Such a low persistence indicates the possibility for the binding ratio to reflect the arrival of information every month.

We focus on the performance difference between portfolios constructed based on the short interest and binding ratios. Beginning at one day after the “Trade Date” in each

month, we construct 10 equally weighted portfolios based on the short interest ratio and the binding ratio, respectively. Portfolio 1 consists of stocks with the lowest short interest ratios or the binding ratios, while portfolio 10 consists of stocks with the largest short interest ratios or the binding ratios. From Table 1 we see that both the short interest ratio and the binding ratio exhibit an increasing trend over our sample period, with the binding ratio fluctuating more. Such a trend might be associated with increases in speculative trading during the market run-up of the late 90s. Despite that, our results are unlikely to be biased since we control for firm characteristics and the trend existed in all the decile portfolios.

4.2 A first look at the portfolio raw return

Different from Desai, et al (2002), we first sort individual stocks into decile portfolios according to their short interest ratios released on the "Publication Date" of the *current* month. But the corresponding portfolio returns are computed by tracing back to the "Trade Date" when the short interest is recorded until the next "Trade Date." These portfolio returns are reported under the "SR_t" for the month in Table 3. In generally, there is an inverse relationship between short interest ratios and average portfolio returns although not strictly monotonic. For comparison, we also follow Desai, et al (2002), by forming the decile portfolios according to the short interest ratios released in the *previous* month. The corresponding portfolio returns are reported under the column "SR_{t-1}" in Table 3. We observe similar patterns on the average portfolio returns. For example, the average portfolio returns for the highest short interest ratio are 0.62 percent and 0.66 percent for the full month for "SR_t" and "SR_{t-1}", respectively. This is due to the high persistence in short interest. If the short interest does not change from current month to the next, both "SR_t" and "SR_{t-1}" portfolio returns will overlap with each other except for the first couple of days.

We next investigate the source of the differential returns across portfolios. For this purpose we decompose the full month return into the information period return and the announcement period return. If short selling contains negative information, portfolio returns will likely to be negative in the information period. This is indeed the case with the most heavily shorted portfolio earning -0.19 percent on average in the information period. In contrast, portfolio returns during the announcement period is much more uniformly

distributed than the whole month portfolio returns, suggesting markets are efficient in reacting to negative news in short interest once it is announced. Notice that the average portfolio returns are positive and higher in announcement period than in the information period. This is consistent with the "Turn-of-Month" effect documented in existing studies (Ariel, 1987 and Lakonishok and Smidt, 1988), where average stock returns are higher around the turn of month than the rest of month. The announcement period in our analysis covers the turn of the month. This is yet another reason to apply the matching method to mitigate the turn-of-month effect in our subsequent analysis.

When using binding ratio to sort individual stocks into portfolio, the returns for the full month under "BR_t" in Table 3 exhibit a very different pattern. In particular, the portfolio with the highest binding ratio has a -0.13 percent average full month return in contrast to the positive return when using short interest in sorting. The difference in the average returns between the short interest sorted portfolio and the binding ratio shorted portfolio is 0.75 percent and is statistically significant at a 1 percent level. This is consistent with the binding ratio being a sharper measure to capture the negative information contained than the pure short interest measure.

We further examine the portfolio return difference between the information period and the announcement period. The portfolio of the most heavily shorted stocks based on the binding ratio has an average return of -0.82 percent during the information period, which is 0.63 percent (statistically significant at 1 percent level) lower than that of portfolio shorted on short interest ratio. In contrast, for the announcement period, the average return for the short interest ratio sorted decile 10 portfolio is 0.82 percent, while the average binding ratio sorted decile 10 portfolio return is 0.89 percent. The difference in the two portfolio returns is statistically insignificant. This indicates that the majority return difference occurred in the information period.[7] There is also no statistically significant difference between decile 1 and decile 10 portfolio returns during the announcement period. Therefore, the markets seem to be efficient once short sale information being announced. The average portfolio returns are also somewhat hump shaped across different deciles. However, the hump shape for the announcement period

[7] Note that the returns in the announcement period and the information period do not add up exactly to that of the whole period due to compounding.

returns is much attenuated than for the whole month return. Such a pattern could be related to individual stocks' characteristics, which provides another motivation to use matching approach.

4.3 Empirical analysis of portfolios without matching

Results from the last subsection suggest that the underperformance in the full month period of the most heavily shorted stock portfolio, formed either by short interest ratio or the binding ratio, is mainly due to the underperformance of the stocks in the information period. However, portfolio return differences could simple due to differences in risk characteristics. We further examine the information content of short interests using the approach in existing studies by estimating the abnormal returns (with respect to the four factors Carhart model) of portfolios formed using the short interest ratio and the binding ratio.

Panel A of Table 4 shows the monthly abnormal returns of different portfolios formed based on the short interest ratio and the binding ratio, respectively. For the most heavily shorted stocks based on the short interest ratio, the average monthly abnormal return is 0.69 percent and is statistically insignificant. For the most heavily shorted stocks based on the binding ratio, the monthly abnormal return is -0.12 percent and continues to be insignificant. At first glance, this result seems to suggest that short interests do not contain any negative information or may even contain positive information about a stock's subsequent return. However, after examining the performances of other portfolios, we find that the abnormal return almost monotonically decreases as the stocks are more heavily shorted using both the short interest ratio and the binding ratio. This evidence indirectly suggests that short interests may indeed contain negative information on stock returns.

When we use the short interest ratio in previous month (SR_{t-1}) to form portfolios as in Desai, et al. (2002), we find similar results as using the short interest ratio in current month to form portfolios. In fact, controlling for the four factors does not seem to change the return magnitude of the most heavily shorted stock portfolio comparing with that from Table 3. These evidences mean that either we have an insufficient control or SR is not very informative when compared to the BR measure. Therefore, we can do a similar exercise by sorting stocks according to their last period's binding ratio ratios (BR_{t-1}). From

the last column in Table 4, we see that the alpha of 0.21 percent (sorting on BR_{t-1}) is significantly larger than that of -0.12 percent (sorting on BR_t). In other words, the last month binding ratio contains much less negative information about current returns than the current binding ratio does. If the markets are efficient, the binding ratio is a more informative measure.

Our results from Panel A of Table 4 seem to be inconsistent with the original results presented in Desai, et al. (2002), who documented very significant abnormal returns for the most heavily shorted stocks according to short interest ratio. Here, we offer three possible reasons. First, their sample period runs from 1988 to 1994, which does not have any overlapping with our sample period. Therefore, the original results could be sensitive to different sample periods. Second, when examining the performance of the 99th percentile portfolio in our sample, we also find significant negative abnormal returns. Thus, it is possible that the negative abnormal returns found in the existing studies are more concentrated on few heavily shorted stocks. In fact, most studies use 95th or 99th percentiles as the threshold to construct their portfolios. In our subsequent analysis, we utilize the matching method and are able to detect the underperformance of the 90th percentile portfolio, suggesting the negative information contained in the short sales is more pervasive than previously documented.

Perhaps, it is more plausible that during our sampling period, NASDAQ stocks have experienced much faster growth than NYSE stocks as shown in Table 1. The four factors used in the regression might capture the risk characteristics of NYSE stocks better than those of NASDAQ stocks. In fact, when regressing NASDAQ composite monthly index returns on the four factors over our sample period, we obtain a statistically significant positive alpha of 0.6 percent. In other words, the NASDAQ stocks as a group have under-priced with respect to the four factor model. A simple exercise is to subtract the NASDAQ index retrun from that of the portfolio return before running the four factor model,[8] The results are reported in Panel B of Table 4. Indeed, the simple adjustment results very significant negative alphas of -0.11 percent and -0.05 percent for short interest ratio and binding ratio shorted portfolios, respectively. This evidence suggests that the

[8] Since the NASDAQ index returns and the market returns are highly correlated over time with different means, including a NASDAQ index as an additional factor in equation (1) will not resolve the issue.

sample selection bias associated with NASDAQ stocks in this particular time period could be significant. In other words, using the standard factor adjusted abnormal returns to study the information content of short interests and its effect on stock prices is insufficient. For correct inference, we use a matching approach in the subsequent analysis.

