

# Does Innovation Explains Momentum and Reversal Effect?

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## ABSTRACT

This essay employs firm size, book-to-market and R&D intensity, as a proxy for growth options, to explain momentum anomaly. 1) It shows that momentum effect is less significant in recent years. 2) The returns of large and medium winners/losers tend to sustain, while small winners/losers tend to reverse quickly. 3) It also shows that R&D investment enhance the reversal effect of small firms, especially in high-tech industries.

**Keywords:** Asset pricing, Portfolio Returns, Momentum, Firm Characteristics

## 1. INTRODUCTION

Momentum effect generally refers to the phenomenon that stocks that perform the best in the recent past continue to perform well in the future. According to the Jegadeesh and Titman (1993), strategies which buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generate significant positive returns over 3- to 12-month holding periods. Briefly, past winner (loser) keeps the winner (loser) position, where winner (loser) is ranked by prior returns. Momentum phenomenon has received attentions for a long time, and scholars mainly explain this phenomenon from behavioral or rational theories (Johnson, 2002a, Hong and Stein, 1999).

We join the search for an explanation of the momentum phenomenon, employing firm size and firm growth option, and this might shed a light to the rational explanation camp. Berk et al. (1999) and Sagi and Seasholes (2007) suggest that firm growth option affects the risks and expected returns of stocks. Moreover, prior studies suggest that R&D investment provides significant return premium to corporations (Ali et al., 2012, Chan et al., 2001b, Chauvin and Hirschey, 1993). For instance, Chan et al. (2001b) present that past losers who are invest heavily on R&D tend to be undervalued. Hence, this paper will examine the market valuation of R&D investment and its impact on momentum portfolios.

The main purpose of this study is to investigate the short-term momentum. This study is built on Berk et al. (1999) and Sagi and Seasholes (2007). While Sagi and Seasholes (2007) use market-to-book as the proxy of growth option, this paper employ R&D as the proxy for growth options, following Cao et al. (2008) and Kraft et al. (2013).

First, this paper shows the performance of JT momentum strategies over 1963-2011, 1963-1989 and 1989-2011 respectively. It shows that momentum effect is less significant over the recent years. It also shows that large firms mainly contribute to the positive returns, whereas small firms do not have significant momentum before 1989 and tend to reversal after 1989. Second, this paper presents that firm size influences momentum strategies. We conclude it from the difference of equally-weighted and value-weighted strategies. Moreover, when testing the performance of double-sorting on firm size and prior returns, it turns out that the enhanced momentum strategies outperform the single-sort momentum strategies. Briefly, the returns of large and medium winners/losers tend to sustain, while small winners/losers tend to reverse quickly. The further test of ex-1989 and post-1989 periods shows that the momentum effect mainly attributes to the effect of large-cap and medium-cap firms over ex-1989 period, while the short-term reversal becomes significant among small-cap firms over the recent period.

Third, this paper test momentum strategies double-sort on BM and past returns, for longer look-back and holding periods, uses equally-weighted and value-weighted methods. Consistent with Sagi and Seasholes (2007), in all full sample period and sub-periods, low BM momentum portfolios significantly outperform high BM momentum portfolios. Also, it shows that the

momentum effect is less significant over post-1989 period, as mentioned earlier. More importantly, the results suggest that small firms with high-BM contribute to the reversal phenomenon reported earlier.

Finally, this paper examines the R&D effect in explaining momentum effect, controlling firm size, and industry effect. It shows the return of momentum strategies of four R&D-assigned groups, of 3\*3 groups double-sorts on Size and R&D, and then of 2\*3\*3 groups conditioning industry technology requirement. Above all, the results indicate that R&D investment enhance the reversal effect of small firms. Then, we find that this effect is especially strong in high-tech industries.

The rest of the paper is organized as follows. Section 2 provides the literature review of the momentum phenomenon. Section 3 explains the risks and returns associate with R&D, and the factors related to R&D effect. Section 4 introduces the data sample, and section 5 explains the details of trading strategies. Section 6 presents the empirical results and discussion. Section 7 concludes.

## 2. LITERATURE

Momentum has also been shown to be robust across national financial markets (Rouwenhorst, 1998, Chui et al., 2010, Griffin et al., 2003). Novy-Marx (2012) finds momentum strategies that trade industries, investment styles, international equity indices, commodities, and currencies all exhibit the same phenomena. Existing explanations for these “abnormal” returns are that they are due to behavioral biases, risk premia for omitted state variables or market friction.

### Behavioral Explanation

Some scholars employ psychology concepts and principles to explain momentum returns from investor side. They argue that there is no smart trader in the market, even those who have received professional training. According to psychological literature, cognitive biases may sometimes lead to perceptual distortion, inaccurate judgment, illogical interpretation, or what is broadly called irrationality (Ariely and Jones, 2008). DeBondt and Thaler (1985) argue that not all investors in the market are rational, however, noise traders in the market actually are influenced by psychological bias. As a result, superior returns are generated by arbitrage of mispricing. Stocks are commonly underpriced or overprice by investor who cannot incorporate information to price instantly and correctly.

Many models of the behavioral theory are typically built on psychological theories, including self-attribution, representative, conservatism and so forth. On the one hand, one camp suggests that momentum phenomenon is a symptom of underreaction—investors react to news and incorporate information into prices slowly (Chan et al., 1996). Barberis et al. (1998) suggested that the conservatism bias in isolation leads to underreaction. Hong and Stein (1999) model a market populated by two types of agents, “newswatchers” and “momentum traders”, which react only to either news or historical price respectively. The gradual-information-diffusion model predicts a reflection delay of information, and the price underreacts in the short run.

On the other hand, some researchers document that prices initially overreact to news about fundamentals or events, such as the positive-feedback-trader model of Long et al. (1990) and the overconfidence model of Daniel et al. (1998). DeBondt and Thaler (1985) argue that people tend to “overreact” to unexpected and dramatic news events, employing experimental psychology to against Bayes’ rule. Similarly, Jegadeesh and Titman (2001) provide supports for the behavioral models that propose that momentum profits are due to delayed overreactions that are eventually reversed.

### Rational Explanation

In classical pricing theory stream, scholars employ potential risks to explain momentum phenomenon. From the classical pricing theories, investors make investment decision based on the expected returns which are related to risks and state possibilities. Even the Fama-French three-factor model may fail to explain momentum profit, there can be some omitted risk proxies. Berk et al. (1999) present a model that the returns to contrarian or momentum strategies are compensation for bearing systematic risks that change in predictable ways. Similarly, Johnson (2002b) presents that a standard model of firm cash-flows discounted by an ordinary pricing kernel can deliver a strong positive correlation between past realized returns and current expected returns.

Some empirical studies suggest that observable attributes, on firm-level, industry-level or broader scope, drive momentum. Sagi and Seasholes (2007) show that enhanced momentum strategies that use firms with high revenue growth volatility, low costs, or valuable growth options outperform traditional momentum strategies by approximately 5% per year. Novy-Marx (2012)

finds momentum strategies that trade industries, investment styles, international equity indices, commodities, and currencies all exhibit the same phenomena. Moskowitz and Grinblatt (1999) find industry momentum investment strategies, which buy stocks from past winning industries and sell stocks from past losing industries, appear highly profitable.

### **Other Explanations**

Despite the risk explanation and behavioral explanation, some studies suggest that momentum only exists over a certain period. Hwang and Rubesam (2015) suggest that the momentum premium has disappeared since the late 1990s. George and Hwang (2007) suggest that long-term reversals in U.S. stock returns are better explained as the rational reactions of investors to locked-in capital gains than an irrational overreaction to news. Kaul and Nimalendran (1990) argue that bid-ask errors in transaction prices are the predominant source of apparent price reversals in the short run for NASDAQ firms.

Some other scholars argue that bad-model errors in expected returns grow faster with the return horizon than the volatility of returns. Conrad and Kaul (1993) show that the returns to the typical long-term contrarian strategy implemented in previous studies are upwardly biased because they are calculated by cumulating single-period (monthly) returns over long intervals.

### **3. GROWTH OPTIONS OF R&D INVESTMENT**

This paper develops the risk explanation of momentum. According to this theoretical model, the average systematic risk of firm, which is determined by all projects in the firm together, is not constant over time. Berk et al. (1999) use a dynamic model to explain that the choice between assets and growth option affects a firm's systematic risk and its expected returns.

The average systematic risk of the firm changes by starting new investments. The risks followed by new investments then reflected on the stock price. Sagi and Seasholes (2007) present two Schemes about stock price increase and firm systematic risks. Obviously, associate with price rise, risky asset can bring higher systematic risk, while risk-free asset lower systematic risk. Therefore, the comparison of current firm risk and potential risks brought by new project would have crucial impact on stock price.

Regarding firm investment, R&D investment is a typical risky and popular activity in recent years, especially after the technology boom in 90s. Prior studies have shown positive excess returns associate with R&D activities, and some scholars suggest that the excess return is the compensation of additional risks (Lev and Sougiannis, 1996, Chambers et al., 2002). Simpson et al. (2006) show that investing in research and development is of increased cost and high market risks, like product failures and intense competition. Also, R&D-intensive firms' risk increases with their financial constraints, since R&D investment is often much less flexible and often determined by science and/or regulation (Li, 2011). Most importantly,

R&D investments are risky assets that sacrifices existing assets in exchange of expected future growth, therefore, R&D firms have more growth options than non-R&D firms (Kraft et al., 2013).

