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An Investigation of the Informational Role of Short Interest in the Nasdaq Market

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ABSTRACT

This paper examines the relationship between the level of short interest and stock returns in the Nasdaq market from June 1988 through December 1994. We find that heavily shorted firms experience significant negative abnormal returns ranging from −0.76 to −1.13 percent per month after controlling for the market, size, book-to-market, and momentum factors. These negative returns increase with the level of short interest, indicating that a higher level of short interest is a stronger bearish signal. We find that heavily shorted firms are more likely to be delisted compared to their size, book-to-market, and momentum matched control firms.

WE INVESTIGATE THE RELATIONSHIP between the level of short interest and the stock returns in Nasdaq firms. Using monthly short interest data for the universe of Nasdaq firms from June 1988 to December 1994, we find that firms with a high level of short interest experience negative and significant abnormal returns when they are heavily shorted. Using a calendar-time portfolio approach, we regress monthly portfolio excess returns of stocks that had at least 2.5 percent short interest (number of shares sold short as a percentage of the shares outstanding) in the *previous* month on the three Fama and French (1993) risk factors and a fourth momentum factor (Carhart (1997)). The regression yields negative and significant abnormal returns of −0.76 percent per month during our sample period. The magnitude of the negative abnormal returns increases with the level of short interest. These results indicate that a high level of short interest is a bearish signal.

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Aitken et al. (1998) show that information in short interest is incorporated quickly into prices of Australian stocks. While the information on short positions is available in real time for stocks traded on the Australian Stock Exchange (Aitken et al.), only aggregate short positions are available on a monthly basis for stocks traded in the United States. Using data available on a real-time basis, Aitken et al. focused on intraday price reaction to information on short positions.[1] In contrast, our study focuses on the longer-term price performance of heavily shorted firms in the Nasdaq market.

Three different perspectives have been offered on the expected relationship between short interest and stock returns. The first perspective, advanced by Diamond and Verrecchia ((1987); hereafter D-V), is that short interest should bear a negative relation with stock returns. They suggest that since short selling is costly, short sales by liquidity traders are less likely. [2] Consequently, if informed traders are more likely to engage in short selling, high short interest conveys adverse information, implying a negative relationship between short interest and stock returns.

An alternative perspective, popular on Wall Street, is that a high level of short interest is a bullish signal because it represents latent demand, which will transform eventually into actual purchase of the shares to cover the short position. Consider the following statement from an article in *Barron's*: "A commonly held idea is that the larger the short interest, the more likely that a stock will go up. That's because shorts eventually will buy back the stock, thereby putting upward pressure on its price" (Epstein (1995)). Incidents of run-up in the stock price of several companies have been attributed to this explanation by the media. For example, *Business Week* (Byrnes (1995)) attributes the run up in L.L. Knickerbocker's stock from $4 to $46 in less than six weeks to this demand–supply perspective. The article states "by July 14, short positions were 31,440. As the stock rose, shorts had to pay for the stock to cover their bets. With only 800,000 shares available, the price climbed." (p. 44).

The third perspective is that short selling may be unrelated to stock returns if it is motivated by hedging strategies, arbitrage transactions, and tax-related reasons (Brent, Morse, and Stice (1990)). For example, traders may take short positions to implement techniques such as shorting against the box. To remove any price-related uncertainty, a trader may sell short securities (usually for tax reasons) on which the trader already has a long position. Such short positions may not trigger any future demand for the shares nor are they motivated by short sellers' negative information.

[1] Using intraday data, they find that the price impact of short trades is negative (−0.20 percent) and that the information in the short trade is impounded into prices quickly (15 to 20 minutes).

[2] Examples of costly constraints on short selling include the uptick rule, legal constraints on short selling by certain institutional investors, and restrictions on immediate collection of proceeds from short sales. See Asquith and Meulbroek (1995) for a detailed explanation of costs associated with short selling.

With the exception of Asquith and Meulbroek ((1995); hereafter A-M), prior research on short interest has failed to document a strong and consistent relationship between short interest and abnormal stock returns. For example, see Figlewski (1981), Conrad (1986), Vu and Caster (1987), Brent et al. (1990), Bhattacharya and Gallinger (1991), Senchack and Starks (1993), Choie and Hwang (1994), and Woolridge and Dickinson (1994). This is likely due to the use of data reported by the media or the use of small random samples. The data reported by the media are incomplete, as they impose arbitrary restrictions on the level of short interest or the change in short interest for a firm to be included in their publications.[3] These restrictions are likely to exclude firms with large and significant short positions relative to the shares outstanding. Also, since a typical firm has short interest of less than one percent of the shares outstanding and since most firms have little or no short interest, samples chosen on a random basis lack the statistical power to detect a significant association between short interest and stock returns. By examining the entire population of short interest in the Nasdaq market, we are able to obtain a large number of firms with material short interest positions.

Using a large sample of NYSE/AMEX firms, Asquith and Meulbroek (1995) document a strong negative relationship between short interest and subsequent abnormal returns. We extend A-M's study to Nasdaq firms. Moreover, recent advances in measurement of stock returns over long horizons have suggested improved methods for the measurement of abnormal returns over long horizons. Our methodology for measuring abnormal returns incorporates these insights.

Our empirical tests strongly support the view that short interest is a bearish signal and that the informativeness of this signal is increasing in the magnitude of short interest. Specifically, we find that the abnormal return for firms with short interest of at least 2.5 percent is negative 76 basis points per month over our sample period. The corresponding abnormal return for firms with short interest of at least 10 percent is negative 113 basis points per month. The negative abnormal returns are not clustered in certain industries, nor are they clustered in calendar time. The negative abnormal returns documented are robust to alternative classifications of heavily shorted firms and to the use of alternative benchmarks for measuring abnormal returns. We also examine the survival status of firms with high short interest. The results indicate that heavily shorted firms are more likely to be liquidated or delisted in the 36 months after being heavily shorted than their size-, book-to-market-, and momentum-matched control firms.

The rest of the paper is organized as follows. Section I describes the data and reports summary statistics for the sample. Empirical analysis of the

[3] For example, the *Wall Street Journal* does not include a firm unless the level of short interest is at least 225,000 shares or the short interest changes by at least 100,000 shares. Moreover, as Senchack and Starks (1993) report, the criteria for inclusion of firms in media publications have varied over time.

association between short interest and stock returns is presented in Section II. Results of the robustness analysis are reported in Section III. Section IV presents the analysis on the survival status of heavily shorted firms. Section V concludes.

I. Descriptive Information on Short Interest

A. Sample Selection

We obtain monthly short interest data directly from the Nasdaq for the period from June 1988 to December 1994.[4] The market makers report the short positions as of the 15th of each month to the Nasdaq within three to four days after the 15th of the month. The Nasdaq, in turn, aggregates the short interest for each security.[5] It then releases the aggregate short interest data and the data are carried by, among others, *The Wall Street Journal*, *Barron's*, and *The New York Times*.

We obtain data on stock returns, firm size, trading volume, share turnover, and delisting status from the CRSP files. To identify firms with a high level of short interest, we implement the following procedure.[6] As in A-M, a firm is considered "heavily" shorted if the number of shares sold short is at least 2.5 percent of the shares outstanding at the end of the month.[7] We call this the 2.5 percent sample. Because the 2.5 percent cutoff is arbitrary, we also analyze samples using cutoffs of 5 percent, 7.5 percent, and 10 percent.

