Short-selling, price momentum and fundamental analysis [†]

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Comments Welcome.

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ABSTRACT: We examine how the positions of short-sellers are associated with prior price momentum, fundamental-to-price ratios and future price momentum. We find evidence consistent with short-sellers using information in fundamental-to-price ratios to identify mispriced stocks when selecting short positions in extreme price momentum quintiles. We document that future price momentum profits are significantly lower for portfolios of stocks with high levels of short-interest than for portfolios of stocks with low levels of short-interest. We also find evidence that the positions taken by short-sellers are associated with more timely momentum reversals for stocks in the extreme momentum portfolios. Collectively our results suggest that short-sellers play a stabilizing role in the market by mitigating the magnitude and persistence of the continuation of extreme prior price momentum.

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1. Introduction

Short-sellers play an integral role in asset pricing models. For example, in the arbitrage theory of Ross (1976), the alignment of prices with their intrinsic values relies upon the ability of investors to take offsetting long and short positions in close economic substitutes. Recent academic literature has investigated the role of short-sale constraints and concludes that short-sale constraints are generally associated with a decrease in the efficiency of price discovery.[1] There is little agreement, however, on whether the aggregate impact of short-sellers on asset pricing is corrective, with regulators typically maintaining the belief that restricting short-selling activity limits the severity of price declines (see for example the discussion in Bris, Goetzmann and Zhu, 2007). Even less is known about how the positions of short-sellers interact with the price momentum anomaly.

In this study, we examine variation in the positions of short-sellers for extreme price momentum portfolios (we refer to these portfolios as the winner and loser portfolios). The study is organized in two parts. In the first part, we document the interaction between short-interest and fundamental-to-price ratios for extreme prior price momentum portfolios.[2] In the second part, we investigate the association between short-interest and the magnitude and persistence of future returns for extreme prior price momentum portfolios. Our findings extend the literature on the role of short-sellers and price momentum.

Our findings extend the literature that examines associations of short-interest with asset pricing anomalies. First, we find a positive association between short-interest and extreme price momentum portfolios (both extreme winner stocks and extreme loser stocks). Second, consistent

[1] The analytical literature in this area includes the work of Miller (1977), Diamond and Verrechia (1997), Duffie, Garleanu, and Pedersen (2002), Abreu and Brunnermeier (2001, 2002), and Scheinkman and Xiong (2003). Recent empirical work that suggests constraints to short-sellers decreases the efficiency of asset pricing includes Jones and Lamont (2002), Ofek and Richardson (2003), Geczy, Musto and Reed (2003), Asquith, Pathak and Ritter (2006) and Diether, Lee and Werner (2007) who collectively show that stocks considered as short-sale constrained are associated with poor future returns. Using proprietary databases, D'Avolio (2002) and Cohen, Diether and Malloy (2007) present consistent evidence using direct measures of short-selling constraints and demand. Outside of the US regulatory setting, Bris et al., (2007) provide evidence of short-selling restrictions being associated with negative skewness and slower incorporation of bad news for a cross-country sample. Chang, Cheng and Yu (2007) show that in the Hong-Kong market, the removal of specific restrictions to short-selling an individual stock are associated with negative future returns. There are some notable exceptions to the finding that constraints to short-selling activity decreases asset pricing efficiency including the work of Allen and Gale (1991) who suggest that short-sales can destabilize the economy and Bernardo and Welch (2004) who suggest that short-selling restrictions may prevent front-running when there is fear of a financial crisis, preventing the magnitude of market crashes.

[2] We measure short-interest as the percentage of shares sold short relative to the number of shares outstanding. Any unqualified references to short-interest in the remainder of this paper refer to this definition.

with Dechow, Hutton, Meulbroek and Sloan (2001) we show, on average, short-interest is positively associated with low fundamental-to-price ratios, however, we also find that this association is significantly greater for extreme winner and extreme loser prior momentum stocks and we do not find these associations for a high fundamental-to-price stocks. Third, we find that short-sellers appear to time their trades, consistent with short-sellers being aware that price momentum reverses over time.

Our findings also extend the literature on price momentum. First, prior research has argued that price momentum is either the result of over-reaction or the result of under-reaction. We find that conditional on the stock's fundamental-to-price ratio being low, short-sellers appear to take positions consistent with price momentum being due to both short-term under-reaction (with higher short-interest in low fundamental-to-price stocks in the loser portfolio) and over-reaction (with higher short-interest in low fundamental-to-price stocks in the winner portfolio). Second, consistent with Lee and Swaminathan (2001) we find that momentum stocks reverse over the longer-term. We show that high short-interest stocks have a more timely momentum reversal relative to low short-interest stocks. This result is mainly due to the timely reversal of momentum returns of stocks in the winner portfolio.

Taken together these findings are important, as they refute the common presumption that extrapolative positions taken by short-sellers are destabilizing by amplifying the severity of a (unwarranted) price decline. While we find that short-sellers do take positions in stocks in the loser prior momentum portfolio, the stocks with the highest short-interest are those loser prior momentum stocks that are also considered overpriced relative to fundamentals (i.e., have a low fundamental-to-price ratio).

2. Related literature and empirical predictions

2.1. Short-sellers

Considerable analytical research has explored the role of short-sellers in the market. Early work by Miller (1977) suggests that asset prices are likely to be more speculative when short-sellers face constraints, as the market price is left to be determined by the more optimistic investors. Diamond and Verrecchia (1987) model the effect of constraints to short-selling on the speed of price discovery. The authors conclude that short-sale restrictions reduce the amount of

private negative information that is incorporated into the prices of individual securities. Recent work that has built on this model includes Abreu and Brunnermeier (2001; 2002) show that the actions of corrective trades from would-be arbitrageurs are delayed due to arbitrage frictions. The authors then show that short-sales constraints increase excessive volatility and are a necessary condition for the development of asset pricing bubbles. A recent paper by Scheinkman and Xiong (2003) also finds that overconfidence inflates asset prices when there are constraints to short-selling. These studies present an important role for short-sellers, the expected role of the short-seller being to remove speculation making market prices more efficient. Despite this stabilizing role expected from short-sellers in the academic literature, short-selling activity is constrained by regulators and often fought by managers (Lamont, 2002).[3]

The majority of the empirical evidence provided by prior literature is consistent with conjecture that stocks with binding short-sales constraints are relatively overpriced, and have subsequent low returns (D'Avolio, 2001; Jones and Lamont, 2002; Ofek and Richardson, 2003; Asquith, Pathak and Ritter, 2006). Several studies have tested the predictions of Miller (1977) and Diamond and Verrecchia (1987) in empirical settings. For example, Danielson and Sorescu (2001) show that the introduction of tradable options for a stock is associated with subsequent low returns, suggesting that options provide the means for the removal of prior constraints to short-selling. The emphasis of the above literature is on the stocks with the most binding short-sales constraints, however, the literature concludes that while some stocks do have high costs to short-selling in the cross-section most stocks are easily and cheaply shorted (e.g., Geczy, Musto and Reed, 2002; D'Avolio, 2002; Ofek, Richardson and Whitelaw, 2004; Asquith, Pathak and Ritter, 2006).

There is also a literature that investigates whether the positions of short-sellers are associated with accounting information. Dechow et al. (2001) find that short-sellers target stocks with low fundamental-to-price ratios. Richardson (2001) finds an association between the positions of short-sellers and earnings quality. Desai et al. (2002) and Effendi et al. (2005) show that the positions of short-sellers are positively associated with future restatements. Generally, this literature assumes that short-sellers are sophisticated investors who can afford to incur

[3] Regulatory constraints vary across countries ranging from outright bans on short-selling (e.g., Spain and China), to the restriction of stocks that can be short-sold (e.g., Brazil), to the up-tick rule common in the US market, where any stock can be short-sold as long as the prior stock price movement was positive. Further evidence on the variation in regulatory regimes can be found in Bris et al. (2007).

relatively large transaction costs by short-selling over-priced securities and subsequently repurchasing them at a lower price.[4]

Most analytical and empirical evidence has suggested that short-sellers trades increase the efficiency of the market. While the evidence above shows that short-sales may be necessary (and effective) in removing overpricing in the market there are no tests of the contrary position often put forward by regulators and managers. Specifically, no study to date has examined whether short-sellers engage in extrapolative short-selling, thereby potentially amplifying price declines. We address this gap in the literature by investigating the association between the positions of short-sellers and the price momentum anomaly.

2.2. Price momentum

Over the past two decades researchers have presented evidence that cross-sectional stock returns are predictable based on past returns. These associations include the short-term reversal of returns at monthly and weekly intervals (Jegadeesh, 1990; Lehmann, 1990), the intermediate continuation of returns over three- to 12-months (Jegadeesh and Titman, 1993) and the long-term reversal of stock prices over intervals of about five-years (DeBondt and Thaler, 1985, 1987; Lee and Swaminathan, 2001).

We focus on the intermediate-term continuation of returns documented in Jegadeesh and Titman (1993) and the reversal of these intermediate-term returns over the longer-term documented in Lee and Swaminathan (2001). Jegadeesh and Titman (1993) show that when forming portfolios based on past three- to 12-month returns, winners on average outperform past losers over the next three- to 12-months. Lee and Swaminathan (2001) show that the price momentum based past three- to 12-month returns reverses over the following four- to five-years.

Explanations for why price momentum continues in the intermediate-term are mixed. Some studies argue that the continuation in returns is due to the underreaction of investors to news events (e.g., Jegadeesh and Titman, 1993; Chan, Jegadeesh and Lakonishok, 1996; Barberis, Shliefer and Vishny, 1998), while other studies suggest that the continuation of returns is due to the overreaction of investors to news events (e.g., DeLong et al., 1990; Daniel, Hirshleifer and Subramahmanyam, 1998; Lee and Swaminathan, 2001). Of course, in the cross-

[4] Not all evidence is consistent with short-sellers as sophisticated investors able to profit from superior information. Daske, Richardson and Tuna (2006) find no evidence that short transactions precede stock price declines.

section and inter-temporally, under- and over-reaction are not mutually exclusive. In particular, Lee and Swaminathan (2001) suggest that trading volume is useful in reconciling an intermediate underreaction effect (a continuation in returns) with a longer-term overreaction effect (a reversal in returns). We expect short-sellers take positions that either trade with under-reaction or trade against over-reaction. We discuss the implications of predictions consistent with both the under- and over-reaction hypotheses on the level of short-interest in extreme winner and loser stocks in the following section.