#### **Size Impact and R&D Risk**

Prior studies show that momentum returns vary over different firm size categories. Hong et al. (2000) find that once one moves past the very smallest stocks, the profitability of momentum strategies declines sharply with firm size. Novy-Marx (2012) illustrates the smallest 10% of stocks, which make up only 0.14% of the market by capitalization, exhibit no momentum. Jegadeesh and Titman (2001) find strong evidence of return reversals for small firms, but the evidence is somewhat weak for large firms, particularly when we evaluate portfolio performance relative to the Fama and French (1993) benchmark. Also, Fama and French (2012) document the winner minus loser spreads in average momentum returns decrease from smaller to larger stocks.

Regarding R&D effect to large-cap and small-cap firms, there are different views. On the one hand, Chauvin and Hirschey (1993) suggest that size advantages make advertising and R&D relatively more profitable for larger firms, while smaller firms do not appear to be precluded from making profitable investments in advertising and R&D. Similarly, Rubera and Kirca (2012) suggest that the positive effects of firm innovativeness on market position and financial position are stronger for larger firms, due to market position and reputation effect. On the other hand, Phillips and Zhdanov (2013) shows that small firms optimally may decide to innovate more when they can sell out to larger firms, whereas large firms may find it easy to obtain access to innovation through acquisition. Innovativeness is more critical for small firms' survival and growth, and is a signal that small firms have the capability to improve over time and increase the firm values (Rubera and Kirca, 2012). Large firms may find it disadvantageous to engage in an "R&D race" with small firms, as they can obtain access to innovation through acquisition.

Phillips and Zhdanov (2013) show that the R&D responsiveness of firms increases with demand, competition, and industry merger and acquisition activity, and that all of these effects are stronger for smaller firms than for larger firms.

Therefore, the R&D and size effect on momentum returns is not that simple. For large firms, R&D investment is relatively less risky, since the amount of the R&D value comparing with firm value is relatively small. Large firms have higher ability in raising money and addressing financing issues. The potential failure possibility of one innovation project will not bring large crisis. Therefore, R&D expense does not trigger big problems and risks on regular operation for them. For small firms, they are easier to come across financial problems. Firms experience poor past performances tend to be riskier when they invest in R&D, than those experience good past performance. R&D investment is a plus to the firm risks. If the R&D procedure fails, it can bring bankrupt to small firms.

### Industry Difference

Prior studies find that technology or industry may play a role in momentum phenomenon. Moskowitz and Grinblatt (1999) find industry momentum investment strategies, which buy stocks from past winning industries and sell stocks from past losing industries, appear highly profitable. Hwang and Rubesam (2015) report that the momentum strategy yields the highest profit among the high-tech bubble of the 1990s and 10 years after the bubble.

While considering R&D investment, its effect varies largely over industries, since different industries have distinct innovation frequency requirement. Chan et al. (2001b) suggests science- and knowledge-based industries are especially active in R&D investment. In high-tech industries (i.e., industries with high dependence on science and technology), innovation is the essential element of competition, thus firms are forced to constantly introduce new products to meet rapidly changing consumer needs (Rubera and Kirca, 2012). The market would automatically kick the firm out, based on the satisfaction of customers, if it fails to innovate. Eisenhardt and Martin (2000) identify the importance of long-term competitive advantage in dynamic and high-velocity markets. In contrast, the pressure of consistently introduce new products are less in low-tech industries (i.e., industries with low dependence on science and technology), accordingly customers are less sensitive to innovativeness (Mizik and Jacobson, 2003). Therefore, the same level of R&D expenses would contribute more returns to firms that operate in high-tech industries than to firms in low-tech industries.

The R&D premium also differs over industries. Jiang (2010) find extreme intangible returns in the high-tech industry, like computers, software, and electronic equipment, and almost zero intangible returns in the utilities industry. It indicates that the intangible information is consistent with different financial performance towards technology-oriented and non-technology-oriented firms. According to Chan et al. (2001b), some industries have significantly high value of R&D capital/book value percentage comparing with average value among all firms. Nelson (2006) conducts a four factor regression which replaced Fama-French HML variable with R&D and ADS factors in 48 industries separately, and the results shows that this intangibles model explains beats the three factor model in industry level.

## 4. DATA

This study employs quarterly research and development expenditure (R&D), sales and book equity from the COMPUSTAT, and merges them with monthly stock returns, shares outstanding and stock prices of all US stocks from CRSP. Quarterly returns for each company are calculated based on the monthly returns. The market value of equity at quarter t-1 is calculated by multiplying stock price by the number of shares outstanding at the end of quarter t-1, and then is used for the weight of portfolio at quarter t. The full data set covers all observations we can get from COMPUSTAT and CRSP over December 1962 to December 2012.

R&D intensity is captured as the prior year R&D value divided by prior year sale, following Chambers et al. (2002). Stocks are divided into two groups, one has no R&D investment, *Non-R&D group*, and the other has R&D data, *R&D group*. The Non-R&D group contains observations with zero or missing R&D value, following Warusawitharana (2015). The R&D group is then assigned into five quintiles based on the breakpoints of firm R&D intensity (20<sup>th</sup>, 40<sup>th</sup>, 60<sup>th</sup>, 80<sup>th</sup> and 100<sup>th</sup> percentile respectively).

## 5. TRADING STRATEGIES

This study employs three momentum trading strategies introduced below. The first momentum strategy is traditional momentum following Jegadeesh and Titman (1993), while the other two strategies are enhanced momentum considering firm-specific

attributes. For each strategy, both equally-weighting and value-weighting methods are used to weighting portfolios, ensuring that the results are not overly influenced by small firm effect. Unrestricted momentum portfolios are rebalanced monthly, while other portfolios are rebalanced quarterly.

### **5.1. Unrestricted Momentum**

Unrestricted momentum portfolios are firstly duplicated, following Jegadeesh and Titman (1993). Firms are ranked into five quintiles from highest to lowest based on their cumulative past returns during a certain period, 1, 2, 3, or 4 quarters respectively. Stocks in the top quintile are “winners” with highest past returns, and stocks in the bottom quintile are “losers” with lowest past returns. At the beginning of each quarter, we form the momentum portfolio that buys past winners and sells past losers, and portfolios are rebalanced monthly. Each portfolio is held for a period from 1 to 4 quarters.

### **5.2. Firm-specific Attributes**

Firms are ranked into three groups according to a firm-specific attribute at the beginning of each quarter. Three different firm-specific proxies, firm size, market-to-book and R&D, are tested in this study. Three groups are formed according to size/BM value as introduced above, while four groups are formed based on R&D level. Within each group classified by single firm-specific attribute, stocks are sorted into “winner/loser” quintiles for calculating winner-minus-loser portfolios. Portfolios double-sorted by size are monthly rebalanced, while other portfolios are rebalanced quarterly.

### **5.3. Size- and R&D-restricted**

To observe the momentum phenomenon and R&D effect in small and large firms respectively, stocks are independently double-sorted by market equity and R&D level. The 30 percent largest firms are assigned into “Large-cap”, the 30 percent smallest firms are assigned into “Small-cap”, and the middle part is assigned into “Medium-cap” group. Similarly, R&D firms are ranked in descending order regarding R&D level, and assigned into “High-R&D”, “Medium-R&D” and “Low-R&D”, while Non-R&D group includes observations with zero or missing R&D value. Hence, the combination generates 3\*4 subgroups conditioning on market equity and R&D intensity. Then, within each subgroup, firms are sorted into “winner/loser” quintiles for calculating winner-minus-loser portfolios.

### **5.4. Size-, R&D and Industry-restricted**

Because the impact of R&D differs from high-tech industry and low-tech industry, a further test is conducted to show the effect of industry technology. Stocks are firstly assigned into high-tech or low-tech industries, following Chan et al. (2001b), and then classified by firm size and R&D intensity as introduced in 4.3. Winner-minus-loser portfolios are then formed within each sub-group.

## **6. EMPIRICAL RESULTS**

### **6.1. Momentum Profits**

We start by examining unconditional momentum strategies over different periods. Table 4.1 shows the results of unrestricted momentum returns of full-sample period, ex-1989 and post-1989 periods. In full-sample period, value-weighted momentum strategies produce significant positive returns, while equally-weighted momentum strategies do not. Excepting 3-3 strategy, all other momentum strategies generate around 0.42%-0.83% per month. However, the results of the two sub-periods are largely different. In ex-1989 period, the momentum is even more significant than the whole period. Some value-weighted strategies pay more than 1% per month. In post-1989 period, the momentum phenomenon tends to be less significant and unlike. Only some value-weighted strategies generate positive returns, and 12-12 equally-weighted strategy produces significant negative returns, about -0.67% ( $t=-2.08$ ).

These finding suggest that large firms mainly contribute to the positive returns, especially before 1989. Small firms show less momentum before 1989, and tend to reverse after 1989.

Table 4.1 compares the momentum returns between using equally-weighted and value-weighted methods. It shows that value-weighted momentum strategies generate significant positive returns, while equally-weighted strategies do not produce significant returns. Large winners/losers are more likely to sustain the drift than small winners/losers.

