Essays in Stock Market Anomalies

LIN YU

Thesis submitted to the University of Nottingham

for the degree of Doctor of Philosophy

November 2016

Dedicate to my lovely daughter.

Abstract

This thesis compromises one literature review chapter and three essays which focus on the theme of valuation, value premium anomaly, R&D premium anomaly, momentum anomaly and emerging markets. The first essay is entitled "Does Low Book-to-market Predict Low Returns? The Other Side of Growth: Research and Development Investment". In this essay, I develop a theoretical framework of the risk and return of R&D, and examine the relation between R&D and BM. This paper documents that the intersections of R&D and BM produce enhanced trading strategies, and that the four-factor model, with a R&D factor, outperforms the three-factor model.

The second essay, entitled "Firm Characteristics and Momentum", studies the momentum anomaly. In this essay, I examine the relations of firm characteristics and momentum in US stocks. Momentum effect seems to be less significant in recent years. Most importantly, this paper presents that firm size and growth option may plays an important role in momentum trading strategy. The returns of large and medium winners/losers tend to sustain, while small winners/losers tend to reverse quickly. Also, it also shows that R&D investment enhance the reversal effect of small firms, especially in high-tech industries.

The third essay, entitle "Firm Attributes and Momentum Strategies in China", focus on the emerging market China. This study investigates the momentum and reversal phenomenon in China, based on most up-to-date data. It shows that Chinese stock market experiences barely momentum effect, but the reversal effect

is increasingly significant in the long horizon. Additionally, two risk proxies, size and R&D expense, are employed to explain momentum and reversal effect. It shows that the returns of large stocks are more likely to be persistent, while that of small firms are more likely reverse. Moreover, R&D investment reduces reversal effect, especially for small firms.

Acknowledgements

Above all, I sincerely appreciate the invaluable guidance, supports and encouragement that I received from my supervisors, Professor Wai Kin Leung and Professor Weimin Liu, throughout my PhD program and career planning. I am thankful to my viva examiners, Professor Hung-Gay Fung and Professor Xiaoquan Liu for their valuable suggestions and corrections to this dissertation and my future researches. My gratitude also goes to the school and department for research environment and resources, and to Ms. Claire Shi for constant help. Most importantly, I would like to say special thanks to my supportive family, my husband, my daughter, my parents and my sister. They have been constant resource of encouragement and companions all the way over the past three years.

Contents

Chapter 1 Introduction

Stock market anomalies describe a situation that cannot be explained by the widely accepted financial models based on efficient market hypothesis. Currently, the most popular pricing model, Fama and French (1993) three-factor model, suggests that stock returns can be explained by overall market factor, firm size and book-to-market ratio. According to this theory, high book-to-market stocks are of high growth potential, while low book-to-market firms are of overvalued assets.

However, the low B/M ratio of high-tech firms might be attributed to heavy investments of intangible assets. GAAP mandates the full expensing of research and development in financial statements, thereby, book value does not capture the investment in research and development, and then book-to-market ratio actually omits the value of R&D inputs. Many of high-tech firms have few tangible assets, in contrast, they invest heavily in research and development projects, and these projects can bring large future cash inflows to the firm and usually push the firm market value to a high level. As a result, these R&D-intensive firms, which are of high growth option, generally have low book-to-market ratio. Therefore, the R&D-intensive high-tech firms are usually undervalued by book-to-market proxy. If we use book-to-market factor as the only proxy of firm growth potential, the growth option of R&D-intensive firms will be overlooked.

Thanks to the 90s high-tech bubble, the industry structure is largely changed. The portion of high-tech firms is increasingly larger after the empirical results

reported by Fama and French in 1992. Whether the results remain the same if we use the up-to-date dataset and replicate the portfolios suggested by Fama and French (1992)? Whether the portfolio returns will be improved if we plus R&D intensity as another risk proxy of growth option? This thesis aims to explore whether current financial models incorporate the value of R&D investment, and whether R&D proxy explains momentum anomaly.

Chapter one concludes the contributions of prior studies on asset pricing models and explaining momentum phenomenon. It explains five financial models introduced in previous researches, including CAPM, investment-based model, FF 3-factor model, Carhart four-factor model and intangible model. Moreover, it introduces the momentum and reversal effects, and states how prior studies attempt to explain them from the rational and behavioral theories.

The later three essays examine the adequacy of using Fama-French three risk factors to predict R&D-intensive firms' stock returns and investigate R&D factor' predictability. Following the method of Fama and French (1992), this thesis captures the time-series average of the monthly equal-weighted/value-weighted portfolio returns (in percent) under different conditions. Additionally, it regress portfolio returns on FF three factors and a four-factor model respectively. It also attempts to explain momentum anomaly using double-sort and triple-sort momentum trading strategies. The data sets includes all US stocks over July 1962 to December 2012 and Chinese A-shares trading in Shanghai and Shenzhen exchanges over 1995-2014.

The first essay explains the difference between value premium and R&D premium, and provides improved trading strategies conditioning on book-to-market ratio and R&D intensity. Using US data, this study presents that book-to-market and R&D intensity are two distinct proxies. Growth stocks with intensive investment in research and development are underestimated by book-to-market, and vice versa. The most profitable strategies are holding investment-active value portfolio and shorting investment-inactive growth portfolios. It also implies that R&D premium cannot be explained by firm size. Finally, this study suggests that a four-factor model (market premium, size, BM and R&D) can explain the returns better than three-factor model.

The second essay employs R&D intensity, as a proxy for growth options, and firm size to explain momentum anomaly. After Jegadeesh and Titman (1993) report momentum 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, scholars have attempted to explain this anomaly for decades. This study joins the research to explore an explanation, and provide some new evidence. On the one hand, the returns of large and medium winners/losers tend to sustain, while small winners/losers tend to reverse quickly. On the other hand, it shows that R&D investment enhance the reversal effect of small firms. Then, when controlling industry factor, it shows that R&D investment is crucial for high-tech small-cap firms with poor past performance, and the R&D investment increases the reversal effect.

The third essay studies the momentum patterns of Chinese stock market, using similar method as the second essay. China is a large emerging market and very different from US stock market in many aspects. Therefore, it is important to explore whether the momentum phenomenon in Chinese stock market is similar as US market. This essay employs all A-shares trading at Shanghai and Shenzhen exchanges to explore the momentum and reversal phenomenon in China. It indicates that the return to momentum strategies in Chinese stock market is close to zero, while the contrarian strategies generate significant profits in the long horizon. Moreover, the significance of reversal effect becomes stronger over the recent years. In addition, it shows that Small firms and No-R&D firms are more likely to reverse.

To sum up, this thesis contributes to the literature by investigating the predictability of R&D intensity. It finds that R&D proxy explains stock returns, and it cannot be dominated by or dominate book-to-market proxy. Also, it shows that R&D investment helps to explain momentum and reversal effect in US market, but this is not significant in Chinese stock market. These results provide new evidence for the literature of financial pricing models and momentum-reversal phenomenon in US and Chinese stock markets.

Chapter 2 Literature Review

2.1 Asset Pricing Models

People walk into financial market for money, expecting that the stocks they select can beat the market. Then, to estimate the value of stocks and to forecast the future returns become constant topics in financial industry and research field. Over the past decades, researchers are keen to develop asset pricing models with diverse parameters, building on different theories.

2.1.1 CAPM

One classical pricing model, named capital asset pricing model (CAPM), is based on the risk measure of individual asset - β. This model was developed by Sharpe (1964) and Treynor (2012), and then further by Mossin (1966) and Black (1972). They employ beta of a single asset to represent risk, and to forecast future cash flows.

The base of CAPM is a return-variance tradeoff. The return of an asset is simply the gap of buying and selling prices. However, the distribution of past returns could be similar or distinct. One stock could pay high return but with low certainty (high risk) while another stock could pay low return with high certainty (low risk). The statistic, "variance", is frequently used to measure the dispersion of a distribution and investment risk as well (Copeland et al., 1983).

The risk of one single risky asset is measured by comparing with market portfolio. The market portfolio, a basket of risky assets, is determined by all the risky assets

and risk-free asset, with best rate of return over variance. Therefore, the quantity of risk (called β) is frequently represented by the value of covariance between returns on the risky asset (i) and market portfolio (M) divided by the variance o the market portfolio.

2.1.2 Investment-based Model

Cochrane (1991) first employs q-theory to study asset prices. He uses investment-to-assets (△A/A) as the annual change in total assets divided by lagged total assets. He suggests that more financially distressed firms earn lower average returns than less financially distressed firms. More important, controlling for traditional risk measures exacerbates the distress anomaly because more distressed firms appear riskier.

Hou et al. (2015) propose a new multifactor model motivated from investment-based asset pricing, which is in turn based on the q-theory of investment. Intuitively, investment predicts returns because given expected cash flows, high costs of capital mean low net present values of new capital and low investment, whereas low costs of capital mean high net present values of new capital and high investment. ROE predicts returns because high expected ROE relative to low investment means high discount rates. The high discount rates are necessary to counteract the high expected ROE to induce low net present values of net capital and subsequently low investment. If the discount rates are not high enough to offset the high expected ROE, firms would instead observe high net present values of new capital and invest more. Their q-factor model outperforms

the Fama-French model and the Carhart (1997) four-factor model, showing that the q-factor model summarizes what we know about the cross-section of returns as of the early 2010s.

2.1.3 Fama-French Three-Factor Model

The mean-variance measure is rejected by Fama and French (1992, 1993) through Fama and MacBeth (1973) regression method. Fama and French (1992) indicate a flat relation between market β and average return.

In contrast, Fama and French (1996) present a three-factor pricing model, including an overall market factor, firm size and book-to-market equity. The overall market factor could represent the performance of the whole market, whereas the other two factors also turn out be common risk factors in returns on stocks.

$$E(Ri) - Rf = bi[E(Rm) - Rf] + si\,E(SMB) + hi\,E(HML)$$

Where $E(Rm) - Rf$ is the market risk premium, SMB is size factor (based on the portfolio of buying small stocks and shorting large stocks), and HML is book-to-market factor (based on the portfolio of buying high book-to-market stocks and shorting low book-to-market stocks).

Consistent with Fama & French (1992, 1993, 1996), a number of researches have examined the significance of size effect and book-to-market equity effect. For example, Liew and Vassalou (2000) support a risk-based explanation for the performance of HML and SMB.

Size Effect

One well-known anomaly, small firm effect, was documented by Banz (1981). He finds that market equity, ME (a stock's price times shares outstanding), adds to the explanation of the cross-section of average returns provided by market /3s. In addition, average returns on small (low ME) stocks are too high given their *ff* estimates, and average returns on large stocks are too low. According to their study, some results change with firm sizes: some effects are more significant on small firms while some others are not.

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. This finding could be explained by investor expectation when they put money on the less admirable stocks.

Book-to-Market Ratio

The book-to-market ratio, value of common equity (BE) over market value (ME), is positively related to average stock returns (Rosenberg et al., 1985, Pontiff and Schall, 1998). Book-to-market ratio indicates the market evaluation of a stock and the expectation of future cash flows (Berk, 1995). High book-to-market ratio

represents low market evaluation while low book-to-market represents high evaluation. Value stocks, with high book-to-market ratio, are usually undervalued by the market and expected to perform poorly continuously, while glamour stocks, with low book-to-market ratio, is expected to perform well like it did in the past (Lakonishok et al., 1994).

Prior studies document value (glamour) stock portfolios generate significant positive (negative) returns. Value stocks with high book-to-market equity outperform the market (Rosenberg et al., 1985). Fama and French (1993) report low earnings on assets for glamour stocks (high book-to-market ratio) and high earnings on assets for value stocks (low book-to-market ratio). Pontiff and Schall (1998) find that the predictability of book-to-market ratios is stem from the relation between book value and future earnings. Recent researches conducted by Asness et al. (2013) show that value effect still persists across assets.

Regarding the explanation of value effect, attempts generally followed two routs: 1) Mispricing. Behavioral finance claim that value portfolio returns is a reward for contrarian investment to naive investment which associates with overreaction and underreaction of good/bad news (DeBondt and Thaler, 1985). Lakonishok et al. (1994) find that value (glamour) stock portfolios experience significantly positive (negative) long-term abnormal returns following the portfolio formations, consistent with the hypothesis that these stocks are undervalued (overvalued) at the time of the portfolio formations. They report that value betas are higher than growth betas in good times but are lower in bad times, a result that directly

contradicts the risk hypothesis. Barberis and Thaler (2003) suggest that value stocks lack common fundamentals but are merely those stocks that are currently out of favor with investors, while growth stocks are merely “glamour stocks” that are currently favored by investors. 2) Risk premium. Alternatively, others argue that risk is a source of the value premium, and the high returns to high book-to-market ratio are the compensation for the fundamental risks (Fama and French, 1992, 1996). Fama and French (1992) argued that book-to-market ratio is a proxy for financial distress of the firms and the abnormal returns generated from this investment strategy represent investors' compensation for this financial distress risk factor. Petkova and Zhang (2005) find that time-varying risk goes in the right direction in explaining the value premium. They document that value-minus- growth betas tend to covary positively with the expected market risk premium, and this result holds for most sample periods and for various value and growth strategies. Campbell et al. (2010) report that the systematic risks of value and growth stocks are determined by the properties of their cash flows.

2.1.4 Carhart Four-factor Model

Due to the significance of momentum phenomenon, Carhart (1997) four-factor model is widely applied in empirical studies. Four-factor model is Fama-French three-factor model plus a Carhart UMD momentum factor.

$$E(Ri) - Rf = bi[E(Rm) - Rf] + si\,E(SMB) + hi\,E(HML) + pi\,E(PR1YR) + ei$$

Where $E(Rm) - Rf$ is the market risk premium, SMB is size factor (based on the portfolio of buying the top 30 percent smallest stocks and shorting the top 30

percent largest stocks), HML is book-to-market factor (based on the portfolio of buying stocks with highest 30 percent book-to-market ratio and shorting stocks with highest 30 percent book-to-market ratio), PR1YR is a one-year momentum factor (based on the portfolio return of buying stocks with highest 30 percent eleven-month returns lagged one month and shorting stocks with the lowest 30 percent eleven-month returns lagged one month).

The creativity of this model is the fourth factor PR1YR which stands for momentum effect. Carhart (1997) employ one year momentum factor PR1YR from Jegadeesh and Titman (1993) as one risk factor of asset pricing model.

2.1.5 Intangible Model

On industry level, both CAPM and Fama-French three-factor model are not able to explain the returns (Fama and French, 1997; Nelson, 2006). Also, three-factor model has difficulty in explaining the returns on NASDAQ firms (Loughran, 1997; Brav et al., 2000). However, Nelson (2006) indicates that intangible model, replacing book-to-market factor with R&D and advertising measures, could fully explain both monthly industry and index returns.

In Nelson's intangibles model, R&D and advertising expenditure are regarded as proxies for a firm's investment in intangible assets. Nelson (2006) employs asset to scale both R&D and advertising expenditure.

$$\mathrm{Rpt} - \mathrm{Rft} = \alpha + \beta(\mathrm{Rmt} - \mathrm{Rft}) + \gamma\,(\mathrm{SMBt}) + \delta\,(\mathrm{R\&}Dt) + \eta\,(ADSt) + \varepsilon$$

where Rpt− Rft is the excess return; (Rmt − Rft) and SMBt is the similar as

Fama and French (1993) used; R&Dt represents the return difference in portfolio returns of high-R&D to low-R&D firms; $ADSt$ presents the return difference in portfolio returns of high-advertising to low-advertising firms.

The intangibles model suggested by Nelson (2006) fits the sample better than Fama-French 3-factor model through multifactor regression in 48 industries separately. It is apparent that the intangibles model explains the returns on all but one of the industry portfolios, while the three factor model does not work for ten of 48.

2.2 Momentum and Contrarian Strategy

2.2.1 Momentum Strategy

Momentum effect, which challenges the traditional asset pricing theory, is 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 "momentum" profit strategy raised by 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 classified by their return ranking among all assets.

This phenomenon has received attention for a long time. Levy (1967) claims that a trading rule that buys stocks with current prices that are substantially higher than their average prices over that past 27 weeks realizes significant abnormal returns. Hong and Stein (1999) report that returns appear to exhibit continuation,

or momentum, in the short to medium run.

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.

Also, many enhanced momentum strategies have been discussed in studies with regard to momentum strategies. 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. Novy-Marx (2012) indicates that strategies based on recent past performance generate positive returns but are less profitable than those based on intermediate horizon past performance, especially among the largest, most liquid stocks.

Apparently, momentum effect is of increasing attention due to its significance, and it is gradually used as a return predictor in many researches. A four-factor model including Fama-French 3-factor model (1993) and a Carhart (1997) one-year momentum factor is widely used in empirical studies. The standardized Carhart (1997) UMD factor employs eleven-month look-back period and one-month holding period.

Jegadeesh and Titman (1993) However, part of the abnormal returns generated in the first year after portfolio formation dissipates in the following two years. A similar pattern of returns around the earnings announcements of past winners and losers is also documented.

2.2.2 Contrarian Strategy

The contrarian strategy, also known as reversal, is an important study topic in finance. Generally speaking, reversal is described as a negative relationship between past returns and current return. While some suggest short-term reversal resulted from short-term price pressure or a lack of liquidity in the market, most studies focus on long-horizon reversal effect. Firms with poor previous performance tend to perform well after a long horizon, whereas firms with good previous performance tend to generate negative returns in the long run.

DeBondt and Thaler (1985) show that loser stocks in the past 3 to 5 years outperform winners by 25% over the next 3 years, which termed as Long-term "reversal", suggesting that contrarian strategies (buying past losers and selling past winners) achieve abnormal returns. They present that, thirty-six months after portfolio formation, loser portfolios of 35 stocks outperform the market by 19.6% on average, whereas winner portfolios earn about 5.0% less than the market.

Similarly, A number of studies document reversal phenomenon after 12 months momentum (Novy-Marx, 2012, Jegadeesh and Titman, 2001). Hong and Stein (1999) suggest that there is also a tendency toward reversals, or fundamental reversion, in the long run. Jegadeesh and Titman (1993) find that the price momentum is not permanent, and past losers realize higher returns than past winners around earnings announcements the following 13 months. Then, Jegadeesh and Titman (2001) present that the cumulative return in months 13 to 60 for momentum portfolio is negative. Griffin et al. (2003) find that momentum

profits reverse over 1- to 5-year horizons, an action inconsistent with existing risk-based explanations of momentum. Besides, George and Hwang (2007) report long-horizon reversal effect in Hong Kong stock market, and there are many papers report excess returns of contrarian strategies in other stock markets.

2.3 Explanations of Momentum and Reversal

Through the documented success of contrarian and momentum strategies, we know that past returns predict the following performance. Existing explanations for these "abnormal" returns are that they are due to behavioral biases, risk premia for omitted state variables or market friction**.**

2.3.1 Behavioral explanation

However, some studies provide evidence that the momentum and contrarian strategies that exploit long-horizon overreaction are not significantly riskier than average. Jegadeesh and Titman (1993) suggest that the profitability of the momentum strategies is not due to their systematic risk or to delayed stock price reactions to common factors. Lakonishok et al. (1994) find little support for the view that value strategies are fundamentally riskier after look at frequency of superior performance of value stocks, the performance at bad states, the betas and standard deviations. Chan et al. (1996) document that market risk, size, and book-to-market effects do not explain the drifts. They find little evidence of subsequent reversals in the returns of stocks with high price and earnings momentum.

Unlike rational explanation under efficient market hypothesis, behavioral finance

theory deputes the idea that investors in the market are ideal and identical. They argue that investors are irrational and unable to make decisions without psychological bias. These scholars argue that 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. For example, Lakonishok et al. (1994) find that value (glamour) stock portfolios experience significantly positive (negative) long-term abnormal returns following the portfolio formations, consistent with the hypothesis that these stocks are undervalued (overvalued) at the time of the portfolio formations.

Many models of the behavioral theory are typically built on psychological theories, including self-attribution, representative, conservatism and so forth. The scholars suggest that there is no smart trader in the market, even those who have received professional training. Based on the "behavioral" (i.e., non-risk-based) explanations, there are a number of theories that can shed a light to positive medium-term return autocorrelations and long-term reversal. They are mainly from two main streams: one of them supports overreaction while the other supports underreaction.

Underreaction

In some models, momentum is a symptom of underreaction— investors underreact to news and incorporate information into prices slowly. For instance, building on the theory of underreaction effect, Barberis et al. (1998) and Hong and Stein (1999) employ different working mechanism to explain the intermediate

momentum and long-term reversal.

Combining with psychological theories, Barberis et al. (1998) employ "representative" and "conservatism" to further the research. The representative heuristic is a factor may lead investors to mistakenly conclude that firms realizing extraordinary earnings growths will continue to experience similar extraordinary growth in the future, while conservatism is defined as the slow updating of models in the face of new evidence by Edwards (1968). When there is a representative investor who suffers from a conservatism bias, this trader does not update his beliefs sufficiently when he observes new public information. Barberis et al. (1998) suggested that the conservatism bias in isolation leads to underreaction, but this behavioral tendency in conjunction with the representative heuristic can lead to long horizon negative returns for stocks with consistently high returns in the past.

Hong and Stein (1999) suggest the market is influenced by gradual information diffusion effect, and the market is composed of heterogeneous investors who observe different pieces of private information at different points in time. They model a market populated by two groups of boundedly rational agents: "newswatchers" and "momentum traders". Neither type is fully rational in the usual sense. Any of them actually is with the bounded rationality being of a simple form: each type of agent is only able to "process" some subset of the available public information. Specifically, the newswatchers make forecasts based on signals that they privately observe about future fundamentals; their limitation

is that they do not condition on current or past prices. In contrast, momentum traders do condition on past price changes, but their forecasts must be univariate functions of the history of past prices. In addition, they have the third assumption, which is more orthodox in nature: private information diffuses gradually across the newswatcher population.

When only newswatchers are active, prices adjust slowly to new information—there is underreaction but never overreaction. When two groups of traders are active, their model can be said to "unify" underreaction and overreaction in the following sense. The stock price firstly experiences a tendency for newswatchers to underreact to private information. Then, when momentum trader tries to exploit this underreaction with a simple arbitrage strategy, they only partially eliminate it, and in so doing, create an excessive momentum in prices that inevitably culminates in overreaction.

In this model, each newswatcher observes some private information, but fails to extract other newswatchers' information from prices. If information diffuses gradually across the population, prices underreact in the short run. The underreaction produced by newswachers means that the momentum traders can profit by trend-chasing. However, if they can only implement simple (i.e., univariate) strategies, their attempts at arbitrage must inevitably lead to overreaction at long horizons.

Collectively, the two types of investors and the assumption of gradual diffusion effect generate underreaction and positive return autocorrelations. Their model

gets both underreaction and overreaction out of just one primitive type of shock: Gradually diffusing news about fundamentals, without any other exogenous shocks to investor sentiment and no liquidity-motivated trades.

Similarly, Cutler et al. (1991) examine autocorrelations in excess returns on various indexes over different horizons and the evidence is consistent with the underreaction hypothesis, which states that underreaction leads to trends in returns over short horizons. The underreaction evidence shows that over horizons of perhaps 1-12 months, security prices underreact to news. Chan et al. (1996) suggest a market that responds only gradually to new information. They find little evidence of subsequent reversals in the returns of stocks with high price and earnings momentum. According to their results, security analysts' earnings forecasts also respond sluggishly to past news, especially in the case of stocks with the worst past performance.

