Acceleration Strategies

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Abstract

We define and measure a firm-level metric we term acceleration. This metric ranks firms on their change in six-month momentum relative to the cross-section of other firms. Our results indicate that trading strategies based on acceleration offer significant abnormal profits of approximately 4.5% annually when controlled for other known regularities in equity returns. We also examine the profitability of momentum strategies refined in a manner that exploits our findings. These refinements produce profits of 2%-3% above the already large returns realized on a conventional univariate long-short momentum strategy. The profitability of acceleration strategies is consistent with recent theoretical behavioral models of equity returns.

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I Introduction

For over a decade, empirical research has provided mounting evidence that equity markets do not exhibit weak-form market efficiency. This body of evidence appears in two strands of literature. One strand indicates investors overreact to information at horizons of three to five years (for example, De Bondt and Thaler (1985), Lakonishok, Shleifer, and Vishny (1994), and La Porta, Lakonishok, Shleifer, and Vishny (1997)), and a second documents apparent underreaction to information over shorter horizons of approximately one year (Bernard and Thomas (1989), Jegadeesh and Titman (1993), and Chan, Jegadeesh, and Lakonishok (1996) to name a few). Much of the evidence provided in the latter strand suggests that investors do not fully react to information immediately, but rather impound information into prices gradually. It is widely believed that this tendency gives rise to the medium-term positive autocorrelation in returns that has been repeatedly documented.

If the manner in which many investors process information deviates significantly from rational economic models, it is possible that astute investors can profit through technical trading strategies. It is well-known to both academics and practitioners that momentum strategies intended to exploit medium-term positive autocorrelation generate high returns. It is also widely agreed that the existence of these profits has not been adequately explained as an equilibrium premium for risk bearing. In contrast, momentum profits are commonly attributed to the exploitation of market underreaction to fundamental news. Yet, if momentum is due to underreaction, there is no reason to believe that simple momentum strategies represent an efficient or optimal means of exploiting this phenomenon.

In this paper, we examine the profitability and risks associated with a class of strategies that we label acceleration strategies. The term *acceleration* arises naturally from the relation between these strategies and more conventional momentum strategies. Our metric for acceleration ranks a firm on its change in six-month return relative to the cross-section of other firms. Thus, like return momentum, acceleration is defined using the historical returns of individual firms. However, momentum is a cross-sectional ranking of past performance, so it does not consider the *change* in a firm's performance over time. In contrast, acceleration measures the performance of individual firms relative to their own historical returns in addition to the population of other equities. Specifically, to compute acceleration we first measure the return on a firm relative to its own return in the recent past, and then perform a cross-sectional ranking of these return differences. As we show, this is an important distinction that allows one to more efficiently exploit investor mis-reactions.

Our motives for studying acceleration strategies are twofold. The first motive for the study of these particular strategies is their basis in behavioral theory. Three influential unified behavioral models of equity returns predict that the profits associated with acceleration strategies should exceed those on momentum strategies. In particular, we thoroughly examine Barberis, Shleifer, and Vishny (1998), Hong and Stein (1999), and Daniel, Hirshleifer, and Subrahmanyam (1998). We find that all three models predict that acceleration strategies should ultimately yield positive abnormal returns that are distinct from those earned by momentum strategies.

Our second motive is evidence gleaned from conversations with fund managers suggesting that, relative to momentum strategies, acceleration strategies are more frequently employed by institutional investors with the intention of earning positive excess returns. To our knowledge, this paper represents the first effort to study and document this type of strategy. A recent example that suggests the popularity of acceleration strategies is Keri (2006), an article published by *Investor's Business Daily*. In this article, the author espouses acceleration by stating (below emphasis added):

> "Some leading companies will flash an even clearer sign of strength: growth acceleration... Wall Street has a history of rewarding companies that show that kind of acceleration. 'It's not just increased earnings that cause a big move,' notes IBD founder and Chairman William O'Neil in his Book 'How to Make Money in Stocks'. 'It's also the size of the increase plus the *improvement from the company's prior percentage rate of growth.*'"

The essential idea underlying acceleration and the idea embodied in the above quotation is that the change in the growth rate, relative to the historical growth of the firm, is an important determinant of the expected return. The particular strategy that Keri describes is centered on acceleration in a firm's quarterly earnings. However, given the prominence of strategies based upon return momentum, whether or not profitable acceleration strategies can be formulated using purely technical data is an obvious question. It is also natural to apply the notion of acceleration to return data, since returns measure growth in prices, and therefore changes in returns provide a measure of acceleration.

In accordance with both the theoretical models of equity returns mentioned above and the popularity of earnings acceleration strategies, we show that acceleration strategies based on historical returns are profitable, and moreover, provide significant positive profits that are distinct from those earned through momentum strategies or exposure to other risk factors. Controlling for these factors using a variety of methodologies, we find that acceleration strategies earn annually an average abnormal return of approximately 4.5%. Motivated by these results, we provide a simple means of refining momentum strategies to enhance returns and create a more favorable risk exposure. These refined strategies are meant to better exploit the tendency of equity prices to underreact in the medium term and yield approximately 3% above traditional long-short univariate momentum strategies.

This article is organized as follows: Section II describes the sample data used in this study and the construction of the acceleration measure. It also details the pre- and post-formation unadjusted returns to decile portfolios formed on our measure of acceleration. Section III contains our main results and examines the profits of acceleration portfolios and a long-short acceleration strategy net of a variety of benchmarks intended to provide risk adjustments and controls for known systematic patterns in equity returns. In Section IV, we use factor models to measure acceleration profits in event time while controlling for pervasive patterns in equity returns. Section V measures the profitability of momentum strategies that have been refined in a manner suggested by the results in the previous two sections. Section VI discusses the relation between our results and several theoretical behavioral models of equity returns. Our concluding remarks are contained in Section VII.

II The Raw Performance of Acceleration Deciles

II.A Sample Data

The primary data used in this study are obtained from the CRSP monthly file. The sample period extends from the beginning of 1926 through the end of 2003. Throughout the analysis we use CRSP measures of share prices, returns, shares outstanding, and exchange codes. We consider only securities listed as ordinary common shares, those with a CRSP share code of either 10 or 11. We also match CRSP firms to the Quarterly Industrial file of the Compustat database in order to obtain observations on book equity for the portion of the sample period that occurs after 1961. Finally, we use three-month Treasury bill rates made available by the Federal Reserve Bank of St. Louis as a proxy for the risk-free rate of interest.

II.B Acceleration Portfolios

Our investigation centers on changes in return momentum associated with individual firms, a metric we term *acceleration*. At the end of each month T in our sample, we measure the acceleration of all firms that have a full return history in the interval $[T-12$ months, $T-1$ month$]$. The acceleration of firm i at time T is computed as:

$$
\begin{aligned}
(1) \qquad A_{i,T} &= \prod_{s=T-6}^{T-1}(1+r_{i,s}) - \prod_{s=T-12}^{T-7}(1+r_{i,s}) \\
&= \text{Momentum}[-6,-1] - \text{Momentum}[-12,-6]
\end{aligned}
$$

The above expression is simply the buy-and-hold return in the interval $[T-6$ months, $T-1$ month$]$ less the buy-and-hold return in the interval $[T-12$ months, $T-7$ months$]$. In all that follows we will refer to the interval of time $[T-12$ months, $T-7$ months$]$ as the initial ranking period and the interval $[T-6$ months, $T-1$ month$]$ as the secondary ranking period. Since acceleration is defined to be the derivative of velocity (or momentum with a constant unit mass) in physics, we apply this term to the measure defined in expression (1). Our use of a six-month period to compute momentum is motivated by studies such as Jegadeesh and Titman (1993) and Lee and Swaminathan (2000), which show six-month momentum to be the strongest predictor of future returns.

After we have computed acceleration for each firm, we divide the cross-section of equities into decile portfolios based on this measure. Decile 1 is the set of firms with lowest acceleration and decile 10 is the set of firms with highest acceleration. We then measure the equal-weighted, buy-and-hold returns accruing to each decile both during the ranking period and during the five years that follow portfolio formation. This procedure is performed on a rolling basis for each month of the sample period.

We skip one month between the ranking and holding periods to attenuate the effect of bid-ask bounce or other liquidity problems. All of the results that follow have also been computed without skipping a month between ranking and holding periods. The qualitative results remain unaffected by this change. Furthermore, the results are insensitive to eliminating stocks that, on the portfolio formation date, have either a share price below $5 or a market capitalization in the lowest decile using NYSE breakpoints. Thus our results are not driven by small firms for which liquidity concerns may be more severe.

II.C Pre-formation Characteristics of Acceleration Deciles

We begin by examining the performance of the acceleration deciles prior to portfolio formation. Table I details both the average monthly returns and cumulative returns associated with each decile over the twelve-month ranking period. As expected, low acceleration firms tend to have high returns during the initial ranking period and low returns during the secondary ranking period. In fact, firms in the lowest decile on average yield 58.56% during the initial period and −7.56% during the following six months. Similarly, firms in the highest decile exhibit the reverse pattern of low average returns (−14.17%) in the initial ranking period and high average returns (54.13%) in the secondary ranking period. Firms in the middle deciles exhibit a return series that is much more stable.

[**Insert Table I About Here**]

For the extreme deciles, the disparity in returns when comparing the initial and secondary ranking periods is enormous. Table II details relevant characteristics of each decile at the time of portfolio formation. To produce this table, on each formation date we measure the size and book-to-market deciles using NYSE breakpoints, along with the return in the secondary ranking period (six-month momentum), the return over the entire ranking period (twelve-month momentum), and the acceleration of each firm.[1] Within portfolios, we then compute cross-sectional means across firms, and finally time-series means of these cross-sectional means across portfolio formation dates. The average acceleration of firms in the bottom decile is approximately -73.71%, whereas firms in the top decile have a mean acceleration of 72.54%.

[**Insert Table II About Here**]

The top and bottom deciles yield almost identical total returns over the twelve-month ranking period, 39.56% and 39.96%, respectively, and therefore by definition exhibit the same twelve-month momentum. The two extreme deciles also do not differ significantly on the dimensions of firm size and book-to-market ratio. Aside from the differences in six-month momentum and acceleration, the two extreme portfolios are nearly equivalent. More generally, by looking across all deciles, Table II shows the high correlation between six-month momentum and acceleration. The fact that high and low decile portfolios have similar twelve-month returns but very different six-month returns points to substantial variation in the timing of when the twelve-month returns accrue. Our acceleration strategies seek to exploit this difference in timing.

II.D Post-formation Raw Returns of Acceleration Deciles

We now examine the raw performance of the acceleration deciles subsequent to portfolio formation along with standard momentum portfolios. We leave the important discussion of risk adjustments and controls for systematic patterns in equity returns until Section III. Table III details the cumulative holding period returns on the ten portfolios constructed on acceleration (Panel A) and ten more constructed independently based on six-month momentum (Panel B). Table IV is analogous and provides average monthly returns for the same set of portfolios. The cumulative returns to the acceleration deciles are also shown graphically in Figure 1.

[**Insert Table III About Here**]

[**Insert Table IV About Here**]

On first inspection, the returns on the acceleration portfolios appear very similar to those of the momentum deciles. Table III shows that in no case does the twelve-month cumulative return on an acceleration decile differ from the same momentum decile by more than one percent, and in most cases the difference is less than fifty basis points. The top and bottom acceleration (momentum) deciles realize average twelve-month returns of 13.83% (13.47%) and 20.68% (20.59%). Except for the last month, the cumulative spread between the top and bottom momentum portfolios is larger than the same spread for acceleration portfolios. The cumulative spread indicates the return that would accrue to a long-short strategy of purchasing stocks in the highest decile and shorting stocks in the lowest decile. These observations are consistent with Table II, which shows the strong, positive correlation between acceleration and six-month momentum. Any patterns in post-ranking returns that may be attributable to acceleration are likely being obscured by the conventional momentum effect. This observation highlights the need to accurately control for momentum when trying to determine any potential irregularities in the returns on the acceleration deciles.

Although there is a close resemblance between the raw performance of acceleration and momentum deciles, there are also some important differences. As detailed in Table IV, in months one through five, the average returns on the lower (upper) acceleration deciles are larger (smaller) than their momentum equivalents. This is evident in the larger monthly profit accruing to the momentum hedge portfolio. However, beginning in month six, this pattern reverses and in general high (low) acceleration portfolios yield monthly returns that are greater (less) than the corresponding momentum decile. At this point the monthly returns associated with the acceleration hedge portfolio become larger than those of the momentum hedge portfolio. It is important to note that during this time, the momentum hedge portfolio yields a positive and substantial return, and therefore cannot be explained by the eventual reversal of momentum profits.[2] This pattern indicates that acceleration is not just a noisy proxy for momentum, and that the returns associated with portfolios constructed on acceleration embody a pattern distinct from the behavior of momentum deciles.

III Main Results

The results in the previous section indicate that the returns associated with acceleration portfolios are distinct from those of six-month momentum portfolios. However, to measure the incremental effect of acceleration, we must control for six-month momentum. In this section we employ three methods that control for momentum and other known determinants of equity returns. These methods allow us to remove confounding effects and isolate the incremental returns that are due to acceleration. The first method we employ is a two-way sort on momentum and acceleration. The second method directly matches a firm to a benchmark portfolio on the basis of that firm's six-month momentum. The third method uses conventional calendar-time methodologies to estimate abnormal returns benchmarked against the Fama-French three factor model and the Fama-French-Carhart four factor model.

III.A Two-Way Sort on Momentum and Acceleration

III.A.1 Methodology

One simple way to control for momentum is to divide the cross-section of equities into portfolios based on momentum, and then within each of these portfolios, compare the returns to firms that vary with respect to acceleration. In this manner, we may compare firms that exhibit similar momentum but opposite and extreme values of acceleration. More specifically, at the beginning of each month T, we rank firms on six-month momentum as of the end of month $T-1$ and form quintile portfolios based on this measure. Within each momentum quintile we then rank firms on acceleration also at the end of $T-1$ and form quintile portfolios. We measure the cumulative equal-weighted, buy-and-hold return on each of the resulting twenty-five portfolios beginning in month $T+1$. In Panel A of Table V we show average three- and twelve-month returns to the twenty-five portfolios, where the average is taken over portfolio formation dates. We denote momentum quintiles as M1–M5, where M1 is the portfolio of firms with the lowest six-month momentum. Acceleration quintiles are denoted by A1–A5, where A1 is the 20% of firms with lowest acceleration within the corresponding momentum portfolio. The last two rows in Panel A measure the returns of high acceleration stocks (top quintile) less low acceleration stocks (bottom quintile) within each momentum quintile; t-statistics shown below in parentheses have been adjusted for the autocorrelation induced by overlapping observations. For comparison, the table also provides three-and twelve-month returns associated with unconditional univariate sorts on both momentum and acceleration. These results are associated with the row and columns labeled "All A" and "All M". For example, the column in the left-hand portion on Panel A labeled "All M" shows the five returns associated with quintile portfolios formed only on acceleration from the entire cross-section.

[**Insert Table V About Here**]

Table V also presents the average six-month momentum and acceleration of firms in each of the twenty-five portfolios in Panel B. To obtain these numbers, on each portfolio formation date we compute the within-portfolio cross-sectional means for both measures at the time of portfolio formation. We then average these cross-sectional means across portfolio formation dates to obtain the entries in Panel B. As described above, "All A" and "All M" refer to unconditional univariate sorts on momentum and acceleration, respectively.