**Table 4.1: Unconditional momentum strategy returns**

		Momentum strategy							
Equally-weighted		Holding period				Value-weighted			
		3	6	9	12	3	6	9	12
The whole period									
LB	3	-0.0038	-0.0009	-0.0001	0.001	0.0027	0.0042	0.0046	0.0054
	3	-1.66*	-0.46	-0.04	0.63	0.98	1.93*	2.37 **	3.10***
	6	0.0002	0.0019	0.0025	0.0017	0.0055	0.0079	0.008	0.0066
	6	0.07	0.79	1.16	0.89	1.81*	3.04***	3.34***	3.05***
	9	0.0011	0.0025	0.0012	-0.0003	0.0063	0.0082	0.0069	0.0051
	9	0.39	1.01	0.5	-0.15	1.99**	2.96***	2.61***	2.08**
	12	0.0012	0.0006	-0.0011	-0.0021	0.0081	0.0083	0.0064	0.0055
	12	0.42	0.25	-0.45	-0.92	2.47**	2.74***	2.24**	2.11**
Before 1989									
LB	3	-0.0041	0.0001	0.0017	0.0032	0.0029	0.004	0.0053	0.006
	3	-1.5	0.03	0.84	1.67*	0.85	1.66*	2.42**	2.80***
	6	0.0021	0.0034	0.0048	0.0042	0.0073	0.0096	0.0099	0.0088
	6	0.63	1.18	1.88*	1.80*	1.94*	3.17***	3.43***	3.45***
	9	0.0019	0.0048	0.0037	0.0031	0.0073	0.0109	0.0104	0.0087
	9	0.54	1.62	1.25	1.12	1.82*	3.45***	3.33***	2.70***
	12	0.004	0.0046	0.0033	0.0033	0.0099	0.0128	0.0116	0.0102
	12	1.16	1.49	1.01	1.11	2.51**	3.87***	3.58***	3.29***
After 1989									
LB	3	-0.0034	-0.0024	-0.0021	-0.0014	0.0033	0.0055	0.0051	0.0053
	3	-0.99	-0.77	-0.74	-0.59	0.79	1.61	1.66*	1.98**
	6	-0.0007	0.0002	-0.0001	-0.0008	0.0056	0.0074	0.0068	0.0053
	6	-0.18	0.06	-0.02	-0.29	1.2	1.84*	1.83*	1.6
	9	0.0009	-0.0003	-0.0018	-0.0035	0.006	0.0061	0.0039	0.0017
	9	0.22	-0.07	-0.52	-1.13	1.29	1.41	0.96	0.45
	12	-0.0009	-0.0034	-0.0058	-0.0067	0.0075	0.0052	0.0024	0.0019

Each quarter, from 1963:Q1 to 2011:Q2, stocks are assigned into 5 quintiles, from winner to loser, based on past cumulative lag returns. 16 trading strategies are considered based on look-back period (LB) and holding period. Both equally-weighted and value-weighted are employed, and the weight used for value-weighted strategy is the market equity at t-1 quarter. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

The result is consistent with Sagi and Seasholes (2007) that momentum effect is robust using quarterly Compustat data and value-weighted trading method. However, according to the return differences generated from equally-weighted and value-weighted strategies, firm size may play an important role in momentum trading strategy.

## 6.2. Firm Size

To address the question that how firm size affects momentum phenomenon, this part double-sort stocks by firm size and past returns, and replicate the strategies within different sub-periods. Stocks are firstly assigned into three groups (Large, Medium and Small) based on their market equity at the end of last quarter, and then by past returns. The returns of large and medium winners/losers tend to sustain, while small winners/losers tend to reverse quickly.

Table 4.2 shows momentum profits conditioning on different firm size. Associate with the predication, in large-cap group, the momentum returns are significant positive, using both equally-weighted and value-weighted methods. The results remain the same in medium-cap group. In small-cap group, the value-weighted portfolios show no significant returns, whereas equally-weighted momentum portfolios generate significant negative returns. These results are consistent with the predication that small firms are more likely to reverse while large firms are more likely to drift.

**Table 4.2: ME-assigned momentum strategy returns**

		ME-assigned Momentum							
Equally-weighted		Holding period				Value-weighted			
		3	6	9	12	3	6	9	12
High ME									
LB	3	0.0027	0.0028	0.004	0.0043	0.0023	0.0031	0.0041	0.0046
	3	1.09	1.42	2.25**	2.82***	0.84	1.46	2.21**	2.79***
	6	0.0044	0.0054	0.0064	0.0048	0.0036	0.0058	0.007	0.0052
	6	1.64	2.37**	3.01***	2.51**	1.25	2.45**	3.20***	2.58***
	9	0.0058	0.0064	0.0055	0.0037	0.0063	0.0069	0.0061	0.0047
	9	2.08**	2.61***	2.38**	1.78*	2.14**	2.72***	2.57**	2.16**
	12	0.006	0.0054	0.004	0.0029	0.0061	0.005	0.0045	0.0035
	12	2.10**	2.14**	1.72*	1.35	2.05**	1.89*	1.84*	1.56
Medium ME									
LB	3	0.0052	0.0056	0.0047	0.005	0.0057	0.0058	0.0048	0.0049
	3	2.16**	2.67***	2.46**	3.24***	2.32**	2.83***	2.47**	3.05***
	6	0.0086	0.0088	0.0074	0.0054	0.0093	0.0089	0.0074	0.0057
	6	3.00***	3.41***	3.14***	2.78***	3.32***	3.49***	3.09***	2.85***
	9	0.0098	0.0088	0.0058	0.0039	0.0106	0.0088	0.0059	0.0042
	9	3.20***	3.27***	2.38**	1.86*	3.45***	3.23***	2.35**	1.96*
	12	0.01	0.0078	0.0048	0.0033	0.011	0.0082	0.0053	0.0039
	12	3.48***	2.93***	1.94*	1.52	3.77***	3.06***	2.08**	1.73*
Low ME									
LB	3	-0.0129	-0.0071	-0.0052	-0.0034	-0.0021	0.0006	0.0008	0.0012
	6	-0.0122	-0.0071	-0.0045	-0.004	0.0008	0.002	0.0029	0.0016
	6	-3.36***	-2.06**	-1.5	-1.44	0.22	0.58	0.94	0.5
	9	-0.0098	-0.006	-0.0057	-0.0066	0.0021	0.0022	0.001	-0.0005
	9	-2.72***	-1.77*	-1.87*	-2.40**	0.61	0.66	0.33	-0.2
	12	-0.0091	-0.0072	-0.0083	-0.0089	0.0017	0.0005	-0.0017	-0.0031
	12	-2.55**	-2.09**	-2.55**	-3.05***	0.5	0.15	-0.51	-1.05

The stocks are firstly assigned into two groups based on ME. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on past cumulative lag returns at each quarter, from 1963:Q1 to 2011:Q2. For each ME-assigned group, 16 trading strategies are considered based on look-back period (LB) and holding period. Both equally-weighted and value-weighted are employed, and the weight used for value-weighted strategy is the market equity at t-1 quarter. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

For a deeper insight, we replicate the trading strategies for periods before and after 1989. Table 4.3 shows the portfolio returns of momentum strategies double-sort on size and prior returns, over ex- and post-1989 period. For large and medium firms, the momentum effect is significant positive before 1989, but less significant after 1989. For small firms, there are some value-weighted momentum strategies producing positive returns before 1989, while equally-weighted momentum strategies produce significant negative returns after 1989. In other words, small-cap firms experience significant reversal after 1989. Hence, the momentum profits mainly attribute to large-cap and medium-cap firms, and become less significant over the recent years. On the contrary, the short-term reversal gets significant among extreme small-cap firms.

### 6.3. Book-to-Market

We extend the empirical test of Sagi and Seasholes (2007), running equally-weighted and value-weighted 16 momentum strategies in three BM-assigned groups. Stocks are firstly assigned into three groups (High-BM, Medium-BM and Low-BM) based on their market-to-book at the end of last quarter, and then by prior cumulative returns. Table 4.4 presents the portfolio returns of the momentum strategies double-sort on book-to-market ratio and past returns. It shows that low-BM momentum portfolios significantly outperform high-BM momentum portfolios, which is consistent with Sagi and Seasholes (2007). The returns from low-BM momentum strategies are significantly positive, around 1% per month,