We denote EN as the month in which a firm first attains a 2.5 percent short interest position in our sample period. A firm remains in this sample as long as its short interest remains at or above the 2.5 percent threshold at the end of each month. If a firm's short interest falls below the 2.5 percent threshold it exits the short interest sample and the month preceding the month of exit is designated as EX. Thus, EX is the last month for which the firm's short interest is at or above the 2.5 percent threshold. Each such incidence in our sample firms gives us one observation. For example, assume that ABC Corp. has 1,000 shares outstanding. Suppose that at the end of January 1994, its short interest first reaches 25 shares. Then, January

[4] The Nasdaq does not have data for February 1990 and July 1990. For these two months, we assume that the level of short interest in these months is the same as that in the immediately preceding month. The tenor of our results is not affected when these two months are excluded from our analysis.

[5] Because of its structure of multiple market makers, the Nasdaq takes somewhat longer than the NYSE/AMEX to compile the information.

[6] We only include ordinary common shares in the analysis. Thus, ADRs, REITS, and closed-end funds are excluded from the analysis.

[7] The mean (median) level of short interest for the entire universe of Nasdaq firms over our sample period is 0.85 percent (0.11 percent). The 90th percentile of short interest for the universe of Nasdaq firms over our sample period is 2.09 percent. Thus, our "heavily" shorted sample consists of firms with short interest in the top decile.

1994 would be designated the EN month for ABC Corp. Having remained at or above 25 shares in February, March, and April, suppose the short interest drops to 10 shares in May 1994. Then, April 1994 would be designated the EX month. Thus, ABC Corp. forms one observation or one event with EN of January 1994 and EX of April 1994.

To implement the calendar-time portfolio approach, we require the firms in the portfolio to meet the threshold level of short interest in the *preceding* month. Thus, ABC Corp. would be included in the portfolio for the months February, March, April, and May. If the short interest for ABC Corp. were to reach 25 shares again, say in October 1994, then ABC Corp would reenter the sample in October 1994, and would be considered a separate observation.

In the 2.5 percent sample, we have 2,726 observations compared to 1,390, 860, and 577 observations in the 5 percent, the 7.5 percent, and the 10 percent samples, respectively. As a comparison, the number of observations in A-M in each of the four comparable subsamples over the period from 1976 to 1993 are 1,438, 734, 431, and 260, for the 2.5 percent, the 5 percent, the 7.5 percent, and the 10 percent short interest samples, respectively (Table 2 in A-M).

B. Summary Statistics

The distribution statistics reported in Panel A of Table I indicate that the level of short interest has increased steadily on the Nasdaq market over our sample period. In particular, the mean (median) short interest for the universe of Nasdaq stocks has increased from 0.51 percent (0.08 percent) in 1988 to 1.14 percent (0.16 percent) in 1994. A-M document a similar pattern of increasing short interest on the NYSE/AMEX. Panel B of Table I reports the distribution of the number of observations in each of the four subsamples of short interest. Consistent with a pattern of increasing short interest over time, the number of heavily shorted firms is also intertemporally increasing.

Table II provides descriptive statistics on the sample firms. Since the descriptive statistics are generally monotonic in the level of short interest, for the sake of brevity, we report statistics only for the 2.5 percent and the 10 percent samples in Panels A and B, respectively. In the 2.5 percent sample, the average (median) number of consecutive months for which the stocks are heavily shorted is 7.94 (3.00) months. The fact that the short positions are held for several months suggests that, at least from the perspective of the short sellers, any negative information they have is not immediately impounded in the stock prices. The mean (median) market value of equity one month prior to entry (EN − 1) in the sample is \$222.32 (\$83.65) million. This corresponds to mean (median) size decile of 7.29 (8.00) relative to the universe of Nasdaq firms, where decile one corresponds to the smallest firms. Given the concerns that the short sellers have about a short squeeze, we expect them to have a preference for more

Table I

Distribution of Short Interest over the Sample Period

The table reports statistics pertaining to the level and the distribution of short interest for the universe of Nasdaq firms. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. Short interest is defined as a ratio of shares shorted to the total number of shares outstanding at the end of each month. A firm enters the short interest sample when its short interest reaches a certain threshold (2.5, 5, 7.5, and 10 percent) in a given month and leaves the sample when its short interest level falls below the threshold. Panel A reports the level of short interest for the universe of Nasdaq firms by year. Panel B reports the distribution of number of observations in each of the four subsamples (2.5, 5, 7.5, and 10 percent) by year.

Panel A: Short Interest for the Nasdaq Universe by Year

Year	Mean (%)	Median (%)	25th Percentile (%)	75th Percentile (%)
1988	0.51	0.08	0.02	0.25
1989	0.59	0.09	0.03	0.29
1990	0.81	0.10	0.03	0.42
1991	0.84	0.11	0.03	0.49
1992	0.87	0.13	0.03	0.58
1993	1.03	0.15	0.04	0.71
1994	1.14	0.16	0.04	0.79

Panel B: Number of Observations in each Short Interest Subsample by Year

Year	2.5% Sample	5% Sample	7.5% Sample	10% Sample
1988	262	120	66	40
1989	251	140	91	61
1990	339	189	121	70
1991	340	172	104	80
1992	416	206	121	83
1993	550	271	167	98
1994	568	292	190	145

liquid stocks.[8] Consistent with this conjecture, we find that the heavily shorted firms are highly liquid. In particular, the mean (median) monthly dollar trading volume is \$54.95 (\$13.85) million in the month prior to entering the 2.5 percent sample. This corresponds to a mean (median) decile

[8] Generally, short sellers borrow the stock from an institutional investor, a brokerage house, or a dealer. However, this borrowed stock (loan) must be repaid on demand. A short squeeze, thus, occurs when the lender of the borrowed shares wants to sell the stock. If the short seller is unable to find another lender, he/she has to repurchase the shares in the open market to fulfill the obligation to repay the loan (shares). Thus, short sellers prefer liquid stocks since it is easier to find alternative lenders in case of a short squeeze. An article in Business Week (Weiss (1995)) quotes Bob Bandera of West Lake Capital, "I tried and simply could not borrow [Netscape] stock and couldn't take a short position." (p. 90).

Table II

Summary Statistics for the Short Interest Sample

The table reports several summary statistics for the sample firms. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. Short interest is defined as a ratio of shares shorted to the total number of shares outstanding at the end of each month. A firm enters the short interest sample when its short interest reaches a certain threshold (2.5, 5, 7.5, and 10 percent) in a given month and leaves the sample when its short interest level falls below the threshold. The market value of equity, monthly dollar trading volume, and monthly turnover are all measured in month −1 relative to a firm's entry into the short interest sample and are all obtained from the CRSP files. Monthly turnover is defined as the number of shares traded in a month as a percentage of shares outstanding. The book-to-market ratio and the cash-flow-to-price ratio are computed using variables from COMPUSTAT. These ratios are also computed in month −1. Book value of equity is annual item #60 and cash flow (operating income before depreciation and amortization) is annual item #13 from the COMPUSTAT files. All of the decile rankings are assigned in month −1 and are relative to the universe of Nasdaq firms. To avoid the look-ahead bias for the book-to-market ratio and the cash-flow-to-price ratio, we use the latest fiscal year-end values for book value of equity and cash flow only if month −1 is at least four months after the firms' fiscal year-end; if not, we use the values from the previous fiscal year-end. Decile 1 corresponds to the smallest value. Fewer observations result from missing values in month −1 or if the firm is not on COMPUSTAT. In addition, we exclude firms with negative values of book value of equity or cash flow. Panel A reports the statistics for the 2.5 percent short interest sample and Panel B reports statistics for the 10 percent short interest sample.