III.A.2 Results of the Two-Way Sort

We focus first on the returns of the double-sorted portfolios. At the relatively short horizon of three months, lower acceleration firms earn higher returns than higher acceleration firms. Within each momentum quintile, the difference between high and low acceleration quintile returns is negative and significant, ranging from -1.11% for M1 to -0.37% for M5. With few exceptions, returns are decreasing across acceleration quintiles within each momentum quintile. Thus, it appears that over short horizons high acceleration firms underperform low acceleration firms when controlling for momentum. Importantly, this result differs from an unreported table that shows a secondary sort on six-month momentum within each momentum quintile produces significantly positive spreads at the three-month horizon. Moreover, the secondary momentum sort yields cumulative returns that, within each primary momentum quintile, are increasing across the secondary quintiles. Thus, the pattern of short-term underperformance exhibited by high acceleration stocks is distinct from the momentum phenomenon.

In contrast to short-term underperformance, over a twelve-month holding period high acceleration stocks yield higher returns than low acceleration stocks after controlling for momentum. In the upper-right portion of Table V, it is clear that cumulative returns to high acceleration firms exceed the returns to low acceleration firms. The spread between the twelve month returns of extreme quintiles ranges from 1.41% (M2) to 2.62% (M5) and is highly significant in all cases.

This changing pattern of relative performance is consistent with Tables III and IV. In Table III, the cumulative returns of high (low) acceleration deciles are lower (higher) relative to the same momentum decile in the first five months after portfolio formation. However, as noted earlier, the twelve-month cumulative returns on the acceleration deciles are very close to the same momentum decile. In other words, despite the initial poor performance, high acceleration firms ultimately catch up to high momentum firms because they enjoy very high returns beginning about six months into the holding period. Direct evidence of this pattern is also visible in Table IV, which shows that high (low) acceleration decile portfolios have lower (higher) average returns than the same momentum decile in the first five months after portfolio formation, and that this pattern reverses around month six.

Despite the consistency with earlier results, it is difficult to draw strong conclusions from the double-sort results because this methodology does not adequately control for momentum. In Panel B, it is evident that within each momentum quintile, six-month momentum is also increasing across acceleration quintiles. For example, the average values of momentum for the five acceleration portfolios within the lowest momentum quintile are {M1/A1, M1/A2, M1/A3, M1/A4, M1/A5} = $\{-29.99, -25.93, -23.89, -22.36, -20.87\}$. The other four momentum quintiles exhibit similar behavior. This pattern indicates that double sorting in this manner does not break the correlation between momentum and acceleration. Thus, in comparing the twelve-month cumulative returns of high and low acceleration firms, it is unclear to what extent the spreads are derived from differences in acceleration and differences in six-month momentum. Despite this difficulty, it is worth noting that the *increasing* relation between six-month momentum and acceleration quintile, while consistent with the positive spread between high- and low-acceleration stocks at the twelve-month horizon, cannot explain the *negative* spread at the three-month horizon. Furthermore, as mentioned above, a secondary momentum sort yields a positive spread between high and low quintiles at both the three- and twelve-month horizons. Finally, microstructure issues, such as bid-ask bounce, cannot provide an adequate explanation, since we skip one month between portfolio formation and the beginning of the holding period.

III.B Firm-Level Momentum Matching

III.B.1 Acceleration-Neutral Momentum Deciles

Due to the difficulty with interpreting the results of the two-way sort, we employ a second method that better controls for momentum. This method compares the returns on each firm to a portfolio of matching firms chosen to have similar momentum but values of acceleration close to zero. In this manner, we measure the returns on each acceleration decile net of the return that would be expected based on six-month momentum. The construction of the benchmark momentum portfolios mirrors the construction of standard momentum portfolios, but with one important difference. At the time firms are ranked on their prior six-month return, they are also ranked on the *absolute value* of their measure of acceleration. All firms with an absolute value of acceleration placing them in the bottom 30% of the sample are termed acceleration-neutral firms.[3] We next form momentum decile breakpoints from the entire cross-section of firms. In the construction of standard momentum portfolios, the final step would be to assign all firms in the cross-section to the appropriate decile. In contrast, we assign only acceleration-neutral firms to the deciles based on momentum breakpoints and measure the decile return as an equal-weighted, buy-and-hold return. We populate the momentum deciles only with acceleration-neutral firms so that the returns on these benchmarks capture average returns due to momentum and not to acceleration.

[**Insert Table VI About Here**]

Table VI presents the average monthly returns (Panel A) and cumulative returns (Panel B) of these new benchmark portfolios. In general the returns on the acceleration-neutral momentum deciles are relatively close to their standard momentum counterparts. One notable observation is that the returns on the upper acceleration-neutral deciles tend to be lower, implying a smaller spread between deciles ten and one. However, the correlations between the two sets of momentum benchmarks are quite high. At the end of each month, we form both standard and acceleration-neutral momentum deciles and then compute the correlation between portfolio returns for corresponding deciles. We perform this procedure using one, three, and five years of monthly returns. Finally, we average over the set of portfolio formation dates that allow independent observations of each correlation. The average correlations obtained in this manner are shown in Table VII with standard deviations below in parentheses. In an unreported table, we find that the acceleration-neutral portfolios do not differ significantly from the standard momentum portfolios with respect to firm size or the book-to-market ratio. With this evidence, we conclude that the acceleration-neutral portfolios retain the essential characteristics of conventional momentum portfolios while providing a cleaner benchmark for the acceleration deciles.

[**Insert Table VII About Here**]

III.B.2 Results of Firm-Level Momentum Matching

We now employ the acceleration-neutral momentum deciles to control for momentum. On each portfolio formation date T, we compute six-month momentum decile breakpoints and form acceleration-neutral momentum deciles as described above. Let the set of momentum breakpoints be denoted as $D_T = \{d_{1,T}, d_{2,T}, \ldots, d_{9,T}\}$ and $M_{i,T}$ be the six-month momentum of firm i at time T. Each firm in the sample is matched to an acceleration-neutral momentum decile by identifying the decile n such that $d_{n-1,T} \leq M_{i,T} \leq d_{n,T}$ where we define $d_{0,T} = \min_i M_{i,T}$ and $d_{10,T} = \max_i M_{i,T}$.[4] After this match has been made, for each month in the holding period, the return on the benchmark portfolio is subtracted from the return on the individual firm. This is done for each firm in the sample and then all firms are assigned to the appropriate acceleration decile. The results of this procedure are presented in Table VIII, which shows average monthly returns in Panel A and cumulative returns in Panel B. For ease of interpretation, the cumulative returns in Panel B are plotted in Figure 2.

[**Insert Table VIII About Here**]

Using the firm-level momentum matching procedure to control for six-month momentum reveals a picture that is consistent with the results of the two-way sort. In the first half of the holding period, firms in the bottom acceleration deciles outperform firms that exhibit similar momentum but low acceleration. Likewise, firms in the top acceleration deciles underperform similar momentum firms during this time. Around six months after the holding period begins, the relative performance of the extreme acceleration deciles reverses. At this point, high (low) acceleration stocks over- (under) perform acceleration-neutral firms of similar momentum, a pattern of performance that continues until the end of the twelve month holding period. After one year, low-acceleration stocks have underperformed high-acceleration stocks by 6.15%. Since acceleration-neutral momentum deciles do not differ significantly relative to the acceleration deciles on dimensions such as average firm size or the book-to-market ratio, it appears unlikely that these factors can offer a sufficient explanation of this large spread.

III.C Factor Models in Calendar-Time

While the above results are consistent with a positive acceleration effect, controlling only for six-month momentum does not preclude the possibility that other risks can account for the post-ranking behavior of the acceleration deciles. To corroborate the previous results we estimate both the standard Fama-French three factor model and the Fama-French-Carhart four factor model. These two models will provide estimates of abnormal returns after controlling for known patterns in equity returns.

The estimation procedure we employ in this section forms return series in calendar-time for each of the acceleration deciles. To provide more power to our tests, we use a method of portfolio construction often described as an overlapping portfolio procedure. Let $R_{s,t,d}$ be the return in month t on acceleration decile d when this decile is formed at the end of month s. As an example, $R_{T,T+1,1}$ represents the return on the lowest acceleration decile in the first month after portfolio formation when formation occurs at the end of month T. To compute the calendar time returns in month T for each acceleration decile, we form acceleration decile portfolios from all available firms at the end of each of the months $T-6,\ T-5, \ldots, T-1$. The calendar time return in month T to acceleration decile d, denoted $R^*_{T,d}$, is computed as:

$$R^*_{T,d} = \frac{1}{6}\sum_{s=1}^{6} R_{T-s,T,d}$$

Thus, the overall return to the acceleration decile is the equal-weighted average of six portfolios formed at different times and held during the month of interest. After we have formed the calendar-time return series, for each $d = 1, 2, \ldots, 10$, we estimate the regressions:

$$\text{(2a)} \qquad R^*_{T,d} = \alpha_d + b_d(MKT_T - \theta_T) + s_d SMB_T + h_d HML_T + \varepsilon_{T,d}$$

$$\text{(2b)} \qquad R^*_{T,d} = \alpha_d + b_d(MKT_T - \theta_T) + s_d SMB_T + h_d HML_T + m_d MOM_T + \varepsilon_{T,d}$$

where MKT is the return on the CRSP value-weighted index, θ is the three-month Treasury bill rate, and SMB and HML are the returns on the size and book-to-market factor mimicking portfolios, respectively. We present estimates obtained for each of the ten deciles in Table IX under the set of columns labeled "Rank Lag 0 Months". Panel A contains the estimates of equation (2a), the Fama-French three factor model, and Panel B contains the estimates of equation (2b), the Fama-French-Carhart four factor model. We also estimate the models when the choice of stocks held in each decile portfolio is lagged by six months relative to the prior description.[5] The lag in ranking and holding acceleration stocks is motivated by the results depicted in Figure 2. In this plot, it is evident that the positive profits associated with a long-short acceleration strategy do not begin to accrue until approximately six months after the portfolio formation date. The second set of estimates are shown under the columns labeled "Rank Lag 6 Months".[6]

[**Insert Table IX About Here**]

In general, the results illustrated in Table IX provide confirmation of the pattern of post-ranking returns observed through the firm-level momentum matching approach. When the ranking lag is set to zero, the acceleration hedge portfolio generates small monthly losses of 18.82 basis points relative to the Fama-French-Carhart four factor model. This figure is similar to the average monthly losses seen in post-ranking events months +1 through +6 in Table VIII. The Fama-French three factor model shows a monthly abnormal return of just over 18 basis points to this calendar time strategy. However, the use of this model is inappropriate because it lacks any control for momentum (we include it only for completeness). Also fitting with previous observations, the extreme acceleration portfolios show higher sensitivities to the market and size factors. However, the acceleration hedge portfolio does not appear to be especially risky. It exhibits only a modest positive loading on HML in the four factor model and, as anticipated, a relatively large loading on the momentum factor.[7]

We expect the performance of the calendar-time strategy when the ranking lag is zero to be different than when the ranking lag is set to six months. When the ranking lag is six months, we average over the latter half of the event window, and therefore expect to see positive abnormal returns associated with the acceleration hedge portfolio. The results in Panel B accord with this expectation. With the exception of the top acceleration decile, the intercept estimates from the four factor model increase monotonically from about -22.7 basis points for the lowest decile to 20.5 basis points for decile 9. The intercept estimate drops off by about 5 basis points for the top acceleration decile.

The monthly abnormal return associated with the acceleration hedge portfolio is approximately 37 basis points, implying an annual return of around 4.5%, which is lower than the month twelve spread of 6.15% seen in Table VIII. However this is not surprising for two reasons. First, the acceleration strategy actually begins to become profitable prior to month seven, and so our choice of splitting the event window in half, while convenient, misses out on some of the positive profits. Furthermore, we are now explicitly controlling for other patterns in equity returns. The acceleration hedge portfolio does not load on the market factor, but does covary positively with the other three factors. The loadings on SMB, HML, and MOM are 0.145, 0.135, 0.286, respectively. Given the monthly mean returns to these three factors and these estimated loadings, 4.5% is consistent with the 6.15% computed using the characteristics approach.

To summarize, the results in this section indicate that a strategy that purchases high-acceleration stocks and shorts low-acceleration stocks earns positive abnormal profits. The positive profits are evident and consistent across the three methodologies we employ. Although it does not provide an ideal control for momentum, the double-sort method indicates at an annual horizon high-acceleration stocks outperform low-acceleration stocks across a large range of momentum values. When we measure the returns of extreme acceleration stocks relative to matched acceleration-neutral momentum deciles, the decile of highest acceleration firms outperforms the bottom decile by approximately 6.15%. The profits are also apparent when we measure the performance of each acceleration decile relative to the Fama-French three factor model and Fama-French-Carhart four factor model. As expected, the introduction of additional controls slightly reduces the spread between extreme acceleration deciles. However, this spread remains large and significant. Hence, we conclude that the profits associated with the acceleration strategy are distinct from previously documented anomalies.

IV Factor Models in Event-Time

IV.A The Fama-French Three Factor Model

The calendar-time regressions described above allow us to collapse event-time into calendar time and conform to standard methodology that is frequently used in the empirical asset pricing literature. However, this procedure inherently sacrifices important details regarding how the acceleration deciles perform relative to momentum deciles in event-time. Our goal is to estimate factor models that provide more complete controls for known patterns in equity returns while also obtaining results that are directly comparable to the firm-level momentum matching approach. As we discuss in Section VI, the relative performance of acceleration deciles and momentum deciles in event-time provides interesting insight into the source of momentum and acceleration returns.

In order to accomplish this goal, we also estimate factor models in event-time. For each acceleration decile, we estimate a set of time-series regressions using all observations available on each of the twelve monthly holding period returns as the dependent variables. This produces estimates of the factor loadings and intercept at different points in event-time. To assess possible abnormal performance, we are primarily interested in the estimates of the intercepts. In the case of the three factor model, we estimate regressions of the form:

$$R_{T,T+\tau,d} - \theta_{T+\tau} = \alpha_{\tau,d} + b_{\tau,d}\left(MKT_{T+\tau} - \theta_{T+\tau}\right) + s_{\tau,d}SMB_{T+\tau} + h_{\tau,d}HML_{T+\tau} + \varepsilon_{T,T+\tau,d} \tag{3}$$

where $T \geq 0$ is a portfolio formation date, $\tau \geq 1$ indexes the post-formation month, and $d \in \{1, 2, \ldots, 10\}$ is an acceleration decile. Therefore, $R_{T,T+\tau,d}$ is the return in month τ of the holding period on acceleration decile d when this decile is formed at T. The variable θ denotes the risk-free rate and MKT, SMB, and HML are the returns on the usual Fama-French factor mimicking portfolios. The estimates of the intercept and factor loadings for each period in event-time are shown in Table X. Panel A of Figure 3 shows the intercepts for each decile accumulated over event-time and Panel B shows profits accruing to an acceleration hedge portfolio after applying the three factor model as a control.

[**Insert Table X About Here**]

As with the calendar time models, the results of estimating expression (3) are consistent with the portfolio characteristics shown in Table II. It is evident that extreme acceleration portfolios favor stocks with lower market capitalizations. The lower average size decile accords with the larger estimate of the coefficient attached to SMB. However, at no time does the difference between the size loadings on the two extreme deciles exceed 0.20. Thus, differences in firm size do not offer a full explanation regarding the profitability of the acceleration hedge portfolio. The estimates of the HML loadings are also in agreement with the measurements of the characteristics. Both extreme deciles tend to favor firms with relatively low book-to-market ratios, implying they should yield HML loadings that are lower than average. In Panel D it is apparent that these two deciles do tend to covary less with this factor than the other deciles. The loading on the top decile also decreases somewhat as it obtains high returns, which is to be expected since the high returns increase the market value of equity without affecting book values. The market risk of the ten portfolios also show some patterns across deciles. The extreme deciles appear somewhat more volatile as evidenced by larger loadings on the market factor. But these differences are small, and a long-short acceleration strategy exhibits very little comovement with the market factor.