**Table 4.3: ME-assigned momentum strategy returns over two periods**

		ME-assigned momentum							
Equally-weighted		Holding period				Value-weighted			
		3	6	9	12	3	6	9	12
<b>High ME</b>									
Before 1989									
LB	3	0.0021	0.004	0.0056	0.0058	0.0004	0.0026	0.0039	0.0055
	3	0.66	1.81*	2.83***	3.03***	0.1	1.05	1.75*	2.59***
	6	0.0047	0.0071	0.0083	0.0069	0.0023	0.0067	0.0079	0.0068
	6	1.43	2.80***	3.30***	2.90***	0.6	2.39**	2.91***	2.67***
	9	0.0061	0.0083	0.0077	0.006	0.0058	0.0082	0.0084	0.0069
	9	1.80*	2.95***	2.83***	2.38**	1.59	2.72***	2.96***	2.63***
	12	0.0062	0.0083	0.0073	0.0057	0.005	0.0071	0.0068	0.0057
	12	1.80*	2.99***	2.83***	2.29**	1.31	2.35**	2.46**	2.17**
After 1989									
LB	3	0.003	0.0018	0.0025	0.0031	0.0033	0.0032	0.004	0.0043
	3	0.81	0.59	0.91	1.39	0.84	1.02	1.44	1.75*
	6	0.0042	0.0044	0.0048	0.0038	0.0044	0.0052	0.006	0.0042
	6	1.08	1.25	1.54	1.37	1.08	1.47	1.88*	1.45
	9	0.0057	0.0052	0.0039	0.0023	0.0062	0.0056	0.004	0.0028
	9	1.38	1.38	1.14	0.77	1.46	1.49	1.15	0.88
	12	0.0054	0.0032	0.0017	0.0011	0.0067	0.0037	0.0029	0.002
	12	1.3	0.84	0.48	0.34	1.57	0.91	0.78	0.6
<b>Medium ME</b>									
Before 1989									
LB	3	0.0043	0.006	0.0061	0.0065	0.0062	0.0074	0.0071	0.006
	3	1.41	2.50**	2.79***	2.88***	2.00**	3.09***	3.35***	2.49**
	6	0.0052	0.0071	0.0081	0.0061	0.0064	0.0081	0.0086	0.0061
	6	1.52	2.55**	3.17***	2.53**	1.94*	2.94***	3.43***	2.71***
	9	0.005	0.0074	0.0064	0.0043	0.0062	0.0096	0.008	0.0043
	9	1.39	2.41**	2.20**	1.67*	1.77*	3.21***	2.77***	1.49
	12	0.0085	0.0088	0.0083	0.0064	0.0109	0.0116	0.01	0.0063
	12	2.41**	2.80***	2.83***	2.32**	3.03***	3.67***	3.38***	2.07**
After 1989									
LB	3	0.0063	0.0053	0.0035	0.0039	0.0058	0.0054	0.0031	0.0036
	3	1.77*	1.64	1.18	1.69*	1.61	1.72*	1.04	1.47
	6	0.0117	0.0095	0.0066	0.0049	0.0121	0.0094	0.006	0.0051
	6	2.68***	2.33**	1.77*	1.61	2.82***	2.33**	1.58	1.64
	9	0.0143	0.0097	0.0052	0.0036	0.015	0.0089	0.0045	0.0036
	9	3.09***	2.31**	1.41	1.13	3.20***	2.07**	1.19	1.1
	12	0.0113	0.0059	0.0018	0.0011	0.0117	0.0056	0.0017	0.0016
	12	2.66***	1.44	0.48	0.33	2.70***	1.37	0.44	0.47
<b>Low ME</b>									
Before 1989									
LB	3	-0.0121	-0.0053	-0.0037	-0.0006	-0.0028	0.0018	0.0007	0.0038
	3	-3.27***	-1.61	-1.28	-0.26	-0.75	0.59	0.19	1.44
	6	-0.0052	-0.0008	0.0009	-0.0001	0.0045	0.0057	0.0067	0.0051
	6	-1.27	-0.23	0.3	-0.02	1.12	1.61	2.18**	1.54
	9	-0.0057	-0.0005	-0.0005	-0.0008	0.0058	0.0079	0.0064	0.0059
	9	-1.38	-0.13	-0.15	-0.26	1.46	2.18**	1.79*	1.93*

(Contd...)



**Table 4.3: (Continued)**

		ME-assigned momentum							
	12	-0.0034	-0.0001	-0.0024	-0.0014	0.0055	0.0067	0.0037	0.0037
	12	-0.87	-0.03	-0.57	-0.42	1.39	1.75*	0.9	1.13
After 1989									
LB	3	-0.0138	-0.0102	-0.0083	-0.0065	-0.001	-0.0003	-0.001	-0.0009
	3	-2.87***	-2.50**	-2.19**	-1.94*	-0.22	-0.08	-0.26	-0.23
	6	-0.017	-0.012	-0.0089	-0.0083	-0.001	-0.0009	-0.0004	-0.0024
	6	-2.97***	-2.21**	-1.86*	-1.87*	-0.18	-0.17	-0.08	-0.48
	9	-0.0136	-0.0117	-0.0108	-0.0117	-0.0003	-0.0028	-0.0036	-0.0051
	9	-2.45**	-2.25**	-2.27**	-2.80***	-0.06	-0.55	-0.75	-1.22
	12	-0.013	-0.0127	-0.0141	-0.0148	0.0001	-0.0033	-0.0063	-0.0078
	12	-2.36**	-2.38**	-2.81***	-3.35***	0.02	-0.62	-1.23	-1.74*

The stocks are firstly assigned into two groups based on ME. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on past cumulative lag returns at each quarter. For each ME-assigned group, 16 trading strategies are considered based on look-back period (LB) and holding period. Both equally-weighted and value-weighted are employed, and the weight used for value-weighted strategy is the market equity at t-1 quarter. The data reported are the average portfolio monthly returns of buying Winners and selling Losers. The results of two periods are reported separately, the middle of them is the fiscal time 1989:Q1.

**Table 4.4: BM-assigned momentum strategy returns**

		ME-assigned momentum							
Equally-weighted		Holding period				Value-weighted			
		3	6	9	12	3	6	9	12
High BM									
LB	3	-0.0114	-0.0065	-0.0033	-0.0008	-0.0021	-0.0006	0.0013	0.0029
	3	-3.99***	-2.66***	-1.69*	-0.45	-0.56	-0.2	0.5	1.37
	6	-0.0069	-0.0028	0	0.0002	0.0002	0.0023	0.005	0.0048
	6	-2.03**	-1	0	0.08	0.04	0.65	1.61	1.75*
	9	-0.0064	-0.0018	-0.0003	-0.0007	0.0008	0.0037	0.0039	0.0038
	9	-1.95*	-0.64	-0.1	-0.31	0.2	1.06	1.18	1.33
	12	-0.0052	-0.0032	-0.0031	-0.0029	0.0049	0.0048	0.0032	0.003
	12	-1.55	-1.08	-1.14	-1.15	1.24	1.33	0.97	0.98
Medium BM									
LB	3	-0.0003	0.0026	0.0029	0.0036	-0.0041	0.0014	0.003	0.0045
	3	-0.14	1.41	1.62	2.49**	-1.66*	0.7	1.67*	2.88***
	6	0.0026	0.0058	0.0064	0.0051	0.0006	0.0053	0.007	0.0059
	6	1.07	2.64***	3.07***	2.85***	0.23	2.30**	3.23***	2.99***
	9	0.005	0.0068	0.005	0.003	0.0004	0.0051	0.0054	0.0048
	9	2.02**	3.12***	2.41**	1.62	0.16	2.09**	2.35**	2.24**
	12	0.0058	0.0049	0.0028	0.0016	0.0039	0.005	0.0052	0.0045
	12	2.42**	2.20**	1.27	0.82	1.39	2.01**	2.26**	2.04**
Low BM									
LB	3	0.0071	0.0052	0.005	0.0045	0.0087	0.0082	0.0083	0.0079
	3	2.72***	2.30**	2.56**	2.56**	2.55**	3.12***	3.60***	3.92***
	6	0.0131	0.0101	0.0078	0.0056	0.0144	0.0141	0.0127	0.0093
	6	4.43***	3.80***	3.40***	2.62***	4.28***	5.03***	4.99***	3.95***
	9	0.0136	0.0091	0.0063	0.0034	0.0167	0.0143	0.0117	0.009
	9	4.36***	3.19***	2.46**	1.4	4.63***	4.66***	4.07***	3.40***
	12	0.0142	0.0078	0.0042	0.0015	0.0165	0.013	0.0106	0.008
	12	4.55***	2.66***	1.58	0.63	4.50***	4.17***	3.66***	2.93***

The stocks are firstly assigned into two groups based on BM. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on past cumulative lag returns at each quarter, from 1963:Q1 to 2011:Q2. For each BM-assigned group, 16 trading strategies are considered based on look-back period (LB) and holding period. Both equally-weighted and value-weighted are employed, and the weight used for value-weighted strategy is the market equity at t-1 quarter. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

**Table 4.5: BM-assigned momentum strategy returns over two periods**

		ME-assigned momentum							
Equally-weighted		Holding period				Value-weighted			
		3	6	9	12	3	6	9	12
<b>High BM</b>									
Before 1989									
LB	3	-0.0087	-0.0037	-0.0013	0.0014	0.0005	0.0026	0.0024	0.0054
	3	-2.39**	-1.21	-0.49	0.66	0.13	0.81	0.87	2.28**
	6	0.0006	0.0023	0.0043	0.0047	0.0075	0.0078	0.0075	0.0084
	6	0.16	0.62	1.44	1.83*	1.68 *	1.79 *	2.06**	2.92***
	9	-0.0008	0.0034	0.0041	0.0043	0.0034	0.0092	0.0082	0.0088
	9	-0.22	0.95	1.27	1.53	0.7	2.48 **	2.26**	2.86***
	12	0.0022	0.003	0.0031	0.0037	0.01	0.0111	0.0089	0.0097
	12	0.57	0.79	0.97	1.32	2.44**	2.94***	2.59***	3.32***
After 1989									
LB	3	-0.0142	-0.0101	-0.0064	-0.0037	-0.0036	-0.0033	-0.0003	0.0013
	3	-3.36***	-2.73***	-2.14**	-1.46	-0.65	-0.73	-0.07	0.4
	6	-0.0129	-0.0082	-0.0044	-0.0042	-0.0061	-0.0028	0.0018	0.0015
	6	-2.43**	-1.88*	-1.18	-1.27	-0.92	-0.49	0.36	0.34
	9	-0.0111	-0.0077	-0.0053	-0.006	-0.0003	-0.0006	-0.0004	-0.0004
	9	-2.16**	-1.79*	-1.35	-1.71*	-0.04	-0.11	-0.07	-0.09
	12	-0.0117	-0.0099	-0.0096	-0.0093	0.0013	-0.0008	-0.0025	-0.0028
	12	-2.27**	-2.19**	-2.36**	-2.47**	0.2	-0.14	-0.47	-0.59
<b>Medium BM</b>									
Before 1989									
LB	3	-0.0028	0.002	0.0044	0.0057	-0.0047	0.0005	0.0035	0.0054
	3	-0.99	0.89	1.93*	2.99***	-1.43	0.19	1.48	2.56**
	6	0.0011	0.0047	0.0059	0.0058	0.002	0.0068	0.0092	0.0092
	6	0.33	1.67*	2.05**	2.38**	0.55	2.32**	3.08***	3.30***
	9	0.0018	0.0058	0.0053	0.0041	-0.0001	0.0062	0.0073	0.0068
	9	0.54	2.12**	1.88*	1.72*	-0.04	2.17**	2.63***	2.66***
	12	0.0046	0.0053	0.0054	0.0047	0.0038	0.0068	0.0087	0.008
	12	1.55	1.88*	2.05**	1.89*	1.04	2.24**	2.97***	2.77***
After 1989									
LB	3	0.0021	0.003	0.0015	0.0022	-0.0031	0.003	0.0032	0.0046
	3	0.69	1.08	0.57	1.07	-0.86	1.03	1.24	2.04**
	6	0.0041	0.0064	0.0053	0.0037	-0.0005	0.0051	0.0058	0.0047
	6	1.21	2.00**	1.79*	1.48	-0.13	1.49	1.84*	1.63
	9	0.0077	0.0071	0.0041	0.0018	0.0017	0.0046	0.0038	0.0032
	9	2.15**	2.20**	1.35	0.66	0.4	1.26	1.14	1.01
	12	0.007	0.004	0.0001	-0.001	0.0042	0.0033	0.0024	0.0026
	12	1.94*	1.2	0.02	-0.36	1.05	0.9	0.72	0.8
<b>Low BM</b>									
Before 1989									
LB	3	0.007	0.0079	0.009	0.0093	0.014	0.0133	0.0131	0.0114
	3	2.09**	3.02***	3.84***	3.78***	3.45***	4.51***	5.11***	3.40***
	6	0.0136	0.0127	0.0133	0.0074	0.019	0.019	0.018	0.0146
	6	3.45***	3.86***	5.00***	2.20**	4.36***	5.38***	5.42***	4.78***