4.4 Empirical analysis of portfolios with matching

We next examine whether the differences in average portfolio returns among different portfolios can be attributed to the differences in firm characteristics. Before matching the non-event firms to our sample according to characteristic, we first examine the differences in size and book-to-market ratio (B/M) of firms. As shown in Table 1, for portfolios constructed based on the short interest ratio, the more heavily shorted stocks are bigger in size, but this trend is not strictly monotonic. The average size of the most heavily shorted stocks is approximately $915 million, while the average size of the least shorted stocks is much smaller at slightly under $150 million. This is partly due to the fact that it is easier to borrow shares of large firms than small firms. For the portfolios constructed based on the binding ratio, the skewness of the size distribution with regard to the binding ratio is much more attenuated. The largest and smallest decile portfolios are both small and are comparable in size, while firms with moderate binding ratio are larger in size. In contrast, the average firm book-to-market ratios are almost monotonically decreasing with the short sale activity based on either their short interest ratios or binding ratios. The average book-to-market ratios increase from 0.44 (0.52) for the largest decile portfolio to 0.89 (0.90) for the smallest decile portfolio shorted on the short interest ratio (binding ratio). This result seems to suggest that the underperformance of the heavily shorted stocks may be due to the lower book-to-market ratio of stocks included in the portfolio.

There are other firm characteristics that can not be simply captured by the differences in the known firm characteristics. As mentioned above, the NASDAQ index return itself has monthly alpha of 0.6 percent with respect to Fama and French factors. In addition, there are a possible “Turn-of-Month” effect in the announcement period and a sample selection bias due to the inclusion of only NASDAQ stocks. A simple approach to control for these factors is to use a matching method to examine the negative information

contained in short interests. The basic idea of the matching method is to compare the performance of the most heavily shorted stocks with the performance of a matching portfolio. Stocks in a matching portfolio are randomly chosen from a pool of NASAQ stocks that are not heavily shorted but with similar other characteristics, such as size and book-to-market. We then form the zero-investment portfolio by taking a long position in the heavily shorted portfolio (we refer to it as the "original portfolio") and a short position in the matching portfolio. We also extend our matching characteristics to include liquidity later.

Since the matching method controls for firm characteristics in both the portfolio of the heavily shorted stocks and the matching portfolio, any abnormal return in the zero-investment portfolio is associated with factors other than the matched firm characteristics. Using a zero investment portfolio also mitigates the sample selection bias problem associated with using NASDAQ stocks only and the particular boom time for the sampling period. Similarly, the matching method can remove the "Turn-of-Month" effect in the zero-investment portfolio because the "Turn-of-Month" effect appears in both the original portfolio and its matching portfolio.

Panel A of Table 5 reports the average daily return of the zero-investment portfolio constructed based on the short interest ratio and the binding ratio, respectively, for three periods: the full month between two consecutive "Trade Dates," the information period, and the announcement period. The average daily return in the full month period is -0.04 percent and statistically significant for the zero-investment portfolio of the most heavily shorted stocks based on short interest ratio. In contrast, the least shorted portfolio has an average return of 0.014 but is insignificant, which is consistent with the hypothesis that short sales contain negative information and shows the importance of matching. For the binding ratio sorted portfolios, the average daily return of the zero investment portfolio for the most heavily shorted stocks is much more negative at -0.058 percent with a significance level of 1% in the full month period. The lowest binding ratio shorted portfolio has an even lower insignificant average daily return of 0.007 percent. Other thing being equal, binding ratio is a better measure in reflecting the negative information in short sales.

To demonstrate when the underperformance of the zero-investment portfolio of the most heavily shorted stocks occurs, we compute the average daily returns in both the information period and the announcement period. We see in Panel A of Table 5 that, for the decile 10 portfolio sorted according to short interest, the average return is -0.05 percent with a significance level of five percent in the information period. In contrast, the daily average return for the most heavily shorted stocks is -0.027 percent and statistically insignificant in the announcement period.[9] When using the binding ratio to form the original portfolios, the average daily return of the zero-investment portfolio of the most heavily shorted stocks is -0.09 percent in the information period and statistically significant at the one percent level. The average return in the announcement period continues to be insignificant. For the least shorted portfolio, there is no statistically significant difference between information period return and announcement period return.

These results continue to suggest that the underperformance in the full month period for the most heavily shorted stocks is mainly due to the underperformance of these stocks in the information period. These stocks do not underperform in the announcement period when the short interest data is revealed to the public. This is consistent with the notion that short interests might contain negative information, but the information is quickly impounded into security prices in an efficient market when the short interests are released to the public. After all, there are no profitable trading strategies based on announced short interest. The negative returns in the information period could reflect either public release of negative news that only short seller might have before the announcement of the short interests.

Our matching method above explicitly controls for the firm size and the book-to-market ratio. To the extent that the zero-investment portfolio may still have positive exposure to other systematic factors such as the momentum factor, we use Equation (1) to estimate the abnormal returns of the zero-investment portfolio. Panel B of Table 5 reports the daily abnormal return for the zero-investment portfolios. Our results confirm that the most heavily shorted stocks, measured by either the short interest ratio or the binding ratio, continue to underperform. For example, when the short interest is used to form the

[9] Since both the information period and the announcement period contains roughly 11 days, the average of the average announcement period daily return and the average information period daily return should be roughly equal to the average whole month daily return.

original portfolio, the daily abnormal returns for decile 10 are -0.05 percent, -0.06 percent and -0.04 percent for the full month, the information period and the announcement period, respectively. Similarly, when the binding ratio is used to form the original portfolios, the daily abnormal returns of the decile 10 portfolio is -0.07 percent, -0.10 percent, and -0.04 percent for the full month, the information period and the announcement period, respectively. Although the abnormal returns are about twice as large in the information period as in the announcement period, all these returns are now statistically significant.

Despite the insignificant average zero investment portfolio returns in the announcement period, these returns have positive correlation with the Fama and French factors, resulting in more negative abnormal returns. In other words, considering the potential other risks the portfolio carries, it performed even worse. Since these returns occurred after the public release, it seems to imply that short interests still have predictive power. Therefore, it is important to understand where the negative announcement period abnormal returns might come from. One possibility is the uncounted liquidity risk. In the next subsection, we extend our matching method to include liquidity as an additional firm characteristic in our matching procedure.

4.5 Liquidity and underperformance of heavily shorted stocks

Recent studies have documented that liquidity is an important factor in determining stock returns. The predictive power of short interests for the underperformance of the most heavily shorted stock portfolio after the public release of the short interests might be attributable to differences in firms' liquidity characteristics omitted from our matching procedure. Various measures of liquidity have been proposed in the literature. We use turnover, defined as the number of shares outstanding divided by the average daily trading volume of the previous month, as a proxy for liquidity in our matching procedure along with the firm size and the book-to-market ratio matching.