The estimates of primary interest are contained in Panel A of Table X, which shows the monthly intercepts per decile accumulated over the twelve-month post-ranking period.[8] The concern is whether or not these intercepts confirm the pattern of returns seen in Figure 2 through the firm-level momentum matching procedure. With this earlier methodology, no explicit controls for market, size, or book-to-market risks were provided. Panel A of Figure 3 shows that the event-time pattern of returns on the acceleration deciles and the profitability of the acceleration hedge portfolio survive these additional controls. However, the support that these estimates provide is somewhat tempered by the fact that the three factor model does not benchmark firms on momentum. Since the acceleration deciles load on a momentum factor in a predictable way, it is necessary to estimate a parametric model that also includes a momentum factor mimicking portfolio.

IV.B A Four Factor Model

We now estimate a variant of the standard four factor model intended to control for momentum in addition to the three patterns in equity returns discussed above. The market, size, and book-to-market factors we employ here are the standard factors that we have used previously. Using the calendar-time overlapping portfolio approach, it was shown in Section III.C that extreme acceleration portfolios exhibit abnormal performance when benchmarked against the standard momentum factor. In the current context, the standard momentum factor is not appropriate for two reasons. First, since momentum and acceleration are highly correlated, a standard momentum factor that ignores acceleration in its construction contains many high acceleration firms. Such a factor would be subject to significant contamination and could potentially obscure measurement of abnormal performance through mechanically induced loadings on the momentum factor. Thus, the first difference between our event-time momentum factor and the standard factor is that we again use only acceleration-neutral firms in its construction.[9]

There is a second and more important problem with the the standard momentum factor. The standard momentum factor is built from four portfolios that are re-formed on a monthly basis. In particular, the conventional methodology computes the return on the momentum factor in month t as:

$$(4)\quad MOM_t = \frac{1}{2}\Big(\text{Big Winners}_{t-2} + \text{Small Winners}_{t-2}\Big) - \frac{1}{2}\Big(\text{Big Losers}_{t-2} + \text{Small Losers}_{t-2}\Big)$$

Firms are ranked on size and past returns at the end of $t-2$, and then one month is skipped before return measurement during month t. The problem is that the breakpoints that define both winners versus losers and small versus big are updated monthly. Using the standard momentum factor would always benchmark acceleration decile returns that occur at different points in event-time to a factor return that occurs in the first post-formation month. This is inappropriate because the use of such a momentum factor would destroy any potential event-time relationship between the returns of acceleration portfolios and firms of similar momentum.

More formally, consider that estimating the standard four factor model in event-time would imply estimating the following regressions:

$$\begin{aligned} R_{T,T+\tau,d} - \theta_{T+\tau} = \; & \alpha_{\tau,d} \; + \; b_{\tau,d} \left(MKT_{T+\tau} - \theta_{T+\tau} \right) \; + \; s_{\tau,d} SMB_{T+\tau} \\ & + \; h_{\tau,d} HML_{T+\tau} \; + \; m_{\tau,d} MOM_{T+\tau} \; + \; \varepsilon_{T,T+\tau,d} \end{aligned} \tag{5}$$

As before, MKT, SMB, and HML are matched to $R_{T,T+\tau,d}$ in calendar-time. The problem is that expression (5) also matches to momentum only on the basis of calendar-time represented by $T+\tau$. Since $MOM_{T+\tau}$ matches only to calendar-time, there is no consideration given to the fact that in one case R might be the first post-formation monthly return and in other cases, it could be the last return in event-time. For the extreme acceleration deciles, there is reason to believe that different values of α would occur in these two cases. Therefore, we require a momentum factor that is matched not just in calendar-time, but also in event-time.

To overcome this problem, we use the following methodology: At the end of each month in the sample, we form the six portfolios required to compute the returns on a momentum factor mimicking portfolio.[10] We then compute the return on this particular instance of the momentum factor for each month over the next year. The important difference is that we do not re-compute the breakpoints that define these six portfolios; once acceleration-neutral firms are assigned to the correct size and momentum portfolios, the constituents of each portfolio remain static over the next year. The value-weighted returns to the four extreme portfolios are computed, and then the return to the overall factor is calculated according to expression (4). The twelve returns to this particular occurrence of the factor are matched in event time to returns on the acceleration deciles. In summary, the regressions we estimate are:

$$\begin{aligned} R_{T,T+\tau,d} - \theta_{T+\tau} = \; & \alpha_{\tau,d} \; + \; b_{\tau,d} \left(MKT_{T+\tau} - \theta_{T+\tau} \right) \; + \; s_{\tau,d} SMB_{T+\tau} \\ & + \; h_{\tau,d} HML_{T+\tau} \; + \; m_{\tau,d} MOM_{T,T+\tau} \; + \; \varepsilon_{T,T+\tau,d} \end{aligned} \tag{6}$$

where now $MOM_{T,T+\tau}$ is correctly matched to $R_{T,T+\tau,d}$. The results of estimating (6) are contained in Table XI. Since the coefficient estimates associated with the market, size, and book-to-market factors are very nearly identical to those of the three factor model shown in Table X, we omit them here. Instead we show just the cumulative intercepts per decile over event-time along with the coefficient estimates associated with the momentum factor. The cumulative event-time alphas are plotted in the lower-left portion of Figure 3.

[**Insert Table XI About Here**]

The pattern of post-ranking performance of the acceleration deciles that is visible using both the firm-level momentum matching approach and the calendar-time factor models again emerges with the event-time regressions. During the first half of the holding period, the higher acceleration deciles exhibit slight underperformance, but gradually begin to do better and end up substantially overperforming the benchmark model. Similarly, the lower deciles initially overperform the benchmark but reverse their relative performance by the sixth month of the holding period. The spread between the two extreme acceleration deciles at the end of the twelve month holding period is approximately 4.2% compared to 6.15% from the momentum matching approach. One way of interpreting this is that failure to control for any market, size, or book-to-market risk inherent to the acceleration hedge portfolio inflates the spread shown in Figure 2 by about 2%. However, this still leaves a sizeable annual profit of over 4% that cannot be explained by the standard empirical asset pricing factors.

V Acceleration Strategies

The results documented thus far suggest several ways to refine conventional momentum strategies in order to enhance their profitability. In this section we examine two refinements to determine whether investors can capitalize on acceleration to earn higher returns. The first strategy implements a long position in high momentum stocks that exhibit high acceleration on the portfolio formation date and a short position in low momentum stocks that exhibit low acceleration on the portfolio formation date. In Section III, a variety of methodologies illustrate that high (low) acceleration stocks ultimately over- (under-) perform by a wide margin similar momentum firms over a twelve-month holding period. Therefore we would expect our first strategy offers additional profits beyond conventional momentum strategies at the end of a twelve-month investment horizon.

The positive spread between high- and low-acceleration deciles does not begin to materialize until approximately six months after the holding period begins. This motivates our second strategy, in which we again include high- (low-) momentum, high- (low-) acceleration stocks in the long (short) portfolio. However, in this case the determination of extreme acceleration stocks is made six months before investment begins. For example, a long portfolio that is implemented at the beginning of month $T+1$ includes stocks that exhibit high six-month returns at the end of month $T-1$ and high acceleration at $T-7$. Similarly, the stocks assigned to the short portfolio are those with low momentum and low acceleration at the same points in time. This strategy allows one to skip the initial period of relatively poor performance for the acceleration stocks, and thus should begin to earn the positive acceleration spread immediately upon implementation.

We present results for both trading strategies over the full sample period in Table XII. Panel A of this table details returns for the first strategy (Rank Lag 0 Months) and Panel B shows the same information when acceleration assignments are lagged by six months (Rank Lag 6 Months). The results for each trading strategy are shown for a variety of definitions of high- and low-acceleration stocks and correspond to columns labeled 10%, 20%, and 30%. These percentages are the acceleration ranking cutoffs used to determine which momentum stocks are included in the portfolio. For instance, the 10% strategy is long stocks that are in the top decile for both momentum and acceleration, and short stocks that are in the bottom decile with respect to both measures. The 20% strategy corresponds to one that is long the set of stocks formed from intersecting the top momentum decile with the top two acceleration deciles. In the column labeled “Mom” we present similar information for a conventional momentum strategy that is long the top momentum decile and short the bottom momentum decile without regard to the acceleration of the constituent firms.

[**Insert Table XII About Here**]

To produce this table, at the beginning of each month we measure the cumulative returns that accrue over the next year to the three acceleration strategies and the conventional momentum strategy. We then compute the differences between the cumulative returns of the acceleration strategies and *matched* conventional momentum strategies. The matching routine ensures that the same number of firms are assigned to the long and short portfolios that constitute both the acceleration and momentum strategies. For instance, in January 1990 for the Rank Lag 0/10% strategy, there are 165 firms in the short portfolio and 309 firms in the long portfolio. The return difference for this date measures the difference between this strategy and investing in a strategy that is long the top 309 momentum firms and short the bottom 165 momentum firms. We measure return differences in this manner to ensure that the spreads are not due to investment in the most extreme momentum stocks. We use the time series of cumulative returns and return differences to compute the means shown in Table XII. As a measure of risk, we also present Sharpe ratios using six- and twelve-month returns. These ratios use the respective mean cumulative return at the end of six or twelve months, and compute the standard deviation from the time series of observations on returns at the appropriate horizon. The numerator of the ratio is the mean cumulative excess return above the three month Treasury bill rate, which is compounded to either six or twelve months as appropriate. The standard deviation is computed in a manner that allows for the non-zero serial correlations induced by overlapping observations.[11] The bottom two rows give an indication of the average number of firms included in both the long and short portfolios. These averages are again computed as time-series averages; since the size of the cross-section grows substantially over the sample period, these should be read as a crude measure of the size of the underlying portfolios.

Table XII shows that the acceleration strategies offer significant profits in excess of a normal momentum strategy. Several important observations are apparent in this table. First, the returns of the two strategies, Rank Lag 0 and Rank Lag 6, accord with expectations concerning the timing of excess profits. The Rank Lag 0 strategy sustains small initial losses relative to a conventional momentum strategy, but then yields a positive additional return in the second half of the holding period. At the end of twelve months, the 10% strategy returns approximately 80 basis points above a conventional momentum strategy. This pattern is fitting with the pattern of returns that accrue to univariate acceleration strategies when controlled for momentum. In contrast, the Rank Lag 6 strategies successfully shift the acceleration spread earlier in the holding period. For this second set of strategies the differences in cumulative returns between the matched momentum strategies and the three refinements is between 210 and 344 basis points six months after investment begins. The annualized spreads of 4.2% to 7.0% represent a significant return in excess of the already large profits realized on the matched univariate momentum strategies. By the end of a twelve-month holding period, the excess profits associated with the three refinements partially dissipate for the Rank Lag 6 strategy.

Examining the Sharpe ratios, one can see that not only do the acceleration strategies offer additional profits, but also lower total risk relative to a standard momentum strategy. The Sharpe ratios of the matched momentum strategies are shown in square brackets below the Sharpe ratios of the corresponding acceleration strategies. When the ranking is not lagged, the acceleration strategies yield twelve-month Sharpe ratios that are significantly larger than both the non-matched and matched momentum strategies. For example, the Rank Lag 0/10% strategy yields a Sharpe ratio of 0.484 relative to 0.385 and 0.355 for the non-matched and matched univariate momentum strategies, respectively. The risk enhancement for the Rank Lag 6 strategies is even more dramatic. In this case, the six-month Sharpe ratios for the acceleration strategies are much larger than univariate momentum strategies. The Rank Lag 6/10% strategy generates an average Sharpe ratio of 0.479 compared to 0.200 for the matched momentum strategy. The number of firms included in the Rank Lag 6/10% strategy is somewhat low, averaging approximately 38 (35) firms in the short (long) portfolio over the entire sample period. As expected, the Sharpe ratios increase substantially as more firms are included for investment. Both the 20% and 30% strategies are associated with Sharpe ratios that are both greater than the 10% strategy and their respective matched momentum strategies.

To check the stability of the above results, we have divided the sample period into three sub-periods: 1934–1961, 1962–1982, and 1983–2003. The first sub-period isolates the portion of the sample that is not examined by previous momentum studies that employ daily CRSP data. The other two sub-periods divide the remaining portion of the sample into halves of equal length. All of the qualitative results concerning the performance of acceleration strategies are also present in each of the sub-periods.[12]

In summary, refining a univariate momentum strategy to exploit the performance of extreme acceleration stocks offers significant advantages to investors. The returns earned on such refined strategies are significantly higher than a univariate strategy, the total risk is lower, and the need to take positions in a large number of stocks is reduced. Thus, these acceleration strategies dominate conventional momentum on the dimensions that are of primary interest to investors.

VI Consistency with Theoretical Behavioral Models

In this section we examine consistency between the empirical results documented in Section III and several theoretical models of equity returns. In particular, we consider the three primary unified models of under- and over-reaction authored by Barberis, Shleifer, and Vishny (1998) (hereafter BSV), Hong and Stein (1999), and Daniel, Hirshleifer, and Subrahmanyam (1998) (hereafter DHS). The goal is to determine to what extent these models can generate two essential features of our acceleration strategies: that high-acceleration stocks ultimately outperform acceleration-neutral stocks of the same momentum; and that this abnormal performance relative to momentum benchmarks is delayed in portfolio formation event time. To provide answers to these two questions, we perform simulations of the three models and study the generated data. In this section, we provide a concise summary of these results along with their intuition. An appendix, available upon request, contains a detailed description of the simulation methods and the results obtained.

VI.A Barberis, Shleifer, and Vishny (1998)

The BSV model posits a risk-neutral representative investor that prices a single asset by forecasting its future earnings. To produce these forecasts, the investor tries to infer the stochastic process that governs earnings generation by observing realized earnings. Although the true earnings process is a random walk, the investor mistakenly believes that earnings either trend in the same direction, or oscillate between negative and positive values. The structure of this model is one way to endow the investor with both conservatism and representativeness, two behavioral biases that have been documented by empirical psychologists.

The BSV model is partially successful at reproducing the acceleration effect we have documented. While this model does yield a positive acceleration effect, it also predicts that the positive spread begins to accrue immediately upon portfolio formation. Thus, there is no period of initial loss to the acceleration hedge portfolio. The reason can be traced to the investor's Bayesian reaction to the patterns of earnings which underly both high- and low-acceleration return series. To illustrate, compare a high-momentum, acceleration-neutral firm to a high-momentum, high-acceleration firm. On average, the acceleration-neutral firm will experience a string of positive earnings realizations which lead to sustained positive returns. The consistency of earnings realizations will bend the investor's belief toward one of trending earnings, and thus the investor will expect that earnings in the next period will also be positive. If earnings turn out negative, the investor will be surprised and the equity will suffer a large capital loss. On the other hand, positive earnings are consistent with the investor's expectations, and the ensuing return will be modestly positive. When these two possible outcomes are weighted by the equal probabilities of a random walk, the true earnings process, it is clear that the expected return to a high-momentum, acceleration-neutral firm is low during the post-ranking period.

In contrast, the high-acceleration firm will tend to have negative earnings followed by positive earnings. The Bayesian investor will shift toward the belief that earnings are oscillating, and given a recent positive realization, will expect next period's earnings to be negative. This time the investor will be surprised by positive future earnings, and the resulting return will be large and positive. However, a negative earnings realization is consistent with expectations and will be associated with a small, negative return. Again weighting by the equal probabilities of the random walk, the average return to a high-momentum, high-acceleration firm will be large and positive. When measured against the low return of a high-momentum, acceleration-neutral benchmark, the return on the high momentum, high acceleration firm appears even larger.