2.3. Implications for the cross-sectional distribution of short-interest

In the first section of our study, we are interested in how the positions of short-sellers vary with extreme prior momentum. Prior research suggests that at the individual-stock level, short-interest appears to be contrarian in nature, with over-priced stocks attracting higher short-interest. Regulators and managers argue that short-sellers (if able) would take extrapolative short positions amplifying price declines and forcing stocks to become under-priced. On the surface, short-sellers that trade on prior price declines could potentially fall into this extrapolative category.

Our predictions are based on the assumption that short-sellers trade based on profiting from the correction of mispricing, and so we condition all of our tests on the basis of the fundamental-to-price ratio (Dechow et al., 2001). We refer to the medium-term continuation of momentum and long-term reversal of momentum documented by Lee and Swaminathan (2001). as the "momentum life-cycle."

In Figure 1, we provide a summary of our predictions based on the under-reaction and over-reaction hypotheses. Our predictions are common for both over- and under-reaction hypotheses, for the expected association between short-interest and low fundamental-to-price ratios (i.e., "overpriced" stocks). We predict that in both cases short-interest will be positively associated with low fundamental-to-price ratios.

Our predictions relating to the expected association between short-interest and extreme prior momentum, however, differ for the under- and over-reaction hypotheses. In both cases we still predict that short-sellers will target stocks that they believe are overpriced. Our predictions are summarized in Figure 1. We assume a long-run target or hypothetical "correct" level of an individual stock's fundamental-to-price ratio. We then assume that the individual stock's price

deviates from, and reverts to, this "correct" level over time with changes in price momentum. The arrows represent the direction of future price movements following the hypothetical stock's (extreme) prior momentum. In the panel A of Figure 1, we present our predictions of the positions of short-sellers consistent with the under-reaction hypothesis. If price momentum is due to under-reaction, then future returns would continue in a consistent direction to prior price movements (represented by the arrows consistently pointing towards the "correct" level of the fundamental-to-price ratio). When this is the case, we expect short-interest will be greater for stocks in the loser portfolios that also have a low fundamental-to-price ratio. Following the under-reaction hypothesis, however, we do not expect that short-interest will be associated with stocks with high fundamental-to-price ratios or stocks in the winner portfolio.

In Panel B of Figure 1, we present our predictions of the positions of short-sellers consistent with the over-reaction hypothesis. If price momentum is due to over-reaction, future returns are expected to continue in the intermediate-term and then reverse over the longer-term relative to the direction of prior price movements (this "turning point" effect is represented by the arrows first moving away from, and then moving towards the "correct" level of the fundamental-to-price ratio). When this is the case, short-interest should be associated with those stocks in the winner portfolio that also have a low fundamental-to-price ratio. Following the over-reaction hypothesis, however, we do not expect that short-interest will be associated with stocks with high fundamental-to-price ratios or stocks in the loser portfolio (in this case short-interest would be extrapolative and be expected to increase the severity of price declines).

We also predict differences in the timing of short-interest for winner and loser stocks due to momentum life-cycle effects (that is the period of time over which the correction of prior movements away from and then back to the "correct" level of the fundamental-to-price ratio). We base these predictions loosely around the costly arbitrage literature (e.g., Shliefer and Vishny, 1997). In short, the longer the expected horizon of the holding period before returns will be realized, the more costly the position is to the would-be arbitrageur. Abreu and Brunnermeier (2001) show that when faced with more costly arbitrage positions an individual short-seller will delay taking a position in the overpriced stock leading to a delay in the correction of the overpriced stock. Their argument is based arbitrageurs being compensated based on relative performance, but their corrective trades requiring co-ordination. In these circumstances they show that would-be arbitrageurs attempt to best time their trades to "beat the gun" allowing the

shortest holding time, but beating other would-be arbitrageurs in taking a profitable position. Based on the effects of costly arbitrage on the timing of trades, we expect that short-interest taking a position in (extreme) negative price momentum stocks will be earlier in the momentum life-cycle than short-interest taking a position in (extreme) positive price momentum stocks. We represent this in Figure 1, with the placement of the expected short-interest along the momentum life-cycle.

To test these predictions, we require a proxy for overpricing relative to fundamentals. We use various measures of low fundamental-to-price ratios following Dechow et al. (2001), who use accounting-based measures of fundamental value as a proxy for the intrinsic value of the stock. As Dechow et al. (2001) show that short-sellers target low fundamentals-to-price stocks, we can test our predictions relating to price momentum by examining whether the positions taken by short-sellers are associated with low fundamental-to-price stocks for various price momentum portfolios. We also require a measure of the momentum life-cycle. We follow the technique used by Lee and Swaminathan (2001) who document that the reversal of prior momentum is more timely for portfolios formed on longer-term prior price movements. Following Lee and Swaminathan (2001) few compare portfolios of price momentum formed over prior three-, six-, nine- and 12-month return formation periods.

2.4. Implications for the magnitude and reversal of price momentum

In addition to examining the association between short-interest and prior price momentum conditional on the fundamental-to-price ratio of the stock, we also examine whether or not the positions of short-sellers are associated with smaller momentum profits and more timely reversals of price momentum. Lee and Swaminathan (2001) show that portfolios of stocks with both high and low trading volume experience timely price momentum reversals. As part of the volume of trade is initiated by short-sellers, we expect that a similar effect will be evident in the positions of short-sellers. That is, the timeliness of the reversal of price momentum is expected to vary with the level of short-interest.

If short-sellers have a corrective influence on the price momentum anomaly, then profits to a momentum strategy would be smaller and the reversal of prior period momentum should be more timely. Our predictions on the effect of short-sellers on future returns are again different when based on the under- or over-reaction hypotheses. In the upper section of Figure 1, we

show that we expect short-interest to be greater for stocks in the loser portfolio (if momentum for these stocks is consistent with under-reaction) and should reduce future returns that are early in the momentum life-cycle. We predict lower momentum returns and a more timely reversal of negative momentum for stocks with high levels of short interest. In the lower section of Figure 1, we show that we expect high levels of short-interest to be timed to coincide with the turning point for winner firms when their momentum profits are expected to reverse. We therefore expect that stocks in the winner portfolios with high levels of short-interest will have lower momentum returns and a more timely momentum reversal.

3. Sample and measurement of variables

We source financial variables, market prices and returns from the merged CRSP-Compustat database. Our sample includes all common stock (share codes 10 and 11) over the period 1995–2002 (as our short-selling data ends in 2002). We exclude ADR stocks as they are not subject to the same short-selling regulations as common shares.[5] We measure earnings as income before extraordinary items (Compustat data item 18), and book-value as shareholders equity (Compustat data item 60).[6]

We source earnings forecast data from the unadjusted I/B/E/S consensus file. We use the mean one-year forecast of earnings per share inflated to firm-level earnings by multiplying it with the I/B/E/S number of shares outstanding. We obtain institutional data from the CDA Spectrum/Thompson One 13-F filings database. This database records all 13-F filings which are required to be disclosed with the SEC for each firm where an institutional investor holds 1000 or greater stocks in that firm. We collect the level of short-interest from the monthly records of the NYSE and the NASDAQ. For NYSE stocks, short-interest for the month is required to be reported in the third week of the month (usually within the 17^{th} – 20^{th} day of the month) and becomes publicly available with two to three days. For NASDAQ listed stocks, short-interest is required to be reported on the 15^{th} day of the month (or if the 15^{th} is not a business day, the

[5] ADRs are exempt from the up-tick rule under Section 10a-1 subsection (e)(8) of the 1934 Securities Exchange Act.
[6] Similar results are found for alternative measures of earnings and book-value. Following Fama and French (1992) we measure earnings as income before extraordinary items (data 18) plus deferred taxes (data 50) minus preferred dividends (data 19) and book-value is defined as shareholders equity (data 60) plus balance sheet deferred taxes (data 35). We also use data 178 (earnings after depreciation) as a measure of earnings. These variables are significantly highly correlated with the measures reported in the paper and using these alternative measures does not change the inferences drawn from our main analysis.

preceding business day) and becomes publicly available on the eighth business day following this report. We match short-interest for each month *t*, with lagged accounting and prior return variables.

3.1. Measurement of short-interest

We measure short-interest based on the monthly records of the NYSE and NASDAQ. We deflate the raw short-interest by the CRSP number of shares outstanding at the end of the month to obtain a percentage measure.[7] The monthly change in short-interest is then measured as the percentage change in this measure (i.e., the percentage of short-interest for month *t* less the percentage of short-interest for month *t*–1 all divided by the percentage of short-interest for month *t*–1).

We are primarily interested in high levels of short-interest, as low levels of short-interest could be due to hedging activities (Dechow, Hutton, Meulbroek and Sloan, 2001). We define a "high level" of short-interest in the following ways. First, we consider short-interest to be high if the percentage of short-interest for the month is in the top decile of all levels of short-interest for our sample of stocks. We also consider percentage threshold-based measures following Dechow et al. (2001), and consider high short positions as those over 0.05%, 1% and 5%. We find qualitatively similar results using these threshold-based measures.

3.2. Measurement of fundamental value

We measure fundamental value using the residual income model (e.g., Ohlson, 1995) and traditional measures using book-value, earnings and dividends. We calculate residual income value using analyst forecasts in a similar manner to Frankel and Lee (1998) and also using linear information dynamics as in Dechow, Hutton and Sloan (1999). We present our main results using a residual income model that is updated on a monthly basis using analyst forecasts. Using the clean surplus relation, the forecast-based residual income model (V_f) can be used to explicitly

[7] The NYSE and NASDAQ levels of short-interest are reported as adjusted for share-splits for the month if the share-split occurred before the reporting period. For share-splits that occurred after the reporting date for short-interest, our percentage measure of short-interest understates the true proportion of the stock held short.

forecast future dividends by using the following structural form with *T*–period ahead observations of forecast earnings:

$$Vf(T)_t = b_t + \frac{f(1)_t - r.b_t}{(1+r)} + \frac{f(2)_t - r.b(1)_t}{(1+r)^2} + \ldots + \frac{f(T)_t - r.b(T-1)_t}{(1+r)^2 r}. \quad (1)$$

The model can then be collapsed to provide an estimate of the Gordon growth model by using a single forecast of earnings and assuming a perpetual growth rate *g*. Specifically:

$$Vf(1)_t = b_t + \frac{f(1)_t - r.b_t}{r-g}. \quad (2)$$

This very simple structure can be used to calibrate multiple measures of value, by implementing the model with alternative measures of both *r* (the rate of return) and *g* (the estimate of growth in residual earnings). While less sensitive to unusual earnings, as book-value is included in the model, the model is similar to an earnings-based approach (and equals the earnings capitalization model when $g = 0$). To implement the model used in the main analysis we set *r* equal to the one-year constant yield to maturity treasury bond rate plus an equity premium of 6% and *g* is set equal to 3%.[8] Book-value, b_t, is the end of year book-value from the most recent fiscal year-end, $f(1)$ is the forecast of earnings and is taken from the I/B/E/S consensus forecast of one-year ahead (median) earnings per share at the end of each month, inflated to firm values using I/B/E/S shares outstanding.