The matching procedure discussed in Section 3 can be modified as follows. In step 2 above, we divided individual stocks into one hundred and twenty five groups by first sorting the entire NASDAQ stocks (excluding the most heavily shorted stocks) into five quintiles based on size. We then further sort stocks in each quintile into five quintiles based on their book-to-market ratios. Finally each sub-quintile is also sorted into three

equally divided groups based on individual stocks' turnover ratios. For each stock in every original portfolio formed based on either the short interest ratio or the binding ratio, we identify the corresponding matched group according to the size, the book-to-market, and the turnover of the stock. We then randomly choose one stock in the identified group as the matching stock. These matched stocks are used to construct our "matching portfolio". The zero-investment portfolios are then formed as before by taking a long position in the original portfolio and a short position in the matching portfolio. Results are reported in Panel C of Table 5

In contrast to the results reported in Panel A of Table 5, the average daily return of the zero-investment portfolio of the most heavily shorted stocks is no longer always negative. In fact, when portfolios are formed based on the short interest ratio, the average daily returns of the most heavily shorted zero-investment portfolio reduce to -0.01 percent in the full month period, -0.04 percent in the information period, and 0.02 percent in the announcement period. Further, none of the estimates is statistically significant. In contrast, when portfolios are sorted on the binding ratio, the average daily return of the zero-investment portfolio of the most heavily shorted stocks is -0.06 percent and statistically significant in the full month period. Furthermore, the underperformance in the full month period is largely due to the underperformance in the information period with an average daily return of -0.13 percent and statistically significant. The actual portfolio return in the announcement period is positive at 0.02 percent but insignificant. These results indicate that the short interest ratio alone is too noisy to display any potential negative information after properly controlling for liquidity, while the binding ratio is indeed a better measure to capture the negative information in short sales. Moreover, the negative information content largely confined in the information period when data on cumulative short positions are collected but yet released. Upon public releasing of the short interest data, it has no predictable power on subsequent stock returns.

We further control for other factors after matching by computing the abnormal returns similar to those reported in Panel B of Table 5. From Panel D of Table 5, we see that the daily abnormal returns of the zero-investment portfolio of the most heavily shorted stocks based on the short interest ratio remain negative and insignificant in all three periods after controlling for the Carhart four factors. The finding is in contrast to those

reported in Panel B of Table 5 when only size and book-to-market are used in the matching procedure. On the contrary, when the binding ratio is used to form the original portfolios, the daily abnormal return of the zero-investment portfolio of the most heavily shorted stocks is -0.06 percent and marginally significant at a five percent level for the full month period. Similar to the finding reported in Panel C of Table 5, the significant negative abnormal return of the zero-investment portfolio is mainly observed in the information period with a magnitude of -0.14 percent (or -35.3 percent annualized) in the information period. The daily abnormal return is less than 0.01 percent and insignificant in the announcement period.

Our results suggest that the short interest ratio alone does not effectively reveal the negative information in short sales after controlling for the liquidity factor in addition to the size and the book-to-market factors in the matching procedure. Findings of the existing studies on the underperformance of the most heavily shorted stocks based on the short interest ratio are likely due to differences in the exposure to the liquidity risk. Meanwhile the binding ratio does reveal negative information in short sales even after carefully controlling for various risks and characteristics. Our results further demonstrate the importance of accounting for the supply side effect of short selling, that is, information based short sale is likely to be confirmed in stocks with limited institutional ownership. Consistent with the efficient market hypothesis, the underperformance of the heavily shorted stocks occurs only in the information period before the short interest data is released to the public, not afterwards.

4.6 Robustness check on the matching order of control variables

Our matching method above is implemented in the order of first matching on firm size, then on the book-to-market, and finally on the liquidity. We now examine whether our results is robust to a matching procedure that is independent of the matching order. Specifically, in step 2 of the matching procedure, we divide the entire NASDAQ stocks (excluding our sample) into one hundred twenty five groups based on firm size, book-to-market, and liquidity independently as follows. Consider that firm size, book-to-market, and liquidity form a three-dimensional space with the firm size and the book-to-market each taking five ranges of values and the liquidity taking three ranges of values. The ranges

of values for each dimension are chosen such that there are equal numbers of stocks in each group on any one dimension. In step 3, for each stock in the original portfolios, we identify its associated group by locating the co-ordinates of size, book-to-market, and liquidity similar to the stock. We then randomly select one stock from that group to be included in the matching portfolio.

The last row in Table 5 presents the results using such an independent ordering procedure. The results are consistent with those using the ordered matching procedure shown in the previous row. When the original portfolios are formed on the short interest ratio, the abnormal returns of the zero-investment portfolio of the most heavily shorted stocks are negative but insignificant in all three periods (the full month, the information period, and the announcement period). In contrast, when the original portfolio is constructed based on the binding ratio, the daily abnormal return of the most heavily shorted portfolio has a mean of -0.07 percent and statistically significant in the full month period. The negative abnormal returns are much larger at -0.12 percent and highly significant in the information period, but much smaller and insignificant at -0.03 percent in the announcement period. Our results are thus robust to variable ordering used in the matching procedure.

5. An Event Study on the Announcement Event

Our empirical analysis on portfolios formed according to either short interest ratio or binding ratio suggests possible information related short sales. The portfolio methodology used in many empirical studies certainly has the advantage to examine the longer horizon returns while avoiding the possible clustering effect. At the same time, the traditional event study approach offers the advantage of controlling for other non-event related effects by pooling events occurred at different calendar dates. However, the difficulty we usually face in event study is finding the right benchmark to compare. Since we have introduced the matching approach, it is useful to further investigate the information content of short sale using the event study approach.

5.1 Cumulative abnormal returns

To implement an event study to investigate the negative information content in short sales, we first define the event day as the "Publication Date" of the short interest. As before, we focus on the group of stocks that are the most heavily shorted. Since there are exactly 11 business days between "Trade Date" and the "Publication Date", we estimate the cumulative abnormal returns of the most heavily shorted stocks for twenty two days starting one day after the "Trade Date" in each month. We also estimate the cumulative abnormal returns of the most heavily shorted portfolio starting at the "Publication Date" and ending one day before the "Trade Date" of next month. We compute the abnormal return as the difference between the returns of the most heavily shorted portfolio and a benchmark portfolio. In particular, two benchmark portfolios are used—the value-weighted market portfolio, and the ordered matching portfolio constructed in Section 4.5 by matching firm size, book-to-market, and liquidity.[10]

Figure 2 shows the cumulated abnormal returns of the most heavily shorted portfolio formed on the short interest ratio or the binding ratio for the event window which covers twenty two days starting one day after the "Trade Date" of each month (Panel A). The cumulated abnormal return is computed based on the abnormal return with respect to the benchmark stocks selected in an ordered match on firm size, book-to-market, and liquidity. During the information period (the first eleven trading days), the cumulated abnormal returns for the most heavily shorted stocks according to binding ratio (the solid line) decline in the information period and remain negative in the announcement period. In fact the CAR is flat during the announcement period, indicating that investors learn the negative news and react rationally. Two possible factors could attribute to the steady decline in the information period. If short seller possess negative information about a firm's future performance and these information gets released or leaked during the information window, stock returns will drop to reflect the negative information, which will cause the CAR to decline. Second, if short sale is in reaction to overreaction to good new, stock prices also tend to correct subsequently. However, as argued in the introduction in the case of overreaction to good news, the drop should be larger for when using short interest sorted portfolio than that using binding ratio shorted portfolio. This is not the case

[10] We have also tried the non-ordered matching portfolio to construct the benchmark as discussed in Section 4.6. The results are similar to those using ordered marching.

here. For the most heavily shorted stock sorted according to short interest, however, the CAR (the dotted line) has a much weaker pattern. There is a small decline five days before the announcement day.

Panel A of Table 6 reports the average cumulative abnormal return for the most heavily shorted portfolios, for the full month period, the information period, and the announcement period. When stocks are selected with the largest short interest ratios, the average cumulative abnormal returns for the full month are -0.56 percent and -0.18 percent with respect to the value-weighted market benchmark and the matching benchmark (with firm size, book-to-market, and the liquidity), respectively, The estimates are insignificant for both cases. For the announcement period, the average cumulative abnormal returns are both positive when the benchmarks are the value-weighted market portfolio and the matching portfolio. These estimates are again insignificant. The average cumulative abnormal returns are -0.86 percent and -0.38 percent in the information period when using the market portfolio and the matching portfolio as benchmarks, respectively. However, only the average CAR with market portfolio as benchmark is statistically significant at the five percent level. This result again demonstrates the need to have a better benchmark in event study.