VI.B Hong and Stein (1999)

The second model we study is an overlapping generations model developed by Hong and Stein. In this model, the market for a single asset is populated by two types of investors, newswatchers and momentum traders. Newswatchers receive fundamental information shocks that concern the dividends to be paid on the asset, and then formulate their demand based on this information. However, not all newswatchers becomes aware of the same information at the same time; instead, information slowly diffuses across the population of newswatchers, thus leading to return momentum. In contrast to newswatchers, momentum traders base their demand only on recent price changes, not on fundamental information. Since the aggregate demand of momentum traders is positively correlated to recent price changes, the resulting effect of their demand is to bid the price too high and induce overreaction.

Like BSV, the Hong and Stein model also generates an immediate, positive acceleration effect. To understand this result, we again compare a return series that exhibits high momentum and low absolute acceleration to another return series of similar momentum and high acceleration. The acceleration-neutral firm is likely to experience a large, positive information shock at the beginning of the ranking period. The shock slowly diffuses over the population of newswatchers, causing the price to drift upward, thus yielding consistently positive returns. As the firm moves from the ranking period to the holding period, the shock becomes fully incorporated into the equity price and the early generations of momentum traders liquidate their long positions and exit the market. At this point there is no source of information or buying pressure to inflate prices, and hence the price corrects downward toward its fundamental value. Since the holding period coincides with the correction phase, the expected return on a high-momentum, acceleration-neutral firm is low.

The high-acceleration firm will be subject to a much different pattern of information shocks. On average, this firm will experience a moderate negative shock at the beginning of the ranking period, followed by a large and positive shock in the middle of the ranking period. During the initial ranking period, returns are negative as the first shock diffuses across newswatchers. However, the magnitude of the later positive shock is sufficient to net out the negative shock and produce positive returns during the secondary ranking period. This pattern produces a return series that exhibits both high momentum and high acceleration during the overall ranking period. During the subsequent holding period, this firm is associated with a high expected return. To understand why, note that upon commencement of the holding period, the negative shock will have become fully incorporated, leaving only the positive shock to influence newswatchers. The positive shock will induce newswatchers to implement long positions, who will then bid up prices and spur buying by the new generations of momentum traders. Early generations of momentum traders will also unwind the short positions implemented in response to the negative shock, thereby causing further upward price pressure. When contrasted against the relatively low expected return of an acceleration-neutral stock, it can be seen that the Hong and Stein model predicts an immediate and positive acceleration effect.

VI.C Daniel, Hirshleifer, and Subrahmanyam (1998)

The final model that we examine is the DHS model of dynamic over-confidence. Similar to BSV, DHS describe a risk-neutral quasi-rational representative agent that suffers from two behavioral biases. However, the two biases on which DHS focus are overconfidence and self-attribution. The investor described by DHS receives both an initial private signal and a series of public signals concerning the value of a single asset. Over-confidence causes the investor to underestimate the error variance associated with the private signal, and thus overweight the private information when valuing the asset. Self-attribution induces an asymmetric reaction to public information. When the public signals are in agreement with the private signal, the confidence in the private signal increases to even greater levels; however, when the two source of information do not agree, the level of confidence in the private signal does not fall commensurately. The dynamic behavior of over-confidence caused by the interaction of the public and private signals will on average lead to both return momentum and overreaction.

In accordance with the previous two models, DHS also predict an acceleration effect that is positive and immediate. In this case, high-acceleration firms are likely to be those firms that have private signals and fundamental values that are both negative, with the private signal substantially less than the fundamental value. Furthermore, the early public signals received by the investor are highly negative. Initially this situation produces a sharp decline in the price of the asset since all available information creates the impression of extremely low value, thereby lending credence to the investor's private signal. However, as less extreme public information becomes available, and the average public signal converges toward the higher fundamental value, the investor quickly losses faith in the low private signal. This causes the price to appreciate rapidly and implies relatively high returns.

In contrast, acceleration-neutral firms are expected to have relatively low returns. The private signals and fundamental value associated with firms of this type tend to be positive, with the fundamental value again greater than the private signal. The early public signals are highly positive and generally exceed the fundamental value. In other words, the fundamental value lies between a low private signal and high public information shocks. The upshot is that the average public signal is far away from the private signal and close to the fundamental value. In this situation, the investor does not develop an extreme level of confidence in the private signal, and thus mis-pricing is not as severe. As a result, the price of the asset moves smoothly upward as the investor reacts to the public information, and hence acceleration-neutral firms tend to have lower, more consistent returns.

As intended, BSV, Hong and Stein, and DHS perform well at simultaneously explaining short-run positive autocorrelations and long-run negative autocorrelations in equity returns. More impressively, consistent with the empirical results we document, all three models also generate a positive acceleration effect. However, none of the three models predicts that the acceleration effect should be delayed in event-time. The delay associated with acceleration is a pattern that is stable across both sample periods and empirical methodologies. Thus, it appears that an important aspect of the return generating process is absent from these models. We leave as a challenge to future theoretical work the task of positing a model that produces momentum, reversals, and a positive, delayed acceleration effect.

VII Conclusions

In this paper we have defined a measure of firm-level acceleration and have examined trading strategies based on this measure. Hedge funds and other institutional investors employ similar strategies with the intention of earning excess profits. We find that univariate acceleration strategies do indeed offer substantial profits, and that these profits are not subsumed by other known regularities in equity returns, including momentum. The spread between the annual returns of extreme acceleration decile portfolios is approximately 6.15% when controlled only for momentum. When controlled explicitly for momentum, market, size, and book-to-market risk, the annual cumulative abnormal return remains large at 4.5%. Thus, univariate acceleration strategies do offer technical traders the opportunity to earn positive abnormal profits.

We have also examined the profitability of acceleration strategies based on the intersection of a conventional momentum strategy and univariate acceleration rankings. These acceleration strategies offer significant additional profits to investors. In general, over a six-month holding period, an investor can earn 2%-3% beyond the return of a conventional momentum strategy by restricting investment to stocks that exhibit extreme measures of both six-month momentum and acceleration. Furthermore, as indicated by higher Sharpe ratios, following this refinement creates a more favorable risk profile relative to univariate momentum. Since the refined strategy applies an additional filter to the cross-section of equities, it also requires investment in far fewer stocks, thereby reducing the need to take positions in a large number of equities. Investors that ignore acceleration by implementing a univariate momentum strategy do not obtain all of these important advantages.

Finally, we have examined consistency between the positive acceleration effect and recent behavioral models of equity prices. Consistent with our findings, Barberis, Shleifer, and Vishny (1998), Hong and Stein (1999), and Daniel, Hirshleifer, and Subrahmanyam (1998) all predict that high-acceleration stocks should outperform benchmark firms that have approximately the same momentum but low acceleration. In each of the three models, the difference in post-ranking returns between the two types of firms can be attributed to investors' reaction to firm-specific information. One notable difference between our empirical results and these models is that they are unable generate an initial period of relative under- (over-) performance for high (low) acceleration firms. This poses a new challenge to understanding how investor behavior affects equity prices.

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Notes

[1]Measuring the book-to-market ratio requires observations on the book value of equity which are available from Compustat only after 1961. Therefore, the book-to-market decile ranks in Table II are computed using only the data from 1961–2003. The other measures use the full sample period 1926–2003.

[2]Jegadeesh and Titman (2001) find that six-month momentum strategies are profitable for approximately one year. However, they examine only the period 1965–1997 and do not skip a month between portfolio ranking and holding periods. This explains the difference in our results, which show losses to the momentum hedge portfolio beginning in month eleven.

[3]The results are insensitive to using the bottom one, two, or three deciles in the definition of acceleration-neutral firms. We choose three deciles because it allows better populated momentum deciles with which to compute averages. The results also remain unchanged if we form momentum decile breakpoints using only the set of acceleration-neutral firms.

[4]We also employ a procedure that provides an exact match on momentum by using a convex combination of the acceleration-neutral momentum deciles. We omit a description of this procedure because our results are invariant to this change. From this exercise we conclude that the results in this section are not due to the failure to exactly match the magnitude of six month momentum.

[5]For instance, consider the return to a particular acceleration decile in January of year N. When we set the ranking lag equal to zero, this return is computed as the equal weighted average of the return in January of year N on the same decile formed in July, August, September, October, November, and December of year $N-1$. In contrast, under the "Rank Lag 6 Months" scenario, the returns that are averaged to form the January return in year N are those on the same decile portfolios ranked as such in January, February, March, April, May, and June of year $N-1$.

[6]The results presented in this section have also been computed using an overlapping portfolio procedure to construct the momentum factor. In this case, we form overlapping momentum decile portfolios and compute calendar-time returns in the same manner as the acceleration returns that appear on the left-hand side of the regression. The results are very similar so we do not present them here. A table summarizing these results is available from the authors upon request.

[7]There is good reason to believe that momentum loadings do not represent exposure to fundamental risks. One convincing example that leads to this conclusion is the highly profitable LAST strategy analyzed by Hong, Lim, and Stein (2000).

[8]The cumulative intercept, α^*, for each decile at each point in event-time is computed as $\alpha^*_{\tau,d} = (\prod_{s=1}^{\tau} 1 + \hat{\alpha}_{s,d}) - 1$.

[9]In actuality, our results in this section change little when we form the event-time momentum factors from all firms, not just acceleration-neutral firms.

[10]The six portfolios arrive from intersecting three momentum portfolios formed using breakpoints set at 30% and 70% with two size portfolios formed using the median NYSE firm size as the breakpoint.

[11]For instance, the six-month Sharpe ratios compute the standard deviation of six-month returns allowing for non-zero values of the first five autocovariances.

[12]Our first sub-period begins in 1934 because this is the first date for which we have available three month Treasury bill rates required to compute Sharpe ratios. A table that provides sub-period results is available upon request.

Table I: Ranking Period Returns to Acceleration Decile Portfolios

At the end of each month in the period 1926–1998 we form decile portfolios based on acceleration. Acceleration for firm i at time T is defined as:

$$A_{i,T} = \prod_{s=T-6}^{T-1} (1 + r_{i,s}) - \prod_{s=T-12}^{T-7} (1 + r_{i,s})$$

where $r_{i,s}$ is the monthly return of firm i in month s. We ignore all firms with missing return data in the interval $[T-12$ months, $T-1$ month$]$. The decile portfolios are constructed as equal-weighted, buy-and-hold portfolios. The below table presents returns accruing to the portfolios during the ranking period used to form deciles. Panel A presents average monthly percentage returns and Panel B shows cumulative returns over the twelve-month ranking period.

Panel A: Average Monthly Returns

Acceleration	Month Relative to Portfolio Formation											
Decile	−12	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1
Low	8.98	8.07	7.91	7.62	7.34	8.01	−2.76	−2.09	−1.95	−1.89	−1.81	−2.13
2	4.10	3.75	3.62	3.32	3.24	3.44	−1.46	−1.17	−1.15	−1.09	−1.06	−1.18
3	2.67	2.45	2.27	2.19	2.10	2.09	−0.66	−0.45	−0.47	−0.48	−0.46	−0.58
4	1.76	1.59	1.52	1.33	1.25	1.25	0.05	0.17	0.07	0.12	0.05	−0.06
5	1.06	0.93	0.88	0.78	0.61	0.57	0.77	0.72	0.61	0.62	0.65	0.48
6	0.37	0.36	0.31	0.17	0.10	−0.02	1.45	1.26	1.20	1.17	1.19	1.04
7	−0.21	−0.17	−0.21	−0.40	−0.46	−0.67	2.28	1.91	1.81	1.84	1.74	1.67
8	−0.88	−0.75	−0.79	−0.91	−1.01	−1.32	3.19	2.75	2.59	2.63	2.62	2.53
9	−1.67	−1.44	−1.44	−1.50	−1.59	−2.07	4.75	4.10	3.78	3.90	3.90	3.90
High	−2.63	−2.26	−2.28	−2.25	−2.34	−3.32	9.52	8.35	8.14	8.16	8.18	8.59

Panel B: Cumulative Returns

Acceleration	Month Relative to Portfolio Formation											
Decile	−12	−11	−10	−9	−8	−7	−6	−5	−4	−3	−2	−1
Low	8.98	17.77	27.08	36.77	46.81	58.56	54.19	50.97	48.03	45.23	42.60	39.56
2	4.10	8.01	11.93	15.64	19.39	23.50	21.70	20.27	18.89	17.60	16.35	14.98
3	2.67	5.18	7.57	9.93	12.24	14.58	13.83	13.32	12.78	12.24	11.73	11.08
4	1.76	3.38	4.95	6.35	7.67	9.02	9.08	9.26	9.33	9.46	9.51	9.45
5	1.06	2.00	2.90	3.71	4.33	4.92	5.73	6.49	7.14	7.80	8.50	9.01
6	0.37	0.73	1.04	1.22	1.32	1.29	2.76	4.05	5.30	6.53	7.80	8.92
7	−0.21	−0.38	−0.60	−0.99	−1.45	−2.11	0.12	2.03	3.88	5.79	7.63	9.43
8	−0.88	−1.62	−2.40	−3.29	−4.26	−5.53	−2.51	0.17	2.76	5.47	8.23	10.96
9	−1.67	−3.08	−4.48	−5.91	−7.40	−9.32	−5.02	−1.12	2.61	6.62	10.78	15.10
High	−2.63	−4.83	−6.99	−9.09	−11.22	−14.17	−6.00	1.85	10.15	19.14	28.89	39.96

Table II: Characteristics of Acceleration Deciles at Ranking

At the end of each month T in the sample period we measure the size decile, book-to-market decile, the buy-and-hold return from $T-6$ through $T-1$ (six-month momentum), the buy-and-hold return from $T-12$ through $T-1$ (twelve-month momentum), and acceleration of each firm. We then assign each firm to a decile portfolio constructed from ranking on accelearation and, within portfolios, compute the cross-sectional mean of each variable. The below table presents the time-series means of these cross-sectional means. The decile breakpoints used to assign size and book-to-market deciles are computed using only NYSE stocks. The lowest size decile contains the smallest firms. The book-to-market decile calculations use only observations after 1961 since observations of book equity are unavailable prior to this date. For book-to-market deciles, 1 indicates growth stocks and 10 indicates value.

Acceleration Decile	Size Decile	Book-to-Market Decile	6 Month Momentum	12 Month Momentum	Acceleration
Low	3.62	4.65	−15.15%	39.56%	−73.71%
2	4.29	5.27	−9.80%	14.98%	−33.30%
3	4.58	5.45	−5.70%	11.08%	−20.28%
4	4.70	5.58	−2.21%	9.45%	−11.23%
5	4.75	5.64	1.32%	9.01%	−3.60%
6	4.75	5.67	4.92%	8.92%	3.63%
7	4.68	5.67	9.09%	9.43%	11.20%
8	4.53	5.60	14.56%	10.96%	20.08%
9	4.25	5.45	23.46%	15.10%	32.78%
High	3.63	4.80	58.38%	39.96%	72.54%

Table III: Cumulative Returns to Acceleration and Six-Month Momentum Decile Portfolios

At the end of each month T we form decile portfolios on acceleration and six-month momentum. We ignore all firms with missing return data in the interval $[T-12$ months, $T-1$ month$]$. The decile portfolios are constructed as equal-weighted, buy-and-hold portfolios. One month is skipped between the ranking and holding periods. The below table presents cumulative returns accruing to decile portfolios during the first twelve months of the holding period. Panel A pertains to acceleration deciles, and Panel B to six-month momentum deciles. The last two rows of both panels show mean differences between deciles 10 and 1 along with t-statistics individually testing the means against zero.