3.3. Measurement of price momentum

We measure price momentum following Jegadeesh and Titman (1993) who show that price momentum (measured over three-, six-, nine- and 12-month holding periods) tends to continue for a subsequent three month period. We measure price momentum monthly for each

[8] We considered implementing the model with alternative assumptions regarding the values for *r* and *g*. Our results are quantitatively similar for values of the equity premium ranging from 0% to 12%. Changing the forecast horizon, by adding additional forecasts to the model, as in Lee et al. (1999) and Frankel and Lee (1998), requires assumptions regarding payout policy. We find similar results when implementing longer-horizon models.

stock for three-, six-, nine- and 12-month holding periods (J = 3, 6, 9, 12) based on buy-and-hold returns over the holding period excluding dividends.[9] Each month, we rank the stocks into quintile portfolios based on prior returns over the portfolio formation period. The stocks with the highest prior returns (i.e., the winner portfolio) are those in the highest quintile of prior returns, and the stocks with the lowest prior returns (i.e., the loser portfolio) are those in the lowest quintile of prior returns. Collectively the winner and loser portfolios are called the extreme momentum portfolios.

3.4. Measurement of control variables

In our multivariate tests we also include the following controls. We include a control for the size of the firm (the log of the market value of the firm) as larger firms are more cheaply and easily shorted (see, D'Avolio, 2001; Dechow, Hutton, Meulbroek and Sloan, 2001). We measure the log of market value as the product of the prior month closing price and number of shares outstanding from the CRSP database. We include a measure of institutional holdings (the percentage of institutional holding) as prior research suggests that institutional holdings proxy for the supply of shares available to be shorted (e.g., Geczy et al., 2002). We measure the percentage of institutional holdings as the sum of the institutional holdings in the firm's stock from the CDA Spectrum/Thompson One database divided by the CRSP number of shares outstanding. We lag the institutional holdings variable by one month and as the institutional holdings are reported quarterly we use the same percentage for all months in the quarter.[10] We include the dividend yield as dividends must be paid by the short-seller out of their own capital (e.g., D'Avolio, 2001).

4. Results

4.1. Descriptive statistics

[9] As sensitivity checks, we also considered 3, 6 and 9 month rolling windows as our measure of price momentum, and 3, 6, 9 and 12-month holding period buy-and-hold returns that include dividends, we also calculated raw (simple) returns based on month-end closing prices. We find similar results using all of these alternative measures of price momentum. We also find similar results when using industry-adjusted returns, and size-adjusted returns using CRSP size deciles.

[10] We also examine the number of institutions holding a stock. We find similar results to those reported when using this alternative measure.

In Panel A of Table 1 we report descriptive statistics relating to the level of short-interest for the stocks in our sample. Consistent with prior research, the average short-interest, expressed as a proportion of shares outstanding, appears low, at an average level of 1.78% and a median of 0.55%. There does not appear to be any substantial variation in the level of short-interest over the four quarters of the year. We also report the proportion of stocks with short-interest at various thresholds. Not surprisingly, just under half of the sample has short-interest of ½% or less. Stocks with extreme short-interest (greater than 5%) make up roughly 9% of the sample.[11]

In Panel B, we report monthly statistics relating to additional key variables. In Columns 2 and 3 we report the statistics for the value-to-price and book-to-price ratios. The median value-to-price ratio for the sample is 0.658 and the median book-to-market ratio for the stock is 0.494. We also report statistics on the momentum return (prior return over the past 12 months) the size rank and the percentage of institutional investors (*InstRank*) in Columns 3 to 5. The average prior period (raw) return for our stocks is 0.207, the average size rank is 5.627 and the average institutional holdings is 40.2%.

4.2. Analysis of short-interest

In Table 2 we summarize results from several regressions that associate short-interest with prior period price momentum, fundamental-to-price ratios and control variables. We report the average coefficients and autocorrelation adjusted *t*-statistics from 96 monthly cross-sectional regressions based on the following model:[12]

[11] As discussed above we define high short-interest as in the highest quintile of short-interest in each year. By definition this means that 20% of our sample is classified as high short-interest. These stocks have an average level of short-interest of 5.6%.

[12] As our tests are run monthly, but the price momentum variable is measured over the preceding three, six, nine and twelve months, we correct our t-statistics for this induced autocorrelation up to lag 11. In untabulated results we confirm that this adjustment produces more conservative *t*-statistics, relative to using Fama-MacBeth *t*-statistics, but does not qualitatively change our results. The level of short-interest is also expected to be autoregressive (Pownall and Simko, 2005).

$$Short_{it} = \gamma_0 + \gamma_1 lowF_{it} + \gamma_2 hiF_{it} + \gamma_3 negMom_{it} + \gamma_4 posMom_{it} + \gamma_5 SzRank_{it} + \gamma_6 Institutions_{it} + \gamma_7 DivYield_{it} + e_{it}, \quad (3)$$

where *Short* equals short-interest (number of shares held short divided by the number of shares outstanding), *lowF* equals one if the stock is ranked in the lowest quintile of the fundamental-to-price ratio (based on value-to-price, book-to-market, or earnings yield) and zero otherwise, *hiF* equals one if the stock is ranked in the highest quintile of the fundamental-to-price ratio and zero otherwise, *negMom* equals one if the stock is ranked in the lowest quintile of prior *J* period returns (where *J* = three, six, nine and 12 months) and zero otherwise, *posMom* equals one if the stock is ranked in the highest quintile of prior *J* period returns. We also include controls for size (*SzRank*, using the NYSE/AMEX/NASDAQ breakpoints from CRSP), the expected ability to borrow shares (using the proxy *Institutions* which equals the number of shares held by institutions divided by the number of shares outstanding), and the stock's dividend yield (*DivYield*, using the most recent prior annual dividend amount).

In Column 4 of Table 2, we confirm the findings of Dechow et al. (2002) that the positions of short-sellers are heavily concentrated in low fundamental-to-price stocks. For example, when using the value-to-price ratio as our proxy for low fundamentals-to-price, we find a positive and significant association between low value-to-price stocks and the level of short-interest (for $J = 3$, $\gamma_1 = 0.007$, with a *t*-statistic of 14.79). We find consistent results when using either book-to-market or earnings yield as our proxy for low fundamentals-to-price stocks. In Column 5, we report the association between high fundamental-to-price stocks and short-interest. Consistent with the argument in Desai et al. (2006) that short-sellers target stocks with poor fundamentals, we find a positive and significant association between high value-to-price stocks and the level of short-interest (for $J = 3$, $\gamma_1 = 0.002$, with a *t*-statistic of 5.19).[13]

In Columns 6 and 7 we confirm that that the positions of short-sellers are greater for stocks in the extreme momentum portfolios. We also provide evidence consistent with the prediction that short-interest following negative price momentum is concentrated in recent portfolio formations, suggesting that short-sellers take larger positions in stocks in the loser portfolios consistent with the underreaction hypothesis. For example, using value-to-price as the

[13] In untabulated results we confirm that the association between short-interest and stocks with low fundamental-to-price is significantly greater than the association between short-interest and stocks with high fundamental-to-price ratios with an average *F*-statistic (for the null $\gamma_1 = \gamma_2$) of 7.43.

proxy for fundamentals-to-price, in the 3 month portfolio formation period (J = 3) the level of short-interest is significantly associated with stocks in the loser portfolio (γ_3 = 0.007, with a t-statistic of 9.84), however in the 12 month portfolio (J = 12) formation this same association is insignificant (γ_3 = –0.006, with a t-statistic of –0.93). We find consistent results when using either book-to-market or earnings yield as our proxy for low fundamentals-to-price stocks. In Column 7 we provide evidence of significantly larger than average short-interest for stocks in the winner portfolios.

In Columns 8 through 10, we report the association between short-interest and our control variables along with the average adjusted R-square for each model. The associations we document here are consistent with expectations based on prior research (e.g., Dechow et al., 2002). For example, using value-to-price as the proxy for fundamentals-to-price, in the 3 month portfolio formation period (J = 3) the level of short-interest is significantly positively associated with size (γ_5 = 0.002, with a t-statistic of 8.71) and institutional holdings (γ_6 = 0.027, with a t-statistic of 6.69), consistent with the commonly held notion that the supply of shares to short is positively associated with these variables. We also find a significant negative relation between the level of short-interest and the dividend yield consistent with the conjecture that short-sellers avoid dividend-paying stocks (γ_7 = –0.494, with a t-statistic of –10.80).

In Table 3 we summarize results from several logistic regressions that examine the probability of a stock having a high level of short-interest, based on prior period price momentum, fundamental-to-price ratios and control variables. We investigate high short positions (identified as those stocks in the top quintile of the percentage short-selling distribution) as a high short-selling position is more likely to be due to consensus between short-sellers (Dechow et al., 2001). We report the average coefficients and autocorrelation adjusted t-statistics from 96 monthly cross-sectional logistic regressions based on the following model:

$$\begin{aligned} hiShort_{it} = {} & \gamma_0 + \gamma_1 lowF_{it} + \gamma_2 hiF_{it} + \gamma_3 negMom_{it} + \gamma_4 posMom_{it} + \gamma_5 SzRank_{it} \\ & + \gamma_6 Institutions_{it} + \gamma_7 DivYield_{it} + e_{it} \end{aligned}, \qquad (4)$$

where *hiShort* equals one if the stock is ranked in the highest short-interest quintile and zero otherwise, all other variables are as defined previously.

As anticipated, many of the associations we document using the high-short model are similar to those documented in Table 2 where we used the level of short-interest. There are some

notable exceptions. In Column 5, the association between high short-positions and high fundamentals-to-price is not significantly different from zero for all portfolio formation periods (J = 3, 6, 9 and 12-months) and for all proxies for fundamentals-to-price (value-to-price, book-to-market and earnings yield). Consistent with our predictions, we find evidence of a momentum life-cycle effect in short-interest associated with negative prior momentum conditional on the low fundamental-to-price ratio. Specifically, the association is significantly positive for portfolio formation periods J = 3, 6, and 9-months but significantly negative for the 12-month portfolio formation period.