Variable	No. of Obs.	Mean	Median	25th Percentile	75th Percentile
Panel A: Summary Statistics for the 2.5% Short Interest Sample					
Number of months in the short interest sample	2,726	7.94	3.00	1.00	10.00
Market value of equity (in million dollars)	2,638	222.32	83.65	27.65	214.01
Size decile rank	2,638	7.29	8.00	6.00	9.00
Monthly dollar volume (in million dollars)	2,636	54.95	13.85	3.76	44.80
Monthly dollar volume decile rank	2,636	8.43	9.00	8.00	10.00
Monthly turnover (%)	2,636	26.76	17.02	9.36	29.71
Monthly turnover decile rank	2,636	8.75	9.00	8.00	10.00
Book-to-market ratio	2,034	0.55	0.36	0.20	0.62
Book-to-market decile rank	2,034	3.99	3.00	2.00	6.00
Cash-flow-to-price ratio	1,473	0.22	0.11	0.06	0.20
Cash-flow-to-price decile rank	1,473	4.27	4.00	2.00	6.00
Panel B: Summary Statistics for the 10% Short Interest Sample					
Number of months in the short interest sample	577	6.73	4.00	1.00	10.00
Market value of equity (in million dollars)	561	235.60	137.33	48.72	278.94
Size decile rank	561	8.07	9.00	7.00	10.00
Monthly dollar volume (in million dollars)	542	93.01	36.93	13.14	100.00
Monthly dollar volume decile rank	561	9.19	10.00	9.00	10.00
Monthly turnover (%)	561	36.54	28.85	17.07	45.71
Monthly turnover decile rank	561	9.42	10.00	9.00	10.00
Book-to-market ratio	424	0.59	0.32	0.18	0.55
Book-to-market decile rank	424	3.70	2.00	3.00	5.00
Cash-flow-to-price ratio	329	0.22	0.10	0.06	0.18
Cash-flow-to-price decile rank	329	3.96	2.00	3.00	6.00

rank of 8.43 (9.00), relative to the universe of Nasdaq stocks. Mean (median) share turnover (shares traded as a percentage of shares outstanding) one month prior to entering the short interest sample is 26.76 percent (17.02 percent). This corresponds to mean (median) decile rank of 8.75 (9.00) relative to the universe of Nasdaq stocks.

An examination of the fundamentals suggests that the heavily shorted firms have low values of fundamentals relative to price. The mean (median) book-to-market ratio of the firms in the 2.5 percent sample is 0.55 (0.36) in month EN − 1 with a cash-flow-to-price ratio of 0.22 (0.11).[9] This corresponds to mean (median) decile rank of 3.99 (3.00) relative to the universe of Nasdaq firms. The corresponding decile rank for the cash-flow-to-price ratio is 4.27 (4.00). These findings are consistent with results in Dechow et al. (2001), who document that firms with high short interest on the NYSE/AMEX have low values of fundamentals relative to market value.

Panel B of Table II reports summary statistics for the 10 percent sample. The statistics indicate that firms in the 10 percent sample are more liquid relative to the firms in the 2.5 percent sample. This finding is consistent with results in Kadiyala and Vetsuypens (2002). Using a sample of stock splits, they document a positive relationship between improved liquidity following a stock split and the level of short interest.

II. Association between Short Interest and Stock Returns

A. Methodology

Several recent papers have proposed methods for measuring long-horizon abnormal stock returns. Barber and Lyon (1997) and Kothari and Warner (1997) show that abnormal returns measured over long horizons are sensitive to the benchmarks used. Barber and Lyon show that the use of portfolio returns as a benchmark (e.g., a CRSP index or size decile portfolios) results in holding period abnormal returns that are biased downwards, leading to misspecified statistics. They recommend using a matching firm methodology. However, one potential limitation of the matching firm approach is the assumption that the buy-and-hold or holding period returns are cross-sectionally independent.

Mitchell and Stafford (2000) advocate the use of time series regressions and a calendar-time portfolio approach to measure performance over long horizons to address the problem of cross-sectional dependence. In this approach, an event portfolio is formed each month to include all firms that experience an event in the previous month (or previous n months, depending on the horizon over which the performance is evaluated). An important advantage of this approach is that the variance of the event portfolios formed in this manner automatically takes into account the cross-sectional correlation among the individual securities that comprise the portfolio. Further-

[9] The book-to-market ratio and the cash-flow-to-price ratio are updated each month.

more, Mitchell and Stafford also show that the calendar-time portfolio approach yields the most conservative results among the various methods to evaluate performance over long horizons. Finally, the calendar-time event portfolio approach represents an implementable investment strategy. Thus, we primarily use the calendar-time portfolio approach in our analysis, although selected results from the matching firm methodology are reported to test the robustness of our findings.

A.1. Calendar-time Portfolio Approach

At the beginning of each month from July 1988 to January 1995, we form equal-weighted portfolios of firms that had at least 2.5 percent (or 5 percent, 7.5 percent, and 10 percent, as the case may be) short interest in the *previous* month. The portfolios are rebalanced monthly to drop all firms that did not meet the threshold of 2.5 percent short interest in the previous month and add firms that attained 2.5 percent short interest in the previous month. Thus, a firm enters the portfolio in month EN + 1 and remains in the portfolio through month EX + 1. As a result, we have monthly portfolio returns from July 1988 to January 1995. We then regress the monthly portfolio excess returns (excess returns are obtained by subtracting the yield on one-month T-bills from raw returns) on the three Fama and French (1993) factors as well as a fourth momentum factor suggested by Carhart (1997). The portfolio excess returns are regressed on the four factors as in equation (1):

$$RPRF_t = a_0 + a_1 RMRF_t + a_2 SMB_t + a_3 HML_t + a_4 PR1YR_t + e_t, \qquad (1)$$

where $RPRF_t$ is the monthly portfolio return for the short interest sample minus the one-month risk-free rate, *RMRF* is the market factor, *SMB* is the size factor, *HML* is the book-to-market factor, and *PR1YR* is the momentum factor. These four factors and their construction are described in detail in Fama and French and Carhart.

B. Stock Market Performance

Table III reports the OLS estimate of equation (1) for the 2.5 percent, the 5 percent, the 7.5 percent, and the 10 percent short interest samples. The coefficient of interest is the intercept, a_0, in equation (1). The intercept for the 2.5 percent sample is −0.76 percent (t-statistic of −3.34), suggesting that over the period from July 1988 to January 1995, the sample firms experienced negative abnormal return of −0.76 percent per month. This result indicates that a high level of short interest conveys negative information.

The results for the 5 percent, the 7.5 percent and the 10 percent samples indicate that the abnormal returns become increasingly negative with increasing levels of short interest. For example, the monthly abnormal returns for the 5 percent, the 7.5 percent and the 10 percent short interest samples

Table III

Calendar-time Abnormal Returns for the Sample of Heavily Shorted Firms: Firms Are in the Portfolio from Month EN + 1 to EX + 1

This table reports the coefficients from a time-series regression of excess monthly portfolio returns (in excess of T-bill rate) on the three factors suggested by Fama and French (1993) and the fourth suggested by Carhart (1997). The following regression is estimated:

$$RPRF_t = a_0 + a_1 RMRF_t + a_2 SMB_t + a_3 HML_t + a_4 PR1YR_t + e_t,$$

where $RPRF_t$ is the portfolio excess return for the sample firms in month t and $RMRF_t$ (market factor) is the excess return of the value-weighted portfolio of NYSE/AMEX and Nasdaq firms. The size factor (SMB_t), the book-to-market factor (HML_t), and the momentum factor ($PR1YR$) are described in Carhart. The portfolio returns for the short interest sample are in calendar time. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. The 2.5 percent short interest sample consists of those firms that had short interest of at least 2.5 percent of the shares outstanding at the end of a given month. The 5 percent, 7.5 percent, and 10 percent short interest samples are defined similarly. For every month from July 1988 to January 1995, the portfolio is formed using all the firms that had at least a 2.5 percent short interest (5 percent, 7.5 percent, and 10 percent as the case may be) at the end of the previous month. Each month new firms get added when they attain the threshold short interest level in the previous month and some firms get dropped when their short interest drops below the threshold in the previous month. Thus, a firm enters the portfolio in month EN + 1 and remains in the portfolio through month EX + 1. The t-statistic is reported in parentheses.