Panel A: Acceleration Decile Portfolios

Acceleration	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.45	2.73	3.88	4.93	5.78	6.48	7.24	8.23	9.26	10.51	12.04	13.83
2	1.49	2.78	4.16	5.26	6.39	7.31	8.24	9.33	10.50	11.90	13.41	15.19
3	1.43	2.77	4.06	5.27	6.41	7.36	8.50	9.66	10.97	12.35	13.90	15.68
4	1.39	2.76	4.13	5.39	6.60	7.82	8.97	10.25	11.54	12.98	14.53	16.31
5	1.41	2.69	4.05	5.34	6.57	7.85	9.08	10.41	11.77	13.26	14.84	16.50
6	1.33	2.64	3.94	5.20	6.44	7.78	9.17	10.55	11.93	13.45	15.10	16.76
7	1.29	2.66	4.04	5.38	6.72	8.11	9.56	10.98	12.41	14.03	15.70	17.34
8	1.24	2.58	3.95	5.30	6.82	8.42	9.98	11.54	13.14	14.84	16.57	18.19
9	1.25	2.61	4.13	5.67	7.22	9.01	10.74	12.37	14.03	15.70	17.51	19.17
High	1.36	2.93	4.49	6.24	8.00	10.13	12.10	13.91	15.61	17.44	19.25	20.68
High − Low	−0.09	0.20	0.61	1.31	2.27	3.65	4.86	5.68	6.35	6.93	7.21	7.85
	(−0.56)	(0.60)	(1.20)	(2.29)	(3.41)	(5.07)	(6.04)	(6.54)	(7.15)	(7.89)	(8.33)	(8.30)

Panel B: Six-Month Momentum Decile Portfolios

Momentum	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.42	2.40	3.29	3.98	4.78	5.41	6.12	7.08	8.16	9.56	11.33	13.47
2	1.21	2.31	3.45	4.46	5.31	6.16	7.10	8.23	9.38	10.85	12.49	14.39
3	1.21	2.53	3.77	4.94	6.02	6.98	8.04	9.22	10.53	12.01	13.71	15.54
4	1.34	2.63	3.96	5.21	6.38	7.48	8.71	9.97	11.36	12.87	14.56	16.24
5	1.33	2.68	4.10	5.39	6.59	7.91	9.19	10.49	11.92	13.47	15.11	16.87
6	1.34	2.69	4.12	5.40	6.74	8.10	9.49	10.91	12.38	13.96	15.59	17.23
7	1.33	2.72	4.17	5.61	7.08	8.57	10.09	11.60	13.03	14.52	16.12	17.71
8	1.36	2.81	4.28	5.77	7.29	8.96	10.57	12.15	13.71	15.30	16.89	18.44
9	1.45	2.95	4.47	6.14	7.77	9.64	11.32	12.95	14.50	16.11	17.73	19.17
High	1.67	3.41	5.20	7.08	8.98	11.04	12.93	14.60	16.16	17.79	19.30	20.59
High − Low	0.25	1.01	1.91	3.10	4.20	5.63	6.81	7.52	8.00	8.23	7.97	7.12
	(0.96)	(1.77)	(2.44)	(3.77)	(4.80)	(6.04)	(6.87)	(7.14)	(7.16)	(6.67)	(5.61)	(4.26)

Table IV: Average Monthly Returns to Acceleration and Six-Month Momentum Decile Portfolios

At the end of each month T we form decile portfolios independently on acceleration and six-month momentum. We ignore all firms with missing return data in the interval [$T-12$ months, $T-1$ month]. The decile portfolios are constructed as equal-weighted, buy-and-hold portfolios. One month is skipped between the ranking and holding periods. Panel A presents average monthly returns to acceleration decile portfolios during the first twelve months of the holding period. Panel B is analogous and pertains to six-month momentum deciles. The last two rows of each panel show mean differences between deciles 10 and 1 along with t-statistics individually testing the means against zero.

Panel A: Acceleration Decile Portfolios

Acceleration	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.45	1.05	0.92	0.96	0.85	0.65	0.72	0.93	0.90	0.97	1.13	1.30
2	1.49	1.12	1.16	1.01	1.09	0.87	0.89	1.02	1.04	1.14	1.18	1.37
3	1.43	1.18	1.12	1.13	1.08	0.90	1.09	1.12	1.17	1.16	1.23	1.40
4	1.39	1.22	1.20	1.20	1.14	1.13	1.08	1.19	1.21	1.23	1.23	1.38
5	1.41	1.16	1.21	1.21	1.20	1.21	1.15	1.20	1.24	1.27	1.28	1.32
6	1.33	1.19	1.16	1.21	1.19	1.27	1.30	1.29	1.26	1.28	1.30	1.31
7	1.29	1.25	1.24	1.28	1.26	1.30	1.35	1.30	1.33	1.36	1.35	1.32
8	1.24	1.24	1.24	1.27	1.40	1.48	1.46	1.40	1.44	1.44	1.37	1.31
9	1.25	1.27	1.36	1.41	1.44	1.63	1.60	1.46	1.47	1.42	1.43	1.30
High	1.36	1.44	1.41	1.54	1.63	1.89	1.71	1.54	1.44	1.45	1.36	1.12
High − Low	−0.09	0.39	0.49	0.58	0.78	1.24	0.98	0.61	0.54	0.48	0.22	−0.18
	(−0.56)	(2.83)	(3.65)	(4.15)	(5.99)	(8.51)	(6.69)	(4.57)	(4.48)	(3.83)	(1.87)	(−1.47)

Panel B: Six-Month Momentum Decile Portfolios

Momentum	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.42	0.73	0.67	0.67	0.83	0.64	0.72	0.98	1.01	1.13	1.33	1.64
2	1.21	0.90	0.90	0.98	0.88	0.86	0.93	1.09	1.13	1.26	1.31	1.45
3	1.21	1.16	1.06	1.11	1.06	0.94	1.01	1.12	1.24	1.27	1.34	1.40
4	1.34	1.16	1.20	1.17	1.15	1.04	1.15	1.18	1.26	1.29	1.31	1.34
5	1.33	1.21	1.27	1.23	1.15	1.23	1.21	1.21	1.26	1.29	1.27	1.37
6	1.34	1.24	1.28	1.21	1.28	1.24	1.29	1.28	1.32	1.31	1.29	1.28
7	1.33	1.30	1.32	1.35	1.35	1.38	1.38	1.36	1.26	1.26	1.29	1.29
8	1.36	1.36	1.35	1.38	1.41	1.50	1.49	1.40	1.35	1.31	1.28	1.22
9	1.45	1.41	1.39	1.52	1.48	1.68	1.52	1.45	1.36	1.34	1.29	1.15
High	1.67	1.63	1.61	1.66	1.68	1.81	1.63	1.43	1.36	1.30	1.19	1.02
High − Low	0.25	0.90	0.94	0.99	0.85	1.17	0.91	0.46	0.35	0.17	-0.14	-0.63
	(0.96)	(3.86)	(4.15)	(4.47)	(4.07)	(5.67)	(4.48)	(2.45)	(1.92)	(0.92)	(-0.80)	(-3.34)

Table V: Two-Way Sort on Momentum and Acceleration

At the beginning of each month T, we rank firms on six-month momentum as of the end of month $T-1$ and form quintile portfolios based on this measure. We denote these quintiles as M1–M5, where M1 is the portfolio of firms with lowest six-month momentum. Within each momentum quintile we then rank firms on acceleration also at the end of $T-1$ and form quintile portfolios. These portfolios are denoted A1–A5, where A1 is the 20% of firms with lowest acceleration within the corresponding momentum portfolio. We measure the cumulative equal-weighted, buy-and-hold return on each of the twenty-five portfolios starting at the beginning of month $T+1$. On each portfolio formation date, we also average firm-level observations on momentum and acceleration and compute the within portfolio cross-sectional means of both variables. The upper panel shows the three and twelve month returns averaged across portfolio formation dates. The bottom panel provides measures of momentum and acceleration for each of the twenty-five portfolios also obtained from computing time-series averages of cross-sectional means. The rows and columns labeled "All A" and "All M" correspond to unconditional univariate sorts into quintile portfolios based on acceleration and momentum, respectively. For example, the "All M" column in the left-hand portion of Panel A provides the three month returns to quintile portfolios based on acceleration formed from the entire cross-section. The last two rows of Panel A present the return differences between high and low acceleration returns within each momentum quintile and associated autocorrelation adjusted t-statistics.

Panel A: Portfolio Returns

	Three Month Returns						Twelve Month Returns					
	M1	M2	M3	M4	M5	All M	M1	M2	M3	M4	M5	All M
A1	3.68	4.32	4.77	4.88	5.25	4.02	13.14	15.18	16.60	17.46	18.29	14.51
A2	3.35	4.21	4.39	4.46	4.87	4.09	12.99	15.77	16.69	17.29	19.76	15.99
A3	3.36	3.96	3.88	4.10	4.81	3.99	13.85	16.07	16.53	17.63	19.73	16.62
A4	3.36	3.68	3.81	3.94	4.36	4.00	14.33	15.87	17.06	18.34	20.59	17.76
A5	3.09	3.21	3.69	3.80	4.88	4.31	15.29	16.59	18.27	19.70	20.90	19.94
All A	3.36	3.87	4.11	4.23	4.84		13.92	15.90	17.04	18.09	19.87	
A5 − A1	−0.58	−1.11	−1.08	−1.08	−0.37		2.15	1.41	1.67	2.24	2.62	
	(−3.47)	(−6.91)	(−6.09)	(−6.15)	(−2.49)		(11.45)	(8.59)	(8.85)	(11.87)	(12.17)	

Panel B: Portfolio Characteristics

	Six-Month Momentum						Acceleration					
	M1	M2	M3	M4	M5	All M	M1	M2	M3	M4	M5	All M
A1	−29.99	−7.30	3.69	15.35	36.29	−12.46	−87.01	−52.63	−38.83	−27.45	−13.57	−53.39
A2	−25.93	−6.88	3.89	15.57	35.89	−3.95	−41.64	−22.18	−11.30	−0.30	20.51	−15.74
A3	−23.89	−6.50	4.22	16.10	39.39	3.11	−25.93	−10.47	−0.50	10.64	33.58	0.00
A4	−22.36	−6.16	4.60	16.89	47.38	11.80	−13.06	−0.14	9.09	20.53	52.59	15.61
A5	−20.87	−5.82	5.05	17.91	89.26	40.97	5.37	16.36	25.11	37.14	102.52	52.69
All A	−24.58	−6.53	4.29	16.37	49.77		−32.18	−13.61	−3.11	8.29	39.81	

Table VI: Returns to Acceleration-Neutral Six-Month Momentum Decile Portfolios

At the end of each month T in the sample we rank each firm independently on six-month momentum (the buy-and-hold return from $T-6$ through $T-1$) and the *absolute value* of acceleration. Firms that appear in the bottom 30% of the sample when ranking on the latter are termed acceleration-neutral firms. We next compute a set of decile breakpoints on six-month momentum from the full sample but populate the decile portfolios only with acceleration-neutral firms. The returns on each decile are measured forward as equal-weighted, buy-and-hold returns. Panel A shows the average monthly returns associated with each of the acceleration-neutral momentum deciles during the twelve months following portfolio formation. Panel B presents the cumulative returns. The last rows of both panels measure the differences between the top and bottom deciles and show corresponding t-statistics individually testing these differences against zero.

Panel A: Average Monthly Returns

Momentum	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.17	0.66	0.67	0.68	0.94	0.83	0.76	1.02	1.35	1.30	1.51	1.55
2	0.97	0.85	0.95	1.02	1.16	1.07	0.91	1.23	1.32	1.21	1.48	1.48
3	1.14	0.95	1.18	1.14	1.07	1.07	0.98	1.23	1.22	1.24	1.34	1.39
4	1.15	1.12	1.07	1.10	1.18	1.06	1.20	1.21	1.30	1.31	1.37	1.40
5	1.27	1.12	1.18	1.19	1.25	1.13	1.16	1.10	1.12	1.12	1.23	1.34
6	1.18	1.13	1.18	1.34	1.21	1.19	1.13	1.24	1.12	1.20	1.28	1.32
7	1.32	1.24	1.29	1.32	1.17	1.22	1.09	1.05	1.18	1.20	1.22	1.18
8	1.37	1.35	1.28	1.31	1.26	1.24	1.16	1.15	1.18	1.13	1.16	1.15
9	1.43	1.32	1.32	1.43	1.38	1.35	1.25	1.20	1.16	1.13	1.15	1.15
High	1.76	1.63	1.52	1.58	1.50	1.54	1.37	1.36	1.13	1.17	1.12	1.06
High − Low	0.59	0.97	0.85	0.90	0.56	0.71	0.61	0.34	-0.22	-0.14	-0.39	-0.50
	(1.96)	(3.30)	(3.17)	(3.46)	(2.14)	(2.85)	(2.78)	(1.40)	(-0.86)	(-0.61)	(-1.80)	(-1.86)

Panel B: Cumulative Returns

Momentum	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.17	2.03	2.80	3.39	4.30	5.17	5.94	6.95	8.99	9.80	11.81	13.80
2	0.97	1.97	3.06	4.11	5.30	6.44	7.35	8.62	10.01	11.37	13.11	14.90
3	1.14	2.20	3.51	4.75	5.82	7.00	8.05	9.30	10.57	12.00	13.64	15.52
4	1.15	2.33	3.54	4.73	5.94	7.09	8.39	9.70	11.07	12.56	14.27	15.98
5	1.27	2.49	3.80	5.02	6.36	7.59	8.86	10.03	11.32	12.67	14.24	15.87
6	1.18	2.38	3.63	5.05	6.33	7.66	8.90	10.24	11.51	12.94	14.52	16.14
7	1.32	2.66	4.08	5.55	6.75	8.12	9.34	10.51	11.84	13.25	14.86	16.40
8	1.37	2.80	4.18	5.60	6.98	8.36	9.64	10.90	12.28	13.61	15.10	16.56
9	1.43	2.82	4.23	5.77	7.26	8.78	10.17	11.55	12.88	14.25	15.67	17.11
High	1.76	3.47	5.13	6.88	8.58	10.35	11.89	13.46	14.77	16.20	17.62	18.98
High − Low	0.59	1.45	2.34	3.48	4.28	5.18	5.95	6.51	6.39	6.40	5.81	5.17
	(1.96)	(2.27)	(2.89)	(4.20)	(4.51)	(4.81)	(4.89)	(4.72)	(4.08)	(3.68)	(2.89)	(2.27)

Table VII: Average Cross-Correlations of Standard and Acceleration-Neutral Momentum Deciles

At the end of each month T in the sample, we measure each firm's six-month momentum and the absolute value of acceleration. Firms in the bottom 30% of the sample when ranked on absolute acceleration are termed acceleration-neutral firms. We form one set of standard momentum portfolios by assigning firms with available data to decile portfolios formed using six-month momentum breakpoints from the full sample. We also construct a second set of portfolios by assigning only acceleration-neutral firms to decile portfolios using the same breakpoints, thereby forming acceleration-neutral momentum deciles. We next measure the correlation between corresponding standard momentum and acceleration-neutral momentum deciles. The correlation is computed using either the one, three, or five years of monthly return data following month T. Finally, we compute an average over the set of portfolio formation dates that allows independent observations of the correlation (which differs between the three columns). These average correlations are shown along with the associated standard deviation.