When the binding ratio is used to form the portfolios, the cumulative abnormal return for the full month is statistically insignificant for all two benchmarks. For the announcement period, the estimate is significantly positive when the benchmark is the market portfolio and insignificant when the matching portfolio is used as the benchmark. However, the cumulative abnormal return for the information period is -0.95 percent and -1.44 percent when the benchmark is the market portfolio and the matching portfolio, respectively. Both estimates are statistically significant at the five percent level. This result is again consistent with our evidence on portfolio returns. By adopting the matching method to remove the sample selection bias, we find that the negative information contained in short sales is more pervasive than previous studies have documented. Our results also confirm the findings that the binding ratio is a more useful measure in capturing the negative information contained in short sales and the underperformance of the most heavily shorted stocks exists only before the short interest data is publicly released. The published short interest data has no predictive power on the future returns.

5.2 Earnings surprises and underperformance of heavily shorted stocks

Our analysis above provides consistent and robust empirical evidence on the negative information content of short sales when the most heavily shorted portfolio is formed on the binding ratio. Furthermore, the negative information seems to exist only in the information period before its public release. Consequently, an important question is the source of the negative information contained in the short interests. One possibility is the anticipated forthcoming earnings announcement of a firm. When investors believe a firm's earning will be below the market expectation, they will short the stock. In other words, it is unlikely that there will be no negative earning surprise when there are enough investors shorting the stock before the earning announcement. Therefore, we further explore the relation between quarterly earnings surprises and the underperformance of the most heavily shorted stocks by examining both the abnormal returns and the cumulative abnormal returns.

To examine if the negative information of the short interests is associated with negative earnings surprises, we divide the most heavily shorted stocks into two groups. The first group consists of stocks with negative earnings surprises reported in the month following the "Trade Date" of that month, while the second group consists of all other stocks. We define earnings surprises as the difference between analysts' consensus earnings forecasts and actual reported quarterly earnings. Earnings announcement data and analysts' earnings forecasts are obtained from the I/B/E/S dataset. We only include forecasts within fifty days prior to the earnings announcement to eliminate stale forecasts and use the mean as the consensus forecast.

Panel B in Table 6 shows the abnormal returns for the most heavily shorted stocks that happen to report negative earnings surprises between the current and the next "Trade Date" and for the most heavily shorted stocks without reporting negative earnings surprises over the full month, When the original portfolios are formed using the short interest ratio, the group of the most heavily shorted stocks reported negative earnings surprises in the following month has a -0.22 percent abnormal return for the full month period and -0.34 percent abnormal return for the information period. Both estimates are highly statistically significant with a p-value less than one percent. For the announcement period, while the

abnormal return remains negative, it is statistically insignificant. In the meantime, for the group of the most heavily shorted stocks according to short interests without experiencing negative earnings surprises in the full month period, the abnormal return ranges from -0.02 percent for the information period to 0.01 percent for the announcement period. The estimates are all statistically insignificant. These results suggest that when short interest ratio contains information, it is mostly related to negative earning surprise. Since these events only count a very small portion of our sample, we cannot claim a pervasive information content in the short interest.

When the binding ratio is used, the group of the most heavily shorted stocks reported negative earnings surprises in the following month has experienced a negative abnormal return of -0.21 percent, -0.37 percent, and -0.06 percent for the full month, the information period, and the announcement period, respectively. The estimates are statistically significant for the full month and the information period but insignificant for the announcement period. For the portfolio of the most heavily shorted stocks without reporting negative earnings surprises in the following month, the abnormal return is insignificant for the full month and the announcement periods. While the abnormal return is significantly negative for the information period with a magnitude of -0.13 percent, which is one third of those stocks that have reported negative earnings surprises. Different from short interest ratio, our results suggests that binding ratio may reflect both negative earning surprises and other negative private information. Moreover, the negative information content is concentrated in the information period and no longer has a large effect on stock returns when it is released to the public.

We can further investigate the cumulative abnormal returns for the most heavily shorted stocks according to binding ratio in Figure 3. For the most heavily shorted stocks with subsequent negative earning surprises, the cumulative abnormal return drop is large and steadily in the information period (the dot-dash line). The drop in CAR continues at the beginning of the announcement period since some of the firms announced earning surprises in this period. For the rest of the firms in our sample, the pattern for the CAR (the dotted line) is very similar to that reported in Figure 2, namely it first decreases in the information period and then is flattened out in the announcement period. For comparison, we have also drawn the total cumulative abnormal returns in Figure 3 (the solid line). It is

interesting to see that despite the large magnitude for the subsample with negative earning surprises, it have very limited impact to our total sample.

In Figure 4, we further separate the negative earning announcement occurred in the information period versus in the announcement period for the most heavily shorted stocks according to the binding ratio. When the negative earning news occurred in the information period, the steady drop in CAR indeed is only in the information period with no further decrease in the announcement period. In contrast, when the negative earning news is in the announcement period, a large drop occurs when short interest is announced, suggesting that investors rationally react to the negative news about the future earnings. It is also interesting to see that there are drops before the announcement day, which could be due to information leakage. The important thing is that such a leakage should be much smaller than the full negative news. This is indeed the case since the solid line is below the dotted line in Figure 4.

To see the statistical significance in the CARs shown in Figure 3, we report the cumulative abnormal returns for the sample of the most heavily shorted stocks reporting negative earnings surprises in the month and without reporting negative earnings surprises for the full month in Panel C of Table 6. When the stocks are selected using the short interest ratio, the cumulative abnormal returns for stocks reported negative earnings surprises is -4.32 percent for the full month, -3.26 percent for the information period, and -1.06 percent for the announcement period, respectively. The estimate is marginally significant for the full month but highly significant for the information period. It is insignificant for the announcement period. In contrast, for the portfolio of heavily shorted stocks without reporting negative earnings surprises, the cumulative abnormal return is statistically insignificant for the full month, the information period, and the announcement period. This is consistent with the daily abnormal return results.

When the portfolios are formed using the binding ratio, the most heavily shorted portfolio of stocks reported negative earnings surprises has a negative cumulative abnormal return of -4.50 percent for the full month and -3.23 percent for the information period, respectively. The estimates are very similar to the ones found for the portfolios formed using the short interest ratio in magnitude and statistical significance. The estimated cumulative abnormal return for the announcement period is much smaller at -

1.22 percent but statistically insignificant. For the portfolio of heavily shorted stocks without reporting negative earnings surprises, the cumulative abnormal return is negative at -1.12 percent for the full month and -1.36 percent for the information period. However, the estimates are much smaller than that for the portfolio of stocks reported negative earnings surprises and only significant for the information period not for the full month. For the announcement period, the estimated abnormal return is positive at 0.24 percent but insignificant.

Panel C of Table 6 also shows that for heavily shorted stocks that also have experienced negative earning announcement only in the information period, the negative information is largely related to the earning announcement since the CAR is only significant in the information period. In contrast, when the announcement occurred in the announcement period, the negative earning news is only part of the negative news reflected in the short sale data since the whole month drop in this case is more than twice as large as that of the first case where earning news is only in the announcement period.

The analysis in this section reveals that, while short interest ratio might contain negative information, such negative information is limited to earning surprises. This is why we tend to see no under performance without separating out the group of stocks with both large short interest and experienced negative earning surprises later. In contrast, our binding ratio is capable of capturing both the negative earning surprises news and other negative information, which makes it a more accurate measure for the information content of short sales.

