The Formation Process of Winners and Losers in Momentum Investing

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Abstract

Previous studies have focused on which stocks are winners or losers but have paid little attention to the formation process of past returns. This paper develops a model showing that past returns and the formation process of past returns have a joint effect on future expected returns. The empirical evidence shows that the zero-investment portfolio, including stocks with specific patterns of historical prices, improves monthly momentum profit by 59%. Overall, the process of how one stock becomes a winner or loser can further distinguish the best and worst stocks in a group of winners or losers.

Keywords: Momentum; Historical Price; Price Movement

JEL code: G12, G14

1. Introduction

Intermediate-term (3–12 months) momentum has been documented by Jegadeesh and Titman (1993, 2001, hereafter JT), while short-term (weekly) and long-term (3–5 years) reversals have been documented by Lehmann (1990) and Jegadeesh (1990) and by DeBondt and Thaler (1985), respectively. Various models and theories have been proposed to explain the coexistence of intermediate-term momentum and long-term reversal. However, most studies have focused primarily on *which* stocks are winners or losers; they have paid little attention to *how* those stocks become winners or losers. This paper develops a model to analyze whether the movement of historical prices is related to future expected returns. We argue that the process of becoming a winner or loser can distill incremental information from past prices in addition to past returns and provide empirical evidence to support this claim.

The phenomena of momentum and reversal have been discussed in numerous studies.[1] Researchers have explored explanations for these phenomena through various routes. Some of these are consistent with the efficient market hypothesis, for instance, those provided by Berk, Green, and Naik (1999), Conrad and Kaul (1998), and Chordia and Shivakumar (2002). Alternative explanations attribute momentum and reversals to systematic violations of rational behavior by investors, for example,

[1] For example, cross-sectional predictability based on past returns appears to be prevalent in different markets (Rouwenhorst, 1998; Doukas and McKnight, 2005) and asset classes (Asness, Moskowitz, and Pedersen, 2013). It also exists between and within industries (Moskowitz and Grinblatt, 1999; Hameed and Mian, 2014).

Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), and Hong and Stein (1999). No matter which explanation is considered, the empirical tests in most studies focus only on the change between two historical prices—the price at the beginning of the ranking period and the price at the end of the ranking period—to decide which stocks are categorized as winners or losers. The assumption is that there is no information embedded in other historical prices; in other words, the movement of historical prices is assumed to incorporate no opinion of traders.

This paper captures the idea that past returns and the formation process of past returns have a joint effect on future expected returns. We argue that *how* one stock becomes a winner or loser—that is, the movement of historical prices—plays an important role in momentum investing. Using a polynomial quadratic model to approximate the nonlinear pattern of historical prices, the model shows that as long as two stocks share the same return over the past n-month, the future expected return of the stock whose historical prices are convex shaped is not lower than one whose historical prices are concave shaped. In other words, when there are two winner (or loser) stocks, the one with convex-shaped historical prices will possess higher future expected returns than the one with concave-shaped historical prices.

To test the model empirically, we regress previous daily prices in the ranking period on an ordinal time variable and the square of the ordinal time variable for each stock. The coefficient of the square of the ordinal time variable is denoted as γ. To be consistent with our model, we use sequential double-sorted portfolios conditioned on ranking-period returns, then on γ. Nine zero-investment strategies are designed. Each strategy buys and short sells stocks with different historical price movements. Given that the future expected return of the stock whose historical prices are convex shaped is not lower than the one whose historical prices are concave shaped, we expect that a strategy that buys the winners whose historical prices are convex shaped and shorts the losers whose historical prices are concave shaped (denoted the *acceleration strategy*) will achieve the highest future expected return.

The empirical result supports our model. For the case of a 12-month ranking period and a 6-month holding period, the plain momentum strategy (buy winners and sell losers) produces a profit of 83.22 basis points per month and a Sharpe ratio of 0.20. However, the acceleration strategy can generate 132.46 basis points per month and a Sharpe ratio of 0.26, improving the momentum profit by 59%. Meanwhile, the strategy that buys and sells stocks in a manner opposite the acceleration strategy produces the lowest return: 46.80 basis points per month and a Sharpe ratio of 0.11. The findings are robust to sample division into subperiods and exchanges, replacing the daily closing prices with the midpoints of bid and ask quotes, removing January returns, and using various holding/ranking periods.

We next examine whether the stocks selected by the acceleration strategy lie in the core of momentum investing. If these stocks generate the most return for the momentum strategy, it is possible for them to have reversals on a larger scale. The result confirms this conjecture. Moreover, we find that the extra profit earned by following the acceleration strategy cannot be covered by momentum investing and other momentum-related strategies. Conversely, the acceleration strategy offers explanatory power to the profit earned by the plain momentum strategy and the 52-week high strategy in George and Hwang (2004).

Our paper belongs to a growing body of work that tries to enhance the momentum profit or Sharpe ratio under different circumstances (for example, Cooper, Gutierrez, and Hameed, 2008; Novy-Marx, 2012; Israel and Moskowitz, 2013; Daniel and Moskowitz, 2013; Da, Gurun, and Warachka, 2014; Barroso and Santa-Clara, 2014). The closest papers to ours are those by Novy-Marx (2012) and Barroso and Santa-Clara (2014). Novy-Marx (2012) splits the ranking period in two and finds that the intermediate-horizon past return (from $t-12$ to $t-7$), rather than the recent past return (from $t-6$ to $t-2$), over the ranking period better predicts future return. Barroso and Santa-Clara (2014) use an estimate of momentum risk to scale the exposure to the strategy so that risk is constant over time. Such a risk-managed momentum strategy eliminates crashes and almost doubles the Sharpe ratio of the momentum strategy. Moreover, Blitz, Huij, and Martens (2011) show that sorting stocks according to their past residuals instead of gross returns produces a more stable version of momentum. However, unlike these pioneering works, which decompose the return in the ranking period or transform the sorting benchmark to improve the profit of momentum, our model provides a method for extracting more information from past return and predicts a new phenomenon as long as momentum occurs.

Practically, given the doubled profit and the small number of stocks required, transaction costs are less of a concern than raw momentum. Although Lesmond, Schill, and Zhou (2004) find that momentum is not exploitable because of trading costs, the acceleration strategy calls for transactions in only approximately 200 stocks, in contrast to the 1,000 to 2,000 required by the plain momentum strategy. Therefore, our study has immediate and profound investment implications in practice, especially in terms of hedge funds.

Theoretically, our model captures the idea that the formation process of past returns is related to future expect returns in addition to past returns. Although this paper does not provide explanations for momentum, it poses a significant challenge to future studies that purport to explain momentum. Because our model is founded on momentum, future studies that explore whether risk factors explain the profit of the plain momentum strategy should also examine whether those risk factors can explain our newly developed strategy.

The remainder of this paper is organized as follows: Section 2 develops our modeling framework. Section 3 details our procedure for measuring the movement of historical prices and proposes new trading strategies. Section 4 reports the empirical findings. Section 5 presents the auxiliary tests. Some auxiliary tests are relegated to the Appendix. Section 6 concludes.

2. Model

We argue that *how* a stock becomes a winner or loser is related to its future expected return. In other words, not only the past return over a specific period but also the price movement over that period provide predictability of the cross-section of expected returns. Under the assumption that recent prices provide more information than further stale prices, we develop a model illustrating the influence of the movement of historical prices on future expected returns.

We simplify the analysis by assuming that there are only two stocks in a group, S_1 and S_2. The price of each stock is assumed to follow the Black-Scholes assumption, i.e.,

$$dS_i(t) = \mu_i S_i(t)dt + \sigma_i S_i(t)dW_i(t), \tag{1}$$

where μ_i and $\sigma_i > 0$ are constant. σ_i is the volatility. $W_i(t)$ is a Wiener process that captures uncertainty. Each pair of (μ_i, σ_i) can be estimated by the attained stock prices of S_i over a period $[0, T]$, where T represents the current time. Therefore, such a pair must incorporate the information within $[0, T]$. The analytical solution of equation (1) is as follows:

$$S_i(t) = S_i(0)e^{\left(\mu_i - \frac{\sigma_i^2}{2}\right)t + \sigma_i W_i(t)}. \tag{2}$$

It results from equation (2) that the expected stock price of S_i at time t is given by

$$\mathbb{E}\{S_i(t)\} = S_i(0)e^{\mu_i t},$$

which, therefore, implies that the expected return on S_i is

$$\mathbb{E}\left\{\frac{S_i(t) - S_i(0)}{S_i(0)}\right\} = e^{\mu_i t} - 1. \tag{3}$$

It can be seen in equation (3) that the expected return on S_i at time t is dependent on only μ_i. One can adopt an appropriate model to estimate the volatility σ_i. To estimate the parameter μ_i, we collect $n + 1$ past stock prices of S_i over the period $[0, T]$,

$$\left\{\widetilde{S}_i(0), \widetilde{S}_i(\Delta t), \ldots, \widetilde{S}_i(j\Delta t), \ldots, \widetilde{S}_i(n\Delta t)\right\},$$

where $\Delta \mathrm{t} = \frac{T}{n}$. Let R_i denote the return on S_i over a period with the length of Δt, i.e.,

$$R_i = \frac{S_i(t+\Delta t) - S_i(t)}{S_i(t)}.$$

Therefore, each

$$\frac{\widetilde{S}_i\big((j+1)\Delta t\big) - \widetilde{S}_i(j\Delta t)}{\widetilde{S}_i(j\Delta t)}$$

is a sample of R_i. We apply the Euler-Maruyama method to discretize equation (1). We then obtain

$$\frac{dS_i(t)}{S_i(t)} \approx \frac{S_i(t+\Delta t) - S_i(t)}{S_i(t)}$$

$$\approx \mu_i \Delta t + \sigma_i\big(W_i(t+\Delta t) - W_i(t)\big) \sim \mathcal{N}\left(\mu_i \Delta t\,,\ \sigma_i^2 \Delta t\right),$$

which results in

$$\mu_i = {}^{mean\ of\ R_i}\!/_{\Delta t} \tag{4}$$

where Δt is sufficiently small.

Prices change as time goes on. Therefore, one can treat prices as a continuous function of time. According to the Weierstrass approximation, every continuous function can be uniformly approximated by polynomial functions, that is, given a continuous function $f(x)$ defined on a closed interval $[a, b]$, and for any small number $\varepsilon > 0$, there exists a polynomial function $p(x)$ such that $|f(x) - p(x)| < \varepsilon$, for every point x in $[a, b]$. Our analysis therefore focuses only on polynomial functions. Here we adopt a quadratic regression function to estimate the relationship between historical prices and time, that is, for *i* = 1, 2, $S_i(t) = Q_i(t) + \epsilon_i$, where

$$Q_i(t) = \alpha_i + \beta_i t + \gamma_i t^2 \ . \tag{5}$$

The expected value of ϵ_i is 0. It is least likely that historical prices follow a linear function. If a linear model does not provide an appropriate fit, a natural alternative is to move from a linear to a quadratic regression function. A quadratic regression function takes into account not only the growth rate of prices at each time but also whether historical prices are convex or concave. Two winner stocks, for example, can have significantly different historical price movements over the period [0, T]: one enjoys significant price enhancement in the first few months but stays steady in recent months, whereas the other does the opposite. Previous studies would treat the two stocks as analogues, but the convexity or concavity of historical prices can distinguish the two. Indeed, there are some other functions that can describe convexity and concavity, such as the exponential function or the reciprocal function. However, here we focus on the argument that the movement of historical prices is related to future expected returns rather than the method of approximating historical prices (which could be a direction for future research). For brevity, a quadratic regression function is adopted.

Note that $\alpha_i > 0$ in equation (5), as it represents the stock price of S_i at t = 0. We define $w(t)$ such that

$$0 \leq w(s) \leq w(t) \ and \ \int_0^T w(t)dt = 1,$$

where $s < t$. In fact, $w(t)$ is a weight function indicating how important the recent information is in estimating μ_i. We assume that the more recent information is more important. This assumption is not unique; we always use the most recent information rather than stale information to rank stocks and construct portfolios. Let $t_j = j\Delta t$, for $j = 0,1, \ldots, n$. Note that

$$\int_{t_j}^{t_{j+1}} w(t)dt$$

indicates the importance of the information within $[t_j, t_{j+1}]$. Note that if Δt is sufficiently small, we have

$$\int_{t_j}^{t_{j+1}} w(t)dt \approx w(t_j)(t_{j+1} - t_j) = w(t_j)\Delta t.$$

As $Q_i(t)$ represents the approximation of actual historical prices of S_i, we substitute $Q_i(t)$ into (4) and then obtain

$$mean\ of\ R_i = \sum_{j=0}^{n-1} \int_{t_j}^{t_{j+1}} w(t)dt \frac{Q_i(t_{j+1}) - Q_i(t_j)}{Q_i(t_j)} \approx \sum_{j=0}^{n-1} w(t_j)\Delta t \frac{Q_i(t_{j+1}) - Q_i(t_j)}{Q_i(t_j)},$$

which implies

$$\mu_i = \frac{mean\ of\ R_i}{\Delta t} \approx \int_0^T \frac{w(t)Q_i'(t)}{Q_i(t)} dt \tag{6}$$

given a sufficiently large *n*. We present the following proposition:

Proposition 1. If $Q_1(t)$ and $Q_2(t)$ are convex shaped ($\gamma_1 > 0$) and concave shaped ($\gamma_2 < 0$), respectively, as well as

$$\frac{Q_1(T)}{Q_1(0)} = \frac{Q_2(T)}{Q_2(0)}$$

then $\mu_1 \geq \mu_2$.