(Contd...)

**Table 4.5: (Continued)**

		ME-assigned momentum							
	9	0.0128	0.0123	0.0124	0.0075	0.0236	0.0216	0.0217	0.0163
	9	3.08 ***	3.52 ***	3.94 ***	2.34 **	4.94 ***	5.32 ***	5.81 ***	3.68 ***
	12	0.0166	0.0123	0.0105	0.0083	0.0244	0.0218	0.0205	0.0147
	12	3.90***	3.53***	3.14***	2.31**	4.83***	5.49***	5.71***	3.36***
After 1989									
LB	3	0.0074	0.0027	0.0018	0.0007	0.0052	0.0052	0.0052	0.0046
	3	1.92*	0.75	0.59	0.28	1.01	1.26	1.42	1.49
	6	0.0144	0.0083	0.0046	0.0033	0.0114	0.0104	0.0085	0.0051
	6	3.37***	2.08**	1.32	1.04	2.32**	2.49**	2.24**	1.49
	9	0.0154	0.0067	0.0026	0.0002	0.0115	0.0085	0.0039	0.0019
	9	3.39***	1.57	0.69	0.06	2.23**	1.93*	0.95	0.51
	12	0.0134	0.0042	-0.0004	-0.0026	0.0117	0.0076	0.004	0.0028
	12	3.00***	0.96	-0.09	-0.72	2.27**	1.66*	0.94	0.72

The stocks are firstly assigned into two groups based on BM. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on past cumulative lag returns at each quarter. For each BM-assigned group, 16 trading strategies are considered based on look-back period (LB) and holding period. Both equally-weighted and value-weighted are employed, and the weight used for value-weighted strategy is the market equity at t-1 quarter.

The data reported are the average portfolio monthly returns of buying Winners and selling Losers. The results of two periods are reported separately, the middle of them is the fiscal time 1989:Q1.

the returns from medium-BM strategies are around 0.48% per month, and that from high-BM strategies are generally not significant or even negative.

Table 4.5 provides a comparison of the ex-1989 and post-1989 periods. The conclusion of full-sample period is robust to both sub-periods. In both periods, low BM momentum portfolios significantly outperform high BM momentum portfolios. Moreover, the momentum effect is less significant over post-1989 period, as mentioned earlier. More importantly, equally-weighted High-BM momentum strategies exhibit significant reversal, whereas value-weighted strategies do not. This phenomenon is not observed in Medium-BM and Low-BM groups, whose equally-weighted and value-weighted strategies perform similarly. These results suggest that small firms with high-BM contribute to the reversal phenomenon reported earlier.

#### 6.4. R&D Investment

Because R&D data is recorded after 1989, we use the post-1989 sample period for our test of R&D effect on momentum. We firstly conduct momentum strategies within four R&D-assigned groups. Stocks are firstly assigned into four groups (High-RD, Medium-RD, Low-RD and Non-RD) based on their R&D-to-Sales (RD) at the end of t-1 quarter, and then by past returns. Table 4.6 presents the portfolio returns of momentum strategies double-sort on RD and prior cumulative returns, using equally-weighted and value-weighted methods. It shows significant reversal in equally-weighted High-RD momentum portfolios. Additionally, the returns to some value-weighted High-RD and equally-weighted Medium-RD strategies are significantly negative. In Low-RD and Non-RD groups, the momentum strategies do not produce significant returns. Generally, small firm seems more sensitive to R&D investment than large firms, by comparing the equally-weighted and value-weighted strategies. Moreover, the effect of R&D intensity is obvious from Table 4.6, due to the influence of size effect.

To observe the effect of size and R&D investment separately, we further triple-sort stocks on Size, R&D/Sales and prior returns. At the end of t-1 quarter, stocks are firstly assigned into 3\*3 groups by market equity (Large-Cap, Medium-Cap and Low-Cap), then by their R&D-to-Sales (RD) (High-RD, Low-RD and Non-RD). Within each of the 3\*3 groups, stocks are classified as winners to losers according to cumulative returns. Table 4.7 presents the portfolio returns of momentum strategies triple-sort on Size, RD and prior cumulative returns, using equally-weighted and value-weighted methods respectively. In Large-Cap group, RD firms do not experience significant either momentum or reversal, while some equally-weighted Non-RD momentum strategies produce positive returns. In Medium-Cap group, High-RD firms do not have positive autocorrelation, while Low-RD and Non-RD firms do. In Small-Cap group, both RD and Non-RD firms tend to reverse with twelve months. Additionally, the reversal phenomenon in High-RD group is stronger than that in Low-RD and Non-RD groups. It shows that R&D investment enhance the reversal effect of small firms.

**Table 4.6: RD-assigned momentum strategy returns over post-1989 period**

		RD-assigned momentum							
Equally-weighted		Holding period				Value-weighted			
		3	6	9	12	3	6	9	12
High RD									
LB	3	-0.0158	-0.011	-0.0084	-0.0073	-0.0013	0.0002	-0.0007	0.0013
	3	-2.47**	-2.12**	-1.83*	-1.76*	-0.18	0.05	-0.15	0.3
	6	-0.0097	-0.0066	-0.0075	-0.008	0.0156	0.0071	0.0041	0.0025
	6	-1.44	-1.1	-1.44	-1.75*	2.03**	1.03	0.7	0.5
	9	-0.0129	-0.0128	-0.0133	-0.0138	0.0025	-0.0011	-0.0052	-0.006
	9	-1.87*	-1.97**	-2.28**	-2.57**	0.34	-0.16	-0.84	-1.09
	12	-0.0109	-0.0134	-0.014	-0.0151	-0.0029	-0.0058	-0.0109	-0.0123
	12	-1.5	-2.03**	-2.31**	-2.83***	-0.36	-0.83	-1.57	-2.07**
Medium RD									
LB	3	-0.0055	-0.0042	-0.0027	-0.0011	0.0057	0.0004	0.0024	0.0046
	3	-1.05	-1.11	-0.82	-0.4	0.97	0.09	0.66	1.44
	6	-0.0091	-0.0071	-0.0038	-0.0036	0.0034	0.001	0.0023	0.0012
	6	-1.61	-1.55	-0.98	-1.07	0.59	0.19	0.56	0.32
	9	-0.0064	-0.0063	-0.0062	-0.008	0.0037	-0.001	-0.0009	-0.0015
	9	-1.11	-1.34	-1.48	-2.10**	0.56	-0.19	-0.17	-0.34
	12	-0.0063	-0.0094	-0.01	-0.0119	0.002	-0.0037	-0.0027	-0.0018
	12	-1.09	-1.92*	-2.24**	-2.82***	0.31	-0.7	-0.59	-0.42
Low RD									
LB	3	-0.0087	-0.0027	-0.0002	-0.003	0.0023	0.0036	0.004	0.0016
	3	-1.44	-0.61	-0.05	-0.95	0.34	0.73	0.87	0.4
	6	-0.0058	0.0011	0.0024	-0.0016	0.0011	0.0036	0.0057	0.0043
	6	-0.97	0.22	0.58	-0.41	0.16	0.67	1.15	0.97
	9	-0.0025	-0.0004	-0.0007	-0.0047	0.003	0.0032	0.0032	0.0023
	9	-0.4	-0.08	-0.15	-1.13	0.46	0.55	0.61	0.48
	12	0.0009	0.0006	-0.0018	-0.0054	0.0061	0.0055	0.0027	0.0009
	12	0.15	0.11	-0.39	-1.25	0.93	0.96	0.49	0.18
Non-RD									
LB	3	-0.0022	-0.0017	-0.0019	-0.0004	0	0.0024	0.0019	0.0034
	3	-0.67	-0.57	-0.7	-0.2	0.01	0.81	0.73	1.51
	6	0	0.0008	0.0005	-0.0001	0.0024	0.005	0.0046	0.0033
	6	-0.01	0.24	0.15	-0.03	0.56	1.39	1.42	1.1
	9	0.0009	0.0015	-0.0001	-0.0012	0.0038	0.0068	0.0046	0.0042
	9	0.22	0.41	-0.04	-0.42	0.93	1.79*	1.27	1.25
	12	0.0011	-0.0015	-0.0039	-0.0042	0.005	0.005	0.0023	0.0025
	12	0.29	-0.41	-1.13	-1.37	1.14	1.21	0.61	0.7