In addition, the literature document the underreaction effect is influence by some factors, such as firm size and analyst coverage. Hong et al. (2000) suggests that to the extent that stock prices do underreact, they are more prone to underreact to bad news than to good news.

a) Firm Size

Hong et al. (2000) indicate that information about small firms gets out more slowly. In the very smallest stocks (which are tiny, with a mean market capitalization of $7 million) momentum is actually negative. By the second size decile, momentum profits are significantly positive, and they reach a peak in the

third size decile. However, once moves past the very smallest stocks, the profitability of momentum strategies declines sharply with firm size. Hong et al. (2000) explain that smaller firms may have slower information diffusion, which would lead to greater momentum, but they probably also have more limited investor participation (i.e., thinner market making capacity) which can lead to more pronounced supply-shock-induced reversals. Under this interpretation, the sharp decline in momentum profits that occurs between the third and the tenth size classes is testament to the economic importance of gradual information diffusion in mid-cap stocks.

b) Analyst Coverage

Regarding analyst coverage as a proxy for the information diffusion speed, Hong et al. (2000) find momentum strategies work better among stocks with low analyst coverage, holding size fixed. Additionally, the effect of analyst coverage is greater for stocks that are past losers than for past winners. These finding are consistent with the hypothesis that firm-specific information, especially negative information, diffuses only gradually across the investing public.

c) Trading Volume

Lee and Swaminathan (2000) document that past volume helps to reconcile intermediate-horizon "underreaction" and long-horizon "overreaction" effects. Specifically, they find that firms with high (low) past turnover ratios exhibit many glamour (value) characteristics, earn lower (higher) future returns, and have consistently more negative (positive) earnings surprises over the next eight

quarters. Past trading volume also predicts both the magnitude and persistence of price momentum. Specifically, price momentum effects reverse over the next five years, and high (low) volume winners (losers) experience faster reversals. Conditional on past volume, they can create Jegadeesh and Titman–type momentum portfolios (winners minus losers) that either exhibit long-horizon return reversals or long-horizon return continuations.

Lee and Swaminathan (2000) indicate that the higher (lower) future returns experienced by low (high) volume stocks are related to investor misperceptions about future earnings. They find that analysts provide lower (higher) long-term earnings growth forecasts for low (high) volume stocks, however, low (high) volume firms experience significantly better (worse) future operating performance. Additionally, they show that short-window earnings announcement returns are significantly more positive (negative) for low (high) volume firms over each of the next eight quarters. This pattern is observed for both past winners and past losers.

Overreaction

In some theories, 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). Similarly, Lee and Swaminathan (2000) suggest that is not simply a market underreaction, but at least a portion of the initial momentum gain is better characterized as an overreaction. They find no significant price reversals through the third year following portfolio formation.

However, over Years 3 through 5, we find that initial winner portfolios significantly underperform initial loser portfolios.

It is widely discussed about the influence of overconfidence and self-attribution, which are terms used in psychology that relates to an individual's self-image or self-esteem, on stock trading. Van den Steen (2004) suggests that when individuals are overoptimistic about their abilities, they tend to overestimate the precision of their predictions, which is the notion of overconfidence discussed in Daniel et al. (1998). On the other hand, Daniel et al. (1998) argue that informed traders suffer from a "self-attribution" bias, and then indicate how the momentum effect can be generated by investors' overconfidence and self-attribution bias.

Daniel et al. (1998) present a model where investors are overconfident about their abilities. The investors in the model observe positive signals about a set of stocks, some of which perform well after the signal is received. Due to cognitive biases, the informed traders attribute the performance of ex-post winners to their stock selection skills and that of the ex-post losers to bad luck. Then, these investors become overconfident about their ability and their information and repeat their trading patterns. Therefore, their trading strategy push up the prices of the winner stocks above the fundamental values.

In addition, Van den Steen (2004) discuss that it is the overconfidence about one's success relative to others (peer-comparison overconfidence) that causes investors to overestimate the precision of their information (i.e., miscalibration).

DeBondt and Thaler (1985) use experimental psychology to explain stock trading

behaviors. They argue that people tend to “overreact” to unexpected and dramatic news events. If stock prices overshoot systematically, then their reversal should be predictable from past return data alone, with no use of any accounting data such as earnings. The empirical results, however, are inconsistent with this hypothesis. They find supports from the research in experimental psychology in violation of Bayes' rule, that, most people tend to "overreact" to unexpected and dramatic news events. This study of market efficiency investigates whether such behavior affects stock prices, based on CRSP monthly return data. The paper also examines the predictions of recent behavioral models that propose that momentum profits are due to delayed overreactions that are eventually reversed. The empirical results are consistent with the overreaction hypothesis and substantial weak form market inefficiencies. They suggest that individuals tend to overweight recent information and underweight prior (or base rate) data in revising their beliefs. Their study also shed new light on the January returns earned by prior "winners" and "losers." Portfolios of losers experience exceptionally large January returns as late as five years after portfolio formation.

A delayed “overreaction” in long run is applied to explain reversals in models. Both Daniel et al. (1998) and Hong and Stein (1999) suggest that momentum is generated by positive feedback trading that leads to a delayed overreaction that is eventually reversed. The overreaction evidence shows that over longer horizons of perhaps 3-5 years, security prices overreact to consistent patterns of news pointing in the same direction. On the contrary, Geoge and Hwang (2004) document that short-term momentum and long-term reversals are largely separate phenomena.

This finding presents a challenge to main theory that models these aspects of security returns as integrated components of the market's response to news.

A model with contrarian investor and naïve investor is built by Lakonishok et al. (1994) to explain the excess returns of contrarian strategies. They demonstrate that some investors earn money from investment because their strategies are contrarian to "naïve" strategies followed by other investors. Lakonishok et al. (1994) pointed out a contrarian model includes overpriced glamour stocks and underpriced value stocks. The model argues that the overpriced glamour stocks are those which, first, have performed well in the past, and second, are expected by the market to perform well in the future. Similarly, the underpriced out-of-favor or value stocks are those that have performed poorly in the past and are expected to continue to perform poorly. According to Lakonishok et al. (1994), naïve investors tend to overreact to both good news and bad news, resulting in overpriced "glamour" stocks and underpriced "value" stocks. These naïve investors assume sustainable positive future returns according to prior success. They might extrapolate past earnings growth too far into the future, assume a trend in stock prices, overreact to good or bad news, or simply equate a good investment with a well-run company irrespective of price. In contrast, value strategies that bet against those investors who extrapolate past performance too far into the future produce superior returns. The contrarian investors invest against naïve investors, buying undervalued stocks and selling overvalued stocks. Their trading strategies change the stock demands and prices, finally outperforming the market.

2.3.2 Rational explanation

The fundamental view of efficient-market hypothesis (EMH) suggests that financial markets are "informationally efficient", and investors cannot consistently achieve excess returns on a risk-adjusted basis. According to classic asset pricing, the model is based on the EMH which assumes rational investors in the market. Even EMH-based asset pricing theory is questioned by anomalies happened in the market, traditional theory insist that risks could answer this phenomenon. As investors come to the market for returns, there is no doubt that they are investing with positive expectation. In EMH, rational investors would receive arbitrage profit when the stock price move inconsistent with reasonable level, pushing the stock price back to the fundamental value. It is argued most forcefully by Fama and French (1992) that strategies that have produced superior returns are fundamentally riskier.

Hence, the momentum profit could be relatively an arbitrage opportunity for rational investors. Scholars in this camp insist that the returns to momentum and contrarian strategies are the compensation for bearing systematic risks. Jegadeesh and Titman (2001) indicate that that the losers are riskier than the winners because they are more sensitive to all three Fama-French factors. Briefly, the winners have a loading of -0.245 on the HML factor whereas the losers have a loading of 20.02. The results show that the CAPM alpha for the winner minus loser portfolio is about the same as the raw return difference, as both winners and losers have about the same betas. Also, the Fama-French alpha for this portfolio is 1.36 percent.

Some scholars suggest that price momentum can be explained by the return or potential returns behand the price. Berk et al. (1999) develop a theoretical model where the cross-sectional variation in risk and expected return generates profits in short-term reversal and intermediate momentum. Sagi and Seasholes (2007) suggest that a firm's revenues, costs, and growth options combine to determine the dynamics of its return autocorrelation. Chordia and Shivakumar (2006) find that price momentum is captured by the systematic component of earnings momentum. They show that the predictive power of past returns is subsumed by a zero-investment portfolio that is long on stocks with high earnings surprises and short on stocks with low earnings surprises.

a) Growth option/opportunities

Berk et al. (1999) develop a theoretical model which relates a firm's systematic risk over time and the profits in short-term reversal and intermediate momentum. They explain how optimal investment choices affect the trade-off between a firm's assets and growth options, and develop a dynamic model to show that this imparts predictability to changes in a firm's systematic risk, and its expected return. The simulations in their study show that the model simultaneously reproduces: (i) the time-series relation between the book-to-market ratio and asset returns; (ii) the cross-sectional relation between book-to-market, market value, and return; (iii) contrarian effects at short horizons; (iv) momentum effects at longer horizons; and (v) the inverse relation between interest rates and the market risk premium.

Berk et al. (1999) employ book-to-market as a state variable summarizing the firm's risk relative to the scale of its asset base. Because good news is, on average, associated with lower risk and bad news is associated with higher risk in their model, changes in risk lead to a role for book-to-market. The study identifies two kinds of assets within firms in the model: (a) in-place assets and (b) growth options. The sum of the two types of assets generates the expected returns of firms. Briefly, in-place assets currently generate cash flows, and growth options make positive net present value (NPV) investments in the future. In each period, the cash flows from existing assets may die off, and new investment opportunities are presented to the firm. An investment that has very low systematic risk looks very attractive to the firm, other things equal, and investing in it leads to a large increase in value.

According to this study, expected returns in a given period are positively related to lagged expected returns because the composition and systematic risk of the firm's assets are persistent, and they are negatively related to lagged realized returns because shocks to the composition of the firm's assets are negatively correlated with changes in systematic risk. As the consequence, stock price experiences momentum effects at longer horizons and contrarian effects at short horizons. The regression results show that in aggregate portfolios there is positive dependence on past expected returns and negative dependence on past realized returns, which means that contrarian and momentum strategies will be profitable at different horizons.

Sagi and Seasholes (2007) introduce an enhanced momentum strategy which entails buying specific winners and selling specific losers in such a manner as to produce larger profits than strategies documented in Jegadeesh and Titman. They identify observable firm-specific attributes that drive momentum. They find that a firm's revenues, costs, and growth options combine to determine the dynamics of its return autocorrelation. Based on these insights, they implement momentum strategies (buying winners and selling losers) with both numerically simulated returns and CRSP/Compustat data. Based on both sets of data, they show that 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. Hence, they suggest that if one can identify firms with time-varying return autocorrelation and can restrict a momentum strategy to those firms whose autocorrelation is conditionally higher than average, this restricted strategy results in enhanced profits because winners (losers) with relatively high autocorrelated returns have more persistent expected returns than winners (losers) from an unrestricted strategy.

In the model, when a trader long risky asset and risky-free asset, an increase in the stock price leads to a higher weighting of the risky asset (the stock) in the portfolio, higher overall systematic risk, and higher expected returns. Then good return is followed by higher risk in this situation. When a trader long risky asset and short risky-free asset, an increase in the stock price leads to lower leverage and thus lower systematic risk for the portfolio. As growth options are risky assets that increase in value more than assets in place when the firm performs well,

therefore, growth options contribute positively to return autocorrelation.

Basically, firms that performed well in the recent past are better poised to exploit their growth options. Moreover, firms with valuable growth options exhibit higher return autocorrelation than firms without such growth options, because firms with valuable growth options are riskier when the options which are risky assets account for a large fraction of firm value. As the compensation to the risks, they are associated with higher expected returns. They also suggest that this effect is only temporary, as firms eventually use or lose their growth options. They use a firm's market-to-book ratio as a proxy for the presence of growth options, and show that high market-to-book firms have higher expected returns after a positive return. Sagi and Seasholes (2007) indicate that the profits of this enhanced strategy attribute to growth options which represent riskiness.

Sagi and Seasholes (2007) find that high market-to-book firms produce approximately 10% higher momentum profits per annum than low market-to-book firms. Regarding the fact that firms with high market-to-book ratios produce enhanced momentum profits, Daniel and Titman (1999) argue that such profitability stems from the large weight of intangible assets in high market-to-book firms and the fact that investors overreact to news related to intangible assets.

b) Expected Dividend Growth Rate

Johnson (2002a) suggests that recent performance is correlated with levels of expected growth rate, which is monotonically related to risk. It indicates a strong

positive correlation between past realized returns and current expected returns, based on a simple, standard model of firm cash-flows discounted by an ordinary pricing kernel. Stochastic expected growth rates are considered as the key to momentum effect.

c) Firm size

Booth et al. (2016) demonstrate that there is no momentum-reversal anomaly, and that, actually, size effect dominates momentum's initial effect, causing stock prices and, hence, returns to move in the opposite direction.

Jegadeesh and Titman (2001) find that winners and losers tend to be smaller firms than the average stock in the sample, because smaller firms have more volatile returns and are thus more likely to be in the extreme return sorted portfolios. Moreover, the average size rank for the winner portfolio is larger than that for the loser portfolio. The empirical results indicate that the market betas for winners and losers are virtually equal, whereas the losers are somewhat more sensitive to the size factor than are the winners.

2.3.3 Other explanations

Some scholars argue that the momentum phenomenon is merely market friction and cannot be explained irrational investor or risk. There are four main streams:

a) Bid-ask Spread

Kaul and Nimalendran (1990) find little evidence of market overreaction when they extract measurement errors in prices caused by the bid-ask spread. Instead,

they find that security returns are positively, and not negatively, autocorrelated. They also show that bid-ask errors lead to substantial spurious volatility in transaction returns; about half of measured daily return variances can be induced by the bid-ask effect.

b) Tax

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. Since capital gains are taxed only when realized, investors with locked-in gains have an incentive not to sell winners in order to delay paying capital gains taxes. Consequently, investors' reservation prices for the sale of winner stocks are elevated by the benefit of capital gains deferral. Using the data from Hong Kong, where investment income is not taxed, reversals are nonexistent, they find that returns are not forecastable either by traditional measures or by measures based on the capital gains lock-in hypothesis that successfully predict U.S. returns.

c) Computing bias

Based on the method DeBondt and Thaler (1985), Conrad and Kaul (1993) implement 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. The cumulating process not only cumulates "true" returns but also the upward bias in single-period returns induced by measurement errors. They also show that the

remaining "true" returns to loser or winner firms have no relation to overreaction.

d) High-tech Bubble

Hwang and Rubesam (2015) conclude that the momentum premium declined during the 1990s and that the disappearance of momentum was delayed to the late 1990s by the high-tech and telecom bubble. During the late 1990s, the momentum premium was driven by winner stocks, many of which were high-tech and telecom stocks that showed extraordinary outperformance. In fact, these high-tech and telecom stocks contributed more than half of the momentum profits during the late 1990s and thus the momentum premium without these stocks in the winner portfolio would have been far less than that reported by Jegadeesh and Titman (2001).

Reference

ARTZ, K. W., NORMAN, P. M., HATFIELD, D. E. & CARDINAL, L. B. 2010. A longitudinal study of the impact of R&D, patents, and product innovation on firm performance. *Journal of Product Innovation Management,* 27**,** 725-740.

BANZ, R. W. 1981. The relationship between return and market value of common stocks. *Journal of financial economics,* 9**,** 3-18.

BHATTACHARYA, N., SAITO, Y., VENKATARAMAN, R. & YU, J. J. 2012. R&D Reporting Rule and Firm Efficiency.

CAMPBELL, J. Y., POLK, C. & VUOLTEENAHO, T. 2009. Growth or glamour? Fundamentals and systematic risk in stock returns. *Review of Financial Studies***,** hhp029.

CAÑIBANO, L., GARCIA-AYUSO, M. & SÁNCHEZ, P. 2000. Accounting for intangibles: a literature review. *Journal of Accounting Literature,* 19**,** 102-130.

CAO, C., SIMIN, T. & ZHAO, J. 2008. Can growth options explain the trend in idiosyncratic risk? *Review of financial studies,* 21**,** 2599-2633.

CHAMBERS, D., JENNINGS, R. & THOMPSON II, R. B. 2002. Excess returns to R&D-intensive firms. *Review of Accounting Studies,* 7**,** 133-158.

CHAN, L. K., LAKONISHOK, J. & SOUGIANNIS, T. 2001. The stock market valuation of research and development expenditures. *The Journal of Finance,* 56**,** 2431-2456.

CHAUVIN, K. W. & HIRSCHEY, M. 1993. Advertising, R&D expenditures and the market value of the firm. *Financial management***,** 128-140.

DEDMAN, E., MOUSELLI, S., SHEN, Y. & STARK, A. W. 2009. Accounting, Intangible Assets, Stock Market Activity, and Measurement and Disclosure Policy—Views From the UK. *Abacus,* 45**,** 312-341.

DUQI, A., JAAFAR, A. & TORLUCCIO, G. 2013. Mispricing and risk of R&D investment in European firms. *The European Journal of Finance***,** 1-22.

EBERHART, A. C., MAXWELL, W. F. & SIDDIQUE, A. R. 2004. An Examination of Long‐Term Abnormal Stock Returns and Operating Performance Following R&D Increases. *The Journal of Finance,* 59**,** 623-650.

FAMA, E. F. & FRENCH, K. R. 1992. The cross‐section of expected stock returns. *The Journal of Finance,* 47**,** 427-465.

FAMA, E. F. & FRENCH, K. R. 2014. A five-factor asset pricing model. *Working Paper*.

FRANZEN, L. A., RODGERS, K. J. & SIMIN, T. T. 2007. Measuring distress risk: The effect of R&D intensity. *The Journal of Finance,* 62**,** 2931-2967.

GARLEANU, N., PANAGEAS, S. & YU, J. 2012. Technological growth and asset pricing. *The Journal of Finance,* 67**,** 1265-1292.

HO, Y. K., XU, Z. & YAP, C. M. 2004. R&D investment and systematic risk. *Accounting & Finance,* 44**,** 393-418.

HOU, K., XUE, C. & ZHANG, L. 2012. Digesting anomalies: An investment approach. National Bureau of Economic Research.

LEE, C.-F., SHIH, W.-K. & CHEN, H.-Y. 2010. Technical, Fundamental, and Combined Information for Separating Winners from Losers. *Working paper*.

LEV, B. & SOUGIANNIS, T. 1996. The capitalization, amortization, and value-relevance of R&D. *Journal of accounting and economics,* 21**,** 107-138.

LI, D. 2011. Financial constraints, R&D investment, and stock returns. *Review of Financial Studies***,** hhr043.

LI, Q., VASSALOU, M. & XING, Y. 2001. An investment-growth asset pricing model. CEPR Discussion Papers.

LIEW, J. & VASSALOU, M. 2000. Can book-to-market, size and momentum be risk factors that predict economic growth? *Journal of Financial Economics,* 57**,** 221-245.

PENMAN, S. & REGGIANI, F. 2013. Returns to buying earnings and book value: Accounting for growth and risk. *Review of Accounting Studies,* 18**,** 1021-1049.

PENMAN, S. H. 2009. Accounting for intangible assets: there is also an income statement. *Abacus,* 45**,** 358-371.

PETKOVA, R. & ZHANG, L. 2005. Is value riskier than growth? *Journal of Financial Economics,* 78**,** 187-202.

RUBERA, G. & KIRCA, A. H. 2012. Firm innovativeness and its performance outcomes: A meta-analytic review and theoretical integration. *Journal of Marketing,* 76**,** 130-147.

SHORTRIDGE, R. T. 2004. Market Valuation of Successful versus Non‐successful R&D Efforts in the Pharmaceutical Industry. *Journal of*

Business Finance & Accounting, 31**,** 1301-1325.

SIMPSON, P. M., SIGUAW, J. A. & ENZ, C. A. 2006. Innovation orientation outcomes: The good and the bad. *Journal of Business Research,* 59**,** 1133-1141.

SKINNER, D. J. 2008. Accounting for intangibles–a critical review of policy recommendations. *Accounting and Business Research,* 38**,** 191-204.

SOOD, A. & TELLIS, G. J. 2009. Do innovations really pay off? Total stock market returns to innovation. *Marketing Science,* 28**,** 442-456.

TITMAN, S., WEI, K.-C. & XIE, F. 2004. Capital investments and stock returns. *Journal of Financial and Quantitative Analysis,* 39**,** 677-700.

TITMAN, S. & WESSELS, R. 1988. The determinants of capital structure choice. *The Journal of finance,* 43**,** 1-19.

Chapter 3 Does Low Book-to-market Predict Low Returns? The Other Side of Growth: Research and Development Investment

Abstract:

This study explains the difference between value premium and R&D premium, and provides improved trading strategies conditioning on book-to-market ratio and R&D intensity. It presents that book-to-market and R&D intensity are two distinct proxies. Low-BM and R&D-intensive stocks are undervalued by BM ratio, and high-BM and R&D-inactive stocks are undervalued by R&D factor. The most profitable strategies are holding high-R&D high-BM portfolio and shorting low-R&D low-BM portfolios. It also implies that R&D premium cannot be explained by firm size. Finally, this study proposes a four-factor model (market premium, size, BM and R&D) that can explain the stock returns better than three-factor model.

Keywords: R&D investment, book-to-market, expected return, asset pricing, risk proxy, conservative accounting principle

JEL: G12; G14

3.1 INTRODUCTION

While BM ratio is a widely accepted risk proxy of stock returns (Chan et al., 2001b, Rosenberg et al., 1985, Fama and French, 1993), some scholars suggest that R&D intensity subsumes BM ratio (Lev and Sougiannis ,1999; Daniel and Titman, 2006; Nelson,2006).

However, it is not reasonable to equate these two factors, because they are associate with different risks. While book-to-market is a risk proxy of financial distress for stock returns (Fama and French, 1992), R&D investment is associate with uncertainty risk of investment outcomes (Cochrane, 1991, Ho et al., 2004). R&D investment and its success are usually not flexible and determined by financial condition, market competition and regulation (Li, 2011). The uncertainty of the events at t+1 generates many possibilities of the investment outcomes, thereby, the investment return is not risk free (Cochrane, 1991). Ho et al. (2004) show that R&D intensity is positively related to systematic risk in the stock market. From firm executive's perspective, investing in research and development is of increased cost and high market risks, like product failures and intense competition (Simpson et al., 2006). Franzen et al. (2007) document that higher research and development spending increases the likelihood of misclassifying solvent firms, and adjusted measures of distress alleviate previously documented anomalously low returns of large, high distress risk, low book-to-market firms.

An insight of the dividend discount model describes the mechanism of market valuation,

$$M_t = \sum_{\tau=1}^{\infty} \frac{E(d_{t+\tau})}{(1+r)^{\tau}}.$$

Expensed investment in R&D is scarifying the current dividend in exchange of future dividend. Intuitively, investment predicts returns because it is a trade-off between the current cash flows and expected future cash flows.

From mathematical side, the increase of R&D investment will result in low BM, and the decrease of R&D will result in high BM. A direct expression of market-to-book ratio, based on the instruction dividend discount model, is

$$\frac{M_t}{B_\tau} = \frac{\sum_{\tau=1}^{\infty} E(d_{t+\tau})/(1+r)^{\tau}}{B_\tau}.$$

GAAP mandates the full expensing of research and development in financial statements, thereby, book value does not capture the investment in research and development, and then book-to-market ratio actually omits the value of R&D inputs. Apparently, since R&D investment reduces book value but brings high expected future dividend, the increase of R&D may results in high M/B or say low B/M. Therefore, if we only look at R&D intensity, high BM stocks will be labelled as bad-buys. Conversely, if we only look at BM, some high R&D stocks may be labelled as bad-buys.

Especially, many high-tech firms have few tangible assets, in contrast, they invest heavily in R&D projects. These R&D projects, which are not recorded in book value, often bring large future cash inflows to the firm and push the firm market value to a high level. Hence, these firms generally have very low book-to-market ratio. If we use BM ratio as the only proxy of firm growth potential, the growth

option and return premia of these high-tech firms will be overlooked. Similarly, it is not fair for low-tech firms if we replace BM proxy with R&D proxy, because R&D investment is not important in their industries.