6. Conclusions

In order to provide convincing evidence on the information content of short interests, we apply a matching approach to control for many asset pricing factors and to explore a unique feature of in the time lag between the establishment of monthly cumulative short positions (the Trade Date) and the public release of the information (the Publication Date) of the monthly NASDAQ short interest data from 1995 to 2000.. By adopting the matching method, we not only account for popular factors such as the firm size, the book-to-market, and the liquidity, but also significantly reduce sample selection bias associated with NASDAQ stocks, the particular sample period associated with the booming stock market,

and the turn-of-month effect, among others. Recognizing the two different time periods allows us to rationalize evidence within the efficient market framework. We also demonstrate the importance of considering the supply side effect of short sales by proposing a binding ratio in order to better capturing the information content of short sales.

Our empirical evidence indicates that the negative information contained in the short interests is more pervasive than previously documented. The portfolio of the most heavily shorted stocks constructed using the binding ratio has an average negative abnormal return as large as -35 percent annualized in the information period after the cumulative short interests date are collected but before the information is released to the public. Upon the release of the short interests data to the public, the portfolio of the most heavily shorted stocks does not significantly underperform when necessary factors are controlled for. This suggests that the published short interest data can not be used to construct trading strategies to generate abnormal profits, which is consistent with the efficient market hypothesis. We also show that the underperformance of the most heavily shorted stocks found in many existing studies using the short interest ratio is closely related to the liquidity factor.

We also attempt to explore the source of the negative information associated with short interests. For those stocks with negative earning news, we found that a large portion of the negative information related reflected by short sales can be counted for by the negative earnings surprises reported after the Trade Date in current month. Moreover, majority information reflected by short sales does not seem to be earning driven. A robustness check using the event study approach, in addition to the portfolio return approach, confirms our findings. Our evidence and approach to draw conclusions provides a unique perspective in establish the link between the short sale activities and the negative information content.

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, *Journal of Finance* 53, 2205-2223.

Amihud, Yakov, 2002, Illiquidity and stock returns: cross-section and time-series effects. *Journal of Financial Markets* 5, 31-56

Amihud,Yakov, and Haim Mendelson, 1986, Asset pricing and the bid-ask spread, *Journal* of *Financial Economics* 17, 223-249.

Ariel, Robert, 1987, A Monthly Effect in Stock Returns, *Journal of Financial Economics* 18, 161-174.

Asquith, Paul, and Lisa Meulbroek, 1995, An empirical investigation of short interest, unpublished M.I.T. working paper.

Asquith, Paul, Parag A. Pathak, and Jay R. Ritter, 2005. Short interest, institutional ownership, and stock returns, *Journal of Financial Economics*, 2005, vol. 78, issue 2, pages 243-276

Bai, Y., E. Chang, and J. Wang, 2006, Asset prices under short-sale constraints, working paper, University of Hong Kong and MIT.

Barber, Brad M., John D. Lyon, 1997, Detecting long-run abnormal stock returns: The empirical power and specification of test statistics, *Journal of Financial Economics*, 1997, vol. 43, pages 341-372

Boehmer, E., C. Jones, and X. Zhang, 2005, Which Shorts are Informed, forthcoming *Journal of Finance*.

Boehme, Rodney D., Bartley R. Danielsen, and Sorin M. Sorescu, 2006, Short sale constraints, differences of opinion, and overvaluation, *Journal of Financial and Quantitative Analysis*, Jun2006, Vol. 41 Issue 2, p455-487

Brennan, Michael, and Avanidhar Subrahmanyam, 1996, Market microstructure and asset pricing: On the compensation for illiquidity in stock returns, *Journal* of *Financial Economics* 41,441-464.

Brent, Averil, Dale Morse, and E. Kay Stice, 1990, Short interest – explanations and tests, *Journal of Financial and Quantitative Analysis* 25, 273-289.

Brown, S., and J. Warner, 1980, Measuring security price performance, *Journal of Financial Economics*, 8, 205-258

Brown, S., and J. Warner, 1985, Using daily stock returns: the case of event studies, *Journal of Financial Economics*, 14, 3-31

Cao, Henry H., Harold H. Zhang, and Xin Zhou, 2007, Short sale constraint, informational efficiency and asset price bias, working paper, Cheung Kong Graduate School of Business and The University of Texas at Dallas.

Chalmers, John M., and G. B. Kadlec, 1998, An empirical examination of the amortization spread, *Journal of Financial Economics* 48,159-188.

Chen, Honghui, and Vijay Singal, 2003, Role of speculative short sales in price formation: the case of weekend effect, *Journal of Finance 58*, 685-705

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

Chordia,Tarun, Richard Roll, and Avanidhar Subrahmanyam, 2000, Commonality in liquidity, *Journal of Financial Economics* 56, 3-28.

D'Avolio, Gene, 2002, The market for borrowing stock, *Journal of Financial Economics* 66, 271-306.

Desai, Hemang, K. Ramesh, S.R. Thiagarajan, and B. V. Balachandran, 2002, An investigation of the informational role of short interest in the Nasdaq market, *Journal of Finance* 57, 2263-2287.

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

Diether, K.B., Lee, Kuan-Hui and Werner, Ingrid M., 2007, Can Short-Sellers Predict Returns? Daily Evidence, EFA 2006 Zurich Meetings

Duffie, D., N. Garleanu and L.H. Pedersen, 2002, Securities Lending, Shorting and Pricing. *Journal of Financial Economics* 66, 307-339.

Fama, Eugene F. and Kenneth R. French, 1992, The cross-section of expected stock returns, *Journal of Finance* 47, 427-465

Figlewski, Stephen, 1981, The informational effects of restrictions on short sales; Some empirical evidence, *Journal of Financial and Quantitative Analysis* 16, 463-476.

Figlewski, S. and G.P. Webb, 1993, Options, Short Sales, and Market Completeness. *Journal of Finance* 48, 761-777.

Harris, Milton and Artur Raviv, 1993, Differences of Opinion Make a Horse Race? Review of Financial Studies 6, 473-506.

Jones, C. and O. Lament, 2002, Short-sale constraints and stock returns, *Journal of Financial Economics* 66, 207-239.

Lakonishok, J. and S. Smidt, 1988, Are Seasonal Anomalies Real? A Ninety Year Perspective, *Review of Financial Studies* 1, 403-425.

Miller, Edward, 1977, Risk, uncertainty, and divergence of opinion, *Journal of Finance* 32, 1151-1168.

Pastor, Lubos and Robert F. Stambaugh, 2003, Liquidity Risk and Expected Stock Returns, *Journal of Political Economy* 111, 642-685.

Scheinkman, J. and W. Xiong, 2003, Overconfidence and speculative bubbles, *Journal of Political Economy* 111, 1183-1219.

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

Table 1 Summary Statistics

This table reports the summary statistics for monthly short interest and binding ratio as well as firm characteristics for each year between 1995 and 2000. For the full sample, these includes the number of firms in the sample, the percentage of market capitalization of these firms in total NASDAQ market capitalization, the average return, the standard deviation, the average return for the NASDAQ (or NYSE) stocks, and the average short interest (or binding) ratio. For Decile 1 and Decile 10 portfolios formed on the short interest (or binding) ratio, the firm characteristics include the average short interest (or binding) ratio (SR or BR), the average return of the portfolio (R_t), the average market capitalization of firms in the portfolio (Size), the average book-to-market ratio (B/M), and the liquidity measured by shares outstanding of a firm divided by its trading volume in the previous month (Liq).