4.3. Analysis of short-interest and the interaction between fundamentals and momentum

In Table 4 we summarize results from several logistic regressions that examine whether short-sellers appear to incrementally target stocks that are both extreme price momentum (winners and losers) and have extreme fundamental-to-price ratios (high and low). We report the average coefficients and autocorrelation adjusted *t*-statistics from 96 monthly cross-sectional logistic regressions based on the following model which includes interaction terms between extreme fundamental-to-price portfolios (*hiF* and *lowF*) and extreme price momentum portfolios (*negMom* and *posMom*):

$$\begin{aligned} hiShort_{it} = {} & \gamma_0 + \gamma_1 (lowF_{it} * negMom_{it}) + \gamma_2 (lowF_{it} * posMom_{it}) + \gamma_3 (hiF_{it} * negMom_{it}) \\ & + \gamma_4 (hiF_{it} * posMom_{it}) + \gamma_5 negMom_{it} + \gamma_6 posMom_{it} + \gamma_7 SzRank_{it} \\ & + \gamma_8 Institutions_{it} + \gamma_9 DivYield_{it} + e_{it} \end{aligned} \quad . \qquad (5)$$

In Columns 4 through 9 we report evidence of the use of fundamental information in the selection of stocks by short-sellers that have had recent extreme returns. The results in Columns 4 and 5 confirm Dechow et al. (2001) that short-sellers target stocks that appear overpriced relative to their fundamentals. We show however, that low fundamental-to-price stocks in the extreme prior momentum portfolios attract significantly greater short-interest than the average low fundamental-to-price stock. For example, using the value-to-price ratio as the measure of the fundamental-to-price ratio, in the 3 month portfolio formation period (J = 3) the probability of the low fundamental-to-price stock having a high level of short-interest is significantly greater for stocks in either the loser portfolio (γ_2 = 0.488, with a *t*-statistic of 7.00) or the winner portfolio (γ_3 = 0.609, with a *t*-statistic of 15.80).

In Columns 6 and 7, we report the association between high levels of short-interest and price momentum conditional on the stock having a high fundamental-to-price ratio. We predict that these stocks are negatively associated with high short-positions as these stocks are less likely to be overpriced. Consistent with this prediction, we present evidence of a weak negative association between high short-interest and high fundamental-to-price ratio stocks in the winner and loser momentum portfolios. The coefficients, however, are not consistently statistically less than zero in all cases. We are also interested in examining the positions of short-sellers in the stocks that are not classified as high or low fundamental-to-price ratios but are in either the winner or loser momentum portfolios. In Columns 8 and 9, we report evidence consistent with short-sellers targeting stocks in the loser portfolios early in the momentum life-cycle and avoiding these stocks in the later part of the momentum life-cycle. This result is stronger than the results in Table 3 as we control for the interaction between stocks with a low fundamental-to-price ratio that are in the loser momentum portfolio. For example, using the value-to-price ratio as the measure of the fundamental-to-price ratio, in the 3-month portfolio formation period (J = 3) the probability of loser momentum stocks having a high level of short-interest is significantly greater than the average stock (γ_5 = 0.693, with a t-statistic of 11.65), in the 12-month portfolio formation period (J = 12) the probability of loser momentum stocks having a high level of short-interest is significantly lower than the average stock (γ_5 = –0.609, with a t-statistic of –3.60). These results are consistent with the timing effects predicted for short-positions in loser stocks over the momentum life-cycle.

In this section, we document a strong association between short-interest and stocks in the extreme price momentum portfolios. This association is stronger when the stock is also overpriced relative to fundamentals, and for loser stocks early in the momentum life-cycle. In the following section we examine the association between short-interest and future returns for extreme momentum portfolios with a focus on whether or not the positions of short-sellers predict the magnitude and reversal of momentum returns.

4.4. Returns and characteristics of price momentum portfolios

In Table 5 we summarize results for price momentum strategies using the extreme momentum portfolios. Each January, stocks are ranked and grouped into quintile portfolios on the basis of their returns over the prior three, six, nine and 12-months. We report the results for

the bottom quintile of extreme losers ($R1$) and the top quintile of extreme winners ($R5$).[14] The remaining price momentum portfolios show results consistent with those documented by Jegadeesh and Titman (1993), and are omitted for simplicity of presentation.

We report in Table 5 the average return and the average short position during the portfolio formation period, the time-series average of the median size decile of the portfolio based on NYSE/AMEX cutoffs (SzRank), and the time-series average of the median stock price at the time of the portfolio formation date for each momentum portfolio. At the portfolio formation date stocks in winner portfolios are typically larger (Column 5) and have a higher price (Column 6) than stocks in loser portfolios. This is not surprising given that the stocks are sorted based on prior returns and these returns are significantly different for three, six, nine and 12-months portfolio formation periods (Column 3).

The results in Column 4 confirm the results about a potential momentum life-cycle effect in the positions of short-sellers documented in Tables 2 through 4. As expected, short-interest is lower for stocks in the winner portfolios than for stocks in the loser portfolios (–0.15%, *t*-statistic = –1.93) for shorter windows ($J = 3$) when price momentum is expected to continue. The reverse is true for longer windows ($J = 12$) when price momentum is less likely to continue. In this case short-interest is higher for stocks in the winner portfolios than for stocks in the loser portfolios (0.13%, *t*-statistic = 2.10).

In Columns 7 through 9 we report equal weighted event time monthly returns over the next K months ($K = 3, 6, 9$). In addition, for each portfolio formation period (J) and holding period (K), we report the mean return from a dollar neutral strategy of buying the stocks in the winner portfolio and short-selling the stocks in the loser portfolio ($R5 - R1$). These results confirm the presence of intermediate-term price momentum continuation as well as the longer-term reversal of price momentum in our sample. For example, the momentum strategy based on a six-month portfolio formation period ($J = 6$), the winner portfolio returns 2.4% over the following three month event window ($K = 3$) and the loser portfolio returns –0.5% over the following three months, the return differential of 2.9% is significant using conventional *t*-tests. With the exception of the 12 month portfolio formation period ($J = 12$) the remaining portfolio

[14] Jegadeesh and Titman (1993) use deciles instead of quintiles, in untabulated results we find that using deciles rather than quintiles produces quantitatively similar results. We use quintiles as our sample is reduced from that of recent price momentum literature such as Lee and Swaminathan (2001) due to our requirement that the stock has available short-interest data.

results are consistent with prior studies that document continued price momentum over the intermediate-term (e.g., Jeegadeesh and Titman, 1993). In the 12-month portfolio formation period (J = 12), there is some weak evidence of intermediate-term reversals. Specifically, for six- and nine-month holding periods (K = 6, 9), the return differential based on the returns to the winner portfolio less the returns to the loser portfolio is a significant –5.3% and –8.8%.

The last five columns of Table 5 report the annual event-time returns for each portfolio for the five 12-month periods following the portfolio formation date. Consistent with Jegadeesh and Titman (1993) and Lee and Swaminathan (2001), we find a reversal in the momentum profits over longer horizons. For example, with a three-month portfolio formation period (J = 3) and a five-year holding period, the winner portfolios return on average 5.6% while the loser portfolios return on average 21.3%, the return differential of –15.7% is significantly less than zero using conventional t-tests. We note, however, that the momentum strategy returns are largely due to large significant positive returns for the loser portfolios.

These results confirm prior research on the long-term reversal of price momentum. We also find that the longer the portfolio formation period used to calculate past winners and losers, the quicker the price momentum reversal (consistent with Lee and Swaminathan, 2001). It also appears that the positions of short-sellers are greater for past losers for shorter portfolio formation periods but greater for past winners for longer portfolio formation periods, suggesting that the positions of short-sellers may be differentially associated with price momentum based on the momentum life-cycle. We expand on this theme in the following section where we discuss tests of our predictions that high short-interest is associated with a more timely reversal of momentum profits.

4.5. Portfolio based tests of the momentum reversal hypothesis

In Table 6, we report intermediate-term future returns (K = 3, 6, and 9 monthly event return windows) for portfolios formed on the basis of a two-way sort between past price momentum and short-interest at the portfolio formation date. We first sort all stocks into price momentum portfolios based the ranking of returns over the past J months into quintile portfolios and we report the extreme portfolios (R1 "losers" and R5 "winners"). We then independently sort these stocks into portfolios based on the level of short-interest in the month prior to the portfolio formation date. We divide these stocks into quintile portfolios and again report only

the extreme portfolios. *S*1 is the portfolio of the lowest short-interest stocks (including stocks with zero short-interest) and *S*5 is the portfolio of high short-interest stocks.

The key results reported in Table 6 are as follows. First, conditional on past returns, the high short-interest portfolio generally underperforms the low short-interest portfolio over the subsequent months. These results are consistent with the short-selling literature that shows a negative association between short-interest and future returns (e.g., Asquith and Meulbroek 1996, Asquith, Pathak and Ritter, 2006). For example in the 12-month portfolio formation period (J = 12), for the subsequent nine-month holding period (K = 9) stocks in the loser portfolio with low levels of short-interest gain returns of 18.05% and stocks in the loser portfolio with high levels of short-interest gain returns of 7.88%, the return differential ($S5 - S1$) of –10.17% is significantly less than zero using conventional t-tests. Similarly in the 12-month formation period and nine-month holding period (J = 12, K = 9) stocks in the winner portfolios with low levels of short-interest have returns on average of 7.8% while stocks in the winner portfolios with high levels of short-interest have returns on average of –3.7%, the difference of –11.55% is significantly less than zero.

Second, the momentum strategy returns ($R5 - R1$) are lower for portfolios with high-short-interest. For example, in the three-month formation period and three-month holding period (J = 3, K = 3) results reported in Column 9, the momentum strategy for stocks with low short-interest return on average 4.5% and the momentum strategy for stocks with high short-interest return on average 1.46%. We also note that in general, short-interest has an asymmetric effect on the positions of the momentum strategy (winner and loser portfolios). The reduction in the returns to winner portfolios associated with high short-interest stocks are on average greater than the reductions to the returns to the loser portfolios associated with high short-interest stocks.

In Table 7, we report results that suggest there is an association between short-interest and both the magnitude and the timeliness of price momentum reversals over the longer-term. All results reported in Table 7 are formed using the 12-month formation period (J = 12), we find similar results using shorter formation periods. We present raw returns in Panel A and size-adjusted returns in Panel B. In Columns 2 through 6 we report the average long-term performance of the loser portfolios for a five-year holding period following the portfolio formation period. We form portfolios of the loser stocks into independently sorted portfolios based on the level of short-interest. The loser portfolio with high levels of short-interest ($R1$, $S5$)

are the independently sorted stocks that are in both the highest quintile of short-interest and the lowest quintile of prior returns over the portfolio formation period. Similarly, the loser portfolio with low levels of short-interest (*R*1, *S*1) are the independently sorted stocks that are in both the lowest quintile of short-interest and the lowest quintile of prior returns over the portfolio formation period. We find that the differences in the returns for all annual holding periods (K = 1, 2, 3, 4 and 5-years) are lower for the high short-interest portfolio. These results are not consistently significant when we measure the performance of the portfolios using size-adjusted returns (see Panel B). We predicted that if loser momentum is due to under-reaction then intermediate returns would be more negative, but not longer-term returns. These results do not support this prediction unless under-reaction is characterized as taking over five years to be resolved.