The main purpose of this study is to identify the risk and return to R&D investment and to investigate its connection with book-to-market ratio and size. First, this paper proposes a negative relation between R&D expenses and book-to-market ratio based on theoretical deduction. It employs “q” theory of investment to explain why investment strategy tend to be growth portfolios, and why R&D investment can provides a hedge to value strategies. The excess return of value strategy has been regarded as the compensation to risk-bearing, and the book-to-market is frequently used as a predictor of stocks returns. However, the relation between book-to-market (or market-to-book) premia and R&D investment premia has not be completely be investigated and documented yet. This study bridges this gap and provides further evidence to the theory of investment-based asset pricing.

Second, this study presents the empirical results of portfolio returns based on different trading strategies. It confirms the predictabilities of book-to-market, size and R&D investment respectively through univariate sort. Furthermore, it implies the relationship book-to-market and R&D investment by showing the cross-sectional return of double-sort portfolios. Consistent with predictions, growth stocks with intensive investment in research and development are underestimated by book-to-market. Moreover, book-to-market cannot be

explained by research and development, which is not consistent with Lev and Sougiannis (1996) and Nelson (2006). This study provides improved value strategies by controlling firm investment in research and development. Similarly, R&D strategies are improved by controlling book-to-market. Since the investment strategies based on research and development are growth strategies, they provide a great hedge for value strategies. The most profitable strategies are holding investment-active value portfolio and shorting investment-inactive growth portfolios.

Third, this paper shows that R&D is crucial for both small firms and large firms, especially for small firms. Controlling R&D level, small cap stocks yield higher returns than large cap stocks on average. The double-sort strategies, on BM and R&D, yield significant higher returns in small cap sample than in large cap sample. Additionally, the equally-weighted strategies outperform the value-weighted strategies on average. These results show that small size effect is significant in the double-sort strategies. It is possible that small firms have higher incentives to invest heavily to survive and to obtain growth opportunities. These results are inconsistent with Chauvin and Hirschey (1993) and Rubera and Kirca (2012) who claim that size advantages make R&D relatively more useful for larger firms than for small firms.

Finally, this study compares the regression details of the three-factor model and a four-factor model, the forth factor of which is a R&D proxy. Thanks to the 90s high-tech bubble, the industry structure is largely changed. The portion of

high-tech firms is increasingly larger after the empirical results reported by Fama and French in 1992. This study separates the stocks with and without R&D inputs, thereby, R&D proxy has two alternative measures. Both alternative four-factor models outperform the three-factor model. The regression results support that R&D investment improves the accuracy of value strategy. Also, the results support that R&D and BM are two independent risk proxies, and reject the argument that the two factors are alike.

The reminder of the paper is organized as follows. Section 2 discusses the risks and options behind investment of research and development. Section 3 describes the data sample and simple definition of measures. Section 4 presents the return premium, portfolio characteristics and time-series factor loadings of investment quintiles. Section 5 investigates the relation between investment and book-to-market, and between investment and market equity. Also, the regression details of three-factor and four-factor models are displayed. Section 6 summarizes the paper.

3.2 DATA

This study employs the monthly stock returns, shares outstanding and stock prices of all US stocks from CRSP, and annual data, including research and development expenditure (R&D), sales, book equity, etc., from COMPUSTAT. Then, the annual accounting data from COMPUSTAT for all fiscal year in calendar year t – 1 are merged with the monthly stock returns for July of year t to June of year t + 1 from CRSP. Following Fama & French (1992), the market capitalization used to

capture book-to-market ratios at t – 1 is the value at the end of December of year t – 1, whereas the firm size is the market equity at June of year t. The full data set covers July 1962 to December 2012.

R&D intensity is captured as the prior year R&D value divided by prior year Sales, following Chambers et al. (2002). This study does not use five year lags of R&D, since it may overlook some firms because some firms may bankrupt within the five years. This study employs Sales from financial report as the scale of R&D investment. Because the initial purpose of R&D expenses is to raise sales and the money for R&D is from selling products, it is reasonable to measure R&D magnitude using sales as the scale.

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 firm R&D intensity, 20^{th}, 40^{th}, 60^{th}, 80^{th} and 100^{th} percentile respectively. According to Table 3.1, the differences of R&D over exchanges are large, and the intensive-R&D firms are mainly in NASDAQ and NYSE MKT exchanges. Therefore, this paper uses all R&D-intensive stocks as the base for RDS breakpoints (percentiles), and uses NYSE breakpoints (percentiles) for book-to-market and size.

[Insert Table 3.1 around here]

3.3 CROSS-SECTION OF INVESTMENT SPREAD

3.3.1 Sorts on R&D investment

Table 3.2 shows portfolio statistics and factor loadings of Fama-French three factor model based on univariate sorts on R&D level [R&D/Sale]. In Panel A, equally-weighted average excess returns is employed as the dependent variable of regression, and value-weighted portfolio returns is used in Panel B.

These results present that the excess returns to high-RD portfolios cannot be explained by FF three factors. Firstly, the intercepts of FF regression in high-RD groups are significant. Moreover, even R&D-active firms tend to be growth firms and R&D-inactive firms tend to be value firms, high-RD portfolios outperform low-RD portfolios. The most R&D-active firms produce 1.05% monthly. It shows that BM cannot explain the excess returns to R&D investment.

From Panel A, we find that the excess return is generally increasing following the increase of R&D investment, and the most R&D-active firms earning 1.05% monthly. From the portfolio BM ratios and the loadings of HML factor, we find that R&D-active firms tend to be growth firms, and R&D-inactive firms tend to be value firms.

[Insert Table 3.2 around here]

Hence, the R&D effect might be decreased by value effect. R&D-inactive

portfolio has a high book-to-market ratio, 5.74, while R&D-active portfolio has a low book-to-market ratio, 0.77. The dramatic difference of the book-to-market between them can result in significant value effect, which is negatively related to R&D effect. Hence, even the return spread of active minus inactive is not very significant, it may probably attributes to that the book-to-market factor influences in the opposite side.

While the R&D-active stocks are typically growth firms, their returns distinctly differ from the common understanding of growth stocks. They are good growth firms, outperforming the market. The abnormal returns of highly ranked active portfolios are significant, around 0.43% per month on average for top two active quintiles.

Additionally, the most R&D-active firms tend to be smaller firms than R&D-inactive firms. The factor loadings of SMB are positive in all R&D groups. While the large firms attribute a large portion to the portfolio, using value-weighted method, the R&D effect is reduced.

3.3.2 Univariate sort on Fama-French factor

This part examines the predictabilities of book-to-market and firm size in this sample dataset. Table 3.3 presents portfolio returns, characteristics and factor loadings of Fama-French three-factor model, based on book-to-market/size. The return spread of equally-weighted (value-weighted) value strategy is 0.84% (0.38%) per month, and the return to equally-weighted (value-weighted) small-minus-big strategy is 0.48% (0.3%) per month . The results support the

book-to-market and size effect, consistent with Pontiff and Schall (1998) and (Banz, 1981).

Most importantly, it shows that low BM firms tend to be more active in R&D investment, consistent with Table 3.2. Moreover, the α of FF3F regression are significant in some groups, which indicate FF factors are not able to explain some returns. Therefore, we suppose that R&D strategy may provide a great hedge for value strategies, providing that a strategy combines two risk factors together. The monthly equally-weighted return spread of the R&D and value strategies presented in Table 3.2 and Table 3.3 are 0.26% and 0.84%, respectively. Running two strategies together would produce higher returns than a single strategy.

[Insert Table 3.3 around here]

The summary statistics of size quintiles indicates that small firms tend to be more active in R&D investment, consistent with Table 3.2. R&D intensity differs over size quintiles, decreasing from 2.6 in small cap portfolios to 0.05 in large cap portfolios. This result is similar with Table 3.2, raising a question that whether there is a co-movement between small size effect and investment effect or not. The answer to this question is presented in Table 3.5, 3.7-3.8 and interpreted later.

3.3.3 Intersection of Fama-French factors

This section further investigates the relation between book-to-market and size,

and their impact on stock returns. Portfolios are formed by double-sorting on book-to-market and market equity, using NYSE breakpoints.

[Insert Table 3.4 around here]

Table 3.4 shows that the returns to value strategy and small-minus-big strategy, are significant and robust. Value strategy yields highest returns in small quintile, and the small-minus-big strategy produces highest returns in high book-to-market quintile. The most profitable strategy is buying small value stocks and selling large growth stocks. The results are robust in both equally-weighted and value-weighted strategies.

It also shows that the intercepts of FF regression on small-minus-big strategies are significant. It means that FF factors cannot explain the return surprise of small firms.

Moreover, the description of investment in Table 3.4 indicates that growth and small firms tend to have higher average R&D investment. It raises the question that whether R&D explains book-to-market and size or not. Therefore, it is interesting to distinct the effect of R&D investment from value effect and small size effect.

3.4 R&D INVESTMENT AND FAMA-FRENCH FACTORS

3.4.1 R&D investment and value

The negative correlation between investment and book-to-market presented in Table 3.2 suggests that value strategies can be improved by controlling for R&D investment and R&D strategies can be improved by controlling for book-to-market. An enhanced value strategy may outperform the initial value strategy if investors separate R&D-active and R&D-inactive firms, and then avoid selling R&D-active stocks and buying R&D-inactive stocks within BM-ranked quintiles. Similarly, an enhanced R&D strategy may outperform the initial strategy if investors separate value and growth firms, and then avoid selling value stocks and buying growth stocks within investment-ranked quintiles.

Portfolios are formed by double-sorting on book-to-market, using NYSE breakpoints, and R&D investment, using the breakpoints based on a sub-sample of R&D firms. Table 3.5 presents the average monthly returns on portfolios formed by a firm's book-to-market ratio and R&D investment intensity. It also shows the high-minus-low portfolio return spreads for both sorts' quintiles, and the results of time-series regressions of these strategy returns on Fama-French factors. The average market equity for each portfolio is provided at the right-bottom corner.

[Insert Table 3.5 around here]

Table 3.5 shows that value strategy and R&D strategy can produce higher profits by controlling the other factor. Within each book-to-market quintile, R&D portfolio return raises with the increase of R&D investment, and the average excess return spread of R&D strategies is around 0.61% per month, which significantly exceeds univariate sorted strategy. Similarly, each value strategy, controlling R&D investment, produces significantly higher returns, around 1.08% monthly, than unconditional value strategy. Also, the results of time series regression on R&D strategies are consistent with the prediction that investment strategies are growth portfolios, with negative factor loadings on HML.

This table suggests that the largest return spread can be obtained by trading the active-value minus inactive-growth portfolios double sort on value and R&D investment. The R&D-active value portfolio generates highest average returns, around 2.01% per month, while the R&D-inactive growth portfolio generates lowest average returns. Hence, both B/M and R&D level is positively related to stock returns, and value and R&D effect are two independent stock return predictors, and. This result is not consistent with Nelson (2006) that replacing B/M indicator with R&D indicator, but confirms that both book-to-market and R&D factor predict stock price.

An interesting pattern is observed from the description of portfolio average market equity. Table 3.5 shows that portfolio size decreases from growth portfolios to value portfolios, but increases from inactive portfolios to active

portfolios. While active growth firms tend to be smaller than inactive growth firms, active value firms tend to be smaller than active growth firms. In sum, the active value portfolio, which pays 2.1% monthly, is the smallest firms in the intersection of value and investment. The factor loadings of SMB show the similar results.

3.4.2 R&D investment and size

This part investigates the relation between investment effect and small size effect. Portfolios are formed by double-sorting on market capitalization, using NYSE breakpoints, and R&D investment, using breakpoints based on a sub-sample of R&D firms. Table 3.6 suggests that the R&D effect is not driven by small size effect, and cannot subsume size effect. Controlling firm size, R&D-active portfolios generally outperform R&D-inactive portfolios, in both small- and large-cap quintiles. Controlling firm R&D investment, small stocks generate higher returns than large firms. Moreover, the equally-weighted strategies are on average outperform the value-weighted strategies, indicating that small size effect improves the trading strategies. This finding, on the other side, indicates that small size effect is significant and it improves R&D strategy.

[Insert Table 3.6 around here]

The table also shows that small-minus-big strategy can be enhanced by

controlling R&D investment. The return spreads of small-minus-big portfolios change dramatically from Non-R&D stocks to R&D-Active stocks. The equally-weighted return spread in Non-R&D group is 0.38% per month, with 0.1% less than that of univariate sort on size. Nevertheless, the return spreads of small-minus-big strategies, within R&D quintiles, are generally paying higher returns than univariate-sort strategy.

Additionally, the return trends of double-sort portfolios, presented in Table 3.6, are not perfect. This can partially be explained by the large variation of book-to-market ratios among the quintiles. Small and inactive portfolios are typically of high book-to-market rate, therefore, value effect is also influence the intersection results.

3.4.3 R&D investment and value conditioning on size

We further create portfolios double-sort on investment and book-to-market are constructed within the large and small cap universes, respectively, where these are defined as firms with market equities above and below the NYSE median. Other conditions are set the same with that of Table 3.5. After controlling the market capitalization, the variation of firm size is reduced and double-sort portfolios are on average of similar size.

Table 3.7 shows that small cap results are consistent with full-sample results that value strategies and R&D strategies can produce higher profits constructed within the other factor quintiles. Within each book-to-market quintile, the portfolio return increases with R&D investment, and the average excess return spread of R&D

strategies is around 0.63% per month which exceeds univariate sorted strategy. Similarly, each value strategy controlling R&D investment produces significantly higher returns, around 1.14% monthly, than unconditional value strategy. Different from Table 3.4, the return spread of value strategy within non-R&D quintile equates the unconditional value strategy. Moreover, the intercepts of FF regression on value and R&D strategy returns are significant in small firms.

[Insert Table 3.7 around here]

Table 3.8 shows the results remain apparent but less significant in large cap stocks than in full-sample and small cap stocks. Similar with all-stock and small cap results, the most profitable portfolio is the active value stocks, producing 2.06% per month. The conditional value strategies are generally less profitable than univariate-sort value strategy. The only value strategy outperforming univariate value strategy is of high R&D investment, generating 1.17% per month. However, this strategy outperforms the value strategy in large cap quintiles shown in Table 3.3. This result suggests that, even in large cap firms, there are still profitable stocks.[1]

[1] Some insignificant return spreads of conditional R&D strategies in book-to-market quintiles are resulted from zero observations in some double-sort portfolios. However, it does not affect the general conclusion of the study.

[Insert Table 3.8 around here]

3.5.4 Model Regression

For a further insight into R&D effect in modeling stock returns, we compare the regression results of FF model and a four factor model. This study investigates a R&D-adjusted model employing univariate-sort SMB factor, and 3*4-sorts HML and AMI factors (alternatively, we replace AMI with RDMN factor). AMI is the return difference between R&D-active and R&D-inactive portfolios, and RDMN is the return difference between R&D and non-R&D portfolios.

[Insert Table 3.9 around here]

Panel A of Table 3.9 shows the intercepts from the FF three-factor regressions for 25 portfolios based on Size and BM. The three factor model has some difficulties in explaining the portfolios of growth stocks. The top two largest portfolios in the Low-BM quintile are of significant positive intercepts, 0.33% (t=6.34) and 0.231% (t=3.93) per month respectively, while the smallest growth portfolio has significant negative intercept, -0.229% per month (t=-3.16). Moreover, the small-cap value portfolio have significant positive intercept, 0.242% per month (t=5.44).

From Panel B, we find that the four-factor model generally reduces the abnormal returns that cannot be explained by three factor model. The forth factor, AMI, reduces the intercepts of two largest growth portfolios to 0.158% (t=2.53) and 0.128% (t=2.02) respectively. The intercepts of other growth portfolios shrink towards zero.

Table 3.10 describes the intercepts and the factor loadings of 24 Size-BM-RD portfolio returns regress on the two models. When we use three-factor model, we find large negative intercept in the non-R&D small-cap growth portfolio, and the large positive intercepts in R&D-intensive small-cap value portfolios and R&D-intensive large-cap growth portfolios. For example, the top two R&D-intensive portfolios in small-value group are of large intercepts, 0.55% (t=4.84) and 0.919% (t=4.04) per month respectively, and the same with the top two R&D-intensive portfolios in large-growth group, 0.322% (t=4.02) and 0.864% (t=5.35) per month respectively.

[Insert Table 3.10 around here]

From Panel B, we find that R&D factor improve the predictability of pricing model. The regression results of four-factor model indicate that the R&D factor, AMI, diminishes the large intercepts. It improves the model's explanary power not only for stocks investing in R&D, but also for those with no R&D investment.

For instance, with the add-in of AMI, the intercept of Non-R&D small-cap growth portfolio raises 17.4 basis points to -0.094% per month (t=-1.39). Besides, AMI brings a large decrease, more than 50%, of the intercepts for the largest two high-R&D low-BM portfolios, resulting in 0.119% (t=1.45) and 0.425% (t=3.25) per month respectively. The improvements trace to positive slopes for the R&D factor, which lower the four-factor estimates of expected returns. The intercepts of other portfolios shrink towards zero.

The Panel C of Table 3.9 and 3.10 imply that the results are robust using an alternative four-factor model. The R&D measure used in the alternative model is RDMN, the average return spread between R&D portfolio and Non-R&D portfolio. This alternative model outperforms the three-factor model in both 25 Size-BM and 24 Size-BM-RD portfolios.

3.6 CONCLUSION

Some profitable growth stocks, having high research and development expenses, may be labeled “bad-buys” measured by book-to-market. Controlling R&D can distinct the valuable growth firms, investing actively in R&D, from growth firms measured by book-to-market, avoiding incorrect estimate of the expected returns. While value strategy generates returns by financing the purchase of cheap (value) assets through the sale of expensive (growth) assets, R&D strategy finance the purchase of stocks investing heavily in R&D in exchange of future cash flows, through the sale of stocks has low potential of future growth. In R&D quintiles, value strategies on average outperform the non-R&D portfolio and univariate

value strategy. The most profitable value strategy is the stocks most actively investing in research and development.

While R&D investment is another dimension of value, R&D factor has significant explanary power on stock returns. This study finds significant and robust R&D premium conditioning on book-to-market and market capitalization. R&D-active stocks tend to generate higher returns than R&D-inactive firms, no matter in low or high BM quintiles. Moreover, R&D strategies are generally growth portfolios, measured either by portfolio characteristics (valuation ratio) or covariance (HML loadings). This finding, on the other side, suggests R&D strategy provides a hedge to value strategy.

In sum, R&D factor is an independent risk proxy and not dominated by book-to-market, conversely, the R&D factor does not dominate book-to-market factor. Moreover, R&D effect cannot be explained by small size effect. The four-factor model proposed in this paper outperforms three-factor models in 5*5 Size-BM portfolios and 2*3*4 Size-BM-R&D portfolios. These findings against Fama and French (1993), Lev and Sougiannis (1999) and Nelson (2006).

REFERENCE

Ali, A., M. Ciftci and W. M. Cready (2012), 'Market Underestimation of the Implications of R&D Increases for Future Earnings: The Us Evidence', Journal of Business Finance & Accounting, Vol. 39, pp. 289-314.

Banz, R. W. (1981), 'The Relationship between Return and Market Value of Common Stocks', Journal of Financial Economics, Vol. 9, pp. 3-18.

Barney, J. (1991), 'Firm Resources and Sustained Competitive Advantage', Journal of management, Vol. 17, pp. 99-120.

Chambers, D., R. Jennings and R. B. Thompson II (2002), 'Excess Returns to R&D-Intensive Firms', Review of Accounting Studies, Vol. 7, pp. 133-158.

Chan, L. K., J. Lakonishok and T. Sougiannis (2001), 'The Stock Market Valuation of Research and Development Expenditures', The Journal of Finance, Vol. 56, pp. 2431-2456.

Chauvin, K. W. and M. Hirschey (1993), 'Advertising, R&D Expenditures and the Market Value of the Firm', Financial management, Vol. 22, pp. 128-140.

Cho, H. J. and V. Pucik (2005), 'Relationship between Innovativeness, Quality, Growth, Profitability, and Market Value', Strategic Management Journal, Vol. 26, pp. 555-575.

Cochrane, J. H. (1991), 'Production ‐ Based Asset Pricing and the Link between Stock Returns and Economic Fluctuations', The Journal of Finance, Vol. 46, pp. 209-237.

Cohen, L., K. Diether and C. Malloy (2013), 'Misvaluing Innovation', Review of Financial Studies, Vol. 26, pp. 635-666.

Daniel, K. and S. Titman (2006), 'Market Reactions to Tangible and Intangible Information', The Journal of Finance, Vol. 61, pp. 1605-1643.

Dedman, E., S. Mouselli, Y. Shen and A. W. Stark (2009), 'Accounting, Intangible Assets, Stock Market Activity, and Measurement and Disclosure Policy—Views from the Uk', Abacus, Vol. 45, pp. 312-341.

Eberhart, A. C., W. F. Maxwell and A. R. Siddique (2004), 'An Examination of Long ‐ Term Abnormal Stock Returns and Operating Performance Following R&D Increases', The Journal of Finance, Vol. 59, pp. 623-650.

Fama, E. F. and K. R. French (1992), 'The Cross ‐ Section of Expected Stock Returns', The Journal of Finance, Vol. 47, pp. 427-465.

Fama, E. F. and K. R. French (1993), 'Common Risk Factors in the Returns on

Stocks and Bonds', Journal of Financial Economics, Vol. 33, pp. 3-56.

Franzen, L. A., K. J. Rodgers and T. T. Simin (2007), 'Measuring Distress Risk: The Effect of R&D Intensity', The Journal of Finance, Vol. 62, pp. 2931-2967.

Ho, Y. K., Z. Xu and C. M. Yap (2004), 'R&D Investment and Systematic Risk', Accounting & Finance, Vol. 44, pp. 393-418.

Jaffe, A. B. (1986), 'Technological Opportunity and Spillovers of R & D: Evidence from Firms' Patents, Profits, and Market Value', The American Economic Review, Vol. 76, pp. 984-1001.

Lakonishok, J., A. Shleifer and R. W. Vishny (1994), 'Contrarian Investment, Extrapolation, and Risk', The Journal of Finance, Vol. 49, pp. 1541-1578.

Lev, B. and T. Sougiannis (1996), 'The Capitalization, Amortization, and Value-Relevance of R&D', Journal of accounting and economics, Vol. 21, pp. 107-138.

Lev, B. and T. Sougiannis (1999), 'Penetrating the Book - to - Market Black Box: The R&D Effect', Journal of Business Finance & Accounting, Vol. 26, pp. 419-449.

Li, D. (2011), 'Financial Constraints, R&D Investment, and Stock Returns', Review of Financial Studies, Vol. 24, pp. 2974-3007.

Merton, R. C. (1973), 'An Intertemporal Capital Asset Pricing Model', Econometrica: Journal of the Econometric Society, Vol. 41, pp. 867-887.

Nelson, J. M. (2006), 'Intangible Assets, Book - to - Market, and Common Stock Returns', Journal of Financial Research, Vol. 29, pp. 21-41.

Penman, S. H. (2009), 'Accounting for Intangible Assets: There Is Also an Income Statement', Abacus, Vol. 45, pp. 358-371.

Pontiff, J. and L. D. Schall (1998), 'Book-to-Market Ratios as Predictors of Market Returns', Journal of Financial Economics, Vol. 49, pp. 141-160.

Rosenberg, B., K. Reid and R. Lanstein (1985), 'Persuasive Evidence of Market Inefficiency', The Journal of Portfolio Management, Vol. 11, pp. 9-16.

Rubera, G. and A. H. Kirca (2012), 'Firm Innovativeness and Its Performance Outcomes: A Meta-Analytic Review and Theoretical Integration', Journal of Marketing, Vol. 76, pp. 130-147.

Shortridge, R. T. (2004), 'Market Valuation of Successful Versus Non - Successful R&D Efforts in the Pharmaceutical Industry', Journal of Business Finance & Accounting, Vol. 31, pp. 1301-1325.