Proof. From equation (6), we can obtain that the difference $\mu_1 - \mu_2$ is dependent on

$$\frac{Q_1'(t)}{Q_1(t)} - \frac{Q_2'(t)}{Q_2(t)} = \frac{D(t)}{\alpha_1 \alpha_1 Q_1(t) Q_2(t)}$$

where

$$D(t) = -\frac{\beta_1\gamma_2 - \beta_2\gamma_1}{\alpha_1\alpha_2}t^2 + 2\left(\frac{\gamma_1}{\alpha_1} - \frac{\gamma_2}{\alpha_2}\right)t + \left(\frac{\beta_1}{\alpha_1} - \frac{\beta_2}{\alpha_2}\right).$$

Note that the condition

$$\frac{Q_1(T)}{Q_1(0)} = \frac{Q_2(T)}{Q_2(0)},$$

leads to

$$\frac{\alpha_1 + \beta_1 T + \gamma_1 T^2}{\alpha_1} = \frac{\alpha_2 + \beta_2 T + \gamma_2 T^2}{\alpha_2},$$

which then implies that

$$\left(\frac{\gamma_1}{\alpha_1} - \frac{\gamma_2}{\alpha_2}\right)T + \left(\frac{\beta_1}{\alpha_1} - \frac{\beta_2}{\alpha_2}\right) = 0.$$

It can be seen that

$$D(0) = \frac{\beta_1}{\alpha_1} - \frac{\beta_2}{\alpha_2} = -(\frac{\gamma_1}{\alpha_1} - \frac{\gamma_2}{\alpha_2})T < 0,$$

because $\gamma_1 > 0$ for convex-shaped historical prices and $\gamma_2 < 0$ for concave-shaped historical prices. On the other hand,

$$D(T) = -\frac{\beta_1\gamma_2 - \beta_2\gamma_1}{\alpha_1\alpha_2}T^2 + \left(\frac{\gamma_1}{\alpha_1} - \frac{\gamma_2}{\alpha_2}\right)T$$

$$= \frac{T}{\alpha_1\alpha_2}[\gamma_1(\beta_2 T + \alpha_2) - \gamma_2(\beta_1 T + \alpha_1)].$$

Because $Q_i(t)$ is the approximation of the historical prices of S_i, $Q_i(t)$ is non-negative, which implies that

$$\beta_i T + \alpha_i \geq -\gamma_i T^2.$$

Furthermore, it can be seen that

$$\gamma_1(\beta_2 T + \alpha_2) \geq -\gamma_1\gamma_2 T^2$$

and

$$-\gamma_2(\beta_1 T + \alpha_1) \geq \gamma_1\gamma_2 T^2.$$

Therefore, one can conclude that $D(T) \geq 0$.

Note that if $D(T) = 0, Q_1(T) = Q_2(T) = 0$. Because $Q_i(t)$ represents an approximation of the historical prices of S_i, we do not consider such a case. Therefore, $D(T)$ is strictly positive. By the intermediate value theorem, there must exist a $t^* \in [0, T]$ such that $D(t^*) = 0$. In addition, $D(T)$ is positive (negative) if t is greater (lower) than t^*, since $D(T)$ is a quadratic polynomial.. According to equation (6), we then obtain the difference of between μ_i of S_1 and S_2 as follows:

$$\mu_1 - \mu_2 = \int_0^T w(t)(\frac{Q_1'(t)}{Q_1(t)} - \frac{Q_2'(t)}{Q_2(t)})dt$$

$$= \int_{t^*}^T w(t)\left(\frac{Q_1'(t)}{Q_1(t)} - \frac{Q_2'(t)}{Q_2(t)}\right)dt + \int_0^{t^*} w(t)\left(\frac{Q_1'(t)}{Q_1(t)} - \frac{Q_2'(t)}{Q_2(t)}\right)dt$$

$$\geq w(t^*) \int_0^T \frac{Q_1'(t)}{Q_1(t)} - \frac{Q_2'(t)}{Q_2(t)}dt$$

$$= w(t^*)\left(ln\left(\frac{Q_1(T)}{Q_1(0)}\right) - ln\left(\frac{Q_2(T)}{Q_2(0)}\right)\right)$$

$$= 0.$$

What we can learn from Proposition 1 follows. One adopts a quadratic regression model to estimate the relationship between time and historical price and then replaces the actual share price movement by the quadratic relationship. If two stocks S_1 and S_2 share the same return over a period [0, T] and the movement of historical prices of S_1 is convex and the movement of historical prices of S_2 is concave, then the current expected return of S_1 is not lower than that of S_2. Note that Proposition 1 is based on the assumption that the more recent information is more important. If $w(t) =$

$\frac{1}{T}$—that is, if the weight of the information at each *t* is equal—then $\mu_1 = \mu_2$ in Proposition 1. This means that investors only care about the returns on the stocks over [0, *T*]. Regarding the relationship between the future expected returns of S_1 and S_2 we present the following proposition:

Proposition 2. *If one adopts a quadratic regression model to estimate the relationship between time and the historical prices, the future expected return of a stock with convex-shaped historical prices is higher than the one with concave-shaped historical prices.*

Proof. Proposition 1 shows that the current expected return of S_1 is higher than that of S_2, i.e.,

$$\mu_{1,[0,T]} \geq \mu_{2,[0,T]},$$

where $\mu_{i,[s,t]}$ denotes the parameter μ_i in (1) over the period [*s*, *t*]. According to the phenomenon of momentum, which shows the continuation of stock returns, we can obtain

$$\mu_{1,[T,T']} \geq \mu_{2,[T,T']},$$

for some $T' > T$. Therefore, equation (3) implies that

$$e^{\mu_{1,[T,T']}(T'-T)} - 1 \geq e^{\mu_{2,[T,T']}(T'-T)} - 1,$$

In other words, the future expected return of S_1, whose pattern of historical prices is convex shaped is higher than the future expected return of S_2, whose pattern of historical prices is concave shaped.

3. Data and trading strategies

Our model suggests that the movement of historical prices is related to future expected returns. We further provide empirical evidence for the foregoing argument. The sample includes all common stocks (share codes 10 and 11) listed in the NYSE, AMEX, and Nasdaq are included in our sample. The data are collected from Center for Research in Security Prices (CRSP) daily and monthly files. The monthly data are used to calculate portfolio returns, while daily data are used in the regression and calculation of firm characteristics during the later stages. The sample period spans from January 1962 to December 2011. We filter out the stocks whose prices are below 5 dollars on the portfolio formation date[2]. We also retrieve accounting data from COMPUSTAT to calculate book-to-market ratios and other variables for our regression analyses. Throughout our analysis, we employ the corrections suggested in Shumway (1997) for the de-listing bias; however, these adjustments have no effect on our results.

According to the model, if two stocks S_1 and S_2 share the same return over a period [0, *T*] and the movement of historical prices of S_1 is convex and that of S_2 is concave, then the future expected return of S_1 is higher than that of S_2. Given the requirement that the two stocks share the same return over a period, we first sort stocks into quintiles based on past *J*-month returns at the beginning of each month *t*, as in JT (1993). The top 20% is categorized as the winner group and the bottom 20% as the loser group. We skip one full month between the formation period and the

[2]We also use all common stocks listed in the NYSE, AMEX, and Nasdaq without any data filter to perform the analysis. All empirical results remain unchanged.

holding period to avoid the microstructure issues (JT, 1993; Chan, Jegadeesh, and Lakonishok, 1996).

We further sort stocks in each return group into quintiles based on the γ in equation (5). Equation (5) is run for each stock using daily data over the past *J* months, where $Q_i(t)$ denotes the daily price of stock *i* at day *t*, and *t* is an ordinal variable, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day respectively[3]. Finally, we have 5×5 portfolios.

When γ is positive (negative), the movement of historical price is a convex (concave) function of time in the past *J* months. The stocks whose γ are in the top 20% of the winner group have convex-shaped historical prices, which means that their historical prices increase at an accelerated rate. We label these stocks AcWinners. *Ac* refers to an acceleration of price increase or decrease. The stocks whose γ are in the bottom 20% of the winner group have concave-shaped historical prices; thereby illustrating that the increasing speed of price rises gradually slows down. These stocks are labeled DeWinners. *De* refers to a deceleration of the price increase or decrease. Based on our model, AcWinners generate higher future expected returns than DeWinners. Therefore, one should buy AcWinners.

Conversely, the loser stocks whose γ are in the top 20%—that is, those that have convex-shaped historical prices—illustrate that the decreasing speed of historical prices gradually slows down. These losers are denoted DeLosers. Meanwhile, the loser stocks whose γ are in the bottom 20% have concave-shaped historical prices, which means that their historical prices decrease at an accelerated rate. These losers are

[3] Running equation (1) with weekly data does not change the results significantly.

denoted AcLosers. Note that our model indicates that the stocks with convex-shaped historical prices generate higher future expected returns than those with concave-shaped historical prices, regardless of winners or losers. Therefore, one should short the stocks with lower expected returns (i.e., short AcLosers).

Following this vein, several trading strategies can be constructed as follows to test our model empirically. The first strategy is the plain momentum strategy documented in JT (1993).

Strategy 1: Buy winners and sell losers.

Strategy 2: Buy winners and sell DeLosers.

Strategy 3: Buy winners and sell AcLosers.

Strategy 4: Buy DeWinners and sell losers.

Strategy 5: Buy AcWinners and sell losers.

Strategy 6: Buy AcWinners and sell AcLosers. This is referred to hereafter as the acceleration strategy.

Strategy 7: The opposite of Strategy 6. Buy DeWinners and sell DeLosers. This is referred to hereafter as the deceleration strategy.

Strategy 8: Buy AcWinners and sell DeLosers.

Strategy 9: Buy DeWinners and sell AcLosers.

In accordance with JT (1993), we hold overlapping portfolios for all strategies. Specifically, the sorting and portfolio formation procedure is repeated each month, and the returns of the long-short portfolio are equally weighted averages of the monthly returns on the overlapping portfolios. Each zero-investment portfolio will be held for K months. The t-values for the portfolio returns are corrected for serial correlations using the Newey-West adjustment.

Based on our model introduced above, several conjectures can be made. First, the profit of Strategy 3 is greater than that of Strategies 1 and 2 in terms of the short side. In a similar vein, we also anticipate that the profit of Strategy 5 will be higher than that of Strategies 1 and 4 in terms of the long side. Strategy 6, the acceleration strategy, should achieve the highest returns among the nine strategies. In contrast to Strategy 6, we expect that the return of Strategy 7, the deceleration strategy, will yield the lowest returns of all the strategies. The Fama-French three-factor model is used to measure the risk-adjusted returns of the nine strategies. The factor data are collected from Kenneth R. French's website.

4. The empirical evidence

4.1. Descriptive statistics

Before showing he returns of nine strategies, we first present descriptive statistics of γ in Table 1. For ease of interpretation, the value of γ is scaled up by 10^3. Table 1 illustrates that the means of γ in the three panels are near to zero, which suggests that empirically the charts of historical prices for most stocks do not exhibit obvious patterns. However, the means of γ in the top and bottom groups are 5 to 6 times greater than those in the middle groups. Some stocks have extreme values of γ. The deletion of outliers does not change materially our conclusion.

[TABLE 1 HERE]

We further observe several firm characteristics in different γ quintiles. Table 2 show the results. Panel A presents the statistics for the stocks that are sorted in the top 20% based on past returns (winners), while Panel B presents the bottom 20% (losers). In the winner and loser groups, we further sort stocks based on γ. In the winner group, we can observe that the AcWinners (winner stocks with accelerating historical prices) are less volatile and more liquid than DeWinners (winner stocks whose increasing speed of historical prices gradually slows) in relation to the smaller volatility, the lower bid-ask spread, and the lower Amihud's illiquidity. For example, the illiquidity of AcWinners is 7.0942 and of DeWinners is 8.1484. The *t*-value for the mean difference test between the two groups is -3.41. Moreover, the AcWinners are related to larger size, increased turnover (ΔTurnover), and larger volume (ΔVOL). This finding suggests that the outperformance of the AcWinners found later is not attributable to illiquidity, volatility, and size premium. This is also a good news for the acceleration strategy because the trading costs are reduced. Similarly, in the loser group, the AcLosers (the loser stocks with accelerating downward historical prices) are smaller, have higher book-to-market ratios, are more volatile, and are less liquid than DeLosers (the loser stocks whose decreasing speed of historical prices gradually slows). However, both AcLosers and DeLosers enjoy more liquidity than the universe does. We also observe that ΔTurnover and ΔVOL are significantly larger in AcLosers than in DeLosers. Significant differences are found across various ranking and holding periods (untabulated). Furthermore, we conduct tests of median difference for these firm characteristics using various combinations of ranking and holding periods. Our findings still hold firm within all of these alternative specifications.

[TABLE 2 HERE]

4.2. The profits of the new strategies

We first conduct a preliminary test to examine whether the pattern of historical prices can further distinguish the best (worst) from the better (worse). Each cell in Panel A, Table 3 reports the monthly raw return of buying AcWinners and sell DeWinners under the alternative ranking (J) and holding (K) periods. Panel B shows the raw return of buying DeLosers and sell AcLosers. For brevity, we only report equally-weighted portfolio returns hereafter. None of our results are materially altered if we use value-weighted portfolios. In Panel A, we can observe that the raw returns of AcWinners are significantly higher than DeWinners under most of (J, K). Such outperformance can also be found in some (J, K) combinations in Panel B.

[TABLE 3 HERE]

Next, we explore the practical implications of our model by showing the performance of the nine zero-investment trading strategies. For brevity, we focus our attention on the case (J, K) = (12, 6) for the remainder of this paper. Panel A of Table 4 presents the raw and risk-adjusted returns under the Fama-French three-factor model for the nine trading strategies. The monthly return of the plain momentum strategy (Strategy 1) is 83.22 basis points (all months included) and 105.89 basis points (excluding January).

Compared with the plain momentum strategy, three features stand out. First and foremost, the acceleration strategy (i.e., buys AcWinners and shorts AcLosers) outperforms all other strategies. Its monthly raw return is 132.46 basis points; approximately 17.11% annually. Moreover, the Sharpe ratio is higher than the plain momentum strategy. Second, contrary to the acceleration strategy, the performance of the deceleration strategy, which buys and shorts stocks whose prices change at a slowing speed in the winner and loser groups (i.e., buys DeWinners and shorts DeLosers), is 46.8 basis points per month; thereby achieving the least profit among all strategies. Both the outperformance of the acceleration strategy and the underperformance of the deceleration strategy provide empirical support to our model.

Third, if we unilaterally buy or sell stocks whose historical prices increase or decrease at an accelerating pace, for example Strategy 5, we can still obtain returns that are higher than the momentum profit but lower than that of the acceleration strategy. The monthly raw return of Strategy 5 is 103.35 basis points, which is higher than the plain momentum profit (Strategy 1) and the Strategy 4 profit, but lower than that of the acceleration strategy. Similarly, in Strategy 3 we buy all winner stocks and short loser stocks whose historical prices decrease at an accelerating pace. The raw return of Strategy 3 is 112.32 basis points, which is greater than Strategies 1 and 2. In a nutshell, selecting stocks based their patterns of historical prices is helpful for the momentum investing, even if it is one-sided.