Short Interest Sample	Intercept	*RMRF*	*SMB*	*HML*	*PR1YR*	Adj. R^2 (%)
2.50%	−0.76%	1.25	1.25	−0.14	−0.51	91.09
	(−3.34)	(18.85)	(12.19)	(−1.25)	(−5.57)	
5%	−0.85%	1.35	1.22	−0.14	−0.55	86.49
	(−2.84)	(15.46)	(9.02)	(−0.95)	(−4.62)	
7.50%	−0.90%	1.40	1.25	−0.03	−0.47	80.97
	(−2.44)	(13.04)	(7.50)	(−0.18)	(−3.17)	
10%	−1.13%	1.36	1.38	−0.17	−0.35	81.59
	(−3.08)	(12.70)	(8.33)	(−0.94)	(−2.37)	

are −0.85 percent (t-statistic of −2.84), −0.90 percent (t-statistic of −2.44), and −1.13 percent (t-statistic of −3.08), respectively. This result implies that a higher level of short interest conveys more negative information.

In the above approach, each firm is in the portfolio from month EN + 1 to EX + 1. The statistics in Table II show that the mean (median) number of months for which firms stay in the portfolio is 7.94 (3.00) for the 2.5 percent sample. Thus, different firms are held in the portfolio for different lengths of time depending upon how long they remain heavily shorted. In an alternative approach, we keep each firm in the portfolio for 12 months (from EN + 1 to EN + 12) after it first enters the portfolio regardless of the level of short

Table IV

Calendar-time Abnormal Returns for the Sample of Heavily Shorted Firms: Firms in the Portfolio from Month EN + 1 to EN + 12

This table reports the coefficients from a time-series regression of excess monthly portfolio returns (in excess of T-bill rate) on the three factors suggested by Fama and French (1993) and the fourth suggested by Carhart (1997). The following regression is estimated:

$$RPRF_t = a_0 + a_1 RMRF_t + a_2 SMB_t + a_3 HML_t + a_4 PR1YR_t + e_t,$$

where $RPRF_t$ is the portfolio excess return for the sample firms in month t and $RMRF_t$ (market factor) is the excess return of the value-weighted portfolio of NYSE/AMEX and Nasdaq firms. The size factor (SMB_t), the book-to-market factor (HML_t), and the momentum factor ($PR1YR$) are described in Carhart. The portfolio returns for the short interest sample are in calendar time. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. The 2.5 percent short interest sample consists of those firms that had short interest of at least 2.5 percent of the shares outstanding at the end of a given month. The 5 percent, 7.5 percent, and 10 percent short interest samples are defined similarly. A firm enters the portfolio if its short interest in the previous month reaches the 2.5 percent threshold for the first time (or 5 percent, 7.5 percent, or 10 percent, as the case may be). The firm remains in the portfolio for 12 consecutive months. Thus, each firm enters the portfolio in month EN + 1 and remains in the portfolio through month EN + 12. Thus, we have monthly portfolio returns from July 1988 to December 1995. The t-statistic is reported in parentheses.

Short Interest Sample	Intercept	*RMRF*	*SMB*	*HML*	*PR1YR*	Adj. R^2 (%)
2.50%	−0.84%	1.18	1.13	−0.16	−0.34	87.64
	(−3.65)	(17.22)	(10.78)	(−1.41)	(−3.67)	
5%	−0.95%	1.21	1.20	−0.09	−0.30	84.20
	(−3.50)	(15.01)	(9.75)	(−0.69)	(−2.75)	
7.50%	−0.92%	1.26	1.19	−0.14	−0.31	82.53
	(−3.09)	(14.35)	(8.79)	(−0.97)	(−2.56)	
10%	−1.09%	1.34	1.17	−0.11	−0.40	75.08
	(−2.84)	(11.70)	(6.69)	(−0.61)	(−2.54)	

interest during the next 11 months. Thus, under this approach, we have monthly portfolio returns from July 1988 to December 1995. The results from this alternative approach reported in Table IV show that the intercept for the 2.5 percent sample is −0.84 percent (t-statistic of −3.65). Thus, a strategy of holding heavily shorted firms for 12 months after they first attain the threshold level of short interest yields negative abnormal return of −0.84 percent per month. The negative abnormal returns for the 5 percent, the 7.5 percent, and the 10 percent samples are −0.95 percent (t-statistic of −3.50), −0.92 percent (t-statistic of −3.09), and −1.09 percent (t-statistic of −2.84) per month, respectively.

The results presented above are consistent with the negative relationship between short interest and abnormal returns documented in A-M. The results in A-M show that the size-and-standard-deviation-adjusted return for

the 10 percent sample over the period for which a firm remains heavily shorted (referred to as period zero in A-M) is −16.1 percent. The mean (median) number of months for which firms remain heavily shorted in their 10 percent sample is 14.2 (6.0). Although the abnormal returns across the two studies cannot be compared directly due to differences in the sample periods as well as differences in the methodology, the results nonetheless show that a high level of short interest conveys negative information, regardless of whether the stock is traded on the NYSE/AMEX or on the Nasdaq market.

C. Analysis of an Alternative Classification of Heavily Shorted Firms

While our identification of heavily shorted firms as those with short interest in excess of 2.5 percent is consistent with A-M, it is admittedly arbitrary. As discussed earlier, the statistics in Table I indicate that shares shorted as a percentage of shares outstanding has steadily increased over time. To the extent the intertemporal increase reflects increased short selling for hedging purposes, a given absolute level of short interest may indicate different levels of adverse information over time. This possibility could be somewhat mitigated by the use of a "relative" cutoff to identify heavily shorted firms. Consequently, we repeat the analysis using an alternative definition in which a firm is classified as heavily shorted in a given month if its level of short interest as a percentage of shares outstanding is above the 90th percentile of all firms with short positions in that month. We also consider a sample of firms with short interest above the 95th percentile.[10]

To implement the calendar-time portfolio approach, for each month from July 1988 to January 1995, we form portfolios of firms that had short interest in the 90th percentile or higher in the previous month. The portfolio is rebalanced monthly to drop all firms whose short interest fell below the 90th percentile in the previous month and to add firms whose short interest meets the 90th percentile cutoff in the previous month. The 95th percentile portfolio is formed in a similar manner. The results (not reported in tables) show that the abnormal return for firms with short interest above the 90th (95th) percentile is −0.65 percent (−0.77 percent) per month with a t-statistic of −3.11 (−3.00). These results show that our finding that a high level of short interest conveys negative information is robust to alternative classification of heavily shorted firms.

D. An Analysis of Intertemporal Increases in Short Interest

The results documented so far suggest that a high level of short interest is a bearish signal. To test the robustness of the levels analysis, we examine the informativeness of increases in short interest positions. If short interest is a bearish signal, we should expect, on average, a negative association

[10] The number of observations in the 90th percentile sample and the 95th percentile sample are 24,318, and 12,173, respectively.

between a large increase in short interest and stock returns. This analysis is closer in spirit to the D-V model which predicts that an "announcement of an unexpected increase in short interest in a security is bad news" (p. 301). We define change in short interest in a given month as the change in the number of shares sold short relative to the previous month, as a percentage of the total number of shares outstanding.