Decile	1 Year	3 Years	5 Years
Low	0.9417 (0.0642)	0.9555 (0.0314)	0.9590 (0.0258)
2	0.9382 (0.0631)	0.9523 (0.0322)	0.9561 (0.0272)
3	0.9373 (0.0622)	0.9504 (0.0319)	0.9542 (0.0270)
4	0.9382 (0.0598)	0.9492 (0.0339)	0.9543 (0.0265)
5	0.9348 (0.0690)	0.9489 (0.0343)	0.9533 (0.0281)
6	0.9361 (0.0655)	0.9486 (0.0350)	0.9534 (0.0281)
7	0.9384 (0.0674)	0.9490 (0.0365)	0.9529 (0.0301)
8	0.9373 (0.0703)	0.9477 (0.0367)	0.9525 (0.0291)
9	0.9364 (0.0672)	0.9468 (0.0374)	0.9507 (0.0311)
High	0.9352 (0.0654)	0.9465 (0.0401)	0.9509 (0.0330)

Table VIII: Returns to Acceleration Deciles Net of Acceleration-Neutral Six-Month Momentum Deciles

The below tables shows the returns to acceleration decile portfolios when individual stocks are matched to momentum benchmark portfolios. The benchmark portfolios are six-month momentum decile portfolios that include only acceleration-neutral firms (those with an absolute value of acceleration placing them in the bottom 30% of the sample). Returns on the acceleration-neutral momentum deciles are computed as equal-weighted, buy-and-hold returns. For each portfolio formation date, a firm is matched to the appropriate benchmark portfolio on the basis of its six-month momentum. We subtract the cumulative return on the benchmark portfolio from the cumulative return on the matched firm for each of the months in the holding period. Finally, we average returns across firms in each portfolio and then average again across portfolio formation dates. Panel A shows the net average monthly returns and Panel B shows the net cumulative returns. The cumulative returns from Panel B are graphed in Figure 2.

Panel A: Average Monthly Returns

Acceleration	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	0.32	0.01	−0.23	−0.25	−0.50	−0.70	−0.46	−0.41	−0.61	−0.45	−0.64	0.09
2	0.35	0.03	0.01	−0.23	−0.21	−0.41	−0.25	−0.30	−0.35	−0.20	−0.52	−0.56
3	0.27	0.05	−0.09	−0.16	−0.18	−0.33	−0.09	−0.19	−0.13	−0.13	−0.31	0.20
4	0.18	0.07	0.00	−0.09	−0.11	−0.08	−0.11	−0.09	−0.13	−0.11	−0.26	0.45
5	0.17	−0.04	−0.01	−0.07	−0.11	−0.03	−0.05	0.01	−0.03	0.00	−0.20	0.08
6	0.07	−0.03	−0.09	−0.11	−0.08	0.01	0.09	0.05	−0.02	0.06	−0.04	−0.06
7	0.01	0.01	−0.04	−0.06	0.01	0.05	0.17	0.10	0.03	0.12	−0.01	−0.10
8	−0.10	−0.05	−0.04	−0.11	0.13	0.18	0.25	0.23	0.21	0.24	0.11	−0.01
9	−0.13	−0.09	0.03	0.02	0.09	0.32	0.34	0.25	0.30	0.26	0.29	0.09
High	−0.23	−0.07	−0.04	0.05	0.14	0.42	0.34	0.20	0.13	0.12	0.81	−0.07
High - Low	−0.56	−0.08	0.19	0.30	0.64	1.12	0.80	0.61	0.74	0.58	1.45	−0.15
	(−2.66)	(−0.37)	(0.91)	(1.39)	(3.13)	(4.44)	(3.09)	(2.72)	(2.42)	(1.86)	(2.60)	(−0.36)

Panel B: Cumulative Returns

Acceleration	Month Relative to Portfolio Formation											
Decile	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	0.32	0.36	0.13	−0.09	−0.59	−1.25	−1.70	−2.12	−2.69	−3.08	−3.51	−3.74
2	0.35	0.40	0.43	0.23	0.00	−0.44	−0.73	−1.01	−1.34	−1.49	−1.85	−1.99
3	0.27	0.32	0.24	0.10	−0.07	−0.43	−0.52	−0.71	−0.83	−0.98	−1.24	−1.35
4	0.18	0.24	0.26	0.17	0.06	−0.03	−0.16	−0.25	−0.37	−0.47	−0.66	−0.69
5	0.17	0.13	0.12	0.04	−0.06	−0.11	−0.16	−0.15	−0.19	−0.18	−0.34	−0.44
6	0.07	0.04	−0.03	−0.15	−0.23	−0.22	−0.15	−0.09	−0.10	−0.04	−0.07	−0.09
7	0.01	0.03	0.01	−0.06	−0.05	0.00	0.18	0.29	0.32	0.44	0.46	0.45
8	−0.10	−0.15	−0.18	−0.29	−0.16	0.04	0.29	0.53	0.74	0.99	1.10	1.16
9	−0.13	−0.22	−0.18	−0.15	−0.05	0.27	0.63	0.91	1.23	1.49	1.76	1.88
High	−0.23	−0.29	−0.33	−0.24	−0.09	0.38	0.83	1.15	1.52	1.95	2.38	2.41
High - Low	−0.56	−0.65	−0.46	−0.15	0.50	1.63	2.53	3.27	4.21	5.02	5.89	6.15
	(−2.66)	(−1.68)	(−0.91)	(−0.21)	(0.58)	(1.59)	(2.10)	(2.43)	(2.90)	(3.32)	(3.67)	(3.66)

Table IX: Calendar-Time Factor Model Estimates

The below table presents results of estimating calendar-time factor models using overlapping portfolios for each acceleration decile. The factor models are:

$$R^*_{T,d} - \theta_T = \alpha_d + b_d(MKT_T - \theta_T) + s_d SML_T + h_d HML_T + \varepsilon_{T,d}$$
$$R^*_{T,d} - \theta_T = \alpha_d + b_d(MKT_T - \theta_T) + s_d SML_T + h_d HML_T + m_d MOM_T + \varepsilon_{T,d}$$

Where $R^*_{T,d}$ is the return during month T obtained by simultaneously holding a set of portfolios constructed from acceleration decile d, MKT is the CRSP value-weighted index, θ is the monthly three month T-bill rate, and HML and SMB are the normal Fama-French factor mimicking portfolios. MOM is the standard momentum factor mimicking portfolio. The return to any acceleration decile in a month, $R^*_{T,d}$, is an average of the returns of stocks assigned to that decile in any of the previous six months. For instance, the return to decile $d = 1$ during January of any particular year is the equal-weighted average of the returns in this January on acceleration decile 1 when formed in July, August, September, October, November, and December of the previous year. These results are labeled "Rank Lag 0 Months". We also estimate the models when the choice of stocks held in each decile portfolio is lagged by six months and present them under the set of columns labeled "Rank Lag 6 Months". In this case $R^*_{T,d}$ for the same January would be the equal-weighted average of the returns on acceleration decile 1 when formed in January, February, March, April, May, and June of the previous year. Intercepts are measured in basis points.

Panel A: Three Factor Model

Acceleration Decile	Rank Lag 0 Months					Rank Lag 6 Months				
	α	MKT	SMB	HML	R^2	α	MKT	SMB	HML	R^2
Low	-7.36	1.081	1.235	0.232	0.918	-36.44	1.055	1.104	0.236	0.918
	(-0.97)	(41.32)	(27.36)	(5.41)		(-5.27)	(39.09)	(25.78)	(5.15)	
2	0.15	1.020	1.023	0.281	0.941	-17.29	0.991	0.911	0.254	0.950
	(0.03)	(46.19)	(24.32)	(6.11)		(-3.54)	(50.63)	(34.80)	(10.76)	
3	2.72	0.982	0.888	0.286	0.954	-6.70	0.963	0.833	0.279	0.959
	(0.56)	(49.19)	(27.75)	(9.04)		(-1.63)	(49.62)	(34.95)	(13.75)	
4	5.55	0.970	0.830	0.301	0.963	-1.28	0.951	0.816	0.337	0.964
	(1.37)	(58.81)	(29.07)	(10.47)		(-0.34)	(58.33)	(25.69)	(9.07)	
5	5.26	0.945	0.819	0.332	0.968	5.70	0.941	0.806	0.335	0.973
	(1.48)	(71.98)	(29.73)	(11.19)		(1.77)	(70.32)	(35.02)	(16.64)	
6	3.27	0.942	0.803	0.322	0.969	8.64	0.943	0.797	0.334	0.975
	(0.97)	(70.52)	(29.78)	(11.20)		(2.80)	(96.06)	(35.05)	(15.67)	
7	3.83	0.933	0.802	0.326	0.971	13.85	0.951	0.813	0.323	0.975
	(1.16)	(80.69)	(35.61)	(18.06)		(4.41)	(94.29)	(39.55)	(20.04)	
8	3.43	0.930	0.821	0.311	0.965	19.49	0.955	0.888	0.326	0.970
	(0.93)	(81.13)	(32.60)	(12.46)		(5.27)	(92.23)	(35.04)	(17.28)	
9	5.77	0.959	0.888	0.289	0.954	23.56	0.983	0.982	0.323	0.960
	(1.28)	(69.32)	(27.61)	(7.87)		(5.46)	(71.41)	(31.82)	(11.21)	
High	10.95	1.004	1.073	0.260	0.909	28.39	1.040	1.174	0.294	0.918
	(1.53)	(41.99)	(22.01)	(4.98)		(4.39)	(44.47)	(25.40)	(6.59)	
High - Low	18.31	-0.076	-0.162	0.028	0.062	64.82	-0.014	0.070	0.058	0.011
	(1.87)	(-1.94)	(-2.79)	(0.44)		(8.38)	(-0.37)	(1.46)	(1.12)	

Table IX Continued: Calendar-Time Factor Model Estimates

Panel B: Four Factor Model

Acceleration Decile	Rank Lag 0 Months α	MKT	SMB	HML	MOM	R^2	Rank Lag 6 Months α	MKT	SMB	HML	MOM	R^2
Low	4.28	1.075	1.205	0.200	-0.117	0.921	-22.71	1.048	1.066	0.198	-0.142	0.923
	(0.54)	(45.00)	(26.70)	(4.59)	(-3.88)		(-2.97)	(47.51)	(25.16)	(4.29)	(-2.94)	
2	21.96	1.008	0.968	0.221	-0.219	0.954	-1.57	0.983	0.868	0.211	-0.162	0.958
	(3.84)	(63.65)	(30.68)	(7.90)	(-8.34)		(-0.32)	(68.95)	(33.08)	(8.30)	(-6.19)	
3	22.29	0.972	0.839	0.232	-0.197	0.966	8.36	0.955	0.792	0.238	-0.155	0.967
	(4.88)	(72.76)	(33.14)	(12.25)	(-9.83)		(1.96)	(68.64)	(34.11)	(10.90)	(-6.19)	
4	22.67	0.961	0.787	0.254	-0.172	0.973	14.13	0.943	0.774	0.295	-0.159	0.973
	(5.95)	(86.80)	(36.73)	(15.08)	(-10.71)		(3.65)	(83.66)	(34.88)	(13.99)	(-7.11)	
5	19.48	0.938	0.783	0.293	-0.143	0.975	17.14	0.934	0.775	0.304	-0.118	0.977
	(5.48)	(98.72)	(38.88)	(16.80)	(-8.73)		(5.21)	(93.96)	(39.95)	(23.07)	(-8.57)	
6	16.53	0.936	0.769	0.286	-0.133	0.975	17.11	0.939	0.775	0.311	-0.087	0.978
	(4.57)	(94.29)	(38.23)	(17.27)	(-7.69)		(5.15)	(107.92)	(39.61)	(20.11)	(-6.88)	
7	10.84	0.929	0.784	0.306	-0.071	0.973	19.39	0.948	0.798	0.308	-0.057	0.976
	(2.98)	(90.70)	(36.38)	(18.81)	(-5.24)		(5.69)	(103.65)	(40.29)	(21.47)	(-4.54)	
8	5.36	0.938	0.816	0.306	-0.019	0.965	20.40	0.954	0.886	0.324	-0.009	0.969
	(1.27)	(81.62)	(33.75)	(12.97)	(-1.00)		(4.94)	(92.23)	(35.97)	(18.12)	(-0.61)	
9	-1.82	0.962	0.907	0.310	0.077	0.956	20.47	0.984	0.990	0.332	0.032	0.960
	(-0.38)	(75.54)	(33.65)	(10.88)	(3.18)		(4.06)	(75.77)	(34.21)	(12.33)	(1.17)	
High	-14.53	1.017	1.138	0.331	0.256	0.926	14.39	1.047	1.212	0.333	0.144	0.932
	(-2.20)	(56.42)	(31.33)	(9.76)	(10.08)		(2.01)	(49.23)	(26.88)	(7.59)	(5.56)	
High - Low	-18.82	-0.058	-0.067	0.131	0.373	0.297	37.09	-0.001	0.145	0.135	0.286	0.176
	(-2.13)	(-2.04)	(-1.54)	(2.87)	(10.28)		(4.31)	(-0.00)	(2.92)	(2.35)	(5.00)	

Table X: Event-Time Three Factor Model Coefficient Estimates

The below table shows results from regressing the returns on acceleration decile portfolios on the Fama-French three factor model:

$$R_{T,T+\tau,d} - \theta_{T+\tau} = \alpha_{\tau,d} + b_{\tau,d}\left(MKT_{T+\tau} - \theta_{T+\tau}\right) + s_{\tau,d}SMB_{T+\tau} + h_{\tau,d}HML_{T+\tau} + \varepsilon_{T,T+\tau,d}$$

where T is a portfolio formation date, τ indexes the post-formation month, and $d \in \{1, 2, \ldots, 10\}$ is an acceleration decile. Therefore, $R_{T,T+\tau,d}$ is the return in month τ of the holding period on acceleration decile d when this decile is formed at T. θ is the risk-free rate and MKT, SMB, and HML are the usual Fama-French factor mimicking portfolios.