The stocks are firstly assigned into two groups based on R&D/SALE. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on past cumulative lag returns at each quarter, since fiscal time 1989:Q1 to 2011:Q2. For each BM-assigned group, 16 trading strategies are considered based on look-back period (LB) and holding period. Both equally-weighted and value-weighted are employed, and the weight used for value-weighted strategy is the market equity at t-1 quarter. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

To test the R&D effect over industries, we sort stocks are assigned into high-tech and low-tech industries according to Chan et al. (2001b), and then into momentum portfolios using the triple-sorting method as used in Table 4.7. Table 4.8 shows the portfolio returns of momentum strategies triple-sort on Size, RD and prior cumulative returns within High-Tech and Low-Tech industry subsamples. In Large-Cap group, High-Tech momentum portfolios tend to be more profitable than Low-Tech momentum

**Table 4.7: RD-assigned momentum strategy returns in three ME Cap Groups over post-1989 period**

		RD-assigned momentum							
Equally-weighted		Holding period				Value-weighted			
		3	6	9	12	3	6	9	12
<b>Large-cap</b>									
High RD									
LB	3	0.003	0.0025	0.003	0.0026	0.0074	0.0045	0.0047	0.0043
	3	0.54	0.57	0.79	0.82	1.3	0.95	1.21	1.31
	6	0.0084	0.0059	0.0069	0.0043	0.0099	0.0059	0.0075	0.0052
	6	1.44	1.14	1.56	1.14	1.52	1.06	1.56	1.24
	9	0.0056	0.0015	0.0025	0.0005	0.009	0.0038	0.0041	0.0012
	9	1	0.31	0.54	0.14	1.52	0.77	0.88	0.3
	12	0.0053	0.0028	-0.0007	-0.0022	0.0101	0.0074	0.0033	0.0007
	12	0.92	0.59	-0.16	-0.58	1.77*	1.52	0.74	0.17
Low RD									
LB	3	-0.0004	-0.0016	0.0012	0.002	0.0013	-0.001	0.0012	0.0025
	3	-0.09	-0.39	0.34	0.67	0.25	-0.22	0.31	0.78
	6	-0.0041	-0.001	0.0005	0.0022	-0.0017	0.0013	0.0031	0.0044
	6	-0.85	-0.22	0.11	0.58	-0.3	0.27	0.69	1.07
	9	0.0008	0.0001	0.001	0.0019	-0.0001	0.0027	0.0043	0.0052
	9	0.16	0.02	0.24	0.48	-0.02	0.55	0.97	1.28
	12	0.0037	-0.0004	0.0014	0.0012	0.0031	0.0012	0.0035	0.0037
	12	0.67	-0.08	0.31	0.29	0.53	0.23	0.76	0.88
Non-RD									
LB	3	0.0012	0.0013	0.0013	0.0027	-0.0017	0.0005	0.0008	0.0017
	3	0.44	0.62	0.67	1.49	-0.57	0.21	0.37	0.85
	6	0.0027	0.0043	0.0042	0.0033	0.002	0.004	0.0039	0.0033
	6	0.9	1.63	1.78*	1.51	0.62	1.39	1.49	1.38
	9	0.0036	0.0059	0.0036	0.0024	0.0015	0.0041	0.0022	0.0017
	9	1.14	2.09**	1.4	1.03	0.43	1.32	0.77	0.63
	12	0.0054	0.0047	0.0023	0.0021	0.0044	0.0036	0.0021	0.002
	12	1.68*	1.64	0.89	0.87	1.28	1.17	0.73	0.75
<b>Medium-cap</b>									
High RD									
LB	3	0.0004	0.0013	-0.0019	-0.0011	0	0.0017	-0.0018	-0.001
	3	0.08	0.3	-0.45	-0.31	0	0.38	-0.44	-0.28
	6	0.0017	0.0033	0.0009	-0.0001	0.0041	0.0036	0.0012	0
	6	0.25	0.55	0.17	-0.02	0.64	0.6	0.22	0.01
	9	0.0079	0.0039	-0.0034	-0.0042	0.0053	0.0032	-0.0033	-0.004
	9	1.1	0.64	-0.6	-0.92	0.73	0.54	-0.63	-0.9
	12	0.0015	-0.0028	-0.0089	-0.0083	0.0041	0.001	-0.0066	-0.0063
	12	0.22	-0.46	-1.6	-1.69 *	0.57	0.17	-1.17	-1.24
Low RD									
LB	3	0.006	0.0033	0.0031	0.0025	0.0062	0.0038	0.003	0.0026
	3	1.06	0.79	0.81	0.8	1.06	0.86	0.72	0.78
	6	0.0082	0.0065	0.006	0.0048	0.0114	0.0101	0.0077	0.0078

(Contd...)

**Table 4.5: (Continued)**

**RD-assigned momentum**

		<b>Medium-cap</b>							
	6	1.36	1.38	1.41	1.29	1.88*	2.00**	1.62	1.94*
	9	0.0111	0.0073	0.0051	0.0024	0.013	0.0104	0.0077	0.0056
	9	1.84*	1.5	1.18	0.64	2.06**	2.06**	1.68*	1.41
	12	0.0108	0.0065	0.0028	0.0005	0.0123	0.0107	0.0052	0.0028
	12	1.93*	1.37	0.67	0.13	2.08**	2.10**	1.16	0.7
	Non-RD								
LB	3	0.0061	0.0045	0.0035	0.0041	0.0049	0.0034	0.0024	0.0036
	3	1.72*	1.41	1.23	1.79*	1.47	1.09	0.88	1.57
	6	0.0108	0.009	0.007	0.0062	0.0102	0.0073	0.0052	0.0054
	6	2.73***	2.37**	2.10**	2.19**	2.60***	1.93*	1.54	1.83*
	9	0.0144	0.0105	0.0068	0.0058	0.0136	0.0077	0.005	0.0046
	9	3.55***	2.70***	1.95*	1.87 *	3.38***	1.94*	1.39	1.44
	12	0.0126	0.0071	0.0036	0.0032	0.011	0.0047	0.0023	0.0028
	12	3.15***	1.76 *	0.98	0.99	2.80***	1.16	0.63	0.84
		<b>Small-cap</b>							
	High RD								
LB	3	-0.0365	-0.0216	-0.0144	-0.0124	-0.0226	-0.0107	-0.0067	-0.0063
	3	-3.30***	-2.70***	-2.28**	-2.37**	-1.90*	-1.31	-1.02	-1.18
	6	-0.031	-0.0212	-0.0158	-0.0126	-0.0218	-0.0117	-0.0086	-0.0067
	6	-2.86***	-2.55**	-2.34**	-2.24**	-1.94*	-1.43	-1.3	-1.2
	9	-0.0342	-0.0198	-0.0179	-0.0173	-0.0243	-0.0137	-0.0139	-0.0148
	9	-3.00***	-2.17**	-2.48**	-2.61***	-2.21**	-1.57	-2.03**	-2.34**
	12	-0.0316	-0.0178	-0.0198	-0.0178	-0.0188	-0.0107	-0.0153	-0.0142
	12	-2.82***	-2.21**	-2.82***	-2.69***	-1.71*	-1.36	-2.30**	-2.22**
	Low RD								
LB	3	-0.017	-0.0192	-0.0073	-0.0117	0.0001	-0.0081	0.0001	-0.0045
	3	-1.74*	-2.95***	-1.48	-2.11**	0.01	-1.23	0.02	-0.82
	6	-0.0233	-0.0136	-0.0079	-0.0104	-0.0077	-0.0029	-0.0002	-0.0037
	6	-2.36**	-2.07**	-1.49	-1.90*	-0.91	-0.46	-0.03	-0.71
	9	-0.0096	-0.0088	-0.0063	-0.0145	-0.0002	-0.0025	-0.0011	-0.009
	9	-0.96	-1.26	-1.05	-2.42**	-0.03	-0.37	-0.18	-1.49
	12	-0.0038	-0.0064	-0.0094	-0.0125	0.0065	0.0006	-0.0033	-0.0066
	12	-0.37	-0.85	-1.4	-1.99**	0.71	0.08	-0.51	-1.1
	Non-RD								
LB	3	-0.0085	-0.0065	-0.006	-0.0045	0.0019	0.0015	0.0004	0.0003
	3	-1.69*	-1.57	-1.47	-1.18	0.4	0.35	0.11	0.06
	6	-0.0113	-0.0075	-0.0071	-0.0064	0.0045	0.0032	0.0014	-0.0001
	6	-1.88*	-1.5	-1.5	-1.39	0.77	0.65	0.28	-0.02
	9	-0.0099	-0.0124	-0.0118	-0.0117	0.0042	-0.0042	-0.0041	-0.0046
	9	-1.65*	-2.04**	-2.03**	-2.42**	0.71	-0.59	-0.65	-0.9
	12	-0.0111	-0.0138	-0.0148	-0.0144	0.0019	-0.0062	-0.0066	-0.0073
	12	-1.88*	-2.25**	-2.53**	-2.92***	0.33	-	-1.02	-1.37

Table 4.8: RD-assigned momentum strategy returns in three ME cap groups over post-1989 period conditioning industry technology requirement