Similar to the approach used in our levels analysis, we form four portfolios of stocks with a large increase in short-interest positions. For the entire universe of Nasdaq stocks, the mean (median) month-to-month change in short interest over our sample period is 0.000805 percent (0.0 percent) of the shares outstanding. Given that the month-to-month change in short interest is small, similar to our levels analysis, we use ad hoc cutoffs to form portfolios of stocks with relatively large increase in short interest. The cutoffs are increases in short interest of 1 percent, 1.5 percent, 2 percent, and 2.5 percent of the shares outstanding in a month. The number of observations in each of the above samples are 6,914, 4,291, 2,856, and 2,026, respectively. Similar to the approach used earlier, we measure abnormal returns for the samples of large increase in short interest using the calendar-time portfolio approach.

In particular, for August 1988 to January 1995, we form a portfolio of all stocks that had at least a 1 percent (or 1.5 percent, 2 percent, or 2.5 percent, as the case may be) increase in short interest in the previous month. The portfolio is rebalanced monthly to drop all stocks that did not have an increase in short interest of at least 1 percent in the previous month and add stocks whose short interest increased by at least 1 percent of the shares outstanding in the previous month. We find that the abnormal return experienced by this portfolio over the sample period is -0.41 percent per month with a t-statistic of -17.46 (results not reported in tables). The corresponding monthly abnormal returns for the 1.5 percent, the 2 percent, and the 2.5 percent portfolios are -0.42 percent (t-statistic of -10.48), -0.42 percent (t-statistic of -4.48), and -0.45 percent (t-statistic of -7.53), respectively.

Thus, the results for the increase in short interest are consistent with the results documented for the level of short interest and further support the conclusion that high short interest is a bearish signal. The results also seem to be consistent with the prediction in D-V that an increase in short interest conveys negative information.

E. Clustering by Time

To evaluate whether the negative performance of heavily shorted firms is specific to a particular time period, we divide the sample period of 79 months (from June 1988 to December 1994) into two periods of 40 months (from June 1988 to September 1991) and 39 months (from October 1991 to December 1994). Since the results for portfolios formed using returns from month EN + 1 to EX + 1 and from month EN + 1 to EN + 12 are similar, we only report the results for the former. Also, since the abnormal returns are

Table V

Calendar-time Abnormal Returns for the Heavily Shorted Firms: June 1988 to September 1991 versus October 1991 to December 1994

This table reports the coefficients from a time-series regression of excess monthly portfolio returns (in excess of T-bill rate) on the three factors suggested by Fama and French (1993) and the fourth suggested by Carhart (1997). The following regression is estimated:

$$RPRF_t = a_0 + a_1 RMRF_t + a_2 SMB_t + a_3 HML_t + a_4 PR1YR_t + e_t,$$

where $RPRF_t$ is the portfolio excess return for the sample firms in month t and $RMRF_t$ (market factor) is the excess return of the value-weighted portfolio of NYSE/AMEX and Nasdaq firms. The size factor (SMB_t), the book-to-market factor (HML_t), and the momentum factor ($PR1YR$) are described in Carhart. The portfolio returns for the short interest sample are in calendar time. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. The 2.5 percent short interest sample consists of those firms that had short interest of at least 2.5 percent of the shares outstanding at the end of a given month. The 10 percent short interest sample is defined similarly. The sample period is divided into two almost equal time periods, from June 1988 to September 1991 and from October 1991 to December 1994. For every month from July 1988 to October 1991, the portfolio is formed using all the firms that had at least 2.5 percent (or 10 percent) short interest in the previous month. New firms get added each month if their short interest attains the threshold in the previous month, and some firms get dropped if their short interest drops below the threshold in the previous month. The same procedure is implemented from November 1991 to January 1995. Panel A reports the results for the 2.5 percent short interest sample and Panel B reports results for the 10 percent short interest sample. The t-statistic is reported in parentheses.

Time Period	Intercept	*RMRF*	*SMB*	*HML*	*PR1YR*	Adj. R^2 (%)
Panel A: 2.5% Short Interest Sample						
June 1988 to September 1991	−0.94% (−2.94)	1.26 (13.49)	0.97 (5.91)	−0.04 (−0.16)	−0.61 (−4.61)	92.42
October 1991 to December 1994	−0.57% (−1.76)	1.36 (12.31)	1.42 (11.05)	−0.19 (−1.49)	−0.51 (−4.05)	90.52
Panel B: 10% Short Interest Sample						
June 1988 to September 1991	−1.19% (−2.08)	1.31 (7.88)	1.56 (5.32)	0.01 (0.02)	−0.27 (−1.16)	82.14
October 1991 to December 1994	−0.87% (−1.70)	1.51 (8.70)	1.25 (6.19)	−0.28 (−1.41)	−0.46 (−2.34)	79.32

generally monotonic in the level of short interest, we report results only for the 2.5 percent sample and the 10 percent sample.

Table V provides the results of the analysis for the two subperiods. Panel A reports the results for the 2.5 percent sample and Panel B reports the results for the 10 percent sample. The results for the 2.5 percent sample show that in the first half of the sample period (June 1988 to September 1991), the monthly abnormal returns are −0.94 percent (t-statistic of −2.94). The

abnormal returns over the second half (October 1991 to December 1994) are smaller (−0.57 percent per month), but are significant at the 10 percent level with a *t*-statistic of −1.76. The results are similar for the 10 percent short interest sample.[11]

We also repeat the above analysis using an alternative definition of heavily shorted firms. For the 90th percentile short interest sample, we find that the abnormal returns using the calendar-time portfolio approach are −0.80 percent per month (*t*-statistic of −2.89) in the first half of the sample period and −0.60 percent per month (*t*-statistic of −1.94) in the second half of the sample period. For the 95th percentile sample, the monthly abnormal returns are −0.81 percent (*t*-statistic of −2.00) and −0.73 percent (*t*-statistic of −2.17) in the first half and the second half, respectively.

Similarly, we also analyze the informativeness of the increase in short interest over the two subperiods. We find that for the 1 percent increase in short interest sample, the abnormal returns (using calendar-time portfolio approach) are −0.60 percent per month (*t*-statistic of −10.38) in the first subperiod and −0.25 percent (*t*-statistic of −5.92) in the second subperiod. The corresponding abnormal returns for the 2 percent increase in short interest sample over the first and the second subperiods are −0.58 percent (*t*-statistic of −3.90) and −0.31 (*t*-statistic of −2.74), respectively. Taken together, the results suggest that the negative abnormal returns documented for the heavily shorted firms are not confined to a particular time period.[12]

III. Robustness Checks

We perform two robustness checks to examine whether the results are sensitive to the benchmark used for measuring abnormal returns. First, we replicate the calendar-time portfolio analysis using value-weighted returns, and second, we replicate the analysis using a matching firm methodology.

A. An Analysis of Value-Weighted Portfolio Returns

Since the common asset pricing models have difficulty explaining the cross section of average returns of small stocks (see Fama (1998)), and since, for the most part, the abnormal returns in long-horizon event studies are most

[11] We also examine if the sample is clustered in certain industries. We find that 63 different industries (at the two-digit SIC code level) are represented in the 2.5 percent sample. The distribution is similar for the 5 percent, the 7.5 percent, and the 10 percent short interest samples. There are six industries that each represent more than 5 percent of the sample. The results show that the abnormal returns are not driven by specific industries.