[TABLE 4 HERE]

In Panel B of Table 4, we conduct the mean difference tests and report the *t*-values in order to observe whether the average returns of these new strategies outperform significantly the plain momentum strategy. The results are overwhelming. With the exception of Strategies 2, 4, 7, and 9, which long or short the stocks with the “wrong” patterns of historical prices, the other strategies all outperform significantly the momentum strategy, despite the inclusion or exclusion of January. In addition to the high profit of the acceleration strategy, the Sharpe ratio of the acceleration strategy (0.210) is double the ratio of the plain momentum strategy (0.095).

In the untabulated results, we use alternative combinations of (J, K). The main results remain similar quantitatively and qualitatively within alternative combinations. Table A1 in Appendix repeats Table 4 under (J, K)=(24, 6). Empirically, when the ranking period is longer (i.e. J is larger), the raw and risk-adjusted returns of the acceleration strategy are higher, especially when J is larger than 9. However, when J is smaller than 3, the profit difference between the plain momentum strategy and the acceleration strategy becomes insignificant.

Note that our results do not contradict those in Novy-Marx (2012), who finds that intermediate-horizon past performance primarily drives momentum. Theoretically, Novy-Marx (2012) investigates the driving force of momentum, but we propose a new phenomenon that should hold as long as momentum is profitable. Empirically, Novy-Marx decomposes past returns and sorts stocks based on past returns from the intermediate and recent horizons, respectively, but we sort stocks based on the overall pattern of historical prices.

4.2. Fama-Macbeth regression

We have already demonstrated that, in relation to time-series, the returns yielded from the new strategies cannot be subsumed by traditional risk factors. However, some may argue that the acceleration strategy may incidentally capture the predictability of other return determinants. Insofar as momentum is a cross-sectional phenomenon, we run Fama-MacBeth regressions using dummy variables to assess whether our results still hold after controlling for certain firm characteristics.

The dependent variable in these regressions is the month *t* return to stock *i*, $R_{i,t}$.The control variables include firm size in the month (*Size*, in billion dollars), the book-to-market ratio (*BM*), total turnover for the month (*Turnover*), volatility in the month (*Volatility*), and Amihud's illiquidity measure (*Illiq*) (Amihud, 2002). Moreover, we include the lagged monthly return (R_{t-1}) by skipping a month between ranking and holding periods. This demonstrates that our results are not a simple manifestation of the monthly reversals presented by Jegadeesh (1990), and to mitigate the impact of bid-ask bounce.

We also include dummies that indicate whether stock *i* is held (either long or short) in month *t* as part of the plain momentum strategy, the acceleration strategy, and the

52-week high strategy. George and Hwang (2004) find that nearness to the 52-week high price dominates and improves the profits gained using the momentum strategy[4]. The premise of their argument is that investors will pay more attention to whether a stock's price is near or far from its 52-week high. When investors are attracted by a stock's nearness to its 52-week high, they are more likely to ignore the firm's fundamentals; therefore, anchoring bias occurs. The failure of instantaneously incorporating the news into prices leads to underreaction and return predictability. The following regression is estimated.

$$
\begin{aligned}
R_{i,t} = {} & \beta_{0jt} + \beta_{1jt}Size_{i,t-1} + \beta_{2jt}BM_{i,t-1} + \beta_{3jt}Turnover_{i,t-1} + \beta_{4jt}Volatility_{i,t-1} \\
& + \beta_{5jt}Illiq_{i,t-1} + \beta_{6jt}R_{i,t-1} + \beta_{7jt}Winner_{i,t-j} + \beta_{8jt}Loser_{i,t-j} \\
& + \beta_{9jt}FHH_{i,t-j} + \beta_{10jt}FHL_{i,t-j} + \beta_{11jt}AcWinner_{i,t-j} + \beta_{12jt}DeWinner_{i,t-j} \\
& + \beta_{13jt}AcLoser_{i,t-j} + \beta_{14jt}DeLoser_{i,t-j} \qquad (7)
\end{aligned}
$$

where $Winner_{i,t-j}$ equals one if stock i's past performance over the 12-month period ($t-j-12, t-j$) is in the top group when measured by JT's performance criterion, and

[4] We first construct the 52-week high strategy and find that the monthly raw return from January 1962 through December 2011 is 55.53 basis points. The winner (loser) portfolio for the 52-week high strategy is the equally weighted portfolio of the 20% of stocks with the highest (lowest) ratio of current price to 52-week high. The ranking period for the 52-week high strategy is 12 months and the holding period is 6 months .In George and Hwang (2004), the monthly portfolio return from July 1963 through December 2001 is 45 basis points. Note that we remove the stocks whose prices are under $5 when the portfolios are constructed, while George and Hwang (2004) do not.

is zero otherwise; $Loser_{i,t-j}$ equals one if stock *i*'s past performance over the period (*t* – *j* –*12, t* – *j*) is in the bottom group when measured by JT's performance criterion, and is zero otherwise. The variables *FHH* and *FHL* are defined similarly for the 52-week high strategy in George and Hwang (2004). $FHH_{i,t-j}$ ($FHL_{i,t-j}$) is the 52-week high winner (loser) dummy that equals 1 if the 52-week high measure[5] for stock *i* is ranked in the top (bottom) 30% in month *t* – *j*, and zero otherwise. We further define four dummies: *AcWinner, DeWinner*, *AcLoser*, and *DeLoser*. *AcWinner* (*AcLoser*) equals one if a winner (loser) stock sorted to the top (bottom) 20% based on the coefficient γ in equation (5) over the period (*t* – *j* –*12, t* – *j*), and is zero otherwise. The other two dummies are defined analogously.

We parallel the method in George and Hwang (2004): for a (12, 6) strategy, the total return in month *t* (as a monthly return) of the set of pure winner or pure loser portfolios can be expressed as the equation: $\frac{1}{6}(\sum_{j=2}^{7}\beta_{7jt}+\sum_{j=2}^{7}\beta_{8jt}+\cdots+\sum_{j=2}^{7}\beta_{14jt})$, where the individual coefficients are computed from separate cross-sectional regressions for each *j* = 2, …, 7.

Table 5 illustrates the time-series averages of the month-by-month coefficients from the cross-section regressions and the *t*-values with the Newey-West adjustment. For brevity, we report the results of a (12, 6) strategy in Table 5 and leave the results of a (12, 12) strategy for Table A2 in Appendix[6]. To avoid the possibility that the

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[5] Following George and Hwang (2004), the 52-week high measure in month *t* – *j* is the ratio of price level in month *t* – *j* to the highest price achieved in months *t* – *j* – *12* to *t* – *j*.

[6] The analysis is performed for various ranking and holding periods in addition to the (12, 6) and (12, 12) strategies. The results are all similar.

acceleration strategy is a manifestation of the plain momentum strategy with finer partition, the dummy $Winner_{i,t-j}$ ($Loser_{i,t-j}$) equals 1 if stock *i*'s past performance over the 12-month period is in the top (bottom) 20% in Panel A and 4% in Panel B, and is zero otherwise. For ease of exposition, we scale up the illiquidity measure by 10^3.

First, consistent with the propositions made by the model, the dummy *AcWinner* is significantly positive, while the dummy *DeWinner* is significantly negative in Panels A and B, irrespective of the strong effects of all the control variables. Meanwhile, the dummies *Winner* and *FHH* are barely significant. For example, after including for all control variables, the coefficient of the dummy *AcWinner* is 0.0013 (t = 2.30) in Panel B, while the coefficients of the dummies *Winner* and *FHH* are -0.0009 (t = –0.92) and 0.0006 (t = –0.81) respectively. This finding suggests that the predictive power of the dummies *Winner* and *FHH* are subsumed by *AcWinner* and *DeWinner*. In addition, the opposite signs of the coefficients of *AcWinner* and *DeWinner* indicate that the pattern of historical prices can further identify the best stocks from a group of winners.

Moreover, the dummy *AcLoser* dominates the dummy *DeLoser* in terms of magnitude and statistical significance in Panels A and B. This means that the returns of DeLosers, whose historical prices decrease at an accelerating pace, will decrease more significantly in the future. In other words, shorting DeLosers is more profitable. The average slopes for the dummy *AcLoser* range from -0.0021 (t=-4.05) to -0.0060 (t=0.6.94) across different specifications in Panel B.

In summary, our model is empirically supported. The results from the portfolio construction and the regressions both indicate that *how* a stock becomes a winner or loser is related to future expected return. Moreover, the shape of historical prices subsumes the predictability of past price changes and the nearness of the current price to the 52-week high in Fama-MacBeth regressions. The acceleration strategy is not merely a manifestation of other return determinants or of the plain momentum strategy with finer partition.

[TABLE 5 HERE]

4.3. Factor models

If the shape of historical prices can subsume the predictability of past returns and the nearness of the current price to the 52-week high in Fama-MacBeth regressions, we expect that it can also explain the returns earned by the plain momentum strategy and the 52-week high strategy in terms of factor models.

Four models are adopted: (i) the Fama-French three-factor model; (ii) the three-factor model with the plain momentum strategy[7]; (iii) the three-factor model with the 52-week high strategy; and (iv) the three-factor model with the acceleration strategy.

---

[7]The calculation of the plain momentum strategy is identical to Strategy 1 outlined in Table 4. We sort stocks into quintiles based on the past returns from month *t-13* to *t-2* and hold the zero-investment portfolio for 6 months. Note that the momentum factor is calculated differently in JT (1993), Carhart (1997), and Kenneth R. French's website. We also use the methods in Carhart (1997) and French's website to compute the momentum factor and repeat the tests in Table 6. The conclusion is not materially changed.

The three-factor model with the 52-week high strategy includes the market factor, size factor, book-to-market factor, and the monthly return of long-short portfolio based on nearness to the 52-week high[8]. The three-factor factor model with the acceleration strategy is defined analogously. Note that we do not regard the 52-week high and the acceleration strategy as risk factors but rather as long-short portfolios that may explain a portion of the returns earned by other trading strategies.

Table 6 presents the results and three stand-out features are observed. First and foremost, the profit of the acceleration strategy cannot be explained by the other three factor models. For example, under the three-factor model with the 52-week high strategy, the acceleration strategy continues to generate 80.57 basis points per month. Second, when the acceleration strategy is introduced, the monthly risk-adjusted returns of the 52-week high strategy and the plain momentum strategy are no longer significant. Third, the plain momentum strategy cannot be explained by the model with the 52-week high strategy. The plain momentum strategy remains profitable; 58.67 basis points per month under the three-factor model with the 52-week high strategy. Conversely, the 52-week high strategy can be explained by the model with the JT momentum strategy. These results can be interpreted as suggestive evidence in favor of the argument that the process of becoming a winner or a loser further distills the momentum profit by generating extra unexplained profit.

[TABLE 6 HERE]

[8] See Note 8 for the construction of the long-short portfolio based on nearness to the 52-week high.

4.4. Reversals under longer holding periods

If the acceleration strategy lies in the core of the momentum strategy in term of the factor models, one can expect that the reversals should also be initiated by the stocks selected by the acceleration strategy—that is, the return of the acceleration strategy is reversed on a larger scale. To investigate this, we use overlapping portfolios, in accordance with JT (1993), to recalculate the monthly return for each strategy in the K^{th} month, where K is equal to 1, 12, 24, 36, 48, or, 60.The ranking period (J) is set at 12. Essentially, we would like to observe whether the monthly returns reduce substantially if the holding period is extended.

Table 7 presents the results and three regularities are notable. First, in Panel A we can confirm the existence of reversals for a holding period of 24 months or longer. In the 24^{th} month of implementing these strategies, the profits of most strategies significantly turn to negative. Second, compared with the plain momentum strategy in Panel B, the reversals occur sooner on a larger scale, provided we focus on buying AcWinners; i.e. Strategies 5, 6 (the acceleration strategy), and 8. This finding suggests that the reversals are caused mainly by winners rather than losers. Finally, but significantly, Panel B illustrates that the profit made from the acceleration strategy is significantly lower than that of plain momentum strategy in the 24^{th} and the 36^{th} months. In accordance with the factor models in the above section, this result also implies that the acceleration strategy lies in the core of the momentum strategy because the return of the acceleration strategy reverse on a larger scale.

[TABLE 7 HERE]

5. Auxiliary tests

5.1. Time partition

To investigate whether our findings are conditional on time, we examine the performance of the nine strategies in three equal and non-overlapping subperiods. Table 8 presents the average monthly returns for the nine trading strategies.

[TABLE 8 HERE]

The evidence indicates that the acceleration strategy always outperforms, and the deceleration strategy always underperforms, other strategies in all subperiods. In the last two decades, the profit of the acceleration strategy achieves 98.53 basis points per month; approximately 12.49% annually. Although the profit of the acceleration strategy remains significant, it is obvious that the profits of the other eight strategies have become insignificant in the last two decades. Given the dotcom bubble and the subprime mortgage crisis over the last 10 years, we follow Chordia and Shivakumar (2002) to analyze whether the profitability of these strategies is related to business cycles. Like Chordia and Shivakumar (2002), our sample is divided into two economic environments: expansionary and recessionary periods, based on the definition provided by NBER[9]. The returns of all strategies are examined in each of these environments.

The results in Table 8 corroborate the findings of Chordia and Shivakumar (2002), Cooper, Gutierrez, and Hameed (2004), and Daniel and Moskowitz (2013). The profitability of all strategies is significantly positive during the expansionary period, but insignificant during the recessionary period. During the expansionary period, the acceleration strategy earns a significant profit of 154.83 basis points, but yields only an insignificant profit of 49 basis points during the recessionary period. Moreover, the profits of the remaining eight strategies are significant only during the expansionary period.

5.2. Implementing the strategies with midpoints of bid-ask quotes

Our main results are based on the one-month gap between the ranking and the holding periods. Therefore, potential micro-structure issues are largely avoided. Nevertheless, to ensure that our results are not driven by bid-ask bounce, we repeat the analysis by replacing closing prices with the midpoints of closing bid and ask quotes, obtained from CRSP. Since CRSP only began reporting the closing quotes in the early 90s, this analysis relates specifically to the period 1994–2011.

[TABLE 9 HERE]

Table 9 illustrates that our results are not driven by bid-ask bounce. The

[9]See http://www.nber.org/cycles.html

acceleration strategy continues to outperform the plain momentum strategy (Strategy 1) by 56.45 basis points per month. The profit of the deceleration strategy is also lower than the plain momentum strategy by 41.85 basis points per month. Furthermore, we repeat the time partition analysis in Table 8 and discover that the outperformance of the acceleration strategy obtained using midpoints is not sensitive to time period either.