Simpson, P. M., J. A. Siguaw and C. A. Enz (2006), 'Innovation Orientation Outcomes: The Good and the Bad', Journal of Business Research, Vol. 59, pp. 1133-1141.

Sood, A. and G. J. Tellis (2009), 'Do Innovations Really Pay Off? Total Stock Market Returns to Innovation', Marketing Science, Vol. 28, pp. 442-456.

Warusawitharana, M. (2015), 'Research and Development, Profits, and Firm Value: A Structural Estimation', Quantitative Economics, Vol. 6, pp. 531–565.

Xing, Y. (2008), 'Interpreting the Value Effect through the Q-Theory: An Empirical Investigation', Review of Financial Studies, Vol. 21, pp. 1767-1795.

Table 3.1 Characteristics summary over exchanges

Exchanges	obs	BM	ME	RDS	XRD	Lag Cum Ret	Cum Ret
All	2579691	4.18984	1367995	1.9075	59.5551	0.1567	0.1445
NYSE(1)	1061112	5.60169	2673394	0.06192	123.521	0.1686	0.1654
NYSE MKT(2)	299501	3.13886	93204.3	1.47914	2.8784	0.1379	0.1286
NASDAQ(3)	1218327	3.22067	545104	3.24312	27.1928	0.1502	0.1303
NYSE Arca(4)	751	0.71732	271033	0.9614	1.9315	0.1231	0.0604

Note: This table provides summary statistics classified by stock exchanges. BM is the book value at year t-1 divided by the market equity at December of year t-1. ME, in thousands, is the market equity at June of year t. XRD, in millions of dollar, is the raw data of research and development amount at year t-1 directly extracted from database, while RDS is XRD scaled by SALE at year t-1. Lag Cum Ret is the average equally-weighted cumulative returns of year t-1, and Cum Ret is the average equally-weighted cumulative returns of year t. The full sample includes all NYSE, AMEX, and NASDAQ stocks listed on CRSP and COMPUSTAT files.

Table 3.2 Excess returns to portfolios sorted on investment

Ranks	mean	Intercept	mkt	smb	hml	R^2	Adj R^2	BM	ME	RDS	XRD
Panel A Equally-weighted											
Non-R&D	0.77	-0.05	0.9531 ***	0.7412 ***	0.4469 ***	0.92	0.92	4.47	1,072,074	0	0
	[3.49]	[-0.76]	[62.27]	[34.20]	[19.10]						
InActive	0.79	-0.04	1.0305 ***	0.7143 ***	0.3829 ***	0.88	0.88	5.74	2,436,552	-0.005	21.71
	[3.32]	[-0.42]	[51.79]	[25.36]	[12.59]						
2	0.87	0.07	1.0232 ***	0.7573 ***	0.3007 ***	0.91	0.91	5.26	2,067,366	0.022	80.54
	[3.65]	[0.94]	[58.00]	[30.32]	[11.15]						
3	0.97	0.2470 **	1.0386 ***	0.9367 ***	-0.03	0.87	0.87	4.81	1,974,397	0.056	118.05
	[3.54]	[2.49]	[44.45]	[28.32]	[-0.91]						
4	1.11	0.4643 ***	1.0900 ***	1.0295 ***	-0.3481 ***	0.84	0.84	1.68	2,439,373	0.118	126.77
	[3.53]	[3.58]	[35.66]	[23.79]	[-7.45]						
Active	1.05	0.4027 **	1.0921 ***	1.3877 ***	-0.5611 ***	0.79	0.79	0.77	500,860	12.126	35.06
	[2.81]	[2.31]	[26.54]	[23.82]	[-8.92]						
Act-InC	0.26	0.4384 ***	0.06	0.6734 ***	-0.9440 ***	0.5	0.49				
	[1.15]	[2.67]	[1.59]	[12.29]	[-15.96]						

Panel B Value-weighted											
Non-R&D	0.52	-0.1004 **	1.0534 ***	-0.01	0.2799 ***	0.94	0.94	4.47	1,072,074	0	0
	[2.73]	[-2.12]	[94.22]	[-0.43]	[16.38]						
InActive	0.52	0.02	0.9717 ***	-0.1963 ***	0.1698 ***	0.79	0.79	5.74	2,436,552	-0.005	21.71
	[2.75]	[0.27]	[46.63]	[-6.65]	[5.33]						
2	0.56	0	1.0577 ***	-0.0916 ***	0.1693 ***	0.84	0.84	5.26	2,067,366	0.022	80.54
	[2.78]	[0.01]	[54.85]	[-3.36]	[5.74]						
3	0.56	0.09	1.0756 ***	0.02	-0.1418 ***	0.87	0.87	4.81	1,974,397	0.056	118.05
	[2.59]	[1.11]	[57.18]	[0.78]	[-4.93]						
4	0.51	0.1776 *	1.0166 ***	0.02	-0.4415 ***	0.83	0.82	1.68	2,439,373	0.118	126.77
	[2.21]	[1.80]	[43.75]	[0.69]	[-12.43]						
Active	0.64	0.3700 **	1.0878 ***	0.3579 ***	-0.8861 ***	0.76	0.76	0.77	500,860	12.126	35.06
	[2.07]	[2.37]	[29.58]	[6.87]	[-15.76]						
Act-InC	0.12	0.3465 *	0.1161 **	0.5542 ***	-1.0558 ***	0.43	0.43				
	[0.49]	[1.77]	[2.52]	[8.51]	[-15.01]						

Note: This table shows monthly average excess returns to portfolios sorted on investment[R&D/Sales], and results of time series regressions of these portfolios' returns on the Fama and French factors[the market factor(MKT),the size factor small-minus-large (SMB),and the value factor high-minus-low(HML)]. The breakpoints used to sort stocks with R&D expenses are assigned based on all the stocks that have R&D expenses. The Means of first five portfolios assigned by NYSE breakpoints are the portfolio average excess returns in %, and that of "Act-InC" groups are portfolio return spreads. The dependent variable of Pane A is the equally-weighted return spread while that of Panel B is the value-weighted return spread. The weight of value-weighted portfolios is the stock market capitalization at June of year t-1. The sample covers July 1962 to December 2012, and the benchmark is the one-month interest-free rate.

Table 3.3 Excess returns to portfolios sorted on book-to-market and size

Panel A Portfolios sorted on book-to-market

A1 Equally-weighted

B/M	Mean	α	mkt	smb	hml	R2	Adj R2	BM	ME	RDS	XRD
Low	0.43	-0.1876 **	1.0839 ***	0.8359 ***	-0.2732 ***	0.90	0.90	0.25	2,165,336	3.22	57.03
	[1.56]	[-2.07]	[50.86]	[27.71]	[-8.39]						
2	0.77	0.0458	0.9967 ***	0.7476 ***	0.1439 ***	0.93	0.93	0.55	1,692,233	1.39	48.82
	[3.29]	[0.73]	[66.99]	[35.49]	[6.33]						
3	0.9	0.1147 **	0.9413 ***	0.7289 ***	0.3862 ***	0.93	0.93	0.76	1,269,317	3.02	41.45
	[4.16]	[2.02]	[70.26]	[38.43]	[18.86]						
4	1.02	0.1950 ***	0.9168 ***	0.7836 ***	0.4985 ***	0.93	0.93	1.01	944,682	0.50	34.11
	[4.76]	[3.37]	[67.24]	[40.60]	[23.92]						
High	1.28	0.3575 ***	0.9310 ***	0.9364 ***	0.6116 ***	0.88	0.88	15.93	545,559	0.37	101.81
	[5.37]	[4.25]	[47.00]	[33.39]	[20.20]						
High-Low	0.84	0.5451 ***	-0.1529 ***	0.1005 ***	0.8848 ***	0.67	0.67				
	[6.15]	[6.81]	[-8.11]	[3.77]	[30.72]						

A2 Value-weighted											
B/M	Mean	α	mkt	smb	hml	R2	Adj R2	BM	ME	RDS	XRD
Low	0.44	0.0912 **	1.0291 ***	-0.1064 ***	-0.3246 ***	0.95	0.95	0.25	2,165,336	3.22	57.03
	[2.16]	[1.97]	[94.16]	[-6.88]	[-19.44]						
2	0.55	0.0162	1.0113 ***	-0.0793 ***	0.1387 ***	0.93	0.93	0.55	1,692,233	1.39	48.82
	[2.95]	[0.32]	[85.38]	[-4.73]	[7.66]						
3	0.6	-0.0405	1.0086 ***	-0.029	0.3967 ***	0.91	0.91	0.76	1,269,317	3.02	41.45
	[3.26]	[-0.70]	[74.45]	[-1.51]	[19.16]						
4	0.74	-0.0139	1.0369 ***	0.0808 ***	0.5712 ***	0.90	0.90	1.01	944,682	0.50	34.11
	[3.79]	[-0.22]	[70.51]	[3.88]	[25.42]						
High	0.82	-0.0255	1.0877 ***	0.2238 ***	0.6775 ***	0.91	0.91	15.93	545,559	0.37	101.81
	[3.94]	[-0.39]	[70.64]	[10.27]	[28.79]						
High-Low	0.38	-0.1167	0.0586 ***	0.3303 ***	1.0021 ***	0.72	0.72				
	[2.86]	[-1.60]	[3.42]	[13.62]	[38.28]						

Panel B Portfolios sorted on market capitalization

B1 Equally-weighted

Size Ranks	Mean	α	mkt	smb	hml	R^2	Adj R^2	BM	ME	RDS	XRD
Small	1	0.1339	0.9387 ***	1.1664 ***	0.3390 ***	0.87	0.87	6.47	65,924	2.62	9.21
	[3.75]	[1.34]	[39.97]	[35.08]	[9.45]						
2	0.74	-0.0817	1.0803 ***	0.8009 ***	0.2680 ***	0.96	0.96	1.39	354,870	2.10	32.83
	[3.02]	[-1.54]	[86.58]	[45.34]	[14.05]						
3	0.72	-0.0171	1.0729 ***	0.5449 ***	0.2168 ***	0.95	0.95	1.01	801,929	0.20	59.95
	[3.18]	[-0.32]	[84.51]	[30.32]	[11.17]						
4	0.67	-0.0092	1.0980 ***	0.2560 ***	0.1971 ***	0.94	0.94	0.81	1,952,856	0.22	113.06
	[3.12]	[-0.18]	[89.08]	[14.67]	[10.46]						
Big	0.52	-0.0137	1.0651 ***	-0.0897 ***	0.0974 ***	0.96	0.96	0.69	13,251,938	0.05	435.51
	[2.72]	[-0.34]	[113.74]	[-6.77]	[6.81]						
Small-Big	0.48	0.1476	-0.1265 ***	1.2561 ***	0.2416 ***	0.70	0.70				
	[2.67]	[1.47]	[-5.33]	[37.43]	[6.67]						

B2 Value-weighted

Size Ranks	Mean	α	mkt	smb	hml	R2	Adj R2	BM	ME	RDS	XRD
Small	0.77	-0.1116	1.0164 ***	1.0816 ***	0.3181 ***	0.93	0.93	6.47	65,924	2.62	9.21
	[2.92]	[-1.55]	[59.84]	[44.98]	[12.25]						
2	0.74	-0.0788	1.0771 ***	0.7868 ***	0.2621 ***	0.96	0.96	1.39	354,870	2.10	32.83
	[3.02]	[-1.50]	[87.13]	[44.96]	[13.87]						
3	0.72	-0.0129	1.0732 ***	0.5214 ***	0.2137 ***	0.95	0.95	1.01	801,929	0.20	59.95
	[3.19]	[-0.24]	[84.56]	[29.02]	[11.02]						
4	0.66	-0.007	1.0998 ***	0.2385 ***	0.1977 ***	0.94	0.94	0.81	1,952,856	0.22	113.06
	[3.12]	[-0.13]	[89.15]	[13.65]	[10.49]						
Big	0.46	0.0265	1.0173 ***	-0.2233 ***	-0.0157	0.98	0.98	0.69	13,251,938	0.05	435.51
	[2.55]	[0.94]	[152.49]	[-23.64]	[-1.54]						
Small-Big	0.3	-0.1380 **	-0.0009	1.3048 ***	0.3338 ***	0.87	0.87				
	[1.76]	[-2.17]	[-0.06]	[61.47]	[14.56]						

Note: Pane A shows monthly average returns to portfolios sorted on book-to-market, employing NYSE breakpoints, and results of time series regressions of these portfolios' returns on the Fama and French factors[the market factor(MKT),the size factor small-minus-large (SMB),and the value factor high-minus-low(HML). The Means of first five portfolios are the portfolio average excess returns in %, and that of "High-Low" are portfolio return spreads. The dependent variable of Pane A1 is the equally-weighted return spread while that of Panel A2 is the value-weighted return spread. Panel B provides similar results for portfolios sorted on stock market capitalization at June of year t-1, employing NYSE breakpoints. The sample covers July 1962 to December 2012, and the benchmark is the one-month interest-free rate.

Table 3.4 Double sorts on book-to-market and market capitalization

Panel A Equally-weighted

		BM						Value Strategies				
		Low	_2	_3	_4	High	High-Low	mean	Intercept	mkt	smb	hml
Size	Small	0.51629	0.90291 ***	1.03737 ***	1.13330 ***	1.38713 ***	0.87084 ***	0.87	0.7341 ***	-0.1738 ***	-0.2782 ***	0.7365 ***
								[5.37]	[6.29]	[-6.32]	[-7.15]	[17.53]
	2	0.52300 *	0.80291 ***	0.86524 ***	1.00252 ***	0.89366 ***	0.37067 **	0.37	0.0448	-0.0447 *	-0.2395 ***	1.0352 ***
								[2.22]	[0.44]	[-1.86]	[-7.06]	[28.26]
	3	0.47327 *	0.78249 ***	0.83669 ***	0.96985 ***	0.81988 ***	0.34661 **	0.35	0.0219	-0.0548 **	-0.2021 ***	1.0221 ***
								[2.04]	[0.20]	[-2.10]	[-5.46]	[25.60]
	4	0.58635 **	0.64473 ***	0.67730 ***	0.74101 ***	0.90408 ***	0.31773 **	0.32	-0.0778	0.0257	-0.0507	1.0103 ***
								[2.03]	[-0.74]	[1.03]	[-1.44]	[26.63]
	Big	0.44443 **	0.59019 ***	0.61437 ***	0.66656 ***	0.77345 ***	0.32901 **	0.33	-0.0557	-0.0038	0.0589 *	0.9527 ***
								[2.20]	[-0.54]	[-0.16]	[1.71]	[25.61]
	Small-Big	0.07186	0.31272	0.42300 **	0.46674 ***	0.61369 ***						

Continued-

	Small-Big Strategies				
mean	0.07	0.31	0.42	0.47	0.61
	[0.30]	[1.52]	[2.31]	[2.70]	[3.22]
Intercept	-0.3248 **	0.0806	0.2482 **	0.3584 ***	0.4651 ***
	[-2.07]	[0.65]	[2.26]	[3.26]	[3.45]
mkt	-0.0252	-0.1037 ***	-0.1442 ***	-0.2138 ***	-0.1952 ***
	[-0.68]	[-3.57]	[-5.58]	[-8.26]	[-6.15]
smb	1.4699 ***	1.3370 ***	1.2009 ***	1.1001 ***	1.1327 ***
	[28.06]	[32.48]	[32.81]	[30.03]	[25.21]
hml	0.1491 ***	-0.0924 **	-0.1053 ***	-0.1269 ***	-0.067
	[2.64]	[-2.08]	[-2.66]	[-3.21]	[-1.38]

Portfolio RDS

	BM				
	Low	2	3	4	High
Small	4.6768	2.2126	5.2905	0.5853	0.4558
2	4.519	1.4112	0.1537	0.7326	0.0424
3	0.3974	0.1116	0.0663	0.0866	0.0351
4	0.4734	0.0367	0.0368	0.028	0.036
Big	0.0754	0.0358	0.032	0.029	0.0281

Pane B Value-weighted

		BM						Value Strategies				
		Low	_2	_3	_4	High	High-Low	mean	Intercept	mkt	smb	hml
Size	Small	0.33224	0.78167***	0.86211***	0.96602***	1.13710***	0.80486***	0.8	0.5912***	-0.1237***	-0.3114***	0.8909***
								[4.71]	[5.18]	[-4.60]	[-8.18]	[21.67]
	2	0.53602*	0.80347***	0.86072***	1.00002***	0.87186***	0.33584**	0.34	0.0058	-0.0432*	-0.2216***	1.0331***
								[2.04]	[0.06]	[-1.84]	[-6.66]	[28.76]
	3	0.47875*	0.76457***	0.83434***	0.97013***	0.82716***	0.34841**	0.35	0.0238	-0.0582**	-0.1828***	1.0143***
								[2.05]	[0.21]	[-2.21]	[-4.89]	[25.15]
	4	0.58234**	0.63750***	0.68636***	0.72110***	0.91333***	0.33098**	0.33	-0.065	0.026	-0.0463	1.0084***
								[2.12]	[-0.62]	[1.05]	[-1.32]	[26.57]
	Big	0.45517**	0.52208***	0.51455***	0.63832***	0.69875***	0.24358	0.24	-0.2369**	0.0813***	0.1748***	1.0205***
								[1.55]	[-2.13]	[3.10]	[4.71]	[25.46]
	Small-Big	-0.1229	0.25959	0.34756**	0.32771**	0.43835**						

Continued-

	Small-Big Strategies				
mean	-0.12	0.26	0.35	0.33	0.44
	[-0.51]	[1.33]	[2.00]	[1.98]	[2.53]
Intercept	-0.5912 ***	-0.071	0.0954	0.1513	0.2368 **
	[-4.44]	[-0.78]	[1.09]	[1.57]	[2.02]
mkt	0.1171 ***	0.0022	-0.0779 ***	-0.1350 ***	-0.0879 ***
	[3.73]	[0.10]	[-3.78]	[-5.94]	[-3.18]
smb	1.5435 ***	1.3740 ***	1.2261 ***	1.1069 ***	1.0573 ***
	[34.73]	[45.47]	[41.96]	[34.44]	[27.06]
hml	0.1097 **	0.0045	-0.0056	-0.0554	-0.0198
	[2.29]	[0.14]	[-0.18]	[-1.60]	[-0.47]

Portfolio RDS

	BM				
	Low	2	3	4	High
Small	4.6768	2.2126	5.2905	0.5853	0.4558
2	4.519	1.4112	0.1537	0.7326	0.0424
3	0.3974	0.1116	0.0663	0.0866	0.0351
4	0.4734	0.0367	0.0368	0.028	0.036
Big	0.0754	0.0358	0.032	0.029	0.0281

Note: This table shows the average returns to portfolios double-sorted on book-to-market and market equity, employing NYSE breakpoints, and results of time series regressions of both sorts' high-minus-low portfolio returns on the Fama and French factors [the market factor(MKT),the size factor small-minus-large (SMB),and the value factor high-minus-low(HML)]. The return rates of the intersections are in %. Pane A employs equally-weighted strategy, while Panel B employs value-weighted strategy. The weight of value-weighted portfolios is the stock market capitalization at June of t-1 year. The sample covers July 1962 to December 2012, and the benchmark is the one-month interest-free rate.

Table 3.5 Double sorts on book-to-market and R&D investment

Panel A Equally-weighted

		B/M						Value Strategies				
		Low	_2	_3	_4	High	High-Low	mean	Intercept	mkt	smb	hml
RDS	Non-R&D	0.34477	0.62226***	0.79994***	0.90673***	1.18356***	0.83879***	0.84	0.5984***	-0.1303***	0.1805***	0.7173***
								[6.61]	[5.93]	[-5.60]	[5.49]	[20.40]
	InActive	0.19051	0.66822***	0.89469***	1.00129***	1.29281***	1.02885***	1.03	0.7725***	-0.0507	-0.0124	0.6800***
								[5.63]	[4.76]	[-1.36]	[-0.23]	[12.04]
	2	0.34603	0.85256***	0.85859***	0.84904***	1.45039***	1.06427***	1.06	0.7565***	-0.0377	0.1634***	0.6126***
								[6.00]	[4.77]	[-1.03]	[3.16]	[11.10]
	3	0.54685*	0.90463***	0.88682***	1.33696***	1.37132***	0.83230***	0.83	0.5753***	-0.2020***	0.3560***	0.6078***
								[4.49]	[3.58]	[-5.46]	[6.80]	[10.87]
	4	0.66861**	1.08609***	1.40304***	1.69128***	1.93888***	1.21514***	1.22	0.9117***	-0.1154***	0.3339***	0.7682***
								[5.65]	[4.77]	[-2.62]	[5.35]	[11.53]
	Active	0.70498*	1.17494***	1.52420***	1.65255***	2.01307***	1.25701***	1.26	1.2789***	-0.2079***	0.3400***	0.5623***
								[4.40]	[4.48]	[-3.16]	[3.66]	[5.66]
	Act-InC	0.51447**	0.50672*	0.67111**	0.67355*	0.70602**						

Continued-

R&D Strategies											
mean	0.51	0.51	0.67	0.67	0.71						
	[2.37]	[1.84]	[2.05]	[1.93]	[2.10]	Portfolio Average Market Equity					
Intercept	0.4805 **	0.6412 **	0.6792 **	0.6064 *	0.8902 ***		BM				
	[2.29]	[2.54]	[2.35]	[1.92]	[2.87]		Low	_2	_3	_4	High
mkt	0.0404	0.1031 *	0.0338	0.0272	-0.1153	Non-R&D	1,494,304	1,422,680	1,220,835	946,175	477,802
	[0.84]	[1.77]	[0.51]	[0.37]	[-1.61]	InActive	3,169,168	3,869,463	2,214,919	1,743,243	1,280,904
smb	0.4837 ***	0.8217 ***	1.0112 ***	1.0356 ***	0.8444 ***	2	3,548,917	2,846,777	1,622,622	979,678	628,045
	[7.08]	[9.98]	[10.70]	[10.05]	[8.33]	3	4,038,325	1,418,643	896,338	619,365	503,981
hml	-0.6983 ***	-0.8451 ***	-0.7834 ***	-0.7546 ***	-0.8087 ***	4	4,278,958	1,702,139	1,200,338	602,869	432,371
	[-9.49]	[-9.53]	[-7.69]	[-6.80]	[-7.41]	Active	663,979	379,777	357,609	212,468	107,249

Pane B Value-weighted

		B/M						Value Strategies				
		Low	_2	_3	_4	High	High-Low	mean	Intercept	mkt	smb	hml
RDS	Non-R&D	0.41820 **	0.53869 ***	0.60571 ***	0.65780 ***	0.81180 ***	0.39360 ***	0.39	0.0192	0.0311	0.3024 ***	0.7450 ***
								[3.17]	[0.19]	[1.36]	[9.31]	[21.48]
	InActive	0.31784	0.61713 ***	0.75412 ***	0.80867 ***	0.92381 ***	0.56755 **	0.57	0.063	0.0344	0.3281 ***	0.7686 ***
								[2.56]	[0.31]	[0.74]	[4.97]	[10.90]
	2	0.33347	0.63187 ***	0.64816 ***	0.91483 ***	0.93451 ***	0.56558 ***	0.57	-0.0033	0.1275 ***	0.4359 ***	0.7267 ***
								[2.61]	[-0.02]	[2.81]	[6.80]	[10.61]
	3	0.44097 *	0.60373 **	0.64917 **	0.93100 ***	0.93759 ***	0.48189 **	0.48	-0.0887	0.0268	0.4040 ***	0.8660 ***
								[2.08]	[-0.45]	[0.59]	[6.30]	[12.65]
	4	0.51294 **	0.77657 **	0.45726	1.33334 ***	0.99217 ***	0.39339	0.39	-0.0588	-0.0204	0.6432 ***	0.8218 ***
								[1.45]	[-0.24]	[-0.36]	[7.94]	[9.50]
	Active	0.56131 *	0.90973 **	0.93169 **	1.00540 **	1.54348 ***	0.92662 ***	0.93	0.7166 **	0.0471	0.8711 ***	0.4729 ***
								[2.95]	[2.33]	[0.67]	[8.70]	[4.42]
	Act-InC	0.24346	0.29259	0.25422	0.21538	0.62571						

Continued-

R&D Strategies					
mean	0.24	0.29	0.25	0.22	0.63
	[0.99]	[0.92]	[0.68]	[0.55]	[1.59]
Intercept	0.2158	0.1595	0.1168	-0.0162	0.8518 **
	[0.90]	[0.55]	[0.36]	[-0.05]	[2.41]
mkt	0.0476	0.2753 ***	0.1261 *	0.1948 **	0.0479
	[0.86]	[4.15]	[1.70]	[2.43]	[0.59]
smb	0.4752 ***	0.8626 ***	1.1832 ***	1.1369 ***	1.0369 ***
	[6.08]	[9.18]	[11.28]	[10.01]	[8.98]
hml	-0.8054 ***	-0.9816 ***	-0.8625 ***	-0.8161 ***	-1.0650 ***
	[-9.57]	[-9.70]	[-7.63]	[-6.67]	[-8.57]

Portfolio Average Market Equity

	BM				
	Low	_2	_3	_4	High
Non-R&D	1,494,304	1,422,680	1,220,835	946,175	477,802
InActive	3,169,168	3,869,463	2,214,919	1,743,243	1,280,904
2	3,548,917	2,846,777	1,622,622	979,678	628,045
3	4,038,325	1,418,643	896,338	619,365	503,981
4	4,278,958	1,702,139	1,200,338	602,869	432,371
Active	663,979	379,777	357,609	212,468	107,249

Note: This table shows the average returns to portfolios double-sorted on book-to-market and investment[R&D/Sales], and results of time-series regressions for both sorts' high-minus-low portfolio returns on the Fama and French factors [the market factor(MKT),the size factor small-minus-large (SMB),and the value factor high-minus-low(HML)].This study uses NYSE breakpoints for book-to-market, and the breakpoints for R&D investment are based on all the stocks that have R&D expenses. Test statistics are given in square brackets. The return rates of the intersections are in %. Pane A employs equally-weighted strategy, and Panel B employs value-weighted strategy. The weight of value-weighted portfolios is the stock market capitalization at June of year t-1. The sample covers July 1962 to December 2012, and the benchmark is the one-month interest-free rate.