[12] The increase in short interest for the universe of Nasdaq firms (reported in Table I) coincides with the increasing use of short sales for arbitrage and hedging transactions. To the extent this transactions information is neutral, short interest has become a noisier proxy for adverse information over time. Lack of more refined data limits our ability to further examine the results of the subperiod analysis.

pronounced for small stocks, one cannot rule out the possibility that our results are due to the use of a misspecified asset-pricing model. To the extent empirical asset-pricing models are better specified for large firms, use of value-weighted returns would mitigate the effects of model misspecification by giving less weight to small stocks. In Table VI, we report the main results of our analysis using value-weighted (using market value of equity in the prior month as weights) portfolio returns for the 2.5 percent and the 10 percent samples. In Panel A, we report the result where each firm is included in the portfolio from month EN + 1 to EX + 1 (similar to the analysis in Table III) and in Panel B, we report the results where each firm is included in the portfolio from month EN + 1 to EN + 12 (similar to the analysis in Table IV).

The results in Panel A show that the abnormal return for the 2.5 percent sample is −0.45 percent per month (t-statistic of −1.73) over the sample period. The corresponding abnormal return for the 10 percent sample is −0.85 percent (t-statistic of −2.06). While the abnormal returns using value-weighted portfolio returns are smaller than the corresponding abnormal returns using equal-weighted portfolio returns (Table III), the value-weighted abnormal returns are still large and statistically significant. The results in Panel B for the period EN + 1 to EN + 12 show that, while the abnormal returns for the 2.5 percent sample are small and statistically not significant (−0.17 percent, with a t-statistic of −0.62), the abnormal returns are large and significant for the 10 percent sample. Specifically, for the 10 percent sample, the abnormal returns are −0.80 percent per month with a t-statistic of −2.14.

Thus, the results of the value-weighted analysis indicate that although the magnitude of the abnormal returns accruing to the heavily shorted firms are lower using value-weighted portfolio returns, the abnormal returns are still relatively large, and for the most part, statistically significant. Given that the larger firms are more actively followed, short sellers are more likely to have an informational advantage in smaller stocks. The results of the value-weighted analysis appear to be consistent with this possibility.[13]

B. Matching-Firm-Adjusted Returns

The use of the matching firm or control firm as a benchmark is motivated by the results in Barber and Lyon (1997), who show empirically that the use of the control (matching) firm as a benchmark yields well-specified test statistics. We select matching firms based on size, book-to-market, and prior six-month return momentum. The reason for matching on momentum is that

[13] "Percentage misvaluations, in equilibrium, will be larger for small stocks. Otherwise, arbitrageurs could make more money, net of costs, by finding misevaluations among big stocks. This is the logic in Shleifer and Vishny (1990, 1997). Thus, for any given misvaluations that occur, there will be a stronger force pushing the price towards fundamental value (and thus limiting the magnitude of any misvaluation) for big stocks" (Loughran and Ritter (2000, p. 363)).

Table VI

Calendar-Time Abnormal Returns for the Sample of Heavily Shorted Firms: Value-Weighted Returns

This table reports the coefficients from a time-series regression of excess monthly portfolio returns (in excess of T-bill rate) on the three factors suggested by Fama and French (1993) and the fourth suggested by Carhart (1997). The returns are value-weighted using market value of equity as weights. The following regression is estimated,

$$RPRF_t = a_0 + a_1 RMRF_t + a_2 SMB_t + a_3 HML_t + a_4 PR1YR_t + e_t,$$

where $RPRF_t$ is the portfolio excess return for the sample firms in month t and $RMRF_t$ (market factor) is the excess return of the value-weighted portfolio of NYSE/AMEX and Nasdaq firms. The size factor (SMB_t), the book-to-market factor (HML_t), and the momentum factor ($PR1YR$) are described in Carhart. The portfolio returns for the short interest sample are in calendar time. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. The 2.5 percent short interest sample consists of those firms that had short interest of at least 2.5 percent of the shares outstanding at the end of a given month. The 10 percent short interest sample is defined similarly. Panel A reports the results when firms are in the portfolio from month EN + 1 to EX + 1. Specifically, for every month from July 1988 to January 1995, the portfolio is formed using all the firms that had at least 2.5 percent short interest (or 10 percent, as the case may be) at the end of the previous month. Each month new firms get added when they attain the threshold short interest level in the previous month and some firms get dropped when their short interest drops below the threshold in the previous month. Thus, a firm enters the portfolio in month EN + 1 and remains in the portfolio through month EX + 1. For results reported in Panel B, a firm enters the portfolio if its short interest in the previous month reaches the 2.5 percent threshold for the first time (or 10 percent as the case may be). This firm remains in the portfolio for the 12 consecutive months. Thus, each firm enters the portfolio in month EN + 1 and remains in the portfolio through month EN + 12. Thus, we have monthly portfolio returns from July 1988 to December 1995. The t-statistic is reported in parentheses.

Short Interest Sample	Intercept	*RMRF*	*SMB*	*HML*	*PR1YR*	Adj. R^2 (%)
Panel A: Firms Are in the Portfolio from Month EN + 1 to EX + 1						
2.5%	−0.45%	1.32	1.07	−0.51	−0.42	89.24
	(−1.73)	(17.49)	(9.11)	(−4.05)	(−4.04)	
10%	−0.85%	1.30	1.10	−0.79	−0.31	77.67
	(−2.06)	(10.76)	(5.83)	(−3.94)	(−1.88)	
Panel B: Firms Are in the Portfolio from Month EN + 1 to EN + 12						
2.5%	−0.17%	1.25	0.77	−0.79	−0.30	85.01
	(−0.62)	(15.34)	(6.18)	(−5.87)	(−2.65)	
10%	−0.80%	1.29	0.99	−0.92	−0.25	78.40
	(−2.14)	(11.52)	(5.80)	(−5.07)	(−1.64)	

the sample firms experience a large run-up in price prior to becoming heavily shorted. Lyon, Barber, and Tsai (1999) show that, in cases where the sample firms have experienced extreme prior performance, controlling for the prior performance is especially important.

B.1. Matching-Firm Approach

Each month we sort the entire universe of Nasdaq into 10 size (market-value-of-equity) deciles. Then each size decile is further sorted into five book-to-market quintiles. Thus, each month, the universe of Nasdaq firms is divided into 50 portfolios. To avoid the look-ahead bias, we use the book value of equity in a given month only if that month is at least four months after the company's fiscal year-end, otherwise we use the book value of equity from the previous fiscal year.

For each sample firm, we identify four matching firms that have the same size rank and the book-to-market rank as the sample firm, and have a prior six-month return (momentum) that is closest to the sample firm. Matching firms are selected such that two of the matching firms have a prior six-month return (momentum) larger than the sample firm and the other two have a prior six-month return smaller than the sample firm. The matching firms are selected in month -1 relative to the firm's entry in the short interest sample (i.e., EN $-$ 1). To ensure proper control, we do not allow a sample firm to be a matching firm from six months prior to its entry in the sample (EN $-$ 6) until 36 months after it exits the sample (EX + 36).

From the two matching firms that are closest in six-month return momentum to the sample firm (one with six-month return momentum larger than the sample firm and the other with six-month return momentum smaller than the sample firm), we randomly designate one of the two as the first matching firm. The other firm is designated as the second matching firm. The remaining two matching firms are randomly assigned as the third and the fourth matching firms. We use the first matching firm's returns as the benchmark against which we compare the performance of the sample firm. If the first matching firm disappears, we use that firm's returns until its last available return date. After that, we use the second matching firm's returns and so on. This procedure guarantees that the matching firms are picked at the same time as the sample firms and avoids the potential hindsight bias in the selection of matching firms. If all four matching firms disappear, we use the CRSP value-weighted index returns from that point on. If a sample firm is delisted, we compound the sample firm returns as well as the matching firm returns until the month of the last available return of the sample firm.[14]

We examine the matching-firm abnormal returns using two different methodologies. First, we develop an approach similar to the calendar-time portfolio approach to provide estimates of abnormal returns that are directly comparable to those reported using the calendar-time portfolio approach.