5.3. Lagged one month, data filter, outliers, and exchanges

Further to the tests described above, we have calculated the profits for all strategies: (1) without skipping a month between the ranking and holding periods; (2) without removing stocks whose prices are below 5 dollars; (3) after deleting stocks whose market capitalizations are in the smallest NYSE/AMEX/Nasdaq decile; and (4) in different exchanges.

We find that the profits are higher without skipping one month, especially when the ranking period is long (e.g. $J>12$) and the holding period is short (e.g. $K<6$). Furthermore, the returns will be made more significant by deleting stocks priced below 5 dollars or whose market capitalizations are small at the beginning of the holding period. Moreover, the R^2 increases marginally for the Fama-Macbeth regression. The profit under different exchanges is illustrated in Table A3 in the Appendix. To conclude, our findings remain robust in relation to all of the data winsorization, alternative specifications, and various ranking/holding periods.

6. Conclusion

This study provides fresh insight into momentum investing by considering the fact that *how* one stock becomes a winner or loser—that is, the movement of historical prices—is related to future expected return. In our model, when two stocks S_1 and S_2 share the same return over a period [0, *T*]—that is, when both are either winners or losers—the stock with convex-shaped historical prices will achieve a higher expected return than the one with concave-shaped historical prices. By using a polynomial quadratic model to approximate the movement of historical prices, our model is substantiated by the empirical results. We design several alternative strategies that transact in only a subset of the stocks contained in the winner and loser portfolios. The acceleration strategy—buying winner stocks whose historical prices are convex shaped (i.e., increase at an accelerating pace) and shorting loser stocks whose historical prices are concave shaped (i.e., decrease at an accelerating pace)—produces the highest return. The acceleration strategy generates an annual raw return of 17.11% (132.46 basis points) and a Sharpe ratio of 0.26 for the period from 1962 to 2011.The corresponding momentum strategy generates an annual raw return of 10.46% and a Sharpe ratio of 0.20. We also find that the acceleration strategy explains the returns earned by the 52-week high strategy developed by George and Hwang (2004) and the plain momentum strategy, while the reverse does not hold true.

The new strategy is feasible and easy to implement. Therefore, our study has immediate and profound investment implications for practice. Understanding that the formation process of returns adds benefit for momentum also facilitates the design of more profitable trading strategies. Our paper offers useful guidance for future research.

In addition to the simple quadratic regression model, one can use a more complicated polynomial model to distill additional information that is embedded in historical prices. Moreover, the fact that selecting stocks containing special patterns of historical prices can generate higher returns appears to fuel much of the market efficiency debate and poses a further challenge to any attempt to rationalize momentum.

Appendix

A.1 Portfolio construction: Alternative ranking and holding periods

Table A.1 reports the monthly raw and risk-adjusted returns of the nine trading strategies. The alternative ranking period (*J*) is the past 24 months and the holding period (*K*) is 6 months. Panel A shows that the profit of the acceleration strategy still outperforms all other strategies and the profit of deceleration strategy sits in the bottom. Moreover, the profit difference between the plain momentum strategy and the acceleration strategy shown in Panel B (75.82 basis points) is larger than that shown in Table 4, Panel B (49.26 basis points). It seems that the outperformance of the acceleration strategy becomes more significant when further price information is considered.

Table A1

Performance of trading strategies estimated by simple raw returns and risk-adjusted returns: Alternative ranking and holding periods

This table reports the average monthly returns, the *t*-values, and the Sharpe ratios for nine trading strategies from January 1962 to December 2011. The sample includes all common stocks listed in NYSE, AMEX, and Nasdaq. At the time of sorting and portfolio formation, stocks with a share price of $5 or lower are deleted. For brevity, stocks are sorted into quintiles based on the past 24-month returns lagged 1 month. All equally-weighted portfolios are held for 6 months. The convexity for each stock is defined by regressing the daily prices in the past 24 months on the variable *t* and the square of *t* for each stock, where *t* is an ordinal variable, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day respectively. Stocks whose coefficients of the square of *t* are in the top 20% are those with an accelerating speed of price increase; conversely, stocks whose coefficients of the square of *t* are in the bottom 20% are those whose decreasing speed of historical prices slows. Panel A presents the returns in basis points, the *t*-values, and the Sharpe ratios of the nine trading strategies. The Sharpe ratio in brackets is defined as dividing the excess return of a portfolio by the standard deviation of this excess return. The Sharpe ratio is actually the appraisal ratio: alpha divided by the idiosyncratic volatility of the portfolio returns. The *t*-statistics in parentheses are adjusted for autocorrelation using the Newey-West covariance matrix. For Panel B, the *t*-statistics in parentheses examine whether the performance difference between two different portfolios is significantly different from zero, and bold *t*-values correspond to a significance level of 5% or higher.

Panel A. Portfolio return							
		Raw return			Alphas from the Fama-French three-factor model		
Trading strategy		All months	January only	January excluded	All months	January only	January excluded
1. Plain momentum strategy	Return (bp)	35.86	-290.28	64.89	73.40	-113.77	91.24
Long *Winners*	T-value	**(2.22)**	**(-3.32)**	**(3.69)**	**(5.24)**	(-1.44)	**(6.57)**
Short *Losers*	Sharpe ratio	[0.095]	[-0.600]	[0.185]	[0.095]	[-0.600]	[0.185]
2. Long *Winners*	Return (bp)	14.23	-279.48	40.38	45.98	-105.15	61.84
Short *DeLosers* (Slowing-down loser)	T-value	(0.84)	**(-3.64)**	**(2.24)**	**(2.67)**	(-1.43)	**(3.54)**
	Sharpe ratio	[0.037]	[-0.599]	[0.109]	[0.037]	[-0.599]	[0.109]
3. Long *Winners*	Return (bp)	83.05	-188.02	107.18	121.95	-24.55	136.25
Short *AcLosers* (Accelerative loser)	T-value	**(4.17)**	**(-2.28)**	**(5.01)**	**(7.03)**	(-0.26)	**(7.83)**
	Sharpe ratio	[0.190]	[-0.374]	[0.254]	[0.190]	[-0.374]	[0.254]
4. Long *DeWinners* (Slowing-down winner)	Return (bp)	1.43	-369.82	34.48	37.02	-149.31	54.45
Short *Losers*	T-value	(0.08)	**(-3.71)**	(1.88)	**(2.39)**	(-1.83)	**(3.50)**
	Sharpe ratio	[0.004]	[-0.678]	[0.097]	[0.004]	[-0.678]	[0.097]
5. Long *AcWinners* (Accelerative winner)	Return (bp)	64.44	-337.52	100.22	119.56	-122.27	141.61
Short *Losers*	T-value	**(3.26)**	**(-3.63)**	**(4.64)**	**(7.44)**	(-1.61)	**(8.70)**
	Sharpe ratio	[0.138]	[-0.599]	[0.228]	[0.138]	[-0.599]	[0.228]
6. The accerleration strategy	Return (bp)	111.63	-235.25	142.51	168.12	-33.04	186.62
Long *AcWinners*	T-value	**(4.65)**	**(-2.76)**	**(5.50)**	**(8.16)**	(-0.36)	**(8.86)**
Short *AcLosers*	Sharpe ratio	[0.210]	[-0.394]	[0.276]	[0.210]	[-0.394]	[0.276]
7. The deceleration strategy	Return (bp)	-20.20	-359.02	9.96	9.61	-140.69	25.05
Long *DeWinners*	T-value	(-1.08)	**(-3.98)**	(0.51)	(0.49)	(-1.80)	(1.24)
Short *DeLosers*	Sharpe ratio	[-0.049]	[-0.657]	[0.026]	[-0.049]	[-0.657]	[0.026]
8. Long *AcWinners*	Return (bp)	42.81	-326.71	75.71	92.14	-113.65	112.21
Short *DeLosers*	T-value	**(2.34)**	**(-3.97)**	**(3.87)**	**(5.62)**	(-1.56)	**(6.77)**
	Sharpe ratio	[0.094]	[-0.605]	[0.175]	[0.094]	[-0.605]	[0.175]
9. Long *DeWinners*	Return (bp)	48.62	-267.56	76.76	85.58	-60.09	99.47
Short *AcLosers*	T-value	**(2.64)**	**(-3.01)**	**(3.85)**	**(5.17)**	(-0.60)	**(5.99)**
	Sharpe ratio	[0.120]	[-0.523]	[0.200]	[0.120]	[-0.523]	[0.200]

Panel B. Mean Comparison							
		Raw return			Alphas from the Fama-French three-factor model		
Trading strategy comparison		All months	January only	January excluded	All months	January only	January excluded
2-1	Return (bp)	-21.62	10.81	-24.51	-25.13	-2.37	-26.49
	T-value	**(-2.69)**	(0.37)	**(-2.96)**	**(-3.20)**	(-0.08)	**(-3.25)**
3-1	Return (bp)	47.21	102.26	42.31	47.78	53.77	45.86
	T-value	**(5.67)**	**(2.66)**	**(4.97)**	**(6.36)**	(1.56)	**(5.89)**
4-1	Return (bp)	-34.45	-79.54	-30.44	-29.72	-28.54	-30.13
	T-value	**(-4.05)**	**(-2.75)**	**(-3.42)**	**(-3.73)**	(-1.40)	**(-3.52)**
5-1	Return (bp)	28.60	-47.23	35.35	34.29	-15.87	38.93
	T-value	**(3.16)**	(-1.84)	**(3.84)**	**(3.49)**	(-0.53)	**(4.02)**
6-1	Return (bp)	75.82	55.03	77.67	82.07	37.90	84.79
	T-value	**(5.33)**	(1.39)	**(5.31)**	**(5.64)**	(0.76)	**(5.78)**
7-1	Return (bp)	-56.07	-68.73	-54.94	-54.84	-30.91	-56.63
	T-value	**(-4.28)**	(-1.70)	**(-4.06)**	**(-4.29)**	(-0.87)	**(-4.19)**
8-1	Return (bp)	6.98	-36.42	10.85	9.16	-18.24	12.44
	T-value	(0.89)	(-0.98)	(1.47)	(1.04)	(-0.42)	(1.53)
9-1	Return (bp)	12.76	22.72	11.88	18.07	25.23	15.72
	T-value	(1.67)	(0.69)	(1.46)	**(2.28)**	(0.65)	(1.90)
3-2	Return (bp)	68.83	91.46	66.82	72.91	56.14	72.35
	T-value	**(5.10)**	**(2.09)**	**(4.73)**	**(5.59)**	(1.13)	**(5.32)**
5-4	Return (bp)	63.05	32.31	65.79	64.01	12.67	69.06
	T-value	**(4.17)**	(0.83)	**(4.15)**	**(3.97)**	(0.30)	**(4.14)**

A.2 Fama-MacBeth regression: Alternative ranking and holding periods

Table A2

Fama-MacBeth regressions to control for other return determinants: (12, 12) strategy

This table presents the results of the following Fama-MacBeth regression using all common stocks listed in NYSE, AMEX, and Nasdaq from January 1962 to December 2011. Stocks with a share price of $5 or lower at the time of portfolio construction are deleted. A month is skipped between ranking and holding periods.

$$\begin{aligned} R_{i,t} = {} & \beta_{0jt} + \beta_{1jt} Size_{i,t-1} + \beta_{2jt} BM_{i,t-1} + \beta_{3jt} Turnover_{i,t-1} + \beta_{4jt} Volatility_{i,t-1} + \beta_{5jt} Illiq_{i,t-1} + \beta_{6jt} R_{i,t-1} + \\ & \beta_{7jt} Winner_{i,t-j} + \beta_{8jt} Loser_{i,t-j} + \beta_{9jt} FHH_{i,t-j} + \beta_{10jt} FHL_{i,t-j} + \beta_{11jt} AcWinner_{i,t-j} + \\ & \beta_{12jt} DeWinner_{i,t-j} + \beta_{13jt} AcLoser_{i,t-j} + \beta_{14jt} DeLoser_{i,t-j} \end{aligned}$$

Each month, we regress cross-sectionally returns on the various dummies and control variables, including firm size (*Size*), book-to-market ratio (*BM*), volatility (*Volatility*), turnover (*Turnover*), Amihud's illiquidity measure (*Illiq*), and past 1-month return (R_{t-1}). The illiquidity measure is scaled up by 10^3 and firm size is in billion dollars. The dummies are defined as follows. $Winner_{i,\ t-j}$ equals one if stock *i*'s past performance over the 12-month period ($t - j - 12$, $t - j$) is in the top 20% (Panel A) or top 4% (Panel B). $Loser_{i,\ t-j}$ is defined similarly. $FHH_{i,\ t-j}$ ($FHL_{i,\ t-j}$) takes the value of 1 if the 52-week high measure for stock *i* is ranked in the top (bottom) 30% in month $t - j$, and zero otherwise. The 52-week high measure in month $t - j$ is the ratio of price level in month $t - j$ to the highest price achieved in months $t - j - 12$ to $t - j$. The variable $AcWinner_{i,\ t-j}$ ($DeWinner_{i,\ t-j}$) equals one if the stock is classified into the top (bottom) 20% based on the coefficients of the square of *t* in the winner group in month $t - j$ and zero otherwise. The coefficient of the square of *t* is obtained by regressing the daily price over the period ($t - j - 12$, $t - j$) on an ordinal variable *t*, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day and the square of *t*. By the same token, the variable $AcLoser_{i,\ t-j}$ ($DeLoser_{i,\ t-j}$) is equal to one if the stock is ranked into the bottom (top) 20% based on the coefficients of the square of *t* in the loser group and zero otherwise. The coefficient estimates of a given independent variable are averaged over $j = 2, \ldots, 13$ for the (12, 12) strategy. The *t*-statistics (in parentheses) are calculated from the times series and adjusted for autocorrelation using the Newey-West covariance matrix. Bold t-values correspond to a significance level of 5% or higher.