	Panel A: Short interest ratio															
	Full Sample						Decile 1					Decile 10				
Year	# of firms	% Mkt Cap	Avg R_t %	StD R_t %	NASDAQ Avg R_t %	Avg SI %	SR %	R_t %	Size	B/M	Liq %	SR %	R_t %	Size	B/M	Liq %
1995	3062	80.11	2.50	16.90	2.87	1.15	.0009	1.93	72.5	0.742	3.441	7.93	1.59	449.3	0.395	1.258
1996	3421	82.11	1.84	17.40	1.84	1.21	.0011	1.26	85.9	0.720	1.427	8.04	1.06	689.4	0.354	0.881
1997	3657	84.99	1.00	17.19	1.81	1.42	.0015	1.99	99.8	0.735	2.161	9.33	-0.67	697.3	0.400	1.221
1998	3651	83.16	1.00	24.42	3.22	1.58	.0012	-0.03	103.9	0.852	1.108	10.25	2.47	777.9	0.455	0.010
1999	3485	78.38	3.23	27.12	5.59	1.69	.0007	1.57	234.2	1.023	0.368	11.53	3.70	1072.6	0.437	0.258
2000	3704	92.33	-1.80	27.62	-3.30	1.68	.0006	0.16	287.7	1.266	1.705	10.62	-4.66	1809.0	0.607	0.012
	Panel B: Binding ratio															
	Full Sample						Decile 1					Decile 10				
Year	# of firms	% Mkt Cap	Avg R_t %	StD R_t %	NYSE Avg R_t %	Avg BR	BR	R_t %	Size	B/M	Liq %	BR	R_t %	Size	B/M	Liq %
1995	3062	80.11	2.50	16.90	2.13	0.29	.00006	1.81	82.0	0.764	3.421	2.659	1.30	130.7	0.417	1.693
1996	3421	82.11	1.84	17.40	1.23	0.52	.00007	1.66	104.4	0.741	1.400	4.953	0.39	167.0	0.393	1.089
1997	3657	84.99	1.00	17.19	1.89	0.93	.00011	1.91	156.3	0.742	1.759	9.058	-1.49	177.8	0.490	1.649
1998	3651	83.16	1.00	24.42	1.51	1.54	.00010	-0.18	209.7	0.847	2.729	15.120	1.04	193.6	0.545	0.026
1999	3485	78.38	3.23	27.12	4.59	2.70	.00006	1.26	409.6	1.041	0.365	26.715	3.95	241.6	0.520	0.275
2000	3704	92.33	-1.80	27.62	-1.32	1.59	.00005	0.15	492.5	1.265	1.700	15.530	-5.86	404.2	0.738	1.741

Table 2 Correlation between Monthly Average Short Interest Ratio and Monthly Average Binding Ratio

This table reports the correlation between monthly average short interest ratio and binding ratio for NASDAQ stocks. The monthly short interest ratio (SR_t) is defined as the number of shares shorted divided by the number of shares outstanding. The monthly binding ratio (BR_t) is defined as the short interest ratio divided by the percentage of shares owned by institutional investors, the primary source of equity loan for short selling. SR_{t-1} is the first lagged value of the short interest ratio and BR_{t-1} is the first lagged value of the binding ratio. P values are shown in the parentheses. Our sample spans January 1995 to December 2000.

	SR_t	**BR_t**	**SR_{t-1}**	**BR_{t-1}**
SR_t	1.0000	0.6097 (<.0001)	0.7049 (<.0001)	0.4068 (<.0001)
BR_t	0.6097 (<.0001)	1.0000	0.4403 (<.0001)	0.2762 (0.0206)
SR_{t-1}	0.7049 (<.0001)	0.4403 (<.0001)	1.0000	0.6114 (<.0001)
BR_{t-1}	0.4068 (<.0001)	0.2762 (0.0206)	0.6114 (<.0001)	1.0000

Table 3 Comparison of Mean Portfolio Returns without Matching

This table reports the mean returns of portfolios formed on the short interest ratio, the binding ratio, and the short interest ratio of the previous month (SR_{t-1}), respectively, and the difference in mean returns between the most heavily shorted portfolio formed by the short ratio and the portfolio formed by the binding ratio. Decile 1 represents the portfolio of the least heavily shorted stocks and Decile 10 is the portfolio of the most heavily shorted stocks. "Month" column shows the average portfolio returns (or difference in mean returns) in the full month period between the "Trade Date" in current month and the "Trade Date" next month. "Info." column shows the average portfolio returns (or difference in mean returns) in the information effect period (the time interval between the "Trade Date" and the "Publication Date" in current month). "Announ." column shows the average portfolio returns (or difference in mean returns) in the announcement effect period (the time interval between the "Publication Date" in current month and the "Trade Date" next month). Portfolio return is defined as the equally weighted average return of the stocks in that portfolio and adjusted for dividend and stock split. The number is in percentage. Our sample spans January 1995 to December 2000.

Decile	Short interest ratio (SR_t)			Binding ratio (BR_t)			SR_{t-1}
	Month	Info.	Announ.	Month	Info.	Announ.	Month
1	1.16	0.29	1.05	1.13	0.29	0.98	1.43
2	1.48	0.42	1.18	1.51	0.43	1.14	1.41
3	1.41	0.40	1.13	1.60	0.57	1.07	1.62
4	1.80	0.54	1.36	1.78	0.59	1.27	1.54
5	1.93	0.60	1.43	1.92	0.69	1.29	1.38
6	1.36	0.41	1.00	2.03	0.62	1.42	1.40
7	1.36	0.27	1.20	1.28	0.34	1.03	0.90
8	1.13	0.05	1.09	0.99	0.08	0.98	1.28
9	1.14	0.05	1.09	0.80	-0.22	1.08	0.88
10	0.62	-0.19	0.82	-0.13	-0.82	0.89	0.66

Difference in mean returns	Month		Info.		Announ.	
	Diff	*P* value	Diff	*P* value	Diff	*P* value
($SR_t - BR_t$)	1.55	0.003	1.09	<0.001	-0.51	0.757

Table 4 Abnormal Returns of Constructed Portfolios

This table reports the abnormal return for portfolios constructed each month one day after the "Trade Date" using the short interest ratio (SR_t), the binding ratio (BR_t), the short interest ratio of the previous month (SR_{t-1}), and the binding ratio of the previous month (BR_{t-1}),respectively. Decile 10 is the most heavily shorted portfolio and decile 1 is the least heavily shorted portfolio. The daily abnormal return α is obtained by running the following time series regression:

$$r_{pt} - r_{ft} = \alpha + \beta_1 RMRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_t,$$

where r_{pt} and r_{ft} are the portfolio return and the risk free rate in period *t*, respectively. Under the "NASDAQ index adjustment," we subtract the index return from that of the portfolio return before running the regression. The daily common factor data and risk free interest rate are downloaded from the Fama-French database in WRDS. Our sample spans January 1995 to December 2000. "***", "**", and "*" represents significance level of 1%, 5%, and 10%, respectively. All numbers correspond to monthly alphas in percentage.

Decile	*Short Interest* (SR_t)	*Binding Ratio* (SR_t)	*Short Interest* (SR_{t-1})	*Binding Ratio* (SR_{t-1})
	Panel A: without adjustment			
1	0.57	0.50	0.82*	0.77
2	0.84	0.95*	1.07*	0.85
3	1.01*	1.16**	1.01*	1.07
4	1.59**	1.39**	1.05*	1.00
5	1.62**	1.62**	1.15	1.55
6	1.22	1.95**	1.14	1.55
7	1.35	1.42*	0.95	1.30
8	1.38	1.10	1.48	1.31
9	1.40	1.04	1.15	0.99
10	0.69	-0.12	0.68	0.21
	Panel B: with NASDAQ index adjustment			
1	0.08***	0.04	0.08***	
2	0.06**	0.02	0.07**	
3	0.04	0.00	0.05*	
4	0.04	0.00	0.02	
5	0.02	0.01	-0.01	
6	-0.02	0.00	-0.02	
7	-0.04	-0.04	-0.06**	
8	-0.06**	-0.05**	-0.05*	
9	-0.08***	-0.05*	-0.08***	
10	-0.11***	-0.05*	-0.10***	

Table 5 Return of Zero-Investment Portfolio Matched on Size, Book-to-Market and Liquidity