[14] For the matching firm adjusted analysis, we have 1,842 sample firms in the 2.5 percent sample for which the requisite data are available (most of the observations are lost due to missing book-to-market values and some are lost due to missing prior six-month returns). In 1,472 out of 1,842 cases, only one matching firm's returns were needed. For 283 (52/35) firms, we used two (three/four) matching firms for each sample firm.

Second, we examine the performance of the short interest sample over several holding periods, ranging from one month to 24 months. The results of these analyses are discussed in sequence.

Similar to the calendar-time portfolio approach, for each month from July 1988 to January 1995, we form a portfolio of all firms that have at least 2.5 percent short interest in the previous month. In the calendar-time portfolio approach, portfolio raw return in excess of the risk-free rate is regressed on an intercept and the four asset-pricing factors and the intercept is an estimate of the abnormal return. In the matching firm approach, we compute monthly abnormal return for each firm by subtracting the matching firm's return from the sample firm's return. Then the portfolio abnormal return is calculated each month as the average of the sample firm abnormal returns. The abnormal return to this strategy over the sample period is −0.98 percent per month, with a *t*-statistic of −4.00 (results not reported in tables). The corresponding monthly abnormal return for the 10 percent sample is −1.11 percent with a *t*-statistic of −2.99. We obtain comparable results when firms are retained in the portfolio for 12 months from EN + 1 to EN + 12 (similar to the approach in Table IV).

In an alternative approach, we examine buy-and-hold returns over different holding periods. We calculate a buy-and-hold return for a stock i for T months as

$$R_{iT} = \prod_{t=1}^{T}(1 + r_{it}) - 1.0, \tag{2}$$

where r_{it} is the raw return (with dividends) for stock i in month t. The return for the matching firm is computed in a similar manner and is denoted by R_{mT}. The holding period abnormal return (*HAR*) for stock i is calculated as

$$HAR_{iT} = R_{iT} - R_{mT}. \tag{3}$$

Abnormal return is then averaged over all the stocks in the sample to obtain the average holding period abnormal return (*AHAR*) for a portfolio of n stocks and is given by

$$AHAR_T = \frac{1}{n}\sum_{i=1}^{n} HAR_{iT}. \tag{4}$$

The statistical significance of the $AHAR_T$ is determined by using a *t*-statistic that is computed as

$$t = \frac{AHAR_T}{SE_T}, \tag{5}$$

where SE_T is the estimated standard error of $AHAR_T$.

Table VII

Matching Firm Adjusted Abnormal Returns for the 2.5% Sample

The table reports the mean buy-and-hold (holding period) raw returns for the sample firms (*RAWS*), the corresponding mean returns for the matching firms (*RAWM*), the average abnormal returns (*AHAR*) for the sample firms, the *t*-statistic associated with the mean abnormal returns, and the percentage of firms with positive abnormal returns (*HAR*). The matching firms have the same size decile ranking and the same book-to-market quintile ranking as the sample firm in the month before attaining the threshold level of short interest and are closest in six-month return momentum to the sample firm. The matching firms are selected in month −1 relative to the firm's entry into the short interest sample. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. Short interest is defined as a ratio of shares shorted to the total number of shares outstanding at the end of each month. A firm enters the 2.5 percent short interest sample when its short interest reaches 2.5 percent in a given month and leaves the sample when the short interest level falls below 2.5 percent. EN refers to the month in event time when the sample firm first enters the short interest sample and EX refers to the last consecutive month for which the sample firm's short interest remains at or above the 2.5 percent level. Fewer than 2,726 observations result due to either missing book-to-market values or the firm having fewer than three valid returns in the six-months before entering the sample (EN − 6 to EN − 1).

Subperiod	No. of Obs.	*RAWS* (%)	*RAWM* (%)	*AHAR* (%)	*t*-Statistic	% Positive *HAR*
EN − 6 to EN − 1	1,842	29.76	26.55	3.22	2.77	50.71
EN	1,842	1.18	0.80	0.39	0.51	51.47
EN + 1 to EN + 6	1,841	2.55	7.11	−4.56	−3.30	45.90
EN + 7 to EN + 12	1,829	4.34	5.23	−0.89	−0.63	48.17
EN + 13 to EN + 24	1,785	14.26	15.72	−1.46	−0.59	47.68
EN + 1 to EN + 12	1,841	7.02	13.59	−6.57	−3.03	44.60
EN + 1 to EN + 24	1,841	22.27	31.13	−8.85	−2.28	45.03
EX + 1 to EX + 12	1,802	10.53	17.84	−7.31	−3.11	45.78
EX + 13 to EX + 24	1,687	14.39	18.27	−3.88	−1.55	47.95

B.2. Results

Table VII reports the results for the 2.5 percent sample using the matching firm methodology.[15] The results show that the sample firms experience large run-up in price prior to becoming heavily shorted.[16] The mean raw returns for the sample firms in the six months prior to their entry in the short interest sample (EN − 6 to EN − 1) are 29.76 percent. In the month of entry (EN), that is, the first month for which the short interest reaches the 2.5 percent threshold, the abnormal returns are 0.39 percent (*t*-statistic of 0.51) and are not significant. Recall that the Nasdaq releases the aggregate data on short interest towards the end of the third week or in the early part

[15] The results for the 10 percent sample are similar.

[16] We require the sample firms to have the book-to-market ratio available in month EN − 1 as well as at least three nonmissing returns in the six prior months (from EN − 6 to EN − 1). As a result, the sample size for this analysis is smaller than the sample size for the calendar-time portfolio analysis.

of the fourth week of a month. Thus, a likely reason for the lack of significance of the abnormal return in month EN is that the abnormal return in that month primarily reflects information available prior to the release of the short interest position. The abnormal returns over longer holding periods show that following their becoming heavily shorted, the sample firms significantly underperform their matching firms. The abnormal returns (with *t*-statistic in parenthesis) for holding periods of six months (EN + 1 to EN + 6), 12 months (EN + 1 to EN + 12) and 24 months (EN + 1 to EN + 24) are −4.56 percent (−3.30), −6.57 percent (−3.03), and −8.85 percent (−2.28), respectively.[17]

While market efficiency predicts an immediate adjustment of prices to information contained in the short interest, our results show that the adjustment may not be immediate. The heavily shorted firms continue to experience abnormal returns in the months after the information on short interest is released. While this result does not necessarily indicate market inefficiency, it appears to be consistent with the results in the extant literature documenting postannouncement drift in various contexts (see Fama (1998) for a review of this literature).

We also examine the stock price performance of the sample firms after their short positions fall below the threshold for being considered as heavily shorted, that is, after they exit the sample. The results show that the sample firms experience significant negative abnormal returns for 12 months after ceasing to be heavily shorted (EX + 1 to EX + 12). The abnormal returns over the period EX + 1 to EX + 12 are −7.31 percent with a *t*-statistic of −3.11, while no significant abnormal returns are earned in the following 12 months (EX + 13 to EX + 24).