Panel A. The Dummies *Winner* and *Loser* are the top and bottom 20% respectively					
	(1)	(2)	(3)	(4)	(5)
Intercept	0.0112	0.0117	0.0137	0.0130	0.0146
	(3.89)	**(4.02)**	**(4.37)**	**(5.71)**	**(5.86)**
Size	-0.2690	-0.2804	-0.3216	-0.2611	-0.3066
	(-1.74)	(-1.89)	**(-2.80)**	**(-2.53)**	**(-3.45)**
BM	0.0022	0.0021	0.0017	0.0015	0.0013
	(3.72)	**(3.70)**	**(3.25)**	**(3.26)**	**(2.88)**
Turnover				0.0018	0.0017
				(0.23)	(0.21)
Volatility				-0.0553	-0.0554
				(-1.13)	(-1.20)
Illiq				0.0261	0.0268
				(2.04)	**(2.05)**
R_{t-1}				-0.0001	-0.0007
				(-0.02)	(-0.21)
Winner			-0.0011		-0.0009
			(-0.79)		(-0.90)
Loser			-0.0035		-0.0037
			(-3.79)		**(-4.86)**
FHH			0.0004	-0.0001	0.0006
			(0.40)	(-0.05)	(0.81)
FHL			-0.0021	-0.0029	-0.0017
			(-2.75)	**(-4.34)**	**(-2.59)**
AcWinner		0.0008	0.0010	0.0012	0.0013
		(0.67)	(1.60)	**(2.21)**	**(2.30)**
DeWinner		-0.0024	-0.0015	-0.0020	-0.0013
		(-2.24)	**(-2.61)**	**(-3.63)**	**(-2.62)**
AcLoser		-0.0060	-0.0021	-0.0028	-0.0021
		(-6.94)	**(-4.05)**	**(-5.94)**	**(-4.36)**
DeLoser		-0.0031	0.0001	0.0003	0.0004
		(-3.34)	(0.23)	(0.51)	(0.66)
Average R-square	0.00	0.01	0.02	0.04	0.04

Panel B. The Dummies *Winner* and *Loser* are the top and bottom 4% respectively					
	(1)	(2)	(3)	(4)	(5)
Intercept	0.0112	0.0117	0.0135	0.0126	0.0143
	(3.89)	**(4.02)**	**(4.33)**	**(5.53)**	**(5.73)**
Size	-0.2690	-0.2804	-0.3339	-0.2634	-0.3126
	(-1.74)	(-1.89)	**(-2.87)**	**(-2.53)**	**(-3.49)**
BM	0.0022	0.0021	0.0017	0.0016	0.0013
	(3.72)	**(3.70)**	**(3.27)**	**(3.24)**	**(2.88)**
Turnover				0.0027	0.0023
				(0.34)	(0.28)
Volatility				-0.0483	-0.0491
				(-0.98)	(-1.05)
Illiq				0.0260	0.0270
				(2.02)	**(2.05)**
R_{t-1}				-0.0001	-0.0007
				(-0.02)	(-0.21)
Winner			-0.0010		-0.0008
			(-0.72)		(-0.76)
Loser			-0.0036		-0.0037
			(-3.67)		**(-4.69)**
FHH			-0.0007	-0.0012	-0.0006
			(-0.56)	(-1.11)	(-0.59)
FHL			-0.0021	-0.0035	-0.0015
			(-1.80)	**(-3.54)**	**(-1.55)**
AcWinner		0.0008	0.0018	0.0017	0.0022
		(0.67)	**(2.08)**	(1.92)	**(2.81)**
DeWinner		-0.0024	-0.0009	-0.0016	-0.0005
		(-2.24)	(-1.12)	**(-2.07)**	(-0.72)
AcLoser		-0.0060	-0.0035	-0.0049	-0.0033
		(-6.94)	**(-4.80)**	**(-7.32)**	**(-5.10)**
DeLoser		-0.0031	-0.0012	-0.0015	-0.0007
		(-3.34)	(-1.57)	**(-2.42)**	(-1.18)
Average R-square	0.00	0.01	0.02	0.04	0.04

A.3. Performance of trading strategies in different exchanges

Nasdaq stocks exhibit a much more impressive performance when we implement the acceleration strategy. The acceleration strategy, constructed by using stocks listed in NYSE/AMEX (Nasdaq), can yield 114.43 (152.21) basis points per month. One may infer that the better performance of Nasdaq stocks is due to their smaller size. The untabulated results do not support this inference, because the three-factor risk-adjusted return of the acceleration strategy in the Nasdaq subsample remains significantly higher than in the NYSE/AMEX subsample. This finding is not sensitive to the length of ranking and holding periods.

Table A3

Performance of trading strategies in different exchanges

This table presents the results of repeating the analysis reported in Table 4 by partitioning the sample according to exchanges. All the panels are for a ranking period of 12 months lagged 1 month and holding periods of 6 months. Panel A outlines the results for the common stocks listed in NYSE and AMEX, while and Panel B does likewise for Nasdaq stocks. The sample period spans January 1962 to December 2010. At the time of sorting and portfolio formation, stocks with a share price of $5 or lower are deleted. The Sharpe ratio in brackets is defined as dividing the monthly portfolio excess return by the standard deviation of excess returns. For alphas, we divide alpha by the idiosyncratic volatility of the portfolio returns to give the Sharpe ratio. All the *t*-values are corrected for autocorrelation with the Newey-West adjustment. Bold *t*-values correspond to a significance level of 5% or higher.

Panel A. NYSE and AMEX				
		Raw return		
		All months	January only	January excluded
1. Plain momentum strategy	Return (bp)	69.77	-200.89	93.87
Long *Winners*	T-value	(4.22)	**(-2.83)**	**(5.19)**
Short *Losers*	Sharpe ratio	[0.181]	[-0.419]	[0.256]
2. Long *Winners*	Return (bp)	67.72	-162.08	88.19
Short *DeLosers* (Slowing-down loser)	T-value	**(4.12)**	**(-2.38)**	**(5.15)**
	Sharpe ratio	[0.173]	[-0.371]	[0.232]
3. Long *Winners*	Return (bp)	96.93	-83.19	112.97
Short *AcLosers* (Accelerative loser)	T-value	**(5.29)**	(-1.23)	**(5.60)**
	Sharpe ratio	[0.232]	[-0.149]	[0.283]
4. Long *DeWinners* (Slowing-down winner)	Return (bp)	44.29	-228.58	68.59
Short *Losers*	T-value	**(2.71)**	**(-2.63)**	**(3.78)**
	Sharpe ratio	[0.115]	[-0.449]	[0.188]
5. Long *AcWinners* (Accelerative winner)	Return (bp)	87.27	-263.45	118.51
Short *Losers*	T-value	**(4.56)**	**(-3.53)**	**(5.72)**
	Sharpe ratio	[0.195]	[-0.458]	[0.281]
6. The accerleration strategy	Return (bp)	114.43	-145.75	137.60
Long *AcWinners*	T-value	**(5.48)**	**(-2.04)**	**(5.99)**
Short *AcLosers*	Sharpe ratio	[0.239]	[-0.222]	[0.303]
7. The deceleration strategy	Return (bp)	42.25	-189.77	62.91
Long *DeWinners*	T-value	**(2.61)**	**(-2.31)**	**(3.62)**
Short *DeLosers*	Sharpe ratio	[0.107]	[-0.409]	[0.165]
8. Long *AcWinners*	Return (bp)	85.23	-224.64	112.82
Short *DeLosers*	T-value	**(4.59)**	**(-3.23)**	**(5.83)**
	Sharpe ratio	[0.192]	[-0.424]	[0.265]
9. Long *DeWinners*	Return (bp)	71.45	-110.88	87.69
Short *AcLosers*	T-value	**(4.07)**	(-1.48)	**(4.52)**
	Sharpe ratio	[0.179]	[-0.203]	[0.231]
Mean Comparison				
Trading strategy comparison		All months	January only	January excluded
2-1	Return (bp)	-2.04	38.82	-5.68
	T-value	(-0.38)	(1.91)	(-0.99)
3-1	Return (bp)	27.16	117.71	19.10
	T-value	**(4.85)**	**(3.72)**	**(3.09)**
4-1	Return (bp)	-25.47	-27.69	-25.28
	T-value	**(-4.68)**	(-0.89)	**(-3.87)**
5-1	Return (bp)	17.51	-62.56	24.64
	T-value	**(3.21)**	**(-2.73)**	**(4.55)**
6-1	Return (bp)	44.67	55.15	43.73
	T-value	**(5.38)**	(1.43)	**(4.71)**
7-1	Return (bp)	-27.52	11.13	-30.96
	T-value	**(-3.60)**	(0.36)	**(-3.44)**
8-1	Return (bp)	15.46	-23.74	18.95
	T-value	**(2.42)**	(-0.98)	**(3.00)**
9-1	Return (bp)	1.69	90.02	-6.18
	T-value	(0.27)	**(4.17)**	(-0.88)
3-2	Return (bp)	29.20	78.89	24.78
	T-value	**(3.35)**	**(2.86)**	**(2.53)**
5-4	Return (bp)	42.98	-34.87	49.91
	T-value	**(5.15)**	(-0.84)	**(5.11)**

Panel B. Nasdaq				
		Raw return		
		All months	January only	January excluded
1. Plain momentum strategy	Return (bp)	94.62	-111.03	112.82
Long *Winners*	T-value	**(4.35)**	(-1.70)	**(4.92)**
Short *Losers*	Sharpe ratio	[0.222]	[-0.242]	[0.269]
2. Long *Winners*	Return (bp)	84.49	-113.14	101.99
Short *DeLosers* (Slowing-down loser)	T-value	**(3.57)**	(-1.33)	**(4.13)**
	Sharpe ratio	[0.192]	[-0.220]	[0.237]
3. Long *Winners*	Return (bp)	126.56	-60.39	143.11
Short *AcLosers* (Accelerative loser)	T-value	**(5.95)**	(-0.74)	**(6.26)**
	Sharpe ratio	[0.272]	[-0.094]	[0.323]
4. Long *DeWinners* (Slowing-down winner)	Return (bp)	56.01	-197.97	78.50
Short *Losers*	T-value	**(2.41)**	**(-3.16)**	**(3.17)**
	Sharpe ratio	[0.130]	[-0.433]	[0.187]
5. Long *AcWinners* (Accelerative winner)	Return (bp)	120.26	-149.39	144.13
Short *Losers*	T-value	**(4.85)**	**(-2.23)**	**(5.46)**
	Sharpe ratio	[0.245]	[-0.290]	[0.299]
6. The accerleration strategy	Return (bp)	152.21	-98.75	174.42
Long *AcWinners*	T-value	**(6.16)**	(-1.15)	**(6.47)**
Short *AcLosers*	Sharpe ratio	[0.288]	[-0.136]	[0.348]
7. The deceleration strategy	Return (bp)	45.89	-200.08	67.66
Long *DeWinners*	T-value	(1.85)	**(-2.38)**	**(2.58)**
Short *DeLosers*	Sharpe ratio	[0.104]	[-0.396]	[0.157]
8. Long *AcWinners*	Return (bp)	110.14	-151.50	133.30
Short *DeLosers*	T-value	**(4.28)**	(-1.82)	**(4.90)**
	Sharpe ratio	[0.226]	[-0.274]	[0.280]
9. Long *DeWinners*	Return (bp)	87.96	-147.33	108.79
Short *AcLosers*	T-value	**(4.14)**	(-1.83)	**(4.96)**
	Sharpe ratio	[0.200]	[-0.227]	[0.265]
Mean Comparison				
Trading strategy comparison		All months	January only	January excluded
2-1	Return (bp)	-10.12	-2.11	-10.83
	T-value	(-1.22)	(-0.07)	(-1.29)
3-1	Return (bp)	31.95	50.64	30.29
	T-value	**(3.59)**	(0.91)	**(2.34)**
4-1	Return (bp)	-38.60	-86.95	-34.32
	T-value	**(-4.94)**	**(-3.78)**	**(-4.32)**
5-1	Return (bp)	25.65	-38.36	31.31
	T-value	**(3.07)**	(-1.60)	**(3.52)**
6-1	Return (bp)	57.59	12.28	61.61
	T-value	**(4.47)**	(0.19)	**(3.68)**
7-1	Return (bp)	-48.72	-89.05	-45.15
	T-value	**(-4.51)**	**(-2.12)**	**(-4.00)**
8-1	Return (bp)	15.52	-40.47	20.48
	T-value	(1.57)	(-1.20)	(1.94)
9-1	Return (bp)	-6.65	-36.30	-4.03
	T-value	(-0.79)	(-0.58)	(-0.40)
3-2	Return (bp)	42.07	52.75	41.12
	T-value	**(3.18)**	(0.67)	**(2.50)**
5-4	Return (bp)	64.25	48.58	65.64
	T-value	**(4.87)**	(1.29)	**(4.74)**

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Table 1

Descriptive statistics of γ

This table reports the descriptive statistics of the convexity of stock historical prices from January 1962 to December 2011. The convexity of a stock's historical prices is computed by regressing the daily prices in the past *J* months on the variable *t* and the square of *t*, where *t* is an ordinal variable, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day respectively. For ease of illustration, the value of γ is scaled up by 10^3.

Rank by convexity	Mean	Median	Std	Min	Max	Observations
1 (Low)	-0.6037	-0.3103	9.2377	-1659.4009	0.2453	364292
2	-0.0906	-0.0745	0.1517	-4.5172	0.3971	364534
3	0.0127	0.0108	0.1289	-1.3913	4.0320	364544
4	0.1136	0.0926	0.2307	-0.9109	11.7783	364534
5 (High)	0.5719	0.3074	8.8040	-0.4983	2006.6398	364782
All	0.0009	0.0129	5.7209	-1659.4009	2006.6398	1822686

Table 2

Firm characteristics of stocks in different convexity quintiles

This table presents the firm characteristics of the stocks under the double partition of past returns and the convexity of historical prices. The sample covers all common stocks listed in NYSE, AMEX, and Nasdaq from January 1962 to December 2011. At the time of sorting and portfolio formation, stocks with a share price of $5 or lower are deleted. We first sort stocks into quintiles based on the past 12-month returns. In each return quintile, stocks are sorted into quintiles based on the coefficients of the square of *t* obtained by regressing the daily prices in the past 12 months on the variable *t* and the square of *t* for each stock. *t* is an ordinal variable, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day respectively. Panel A (Panel B) presents the average firm characteristics for the winners (losers) in the top and bottom groups sorted by the coefficients of the square of *t*. For each category of stocks, a cross-sectional monthly mean is revealed for each month; then, the mean size is averaged across time to obtain the final average. Firm size (in thousand dollars) is the product of the number of shares outstanding and the stock price. *BM* is the book-to-market ratio. The monthly illiquidity measure (*Illiq*) for each stock is computed by dividing the daily absolute return by the daily trading volume and then averaging this daily quantity over the month. Monthly volatility (*Volatility*) is calculated using daily prices within each portfolio formation month. $\Delta\mathrm{Turnover}$ denotes the change in turnover, which is defined as the turnover in month *t* (the month of sorting stocks) minus the average turnover from month *t-1* to month *t-12*. $\Delta\mathrm{VOL}$ (in hundred shares) denotes the change of traded shares. Its calculation is similar to $\Delta\mathrm{Turnover}$. The *t*-values for the mean-difference test between different categories of stocks are reported. Bold *t*-values correspond to a significance level of 5% or higher.