This table reports the average return and abnormal return for zero-investment portfolios constructed each month one day after the "Trade Date" by taking a long position in an original portfolio and a short position in a matching portfolio. The original portfolios are formed based on the short interest ratio, the binding ratio, and the short interest ratio in the previous month, respectively. Decile 10 is the most heavily shorted portfolio and decile 1 is the least heavily shorted portfolio. The matching portfolios are constructed by matching the firm size, the book-to-market ratio, and liquidity following the procedure discussed in Section 4.4. Column "Full Month" shows the average daily return or the abnormal return of a zero-investment portfolio in the full month period between the "Trade Date" in current and the next months. Column "Info." shows the average daily return or the abnormal return of a zero-investment portfolio in the information period between the "Trade Date" and the "Publication Date" in current month. Column "Announ." shows the average daily return or the abnormal return of a zero-investment portfolio in the announcement period between the "Publication Date" in current month and "Trade Date" in next month. The daily abnormal return α is obtained by running the following time series regression:

$$r_{pt} - r_{ft} = \alpha + \beta_1 RMRF_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 MOM_t + \varepsilon_t,$$

where r_{pt} and r_{ft} are the portfolio return and the risk free rate in period t, respectively. The daily common factor data and risk free interest rate are downloaded from the Fama-French database in WRDS. Our sample spans January 1995 to December 2000. "***", "**", and "*" represents significance level of 1%, 5%, and 10%, respectively.

Decile	Short interest ratio			Binding ratio		
	Month	Info.	Announ.	Month	Info.	Announ.
	Panel A: Average daily return of zero-investment portfolios matched on size and book-to-market					
1	0.014	0.019	0.007	0.007	0.016	-0.002
	(0.456)	(0.366)	(0.747)	(0.645)	(0.405)	(0.937)
10	-0.04	-0.052	-0.027	-0.058	-0.089	-0.025
	(0.011)	(0.024)	(0.184)	(0.008)	(0.004)	(0.471)
	Panel B: Abnormal daily return of zero-investment portfolios matched on size and book-to-market					
1	-0.003	-0.003	-0.002	-0.009	-0.005	-0.013
	(0.786)	(0.810)	(0.893)	(0.305)	(0.682)	(0.329)
10	-0.052	-0.063	-0.043	-0.07	-0.098	-0.044
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.028)
	Panel C: Average daily return of zero-investment portfolios matched on size, book-to-market, and liquidity					
1	0.005	0.001	0.013	0.006	0.004	0.010
	(0.839)	(0.986)	(0.659)	(0.793)	(0.903)	(0.684)
10	-0.010	-0.036	0.019	-0.055	-0.130	0.023
	(0.648)	(0.302)	(0.577)	(0.029)	(0.006)	(0.593)
	Panel D: Abnormal daily return of zero-investment portfolios matched on size, book-to-market, and liquidity (with ordered matching)					
1	-0.014	-0.023	-0.008	-0.016	-0.022	-0.010
	(0.681)	(0.633)	(0.880)	(0.581)	(0.599)	(0.814)
10	-0.021	-0.059	0.005	-0.060	-0.141	0.007
	(0.405)	(0.116)	(0.894)	(0.060)	(0.003)	(0.877)
	(with non-ordered matching)					
10	-0.060	-0.054	-0.074	-0.075	-0.124	-0.035
	(0.127)	(0.364)	(0.156)	(0.025)	(0.007)	(0.477)

Table 6 Cumulative Abnormal Return of the Most Heavily Shorted Stocks

This table reports the cumulative abnormal return (in percentage) of the most heavily shorted portfolio for the full month, the information period, and the announcement period respectively. The cumulative abnormal return is computed using the abnormal return of stocks selected with the largest short interest ratio or the binding ratio. The Event window starts from one day after the "Trade Date" of each month. We use two benchmarks to compute the abnormal returns: the value-weighted market portfolio, and the matching portfolio constructed to match firm size, book-to-market, and liquidity (see Section 4.5 for details). Panel A reports the cumulative returns separately using the two benchmarks for the three periods. Panel B shows daily average abnormal returns of the most heavily shorted stocks that also reported negative earnings surprises and non-negative earnings surprises, respectively, between the "Trade Date" in the current month and the "Trade Date" next month. Panel C shows the cumulative abnormal returns of the most heavily shorted portfolio of stocks reported negative earnings surprises and non-negative earnings surprises, respectively, for the same period. Column "Month" shows the abnormal return of the portfolio for twenty two days, which covers the full month period. Column "Info." shows the abnormal return of eleven days, which covers the information period. Column "Announ." shows the abnormal return of eleven days, which covers the announcement period. Under "Info Period", the negative earning announcement occurs in the information period, and under "Announ. Period", the negative earning announcement occurs in the announcement period. *P* value is provided in the parentheses.

	Short interest ratio			**Binding ratio**		
	Month	Info.	Announ.	Month	Info.	Announ.
	Panel A. Cumulative Abnormal of the Most Heavily Shorted Stocks					
Market Portfolio	-0.56	-0.86	0.30	0.20	-0.95	1.15
	(0.82)	(0.03)	(0.47)	(0.93)	(0.03)	(0.01)
Matching Portfolio	-0.18	-0.38	0.20	-1.29	-1.44	0.15
	(0.94)	(0.35)	(0.58)	(0.61)	(0.01)	(0.74)
Matching Portfolio	Panel B. Daily Average Abnormal Return and Earning Surprises					
Negative Earnings Surprises Stocks	-0.2153	-0.3416	-0.1167	-0.2105	-0.3728	-0.0596
	(0.005)	(0.001)	(0.291)	(0.033)	(0.005)	(0.684)
Info. Period	-0.1185	-0.3724***	0.1218	-0.1257	-0.3297***	0.1513
Announ. Period	-0.2613**	-0.3070*	-0.2414	-0.2720*	-0.3056**	-0.2520
Non-negative Earnings Surprises Stocks	-0.0003	-0.0199	0.0070	-0.0562	-0.1335	0.0000
	(0.992)	(0.627)	(0.291)	(0.116)	(0.011)	(1.000)
Matching Portfolio	Panel C. Cumulative Abnormal Return and Earning Surprises					
Negative Earnings Surprises Stocks	-4.32	-3.26	-1.06	-4.45	-3.23	-1.22
	(0.093)	(0.003)	(0.372)	(0.091)	(0.018)	(0.416)
Info. Period	-2.31	-3.32***	1.02	-2.33	-3.65***	1.32
Announ. Period	-5.39**	-3.29**	-2.09	-6.21**	-3.30**	-2.91
Non-negative Earnings Surprises Stocks	0.13	-0.15	0.28	-1.12	-1.36	0.24
	(0.976)	(0.881)	(0.462)	(0.655)	(0.012)	(0.626)

Figure 1: Timeline

"Trade Date" is the date when cumulative short positions in the most recent past month are established. "Publication Date" is the date when cumulative short positions are printed in newspapers or publicly released to in the media. The short interest data is published on the 8th business day after the reporting "settlement date". "Information Period" is defined as the period between the "Trade Date" and the "Publication Date" of the same month. "Announcement Period" is defined as the period between the "Publication Date" of the current month and the "Trade Date" of next month.