In Columns 7 through 11, we report similar results for the winner portfolios. Specifically, the high short-interest winner portfolio (*R*5, *S*5) has significantly lower future returns than the low short-interest winner portfolio (*R*5, *S*1) for all annual holding periods in the subsequent five-years. When performance is measured using size-adjusted returns (Columns 7 to 11, Panel B) the returns to the high short-interest winner portfolio (*R*5, *S*5) are significantly less than zero. For example, for a four-year holding period, the high short-interest winner portfolio (*R*5, *S*5) returns on average –0.106 and the low short-interest winner portfolio (*R*5, *S*1) returns on average 0.295, the difference of –0.278 is significantly less than zero using conventional t-tests. These results suggest that winner stocks with high levels of short-interest are likely to experience strong price momentum reversal effects on average.

4.6. Autoregression-based tests of the momentum reversal hypothesis

In Table 8 we provide additional evidence on the association between the positions of short-sellers and price momentum reversals. We use an autoregression-based model as a more formal approach to identifying if there is a negative association between momentum portfolio formation returns and subsequent returns, consistent with momentum reversals. In this table we report the coefficient estimates of the following model:

$$r_{t+K,i} = a_K + b_K r_{t,i} + u_{t+K,i}\,, \qquad (6)$$

where, the *i* subscript refers to the stock *i*, $r_{t+K,i}$ is the annual return *K* years ahead, and $r_{t,i}$ is the prior momentum return measured over the year prior to portfolio formation. We report results for *K* = 1, 2, 3, 4, and 5. The coefficient b_K is the estimate of the average autocorrelation coefficient between the prior momentum return and future returns, for the stocks included in the portfolio. We present results for portfolios containing all stocks with available data, stocks in the extreme momentum portfolios (*R*1 and *R*5), portfolios of loser stocks (*R*1), and portfolios of winner stocks (*R*5). For the momentum portfolios, loser portfolios and winner portfolios we estimate our model comparing those stocks whose stock are also in the low and high short-interest portfolios (*S*1 and *S*5).

In Columns 1 and 2 we confirm the reversal of momentum results indicated in Table 5. In Column 1, which involves all stocks with available data, we confirm that the momentum reversal effect generally increases over the future return holding period in our sample. In Column 2, we present similar evidence for extreme momentum stocks, showing that they tend to have stronger reversals for all annual holding periods in the subsequent five-years.

We present estimates of the slope coefficients for low (*S*1) and high (*S*5) short-interest stocks in the extreme momentum portfolios (*R*1 and *R*5) in Columns 4 and 5. These results show that extreme momentum stocks in the low short-interest portfolio do not have a significant reversal effect in the first year ($b_{K=1}$ = –0.075, *t*-statistic = –1.04) but extreme momentum stocks in the high short-interest portfolio do have a significant reversal effect ($b_{K=1}$ = –0.114, *t*-statistic = –3.81) in the first year following the portfolio formation (Column 5). This result implies a more timely reversal for high short-interest stocks in the extreme momentum portfolios.

We continue our investigation of the association between short-interest and the reversal of price momentum by examining the reversal characteristics for loser momentum portfolios in Columns 6 to 8 and for winner momentum portfolios in Columns 9 to 11. In Column 6 we document a strong reversal for stocks in the loser portfolios in our sample. In Columns 7 and 8 we document that while high short-interest stocks in the loser portfolio do have a significant momentum reversal, the average autocorrelation coefficient ($b_{K=1}$ = –0.386, *t*-statistic = –3.35), is lower than the average autocorrelation coefficient for stocks in the low short-interest loser

portfolio ($b_{K=1}$ = –0.562, *t*-statistic = –2.32). These results are partially consistent with the under-reaction hypothesis, as the momentum reversal is lower for stocks with high levels of short-interest.

In Column 9, we find no evidence of momentum reversal for stocks in the winner portfolio (R5) over a 1 year holding period. We do find evidence of a momentum reversal on average for stocks in the winner portfolio in years 2 and 3. We document a difference in the momentum reversal for stocks in the high short-interest winner portfolio relative to stocks in the low short-interest winner portfolio in Columns 10 and 11. Specifically, we find evidence of price continuation for the low short-interest winner portfolio (*S*1, *R*5) in year 1 ($b_{K=1}$ = 0.268, *t*-statistic = 2.06) and weak evidence of further price continuation in year 2 ($b_{K=2}$ = 0.430, *t*-statistic = 1.93). In contrast, we find no evidence of price continuation in year 1 for the stocks in the high short-interest winner portfolio (*S*5, *R*5) and evidence of momentum reversal in year 2 ($b_{K=2}$ = –0.229, *t*-statistic = –2.83). These results imply a more timely momentum reversal for winner portfolios with high levels of short-interest, consistent with our predictions based on the over-reaction hypothesis.

To summarize our results, we investigated two complementary predictions on the role of short-sellers with respect to extreme price momentum. First, we documented that short-sellers take greater positions in stocks in both the winner and loser portfolios conditional on the stock being in the low fundamental-to-price ratio portfolio. Second, we document a strong momentum reversal effect for firms with large levels of short-interest for winner portfolios. In the following section, we present robustness analysis.

5. Robustness analysis

5.1. Robustness to market structure

There are a number of differences in the market structures of the NASDAQ and the NYSE. There is evidence from prior research that suggests systematic differences in short-selling between the NASDAQ and NYSE (Hirshliefer et al., 2007; Daske et al., 2006). To address this potential concern, we sort stocks into portfolios of those listed on the NASDAQ and those listed on the NYSE and re-estimate our regression models for the sub-samples of stocks

from each of the exchanges. The results are generally consistent across exchanges with larger coefficients (in magnitude and in statistical significance) for the NYSE sub-sample, suggesting that the NASDAQ has potentially more noise in the aggregate short-selling positions.

5.2. Investigation of potential "market sentiment" effects

Lamont and Stein (2004) find that at the market-level, aggregate short-interest moves in a counter cyclical fashion, suggesting that arbitrageurs are reluctant to bet against recent market gains.[15] The authors suggest aggregate short-interest displays extrapolative behavior, i.e., it looks like fewer investors are willing to bet on the market going down after a period in which it has been rising. Their result is premised on the level of short-interest in NASDAQ-traded stocks flattening during the late 1990s, but following the correction in the NASDAQ, short-interest began to increase rapidly. We find some evidence consistent with this broad trend in the trends in the means of short-interest (based on the intercepts in our regressions models) after controlling for other factors.

At the individual stock level, Cooper et al. (2004) present evidence consistent with momentum profits being dependent on the state of the market. Specifically, they find weaker evidence of positive momentum in bear markets, and that the momentum effect is largely due to the high momentum returns in bull markets. We find some weak evidence that during the late 1990s there was a decline in the association between high short-interest and positive price momentum for shorter portfolio formation periods, potentially consistent with short-sellers delaying their positions more during this bull market period. This result is also consistent with anecdotal evidence about the lack of short-selling activity during the late 1990s (e.g., Taulli, 2004).

6. Conclusions

Short-selling activity plays an important role in asset pricing models. Regulators, however, suggest that short-sellers potentially lead to more severe price declines. In this study, we investigate the role of short-sellers in an asset pricing anomaly – the price momentum

[15] Other evidence of an inverse relation between momentum and short sales includes Ali and Trombley (2006) and Asquith, Pathak and Ritter (2006).

anomaly, which is often characterized by continuations in price movements. Using various fundamental-to-price ratios as a measure of relative mispricing, we investigate the association of short-interest with prior stock momentum returns. We present results that provide evidence consistent with short-sellers taking larger positions in extreme prior momentum firms. Consistent with Dechow et al. (2001) we show, on average, short-interest is positively associated with low fundamental-to-price ratios, however, we also find that this association is significantly greater for extreme winner and extreme loser prior momentum stocks and we do not find these associations for a high fundamental-to-price stocks. We also show that short-sellers appear to time their trades, trading on negative momentum earlier in the "momentum life-cycle" of Lee and Swaminathan (2001) consistent with short-sellers being aware that price momentum reverses over time.

We also present results that provide evidence consistent with short-sellers mitigating the magnitude and persistence of prior price movements. Consistent with Lee and Swaminathan (2001) we find that momentum stocks reverse over the longer-term, however, we also show that high short-interest stocks have a more timely momentum reversal relative to low short-interest stocks.

Our results have implications for the understanding and the regulation of the role of short-sellers in the market. Our evidence refutes the presumption that extrapolative positions taken by short-sellers are destabilizing. Instead, we find that positions of short-sellers, both contrarian and extrapolative, have a stabilizing effect by mitigating the continuation of extreme price movements.