		Low-tech																
High-tech		Holding period				Value-weighted				Equally-weighted				Value-weighted				
		Holding period				Value-weighted				Equally-weighted				Value-weighted				
Large-cap		Holding period				Value-weighted				Equally-weighted				Value-weighted				
		3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	
High RD	LB	3	0.0035	0.0024	0.0036	0.0023	0.0091	0.0036	0.0052	0.0045	0.0018	0.0017	-0.0015	-0.005	0.0048	0.0006	-0.0021	-0.008
		3	0.64	0.51	0.89	0.67	1.55	0.73	1.26	1.27	0.16	0.19	-0.21	-0.8	0.4	0.06	-0.28	-1.26
		6	0.0109	0.0068	0.0073	0.0052	0.0147	0.0075	0.0087	0.0067	0.0084	0.0083	0.0066	0.0003	0.0084	0.0054	0.0057	-0.0003
		6	1.70*	1.26	1.55	1.26	2.16**	1.37	1.81*	1.6	0.68	0.81	0.83	0.05	0.66	0.51	0.72	-0.04
		9	0.0057	0	0.0024	0.0011	0.0099	0.0033	0.0057	0.0035	0.0053	0.0004	-0.0046	-0.0067	0.0064	-0.0048	-0.0074	-0.009
		9	0.94	0.01	0.49	0.27	1.6	0.64	1.18	0.84	0.45	0.04	-0.54	-0.89	0.54	-0.45	-0.85	-1.2
		12	0.0011	0.0003	-0.0017	-0.0029	0.0075	0.0054	0.0023	0.0001	0.015	0.0062	-0.0018	-0.0048	0.0155	-0.0007	-0.0042	-0.0039
		12	0.19	0.06	-0.39	-0.75	1.25	1.08	0.5	0.02	1.32	0.64	-0.23	-0.62	1.34	-0.07	-0.51	-0.51
Low RD	LB	3	0.003	-0.0003	0.0018	0.0042	0.0088	0.0013	0.0021	0.0054	-0.0061	-0.0063	-0.0034	-0.0022	-0.0032	-0.0063	-0.0025	-0.002
		3	0.52	-0.06	0.45	1.19	1.36	0.28	0.5	1.49	-1.15	-1.6	-1.05	-0.86	-0.57	-1.55	-0.77	-0.76
		6	0.0025	0.0025	0.0046	0.0056	0.0056	0.0036	0.0053	0.0065	-0.004	-0.0043	-0.0038	-0.002	-0.0028	-0.004	-0.0029	-0.0022
		6	0.39	0.43	0.91	1.2	0.83	0.59	1.03	1.37	-0.77	-1.04	-1.21	-0.75	-0.54	-0.95	-0.88	-0.78
		9	0.006	0.0051	0.0046	0.0048	0.0114	0.0088	0.0077	0.0073	-0.0025	-0.0036	-0.0013	0.0001	-0.0022	-0.0034	-0.0011	0
		9	0.95	0.91	0.92	1.02	1.74*	1.55	1.55	1.58	-0.51	-0.91	-0.4	0.05	-0.45	-0.82	-0.32	0
		12	0.0098	0.005	0.0054	0.0036	0.0091	0.0041	0.0052	0.0036	-0.0033	-0.0061	-0.0043	-0.0021	-0.0054	-0.0069	-0.0047	-0.0026
		12	1.5	0.87	1.04	0.72	1.33	0.68	1	0.74	-0.55	-1.32	-1.14	-0.64	-0.91	-1.52	-1.24	-0.79
Non-RD	LB	3	0.0026	0.0032	0.0053	0.003	0.0018	0.0012	0.0048	0.0024	0.0009	0.0007	0.0008	0.0026	-0.0022	0.0005	0.0008	0.0019
		3	0.39	0.63	1.23	0.84	0.26	0.23	1.14	0.69	0.34	0.33	0.4	1.42	-0.74	0.22	0.38	0.95
		6	-0.004	0.0014	0.0042	-0.0004	-0.0071	-0.0004	0.003	-0.0019	0.0017	0.003	0.0036	0.0027	0.0011	0.0029	0.0036	0.0033
		6	-0.62	0.27	0.91	-0.09	-1.08	-0.07	0.66	-0.49	0.58	1.18	1.55	1.28	0.32	1.04	1.43	1.42
		9	0.0005	0.0073	0.0083	0.0044	-0.0015	0.0065	0.0071	0.0031	0.0029	0.0048	0.003	0.0021	0.0021	0.0044	0.0028	0.0022
		9	0.07	1.31	1.79*	1.02	-0.21	1.17	1.57	0.71	0.94	1.72*	1.16	0.9	0.6	1.43	1.02	0.85
		12	0.0073	0.0072	0.0088	0.0047	0.0055	0.0065	0.0076	0.0038	0.0047	0.0043	0.0019	0.002	0.0049	0.0041	0.0026	0.0026
		12	1.08	1.34	1.86*	1.07	0.82	1.18	1.58	0.85	1.49	1.54	0.72	0.84	1.44	1.37	0.91	0.99

  

		Low-tech																
High-tech		Holding period				Value-weighted				Equally-weighted				Value-weighted				
		Holding period				Value-weighted				Equally-weighted				Value-weighted				
Medium-cap		Holding period				Value-weighted				Equally-weighted				Value-weighted				
		3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	
High RD	LB	3	-0.0005	-0.001	-0.0027	-0.0016	0.0014	0.0019	-0.0003	0.0003	0.0113	0.0199	0.0169	0.0075	0.0164	0.0215	0.0175	0.0084

(Contd...)

Table 4.8: (Continued)

		Low-tech																
		Value-weighted				Equally-weighted				Value-weighted								
High-tech		Holding period			Holding period			Holding period			Holding period							
Equally-weighted		3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12	
Medium-cap		3	-0.09	-0.22	-0.62	-0.44	0.23	0.41	-0.06	0.09	0.92	2.01**	1.89*	0.93	1.3	2.14**	1.93*	1.02
		6	-0.0003	-0.0007	-0.0032	-0.003	0.0023	0.0012	-0.0017	-0.0018	0.0187	0.0253	0.0152	0.0061	0.0124	0.0187	0.0114	0.0029
		6	-0.05	-0.12	-0.61	-0.69	0.36	0.21	-0.32	-0.42	1.31	2.47**	1.63	0.72	0.87	1.81*	1.23	0.34
		9	0.0057	-0.0004	-0.0058	-0.007	0.004	-0.0004	-0.0049	-0.0064	0.0259	0.0161	0.0068	-0.0003	0.0205	0.0112	0.0022	-0.0038
		9	0.75	-0.07	-1.03	-1.46	0.53	-0.07	-0.9	-1.36	2.22**	1.72*	0.81	-0.03	1.72*	1.19	0.26	-0.49
		12	-0.0031	-0.0069	-0.011	-0.0108	-0.0039	-0.0047	-0.0099	-0.0105	0.0125	0.0084	-0.0009	-0.0049	0.0114	0.0047	-0.0048	-0.0067
		12	-0.37	-0.96	-1.73*	-1.95*	-0.47	-0.68	-1.59	-1.92*	1.03	0.85	-0.1	-0.6	0.95	0.47	-0.53	-0.82
Low RD	LB	3	0.006	0.0033	0.0038	0.004	0.0059	0.0032	0.0042	0.0048	-0.013	-0.0104	-0.006	-0.0071	-0.0164	-0.0076	-0.008	
		3	0.92	0.67	0.92	1.18	0.86	0.62	0.98	1.35	-1.28	-1.71*	-1.18	-1.67*	-1.6	-1.92*	-1.51	-1.88*
		6	0.0124	0.0128	0.0101	0.0099	0.0129	0.0165	0.0121	0.0131	-0.0086	-0.0129	-0.009	-0.0083	-0.0095	-0.0135	-0.0096	-0.0085
		6	1.85*	2.28**	1.93*	2.19**	1.79*	2.69***	2.06**	2.64***	-0.92	-1.82*	-1.42	-1.57	-1.02	-1.89*	-1.51	-1.59
		9	0.0129	0.0092	0.0064	0.0059	0.0138	0.0123	0.0077	0.0078	-0.0058	-0.0058	-0.0045	-0.0069	-0.0074	-0.008	-0.0054	-0.0069
		9	1.83*	1.56	1.23	1.3	1.90*	2.05**	1.39	1.65*	-0.77	-0.92	-0.82	-1.43	-0.99	-1.24	-0.98	-1.39
		12	0.0106	0.0085	0.0054	0.0052	0.0124	0.0134	0.0087	0.0087	-0.0022	-0.006	-0.0048	-0.0059	-0.0033	-0.0069	-0.0054	-0.0058
		12	1.39	1.42	1.02	1.07	1.62	2.17**	1.54	1.71*	-0.28	-0.83	-0.79	-1.11	-0.41	-0.95	-0.88	-1.07
Non-RD	LB	3	0.0168	0.0145	0.0067	0.0031	0.0161	0.0124	0.0047	0.0016	0.0046	0.0035	0.0037	0.0045	0.0028	0.0027	0.0029	0.004
		3	2.67***	2.50**	1.35	0.76	2.43**	2.17**	0.98	0.39	1.28	1.15	1.36	1.95*	0.81	0.89	1.09	1.70*
		6	0.0134	0.0099	0.0034	0.0018	0.0145	0.0108	0.0039	0.0017	0.0094	0.0085	0.0075	0.0067	0.0082	0.0063	0.0055	0.0056
		6	2.01**	1.42	0.58	0.37	2.02**	1.57	0.66	0.34	2.32**	2.26**	2.21**	2.27**	2.09**	1.66*	1.57	1.80*
		9	0.0207	0.0113	0.0046	0.0004	0.0202	0.0093	0.0032	-0.0014	0.0134	0.0103	0.0072	0.0064	0.0113	0.0075	0.0056	0.0055
		9	3.03***	1.52	0.71	0.07	2.82***	1.22	0.48	-0.23	3.22***	2.64***	1.96*	1.98**	2.77***	1.89*	1.46	1.62
		12	0.0156	0.0051	-0.001	-0.0026	0.0144	0.0027	-0.0024	-0.0042	0.0124	0.0076	0.0048	0.0046	0.0109	0.0056	0.004	0.0045
		12	2.35**	0.68	-0.16	-0.44	2.07**	0.36	-0.38	-0.68	2.98***	1.88*	1.28	1.36	2.60***	1.37	1.04	1.3
High-tech		Low-tech																
Equally-weighted		Value-weighted				Equally-weighted				Value-weighted								
		Holding period			Holding period			Holding period			Holding period							
Small-cap		3	-0.0352	-0.0227	-0.0164	-0.0127	-0.0275	-0.0158	-0.0111	-0.0088	-0.0402	-0.0159	-0.0075	-0.0106	-0.0219	-0.006	-0.0009	-0.0083
		3	-2.87***	-2.68***	-2.34***	-2.17**	-2.17**	-1.76*	-1.55	-1.51	-1.86*	-1.13	-0.6	-1.05	-0.97	-0.42	-0.07	-0.83
		6	-0.035	-0.029	-0.0229	-0.0193	-0.0249	-0.0184	-0.0149	-0.0131	-0.012	0.0047	0.0073	0.0024	0.0095	0.0188	0.0138	0.0111