Panel A. Winner							
	Size	BM	Illiq	Bid-ask spread	Volatility	△Turnover	△VOL
AcWinner	2,264,826	1.8624	7.0942	1.4390	0.0282	0.4242	23903.4930
DeWinner	2,224,354	3.1903	8.1484	1.6887	0.0285	-0.0557	18827.1310
All	1,442,020	2.1300	9.6978	1.9086	0.0288	0.1962	14120.7503
The t-value of the mean difference test (AcWinner-DeWinner)	0.64	-0.85	**-3.41**	**-16.65**	**-3.50**	**36.72**	**4.07**
The t-value of the mean difference test (AcWinner-All)	**17.82**	-0.24	**-13.63**	**-41.20**	**-7.95**	**20.68**	**12.20**
The t-value of the mean difference test (DeWinner-All)	**16.21**	0.84	**-5.09**	**-17.93**	**-3.63**	**-29.04**	**4.48**
Panel B. Loser							
	Size	BM	Illiq	Bid-ask spread	Volatility	△Turnover	△VOL
AcLoser	1,311,357	1.0935	10.7318	2.3765	0.0322	-0.0482	19187.9435
DeLoser	1,396,791	0.4403	9.6635	2.1552	0.0300	-0.2262	-10774.7283
All	993,169	1.4788	13.9230	2.7537	0.0311	-0.0725	4708.7191
The t-value of the mean difference test (AcLoser-DeLoser)	**-2.01**	**2.04**	**2.32**	**11.29**	**21.73**	**20.81**	**10.35**
The t-value of the mean difference test (AcLoser-All)	**9.72**	-0.51	**-8.65**	**-23.46**	**13.64**	**3.76**	**6.79**
The t-value of the mean difference test (DeLoser-All)	**12.64**	-1.51	**-11.16**	**-39.79**	**-14.23**	**-22.91**	**-6.73**

Table 3

The zero-investment portfolios of stocks sorted by convexity in the winner and loser groups

This table reports the average monthly returns in basis points of portfolios from January 1962 to December 2011. Stocks are first sorted into quintiles based on the past *J*-month returns lagged one month. Then, we regress the daily prices in the past *J* months on the variable *t* and the square of *t* for each stock, where *t* is an ordinal variable, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day respectively. In the winner group (top 20%) and loser group (bottom 20%), the stocks are sorted into quintiles based on convexity of historical prices; i.e. the coefficients of the square of *t* in equation (1). All equally-weighted portfolios are held for *K* months. Each cell in this table reports the monthly raw return of buying the stocks whose coefficients of the square of *t* are in the top 20% and selling the stocks whose coefficients of the square of *t* are in the bottom 20% under alternative ranking (*J*) and holding (*K*) periods in the winner (Panel A) and loser groups (Panel B). The sample includes all common stocks listed in NYSE, AMEX, and Nasdaq. At the time of sorting and portfolio formation, stocks with a share price of $5 or lower are deleted. The *t*-statistics in parentheses are corrected for autocorrelation by the Newey-West procedure. Bold *t*-values correspond to a significance level of 5% or higher.

		Panel A. Winner group						Panel B. Loser group					
J	K=	1	2	3	6	9	12	1	2	3	6	9	12
3		14.06	18.17	10.68	8.73	6.66	7.98	-8.09	6.98	0.66	4.27	-1.09	4.84
		(1.21)	**(2.53)**	**(2.04)**	**(3.00)**	**(2.60)**	**(3.71)**	(-0.61)	(0.86)	(0.11)	(1.27)	(-0.38)	**(1.96)**
6		10.12	4.53	5.38	8.90	18.33	17.16	-9.00	-4.07	3.37	2.11	11.40	12.62
		(0.90)	(0.49)	(0.71)	(1.63)	**(3.94)**	**(4.95)**	(-0.63)	(-0.29)	(0.31)	(0.39)	**(2.80)**	**(3.55)**
9		16.81	19.92	16.95	28.75	33.07	27.61	9.19	18.76	13.99	13.52	27.21	23.37
		(1.45)	(1.74)	(1.55)	**(3.31)**	**(4.96)**	**(5.35)**	(0.81)	(1.83)	(1.48)	(1.81)	**(4.65)**	**(4.77)**
12		47.39	44.78	49.29	54.44	50.08	37.37	-8.47	0.98	11.88	31.22	39.03	34.57
		(3.67)	**(3.57)**	**(4.11)**	**(5.49)**	**(6.26)**	**(5.59)**	(-0.67)	(0.08)	(1.03)	**(3.22)**	**(5.24)**	**(5.72)**
24		87.56	83.03	76.71	63.09	49.97	38.50	69.99	76.81	75.10	69.14	60.65	49.63
		(5.45)	**(5.22)**	**(4.97)**	**(4.18)**	**(3.45)**	**(2.94)**	**(4.64)**	**(5.19)**	**(5.12)**	**(5.13)**	**(4.95)**	**(4.66)**
36		68.16	61.24	57.91	48.85	40.65	31.92	75.95	73.05	68.48	54.28	40.03	29.44
		(3.63)	**(3.31)**	**(3.17)**	**(2.88)**	**(2.64)**	**(2.31)**	**(4.31)**	**(4.53)**	**(4.33)**	**(3.83)**	**(3.15)**	**(2.55)**
48		60.10	56.08	51.53	39.76	32.49	26.64	43.78	39.15	32.97	18.91	9.90	6.00
		(3.57)	**(3.36)**	**(3.10)**	**(2.54)**	**(2.31)**	**(2.09)**	**(2.45)**	**(2.26)**	(1.90)	(1.13)	(0.64)	(0.41)
60		42.40	43.09	39.53	30.56	22.93	16.71	26.63	18.34	14.70	10.89	5.39	4.34
		(2.40)	**(2.62)**	**(2.43)**	**(2.06)**	(1.66)	(1.30)	(1.57)	(1.13)	(0.95)	(0.74)	(0.39)	(0.33)

Table 4

Performance of trading strategies estimated by simple raw returns and risk-adjusted returns

This table reports the average monthly returns, the *t*-values, and the Sharpe ratios for nine trading strategies from January 1962 to December 2011. The sample includes all common stocks listed in NYSE, AMEX, and Nasdaq. At the time of sorting and portfolio formation, stocks with a share price of $5 or lower are deleted. For brevity, stocks are sorted into quintiles based on the past 12-month returns lagged one month. All equally-weighted portfolios are held for 6 months. The convexity for each stock is defined by regressing the daily prices in the past 12 months on the variable *t* and the square of *t* for each stock, where *t* is an ordinal variable, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day respectively. Stocks whose coefficients of the square of *t* are in the top 20% are those with an accelerating speed of price increase; conversely, stocks whose coefficients of the square of *t* are in the bottom 20% are those whose decreasing speed of historical prices slows. The nine trading strategies are constructed by buying and selling stocks with different visual patterns of historical prices. Panel A presents the returns in basis points, the *t*-values, and the Sharpe ratios of the nine trading strategies. The Sharpe ratio in brackets is defined as dividing the excess return of a portfolio by the standard deviation of this excess return. The Sharpe ratio is actually the appraisal ratio: alpha divided by the idiosyncratic volatility of the portfolio returns. The *t*-statistics in parentheses are adjusted for autocorrelation using the Newey-West covariance matrix. For Panel B, the *t*-statistics in parentheses examine whether the performance difference between two portfolios is significantly different from zero, and bold *t*-values correspond to a significance level of 5% or higher.

Panel A. Portfolio return							
		Raw return			Alphas from the Fama-French three-factor model		
Trading strategy		All months	January only	January excluded	All months	January only	January excluded
1. Plain momentum strategy	Return (bp)	83.22	-171.39	105.89	123.14	-52.23	139.62
Long *Winners*	T-value	**(4.77)**	**(-2.44)**	**(5.65)**	**(7.55)**	(-0.70)	**(8.17)**
Short *Losers*	Sharpe ratio	[0.204]	[-0.375]	[0.268]	[0.204]	[-0.375]	[0.268]
2. Long *Winners*	Return (bp)	81.12	-134.44	100.31	117.21	-40.30	131.85
Short *DeLosers* (Slowing-down loser)	T-value	**(4.43)**	(-1.78)	**(5.27)**	**(6.63)**	(-0.48)	**(7.46)**
	Sharpe ratio	[0.197]	[-0.296]	[0.249]	[0.197]	[-0.296]	[0.249]
3. Long *Winners*	Return (bp)	112.32	-72.17	128.75	146.09	27.96	160.03
Short *AcLosers* (Accelerative loser)	T-value	**(6.35)**	(-1.08)	**(6.69)**	**(8.30)**	(0.39)	**(8.70)**
	Sharpe ratio	[0.252]	[-0.126]	[0.299]	[0.252]	[-0.126]	[0.299]
4. Long *DeWinners* (Slowing-down winner)	Return (bp)	48.90	-241.21	74.73	93.45	-123.93	110.78
Short *Losers*	T-value	**(2.66)**	**(-3.14)**	**(3.68)**	**(5.97)**	(-1.53)	**(6.81)**
	Sharpe ratio	[0.121]	[-0.517]	[0.193]	[0.121]	[-0.517]	[0.193]
5. Long *AcWinners* (Accelerative winner)	Return (bp)	103.35	-232.74	133.28	151.75	-70.63	173.09
Short *Losers*	T-value	**(5.29)**	**(-3.22)**	**(6.37)**	**(7.91)**	(-0.92)	**(8.53)**
	Sharpe ratio	[0.221]	[-0.434]	[0.297]	[0.221]	[-0.434]	[0.297]
6. The accerleration strategy	Return (bp)	132.46	-133.52	156.14	174.70	9.56	193.50
Long *AcWinners*	T-value	**(6.56)**	(-1.88)	**(6.99)**	**(8.44)**	(0.12)	**(8.80)**
Short *AcLosers*	Sharpe ratio	[0.260]	[-0.198]	[0.321]	[0.260]	[-0.198]	[0.321]
7. The deceleration strategy	Return (bp)	46.80	-204.27	69.16	87.52	-112.00	103.00
Long *DeWinners*	T-value	**(2.46)**	**(-2.50)**	**(3.37)**	**(5.00)**	(-1.21)	**(5.92)**
Short *DeLosers*	Sharpe ratio	[0.114]	[-0.443]	[0.174]	[0.114]	[-0.443]	[0.174]
8. Long *AcWinners*	Return (bp)	101.25	-195.80	127.71	145.82	-58.70	165.32
Short *DeLosers*	T-value	**(5.12)**	**(-2.63)**	**(6.18)**	**(7.41)**	(-0.71)	**(8.25)**
	Sharpe ratio	[0.221]	[-0.381]	[0.288]	[0.221]	[-0.381]	[0.288]
9. Long *DeWinners*	Return (bp)	78.00	-141.99	97.59	116.40	-43.74	131.18
Short *AcLosers*	T-value	**(4.49)**	**(-2.16)**	**(5.25)**	**(7.23)**	(-0.59)	**(7.99)**
	Sharpe ratio	[0.191]	[-0.265]	[0.250]	[0.191]	[-0.265]	[0.250]

Panel B. Mean Comparison							
		Raw return			Alphas from the Fama-French three-factor model		
Trading strategy comparison		All months	January only	January excluded	All months	January only	January excluded
2-1	Return (bp)	-2.12	36.95	-5.60	-5.49	8.79	-7.18
	T-value	(-0.36)	**(2.00)**	(-0.99)	(-1.08)	(0.56)	(-1.38)
3-1	Return (bp)	29.12	99.22	22.88	22.97	68.48	20.51
	T-value	**(4.65)**	**(2.40)**	**(2.66)**	**(3.93)**	**(2.35)**	**(2.96)**
4-1	Return (bp)	-34.31	-69.83	-31.15	-28.53	-41.74	-28.73
	T-value	**(-5.62)**	**(-3.46)**	**(-4.45)**	**(-5.69)**	(-1.78)	**(-5.05)**
5-1	Return (bp)	20.14	-61.36	27.40	23.54	-32.91	29.04
	T-value	**(3.39)**	**(-2.65)**	**(4.30)**	**(3.75)**	(-1.53)	**(4.39)**
6-1	Return (bp)	49.26	37.86	50.27	46.51	35.57	49.54
	T-value	**(5.15)**	(0.75)	**(4.01)**	**(4.98)**	(0.84)	**(4.41)**
7-1	Return (bp)	-36.43	-32.88	-36.75	-34.02	-32.95	-35.91
	T-value	**(-4.54)**	(-1.21)	**(-4.15)**	**(-4.43)**	(-1.03)	**(-4.24)**
8-1	Return (bp)	18.01	-24.41	21.79	18.05	-24.12	21.86
	T-value	**(2.61)**	(-1.18)	**(3.02)**	**(2.60)**	(-1.23)	**(3.15)**
9-1	Return (bp)	-5.19	29.39	-8.27	-5.56	26.74	-8.22
	T-value	(-0.90)	(0.91)	(-1.36)	(-0.90)	(0.93)	(-1.30)
3-2	Return (bp)	31.24	62.27	28.48	28.46	59.69	27.68
	T-value	**(3.22)**	(1.33)	**(2.50)**	**(3.01)**	(1.50)	**(2.65)**
5-4	Return (bp)	54.45	8.47	58.54	52.06	8.83	57.77
	T-value	**(5.47)**	(0.24)	**(5.05)**	**(5.28)**	(0.22)	**(5.24)**

Table 5

Fama-MacBeth regressions to control for other return determinants: (12, 6) strategy

This table presents the results of the following Fama-MacBeth regression using all common stocks listed in NYSE, AMEX, and Nasdaq from January 1962 to December 2011. Stocks with a share price of $5 or lower at the time of portfolio construction are deleted. A month is skipped between ranking and holding periods.

$$R_{i,t} = \beta_{0jt} + \beta_{1jt} Size_{i,t-1} + \beta_{2jt} BM_{i,t-1} + \beta_{3jt} Turnover_{i,t-1} + \beta_{4jt} Volatility_{i,t-1} + \beta_{5jt} Illiq_{i,t-1} + \beta_{6jt} R_{i,t-1} + \beta_{7jt} Winner_{i,t-j} + \beta_{8jt} Loser_{i,t-j} + \beta_{9jt} FHH_{i,t-j} + \beta_{10jt} FHL_{i,t-j} + \beta_{11jt} AcWinner_{i,t-j} + \beta_{12jt} DeWinner_{i,t-j} + \beta_{13jt} AcLoser_{i,t-j} + \beta_{14jt} DeLoser_{i,t-j} \quad \text{E}$$