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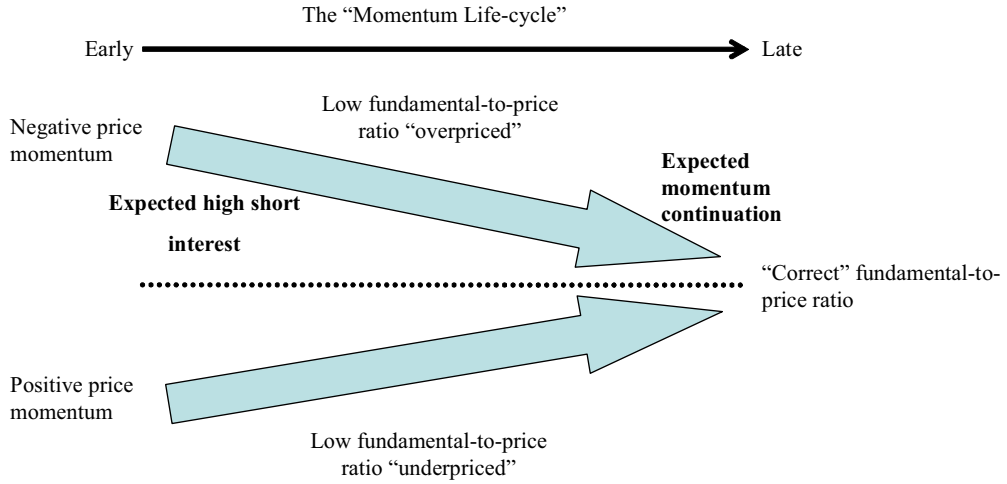
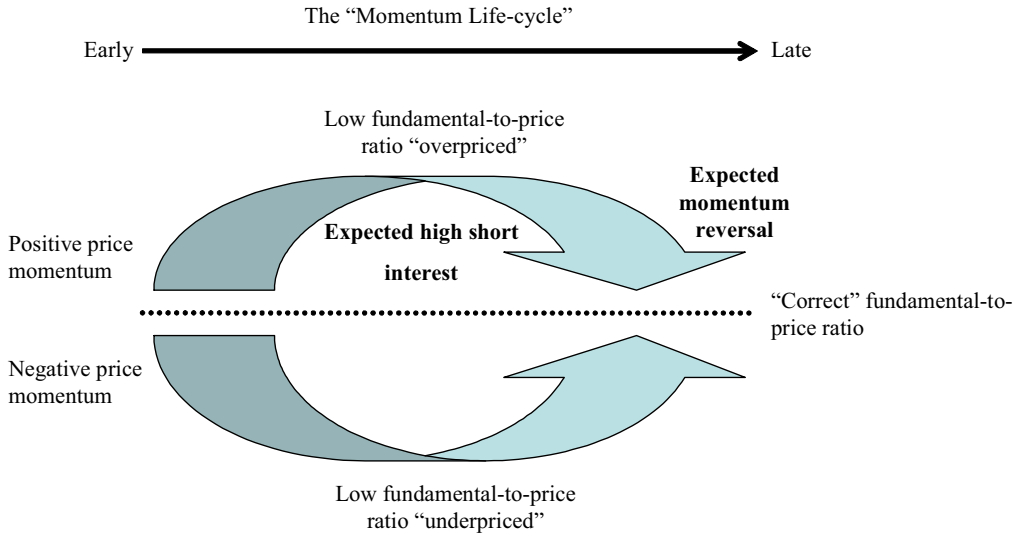
Figure 1
Predictions for levels of short-interest and future momentum for both under- and over-reaction based hypotheses.



Panel A: This figure illustrates our expectations about the associations between the level of short-interest, and the interaction between price momentum and the level of fundamentals to price. Our predictions are based on the assumption that short-sellers trade based on profiting from the correction of mispricing. We refer to the medium-term continuation of momentum and long-term reversal of momentum documented in prior literature as the "momentum life-cycle" (e.g., DeBondt and Thaler, 1985; Jeegadeesh and Titman, 1993; Lee and Swaminathan, 2001). Consistent with the under-reaction hypothesis, we expect that short-sellers will target stocks in the loser portfolios relatively early in the momentum life-cycle, and the negative price momentum for loser stocks is expected to continue.



Panel B: Consistent with the overreaction hypothesis, short-sellers are expected to anticipate and precede a reversal in positive price momentum. Relative to short-selling to profit from underreaction, short-selling to profit from overreaction is expected aimed at stocks in the winner portfolio and to be later in the momentum life-cycle.

Table 1
Descriptive statistics

In this table we present descriptive statistics on short-interest and firm characteristics of our sample. We include 307,707 firm-month observations for the period 1995 – 2002. Quarterly statistics are given as the average for each 3 month calendar quarter. We report both the cross-sectional time-series average and median short position defined as short-interest divided by the number of shares outstanding, and short change, defined as the monthly change in short position. We also provide compositional statistics for the proportion of firms with no short positions (defined as "Nil" on the NYSE/AMEX and NASDAQ short-interest databases) to ½%, from 1½% to 2½%, from 2½% to 5% and the proportion of firms with short positions greater than 5%. In Panel B we report monthly cross-sectional time-series descriptive statistics about the firm characteristics for our sample. Value-to-price is the ratio of fundamental value-to-price where fundamental value is measured using the residual income model with analyst forecasts of earnings and price is the monthly closing price, Book-to-market is the ratio of book-value divided by the monthly closing price, Prior return is the simple return using the prior month closing price and the current month closing return, SzRank is the time-series average of the size decile of the portfolio (using NYSE/AMEX/NASDAQ breakpoints), InstRank is the number of shares owned by institutions (according to 13-F filings) divided by the number of shares outstanding.

Panel A: Short-interest

	Quarterly statistics				Annual
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	
Avg. short position	1.67%	1.74%	1.79%	1.83%	1.76%
Med. short position	0.51%	0.55%	0.58%	0.57%	0.55%
Sample proportions					
0% to ½%	47.31%	45.96%	44.97%	45.11%	45.81%
½% to 1½%	22.10%	22.45%	22.32%	21.66%	22.14%
1½% to 2½%	9.94%	10.27%	10.39%	10.45%	10.27%
2½% to 5%	9.87%	10.25%	10.69%	10.80%	10.41%
greater than 5%	8.28%	8.87%	9.25%	9.53%	8.99%

Panel B: Firm characteristics

	Monthly statistics				
	Value-to-price	Book-to-market	Prior return	SzRank	InstRank
Average	0.687	0.834	0.207	5.627	0.402
Median	0.658	0.494	0.165	6.000	0.381
Standard deviation	4.246	5.840	0.615	2.934	0.258

Table 2

Analysis of the relation between short positions, fundamental analysis and prior price momentum

This table presents average monthly coefficients of the cross-sectional regression of short positions on firm characteristics, for all stocks on the NYSE/AMEX and NASDAQ for the time-period from 1995 – 2002. In Panel A, short position is the level of short-interest divided by the number of shares outstanding measured at the end of the month, Value-to-price is the ratio of fundamental value-to-price where fundamental value is measured using the residual income model with analyst forecasts of earnings and price is the monthly closing price, Book-to-market is the ratio of book-value divided by the monthly closing price, Earnings yield is the ratio of earnings divided by the prior month closing price, Price momentum is measured over *J* months ending at the closing price on the prior month, SzRank is the size decile of the firm using NYSE/AMEX/NASDAQ breakpoints, Institutions is the number of shares owned by institutions (according to 13-F filings) divided by the number of shares outstanding. The dividend yield is the amount of common dividends per share paid during the prior month (excluding preference shares and other disbursements) divided by the prior month closing price per share. Avg. Adj. R^2 refers to the average of the adjusted R^2 from the 96 monthly cross-sectional regressions. The reported parameters are the average of 96 monthly cross-sectional regressions. The *t*-statistics [in brackets] are corrected for autocorrelation induced by the overlap in the price momentum variable. There are 307,707 firm-month observations.

		Intercept	Fundamental ratio		Prior *J* period return		SzRank	Institutions	Dividend yield	Avg. Adj. R^2
			low	high	low	high				
J	Prediction		+	n.p.	+	+	+	+	–	
3	Value-to-price	–0.010	0.007	0.002	0.007	0.005	0.002	0.027	–0.494	0.118
		[–8.99]	[14.79]	[5.19]	[9.84]	[7.2]	[8.71]	[6.69]	[–10.8]	
	Book-to-market	–0.007	0.008	0.001	0.008	0.004	0.001	0.026	–0.459	0.121
		[–5.69]	[12.02]	[1.83]	[10.24]	[7.1]	[7.55]	[6.93]	[–10.52]	
	Earnings yield	–0.010	0.007	0.001	0.007	0.005	0.002	0.026	–0.488	0.119
		[–10.16]	[5.75]	[2.17]	[9.46]	[7.75]	[8.02]	[6.74]	[–11.55]	
6	Value-to-price	–0.010	0.007	0.002	0.008	0.005	0.002	0.026	–0.499	0.118
		[–7.33]	[18.04]	[5.74]	[8.58]	[13.53]	[7.52]	[6.93]	[–7.31]	
	Book-to-market	–0.007	0.008	0.000	0.009	0.004	0.001	0.026	–0.463	0.121
		[–3.80]	[13.82]	[1.25]	[8.92]	[12.86]	[6.40]	[7.07]	[–7.07]	
	Earnings yield	–0.010	0.007	0.001	0.007	0.005	0.002	0.026	–0.491	0.119
		[–7.88]	[6.13]	[1.96]	[8.49]	[13.82]	[7.06]	[7.03]	[–7.92]	
9	Value-to-price	–0.010	0.007	0.002	0.007	0.006	0.002	0.026	–0.506	0.117
		[–4.97]	[18.96]	[6.73]	[5.88]	[8.39]	[5.57]	[8.12]	[–7.90]	
	Book-to-market	–0.007	0.008	0.000	0.008	0.005	0.001	0.026	–0.470	0.120
		[–1.99]	[13.7]	[0.67]	[5.52]	[7.96]	[3.28]	[8.42]	[–7.69]	
	Earnings yield	–0.010	0.007	0.001	0.007	0.006	0.002	0.026	–0.495	0.118
		[–4.66]	[6.88]	[2.04]	[6.65]	[8.49]	[5.35]	[8.49]	[–8.47]	
12	Value-to-price	–0.010	0.007	0.002	–0.006	0.006	0.002	0.026	–0.519	0.115
		[–4.93]	[20.82]	[7.62]	[–0.93]	[14.07]	[6.1]	[8.46]	[–8.44]	
	Book-to-market	–0.007	0.008	0.000	–0.007	0.005	0.001	0.025	–0.484	0.118
		[–3.48]	[11.57]	[0.26]	[–0.88]	[11.76]	[3.33]	[8.76]	[–8.24]	
	Earnings yield	–0.010	0.007	0.001	–0.006	0.006	0.002	0.026	–0.507	0.117
		[–5.03]	[6.37]	[2.46]	[–0.84]	[14.45]	[6.21]	[8.9]	[–8.95]	

Table 3

Logisitic Analysis of the relation between 'high' short positions, fundamental analysis and prior price momentum

This table presents average monthly coefficients of the cross-sectional logistic regression of high short positions on firm characteristics, for all stocks on the NYSE/AMEX and NASDAQ for the time-period from 1995 – 2002. The dependent variable, 'high short position' is equal to one if the short position is in the top quintile of monthly short positions, where short position is the level of short-interest divided by the number of shares outstanding measured at the end of the month, Value-to-price is the ratio of fundamental value-to-price where fundamental value is measured using the residual income model with analyst forecasts of earnings and price is the monthly closing price, Book-to-market is the ratio of book-value divided by the monthly closing price, Earnings yield is the ratio of earnings divided by the prior month closing price, Price momentum is measured over *J* months ending at the closing price on the prior month, SzRank is the size decile of the firm using NYSE/AMEX/NASDAQ breakpoints, Institutions is the number of shares owned by institutions (according to 13-F filings) divided by the number of shares outstanding. The dividend yield is the amount of common dividends per share paid during the prior month (excluding preference shares and other disbursements) divided by the prior month closing price per share. Avg. Adj. R^2 refers to the max rescaled range statistic and is the average of the 96 monthly cross-sectional regressions. The reported parameters are the average of 96 monthly cross-sectional regressions. The *t*-statistics [in brackets] are corrected for autocorrelation induced by the overlap in the price momentum variable. There are 307,707 firm-month observations.