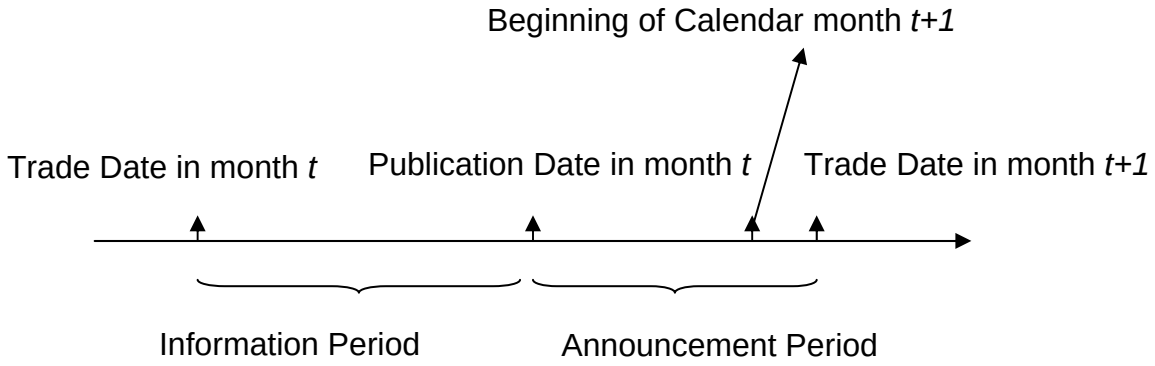

Figure 2: Cumulated Abnormal Return for the Most Heavily Shorted Stocks

This graph shows the cumulative abnormal return for the most heavily shorted stocks according to the short interest ratio as well as according to the binding ratio. CAR is computed based on the abnormal return with respect to the benchmark stocks selected in an ordered match on firm size, book-to-market, and liquidity. The event window starts from one day after "Trade Date" of each month. Full month period covers 22 days. The information period covers first eleven trading days.

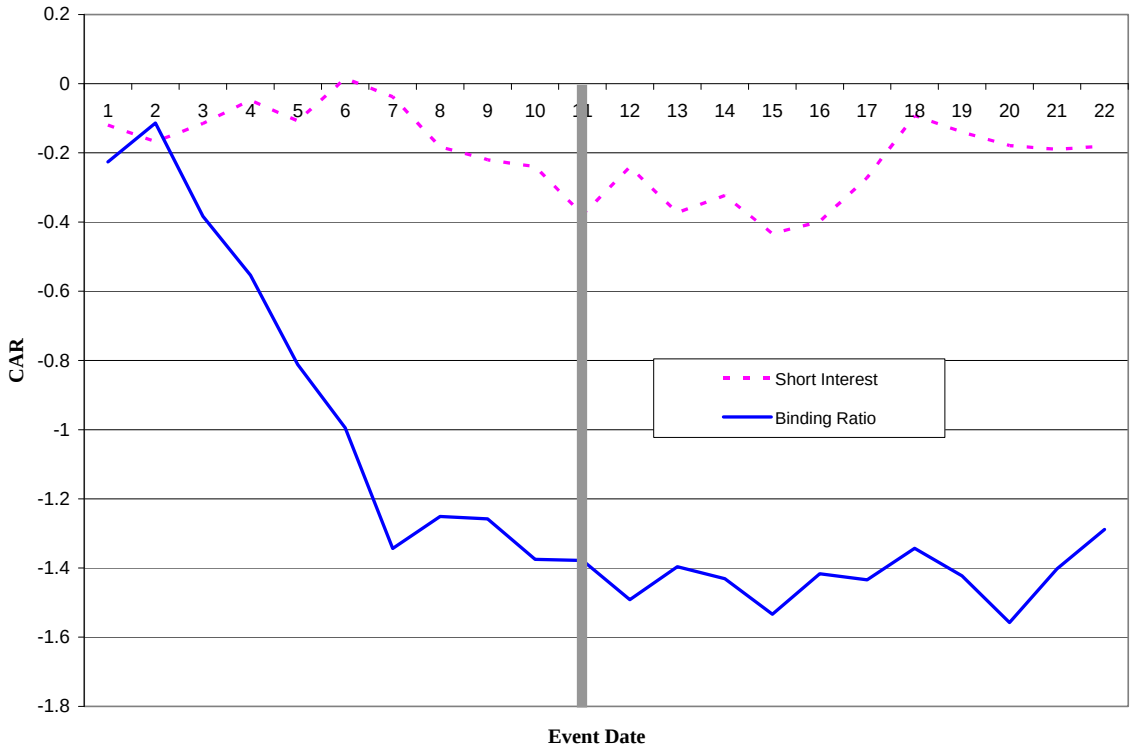

Figure 3: Cumulated Abnormal with Earning Announcement

This graph shows the cumulative abnormal return for the most heavily shorted stocks according to the binding ratio in relation to earning announcement. CAR is computed based on the abnormal return with respect to the benchmark stocks selected in an ordered match on firm size, book-to-market, and liquidity. The event window starts from one day after "Trade Date" of each month. Full month period covers 22 days. The information period covers first eleven trading days.

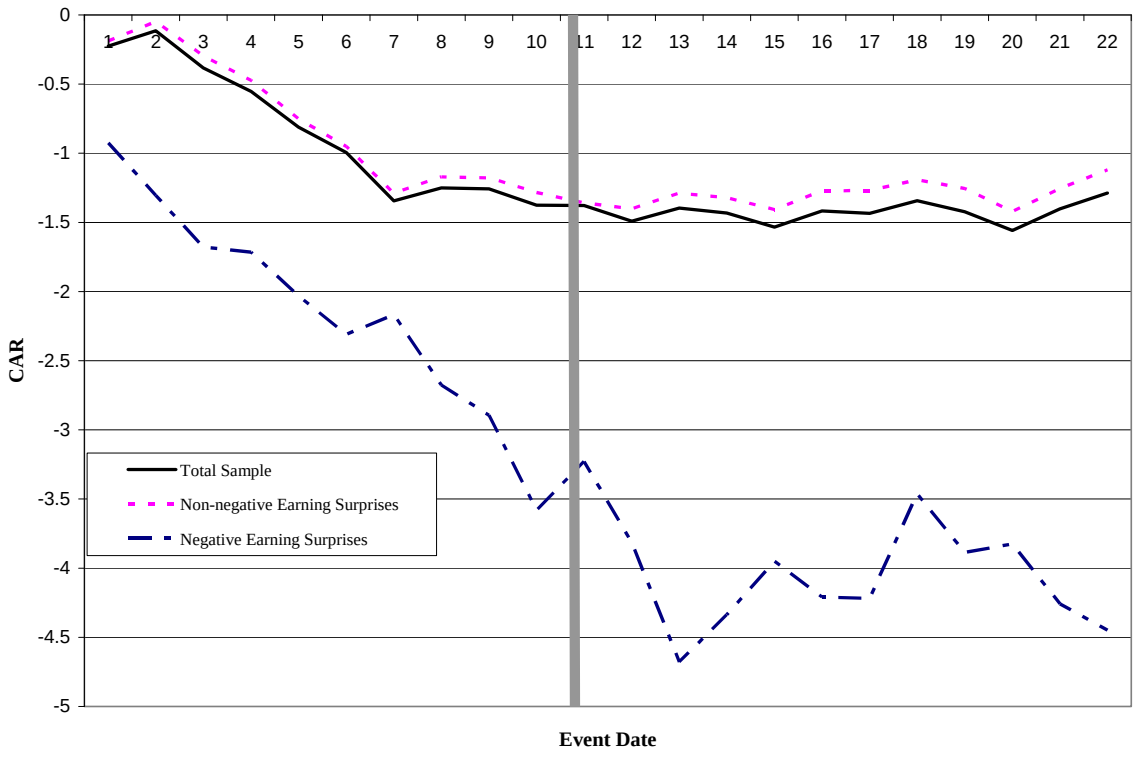

Figure 4: Cumulated Abnormal with Earning Announcement in Different Periods

This graph shows the cumulative abnormal return for the most heavily shorted stocks according to the binding ratio in relation to negative earning surprises occurred in the information period versus announcement period. CAR is computed based on the abnormal return with respect to the benchmark stocks selected in an ordered match on firm size, book-to-market, and liquidity. The event window starts from one day after "Trade Date" of each month. Full month period covers 22 days. The information period covers first eleven trading days.