Each month, we regress cross-sectionally returns on the various dummies and control variables, including firm size (*Size*), book-to-market ratio (*BM*), volatility (*Volatility*), turnover (*Turnover*), Amihud's illiquidity measure (*Illiq*), and past 1-month return (R_{t-1}). The illiquidity measure is scaled up by 10^3 and firm size is in billion dollars. The dummies are defined as follows. $Winner_{i,\,t-j}$ equals one if stock *i*'s past performance over the 12-month period ($t-j-12$, $t-j$) is in the top 20% (Panel A) or top 4% (Panel B). $Loser_{i,\,t-j}$ is defined similarly. $FHH_{i,\,t-j}$ ($FHL_{i,\,t-j}$) takes the value of 1 if the 52-week high measure for stock *i* is ranked in the top (bottom) 30% in month $t-j$, and zero otherwise. The 52-week high measure in month $t-j$ is the ratio of price level in month $t-j$ to the highest price achieved in months $t-j-12$ to $t-j$. The variable $AcWinner_{i,\,t-j}$ ($DeWinner_{i,\,t-j}$) equals one if the stock is classified into the top (bottom) 20% based on the coefficients of the square of *t* in the winner group in month $t-j$ and zero otherwise. The coefficient of the square of *t* is obtained by regressing the daily price over the period ($t-j-12$, $t-j$) on an ordinal variable *t*, which is equal to 1, 2, 3… or *n* for the indication of the past *n*, …, 3, 2, or 1 day and the square of *t*. By the same token, the variable $AcLoser_{i,\,t-j}$ ($DeLoser_{i,\,t-j}$) is equal to one if the stock is ranked into the bottom (top) 20% based on the coefficients of the square of *t* in the loser group and zero otherwise. The coefficient estimates of a given independent variable are averaged over $j = 2, \ldots, 13$ for the (12, 6) strategy. The *t*-statistics (in parentheses) are calculated from the times series and adjusted for autocorrelation using the Newey-West covariance matrix. Bold t-values correspond to a significance level of 5% or higher.

Panel A. The Dummies *Winner* and *Loser* are the top and bottom 20% respectively					
	(1)	(2)	(3)	(4)	(5)
Intercept	0.0112	0.0116	0.0135	0.0130	0.0144
	(3.89)	**(4.04)**	**(4.36)**	**(5.74)**	**(5.84)**
Size	-0.2690	-0.2675	-0.3060	-0.2569	-0.2971
	(-1.74)	(-1.81)	**(-2.68)**	**(-2.50)**	**(-3.34)**
BM	0.0022	0.0021	0.0017	0.0015	0.0013
	(3.72)	**(3.70)**	**(3.22)**	**(3.30)**	**(2.90)**
Turnover				0.0000	-0.0001
				(0.00)	(-0.01)
Volatility				-0.0577	-0.0566
				(-1.19)	(-1.24)
Illiq				0.0256	0.0264
				(2.01)	**(2.02)**
R_{t-1}				-0.0001	-0.0008
				(-0.03)	(-0.25)
Winner			-0.0008		-0.0005
			(-0.58)		(-0.52)
Loser			-0.0038		-0.0041
			(-3.83)		**(-4.94)**
FHH			0.0021	0.0020	0.0025
			(1.95)	(1.72)	**(2.70)**
FHL			-0.0035	-0.0047	-0.0031
			(-4.18)	**(-6.29)**	**(-4.25)**
AcWinner		0.0036	0.0021	0.0022	0.0023
		(2.30)	**(2.65)**	**(2.98)**	**(3.16)**
DeWinner		-0.0013	-0.0020	-0.0027	-0.0018
		(-0.92)	**(-2.94)**	**(-3.53)**	**(-2.63)**
AcLoser		-0.0077	-0.0018	-0.0026	-0.0017
		(-7.97)	**(-2.47)**	**(-3.77)**	**(-2.59)**
DeLoser		-0.0055	-0.0005	-0.0002	-0.0001
		(-5.14)	(-0.69)	(-0.34)	(-0.23)
Average R-square	0.00	0.01	0.02	0.04	0.04

Panel B. The Dummies *Winner* and *Loser* are the top and bottom 4% respectively					
	(1)	(2)	(3)	(4)	(5)
Intercept	0.0112	0.0117	0.0137	0.0130	0.0146
	(3.89)	**(4.02)**	**(4.37)**	**(5.71)**	**(5.86)**
Size	-0.2690	-0.2804	-0.3216	-0.2611	-0.3066
	(-1.74)	(-1.89)	**(-2.80)**	**(-2.53)**	**(-3.45)**
BM	0.0022	0.0021	0.0017	0.0015	0.0013
	(3.72)	**(3.70)**	**(3.25)**	**(3.26)**	**(2.88)**
Turnover				0.0018	0.0017
				(0.23)	(0.21)
Volatility				-0.0553	-0.0554
				(-1.13)	(-1.20)
Illiq				0.0261	0.0268
				(2.04)	**(2.05)**
R_{t-1}				-0.0001	-0.0007
				(-0.02)	(-0.21)
Winner			-0.0011		-0.0009
			(-0.79)		(-0.90)
Loser			-0.0035		-0.0037
			(-3.79)		**(-4.86)**
FHH			0.0004	-0.0001	0.0006
			(0.40)	(-0.05)	(0.81)
FHL			-0.0021	-0.0029	-0.0017
			(-2.75)	**(-4.34)**	**(-2.59)**
AcWinner		0.0008	0.0010	0.0012	0.0013
		(0.67)	(1.60)	**(2.21)**	**(2.30)**
DeWinner		-0.0024	-0.0015	-0.0020	-0.0013
		(-2.24)	**(-2.61)**	**(-3.63)**	**(-2.62)**
AcLoser		-0.0060	-0.0021	-0.0028	-0.0021
		(-6.94)	**(-4.05)**	**(-5.94)**	**(-4.36)**
DeLoser		-0.0031	0.0001	0.0003	0.0004
		(-3.34)	(0.23)	(0.51)	(0.66)
Average R-square	0.00	0.01	0.02	0.04	0.04

Table 6

Performance of trading strategies under various factor models

This table presents the monthly risk-adjusted returns in basis points, its *t*-value, and the Sharpe ratio for three trading strategies – the JT momentum strategy, the 52-week high strategy, and the acceleration strategy – under various factor models. All common stocks listed in NYSE, AMEX, and Nasdaq from January 1962 to December 2011 are included. However, stocks whose share prices are lower than $5 at the time of sorting and portfolio formation are deleted. All strategies are for a ranking period of 12 months lagged 1 month and a holding period of 6 months. To construct the momentum strategy, stocks are sorted into quintiles based on the past 12-month returns lagged 1 month and held for 6 months. In the 52-week high strategy, stocks are ranked into quintiles according to the ratio of the price of stock *i* at the end of month *t-1* to its highest price during the 12-month period that ends on the last day of month *t-1*. The Sharpe ratio in brackets is defined as dividing the monthly portfolio excess return by the standard deviation of excess returns. Bold *t*-values correspond to a significance level of 5% or higher.

		Plain momentum strategy			52-week high strategy			Acceleration strategy		
		Return (bp)	T-value	Sharpe ratio	Return (bp)	T-value	Sharpe ratio	Return (bp)	T-value	Sharpe ratio
The three-factor model	All months	106.84	**(7.06)**	[0.204]	67.19	**(6.16)**	[0.176]	174.70	**(8.44)**	[0.260]
	January only	-58.58	(-0.91)	[-0.375]	-100.73	(-2.53)	[-0.344]	9.56	(0.12)	[-0.198]
	January excluded	123.54	**(7.73)**	[0.268]	81.90	**(6.09)**	[0.246]	193.50	**(8.80)**	[0.321]
Three-factor model with the momentum strategy	All months	--	--	--	20.51	(1.76)	[0.176]	29.13	**(3.01)**	[0.260]
	January only	--	--	--	-80.37	(-1.94)	[-0.344]	47.40	(1.10)	[-0.198]
	January excluded	--	--	--	29.54	(1.76)	[0.246]	31.54	**(2.61)**	[0.321]
Three-factor model with the 52-week high strategy	All months	58.67	**(3.70)**	[0.204]	--	--	--	80.57	**(4.01)**	[0.260]
	January only	-9.18	(-0.17)	[-0.375]	--	--	--	88.12	(1.41)	[-0.198]
	January excluded	64.76	**(3.46)**	[0.268]	--	--	--	87.22	**(3.82)**	[0.321]
Three-factor model with the acceleration strategy	All months	1.29	(0.15)	[0.204]	7.09	(0.63)	[0.176]	--	--	--
	January only	-46.06	(-1.15)	[-0.375]	-92.45	**(-2.26)**	[-0.344]	--	--	--
	January excluded	1.04	(0.15)	[0.268]	15.49	(1.20)	[0.246]	--	--	--

Table 7
Performance of trading strategies under longer holding periods

This table outlines the profit, its *t*-value, and the Sharpe ratio for nine trading strategies with longer holding periods. All common stocks listed in NYSE, AMEX, and Nasdaq from January 1962 to December 2010 are included. At the time of sorting and portfolio formation, we filter out the stocks whose share prices are lower than $5.The sorting and portfolio construction procedures are identical to those presented in Table 4. All the panels are for a ranking period of 12 months lagged 1 month. The only difference refers to the holding period. Unlike the 6-month holding period outlined in Table 4, we hold the nine strategies for 1, 12, 24, 36, 48, and 60 months respectively. The reported profits (in basis points) are average monthly returns of the overlapping portfolios in the K^{th} month. All *t*-values are corrected for potential autocorrelation with the Newey-West adjustment. Bold *t*-values correspond to a significance level of 5% or higher.

		1st month	12th month	24th month	36th month	48th month	60th month
Panel A. Raw return							
1. Plain momentum strategy	Return (bp)	121.36	-23.60	-31.15	-23.36	-31.39	-34.34
Long *Winners*	T-value	**(6.14)**	(-1.73)	**(-2.05)**	(-1.83)	**(-2.29)**	**(-2.76)**
Short *Losers*	Sharpe ratio	[0.260]	[-0.066]	[-0.103]	[-0.084]	[-0.126]	[-0.155]
2. Long *Winners*	Return (bp)	141.12	-16.36	-26.94	-13.78	-28.29	-30.70
Short *DeLosers* (Slowing-down loser)	T-value	**(6.65)**	(-1.01)	(-1.71)	(-0.89)	(-1.73)	**(-2.27)**
	Sharpe ratio	[0.287]	[-0.042]	[-0.082]	[-0.043]	[-0.094]	[-0.111]
3. Long *Winners*	Return (bp)	132.78	-13.27	-32.29	-28.47	-25.31	-25.46
Short *AcLosers* (Accelerative loser)	T-value	**(6.52)**	(-0.78)	**(-1.97)**	**(-2.13)**	(-1.88)	(-1.73)
	Sharpe ratio	[0.248]	[-0.033]	[-0.097]	[-0.088]	[-0.096]	[-0.092]
4. Long *DeWinners* (Slowing-down winner)	Return (bp)	86.10	-20.43	-17.98	-14.93	-31.02	-26.66
Short *Losers*	T-value	**(3.95)**	(-1.42)	(-1.16)	(-1.16)	**(-2.19)**	(-1.91)
	Sharpe ratio	[0.192]	[-0.052]	[-0.052]	[-0.048]	[-0.108]	[-0.100]
5. Long *AcWinners* (Accelerative winner)	Return (bp)	132.59	-32.55	-56.53	-38.84	-38.68	-36.04
Short *Losers*	T-value	**(6.02)**	**(-1.98)**	**(-3.09)**	**(-2.40)**	**(-2.62)**	**(-2.32)**
	Sharpe ratio	[0.246]	[-0.074]	[-0.149]	[-0.112]	[-0.137]	[-0.126]
6. The accerleration strategy	Return (bp)	144.01	-22.22	-57.67	-43.95	-32.59	-27.16
Long *AcWinners*	T-value	**(6.18)**	(-1.12)	**(-3.02)**	**(-2.65)**	**(-2.20)**	(-1.50)
Short *AcLosers*	Sharpe ratio	[0.236]	[-0.046]	[-0.141]	[-0.115]	[-0.108]	[-0.078]
7. The deceleration strategy	Return (bp)	105.86	-13.20	-13.77	-5.35	-27.91	-23.02
Long *DeWinners*	T-value	**(4.60)**	(-0.79)	(-0.82)	(-0.35)	(-1.64)	(-1.51)
Short *DeLosers*	Sharpe ratio	[0.219]	[-0.031]	[-0.037]	[-0.016]	[-0.083]	[-0.072]
8. Long *AcWinners*	Return (bp)	152.34	-25.31	-52.33	-29.26	-35.57	-32.40
Short *DeLosers*	T-value	**(6.70)**	(-1.44)	**(-2.94)**	(-1.69)	**(-2.19)**	**(-2.09)**
	Sharpe ratio	[0.280]	[-0.057]	[-0.136]	[-0.080]	[-0.116]	[-0.106]
9. Long *DeWinners*	Return (bp)	97.52	-10.10	-19.11	-20.04	-24.94	-17.79
Short *AcLosers*	T-value	**(4.73)**	(-0.62)	(-1.20)	(-1.56)	(-1.90)	(-1.20)
	Sharpe ratio	[0.205]	[-0.025]	[-0.055]	[-0.059]	[-0.088]	[-0.061]