Portfolio formation period (*J*) and fundamental-to-price ratio		Intercept	Low Fundamental ratio		Prior *J* period return		SzRank	Institutions	Dividend yield	Avg. Adj. R^2
			low	high	low	high				
J	Prediction	?	+	n.p.	+	+	+	+	–	
3	Value-to-price	–4.538	0.706	0.077	0.729	0.487	0.256	2.000	–106.600	0.216
		[–29.72]	[15.32]	[1.15]	[12.47]	[10.6]	[22.53]	[8.03]	[–8.69]	
	Book-to-market	–4.219	0.572	0.030	0.778	0.450	0.219	1.889	–104.500	0.214
		[–24.22]	[14.85]	[0.77]	[13.6]	[9.98]	[19.34]	[7.89]	[–8.22]	
	Earnings yield	–4.670	0.838	0.002	0.670	0.500	0.273	1.987	–106.200	0.222
		[–40.71]	[12.64]	[0.47]	[11.29]	[11.09]	[19.77]	[7.65]	[–8.91]	
6	Value-to-price	–4.558	0.704	0.067	0.800	0.498	0.259	1.990	–107.200	0.216
		[–23.87]	[13.93]	[0.91]	[13.29]	[12.33]	[18.96]	[8.23]	[–5.46]	
	Book-to-market	–4.219	0.585	–0.013	0.872	0.435	0.219	1.893	–105.000	0.215
		[–20.19]	[15.1]	[–0.04]	[13.32]	[11.77]	[17.31]	[7.77]	[–5.17]	
	Earnings yield	–4.543	0.833	–0.011	0.739	0.525	0.260	1.969	–108.100	0.223
		[–16.89]	[8.74]	[0.49]	[13.17]	[12.00]	[23.93]	[7.98]	[–6.96]	
9	Value-to-price	–4.543	0.708	0.067	0.789	0.494	0.260	1.976	–108.100	0.215
		[–16.89]	[11.85]	[0.43]	[6]	[11.89]	[23.93]	[9.57]	[–6.96]	
	Book-to-market	–4.191	0.598	–0.044	0.877	0.418	0.218	1.886	–105.700	0.214
		[–15.99]	[13.5]	[–0.74]	[0.55]	[10.31]	[19.94]	[9.01]	[–6.77]	
	Earnings yield	–4.676	0.841	–0.018	0.727	0.529	0.276	1.957	–107.100	0.222
		[–19.16]	[8.69]	[0.19]	[7.97]	[11.88]	[20.64]	[9.42]	[–7.2]	
12	Value-to-price	–4.519	0.719	0.069	–0.735	0.502	0.260	1.960	–110.900	0.214
		[–18.23]	[14.13]	[0.77]	[–2.28]	[12.03]	[11.02]	[11.18]	[–9.63]	
	Book-to-market	–4.159	0.604	–0.059	–0.833	0.422	0.217	1.866	–108.600	0.213
		[–18.32]	[8.35]	[–1.10]	[–2.36]	[9.19]	[6.9]	[10.05]	[–8.98]	
	Earnings yield	–4.653	0.858	–0.024	–0.672	0.540	0.276	1.945	–109.400	0.221
		[–19.25]	[9.48]	[–0.14]	[–2.39]	[12.94]	[10.33]	[10.78]	[–9.71]	

Table 4

Logisitic Analysis of the relation between 'high' short positions and the interaction between prior price momentum and fundamental analysis

This table presents average monthly coefficients of the cross-sectional logistic regression of high short positions on firm characteristics, for all stocks on the NYSE/AMEX and NASDAQ for the time-period from 1995 – 2002. The dependent variable, 'high short position' is equal to one if the short position is in the top quintile of monthly short positions, where short position is the level of short-interest divided by the number of shares outstanding measured at the end of the month, Value-to-price is the ratio of fundamental value-to-price where fundamental value is measured using the residual income model with analyst forecasts of earnings and price is the monthly closing price, Book-to-market is the ratio of book-value divided by the monthly closing price, Earnings yield is the ratio of earnings divided by the prior month closing price, Price momentum is measured over *J* months ending at the closing price on the prior month, SzRank is the size decile of the firm using NYSE/AMEX/NASDAQ breakpoints, Institutions is the number of shares owned by institutions (according to 13-F filings) divided by the number of shares outstanding. The dividend yield is the amount of common dividends per share paid during the prior month (excluding preference shares and other disbursements) divided by the prior month closing price per share. Avg. Adj. R^2 refers to the max rescaled range statistic and is the average of the 96 monthly cross-sectional regressions. The reported parameters are the average of 96 monthly cross-sectional regressions. The *t*-statistics [in brackets] are corrected for autocorrelation induced by the overlap in the price momentum variable. There are 307,707 firm-month observations.

		Intercept	Low Fundamental ratio		High Fundamental ratio		Prior *J* period return		SzRank	Institutions	Dividend	Avg. Adj.
	Fundamental ratio		Prior *J* period return		Prior *J* period return						yield	R^2
J		(Prediction)	low (+)	high (+)	low (–)	high(–)	low (?)	high(+)	(+)	(+)	(–)	
3	Value-to-price	–4.306	0.488	0.609	–0.117	–0.069	0.693	0.404	0.245	1.939	–113.300	0.209
		[–27.03]	[7.00]	[15.80]	[–0.95]	[–1.88]	[11.65]	[7.44]	[22.61]	[7.96]	[–8.94]	
	Book-to-market	–4.147	0.576	0.591	–0.127	–0.347	0.678	0.313	0.228	1.905	–111.500	0.210
		[–23.79]	[9.14]	[14.06]	[–2.51]	[–1.58]	[10.89]	[6.46]	[20.93]	[7.62]	[–8.82]	
	Earnings yield	–4.362	0.558	0.759	–0.114	–0.377	0.645	0.400	0.252	1.935	–113.100	0.211
		[–30.90]	[10.49]	[7.75]	[–1.55]	[–1.78]	[9.74]	[7.11]	[21.41]	[7.65]	[–8.97]	
6	Value-to-price	–4.328	0.407	0.643	–0.116	0.166	0.798	0.392	0.248	1.922	–114.300	0.209
		[–22.72]	[4.91]	[10.36]	[–2.24]	[2.43]	[10.71]	[7.96]	[20.99]	[8.01]	[–5.68]	
	Book-to-market	–4.150	0.589	0.668	–0.209	–0.512	0.793	0.269	0.228	1.891	–112.200	0.211
		[–19.38]	[9.28]	[14.69]	[–3.52]	[–1.44]	[11.08]	[6.05]	[19.15]	[7.6]	[–5.62]	
	Earnings yield	–4.386	0.497	0.793	–0.188	–0.182	0.746	0.411	0.256	1.914	–114.000	0.212
		[–24.37]	[7.49]	[5.28]	[–2.40]	[–1.63]	[10.17]	[7.26]	[18.34]	[7.73]	[–5.81]	
9	Value-to-price	–4.293	0.340	0.662	–0.150	0.070	–0.795	0.380	0.247	1.909	–115.700	0.207
		[–15.99]	[4.82]	[10.25]	[–1.02]	[0.49]	[–0.60]	[7.12]	[26.3]	[9.30]	[–7.56]	
	Book-to-market	–4.125	0.480	0.674	–0.313	–0.736	0.836	0.254	0.229	1.869	–113.600	0.209
		[–15.38]	[5.25]	[13.62]	[–3.76]	[–2.14]	[0.24]	[4.85]	[25.35]	[8.85]	[–7.51]	
	Earnings yield	–4.356	0.441	0.836	–0.170	–0.312	–0.737	0.400	0.255	1.902	–115.400	0.210
		[–17.59]	[5.18]	[5.59]	[–2.85]	[–1.44]	[–1.01]	[7.11]	[23.67]	[8.99]	[–7.59]	
12	Value-to-price	–4.252	0.376	0.655	–0.082	0.238	–0.716	0.372	0.246	1.890	–119.200	0.205
		[–17.1]	[5.54]	[4.9]	[2.86]	[1.87]	[–3.6]	[6.46]	[10.89]	[10.28]	[–10.3]	
	Book-to-market	–4.096	0.480	0.667	–0.287	–0.831	–0.780	0.251	0.229	1.850	–117.100	0.207
		[–16.52]	[4.85]	[10.37]	[–0.61]	[–1.81]	[–4.34]	[5.48]	[15.45]	[9.77]	[–10.06]	
	Earnings yield	–4.309	0.447	0.852	–0.092	–0.126	–0.665	0.405	0.253	1.881	–118.600	0.208
		[–17.82]	[6.76]	[5.54]	[–0.58]	[–2.52]	[–2.7]	[6.48]	[7.73]	[10.04]	[–10.04]	

Table 5
Returns and characteristics of price momentum portfolios
This table presents average monthly and annual returns in percentages for price momentum portfolio strategies involving NYSE/AMEX and NASDAQ stocks for the time-period from 1995 – 2002. At the beginning of each month starting in January 1995, all stocks are sorted based on their previous *J* months' returns and divided into 5 equal-weighted portfolios. *R*1 represents the loser portfolio with the lowest returns and *R*5 represents the winner portfolio with the highest returns during the prior J months. K represents the monthly holding periods for future returns where *K* = three, six, nine or 12 months. Monthly holding period returns are calculated as the equal weighted average of returns from strategies initiated at the beginning of this month and prior months. The annual returns computed for Year 1 through 5 are computed as the event time returns for one to five 12 month periods following the portfolio formation date. We also provide the firm characteristics of the portfolios, where Return is the average geometric return for the portfolio over the prior *J* months, Short% refers to the average level of short-interest divided by the number of shares outstanding measured over the prior *J* months. SzRank is the time-series average of the size decile of the portfolio using NYSE/AMEX/NASDAQ breakpoints, and Price is the average of the median stock price, both SzRank and Price are measured at the time of the portfolio formation. The *t*-statistics [in brackets] for the monthly returns are simple statistics and the annual returns are corrected for autocorrelation up to lag 11 following Hansen and Hodrick (1980).