Table 3.6 Double sorts on market capitalization and R&D investment

Panel A Equally-weighted

		Size						Small-Big Strategies				
		Small	_2	_3	_4	Big	Small-Big	mean	Intercept	mkt	smb	hml
RDS	Non-R&D	0.88312 ***	0.74651 ***	0.68777 ***	0.63937 ***	0.49867 ***	0.38446 **	0.38	0.0881	-0.1505 ***	1.1491 ***	0.2222 ***
								[2.25]	[0.81]	[-5.93]	[32.15]	[5.76]
	InActive	1.03856 ***	0.64464 **	0.72970 ***	0.59857 **	0.56863 ***	0.46993 **	0.47	0.0149	-0.0494	1.3729 ***	0.1744 ***
								[2.06]	[0.10]	[-1.38]	[27.32]	[3.21]
	2	1.11498 ***	0.73201 ***	0.78517 ***	0.75827 ***	0.57387 ***	0.54111 **	0.54	0.2587	-0.1640 ***	1.2687 ***	0.1080 *
								[2.45]	[1.57]	[-4.24]	[23.29]	[1.84]
	3	1.23181 ***	0.96317 ***	0.77309 ***	0.76853 ***	0.64854 ***	0.60362 ***	0.6	0.2193	-0.0826 **	1.3243 ***	0.2677 ***
								[2.66]	[1.35]	[-2.16]	[24.65]	[4.61]
	4	1.39373 ***	0.90804 ***	1.03718 ***	0.73576 **	0.56109 **	0.86345 ***	0.86	0.3579	0.0133	1.3868 ***	0.3473 ***
								[2.88]	[1.45]	[0.23]	[17.01]	[3.94]
	Active	1.29471 ***	0.49166	0.97479 **	1.07631 ***	0.78463 **	0.57719	0.58	-0.0883	-0.0574	1.8250 ***	0.5470 ***
								[1.58]	[-0.30]	[-0.84]	[19.09]	[5.30]
	Act-InC	0.35553	-0.1929	0.24509	0.47774	0.216						

Continued-

R&D Strategies					
mean	0.36	-0.19	0.25	0.48	0.22
	[1.32]	[-0.68]	[0.81]	[1.55]	[0.81]
Intercept	0.3763	0.026	0.6291 **	0.7698 ***	0.5189 **
	[1.64]	[0.11]	[2.56]	[2.92]	[2.20]
mkt	0.0912 *	0.1345 **	0.1414 **	0.0632	0.1087 **
	[1.70]	[2.53]	[2.45]	[1.02]	[1.97]
smb	0.6911 ***	0.5010 ***	0.5238 ***	0.5303 ***	0.2280 ***
	[9.06]	[6.65]	[6.41]	[6.06]	[2.92]
hml	-0.7646 ***	-1.1588 ***	-1.3383 ***	-1.2828 ***	-1.1277 ***
	[-9.37]	[-14.37]	[-15.32]	[-13.71]	[-13.49]

Portfolio Average Book-to-market

ME

	Small	2	3	4	Big
Non-R&D	7.03	1.25	0.93	0.77	0.75
InActive	9.18	2.56	1.63	1.28	0.87
2	8.93	1.84	1.32	0.88	0.60
3	7.39	2.17	1.47	0.86	0.55
4	2.35	1.11	0.68	0.65	0.50
Active	0.92	0.40	0.40	0.43	0.37

Pane B Value-weighted

		Size						Small-Big Strategies				
		Small	_2	_3	_4	Big	Small-Big	mean	Intercept	mkt	smb	hml
RDS	Non-R&D	0.69427 ***	0.74606 ***	0.67929 ***	0.63884 ***	0.45800 **	0.23627	0.24	-0.1149	-0.0869 ***	1.1712 ***	0.2971 ***
								[1.49]	[-1.51]	[-4.87]	[46.69]	[10.97]
	InActive	0.92750 ***	0.61461 **	0.73460 ***	0.62658 ***	0.49520 ***	0.43230 *	0.43	-0.2135	0.0895 **	1.4236 ***	0.2906 ***
								[1.80]	[-1.40]	[2.51]	[28.33]	[5.36]
	2	0.87308 ***	0.70456 **	0.76672 ***	0.74554 ***	0.52764 ***	0.34544	0.35	-0.0686	-0.0084	1.3144 ***	0.2242 ***
								[1.59]	[-0.46]	[-0.24]	[26.88]	[4.25]
	3	0.97492 ***	0.97419 ***	0.81069 ***	0.76231 ***	0.51059 **	0.49146 **	0.49	0.0398	0.0423	1.3867 ***	0.2084 ***
								[2.15]	[0.27]	[1.22]	[28.30]	[3.94]
	4	1.13254 ***	0.89372 **	1.05534 ***	0.72225 **	0.48044 **	0.69723 **	0.7	0.0952	0.2206 ***	1.4861 ***	0.2888 ***
								[2.25]	[0.40]	[3.95]	[18.92]	[3.41]
	Active	0.83991 *	0.50769	1.03175 **	1.06393 ***	0.69237 **	0.21659	0.22	-0.4753 *	0.094	1.8600 ***	0.4122 ***
								[0.60]	[-1.76]	[1.48]	[20.86]	[4.28]
	Act-InC	0.0847	-0.1434	0.29715	0.43735	0.19718						

Continued-

R&D Strategies					
mean	0.08	-0.14	0.3	0.44	0.2
	[0.31]	[-0.50]	[0.96]	[1.45]	[0.74]
Intercept	0.1329	0.1076	0.7190 ***	0.7330 ***	0.4432 *
	[0.59]	[0.47]	[2.85]	[2.78]	[1.81]
mkt	0.1097 **	0.1302 **	0.1344 **	0.0563	0.1143 **
	[2.07]	[2.42]	[2.28]	[0.91]	[1.99]
smb	0.6886 ***	0.4738 ***	0.5258 ***	0.4701 ***	0.2316 ***
	[9.18]	[6.21]	[6.29]	[5.37]	[2.84]
hml	-0.8830 ***	-1.2193 ***	-1.3896 ***	-1.2347 ***	-0.9984 ***
	[-11.01]	[-14.93]	[-15.53]	[-13.18]	[-11.46]

Portfolio Average Book-to-market

	ME				
	Small	2	3	4	Big
Non-R&D	7.03	1.25	0.93	0.77	0.75
InActive	9.18	2.56	1.63	1.28	0.87
2	8.93	1.84	1.32	0.88	0.60
3	7.39	2.17	1.47	0.86	0.55
4	2.35	1.11	0.68	0.65	0.50
Active	0.92	0.40	0.40	0.43	0.37

Note: This table shows the average returns to portfolios double-sorted on market equity and investment[R&D/Sales], and results of time-series regressions for both sorts' high-minus-low portfolio returns on the Fama and French factors [the market factor(MKT),the size factor small-minus-large (SMB),and the value factor high-minus-low(HML)].This study uses NYSE breakpoints for market equity, and the breakpoints for R&D investment are based on all the stocks that have R&D expenses. Test statistics are given in square brackets. Pane A employs equally-weighted strategy, and Panel B employs value-weighted strategy. The weight of value-weighted portfolios is the stock market capitalization at June of year t-1. The sample covers July 1962 to December 2012, and the benchmark is the one-month interest-free rate.

Table 3.7 Double sorts on book-to-market and R&D investment for small firms

		B/M						Value Strategies				
		Low	_2	_3	_4	High	High-Low	mean	Intercept	mkt	smb	hml
RDS	Non-R&D	0.40219	0.68507 ***	0.85227 ***	0.95666 ***	1.20579 ***	0.80359 ***	0.8	0.6756 ***	-0.1235 ***	-0.0176	0.6750 ***
								[5.99]	[5.88]	[-4.70]	[-0.47]	[16.96]
	InActive	0.17283	0.65067 **	1.06415 ***	1.04745 ***	1.31713 ***	1.08747 ***	1.09	0.9525 ***	-0.1032 **	-0.2156 ***	0.6610 ***
								[4.10]	[4.91]	[-2.33]	[-3.38]	[9.84]
	2	0.42126	0.83666 ***	0.92987 ***	0.89562 ***	1.52730 ***	0.94499 ***	0.94	0.8222 ***	-0.0998 **	-0.1118 *	0.6421 ***
								[3.77]	[4.27]	[-2.26]	[-1.77]	[9.63]
	3	0.43917	1.04224 ***	1.03501 ***	1.71772 ***	1.38365 ***	0.94221 ***	0.94	0.8360 ***	-0.2044 ***	0.0713	0.5104 ***
								[4.12]	[4.20]	[-4.49]	[1.09]	[7.41]
	4	0.85887 **	1.03299 ***	1.53793 ***	1.65973 ***	2.06962 ***	1.19665 ***	1.2	0.9924 ***	-0.1528 ***	0.0096	0.6126 ***
								[5.07]	[4.64]	[-3.12]	[0.14]	[8.28]
	Active	0.77944 *	1.19764 ***	1.63854 ***	1.67851 ***	2.09089 ***	1.54923 ***	1.55	1.4617 ***	-0.2677 ***	0.0986	0.4149 ***
								[5.21]	[4.95]	[-3.96]	[1.02]	[4.06]
	Act-InC	0.3948	0.57258 *	0.65361 *	0.74875 **	0.79320 **						

Continued-

R&D Strategies					
mean	0.39	0.57	0.65	0.75	0.79
	[1.49]	[1.84]	[1.69]	[2.12]	[2.27]
Intercept	0.4635 **	0.7202 ***	0.7648 **	0.6512 *	0.9606 ***
	[2.23]	[2.63]	[2.11]	[1.92]	[3.00]
mkt	0.0164	0.1383 **	0.0474	0.066	-0.1365 *
	[0.35]	[2.22]	[0.57]	[0.85]	[-1.87]
smb	0.4534 ***	0.5558 ***	0.9089 ***	0.8580 ***	0.7896 ***
	[6.71]	[6.25]	[7.71]	[7.78]	[7.61]
hml	-0.6097 ***	-0.8086 ***	-0.7338 ***	-0.7464 ***	-0.8319 ***
	[-8.41]	[-8.47]	[-5.80]	[-6.31]	[-7.47]

Portfolio Average Market Equity

	BM				
	Low	_2	_3	_4	High
Non-R&D	172,859	201,313	196,165	170,020	109,465
InActive	185,147	222,651	213,017	167,732	149,511
2	222,458	226,457	206,023	157,663	120,824
3	222,355	214,231	170,049	118,850	95,181
4	212,052	196,512	176,221	132,525	87,794
Active	157,074	137,663	113,663	97,685	65,104

Note: This table shows the equally-weighted average returns to portfolios double-sorted on book-to-market and investment[R&D/Sales], and results of time series regressions of both sorts' high-minus-low portfolio- returns on the Fama and French factors [the market factor(MKT),the size factor small-minus-large (SMB),and the value factor high-minus-low(HML)].This study uses NYSE breakpoints for book-to-market, and the breakpoints for R&D investment are based on all the stocks that have R&D expenses. Test statistics are given in square brackets. The sample includes all small stocks whose market equity is less or equal to the median value of NYSE breakpoints and it covers July 1962 to December 2012.

Table 3.8 Double sorts on book-to-market and R&D investment for large firms

		B/M						Value Strategies				
		Low	_2	_3	_4	High	High-Low	mean	Intercept	mkt	smb	hml
RDS	Non-R&D	0.43234 *	0.58642 ***	0.68013 ***	0.71657 ***	0.84142 ***	0.40907 ***	0.41	0.0234	0.043	-0.1183 **	0.9716 ***
								[3.07]	[0.16]	[1.18]	[-2.13]	[19.21]
	InActive	0.45537 *	0.62306 ***	0.62126 ***	0.96402 ***	1.02493 ***	0.42297 **	0.42	-0.0798	0.1291 **	-0.0532	0.5825 ***
								[1.97]	[-0.31]	[1.99]	[-0.54]	[6.48]
	2	0.33285	0.75844 ***	0.74117 ***	0.81600 ***	0.82131 ***	0.46420 **	0.46	-0.3341	0.1874 ***	0.0397	0.8921 ***
								[2.30]	[-1.20]	[2.70]	[0.38]	[9.28]
	3	0.59292 **	0.62442 **	0.76887 ***	0.87220 ***	0.91823 ***	0.30952	0.31	-0.6319 **	-0.1289 *	0.1517	1.0364 ***
								[1.31]	[-2.22]	[-1.82]	[1.41]	[10.57]
	4	0.58012 **	0.84811 **	0.62464 *	1.42986 ***	1.12841 ***	0.3995	0.4	-0.6312	-0.3420 ***	0.3828 **	1.6584 ***
								[1.04]	[-1.25]	[-2.74]	[2.01]	[9.58]
	Active	1.03569 ***	1.11483 ***	0.51481	1.38850 **	2.05790 ***	1.17305 **	1.17	1.0923 *	0.3035 *	-0.2598	0.7372 ***
								[2.13]	[1.74]	[1.95]	[-1.09]	[3.41]
	Act-InC	0.58032 **	0.49715	0.08435	0.30073	0.87243						

Continued-

R&D Strategies					
mean	0.58 [2.09]	0.5 [1.49]	0.08 [0.15]	0.3 [0.54]	0.87 [1.52]
Intercept	0.5463 [1.38]	0.0579 [0.12]	-0.2268 [-0.44]	-0.6665 [-1.03]	0.9845 [1.63]
mkt	0.1897 * [1.94]	0.2456 ** [2.04]	0.3299 *** [2.62]	0.3400 ** [2.13]	0.2766 * [1.85]
smb	0.0562 [0.39]	0.2851 [1.61]	0.4785 ** [2.57]	0.4782 ** [2.03]	-0.1709 [-0.78]
hml	-0.6236 *** [-4.06]	-0.4755 ** [-2.51]	-0.6718 *** [-3.39]	-0.3048 [-1.22]	-0.186 [-0.79]

Portfolio Average Market Equity

	BM				
	Low	_2	_3	_4	High
Non-R&D	4,867,952	4,462,325	4,431,720	4,444,825	4,255,497
InActive	10,445,891	10,606,989	7,004,053	6,624,479	7,614,658
2	9,671,313	7,741,486	5,003,896	4,404,608	4,820,089
3	12,240,402	4,770,928	3,602,762	3,355,046	3,708,761
4	13,507,240	6,978,301	6,629,707	3,651,540	3,707,938
Active	3,626,044	2,526,428	3,324,399	2,339,734	1,625,635

Note: This table shows the equally-weighted average returns to portfolios double-sorted on book-to-market and investment[R&D/Sales], and results of time series regressions of both sorts' high-minus-low portfolio- returns on the Fama and French factors [the market factor(MKT),the size factor small-minus-large (SMB),and the value factor high-minus-low(HML)].This study uses NYSE breakpoints for book-to-market, and the breakpoints for investment are based on all the stocks that have R&D expenses. Test statistics are given in square brackets. The sample includes all small stocks whose market equity is more than the median value of NYSE breakpoints and it covers July 1962 to December 2012.

Table 3.9 Regressions for 25 Size-BM portfolios

	Low	2	3	4	High	Low	2	3	4	High
Panel A: R_i-R_f= α+β_1*MKT+β_2*SMB|BM+β_3*HML|ME+ε										
			α					**t(α)**		
Small	-0.229	0.076	0.106	0.132	0.242	-3.16	1.32	1.96	2.8	5.44
2	0.025	0.102	0.027	0.086	-0.181	0.34	1.43	0.36	1.18	-2.6
3	0.095	0.12	0.072	0.076	-0.173	1.35	1.82	1.11	1.16	-2.27
4	0.33	0.04	-0.064	-0.108	-0.033	6.34	0.75	-1.06	-1.8	-0.42
Big	0.231	0.127	0.017	-0.069	-0.029	3.93	2.35	0.29	-0.99	-0.32
Panel B: R_i-R_f= α+β_1*MKT+β_2*SMB+β_3*HML|RD +β_4*AMI|BM+ε										
			α					**t(α)**		
Small	-0.23	0.068	0.126	0.123	0.199	-2.84	1.08	2.24	2.49	4.16
2	0.017	0.11	0.126	0.13	-0.157	0.21	1.47	1.68	1.67	-1.97
3	-0.009	0.097	0.06	0.071	-0.132	-0.1	1.41	0.88	0.92	-1.44
4	0.158	0.014	-0.1	-0.101	-0.036	2.53	0.25	-1.58	-1.35	-0.38
Big	0.128	0.115	-0.013	-0.057	0.027	2.02	2.04	-0.2	-0.7	0.25
			β_3					**t(β_3)**		
Small	-0.484	-0.16	0.053	0.251	0.413	-15.65	-6.72	2.49	13.35	22.59
2	-0.507	-0.106	0.122	0.267	0.399	-15.79	-3.72	4.24	9.01	13.15
3	-0.429	0.062	0.235	0.388	0.399	-13.37	2.36	9.11	13.23	11.44
4	-0.332	0.105	0.302	0.373	0.423	-13.94	4.92	12.46	13.08	11.6
Big	-0.237	0.061	0.251	0.33	0.372	-9.85	2.84	10.23	10.54	8.93
			β_4					**t(β_4)**		
Small	0.219	0.103	-0.035	-0.078	-0.094	11.9	7.26	-2.77	-6.99	-8.61
2	0.163	-0.039	-0.184	-0.177	-0.191	8.51	-2.29	-10.77	-10	-10.57
3	0.165	-0.074	-0.152	-0.165	-0.193	8.64	-4.72	-9.92	-9.45	-9.27
4	0.192	-0.096	-0.171	-0.181	-0.156	13.54	-7.59	-11.85	-10.62	-7.17
Big	0.097	-0.113	-0.133	-0.185	-0.174	6.79	-8.88	-9.1	-9.9	-7.02

Panel C: R_i-R_f= $\alpha+\beta_1$*MKT+β_2*SMB+β_3*HML|RD +β_4*RDMN|BM+ε

			α					$t(\alpha)$		
Small	-0.218	0.07	0.13	0.127	0.193	-2.65	1.13	2.32	2.6	4
2	0.015	0.105	0.121	0.133	-0.174	0.18	1.4	1.61	1.74	-2.14
3	-0.005	0.093	0.06	0.072	-0.151	-0.06	1.35	0.9	0.94	-1.62
4	0.161	0.013	-0.103	-0.11	-0.047	2.59	0.23	-1.62	-1.46	-0.49
Big	0.127	0.107	-0.013	-0.059	0.026	2.03	1.89	-0.21	-0.72	0.24
			β_3					$t(\beta_3)$		
Small	-0.499	-0.166	0.052	0.252	0.419	-15.99	-6.98	2.46	13.64	22.87
2	-0.512	-0.102	0.131	0.272	0.416	-16.18	-3.59	4.6	9.36	13.47
3	-0.437	0.067	0.24	0.394	0.417	-13.71	2.55	9.46	13.63	11.78
4	-0.341	0.109	0.31	0.385	0.436	-14.48	5.16	12.91	13.43	11.91
Big	-0.24	0.069	0.256	0.338	0.379	-10.1	3.21	10.57	10.9	9.17
			β_4					$t(\beta_4)$		
Small	0.351	0.175	-0.078	-0.154	-0.148	10.97	7.19	-3.59	-8.13	-7.87
2	0.3	-0.054	-0.312	-0.329	-0.283	9.25	-1.84	-10.64	-11.07	-8.94
3	0.284	-0.119	-0.275	-0.299	-0.278	8.68	-4.45	-10.55	-10.1	-7.67
4	0.337	-0.169	-0.299	-0.291	-0.24	13.97	-7.78	-12.18	-9.9	-6.4
Big	0.176	-0.178	-0.237	-0.326	-0.308	7.22	-8.06	-9.57	-10.25	-7.27

Note: At the end of June each year, stocks are independently allocated to five size quintiles and five BM quintiles, using NYSE breakpoints. The intersections of the two sorts produce 25 Size-BM portfolios, whose equally-weighted excess returns are later used as the dependent variables of time-series regression. The table provides results of time series regressions of these portfolios' equally-weighted excess returns on the market factor (MKT), Size factor (SMB), the value factor (HML), and the RD factor (AMI/RDMN). AMI is the return difference between R&D-active and R&D-inactive portfolios, and RDMN is the return difference between R&D and non-R&D portfolios. The sample covers July 1962 to December 2012, and the benchmark is the one-month risk-free *rate*.