Panel B. Mean Comparison							
Trading strategy comparison		1st month	12th month	24th month	36th month	48th month	60th month
2-1	Return (bp)	19.75	7.24	4.21	9.58	3.11	3.64
	T-value	**(2.74)**	(0.87)	(0.56)	(1.07)	(0.37)	(0.54)
3-1	Return (bp)	11.42	10.34	-1.14	-5.11	6.09	8.87
	T-value	(1.34)	(1.41)	(-0.16)	(-0.73)	(0.87)	(1.03)
4-1	Return (bp)	-35.26	3.17	13.17	8.43	0.37	7.68
	T-value	**(-4.50)**	(0.47)	(1.86)	(1.46)	(0.06)	(1.17)
5-1	Return (bp)	11.23	-8.95	-25.38	-15.48	-7.29	-1.70
	T-value	(1.43)	(-1.21)	**(-3.67)**	**(-2.01)**	(-1.08)	(-0.23)
6-1	Return (bp)	22.64	1.39	-26.52	-20.58	-1.20	7.17
	T-value	(1.74)	(0.12)	**(-2.73)**	**(-1.99)**	(-0.12)	(0.58)
7-1	Return (bp)	-15.51	10.41	17.38	18.01	3.48	11.32
	T-value	(-1.50)	(0.98)	(1.55)	(1.71)	(0.32)	(1.14)
8-1	Return (bp)	30.98	-1.71	-21.18	-5.90	-4.18	1.94
	T-value	**(3.34)**	(-0.18)	**(-2.56)**	(-0.59)	(-0.46)	(0.23)
9-1	Return (bp)	-23.84	13.51	12.04	3.33	6.46	16.55
	T-value	**(-3.07)**	(1.85)	(1.38)	(0.40)	(0.81)	(1.86)
3-2	Return (bp)	-8.34	3.10	-5.34	-14.69	2.98	5.23
	T-value	(-0.67)	(0.25)	(-0.47)	(-1.21)	(0.24)	(0.43)
5-4	Return (bp)	46.49	-12.12	-38.56	-23.91	-7.66	-9.38
	T-value	**(3.62)**	(-1.19)	**(-3.44)**	**(-2.26)**	(-0.82)	(-0.88)

Table 8
Performance of trading strategies conditional on time

This table presents the monthly raw returns, the *t*-values, and the Sharpe ratios for nine trading strategies in three non-overlapping subperiods. The holding periods are also classified into two business cycles determined by the NBER (www.nber.org/cycles.html). The sample includes all common stocks listed in NYSE, AMEX, and Nasdaq from January 1962 to December 2011. Stocks whose share prices are lower than $5 at the time of sorting and portfolio formation are deleted. The ranking period is 12 months lagged 1 month and the holding period is 6 months. Panel A reports the average monthly returns in basis points, the t-values, and Sharpe ratios. Sharpe ratios are calculated using monthly portfolio excess returns and standard deviations. Panel B reports the *t*-statistics (in parentheses) for the mean-difference test of returns between different trading strategies. The *t*-statistics are corrected for autocorrelation using the Newey-West procedure. Bold *t*-values correspond to a significance level of 5% or higher.

Panel A. Raw returns						
Trading strategy		196201-197808	1978/09-1995/04	1995/05-2011/12	Expansion	Recession
1. Plain momentum strategy	Return (bp)	98.27	106.19	46.19	98.07	30.31
Long *Winners*	T-value	**(4.45)**	**(4.76)**	(1.17)	**(5.53)**	(0.56)
Short *Losers*	Sharpe ratio	[0.266]	[0.348]	[0.090]	[0.259]	[0.054]
2. Long *Winners*	Return (bp)	103.83	98.11	42.84	94.08	33.50
Short *DeLosers* (Slowing-down loser)	T-value	**(4.39)**	**(4.46)**	(1.03)	**(4.92)**	(0.61)
	Sharpe ratio	[0.280]	[0.316]	[0.082]	[0.247]	[0.058]
3. Long *Winners*	Return (bp)	133.29	134.90	70.21	130.39	49.52
Short *AcLosers* (Accelerative loser)	T-value	**(5.01)**	**(5.73)**	(1.80)	**(7.69)**	(0.74)
	Sharpe ratio	[0.342]	[0.420]	[0.121]	[0.318]	[0.078]
4. Long *DeWinners* (Slowing-down winner)	Return (bp)	65.75	82.59	-0.50	59.57	15.66
Short *Losers*	T-value	**(3.11)**	**(3.57)**	(-0.01)	**(3.07)**	(0.32)
	Sharpe ratio	[0.173]	[0.258]	[-0.001]	[0.159]	[0.029]
5. Long *AcWinners* (Accelerative winner)	Return (bp)	115.28	121.07	74.52	122.51	29.79
Short *Losers*	T-value	**(4.60)**	**(4.90)**	(1.70)	**(6.21)**	(0.48)
	Sharpe ratio	[0.268]	[0.365]	[0.124]	[0.278]	[0.048]
6. The accerleration strategy	Return (bp)	150.30	149.78	98.53	154.83	49.00
Long *AcWinners*	T-value	**(5.04)**	**(5.74)**	**(2.22)**	**(7.99)**	(0.65)
Short *AcLosers*	Sharpe ratio	[0.340]	[0.430]	[0.145]	[0.324]	[0.071]
7. The deceleration strategy	Return (bp)	71.32	74.50	-3.85	55.58	18.85
Long *DeWinners*	T-value	**(3.21)**	**(3.30)**	(-0.09)	**(2.77)**	(0.40)
Short *DeLosers*	Sharpe ratio	[0.189]	[0.230]	[-0.008]	[0.146]	[0.034]
8. Long *AcWinners*	Return (bp)	120.84	112.99	71.16	118.52	32.97
Short *DeLosers*	T-value	**(4.82)**	**(4.70)**	(1.60)	**(5.92)**	(0.53)
	Sharpe ratio	[0.287]	[0.341]	[0.122]	[0.277]	[0.053]
9. Long *DeWinners*	Return (bp)	100.78	111.29	23.52	91.89	34.87
Short *AcLosers*	T-value	**(4.23)**	**(4.74)**	(0.63)	**(5.24)**	(0.60)
	Sharpe ratio	[0.270]	[0.344]	[0.047]	[0.245]	[0.059]

Panel B. Mean comparison						
Trading strategy comparison		196201-197808	1978/09-1995/04	1995/05-2011/12	Expansion	Recession
2-1	Return (bp)	5.57	-8.08	-3.36	-3.99	3.19
	T-value	(0.73)	(-1.05)	(-0.25)	(-0.53)	(0.19)
3-1	Return (bp)	35.02	28.70	24.01	32.32	19.21
	T-value	**(3.35)**	**(3.84)**	(1.67)	**(5.09)**	**(0.86)**
4-1	Return (bp)	-32.51	-23.61	-46.69	-38.50	-14.65
	T-value	**(-3.26)**	**(-3.90)**	**(-3.63)**	**(-5.80)**	(-0.79)
5-1	Return (bp)	17.01	14.88	28.32	24.44	-0.53
	T-value	(1.81)	**(2.71)**	**(2.24)**	**(3.73)**	(-0.03)
6-1	Return (bp)	52.04	43.58	52.34	56.76	18.68
	T-value	**(3.38)**	**(4.31)**	**(2.44)**	**(5.78)**	(0.57)
7-1	Return (bp)	-26.95	-31.69	-50.05	-42.49	-11.47
	T-value	**(-2.33)**	**(-3.43)**	**(-2.69)**	**(-4.85)**	(-0.55)
8-1	Return (bp)	22.58	6.79	24.97	20.45	2.66
	T-value	**(2.59)**	(0.80)	(1.65)	**(2.65)**	(0.12)
9-1	Return (bp)	2.51	5.10	-22.68	-6.18	4.56
	T-value	(0.24)	(0.71)	**(-2.02)**	(-0.95)	(0.25)
3-2	Return (bp)	29.46	36.79	27.37	36.31	16.02
	T-value	**(2.03)**	**(2.95)**	(1.21)	**(3.36)**	(0.54)
5-4	Return (bp)	49.53	38.49	75.01	62.94	14.13
	T-value	**(3.27)**	**(4.46)**	**(3.54)**	**(5.96)**	(0.50)

Table 9
Performance of trading strategies measured by midpoints of bid and ask quotes

This table presents the monthly profit in basis points, its *t*-value, and the Sharpe ratio for nine trading strategies in Panel A. Panel B reports the *t*-values for the mean difference tests. All aspects of the strategy and calculations are identical to those in Table 4, with the exception that we replace the daily closing prices by the midpoints of bid and ask quotes in the return calculation. All common stocks listed in NYSE, AMEX, and Nasdaq from January 1962 to December 2011 are included. However, stocks whose share prices are lower than a mid-quote of $5 at the time of sorting and portfolio formation are deleted. All the panels are for a ranking period of 12 months lagged 1 month and holding periods of 6 months. The Sharpe ratio in brackets is defined as dividing the monthly portfolio excess return by the standard deviation of excess returns; that is, we divide alpha by the idiosyncratic volatility of the portfolio returns to give the Sharpe ratio. All the *t*-values in parentheses are adjusted for potential autocorrelation with the Newey-West procedure. Bold *t*-values correspond to a significance level of 5% or higher.

Panel A. Portfolio return		Raw return			Alphas from the Fama-French three-factor model		
Trading strategy		All months	January only	January excluded	All months	January only	January excluded
1. Plain momentum strategy	Return (bp)	92.96	-67.73	107.66	114.03	-66.10	134.06
Long *Winners*	T-value	**(3.43)**	(-1.06)	**(3.73)**	**(5.05)**	(-1.00)	**(5.69)**
Short *Losers*	Sharpe ratio	[0.204]	[-0.172]	[0.235]	[0.204]	[-0.172]	[0.235]
2. Long *Winners*	Return (bp)	82.42	-56.76	94.79	101.56	-68.24	118.88
Short *DeLosers* (Slowing-down loser)	T-value	**(3.05)**	(-0.73)	**(3.37)**	**(4.20)**	(-0.93)	**(4.92)**
	Sharpe ratio	[0.180]	[-0.134]	[0.207]	[0.180]	[-0.134]	[0.207]
3. Long *Winners*	Return (bp)	118.39	-39.31	132.41	138.38	-6.95	157.22
Short *AcLosers* (Accelerative loser)	T-value	**(4.50)**	(-0.45)	**(4.63)**	**(6.01)**	(-0.09)	**(6.22)**
	Sharpe ratio	[0.239]	[-0.061]	[0.277]	[0.239]	[-0.061]	[0.277]
4. Long *DeWinners* (Slowing-down winner)	Return (bp)	60.81	-76.10	73.33	81.97	-72.56	98.35
Short *Losers*	T-value	**(2.01)**	(-1.22)	**(2.32)**	**(3.41)**	(-1.00)	**(4.12)**
	Sharpe ratio	[0.132]	[-0.164]	[0.160]	[0.132]	[-0.164]	[0.160]
5. Long *AcWinners* (Accelerative winner)	Return (bp)	126.06	-64.85	143.52	146.84	-68.90	171.13
Short *Losers*	T-value	**(3.90)**	(-0.99)	**(4.28)**	**(5.11)**	(-1.04)	**(5.75)**
	Sharpe ratio	[0.233]	[-0.133]	[0.265]	[0.233]	[-0.133]	[0.265]
6. The accerleration strategy	Return (bp)	144.43	-69.34	163.43	165.03	-33.75	190.06
Long *AcWinners*	T-value	**(4.83)**	(-0.68)	**(4.94)**	**(5.85)**	(-0.40)	**(6.01)**
Short *AcLosers*	Sharpe ratio	[0.253]	[-0.091]	[0.298]	[0.253]	[-0.091]	[0.298]
7. The deceleration strategy	Return (bp)	46.13	-111.14	60.11	65.66	-107.80	82.88
Long *DeWinners*	T-value	(1.60)	(-1.46)	**(1.99)**	**(2.63)**	(-1.31)	**(3.30)**
Short *DeLosers*	Sharpe ratio	[0.100]	[-0.254]	[0.130]	[0.100]	[-0.254]	[0.130]
8. Long *AcWinners*	Return (bp)	108.46	-86.79	125.82	128.22	-95.04	151.71
Short *DeLosers*	T-value	**(3.73)**	(-1.17)	**(4.15)**	**(4.64)**	(-1.37)	**(5.37)**
	Sharpe ratio	[0.214]	[-0.187]	[0.247]	[0.214]	[-0.187]	[0.247]
9. Long *DeWinners*	Return (bp)	82.10	-93.69	97.72	102.47	-46.50	121.23
Short *AcLosers*	T-value	**(3.11)**	(-1.15)	**(3.52)**	**(4.64)**	(-0.64)	**(5.21)**
	Sharpe ratio	[0.180]	[-0.150]	[0.224]	[0.180]	[-0.150]	[0.224]

Panel B. Mean Comparison							
		Raw return			Alphas from the Fama-French three-factor model		
Trading strategy comparison		All months	January only	January excluded	All months	January only	January excluded
2-1	Return (bp)	-5.56	5.09	-6.50	-8.26	-6.14	-9.37
	T-value	(-0.60)	(0.20)	(-0.72)	(-1.05)	(-0.26)	(-1.19)
3-1	Return (bp)	30.41	22.53	31.11	28.55	55.16	28.98
	T-value	**(3.15)**	(0.42)	**(2.19)**	**(3.37)**	(1.46)	**(2.69)**
4-1	Return (bp)	-32.15	-8.37	-34.33	-32.06	-6.46	-35.71
	T-value	**(-3.22)**	(-0.16)	**(-3.40)**	**(-3.69)**	(-0.14)	**(-4.11)**
5-1	Return (bp)	33.09	2.88	35.86	32.81	-2.80	37.07
	T-value	**(2.93)**	(0.06)	**(3.29)**	**(3.02)**	(-0.09)	**(3.46)**
6-1	Return (bp)	56.45	-7.50	62.13	55.21	28.36	61.81
	T-value	**(3.94)**	(-0.10)	**(3.15)**	**(3.93)**	(0.50)	**(3.49)**
7-1	Return (bp)	-41.85	-49.29	-41.19	-44.17	-45.70	-45.36
	T-value	**(-3.30)**	(-1.32)	**(-3.03)**	**(-3.61)**	(-1.04)	**(-3.43)**
8-1	Return (bp)	20.48	-24.95	24.52	18.39	-32.94	23.47
	T-value	**(1.98)**	(-1.01)	**(2.22)**	(1.83)	**(-2.08)**	**(2.24)**
9-1	Return (bp)	-5.88	-31.85	-3.57	-7.35	15.60	-7.01
	T-value	(-0.69)	(-0.59)	(-0.37)	(-0.83)	(0.50)	(-0.75)
3-2	Return (bp)	35.97	17.45	37.61	36.81	61.30	38.35
	T-value	**(2.42)**	(0.25)	**(2.07)**	**(2.57)**	(1.03)	**(2.32)**
5-4	Return (bp)	65.25	11.25	70.19	64.87	3.66	72.78
	T-value	**(4.26)**	(0.26)	**(3.96)**	**(4.30)**	(0.08)	**(4.23)**