						Monthly event time returns			Annual event time returns				
J	Portfolio	Return	Short%	SzRank	Price	K=3	K=6	K=9	Year 1	Year 2	Year 3	Year 4	Year 5
3	R1	–0.322	0.0214	6.12	12.74	–0.005	0.019	–0.011	0.024	0.102	0.184	0.168	0.213
	R5	0.411	0.0200	6.14	23.64	0.024	0.053	0.101	0.120	0.122	0.068	0.037	0.056
	R5 – R1	0.732*	–0.0015*	0.02	10.91*	0.029*	0.034*	0.112*	0.096*	0.020	–0.116*	–0.130*	–0.157*
		[40.42]	[–1.93]	[0.20]	[16.21]	[4.43]	[3.45]	[8.87]	[5.57]	[0.76]	[–3.00]	[–2.80]	[–2.55]
6	R1	–0.431	0.0215	6.01	11.11	0.000	0.027	0.026	0.083	0.192	0.289	0.275	0.394
	R5	0.607	0.0204	6.13	24.82	0.031	0.062	0.083	0.088	0.089	–0.001	0.043	0.109
	R5 – R1	1.037*	–0.0011	0.12	13.71*	0.031*	0.034*	0.057*	0.005	–0.103*	–0.290*	–0.232*	–0.286*
		[43.02]	[–1.73]	[1.18]	[21.68]	[4.59]	[3.39]	[4.30]	[0.29]	[–3.71]	[–7.26]	[–4.61]	[–4.00]
9	R1	–0.486	0.0210	5.93	10.64	0.007	0.054	0.068	0.131	0.213	0.333	0.296	0.335
	R5	0.797	0.0211	6.19	25.37	0.031	0.043	0.062	0.058	0.061	0.011	0.052	0.107
	R5 – R1	1.284*	0.0001	0.26*	14.73*	0.023*	–0.010	–0.006	–0.073*	–0.153*	–0.322*	–0.244*	–0.228*
		[44.82]	[0.18]	[2.50]	[24.72]	[3.45]	[–1.01]	[–0.48]	[–3.99]	[–5.44]	[–7.85]	[–4.79]	[–3.33]
12	R1	–0.494	0.0201	5.88	10.96	0.022	0.081	0.113	0.172	0.295	0.427	0.391	0.514
	R5	1.001	0.0214	6.27	25.55	0.019	0.028	0.024	0.021	0.023	–0.035	–0.014	–0.025
	R5 – R1	1.495*	0.0013*	0.39*	14.59*	–0.002	–0.053*	–0.088*	–0.151*	–0.272*	–0.462*	–0.405*	–0.539*
		[49.23]	[2.10]	[3.85]	[20.85]	[–0.31]	[–4.89]	[–6.31]	[–8.02]	[–9.06]	[–10.55]	[–7.58]	[–7.38]

Table 6

Monthly returns for portfolios based on price momentum and the magnitude of short positions

This table presents average monthly and annual returns in percentages for price momentum portfolio strategies involving NYSE/AMEX and NASDAQ stocks for the time-period from 1995 – 2002. At the beginning of each month starting in January 1995, all stocks are independently sorted into 5 equal-weighted portfolios based on their previous *J* months' returns and into 5 equal-weighted portfolios based on their level of short positions. R1 represents the loser portfolio with the lowest returns and R5 represents the winner portfolio with the highest returns during the prior *J* months. S1 represents firms with the lowest short-positions and S5 represents firms with the largest short positions. *K* represents the monthly holding periods for future returns where *K* = three, six, nine or 12 months. Monthly holding period returns are calculated as the equal weighted average of returns from strategies initiated at the beginning of this month and prior months. The *t*-statistics (in parentheses) for the monthly returns are simple statistics.

		R1 (losers)			R10 (winners)			R10 – R1 (momentum return)		
J	Portfolio	K=3	K=6	K=9	K=3	K=6	K=9	K=3	K=6	K=9
3	S1	–0.002	0.0522	0.0515	0.043	0.0945	0.1612	0.045	0.0423	0.1097
	S5	–0.013	–0.001	–0.056	0.0016	0.0222	0.0586	0.0146	0.0232	0.1146
	S5–S1	–0.0113	–0.0533	–0.1074	–0.0414	–0.0723	–0.1026	–0.0301	–0.019	0.0048
		[–0.75]	[–2.20]	[–3.54]	[–3.07]	[–3.38]	[–3.49]			
6	S1	0.015	0.073	0.1045	0.047	0.102	0.1587	0.032	0.029	0.0542
	S5	0.001	0.0153	–0.018	–0.002	0.0238	0.0348	–0.00144	0.0085	0.0528
	S5–S1	–0.0155	–0.0577	–0.1221	–0.0495	–0.0782	–0.1239	–0.034	–0.0205	–0.0018
		[–0.97]	[–2.31]	[–3.69]	[–3.53]	[–3.58]	[–4.10]			
9	S1	0.0216	0.0783	0.1216	0.0365	0.0632	0.1187	0.0149	–0.0151	–0.0029
	S5	0.0035	0.043	0.0301	0.0051	0.0071	0.0132	0.0016	–0.0359	–0.0169
	S5–S1	–0.0181	–0.0353	–0.0914	–0.0314	–0.0561	–0.1055	–0.0133	–0.0208	–0.0141
		[–1.14]	[–1.39]	[–2.67]	[–2.25]	[–2.61]	[–3.58]			
12	S1	0.0405	0.1109	0.1805	0.0345	0.0407	0.078	–0.006	–0.0702	–0.1025
	S5	0.017	0.0636	0.0788	–0.014	–0.011	–0.037	–0.031	–0.0746	–0.1158
	S5–S1	–0.0236	–0.0473	–0.1017	–0.0482	–0.0517	–0.1155	–0.0246	–0.0044	–0.0138
		[–1.42]	[–1.78]	[–2.76]	[–3.21]	[–2.33]	[–3.98]			

Table 7

Annual returns for portfolios based on price momentum and the magnitude of short positions

This table presents average annual returns in percentages for price momentum portfolio strategies involving NYSE/AMEX and NASDAQ stocks for the time-period from 1995 – 2002. At the beginning of each month starting in January 1995, all stocks are independently sorted into 5 equal-weighted portfolios based on their previous *J* months' returns and into 5 equal-weighted portfolios based on their level of short positions. R1 represents the loser portfolio with the lowest returns and R5 represents the winner portfolio with the highest returns during the prior *J* months. S1 represents firms with the lowest short-positions and S5 represents firms with the largest short positions. *K* represents the monthly holding periods for future returns where *K* = three, six, nine or 12 months. Monthly holding period returns are calculated as the equal weighted average of returns from strategies initiated at the beginning of this month and prior months. The annual returns computed for Year 1 through 5 are computed as the event time returns for one to five 12 month periods following the portfolio formation date. The *t*-statistics (in parentheses) for the monthly returns are simple statistics.

Panel A: Raw returns

	R1 (losers)					R10 (winners)					R10 – R1 (momentum return)				
Portfolio	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
S1	0.491	0.918	1.335	1.387	1.739	0.361	0.697	0.954	1.021	1.067	–0.130	–0.221	–0.381	–0.366	–0.673
S5	0.293	0.546	0.847	0.768	0.954	0.083	0.151	0.268	0.272	0.328	–0.210	–0.395	–0.579	–0.495	–0.627
S5–S1	–0.198	–0.372	–0.488	–0.620	–0.785	–0.278	–0.547	–0.686	–0.749	–0.739	–0.081	–0.175	–0.198	–0.130	0.046
	[–3.61]	[–4.33]	[–3.74]	[–3.82]	[–3.58]	[–6.41]	[–7.92]	[–7.22]	[–5.86]	[–4.59]					

Panel B: Size-adjusted returns

	R1 (losers)					R10 (winners)					R10 – R1 (momentum return)				
Portfolio	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5	Year 1	Year 2	Year 3	Year 4	Year 5
S1	0.227	0.397	0.528	0.567	0.659	0.095	0.166	0.166	0.295	0.219	–0.132	–0.230	–0.363	–0.272	–0.441
S5	0.136	0.238	0.367	0.319	0.379	–0.031	–0.069	–0.113	–0.106	–0.168	–0.167	–0.307	–0.480	–0.425	–0.547
S5–S1	–0.091	–0.159	–0.161	–0.248	–0.280	–0.126	–0.235	–0.278	–0.401	–0.387	–0.035	–0.077	–0.117	–0.152	–0.107
	[–1.84]	[–1.94]	[–1.30]	[–1.58]	[–1.31]	[–3.13]	[–3.61]	[–3.08]	[–3.28]	[–2.51]					

Table 8

Regression tests of return continuation and reversals for price momentum portfolios based on the magnitude of short positions

This table presents the time-series average of slope coefficients estimated from monthly Fama-MacBeth cross-sectional regressions run from January 1995 to January 2007. The regression model is specified as:

$r_{t+K,i} = a_K + b_{Krt,i} + u_{t+K,i}$

where, the *i* subscript refers to the stock *i*, $r_{t+K,i}$ is the annual return *K* years ahead, and $r_{t,i}$ is the prior momentum return measured over the year prior to portfolio formation. We report results for K = 1, 2, 3, 4, and 5. The coefficient b_K is the estimate of the average autocorrelation coefficient between the momentum return and future returns, for the stocks included in the portfolio, the annual returns are corrected for autocorrelation following Hansen and Hodrick (1980).

		Time-series average slope coefficients, b_K								
	All stocks	Momentum stocks (R1 and R5)			Extrapolative portfolios (R1)			Contrarian portfolios (R5)		
Year		All R1 and R5 stocks	Low short (S1)	High short (S5)	All R1 stocks	Low short (S1)	High short (S5)	All R5 stocks	Low short (S1)	High short (S5)
1	–0.100	–0.127	–0.075	–0.114	–0.476	–0.562	–0.386	0.024	0.268	0.002
	[–7.23]	[–7.09]	[–1.04]	[–3.81]	[–6.68]	[–2.32]	[–3.35]	[0.82]	[2.06]	[0.04]
2	–0.252	–0.306	–0.216	–0.242	–0.689	–0.899	–0.051	–0.143	0.430	–0.229
	[–9.56]	[–8.48]	[–1.6]	[–4.58]	[–4.25]	[–1.85]	[–0.24]	[–2.99]	[1.93]	[–2.83]
3	–0.413	–0.481	–0.418	–0.424	–1.063	–1.462	–0.497	–0.245	–0.041	–0.240
	[–11.67]	[–9.01]	[–2.83]	[–3.21]	[–4.09]	[–2.79]	[–0.68]	[–4.34]	[–0.16]	[–2.65]
4	–0.369	–0.413	–0.520	–0.205	–1.216	–2.579	–0.500	–0.101	0.294	–0.065
	[–9.3]	[–7.35]	[–3]	[–2.67]	[–4.78]	[–4.09]	[–2.01]	[–1.39]	[1.08]	[–0.47]
5	–0.423	–0.503	–0.279	–0.389	–1.437	–1.657	–0.443	–0.114	0.828	–0.265
	[–8.25]	[–6.59]	[–1.1]	[–5.17]	[–3.92]	[–1.91]	[–1.26]	[–1.35]	[1.80]	[–2.69]