We find that the continuation of poor performance after exiting the short interest sample is driven by continuing large short positions even after exiting the sample. Although a firm is not considered heavily shorted if its short interest drops below 2.5 percent, the choice of 2.5 percent as the cutoff is arbitrary. We find that the mean (median) short interest of the sample firms in the month in which they drop out of the 2.5 percent sample is 1.32 percent (1.52 percent). For the 10 percent sample, the corresponding mean (median) is 5.9 percent (7.8 percent). The 75th percentile of short interest for the universe of Nasdaq firms over our sample period is 0.5 percent. Thus, the sample firms continue to have relatively large short positions even after they exit the sample.

To mitigate this effect, we examine the abnormal returns surrounding large decreases in short interest position (results not reported in tables). Specifically, we identify stocks whose short interest declined by at least 2.5 percentage points in a month and, after the decrease in short interest, their

[17] In addition to the buy-and-hold abnormal returns, we also examine monthly abnormal returns for each month from EN + 1 to EN + 12. We find that the abnormal returns are negative in 11 out of 12 months and are statistically significant in months EN + 1, EN + 3, and EN + 4.

short interest level dropped below 2.5 percent of the shares outstanding. We also examine a sample of stocks with at least a 5 percentage points decrease in short interest. In these two samples, we find that the mean (median) level of short interest is only 0.55 percent (0.22 percent) and 0.44 percent (0.14 percent), respectively, immediately after the large decline in short interest. In the month subsequent to their exit, the abnormal returns in the above two samples are −0.007 percent (t-statistic of −0.02) and −0.17 percent (t-statistic of −0.09), respectively. Thus, when the short interest positions are largely unwound, the abnormal returns do not appear to persist.

IV. Survival Status of the Firms Following Periods of Heavy Short Selling

The results reported in the previous sections show that high level of short interest conveys negative information as evidenced by subsequent poor stock market performance. Given that heavily shorted firms perform poorly relative to their matching firms, it is reasonable to expect a higher incidence of liquidations and bankruptcies in the sample firms than in their matching firms. Thus, we expect to observe a higher incidence of performance related delistings in the sample firms than in their matching firms.[18]

In this section, we test whether the sample firms experience a higher incidence of performance-related delistings than their size-, book-to-market-, and momentum-matched matching firms.[19] This analysis provides an alternative test of the informational role of short interest without relying on the magnitude of the abnormal returns. To conduct this analysis, we track the survival status of the sample firms and their matching firms for 36 months following the sample firms' entry in the short interest sample.

We use a nonparametric binomial test to examine whether the delisting frequency in the sample firms is significantly higher than the matching firms. We define n as the number of sample firms that have delisted in the 36 months following their entry into the short interest sample and m as the corresponding number of matching firms that have delisted over the same period. If the probability of delisting of the sample firms is the same as that of the control firms, then the expected value of the number of delistings for the sample firms is $(n + m) * 0.5$ and variance is $(n + m) * 0.5 * 0.5 * ((N + M - (n + m))/(N + M - 1))$, where N and M are the total number of sample firms and control firms, respectively (DeGroot (1986, pp. 249–250)).

[18] We identify delistings and the cause of delistings from the CRSP delisting codes. For example, firms are delisted if their share price falls below a certain level, if the firm has insufficient capital, or if the firm does not meet the exchange's financial guidelines for continued listing.

[19] For the purpose of this test, we compare the survival status of a sample firm with the survival status of one matching firm. We have a pool of four matching firms that were selected based on size, book-to-market, and momentum. From the first two matching firms, we randomly designate one of them as the matching firm for the purpose of this analysis.

Table VIII

A Comparison of Delistings of Sample Firms and Their Matching Firms 36 Months after Entry into the Short Interest Sample

The table reports the frequency of delisting of the sample firms and their corresponding matching firms 36 months after the sample firm enters the short interest sample. The sample consists of all firms on the Nasdaq from June 1988 to December 1994 whose short interest exceeds a certain level. Data are available from June 1988 to December 1994, except for February 1990 and July 1990. For these two months, the firms are assumed to have the same level of short interest as the previous month. Short interest is defined as a ratio of number of shares shorted to the total number of shares outstanding at the end of each month. A firm enters the short interest sample when its short interest reaches a certain threshold (2.5 percent or 10 percent) in a given month and leaves the sample when the short interest level falls below the threshold. The delisting data are obtained from the CRSP files. The delistings are assumed to follow a binomial distribution and the *z*-statistic is for the difference in the delisting frequency for the sample firms and their matching firms. The matching firm for each sample firm is selected randomly from the two matching firms that are in the same size decile and the same book-to-market quintile as the sample firm and that are closest in prior six-month return momentum (one with return momentum larger than the sample firm and the other with return momentum smaller than the sample firm). The matching is done in month −1 relative to the firm's entry into the short interest sample. Fewer observations result due to missing book-to-market values and missing six-month momentum for the sample firm and missing delisting code for either the sample or the matching firm. Panel A presents the analysis for the 2.5 percent short interest sample and Panel B presents analysis for the 10 percent short interest sample.

Listing Status	Frequency (Sample)	Percent (Sample)	Frequency (Matching Firm)	Percent (Matching Firm)	z-Statistic for the Difference in Frequency
Panel A: Delisting Analysis of the 2.5% Short Interest Sample					
Active	1,425	81.38	1,469	83.89	−0.82
Mergers or exchanges	185	10.57	170	9.71	0.80
Liquidations or delisted by the exchange	141	8.05	112	6.40	1.82
Total	1,751	100.00	1,751	100.00	
Panel B: Delisting Analysis of the 10% Short Interest Sample					
Active	318	81.96	347	89.43	−1.12
Mergers or exchanges	42	10.82	27	6.96	1.81
Liquidations or delisted by the exchange	28	7.22	14	3.61	2.16
Total	388	100.00	388	100.00	

Table VIII reports the survival status of the sample firms and the matching firms 36 months after the sample firms' entry in the short interest sample (i.e., in month EN + 36) as well as the *Z*-statistic from the binomial test. Panel A reports the results for the 2.5 percent short interest sample and Panel B reports the results for the 10 percent short interest sample. In the 2.5 percent sample, we find that 8.05 percent of the sample firms either liquidated or were forced to delist by the exchange within 36 months of their entry in the short interest sample. On the other hand, 6.40 percent of the

matching firms suffered the same fate. This difference is statistically significant at the 10 percent level with a z-statistic of 1.82. The results for the 10 percent short interest sample reported in Panel B of Table VIII are similar. The proportion of sample firms that are either liquidated or delisted by the exchange is 7.22 percent; the corresponding proportion for the matching firms is 3.61 percent. The difference is statistically significant, with a z-statistic of 2.16. The above results provide further support to the assertion that a high level of short interest conveys negative information.[20]

V. Conclusions

Short positions have been posited in the literature as being bearish, bullish, or neutral signals. The purpose of this paper is to examine which of these perspectives is supported by empirical evidence. Our examination reveals that large short positions are bearish signals. We find that firms with large short positions experience negative and significant abnormal returns when they are heavily shorted. The negative abnormal returns are increasing in the level of short interest, suggesting that a higher level of short interest is a stronger bearish signal. We also document a negative relationship between large increases in short interest and subsequent abnormal returns. The results are consistent with short sellers having private information. Our results also suggest that short sellers target highly liquid firms whose prices are high relative to their fundamentals. An examination of the survival characteristics shows that heavily shorted firms experience a significantly higher incidence of liquidations or forced delisting than their size-, book-to-market-, and momentum-matched control firms. Overall, the results suggest that, on average, high level of short interest conveys negative information.

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[20] Given that the same firm can appear in the sample twice, we have replicated this analysis using each sample firm just once (the first time it enters the sample). The results are similar.

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