Table 3.10 Regressions for 24 Size-BM-RD portfolios

	Small						Big					
	Low	2	High	Low	2	High	Low	2	High	Low	2	High
Panel A: R_i-R_f= α+β_1*MKT+β_2*SMB|BM+β_3*HML|ME+ε												
	α			**t(α)**			**α**			**t(α)**		
Non	-0.268	-0.063	0.035	-3.87	-1.08	0.87	0.012	-0.004	-0.094	0.23	-0.07	-1.75
Inc	-0.506	0.047	0.071	-2.21	0.41	0.84	0.13	-0.022	0.082	1.6	-0.26	0.7
2	0.083	0.401	0.55	0.63	3.96	4.84	0.322	0.159	0.038	4.02	1.73	0.3
Act	0.202	0.808	0.919	1.42	4.56	4.04	0.864	0.391	0.455	5.35	1.71	1.48
Panel B: R_i-R_f= α+β_1*MKT+β_2*SMB+β_3*HML|RD +β_4*AMI|BM+ε												
	α			**t(α)**			**α**			**t(α)**		
Non	-0.094	0.083	0.113	-1.39	1.64	2.53	0.053	-0.003	-0.036	1.03	-0.05	-0.45
Inc	-0.307	0.122	0.055	-1.3	1.07	0.69	0.207	-0.002	0.089	2.64	-0.02	0.71
2	-0.081	0.273	0.109	-0.62	2.68	1.11	0.119	-0.072	-0.165	1.45	-0.78	-1.23
Act	0.032	0.309	-0.369	0.29	2.42	-2.84	0.425	-0.194	-0.243	3.25	-0.9	-0.83
	β_3			**t(β_3)**			**β_3**			**t(β_3)**		
Non	-0.363	0.103	0.367	-13.98	5.3	21.48	-0.177	0.285	0.389	-9.01	12.51	12.44
Inc	-0.363	0.097	0.402	-3.99	2.21	13.12	-0.175	0.242	0.378	-5.8	7.47	7.81
2	-0.354	-0.07	0.519	-6.97	-1.8	13.82	-0.283	0.292	0.511	-8.97	8.35	9.94
Act	-0.662	-0.062	1.046	-15.66	-1.27	21.03	-0.505	0.008	0.528	-10.05	0.1	4.7
	β_4			**t(β_4)**			**β_4**			**t(β_4)**		
Non	-0.124	-0.239	-0.218	-7.77	-20.11	-20.78	-0.109	-0.19	-0.183	-9	-13.55	-9.51
Inc	-0.044	-0.185	-0.211	-0.79	-6.88	-11.21	-0.163	-0.219	-0.226	-8.82	-11.03	-7.6
2	0.366	0.202	0.257	11.74	8.43	11.14	0.262	0.109	-0.002	13.54	5.06	-0.05
Act	0.65	0.813	1.021	25.01	27.12	33.42	0.756	0.663	0.663	24.51	13.07	9.61

Panel C: R_i-R_f= $\alpha+\beta_1$*MKT+β_2*SMB+β_3*HML|RD +β_4*RDMN|BM+ε

	α			t(α)			α			t(α)		
Non	-0.084	0.087	0.109	-1.28	1.96	2.65	0.057	0.0003	-0.041	1.16	0.01	-0.51
Inc	-0.382	0.058	-0.033	-1.61	0.49	-0.38	0.153	-0.064	0.021	1.85	-0.71	0.16
2	-0.068	0.241	0.081	-0.52	2.55	0.91	0.106	-0.098	-0.199	1.41	-1.12	-1.49
Act	0.066	0.369	-0.277	0.61	2.79	-1.9	0.497	-0.187	-0.187	3.53	-0.9	-0.63
	β_3			t(β_3)			β_3			t(β_3)		
Non	-0.369	0.102	0.371	-14.83	6.06	23.53	-0.179	0.284	0.394	-9.47	13.31	12.79
Inc	-0.317	0.138	0.459	-3.51	3.06	13.64	-0.14	0.283	0.422	-4.43	8.16	8.44
2	-0.365	-0.051	0.535	-7.31	-1.43	15.8	-0.277	0.308	0.532	-9.63	9.21	10.44
Act	-0.689	-0.105	0.98	-16.55	-2.08	17.68	-0.555	-0.002	0.488	-10.34	-0.02	4.33
	β_4			t(β_4)			β_4			t(β_4)		
Non	-0.271	-0.466	-0.402	-10.33	-26.2	-24.25	-0.222	-0.371	-0.33	-11.11	-16.51	-10.18
Inc	0.162	-0.138	-0.106	1.71	-2.91	-3	-0.131	-0.208	-0.203	-3.95	-5.69	-3.86
2	0.648	0.492	0.582	12.34	12.97	16.32	0.541	0.295	0.107	17.85	8.39	2
Act	1.117	1.343	1.629	25.48	25.25	27.9	1.198	1.233	1.069	21.2	14.74	9.01

Note: At the end of June each year, stocks are independently allocated to two Size quintiles, three BM quintiles, using NYSE breakpoints, and four R&D quintiles, using breakpoints based on all the stocks that have positive R&D investment. The intersections of the three sorts produce 2*3*4 Size-BM portfolios, whose equally-weighted excess returns are later used as the dependent variables of time-series regression. The table provides results of time-series regressions of these portfolios' equally-weighted excess returns on the market premium (MKT), Size factor (SMB), the value factor (HML), and the RD factor (AMI/RDMN). AMI is the return difference between R&D-active and R&D-inactive portfolios, and RDMN is the return difference between R&D and non-R&D portfolios. The sample covers July 1962 to December 2012, and the benchmark is the one-month interest-free rate.

Chapter 4 Firm Characteristics and Momentum

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.

Key Words: Asset pricing; Portfolio Returns; Momentum; Firm Characteristics

JEL: G11; G12; G14

4.1 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.

4.2 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.

4.3 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.

4.4 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^{th}, 40^{th}, 60^{th}, 80^{th} and 100^{th} percentile respectively).

4.5 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.

4.5.1 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.

4.5.2 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.

4.5.3 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.

4.5.4 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.

4.6 Empirical Results

4.6.1 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-1989period, 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.

[Insert Table 4.1 around here]

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.

4.6.2 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.

[Insert Table 4.2 around here]

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.

[Insert Table 4.3 around here]

4.6.3 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, 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.

[Insert Table 4.4 around here]

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.

[Insert Table 4.5 around here]

4.6.4 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.

[Insert Table 4.6 around here]

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.

[Insert Table 4.7 around here]

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 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.

[Insert Table 4.8 around here]

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.

4.7 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.

Reference

ALI, A., CIFTCI, M. & CREADY, W. M. 2012. Market underestimation of the implications of R&D increases for future earnings: the US evidence. *Journal of Business Finance & Accounting,* 39**,** 289-314.

ARIELY, D. & JONES, S. 2008. *Predictably irrational*, HarperCollins New York.

BARBERIS, N., SHLEIFER, A. & VISHNY, R. 1998. A model of investor sentiment. *Journal of Financial Economics,* 49**,** 307-343.

BERK, J. B., GREEN, R. C. & NAIK, V. 1999. Optimal investment, growth options, and security returns. *The Journal of Finance,* 54**,** 1553-1607.

CAO, C., SIMIN, T. & ZHAO, J. 2008. Can growth options explain the trend in idiosyncratic risk? *Review of financial studies,* 21**,** 2599-2633.

CHAMBERS, D., JENNINGS, R. & THOMPSON II, R. B. 2002. Excess returns to R&D-intensive firms. *Review of Accounting Studies,* 7**,** 133-158.

CHAN, L. K., LAKONISHOK, J. & SOUGIANNIS, T. 2001. The stock market valuation of research and development expenditures. *The Journal of Finance,* 56**,** 2431-2456.

CHAN, L. K. C., JEGADEESH, N. & LAKONISHOK, J. 1996. Momentum strategies. *The Journal of Finance,* 51**,** 1681-1713.

CHAUVIN, K. W. & HIRSCHEY, M. 1993. Advertising, R&D expenditures and the market value of the firm. *Financial management,* 22**,** 128-140.

CHUI, A. C., TITMAN, S. & WEI, K. J. 2010. Individualism and momentum around the world. *The Journal of Finance,* 65**,** 361-392.

CONRAD, J. & KAUL, G. 1993. Long‐Term Market Overreaction or Biases in Computed Returns? *The Journal of Finance,* 48**,** 39-63.

DANIEL, K., HIRSHLEIFER, D. & SUBRAHMANYAM, A. 1998. Investor Psychology and Security Market Under- and Overreactions. *The Journal of Finance,* 53**,** 1839-1885.

DEBONDT, W. F. & THALER, R. 1985. Does the stock market overreact? *The Journal of finance,* 40**,** 793-805.

EISENHARDT, K. M. & MARTIN, J. A. 2000. Dynamic capabilities: what are they? *Strategic management journal,* 21**,** 1105-1121.

FAMA, E. F. & FRENCH, K. R. 1993. Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics,* 33**,** 3-56.

FAMA, E. F. & FRENCH, K. R. 2012. Size, value, and momentum in international stock returns. *Journal of Financial Economics,* 105**,** 457-472.

GEORGE, T. J. & HWANG, C.-Y. 2007. Long-Term Return Reversals: Overreaction or Taxes? *The Journal of Finance,* 62**,** 2865-2896.

GRIFFIN, J. M., JI, X. & MARTIN, J. S. 2003. Momentum investing and business cycle risk: Evidence from pole to pole. *The Journal of Finance,* 58**,** 2515-2547.

HONG, H., LIM, T. & STEIN, J. C. 2000. Bad news travels slowly: Size, analyst coverage, and the profitability of momentum strategies. *The Journal of Finance,* 55**,** 265-295.

HONG, H. & STEIN, J. C. 1999. A unified theory of underreaction, momentum trading, and

overreaction in asset markets. *The Journal of Finance,* 54**,** 2143-2184.

HWANG, S. & RUBESAM, A. 2013. The disappearance of momentum. *The European Journal of Finance***,** 1-24.

JEGADEESH, N. & TITMAN, S. 1993. Returns to buying winners and selling losers: Implications for stock market efficiency. *The Journal of Finance,* 48**,** 65-91.

JEGADEESH, N. & TITMAN, S. 2001. Profitability of Momentum Strategies: An Evaluation of Alternative Explanations. *The Journal of Finance,* 56**,** 699-720.

JIANG, H. 2010. Institutional investors, intangible information, and the book-to-market effect. *Journal of Financial Economics,* 96**,** 98-126.

JOHNSON, T. C. 2002a. Rational momentum effects. *The Journal of Finance,* 57**,** 585-608.

JOHNSON, T. C. 2002b. Volatility, momentum, and time-varying skewness in foreign exchange returns. *Journal of Business & Economic Statistics,* 20**,** 390-411.

KAUL, G. & NIMALENDRAN, M. 1990. Price reversals: Bid-ask errors or market overreaction? *Journal of Financial Economics,* 28**,** 67-93.

KRAFT, H., SCHWARTZ, E. S. & WEISS, F. 2013. Growth options and firm valuation. National Bureau of Economic Research.

LEV, B. & SOUGIANNIS, T. 1996. The capitalization, amortization, and value-relevance of R&D. *Journal of accounting and economics,* 21**,** 107-138.

LI, D. 2011. Financial Constraints, R&D Investment, and Stock Returns. *Review of Financial Studies,* 24**,** 2974-3007.

LONG, J. B., SHLEIFER, A., SUMMERS, L. H. & WALDMANN, R. J. 1990. Positive feedback investment strategies and destabilizing rational speculation. *the Journal of Finance,* 45**,** 379-395 %.

MIZIK, N. & JACOBSON, R. 2003. Trading off between value creation and value appropriation: The financial implications of shifts in strategic emphasis. *Journal of Marketing,* 67**,** 63-76.

MOSKOWITZ, T. J. & GRINBLATT, M. 1999. Do industries explain momentum? *The Journal of Finance,* 54**,** 1249-1290.

NELSON, J. M. 2006. INTANGIBLE ASSETS, BOOK‐TO‐MARKET, AND COMMON STOCK RETURNS. *Journal of Financial Research,* 29**,** 21-41.

NOVY-MARX, R. 2012. Is momentum really momentum? *Journal of Financial Economics,* 103**,** 429-453.

PHILLIPS, G. M. & ZHDANOV, A. 2012. R&D and the Incentives from Merger and Acquisition Activity. *Review of Financial Studies***,** hhs109.

ROUWENHORST, K. G. 1998. International momentum strategies. *The Journal of Finance,* 53**,** 267-284.

RUBERA, G. & KIRCA, A. H. 2012. Firm innovativeness and its performance outcomes: A meta-analytic review and theoretical integration. *Journal of Marketing,* 76**,** 130-147.

SAGI, J. & SEASHOLES, M. 2007. Firm-specific attributes and the cross-section of momentum. *Journal of Financial Economics,* 84**,** 389-434.

SIMPSON, P. M., SIGUAW, J. A. & ENZ, C. A. 2006. Innovation orientation outcomes: The good and the bad. *Journal of Business Research,* 59**,** 1133-1141.

WARUSAWITHARANA, M. 2015. Research and development, profits, and firm value: A structural estimation. *Quantitative Economics,* 6**,** 531–565.

Table 4.1 Unconditional Momentum Strategy Returns

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.

		Momentum Strategy							
		equally-weighted				*value-weighted*			
		Holding period							
		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
	12	-0.22	-0.86	-1.58	-2.08 **	1.51	1.12	0.54	0.49

Table 4.2 ME-assigned Momentum Strategy Returns

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.

		ME-assigned Momentum							
		equally-weighted				value-weighted			
		Holding period							
		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
	3	-4.10 ***	-2.64 ***	-2.17 **	-1.58	-0.7	0.24	0.32	0.51
	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

Table 4.3 ME-assigned Momentum Strategy Returns over Two Periods

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.

		ME-assigned Momentum							
		equally-weighted				value-weighted			
		Holding period							
		3	6	9	12	3	6	9	12
		High ME							
		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
		Medium ME							
		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

Continued-

					Low ME				
					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 *
	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 *

Table 4.4 BM-assigned Momentum Strategy Returns

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.

		ME-assigned Momentum							
		equally-weighted				*value-weighted*			
		Holding period							
		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 ***

Table 4.5 BM-assigned Momentum Strategy Returns over Two Periods

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.

		ME-assigned Momentum							
		equally-weighted				value-weighted			
		Holding period							
		3	6	9	12	3	6	9	12
		High BM							
		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
		Medium BM							
		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

Continued-

					Low BM				
					Before 1989				
	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
LB	6	3.45 ***	3.86 ***	5.00 ***	2.20 **	4.36 ***	5.38 ***	5.42 ***	4.78 ***
	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				
	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
LB	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

Table 4.6 RD-assigned Momentum Strategy Returns over post-1989 period

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.

		RD-assigned Momentum							
		equally-weighted				value-weighted			
		Holding period							
		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			
	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
LB	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

Table 4.7 RD-assigned Momentum Strategy Returns in Three ME Cap Groups over post-1989 period

*The stocks are firstly assigned into 3*3 groups based on ME and R&D/Sale. 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.*

		RD-assigned Momentum							
		equally-weighted				*value-weighted*			
		Holding period							
Large-Cap		**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
		High RD							
	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
LB	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							
	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
LB	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							
	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
LB	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

Continued-

Medium-Cap									
		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
	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

Continued-

Small-Cap									
		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	-0.86	-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

*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.*

			High-Tech								***Low-Tech***							
			equally-weighted				*value-weighted*				*equally-weighted*				*value-weighted*			
			Holding period								***Holding period***							
Large-Cap			**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
		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
High RD	***LB***	**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

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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

Continued-

			High-Tech								***Low-Tech***							
			equally-weighted				*value-weighted*				*equally-weighted*				*value-weighted*			
			Holding period								***Holding period***							
Medium-Cap			**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
		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
		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
High RD	***LB***	**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
		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	-0.0116	-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
Low RD	***LB***	**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

Continued-

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

Continued-

		High-Tech								*Low-Tech*							
		equally-weighted				*value-weighted*				*equally-weighted*				*value-weighted*			
		Holding period								***Holding period***							
		3	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**	**3**	**6**	**9**	**12**
Small-Cap		**High RD**								**High RD**							
LB	**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
	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

Continued-

		Low RD								Low RD							
	3	-0.0182	-0.0168	-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
L B	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								**Non-RD**							
	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
L B	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

Chapter 5 Firm Attributes and Momentum Strategies in China

Abstract

This study investigates the momentum and reversal phenomenon in China, based on the most up-to-date data. It shows that Chinese stock market barely experiences momentum effect, but the long-horizon reversal effect is becoming increasingly significant in the recent years. Additionally, two risk proxies, size and R&D investment, are employed to explain the momentum and reversal phenomenon. It shows that the returns of large stocks are more likely to be persistent, while that of small firms are more likely reverse. Moreover, R&D investment reduces reversal effect, especially for small firms.

Key Words: Chinese Stock Market; Momentum; Reversal; Firm Size; R&D

JEL: G11; G12; G15

5.1 Introduction

The excess returns generated by momentum and contrarian strategies have been discussed for decades by practitioners and academic scholars. Jegadeesh and Titman (1993) suggest momentum 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. On the other hand, the contrarian strategy, also known as reversal, describes a negative relationship between past returns and current return. DeBondt and Thaler (1985) show that loser stocks in the past 3 to 5 years outperform winner stocks by 25% over the next 3 years, which is named as long-term "reversal", suggesting that contrarian strategies (long past losers and short past winners) produce significant returns.

Momentum has also been shown to be robust across many financial markets (Rouwenhorst, 1998, Chui et al., 2010, Griffin et al., 2003, Novy-Marx, 2012). However, prior studies have not reached a conclusion of the momentum patterns in Chinese market (Kang et al., 2002, Qi and Zhong-guo, 2015, Lee and Kuo, 2010, Lu and Zou, 2007) . While some scholars document significant returns to some contrarian and momentum strategies (Kang et al., 2002, Chan and Chang, 2014), other researchers find no momentum effect based on different data sample (Griffin et al., 2003, Wu, 2011).

Regarding Chinese stock market, which is less developed and has short-selling restrict, its stock prices are driven by rumors and investor sentiment, rather than

information. Moreover, because Chinese stock trading is dominated by individual investors who are lack of good finance knowledge, they generally trade relying on historical price trends and market rumors. Kang et al. (2002) argue that Chinese are more likely to misprice stocks. Therefore, it is interesting to study the returns to momentum and contrarian strategies and the rationales.

The main purpose of this study is to explore and explain the momentum and reversal phenomenon in Chinese stock market. Building on Berk et al. (1999) and Sagi and Seasholes (2007), this study reports the returns of momentum and contrarian strategies in China, and explains the returns by firm attributes. It employs most recent data from CSMAR and WIND databases which are well-known Chinese stock data sources.

This study has two main contributions which may shed a light to a better understanding of Chinese stock market and trading strategies. First, this study shows the performance of JT momentum strategies in Chinese stock market, using all A-Shares over 1995-2014. From the empirical results, we can conclude that the return to momentum strategies in Chinese stock market is close to zero, while the contrarian strategies generate significant profits in the long horizon. Moreover, the significance of reversal effect becomes stronger over the recent years. These results provide new evidence for the literature of momentum and reversal phenomenon in China.

Second, this study tries to explain momentum and reversal patterns in China based on firm size and R&D investment. Based on double-sort and triple-sort

methods, it employs firm size and R&D investment to investigate whether these two proxies can help to explain momentum and reversal effect in China. There are three main conclusions in this part. Above all, large firms experience momentum effect in early years of Chinese market development, while small firms are more likely to reverse and the reversal effect is more notable in recent years. In addition, it seems that the reversal effect is largely decreased when firms invests in research and development. What is more, the influence of R&D investment is apparent in both large-cap and small-cap groups, and R&D investment has stronger impact on small firms than on large firms.

5.2 Literature Review

While behavioral explanation suggests that investors' cognitive bias generates price momentum (DeBondt and Thaler, 1985, Hong and Stein, 1999), rational explanation argues that the momentum profits are the compensation of risks (Berk et al., 1999, Johnson, 2002b). Some empirical studies suggest that some observable attributes of firm-level, industry-level or broader scope, drive momentum (Sagi and Seasholes, 2007, Moskowitz and Grinblatt, 1999). More recently, Vassalou and Apedjinou (2004) find that price momentum strategy is only profitable when constructed within the two high corporate innovation portfolios based on past 6 month return and innovation. Berk et al. (1999) and Sagi and Seasholes (2007) suggest that firm growth option affects a firm's systematic risk and its expected returns.

We select firm size as one risk proxy because previous findings indicate that size

explains US momentum and Chinese stock price (Booth et al., 2016, Jegadeesh and Titman, 2001, Wong et al., 2006). 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.

The other firm attribute, R&D investment, is used as the proxy of growth option. Being a typical risky and popular activity in recent years, especially after the technology boom in 90s, R&D investment has received lots of discussion on its risks and values. Prior studies suggest that excess returns are the compensation of risks, like product failures and intense competition pressure associate with R&D activities (Simpson et al., 2006, Li, 2011). Most importantly, R&D investments are risky assets that sacrifice existing assets in exchange of expected future growth, therefore, R&D firms have more growth options and risks than non-R&D firms (Kraft et al., 2013, Sagi and Seasholes, 2007).

Moreover, some papers suggest that R&D plays different roles in large firms and small firms. Some scholars suppose that the profits brought from R&D investment are higher in large firms than in small firms (Chauvin and Hirschey, 1993, Rubera and Kirca, 2012), whereas the others believe that there are more reasons for small

firms to invest in R&D projects (Phillips and Zhdanov, 2013). 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. 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.

5.3 Data and Measures

Monthly stock returns, price, number of outstanding shares and quarterly corporate financial statement information are obtained from CSMAR database, and the annual R&D expenses are from WIND. We choose all A-shares in both Shanghai and Shenzhen Stock Exchanges, and do not include B-share and H-share because the total firm number of these shares is only around one hundred and their movements differ from A-shares (Chen et al., 2010, Chan et al., 2001a). We use a sample covers stock return data from January 1995 to December 2014 and related financial statement data. The sample period excludes the first four years after the initial setup of the two exchanges in December 1990, since the stock market size is very small before 1995. Based on the large change and development of Chinese stocks over the years, we compare two sub-samples which cover 1995-2004 and 2005-2014 respectively.

Following Wong et al. (2006), we define firm size as the market value of A-shares which is the number of A-shares outstanding multiplied by the market price per share, measured in millions of RMB. Based on the monthly data, we are able to

calculate firm size at the end of each month.

Table 5.1 provides summary statistics of the variables for selected years from 1995 to 2014. All statistics are summarized based on observations at June of each year. For example, in June 2014, there are 2027 A-stocks in the sample. The average market capitalization is RMB9.202 billion, where the largest stock is valued at RMB1220.892 billion and the smallest is valued at RMB286 million. The average monthly return is 4%, where the highest return rate is 107% and the lowest rate is -32%. Over the sample period, the stock number and market capitalization has notably increased, and the return rate changes largely over time.

[Insert Table 5.1 around here]

Till the end of fiscal year 2014, WIND database provides research and development expense over 2005 to 2014 for 2780 firms. Most firms started to report R&D investment information since 2006, required by the regulation (no data revealed before 2005, and only firms reported at 2005). Because most firms only report annual R&D expense, we only collect annual data for the stocks. Hence, our dataset of R&D expense covers yearly data from 2006 to 2014.

R&D intensity is captured as the prior year R&D value divided prior year sales (total operating revenue)[1], according to Chambers et al. (2002). Since most Chinese firms do not report quarterly R&D data, we suppose firms allocate R&D

expense equally and gain equal revenue throughout the year, hence the quarterly R&D level equates annual level. Table 5.2 provides the statistical summary of R&D firms and No-R&D firms. Following Warusawitharana (2015), we define No-R&D firms as those with zero or missing R&D value. The R&D group is then assigned into five quintiles based on the breakpoints of firm R&D intensity (20^{th}, 40^{th}, 60^{th}, 80^{th} and 100^{th} percentile respectively).

During 2014 fiscal year, there are 2200 firms investing in research and development, and the remaining 580 firms are not. The market capitalization of largest No-R&D firm is RMB1, 750 billion, while the largest R&D firm has market value of RMB711 million. The average market capitalization of No-R&D firms is higher than that of R&D firms. The mean of R&D level (R&D/Sales) is slightly increased over the years, between 0.01 and 0.04, where the most active firms invest in an amount higher than its sales.

[Insert Table 5.2 around here]

5.4 Trading Strategies

This study employs unrestricted, double-sort and triple-sort momentum trading strategies introduced following, for a better understanding of the relation between firm characteristics and momentum profits. The unconditional momentum strategy is the strategies explained Jegadeesh and Titman (1993), while the other

strategies are enhanced momentum strategies considering firm-specific attributes. Strategies involving R&D data are quarterly rebalancing, while others are monthly rebalancing.