(Contd...)



Table 4.8: (Continued)

		Low-tech															
		High-tech				Value-weighted				Equally-weighted				Value-weighted			
		Holding period			Value-weighted			Equally-weighted			Holding period			Value-weighted			
Small-cap		3	6	9	12	3	6	9	12	3	6	9	12	3	6	9	12
	6	-3.21***	-3.27***	-3.09***	-3.02***	-2.29**	-2.10**	-2.05**	-2.11**	-0.51	0.27	0.49	0.18	0.4	1.14	0.92	0.84
	9	-0.0459	-0.0298	-0.0278	-0.0263	-0.0372	-0.0236	-0.0225	-0.0221	-0.0009	0.0081	0.0164	0.0056	0.0164	0.0241	0.0286	0.0163
	9	-3.38***	-2.95***	-3.33***	-3.46***	-2.78***	-2.40**	-2.81***	-3.05***	-0.04	0.47	1.15	0.46	0.77	1.47	2.06**	1.42
	12	-0.0405	-0.025	-0.0299	-0.0258	-0.0319	-0.0149	-0.0235	-0.0214	-0.0036	0.0079	0.01	0.0055	0.0148	0.0207	0.0223	0.0166
	12	-3.12***	-2.78***	-3.38***	-3.19***	-2.40**	-1.71*	-2.72***	-2.66***	-0.15	0.45	0.66	0.43	0.68	1.22	1.58	1.37
					Low RD												
LB	3	-0.0182	-0.168	-0.0089	-0.0103	0.0002	-0.0035	-0.0002	-0.0032	-0.0001	-0.005	-0.0009	-0.0011	0.0027	-0.0026	-0.0003	0.0002
	3	-1.58	-2.26**	-1.58	-1.72*	0.02	-0.44	-0.04	-0.52	-0.01	-0.66	-0.14	-0.19	0.28	-0.36	-0.05	0.03
	6	-0.031	-0.0178	-0.0114	-0.0133	-0.0137	-0.0052	-0.0035	-0.0079	-0.0112	-0.0019	0.0018	-0.0015	-0.0071	0.0013	0.0052	0.0022
	6	-2.70***	-2.31**	-1.80*	-2.02**	-1.39	-0.72	-0.56	-1.25	-1.09	-0.23	0.26	-0.25	-0.7	0.17	0.76	0.36
	9	-0.0235	-0.0159	-0.0106	-0.0168	-0.013	-0.0075	-0.0045	-0.0108	0.0131	0.0066	0.0024	-0.0027	0.0135	0.0081	0.0044	-0.0005
	9	-2.09**	-2.01**	-1.56	-2.52**	-1.23	-0.99	-0.62	-1.62	1.19	0.72	0.31	-0.39	1.26	0.9	0.57	-0.07
	12	-0.0203	-0.0192	-0.0176	-0.0208	-0.0066	-0.0098	-0.0086	-0.0138	0.0076	-0.0008	-0.0034	-0.0084	0.0091	0.0009	-0.0004	-0.0051
	12	-1.71*	-1.95*	-2.06**	-2.48**	-0.6	-1.06	-1.05	-1.69*	0.68	-0.09	-0.43	-1.21	0.8	0.1	-0.06	-0.74
					Non-RD												
LB	3	-0.0182	-0.0153	-0.0121	-0.0106	-0.0119	-0.0093	-0.0066	-0.0047	-0.0086	-0.0045	-0.0051	-0.0043	0.0016	0.0024	0.0006	-0.0005
	3	-1.57	-1.85*	-1.74*	-1.72*	-0.9	-0.99	-0.86	-0.73	-1.67*	-1.13	-1.26	-1.06	0.35	0.59	0.15	-0.1
	6	-0.0285	-0.0131	-0.0107	-0.0123	-0.0128	-0.0031	-0.0017	-0.0019	-0.0107	-0.0102	-0.0089	-0.0077	0.0033	-0.003	-0.0033	-0.0031
	6	-2.24**	-1.44	-1.4	-1.80*	-0.93	-0.32	-0.22	-0.29	-1.96**	-1.77*	-1.53	-1.33	0.63	-0.43	-0.47	-0.43
	9	-0.0252	-0.0168	-0.0165	-0.0197	-0.0118	-0.0055	-0.007	-0.0108	-0.0087	-0.0112	-0.0108	-0.0101	0.0038	-0.005	-0.0056	-0.005
	9	-1.93*	-1.74*	-2.00**	-2.61***	-0.82	-0.54	-0.84	-1.43	-1.54	-1.69*	-1.62	-1.86*	0.7	-0.63	-0.71	-0.82
	12	-0.0218	-0.0221	-0.0168	-0.0163	-0.0106	-0.0136	-0.01	-0.01	-0.0094	-0.0129	-0.0138	-0.0143	0.0033	-0.0061	-0.0071	-0.0086
	12	-1.72*	-2.20**	-1.90*	-2.04**	-0.79	-1.32	-1.12	-1.24	-1.66*	-1.96*	-2.17**	-2.70***	0.62	-0.77	-1.02	-1.52

The stocks are firstly assigned into high-tech/low-tech subsamples, based on Chan et al.(2001), and then into 3\*3 groups based on ME and R&D/Sale. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on past cumulative lag returns at each quarter, since fiscal time 1989:Q1 to 2011:Q2. For each BM-assigned group, 16 trading strategies are considered based on look-back period (LB) and holding period. Both equally-weighted and value-weighted are employed, and the weight used for value-weighted strategy is the market equity at t-1 quarter. The data reported is the average portfolio monthly returns of buying Winners and selling Losers.

portfolios. In Medium-Cap group, R&D investment does not bring significant positive effect to momentum strategies. In High-Tech industries, Low-RD momentum portfolios produce significant positive returns, while High-RD momentum portfolios do not. Conversely, in Low-Tech industries, some High-RD momentum portfolios produce significant positive returns, while Low-RD momentum portfolios generate negative returns. Moreover, in all industries, Non-RD momentum strategies generate significant momentum effect.

In Small-Cap group, the portfolio returns of RD and Non-RD firms are largely different. In High-Tech industries, High-RD momentum strategies produce significant higher negative returns than Low-RD strategies, while less equally-weighted Non-RD strategies produce significant negative returns. The average monthly return of High-RD momentum strategies is around -2.5%, which means that R&D-intensive small firms, in high-tech industries, tend to reverse in the short run, and R&D investment contributes to this strong reversal. In Low-Tech industries, both RD groups do not experience significant reversal effect, whereas Non-RD momentum strategies produce significant negative returns, but less significant than the counterparts in High-Tech industries.

Therefore, R&D investment contributes to enhanced momentum strategies, and the effect is not dominated by firm size and industry factor. High-tech small-cap firms are more likely to reverse in the short-run, and R&D investment increases the reversal effect.

## 7. CONCLUSION

This paper contributes to the literature of momentum phenomenon. We provide profitable trading strategies conditioning on past returns and firm characteristics. Our results shed a light on the explanation of momentum strategies and cross-section of returns, and demonstrate that growth options and firm size play an important role in explaining stock returns.

First, we provide a theoretical explanation of return premium to different firm characteristics. We identify relevant firm characteristic, like firm size, book-to-market ratio, R&D level, industry requirement and time period.

Second, this study employs univariate, double-sort and triple-sort JT momentum strategies, based on all stocks obtained from CRSP/Compustat database. We classify sample firms so as to test the historic market risk premium, size premium, value premium, R&D premium, industry premium and momentum premium. We conduct simple momentum and enhanced momentum strategies over different time periods. Our improved strategies produce greater profits than simple momentum strategies. Specifically, momentum strategies in large firms, low book-to-market firms and ex-1989 firms produce greater profits than the original Jegadeesh and Titman (1993) strategy. We confirm that return autocorrelation is increasing with market-to-book and firm size. Also, R&D investment in small firms leads to negative return autocorrelation, and these effects are strong in high-tech industries.

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