Panel A: Cumulative Intercepts (in percentages)

Decile	Month Relative to Portfolio Formation											
	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	-0.08	-0.26	-0.45	-0.66	-0.95	-1.44	-1.86	-2.24	-2.58	-2.91	-3.11	-3.13
	(-0.81)	(-1.86)	(-2.79)	(-3.60)	(-4.72)	(-6.61)	(-7.96)	(-9.03)	(-9.81)	(-10.46)	(-10.63)	(-10.25)
2	-0.03	-0.11	-0.16	-0.28	-0.35	-0.60	-0.87	-1.00	-1.17	-1.29	-1.35	-1.26
	(-0.36)	(-1.10)	(-1.25)	(-1.91)	(-2.20)	(-3.48)	(-4.64)	(-5.09)	(-5.61)	(-5.93)	(-5.92)	(-5.28)
3	0.08	0.04	-0.00	-0.00	-0.05	-0.25	-0.33	-0.36	-0.39	-0.43	-0.42	-0.30
	(1.45)	(0.50)	(-0.00)	(-0.01)	(-0.35)	(-1.77)	(-2.16)	(-2.18)	(-2.26)	(-2.36)	(-2.22)	(-1.49)
4	0.06	0.07	0.09	0.14	0.14	0.12	0.05	0.07	0.05	0.07	0.08	0.16
	(1.17)	(0.88)	(1.00)	(1.31)	(1.23)	(0.95)	(0.39)	(0.48)	(0.31)	(0.46)	(0.49)	(0.91)
5	0.08	0.13	0.16	0.18	0.20	0.23	0.25	0.32	0.41	0.48	0.59	0.71
	(1.61)	(1.98)	(1.95)	(1.93)	(1.89)	(2.03)	(2.02)	(2.46)	(3.01)	(3.29)	(3.86)	(4.48)
6	0.04	0.06	0.10	0.10	0.16	0.24	0.35	0.45	0.55	0.65	0.74	0.80
	(0.74)	(0.90)	(1.27)	(1.05)	(1.58)	(2.12)	(2.89)	(3.50)	(4.06)	(4.54)	(4.95)	(5.14)
7	0.04	0.13	0.20	0.27	0.31	0.46	0.62	0.75	0.90	1.07	1.20	1.25
	(0.90)	(1.86)	(2.49)	(2.89)	(2.90)	(4.04)	(4.94)	(5.64)	(6.44)	(7.25)	(7.70)	(7.73)
8	-0.01	0.09	0.18	0.28	0.45	0.70	0.97	1.20	1.42	1.58	1.71	1.78
	(-0.17)	(1.30)	(2.10)	(2.79)	(3.93)	(5.48)	(7.00)	(8.12)	(9.04)	(9.54)	(9.74)	(9.79)
9	0.03	0.16	0.32	0.53	0.71	1.07	1.40	1.59	1.82	2.03	2.24	2.33
	(0.53)	(1.84)	(3.00)	(4.32)	(5.10)	(6.88)	(8.32)	(8.89)	(9.64)	(10.25)	(10.93)	(10.91)
High	0.07	0.33	0.57	0.89	1.29	1.86	2.32	2.61	2.85	3.10	3.23	3.08
	(0.86)	(2.61)	(3.71)	(4.93)	(6.37)	(8.23)	(9.41)	(9.94)	(10.33)	(10.78)	(10.84)	(10.00)

Panel B: Market Factor (MKT)

Decile	Month Relative to Portfolio Formation											
	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.10	1.09	1.08	1.08	1.06	1.05	1.05	1.05	1.06	1.07	1.05	1.06
	(45.75)	(36.39)	(33.07)	(30.97)	(33.64)	(32.86)	(29.97)	(36.37)	(38.03)	(39.78)	(36.20)	(41.17)
2	1.03	1.04	1.02	1.00	1.02	1.00	0.97	0.98	0.99	1.00	1.01	1.01
	(53.07)	(43.41)	(34.90)	(34.00)	(33.69)	(35.51)	(38.48)	(39.99)	(45.69)	(53.64)	(49.63)	(59.60)
3	0.99	0.98	0.98	0.98	0.97	0.96	0.96	0.96	0.96	0.97	0.97	0.98
	(64.20)	(46.67)	(36.01)	(39.92)	(41.67)	(37.76)	(38.54)	(37.59)	(42.97)	(51.36)	(62.40)	(56.81)
4	0.99	0.98	0.96	0.95	0.96	0.96	0.95	0.94	0.96	0.94	0.96	0.97
	(53.81)	(48.51)	(50.53)	(50.47)	(44.10)	(50.28)	(50.81)	(50.98)	(49.27)	(62.48)	(56.66)	(61.64)
5	0.94	0.93	0.95	0.96	0.95	0.93	0.94	0.95	0.93	0.95	0.94	0.93
	(56.39)	(74.50)	(62.68)	(55.79)	(68.46)	(57.82)	(55.46)	(63.47)	(74.60)	(62.93)	(65.31)	(75.12)
6	0.93	0.94	0.94	0.95	0.94	0.94	0.94	0.94	0.94	0.94	0.94	0.94
	(48.58)	(64.24)	(72.68)	(65.60)	(60.87)	(79.59)	(81.06)	(76.23)	(67.65)	(76.89)	(74.72)	(72.52)
7	0.94	0.92	0.94	0.94	0.96	0.95	0.95	0.95	0.95	0.95	0.96	0.94
	(70.35)	(67.42)	(71.77)	(72.53)	(66.77)	(79.79)	(61.17)	(67.48)	(74.13)	(77.48)	(68.64)	(71.57)
8	0.94	0.93	0.94	0.94	0.95	0.96	0.96	0.93	0.95	0.96	0.96	0.95
	(62.94)	(60.49)	(62.58)	(64.49)	(70.24)	(63.49)	(60.61)	(67.01)	(66.03)	(70.39)	(52.56)	(60.64)
9	0.95	0.96	0.96	0.97	0.96	0.98	0.97	0.99	0.98	0.97	0.98	0.98
	(50.93)	(54.89)	(54.37)	(45.90)	(47.90)	(46.58)	(49.71)	(54.17)	(54.42)	(50.61)	(55.60)	(44.60)
High	1.00	1.01	1.02	1.01	1.02	1.03	1.05	1.05	1.04	1.03	1.02	1.02
	(37.56)	(40.34)	(36.53)	(32.65)	(30.73)	(31.10)	(34.47)	(34.22)	(41.57)	(43.27)	(38.99)	(37.64)

Table X Continued: Event-Time Three Factor Model Coefficient Estimates

Panel C: Size Factor (SMB)

Decile	Month Relative to Portfolio Formation											
	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	1.27	1.22	1.22	1.19	1.14	1.06	1.10	1.15	1.08	1.09	1.10	1.18
	(23.76)	(22.85)	(25.60)	(26.21)	(27.85)	(25.57)	(28.01)	(28.19)	(18.10)	(18.78)	(16.32)	(19.99)
2	1.04	0.99	1.02	1.01	0.99	0.90	0.95	0.94	0.89	0.88	0.91	1.00
	(20.75)	(24.52)	(22.29)	(24.28)	(20.10)	(29.71)	(19.06)	(28.14)	(20.38)	(21.82)	(17.58)	(26.18)
3	0.89	0.88	0.90	0.91	0.87	0.80	0.84	0.85	0.81	0.83	0.88	0.85
	(27.03)	(21.53)	(24.45)	(21.98)	(22.55)	(29.90)	(28.11)	(28.02)	(26.00)	(24.78)	(29.05)	(22.98)
4	0.82	0.83	0.86	0.79	0.84	0.79	0.84	0.81	0.83	0.81	0.81	0.86
	(25.48)	(26.63)	(24.30)	(28.74)	(21.50)	(27.95)	(14.67)	(24.55)	(22.63)	(30.37)	(29.63)	(20.43)
5	0.82	0.83	0.82	0.80	0.81	0.78	0.80	0.81	0.82	0.82	0.83	0.82
	(25.12)	(27.33)	(17.96)	(29.94)	(28.94)	(31.09)	(30.05)	(32.94)	(29.36)	(22.80)	(33.68)	(24.29)
6	0.83	0.79	0.78	0.81	0.78	0.79	0.81	0.79	0.78	0.82	0.79	0.80
	(30.00)	(25.97)	(34.12)	(19.13)	(31.11)	(31.63)	(29.45)	(29.60)	(30.09)	(22.79)	(29.09)	(30.26)
7	0.80	0.82	0.78	0.84	0.81	0.82	0.79	0.77	0.84	0.83	0.83	0.83
	(26.51)	(30.53)	(27.29)	(20.06)	(23.88)	(31.81)	(23.04)	(25.42)	(26.71)	(20.96)	(30.90)	(20.55)
8	0.83	0.82	0.82	0.84	0.84	0.89	0.86	0.88	0.92	0.84	0.89	0.81
	(30.22)	(27.51)	(27.31)	(27.05)	(22.90)	(27.41)	(19.70)	(24.14)	(23.66)	(28.18)	(14.58)	(26.98)
9	0.87	0.90	0.86	0.88	0.95	1.04	0.96	0.96	0.98	0.98	0.92	0.87
	(24.91)	(28.11)	(16.75)	(25.33)	(23.99)	(20.22)	(26.19)	(25.64)	(25.82)	(25.80)	(30.93)	(30.54)
High	1.07	1.06	1.09	1.06	1.11	1.24	1.18	1.16	1.15	1.14	1.10	1.01
	(22.38)	(20.09)	(20.90)	(14.21)	(15.57)	(19.34)	(19.27)	(21.08)	(24.75)	(23.74)	(28.17)	(24.13)

Panel D: Book-to-Market Factor (HML)

Decile	Month Relative to Portfolio Formation											
	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	0.30	0.24	0.22	0.23	0.18	0.17	0.19	0.30	0.24	0.32	0.25	0.32
	(5.28)	(4.57)	(4.87)	(5.19)	(4.42)	(4.55)	(4.79)	(7.77)	(3.32)	(4.70)	(3.12)	(5.03)
2	0.31	0.27	0.30	0.25	0.31	0.24	0.29	0.26	0.23	0.26	0.28	0.33
	(5.65)	(7.77)	(5.84)	(5.71)	(5.01)	(8.50)	(4.48)	(6.64)	(4.76)	(5.95)	(4.42)	(9.11)
3	0.30	0.30	0.30	0.30	0.30	0.26	0.28	0.26	0.28	0.27	0.35	0.33
	(10.37)	(7.39)	(8.72)	(5.81)	(6.34)	(9.84)	(9.56)	(9.13)	(9.10)	(7.06)	(13.31)	(10.10)
4	0.31	0.30	0.31	0.30	0.33	0.33	0.38	0.32	0.34	0.35	0.32	0.40
	(10.71)	(10.32)	(7.35)	(12.15)	(7.17)	(10.77)	(5.07)	(8.65)	(8.23)	(12.01)	(12.30)	(8.24)
5	0.32	0.32	0.36	0.35	0.36	0.32	0.33	0.35	0.33	0.35	0.34	0.38
	(9.32)	(9.99)	(6.15)	(13.96)	(12.33)	(15.28)	(18.56)	(15.20)	(11.69)	(8.08)	(14.70)	(10.52)
6	0.32	0.31	0.28	0.38	0.32	0.35	0.33	0.32	0.32	0.35	0.35	0.34
	(12.27)	(11.78)	(14.22)	(7.64)	(14.73)	(16.85)	(12.68)	(14.98)	(13.43)	(7.42)	(13.49)	(17.04)
7	0.30	0.33	0.32	0.38	0.36	0.34	0.32	0.28	0.35	0.33	0.33	0.37
	(8.95)	(12.01)	(12.95)	(7.34)	(11.89)	(16.92)	(8.50)	(8.45)	(8.73)	(6.72)	(11.99)	(7.24)
8	0.32	0.30	0.32	0.31	0.32	0.33	0.28	0.29	0.36	0.32	0.36	0.29
	(12.05)	(9.35)	(11.24)	(9.01)	(8.72)	(13.54)	(5.85)	(7.79)	(9.13)	(10.89)	(4.38)	(8.24)
9	0.25	0.29	0.29	0.28	0.31	0.36	0.31	0.36	0.35	0.30	0.26	0.22
	(6.55)	(9.38)	(4.65)	(7.67)	(7.80)	(6.11)	(9.24)	(11.02)	(8.58)	(7.58)	(8.03)	(7.75)
High	0.26	0.27	0.25	0.21	0.21	0.32	0.34	0.35	0.30	0.22	0.19	0.11
	(6.06)	(5.11)	(4.37)	(2.30)	(2.61)	(4.98)	(5.59)	(6.31)	(6.63)	(4.53)	(5.29)	(2.41)

Table XI: Event-Time Four Factor Model Coefficient Estimates

The below table shows results from estimating the regressions:

$$R_{T,T+\tau,d} - \theta_{T+\tau} = \alpha_{\tau,d} + b_{\tau,d}\left(MKT_{T+\tau} - \theta_{T+\tau}\right) + s_{\tau,d}SMB_{T+\tau} + h_{\tau,d}HML_{T+\tau} + m_{\tau,d}MOM_{T,T+\tau} + \varepsilon_{T,T+\tau,d}$$

where T is a portfolio formation date, τ indexes the post-formation month, and $d \in \{1, 2, \ldots, 10\}$ is an acceleration decile. Therefore, $R_{T,T+\tau,d}$ is the return in month τ of the holding period on acceleration decile d when this decile is formed at T. θ is the risk-free rate and MKT, SMB, and HML are the usual Fama-French factor mimicking portfolios. MOM is a momentum factor mimicking portfolio populated by the returns of acceleration-neutral firms.

Panel A: Cumulative Intercepts (in percentages)

Decile	Month Relative to Portfolio Formation											
	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	0.54	0.50	0.37	0.22	0.04	-0.24	-0.69	-1.09	-1.45	-1.77	-2.08	-2.28
	(5.15)	(3.39)	(2.16)	(1.15)	(0.17)	(-1.06)	(-2.83)	(-4.22)	(-5.32)	(-6.02)	(-6.96)	(-7.31)
2	0.45	0.54	0.55	0.59	0.54	0.53	0.34	0.11	0.01	-0.14	-0.26	-0.32
	(6.01)	(5.18)	(4.43)	(4.09)	(3.39)	(3.02)	(1.83)	(0.53)	(0.01)	(-0.66)	(-1.13)	(-1.34)
3	0.27	0.47	0.53	0.57	0.64	0.66	0.51	0.47	0.47	0.46	0.44	0.45
	(4.50)	(5.73)	(5.34)	(4.96)	(4.96)	(4.65)	(3.36)	(2.89)	(2.75)	(2.57)	(2.36)	(2.33)
4	0.27	0.47	0.57	0.68	0.79	0.87	0.90	0.86	0.92	0.91	0.95	0.96
	(5.38)	(6.45)	(6.47)	(6.81)	(7.13)	(7.10)	(6.83)	(6.06)	(6.06)	(5.71)	(5.72)	(5.57)
5	0.20	0.39	0.52	0.65	0.73	0.81	0.89	0.94	1.05	1.16	1.23	1.34
	(4.55)	(6.06)	(6.66)	(7.05)	(7,24)	(7.36)	(7,57)	(7.53)	(7.91)	(8.30)	(8.37)	(8.78)
6	0.12	0.27	0.36	0.47	0.53	0.65	0.77	0.90	1.03	1.15	1.25	1.34
	(2.64)	(4.17)	(4.62)	(5.25)	(5.24)	(5.87)	(6.47)	(7.16)	(7.76)	(8.20)	(8.52)	(8.77)
7	-0.03	0.06	0.19	0.32	0.45	0.53	0.72	0.91	1.07	1.25	1.42	1.54
	(-0.60)	(0.85)	(2.29)	(3.36)	(4.22)	(4.57)	(5.81)	(6.84)	(7.67)	(8.43)	(9.17)	(9.55)
8	-0.21	-0.17	-0.05	0.07	0.22	0.42	0.71	1.02	1.26	1.49	1.65	1.78
	(-4.02)	(-2.35)	(-0.57)	(0.67)	(1.88)	(3.32)	(5.13)	(6.86)	(8.06)	(8.98)	(9.51)	(9.75)
9	-0.35	-0.35	-0.24	-0.09	0.13	0.31	0.69	1.02	1.21	1.45	1.65	1.87
	(-5.47)	(-3.94)	(-2.22)	(-0.75)	(0.90)	(1.98)	(4.01)	(5.57)	(6.31)	(7.18)	(7.86)	(8.60)
High	-0.66	-0.70	-0.57	-0.43	-0.19	0.14	0.66	1.09	1.34	1.55	1.80	1.92
	(-6.97)	(-5.47)	(-3.67)	(-2.24)	(-0.95)	(0.63)	(2.73)	(4.14)	(4.84)	(5.36)	(5.96)	(6.17)

Panel B: Acceleration-Neutral Momentum Factor (MOM)