5.4.1 Unrestricted Momentum

Following Jegadeesh and Titman (1993), we replicate unconditional momentum strategies. Firms are ranked into five quintiles from the highest to the lowest according to their past cumulative returns over a given period, over the past 1-15 quarters. Stocks in the top quintile are "winners" with the highest past returns, and stocks in the bottom quintile are "losers" with the lowest past returns. At the beginning of each quarter, we form the momentum portfolio that buys past winners and sells past losers. Each long-short portfolios are held for holding period from 1 to 15 quarters.

5.4.2 Double-Sort Momentum

In two-way sort momentum strategies, stocks are ranked into three groups according to a firm-specific attribute at the beginning of each quarter. The top 30 percent are assigned into "high", the bottom 30 percent are assigned into "low", and the remaining are assigned into "medium" group. This study considers two different firm-specific proxies: firm size and R&D. Three groups are formed according to size as introduced above, while four groups are formed based on R&D level where the forth group is No-R&D group. After that, within each group classified by single firm-specific attribute, stocks are then sorted into "winner/loser" quintiles for replicating JT momentum strategies introduced above.

5.4.3 Triple-Sort Momentum

To observe the momentum phenomenon and R&D effect without influenced by size effect, we triple-sort stocks first by size, second by R&D intensity and third by previous returns[2]. Since the market capitalization of No-R&D firms is generally larger than R&D firms, we firstly divide stocks into one group with R&D investment and the other without R&D investment (R&D firms and No-R&D firms). For all R&D firms, we sort them into "large-cap" and "small-cap" based on market capitalization, using the median value as the dividing point. Within each size-assigned group, the stocks are then sorted into "high-R&D" (top 50 percent) and "low-R&D" (bottom 50 percent) based on R&D level. For firms without R&D, we sort them into "large-cap" or "small-cap" based on market capitalization, and label all as "No-R&D" firms. Finally, we have 2*2+2 subgroups conditioning on market capitalization and R&D intensity. Then, within each subgroup, firms are sorted into "winner/loser" quintiles for JT momentum portfolios.

5.5 Results and Discussion

5.5.1 Price momentum effect

We start by examining unconditional momentum strategies over different periods, including 1995-2014, 1995-2004 and 2005-2014, to observe the changes over past 20 years. Table 5.3 presents the results of equally-weighted unrestricted winner-loser monthly returns for the three sample periods. It indicates that the returns of unconditional momentum strategies are close to zero in short horizon,

but long-horizon contrarian strategies generate pervasive returns for holding periods of 12-60 months, over 1995-2014. These results largely differ from the patterns in US and other developed stock markets. The insignificant of momentum effect and the significance of reversal effect may result from the lack of public information. Chinese traders are more likely to receive delayed news, and fail to value the firm accurately.

Moreover, the magnitude and significance of the returns of contrarian strategies over 2005-2014 are significantly larger than that over 1995-2004. It may results from the increased information and news to investors over recent years. Thanks to the development of social media and trading regulations, there are more and frequent information available for investors than before, which can lead to severe overreaction and then reversal.

[Insert Table 5.3 around here]

5.5.2 Size and momentum

To address the question that whether firm size affect momentum phenomenon, this part double-sort stocks by firm size and past returns, and replicate momentum strategies within different sub-periods. Stocks are firstly assigned into three groups, Large, Medium and Small, before forming momentum portfolios, based on their market capitalization at the end of last quarter. Table 5.4 shows monthly

returns of equally-weighted winner-loser strategies conditioning on firm size [3]. It reveals that large firms experience momentum effect in early years, whereas small firms are more likely to reverse and the reversal effect is more notable in recent years.

Specifically, for the full sample period over 1995-2014, Large-Cap winner-loser portfolio does not generate significant positive returns, but produce significantly negative returns in some long horizons (Panel A). Over 1995-2004, there are some short-horizon Large-Cap momentum strategies producing significant positive returns (within 9 months), but the reversal effect is not pervasive. Over 2005-2014, both momentum effect and reversal effect disappear, and there is no strategy produce significant returns. Panel B shows that some Medium-Cap long-horizon contrarian strategies produce significant returns over 1995-2014, but the reversal almost disappears in sub-periods.

In Small-Cap group, short-term momentum portfolio does not continuously generate significant returns, but contrarian strategies produce significant returns for holding period of 12-60 months over 1995-2014 (Panel C). Similar to the unrestricted strategies, the reversal effect is significantly enhanced in recent years. Only some contrarian strategies make significant profits during 1995-2004, whereas all long-term contrarian strategies produce significant returns during 2005-2015.

Hence, the Small-Cap long-horizon contrarian strategies generate higher and more frequent returns than Large-Cap long-horizon contrarian strategies. We can

conclude that the significant returns of unrestricted contrarian strategies are mostly attribute to small-cap contrarian strategies. As the news and events of small firms are more likely to be delayed, the reversal effect is more likely to take place.

[Insert Table 5.4 around here]

5.5.3 R&D Investment

Since R&D data is recorded since 2006, we use the post-2006 sample period in this part. Also, to observe the effect of size and R&D investment separately, both double-sort and triple-sort methods are applied. Using double-sort method, stocks are firstly assigned into four groups, High-RD, Medium-RD, Low-RD and No-RD, based on their R&D-to-Sales at the end of t-1 quarter. Again, No-R&D firms are those with zero or missing R&D value, and the remaining R&D firms are ranked by R&D intensity. The top 30 percent highest of R&D firms are assigned into “high-R&D”, the bottom 30 percent are assigned into “low-R&D”, and the middle part are assigned into “medium-R&D” group. Within each group, we then sort stocks into winner/loser based on prior cumulative returns, and conduct momentum long-short strategies.

Table 5.5 indicates monthly returns of equally-weighted winner-loser portfolios sorted by R&D intensity (R&D/Sale) [4]. It shows that No-R&D firms are more

likely to reverse than R&D firms. Only some R&D contrarian strategies generate significant returns, whereas No-R&D contrarian strategies produce notably significant returns from short-horizon to intermediate-horizon. Specifically, some short-horizon and long-horizon high-R&D contrarian strategies produce profits, but there is no apparent difference or trend among the three R&D groups. The return differences between winner and losers are larger in High-R&D group than that in Medium-R&D and Low-R&D groups. The results of No-R&D contrarian strategies present significantly strong reversal effect for holding period of 3-18 month. From the results, we can conclude that the reversal effect is largely decreased when firms invests in research and development.

[Insert Table 5.5 around here]

We further triple-sort stocks on Size, R&D/Sales and prior returns. Again, we sort all stocks first by size, second by R&D intensity and third by previous returns. Using the triple-sort method introduced earlier, we finally have 6 subgroups conditioning on market capitalization and R&D intensity. Then, within each subgroup, firms are sorted into "winner/loser" quintiles for JT momentum portfolios.

Table 5.6 presents the equally-weighted portfolio returns of momentum strategies triple-sort on Size, R&D intensity and prior cumulative returns. In both Large-cap

and Small-cap groups, No-R&D firms experience stronger reversal effect than R&D firms. We find that R&D investment reduces the reversal effect, which is not influenced by firm size effect.

For Large-Cap firms, No-R&D firms experience strong short-horizon reversal, while only some contrarian strategies produce significant returns in High-R&D and Low-R&D groups (Panel A). For Small-Cap firms, No-R&D contrarian strategies produce significant returns for holding period of 3-18 month, while there is few profitable momentum or contrarian strategy in High-R&D or Low-R&D groups (Panel B). Hence, these results suggest that R&D investment has stronger impact on small firms than on large firms. The rationale of these results may as follows: R&D investment is relatively less risky for large firms, thanks to their financial and market positions. Large firms has more resource to deal with financial problems, hence, R&D expense does not trigger big problems and risks on regular operation for them. However, if the R&D procedure fails, it can bring bankrupt to small firms who are easier to come across financial problems.

[Insert Table 5.6 around here]

5.6 Conclusion

This study employs all Chinese A-shares, trading in Shanghai and Shenzhen Stock

Exchanges, from January 1995 to December 2014 to investigate momentum and reversal patterns in Chinese stock market. Based on the most up-to-date data, it provides new evidence to the debate of Chinese momentum and reversal phenomenon. We extend the findings of past studies using different trading strategies conditioning on past returns and firm attributes.

We conduct JT momentum strategies with Chinese data, and compare the returns over different time periods. The empirical results show that the momentum effect is very weak and the reversal effect is significant in China. The returns of JT momentum strategies are close to zero in the short horizon, but long-horizon contrarian strategies generate pervasive returns for holding periods of 12-60 months. It also reveals that reversal effect becomes stronger over the recent years, which needs to be explained in future researches.

Moreover, this study identifies two risk proxies, firm size and R&D investment, which help to explain momentum and reversal patterns in China. We employ firm size which is discussed in US market, and R&D ratio which is one proxy of growth option. Based on double-sort and triple-sort trading methods, we provide some profitable enhanced trading strategies of Chinese stocks. On the one hand, it reveals that large firms experience weak momentum effect in first decade of Chinese stock market development history, while small firms are more likely to reverse and the reversal effect is stronger in the recent decade. Additionally, small firms are more likely to reverse in the long horizon. On the other hand, R&D investment reduces reversal effect, and this pattern is robust to both large and

small firms. In sum, both firm size and R&D investment contribute to the momentum and reversal patterns in Chinese stock markets.

NOTES

1. Alternatively, we use R&D expense over market capitalization for robustness check, following Chan et al. (2001b).

2. We get similar results when use an alternative sorting method by market capitalization, R&D intensity and prior returns. The alternative method is explained as follows. All stocks are ranked by market capitalization, where the top 50 percent largest firms are assigned into "Large-cap", and the remaining firms are assigned into "Small-cap". Then, all stocks having no R&D investment are labeled "No-R&D", whereas all R&D-firms are ranked in descending order regarding R&D level. The top 50 highest R&D firms are assigned into "High-R&D", and the remaining firms are assigned into "Low-R&D". Hence, each firm has a rank based on size (Large-cap or Small-cap) and another rank based on R&D (high-R&D, Low-R&D or No-R&D). Finally, the combination generates 2*3 subgroups conditioning on market capitalization and R&D intensity. Then, within each subgroup, firms are sorted into "winner/loser" quintiles for JT momentum portfolios as explained in unconditional strategies.

3. We also observe that Small-Cap winner/losers are generally produce higher profits than large-Cap winner/losers. It reveals that small stocks generally produce higher returns than large stocks, consistent with Wong et al. (2006).

4. Using R&D/market capitalization as R&D indicator indicates similar results.

REFERENCE

ALI, A., CIFTCI, M. & CREADY, W. M. 2012. Market underestimation of the implications of R&D increases for future earnings: the US evidence. *Journal of Business Finance & Accounting,* 39**,** 289-314.

ARIELY, D. & JONES, S. 2008. *Predictably irrational*, HarperCollins New York.

ASNESS, C. S., MOSKOWITZ, T. J. & PEDERSEN, L. H. 2013. Value and momentum everywhere. *The Journal of Finance,* 68**,** 929-985.

BANZ, R. W. 1981. The relationship between return and market value of common stocks. *Journal of financial economics,* 9**,** 3-18.

BARBERIS, N., SHLEIFER, A. & VISHNY, R. 1998. A model of investor sentiment. *Journal of Financial Economics,* 49**,** 307-343.

BARBERIS, N. & THALER, R. 2003. A survey of behavioral finance. *Handbook of the Economics of Finance,* 1**,** 1053-1128.

BERK, J. B. 1995. A critique of size-related anomalies. *Review of Financial Studies,* 8**,** 275-286.

BERK, J. B., GREEN, R. C. & NAIK, V. 1999. Optimal investment, growth options, and security returns. *The Journal of Finance,* 54**,** 1553-1607.

BLACK, F. 1972. Capital market equilibrium with restricted borrowing. *The Journal of Business,* 45**,** 444-455.

BOOTH, G. G., FUNG, H.-G. & LEUNG, W. K. 2016. A Risk-Return Explanation of the Momentum-Reversal "Anomaly". *Journal of Empirical Finance* 35**,** 68–77.

BRAV, A., GECZY, C. & GOMPERS, P. A. 2000. Is the abnormal return following equity issuances anomalous? *Journal of Financial Economics,* 56**,** 209-249.

CAMPBELL, J. Y., POLK, C. & VUOLTEENAHO, T. 2010. Growth or glamour? Fundamentals and systematic risk in stock returns. *Review of Financial Studies,* 23**,** 305-344.

CAO, C., SIMIN, T. & ZHAO, J. 2008. Can growth options explain the trend in idiosyncratic risk? *Review of financial studies,* 21**,** 2599-2633.

CARHART, M. M. 1997. On persistence in mutual fund performance. *The Journal of finance,* 52**,** 57-82.

CHAMBERS, D., JENNINGS, R. & THOMPSON II, R. B. 2002. Excess returns to R&D-intensive firms. *Review of Accounting Studies,* 7**,** 133-158.

CHAN, K. C. & CHANG, C.-H. 2014. Analysis of Bond, Real Estate, and Stock Market Returns in China. *Chinese Economy,* 47**,** 27-40.

CHAN, K. C., CHENG, L. T. W. & FUNG, J. K. W. 2001a. Ownership Restrictions and Stock-Price Behavior in China. *The Chinese Economy,* 34**,** 29-48.

CHAN, L. K., LAKONISHOK, J. & SOUGIANNIS, T. 2001b. The stock market valuation of research and development expenditures. *The Journal of Finance,* 56**,** 2431-2456.

CHAN, L. K. C., JEGADEESH, N. & LAKONISHOK, J. 1996. Momentum strategies. *The Journal of Finance,* 51**,** 1681-1713

CHAUVIN, K. W. & HIRSCHEY, M. 1993. Advertising, R&D expenditures and the market value of the firm. *Financial management,* 22**,** 128-140.

CHEN, X., KIM, K. A., YAO, T. & YU, T. 2010. On the predictability of Chinese stock returns. *Pacific-basin finance journal,* 18**,** 403-425

CHORDIA, T. & SHIVAKUMAR, L. 2006. Earnings and price momentum. *Journal of financial economics,* 80**,** 627-656

CHUI, A. C., TITMAN, S. & WEI, K. J. 2010. Individualism and momentum around the world. *The Journal of Finance,* 65**,** 361-392.

COCHRANE, J. H. 1991. Production‐based asset pricing and the link between stock returns and economic fluctuations. *The Journal of Finance,* 46**,** 209-237.

CONRAD, J. & KAUL, G. 1993. Long‐Term Market Overreaction or Biases in Computed Returns? *The Journal of Finance,* 48**,** 39-63.

COPELAND, T., WESTON, J. & SHASTRI, K. 1983. *Financial theory and corporate policy,* New York, USA, Massachusetts: Addison-Wesley.

CUTLER, D. M., POTERBA, J. M. & SUMMERS, L. H. 1991. Speculative dynamics. *The*

Review of Economic Studies, 58**,** 529-546.
DANIEL, K., HIRSHLEIFER, D. & SUBRAHMANYAM, A. 1998. Investor Psychology and Security Market Under- and Overreactions. *The Journal of Finance,* 53**,** 1839-1885.
DANIEL, K. & TITMAN, S. 1999. Market efficiency in an irrational world. *Financial Analysts Journal,* 55**,** 28-40.
DEBONDT, W. F. & THALER, R. 1985. Does the stock market overreact? *The Journal of finance,* 40**,** 793-805.
EDWARDS, W. 1968. Conservatism in human information processing. *Formal representation of human judgment,* 17**,** 51.
EISENHARDT, K. M. & MARTIN, J. A. 2000. Dynamic capabilities: what are they? *Strategic management journal,* 21**,** 1105-1121.
FAMA, E. F. & FRENCH, K. R. 1992. The cross‐section of expected stock returns. *The Journal of Finance,* 47**,** 427-465.
FAMA, E. F. & FRENCH, K. R. 1993. Common risk factors in the returns on stocks and bonds. *Journal of Financial Economics,* 33**,** 3-56.
FAMA, E. F. & FRENCH, K. R. 1996. Multifactor explanations of asset pricing anomalies. *The Journal of Finance,* 51**,** 55-84.
FAMA, E. F. & FRENCH, K. R. 1997. Industry costs of equity. *Journal of financial economics,* 43**,** 153-193.
FAMA, E. F. & FRENCH, K. R. 2012. Size, value, and momentum in international stock returns. *Journal of Financial Economics,* 105**,** 457-472.
FAMA, E. F. & MACBETH, J. D. 1973. Risk, return, and equilibrium: Empirical tests. *The Journal of Political Economy,* 81**,** 607-636.
FRANZEN, L. A., RODGERS, K. J. & SIMIN, T. T. 2007. Measuring distress risk: The effect of R&D intensity. *The Journal of Finance,* 62**,** 2931-2967.
GEORGE, T. J. & HWANG, C.-Y. 2007. Long-Term Return Reversals: Overreaction or Taxes? *The Journal of Finance,* 62**,** 2865-2896.
GRIFFIN, J. M., JI, X. & MARTIN, J. S. 2003. Momentum investing and business cycle risk: Evidence from pole to pole. *The Journal of Finance,* 58**,** 2515-2547.
HO, Y. K., XU, Z. & YAP, C. M. 2004. R&D investment and systematic risk. *Accounting & Finance,* 44**,** 393-418.
HONG, H., LIM, T. & STEIN, J. C. 2000. Bad news travels slowly: Size, analyst coverage, and the profitability of momentum strategies. *The Journal of Finance,* 55**,** 265-295.
HONG, H. & STEIN, J. C. 1999. A Unified Theory of Underreaction, Momentum Trading, and Overreaction in Asset Markets. *The Journal of Finance,* 54**,** 2143-2184.
HOU, K., XUE, C. & ZHANG, L. 2015. Digesting anomalies: An investment approach. *Review of Financial Studies***,** Advance Access publication.
HWANG, S. & RUBESAM, A. 2015. The disappearance of momentum. *The European Journal of Finance,* 21**,** 584-607.
JEGADEESH, N. & TITMAN, S. 1993. Returns to buying winners and selling losers: Implications for stock market efficiency. *The Journal of Finance,* 48**,** 65-91.
JEGADEESH, N. & TITMAN, S. 2001. Profitability of Momentum Strategies: An Evaluation of Alternative Explanations. *The Journal of Finance,* 56**,** 699-720.
JIANG, H. 2010. Institutional investors, intangible information, and the book-to-market effect. *Journal of Financial Economics,* 96**,** 98-126.
JOHNSON, T. C. 2002a. Rational momentum effects. *The Journal of Finance,* 57**,** 585-608.
JOHNSON, T. C. 2002b. Volatility, momentum, and time-varying skewness in foreign exchange returns. *Journal of Business & Economic Statistics,* 20**,** 390-411.
KANG, J., LIU, M.-H. & NI, S. X. 2002. Contrarian and momentum strategies in the China stock market: 1993–2000. *Pacific-Basin Finance Journal,* 10**,** 243-265.
KAUL, G. & NIMALENDRAN, M. 1990. Price reversals: Bid-ask errors or market overreaction? *Journal of Financial Economics,* 28**,** 67-93.
KRAFT, H., SCHWARTZ, E. S. & WEISS, F. 2013. Growth options and firm valuation. National Bureau of Economic Research.
LAKONISHOK, J., SHLEIFER, A. & VISHNY, R. W. 1994. Contrarian investment, extrapolation,

and risk. *The journal of finance,* 49**,** 1541-1578.
LEE, C. M. C. & SWAMINATHAN, B. 2000. Price Momentum and Trading Volume. *The Journal of Finance,* 55**,** 2017-2069.
LEE, J.-S. & KUO, C.-T. 2010. Momentum Effect and Market Conditions: Evidence from Chinese Real Estate Stocks. *Chinese Economy,* 43**,** 70-94
LEV, B. & SOUGIANNIS, T. 1996. The capitalization, amortization, and value-relevance of R&D. *Journal of accounting and economics,* 21**,** 107-138.
LEV, B. & SOUGIANNIS, T. 1999. Penetrating the book - to - market black box: The R&D effect. *Journal of Business Finance & Accounting,* 26**,** 419-449.
LEVY, R. A. 1967. Relative strength as a criterion for investment selection. *The Journal of Finance,* 22**,** 595-610
LI, D. 2011. Financial Constraints, R&D Investment, and Stock Returns. *Review of Financial Studies,* 24**,** 2974-3007.
LIEW, J. & VASSALOU, M. 2000. Can book-to-market, size and momentum be risk factors that predict economic growth? *Journal of Financial Economics,* 57**,** 221-245.
LONG, J. B., SHLEIFER, A., SUMMERS, L. H. & WALDMANN, R. J. 1990. Positive feedback investment strategies and destabilizing rational speculation. *The Journal of Finance,* 45**,** 379-395
LOUGHRAN, T. 1997. Book-to-market across firm size, exchange, and seasonality: Is there an effect? *Journal of financial and quantitative analysis,* 32**,** 249-268.
LU, Z. & ZOU, H. 2007. Momentum and Reversal in China Stock Market. *Economic Research Journal (in Chinese),* 42**,** 145-155.
MIZIK, N. & JACOBSON, R. 2003. Trading off between value creation and value appropriation: The financial implications of shifts in strategic emphasis. *Journal of Marketing,* 67**,** 63-76.
MOSKOWITZ, T. J. & GRINBLATT, M. 1999. Do industries explain momentum? *The Journal of Finance,* 54**,** 1249-1290.
MOSSIN, J. 1966. Equilibrium in a capital asset market. *Econometrica,* 34**,** 768-783.
NELSON, J. M. 2006. INTANGIBLE ASSETS, BOOK - TO - MARKET, AND COMMON STOCK RETURNS. *Journal of Financial Research,* 29**,** 21-41.
NOVY-MARX, R. 2012. Is momentum really momentum? *Journal of Financial Economics,* 103**,** 429-453.
PETKOVA, R. & ZHANG, L. 2005. Is value riskier than growth? *Journal of Financial Economics,* 78**,** 187-202.
PHILLIPS, G. M. & ZHDANOV, A. 2013. R&D and the Incentives from Merger and Acquisition Activity. *Review of Financial Studies,* 26**,** 34-78.
PONTIFF, J. & SCHALL, L. D. 1998. Book-to-market ratios as predictors of market returns. *Journal of Financial Economics,* 49**,** 141-160.
QI, D. & ZHONG-GUO, Z. 2015. Offline Oversubscription, Issue Size, and Market Momentum: The Driving Forces for ChiNext IPOs' Initial Underpricing. *Chinese Economy,* 48**,** 114-129.
ROSENBERG, B., REID, K. & LANSTEIN, R. 1985. Persuasive evidence of market inefficiency. *The Journal of Portfolio Management,* 11**,** 9-16.
ROUWENHORST, K. G. 1998. International momentum strategies. *The Journal of Finance,* 53**,** 267-284.
RUBERA, G. & KIRCA, A. H. 2012. Firm innovativeness and its performance outcomes: A meta-analytic review and theoretical integration. *Journal of Marketing,* 76**,** 130-147.
SAGI, J. & SEASHOLES, M. 2007. Firm-specific attributes and the cross-section of momentum. *Journal of Financial Economics,* 84**,** 389-434.
SHARPE, W. F. 1964. Capital asset prices: A theory of market equilibrium under conditions of risk*. *The journal of finance,* 19**,** 425-442.
SIMPSON, P. M., SIGUAW, J. A. & ENZ, C. A. 2006. Innovation orientation outcomes: The good and the bad. *Journal of Business Research,* 59**,** 1133-1141.
TREYNOR, J. L. 2012. Toward a Theory of Market Value of Risky Assets, in Treynor on Institutional Investing. Hoboken, NJ, USA: John Wiley & Sons, Inc.