Decile	Month Relative to Portfolio Formation											
	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12
Low	-0.05	-0.05	-0.08	-0.07	-0.04	-0.03	-0.10	-0.06	-0.07	-0.09	-0.11	-0.03
	(-1.64)	(-1.28)	(-2.91)	(-2.10)	(-0.99)	(-0.75)	(-2.49)	(-1.33)	(-1.69)	(-2.24)	(-2.49)	(-0.62)
2	-0.17	-0.14	-0.13	-0.14	-0.14	-0.13	-0.13	-0.08	-0.09	-0.09	-0.06	-0.06
	(-4.58)	(-5.47)	(-6.25)	(-4.11)	(-3.84)	(-3.38)	(-4.00)	(-2.49)	(-2.74)	(-3.07)	(-2.02)	(-1.73)
3	-0.13	-0.14	-0.16	-0.14	-0.12	-0.12	-0.12	-0.10	-0.08	-0.11	-0.12	-0.12
	(-4.82)	(-7.25)	(-7.84)	(-4.39)	(-3.91)	(-3.67)	(-3.76)	(-3.04)	(-2.36)	(-4.60)	(-4.35)	(-5.10)
4	-0.14	-0.15	-0.15	-0.15	-0.12	-0.14	-0.10	-0.09	-0.09	-0.06	-0.10	-0.06
	(-6.88)	(-7.97)	(-8.85)	(-5.00)	(-4.60)	(-4.61)	(-3.43)	(-2.97)	(-3.72)	(-2.57)	(-3.71)	(-2.89)
5	-0.12	-0.13	-0.12	-0.15	-0.12	-0.13	-0.10	-0.10	-0.07	-0.07	-0.06	-0.09
	(-6.67)	(-7.85)	(-7.20)	(-3.93)	(-5.68)	(-6.27)	(-4.38)	(-4.34)	(-3.62)	(-3.51)	(-1.99)	(-4.00)
6	-0.14	-0.13	-0.10	-0.10	-0.12	-0.11	-0.09	-0.07	-0.08	-0.06	-0.04	-0.04
	(-5.26)	(-5.75)	(-8.17)	(-7.11)	(-5.87)	(-4.56)	(-5.12)	(-3.59)	(-3.77)	(-2.67)	(-1.94)	(-1.93)
7	-0.05	-0.06	-0.08	-0.09	-0.11	-0.10	-0.07	-0.09	-0.09	-0.05	-0.04	-0.04
	(-1.55)	(-2.37)	(-4.36)	(-4.90)	(-5.12)	(-5.08)	(-3.75)	(-4.37)	(-4.45)	(-2.86)	(-1.40)	(-0.99)
8	-0.01	-0.06	-0.03	-0.05	-0.09	-0.08	-0.08	-0.09	-0.04	-0.02	-0.03	-0.07
	(-0.48)	(-2.86)	(-1.00)	(-1.95)	(-4.00)	(-2.96)	(-4.12)	(-3.97)	(-1.75)	(-0.67)	(-1.20)	(-1.91)
9	0.06	0.03	0.02	0.03	-0.02	-0.01	-0.04	-0.02	-0.02	-0.02	0.02	0.02
	(2.01)	(1.06)	(0.76)	(0.63)	(-0.57)	(-0.18)	(-1.07)	(-0.59)	(-0.61)	(-0.85)	(0.38)	(0.74)
High	0.17	0.14	0.18	0.17	0.14	0.15	0.07	0.08	0.07	0.10	0.06	0.13
	(5.25)	(4.82)	(7.01)	(4.44)	(3.06)	(3.04)	(1.51)	(1.61)	(1.79)	(2.85)	(1.60)	(3.70)

Table XII: Performance of Acceleration Strategies in the Full Sample

The below table shows performance measures for different acceleration strategies. At the end of each month, we implement a long-short strategy in a set of stocks and then measure the cumulative return over the next twelve months. The first strategy is labeled "Mom" and refers to a conventional univariate six-month momentum strategy based on long and short deciles. The other three strategies (denoted 10%, 20%, and 30%) refine the univariate momentum strategy in a particular way. The $X\%$ strategy forms a long (short) portfolio from the interesection of the top (bottom) momentum decile with the $X\%$ of firms with highest (lowest) acceleration. The columns labeled "Return Difference" measure the returns of the three acceleration strategies relative to *matched* univariate momentum strategies. The matching routine ensures that the same number of firms are assigned to the long and short portfolios that constitute both the acceleration and momentum strategies. For instance, in January 1990 for the Rank Lag 0/10% strategy there are 165 firms in the short portfolio and 309 firms in the long portfolio. The return difference for this date measures the difference between this strategy and investing in a strategy that is long the top 309 momentum firms and short the bottom 165 momentum firms. The Sharpe ratios are computed using three month T-Bill rates in the numerator and are corrected for non-zero autocovariances due to overlapping observations. The numbers in square brackets present the Sharpe ratios of the matched momentum strategies. The bottom two rows show the time-series means of the number of firms included in the long and short portfolios.

Panel A: Rank Lag 0 Months

Event	Cumulative Returns				Return Difference			Sharpe Ratios			
Month	Mom	10%	20%	30%	10%	20%	30%	Mom	10%	20%	30%
+1	0.52	0.38	0.48	0.49	-0.04	0.01	0.01				
+2	1.60	1.36	1.52	1.55	-0.21	-0.12	-0.06				
+3	2.68	2.39	2.55	2.64	-0.39	-0.20	-0.06				
+4	3.71	3.39	3.59	3.69	-0.47	-0.25	-0.10				
+5	4.63	4.49	4.60	4.68	-0.44	-0.31	-0.11				
+6	5.84	6.09	6.02	6.06	-0.21	-0.23	-0.03	0.428	0.431	0.430	0.448
+7	6.84	7.41	7.24	7.15	0.03	-0.08	0.00		[0.393]	[0.422]	[0.431]
+8	7.49	8.23	8.02	7.94	0.04	0.01	0.09				
+9	8.04	9.01	8.70	8.57	0.31	0.17	0.15				
+10	8.62	9.78	9.38	9.26	0.55	0.28	0.32				
+11	8.75	10.04	9.60	9.46	0.65	0.30	0.34				
+12	8.29	9.55	9.16	8.97	0.80	0.43	0.34	0.385	0.484	0.470	0.458
									[0.355]	[0.381]	[0.388]
N Short	266	101	160	197							
N Long	267	167	211	229							

Panel B: Rank Lag 6 Months

Event	Cumulative Returns				Return Difference			Sharpe Ratios			
Month	Mom	10%	20%	30%	10%	20%	30%	Mom	10%	20%	30%
+1	0.52	1.62	1.43	1.25	1.58	1.02	0.82				
+2	1.60	3.63	3.23	3.04	2.81	1.77	1.39				
+3	2.68	5.42	4.94	4.61	2.88	1.97	1.72				
+4	3.71	6.79	6.39	6.01	3.25	2.55	2.03				
+5	4.63	7.70	7.53	7.24	3.82	2.87	2.40				
+6	5.84	8.74	8.61	8.34	3.44	2.34	2.10	0.428	0.479	0.573	0.630
+7	6.84	9.19	9.12	8.97	2.74	1.58	1.46		[0.200]	[0.325]	[0.355]
+8	7.49	9.61	9.60	9.52	2.63	1.19	1.20				
+9	8.04	9.56	9.86	9.78	2.16	0.97	1.11				
+10	8.62	9.50	9.91	9.97	1.81	0.60	0.89				
+11	8.75	9.21	9.55	9.72	1.78	0.21	0.55				
+12	8.29	9.11	9.51	9.56	2.62	1.11	1.29	0.385	0.259	0.343	0.434
									[0.147]	[0.295]	[0.304]
N Short	266	38	63	84							
N Long	267	35	62	85							

Figure 1: Cumulative Post-Formation Returns to Acceleration Deciles

The plot presented below illustrates raw cumulative returns to decile portfolios based on acceleration. At the end of each month in the sample, we measure the acceleration of each firm with return data available over the previous year. We then form decile portfolios from ranking firms on acceleration. We skip one month before the holding period to attenuate potential biases due to low liquidity. The decile portfolio returns are computed as equal-weighted, buy-and-hold returns. The numbers underlying this plot are contained in Panel A of Table III.

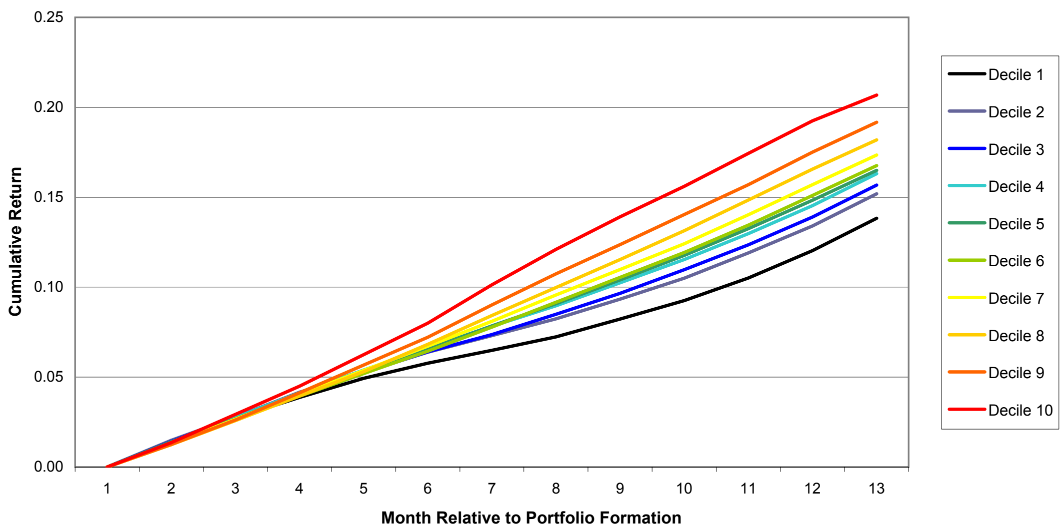


Figure 2: Net Cumulative Post-Formation Returns to Acceleration Deciles

The plot presented below illustrates cumulative returns to decile portfolios constructed from rankings on acceleration. The returns are equal-weighted, buy-and-hold returns and are shown net of the returns on a set of benchmark portfolios. These benchmark portfolios are six-month momentum decile portfolios that include only acceleration-neutral firms (those with an absolute value of acceleration placing them in the bottom 30% of the sample). Returns on the acceleration-neutral momentum deciles are computed as equal-weighted, buy-and-hold returns. For each portfolio formation date, a firm is matched to the appropriate benchmark portfolio on the basis of its six-month momentum. We then subtract the cumulative return on the benchmark portfolio from the cumulative return on the matched firm for each of the months in the holding period. Finally we average returns across firms in each portfolio and then average again across portfolio formation dates. The underlying numbers are from Table VIII, Panel B.

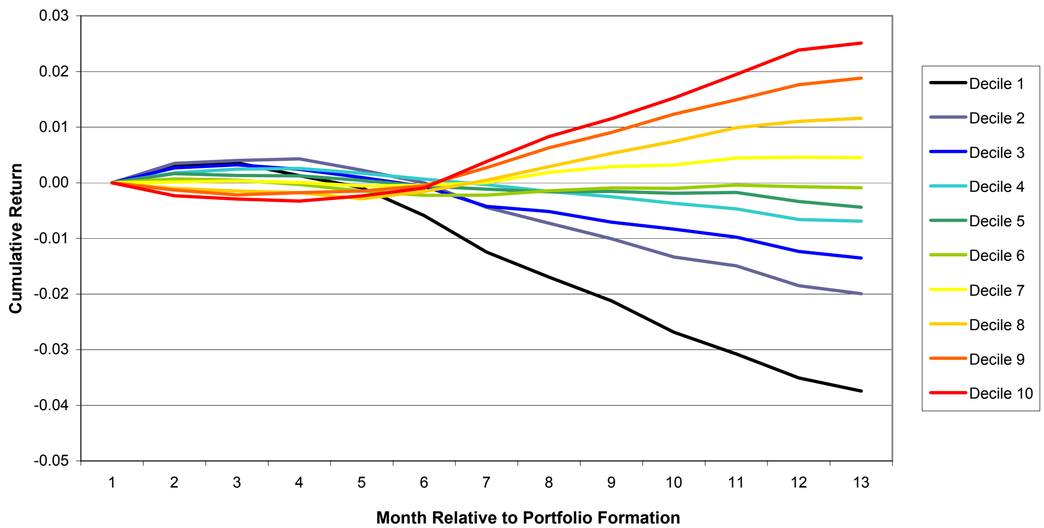
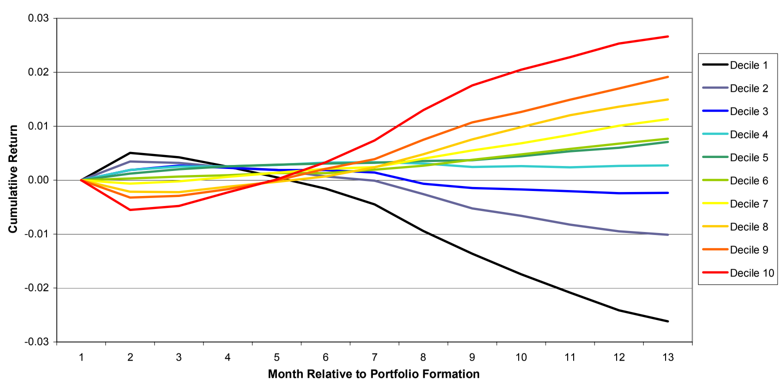


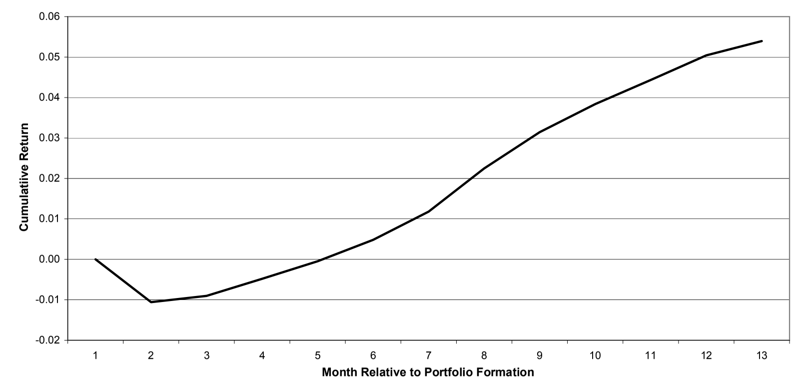
Figure 3: Cumulative Event-Time Alphas and Adjusted Hedge Portfolio Returns

The below plots illustrate cumulative abnormal returns to acceleration decile portfolios and acceleration hedge portfolios during the first year of the post-formation holding period after using multivariate controls. Panel A shows the abnormal returns associated with each decile when benchmarked against the standard Fama-French three factor model. Panel B shows the cumulative abnormal profits, relative to the three factor model, associated with a strategy that purchases firms in the top acceleration decile and shorts those in the bottom acceleration decile. Panel C (Panel D) is analogous to Panel A (Panel B) but uses a four-factor model as a benchmark. The four factor model augments the three factor model by including observations on momentum factors that are built using only acceleration-neutral firms and are matched to the acceleration decile returns in both calendar and event time.

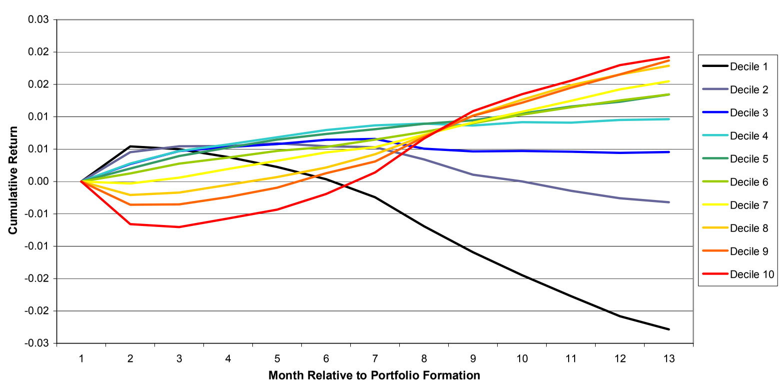
Panel A: Three Factor Model Cumulative Alphas



Panel B: Three Factor Model Adjusted Cumulative Hedge Portfolio Profts



Panel C: Four Factor Model Cumulative Alphas



Panel D: Four Factor Model Adjusted Cumulative Hedge Portfolio Profits