VAN DEN STEEN, E. 2004. Rational overoptimism (and other biases). *American Economic Review,* 94**,** 1141-1151.
VASSALOU, M. & APEDJINOU, K. Corporate innovation, price momentum, and equity returns. EFA 2005 Moscow Meetings Paper, 2004.
WARUSAWITHARANA, M. 2015. Research and development, profits, and firm value: A structural estimation. *Quantitative Economics,* 6**,** 531–565.
WONG, K. A., TAN, R. S. K. & LIU, W. 2006. The cross-section of stock returns on the Shanghai Stock Exchange. *Review of Quantitative Finance and Accounting,* 26**,** 23-39
WU, Y. 2011. Momentum trading, mean reversal and overreaction in Chinese stock market. *Review of Quantitative Finance and Accounting,* 37**,** 301-323.

Table 5.1 Summary Statistics

Year		1995	1999	2004	2009	2014
No. of stocks in sample		297	872	1297	1562	2027
Market capitalization	Mean	270	1,013	911	5,745	9,202
	Min	55	97	60	261	286
	P25	151	464	370	1,130	1,992
	P50	208	742	548	2,030	3,379
	P75	315	1,171	952	4,342	6,548
	Max	2,727	29,493	17,250	269,933	1,220,892
Monthly return	Mean	-0.08	0.33	-0.13	0.09	0.04
	Min	-0.24	-0.14	-0.5	-0.19	-0.32
	P25	-0.12	0.21	-0.17	0	-0.01
	P50	-0.09	0.28	-0.13	0.05	0.03
	P75	-0.06	0.41	-0.08	0.12	0.07
	Max	0.35	1.48	0.13	22.05	1.07

Notes: We collect monthly stock returns, price, number of outstanding shares of all A-shares in both Shanghai and Shenzhen Stock Exchanges from CSMAR database, and the sample covers January 1995 to December 2014. The market capitalization is in millions of RMB. We report here the June values for each year.

Table 5.2 R&D firms and No-R&D firms Summary

Year		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
No. of stocks in sample		2780	2780	2780	2780	2780	2780	2780	2780	2780	2780
Market capitalization	Mean	735	1,704	6,166	2,781	9,135	10,221	8,029	8,421	9,080	14,190
	Min	42	71	243	104	369	443	213	248	297	360
	Medium	384	700	2,319	975	2,781	3,195	2,241	2,368	3,014	4,461
	Max	19,487	77,038	249,202	118,071	1,365,235	1,812,278	1,573,225	1,460,160	1,248,419	1,750,378
No. of stocks with R&D investment		3	577	939	1237	1422	1684	1931	2158	2189	2200
Market capitalization	Mean	.	1,544	5,612	2,015	7,072	6,850	5,072	5,952	7,118	10,771
	Min	.	164	326	157	387	443	213	248	297	360
	Medium	.	763	2,448	809	2,573	3,083	2,063	2,203	3,058	4,468
	Max	.	32,686	199,132	90,096	985,200	563,572	502,040	484,675	407,912	711,124
R&D intensity (R&D/Sales)	Mean	.	0.010	0.021	0.022	0.029	0.028	0.033	0.040	0.041	0.042
	Min	.	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
	Medium	.	0.005	0.006	0.010	0.019	0.022	0.027	0.032	0.032	0.032
	Max	.	0.213	1.323	0.168	0.391	0.399	0.984	0.719	0.550	1.694
R&D expense	Mean	15	30	45	37	48	61	70	107	124	142
	Min	4	0.064	0.011	0.027	0.001	0.007	0.001	0.024	0.003	0.0001
	Medium	15	6	9	11	13	16	20	29	34	38
	Max	26	4,260	5,315	3,994	5,782	8,825	8,493	8,829	8,516	9,710

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No. of stocks without R&D investment		2777	2203	1841	1543	1358	1096	849	622	591	580
Market capitalization	Mean	735	1,738	6,341	3,103	10,307	14,576	12,684	14,968	14,589	24,324
	Min	42	71	243	104	369	489	278	362	311	479
	Medium	384	682	2,300	1,046	2,901	3,368	2,481	2,701	2,933	4,432
	Max	19,487	77,038	249,202	118,071	1,365,235	1,812,278	1,573,225	1,460,160	1,248,419	1,750,378

Note: We collect stock price and number of outstanding shares from CSMAR database and R&D expense data from WIND database, including all A-shares in both Shanghai and Shenzhen Stock Exchanges. The research and development expense obtained from WIND is annual data over 2005 to 2014. The R&D intensity is the ratio of R&D expense over sales. The market capitalization and R&D expense are in millions of RMB.

Table 5.3 Unconditional Momentum Strategy Returns

						Holding Period						
Look-back Period	**3**	**6**	**9**	**12**	**15**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
							1995-2014						
3	-0.002	0.0006	0.0003	-0.0001	-0.0013	-0.0016	-0.0023	-0.0028	-0.0029	-0.0026	-0.0021	-0.0021	-0.0022
t-stat	-0.72	0.3	0.19	-0.05	-0.84	-1.08	-1.74 *	-2.26 **	-2.53 **	-2.46 **	-2.08 **	-2.21 **	-2.41 **
6	0.0003	0.001	0.0001	-0.0015	-0.0027	-0.0032	-0.0039	-0.0044	-0.0042	-0.0036	-0.003	-0.0032	-0.0033
t-stat	0.08	0.36	0.04	-0.63	-1.23	-1.54	-2.04 **	-2.48 **	-2.62 ***	-2.33 **	-2.14 **	-2.42 **	-2.57 **
9	-0.0006	-0.0006	-0.0024	-0.0036	-0.0046	-0.0049	-0.0057	-0.0061	-0.0056	-0.0046	-0.004	-0.0042	-0.0043
t-stat	-0.19	-0.19	-0.83	-1.35	-1.80 *	-1.97 **	-2.45 **	-2.80 ***	-2.83 ***	-2.43 **	-2.36 **	-2.63 ***	-2.79 ***
12	-0.0026	-0.0035	-0.0048	-0.0058	-0.0064	-0.0067	-0.0074	-0.0074	-0.0065	-0.0052	-0.0047	-0.0049	-0.0052
t-stat	-0.73	-1.05	-1.51	-1.93 *	-2.19 **	-2.37 **	-2.80 ***	-3.02 ***	-2.85 ***	-2.50 **	-2.57 **	-2.83 ***	-3.04 ***
							1995-2004						
3	0.0015	0.0042	0.0023	0.002	0.0005	-0.0003	-0.0018	-0.0025	-0.0028	-0.0024	-0.0015	-0.0014	-0.0016
t-stat	0.37	1.46	0.92	0.88	0.22	-0.17	-1.02	-1.48	-1.78 *	-1.67 *	-1.13	-1.11	-1.24
6	0.0056	0.0045	0.0027	0.001	-0.0009	-0.0023	-0.0036	-0.0043	-0.0043	-0.0033	-0.0022	-0.0022	-0.0025
t-stat	1.25	1.16	0.77	0.3	-0.3	-0.76	-1.32	-1.66 *	-1.87 *	-1.53	-1.16	-1.27	-1.4
9	0.0032	0.0025	-0.0003	-0.0021	-0.0038	-0.0045	-0.0058	-0.0064	-0.0061	-0.0044	-0.0033	-0.0033	-0.0035
t-stat	0.65	0.58	-0.07	-0.54	-1	-1.23	-1.69 *	-1.99 **	-2.05 **	-1.55	-1.36	-1.47	-1.6
12	0.0012	-0.0006	-0.0032	-0.0048	-0.0061	-0.0068	-0.0079	-0.008	-0.007	-0.005	-0.0039	-0.0041	-0.0045
t-stat	0.24	-0.12	-0.68	-1.08	-1.38	-1.6	-1.98 **	-2.16 **	-2.04 **	-1.6	-1.53	-1.70 *	-1.88 *

Continued-

						2005-2014							
3	-0.0055	-0.003	-0.0016	-0.0021	-0.003	-0.0028	-0.0028	-0.0031	-0.003	-0.0028	-0.0026	-0.0027	-0.0028
t-stat	-1.42	-1.03	-0.64	-0.86	-1.37	-1.34	-1.42	-1.71 *	-1.79 *	-1.80 *	-1.78 *	-1.97 **	-2.15 **
6	-0.0051	-0.0026	-0.0025	-0.0039	-0.0044	-0.0041	-0.0042	-0.0046	-0.0042	-0.0038	-0.0038	-0.0042	-0.0042
t-stat	-1.21	-0.71	-0.72	-1.2	-1.45	-1.44	-1.56	-1.84 *	-1.83 *	-1.76 *	-1.83 *	-2.10 **	-2.21 **
9	-0.0044	-0.0037	-0.0044	-0.0052	-0.0055	-0.0053	-0.0055	-0.0057	-0.0052	-0.0048	-0.0047	-0.0051	-0.0051
t-stat	-0.99	-0.86	-1.12	-1.4	-1.56	-1.57	-1.77 *	-1.98 **	-1.94 *	-1.90 *	-1.98 **	-2.24 **	-2.34 **
12	-0.0064	-0.0064	-0.0064	-0.0069	-0.0068	-0.0066	-0.0069	-0.0068	-0.0059	-0.0055	-0.0056	-0.0058	-0.0058
t-stat	-1.3	-1.39	-1.49	-1.68 *	-1.74 *	-1.77 *	-1.99 **	-2.10 **	-1.99 **	-1.95 *	-2.09 **	-2.29 **	-2.41 **

Notes: We sort stocks into 5 quintiles, from winner to loser, based on previous 3-, 6-, 9- or 12-month returns using the Jegadeesh and Titman (1993) method. 16 trading strategies are considered based on look-back period and holding period, using equally-weighted method when forming portfolios. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

Table 5.4 Double-sort Momentum Strategy: First by Size, Second by Prior Returns

Panel A Large-Cap

	Holding Period												
Look-back Period	**3**	**6**	**9**	**12**	**15**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
							1995-2014						
3	0.0013	0.0027	0.0033	0.0019	0.0006	0.0001	-0.0006	-0.0014	-0.0014	-0.001	-0.0009	-0.0009	-0.0011
t-stat	0.4	1.15	1.6	1.02	0.34	0.04	-0.42	-1.03	-1.12	-0.86	-0.86	-0.94	-1.28
6	0.0043	0.0042	0.0029	0.0008	-0.0005	-0.0012	-0.0021	-0.0029	-0.0028	-0.0021	-0.0021	-0.002	-0.0022
t-stat	1.21	1.36	1.05	0.33	-0.19	-0.53	-0.98	-1.52	-1.61	-1.32	-1.42	-1.47	-1.73 *
9	0.0048	0.003	0.0011	-0.0005	-0.0018	-0.0024	-0.0034	-0.0041	-0.0038	-0.0029	-0.0026	-0.0023	-0.0026
t-stat	1.32	0.88	0.34	-0.16	-0.61	-0.88	-1.33	-1.72 *	-1.74 *	-1.43	-1.39	-1.39	-1.61
12	0.0018	0.0001	-0.0013	-0.0027	-0.0036	-0.004	-0.0052	-0.0057	-0.0045	-0.0037	-0.003	-0.0031	-0.0034
t-stat	0.47	0.02	-0.37	-0.79	-1.07	-1.26	-1.77 *	-2.11 **	-1.80 *	-1.6	-1.46	-1.58	-1.78 *
							1995-2004						
3	0.0039	0.0063	0.0052	0.0037	0.0022	0.0011	-0.0004	-0.0013	-0.0016	-0.0012	-0.0014	-0.001	-0.0013
t-stat	0.93	2.04 **	1.92 *	1.58	0.96	0.46	-0.18	-0.68	-0.9	-0.76	-0.98	-0.83	-1.17
6	0.0096	0.0083	0.0055	0.0032	0.0012	-0.0007	-0.0023	-0.0031	-0.0035	-0.0028	-0.003	-0.0023	-0.0026
t-stat	1.94 *	1.95 *	1.48	0.95	0.34	-0.2	-0.73	-1.08	-1.32	-1.21	-1.39	-1.2	-1.47
9	0.0087	0.0059	0.0033	0.001	-0.0016	-0.0029	-0.0042	-0.0049	-0.0052	-0.0042	-0.0036	-0.0026	-0.003
t-stat	1.69 *	1.25	0.74	0.23	-0.36	-0.68	-1.05	-1.32	-1.5	-1.33	-1.27	-1.04	-1.24
12	0.0054	0.0031	0.0001	-0.0024	-0.0042	-0.0051	-0.0067	-0.0076	-0.0064	-0.0054	-0.0039	-0.0037	-0.0042
t-stat	1.06	0.61	0.02	-0.46	-0.83	-1.04	-1.43	-1.76 *	-1.6	-1.49	-1.24	-1.23	-1.42

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						2005-2014							
3	-0.0014	-0.0008	0.0014	0.0001	-0.001	-0.001	-0.0009	-0.0015	-0.0012	-0.0008	-0.0004	-0.0008	-0.0009
t-stat	-0.31	-0.23	0.44	0.02	-0.4	-0.42	-0.42	-0.77	-0.68	-0.47	-0.25	-0.53	-0.69
6	-0.0009	0	0.0003	-0.0016	-0.0021	-0.0018	-0.0018	-0.0027	-0.0021	-0.0014	-0.0012	-0.0017	-0.0018
t-stat	-0.19	0.01	0.07	-0.43	-0.62	-0.57	-0.66	-1.07	-0.93	-0.64	-0.6	-0.88	-0.99
9	0.0008	0.0001	-0.0011	-0.002	-0.002	-0.002	-0.0026	-0.0032	-0.0024	-0.0015	-0.0016	-0.0021	-0.0022
t-stat	0.16	0.01	-0.24	-0.47	-0.51	-0.55	-0.81	-1.09	-0.91	-0.62	-0.65	-0.92	-1.02
12	-0.0019	-0.003	-0.0028	-0.0031	-0.0029	-0.0029	-0.0037	-0.0038	-0.0025	-0.0019	-0.0021	-0.0025	-0.0026
t-stat	-0.36	-0.58	-0.57	-0.67	-0.68	-0.72	-1.04	-1.16	-0.86	-0.68	-0.79	-0.99	-1.07
Panel B Medium-Cap													
						Holding Period							
Look-back Period	**3**	**6**	**9**	**12**	**15**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
						1995-2014							
3	-0.0005	0.0013	0.0005	0.0001	-0.0004	-0.0006	-0.0011	-0.0013	-0.0016	-0.0013	-0.0008	-0.0009	-0.001
t-stat	-0.18	0.68	0.29	0.08	-0.3	-0.51	-1.01	-1.28	-1.59	-1.39	-0.9	-1	-1.15
6	0.0008	0.0006	-0.0003	-0.0012	-0.0019	-0.0022	-0.0024	-0.0026	-0.0023	-0.0019	-0.0015	-0.0018	-0.0022
t-stat	0.29	0.26	-0.12	-0.61	-1.02	-1.28	-1.53	-1.70 *	-1.61	-1.32	-1.13	-1.38	-1.55
9	-0.0011	-0.0009	-0.0023	-0.003	-0.0035	-0.0035	-0.0039	-0.0041	-0.0037	-0.0026	-0.0023	-0.0026	-0.0029
t-stat	-0.35	-0.31	-0.87	-1.3	-1.59	-1.74 *	-2.10 **	-2.35 **	-2.23 **	-1.67 *	-1.6	-1.91 *	-1.99 **
12	-0.0024	-0.0029	-0.0041	-0.0046	-0.0047	-0.0047	-0.0047	-0.0044	-0.0041	-0.0031	-0.0027	-0.003	-0.0031
t-stat	-0.72	-0.96	-1.45	-1.76 *	-1.93 *	-2.05 **	-2.21 **	-2.20 **	-2.05 **	-1.70 *	-1.63	-1.94 *	-1.96 *

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						1995-2004							
3	0.0033	0.004	0.0023	0.0017	0.0009	0.0005	-0.0008	-0.0011	-0.0017	-0.0014	-0.0006	-0.0008	-0.001
t-stat	0.78	1.32	0.91	0.77	0.46	0.27	-0.46	-0.68	-1.11	-0.93	-0.39	-0.53	-0.7
6	0.0042	0.0028	0.0013	0.0001	-0.001	-0.0019	-0.0027	-0.003	-0.0028	-0.0022	-0.0017	-0.0021	-0.0029
t-stat	0.97	0.77	0.41	0.03	-0.36	-0.73	-1.11	-1.22	-1.23	-0.95	-0.76	-0.99	-1.2
9	0.0015	0.0012	-0.0011	-0.0023	-0.0031	-0.0036	-0.0045	-0.0051	-0.0049	-0.0031	-0.0027	-0.0032	-0.0038
t-stat	0.3	0.27	-0.25	-0.61	-0.89	-1.1	-1.56	-1.83 *	-1.76 *	-1.21	-1.17	-1.46	-1.58
12	0.0011	-0.0009	-0.0031	-0.0041	-0.0047	-0.005	-0.0054	-0.005	-0.0052	-0.0038	-0.003	-0.0039	-0.004
t-stat	0.19	-0.19	-0.69	-0.97	-1.19	-1.35	-1.53	-1.53	-1.51	-1.21	-1.12	-1.48	-1.5
						2005-2014							
3	-0.0043	-0.0014	-0.0013	-0.0014	-0.0017	-0.0017	-0.0015	-0.0016	-0.0014	-0.0012	-0.001	-0.001	-0.001
t-stat	-1.31	-0.59	-0.64	-0.76	-1.03	-1.08	-1.01	-1.19	-1.15	-1.08	-0.98	-0.97	-1.05
6	-0.0026	-0.0016	-0.0018	-0.0025	-0.0028	-0.0025	-0.0021	-0.0022	-0.0018	-0.0015	-0.0013	-0.0014	-0.0014
t-stat	-0.74	-0.52	-0.66	-0.99	-1.16	-1.12	-1.05	-1.19	-1.06	-0.96	-0.89	-0.99	-1.01
9	-0.0037	-0.0029	-0.0035	-0.0038	-0.0039	-0.0035	-0.0032	-0.0031	-0.0026	-0.0021	-0.0019	-0.002	-0.0019
t-stat	-1.02	-0.87	-1.12	-1.34	-1.45	-1.4	-1.4	-1.48	-1.37	-1.2	-1.1	-1.23	-1.22
12	-0.0059	-0.0049	-0.005	-0.0051	-0.0048	-0.0044	-0.0041	-0.0037	-0.003	-0.0025	-0.0023	-0.0022	-0.0022
t-stat	-1.54	-1.4	-1.53	-1.66 *	-1.63	-1.61	-1.64	-1.64	-1.44	-1.27	-1.24	-1.27	-1.29

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Panel C Small-Cap													
							Holding Period						
Look-back Period	**3**	**6**	**9**	**12**	**15**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
							1995-2014						
3	-0.0035	0.0001	-0.0003	-0.0001	-0.0014	-0.0013	-0.0021	-0.0028	-0.003	-0.0027	-0.0022	-0.0021	-0.0018
t-stat	-1.22	0.04	-0.17	-0.07	-0.98	-1.14	-2.05 **	-3.14 ***	-3.65 ***	-3.38 ***	-2.94 ***	-2.63 ***	-2.27 **
6	-0.0009	0.0005	-0.0002	-0.0014	-0.0025	-0.0027	-0.0035	-0.0041	-0.0039	-0.0035	-0.0031	-0.003	-0.0028
t-stat	-0.29	0.18	-0.07	-0.63	-1.35	-1.68 *	-2.39 **	-3.03 ***	-3.20 ***	-2.90 ***	-2.70 ***	-2.68 ***	-2.54 **
9	-0.0013	-0.0005	-0.0021	-0.0029	-0.0038	-0.0038	-0.0046	-0.005	-0.0047	-0.0041	-0.0039	-0.0039	-0.0035
t-stat	-0.37	-0.15	-0.8	-1.28	-1.87 *	-1.93 *	-2.52 **	-2.89 ***	-2.82 ***	-2.43 **	-2.36 **	-2.35 **	-2.12 **
12	-0.0022	-0.0025	-0.0032	-0.0042	-0.0048	-0.0049	-0.0062	-0.0062	-0.0056	-0.0051	-0.0052	-0.0051	-0.0049
t-stat	-0.63	-0.83	-1.18	-1.70 *	-2.01 **	-2.12 **	-2.77 ***	-2.81 ***	-2.62 ***	-2.35 **	-2.41 **	-2.37 **	-2.26 **
							1995-2004						
3	-0.0014	0.0011	-0.0001	0.0006	-0.0006	-0.0009	-0.0018	-0.0025	-0.0029	-0.002	-0.0013	-0.0006	-0.0002
t-stat	-0.3	0.31	-0.04	0.21	-0.27	-0.49	-1.18	-1.88 *	-2.35 **	-1.70 *	-1.12	-0.48	-0.16
6	0.0011	0.0013	0.0011	0.0001	-0.0013	-0.0019	-0.0028	-0.0034	-0.0033	-0.0023	-0.0013	-0.0006	-0.0006
t-stat	0.21	0.27	0.25	0.02	-0.41	-0.75	-1.24	-1.6	-1.73 *	-1.25	-0.74	-0.4	-0.36
9	0.0004	0.001	-0.0006	-0.0012	-0.0021	-0.0022	-0.0032	-0.0037	-0.0033	-0.002	-0.0013	-0.0011	-0.0006
t-stat	0.07	0.19	-0.13	-0.33	-0.64	-0.7	-1.12	-1.33	-1.24	-0.73	-0.5	-0.4	-0.21
12	0.0002	-0.0009	-0.0017	-0.0026	-0.0034	-0.0036	-0.0053	-0.0051	-0.0044	-0.0031	-0.003	-0.0026	-0.0025
t-stat	0.03	-0.17	-0.38	-0.65	-0.86	-0.96	-1.43	-1.38	-1.2	-0.84	-0.78	-0.69	-0.66

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	2005-2014												
3	-0.0056	-0.0009	-0.0005	-0.0008	-0.0022	-0.0017	-0.0024	-0.0031	-0.0031	-0.0034	-0.0032	-0.0036	-0.0035
t-stat	-1.79 *	-0.4	-0.23	-0.42	-1.33	-1.21	-1.75 *	-2.59 ***	-2.84 ***	-3.14 ***	-3.13 ***	-3.41 ***	-3.40 ***
6	-0.0029	-0.0003	-0.0014	-0.0029	-0.0038	-0.0035	-0.0042	-0.0048	-0.0046	-0.0046	-0.005	-0.0054	-0.0051
t-stat	-0.87	-0.09	-0.51	-1.18	-1.76 *	-1.77 *	-2.26 **	-2.84 ***	-2.91 ***	-3.06 ***	-3.23 ***	-3.40 ***	-3.31 ***
9	-0.003	-0.0019	-0.0037	-0.0047	-0.0056	-0.0054	-0.006	-0.0064	-0.006	-0.0061	-0.0064	-0.0067	-0.0064
t-stat	-0.84	-0.59	-1.22	-1.73 *	-2.27 **	-2.24 **	-2.61 ***	-3.04 ***	-3.06 ***	-3.28 ***	-3.40 ***	-3.51 ***	-3.43 ***
12	-0.0045	-0.0042	-0.0047	-0.0058	-0.0062	-0.0062	-0.0072	-0.0072	-0.0068	-0.007	-0.0075	-0.0077	-0.0073
t-stat	-1.24	-1.23	-1.49	-2.00 **	-2.26 **	-2.31 **	-2.78 ***	-3.03 ***	-3.05 ***	-3.32 ***	-3.51 ***	-3.53 ***	-3.41 ***

Notes: We sort stocks into three groups based on market capitalization, large-cap, medium-cap and small-cap. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on previous 3-, 6-, 9- or 12-month returns using the Jegadeesh and Titman (1993) method. 16 trading strategies are considered based on look-back period and holding period, using equally-weighted method when forming portfolios. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

Table 5.5 Double-sort Momentum Strategy: First by R&D, Second by Prior Returns

						Holding Period							
Look-back Period	**3**	**6**	**9**	**12**	**15**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
							High-R&D						
3	-0.0102	-0.001	-0.0026	-0.0018	-0.0033	-0.0029	-0.0024	-0.0027	-0.0024	-0.0022	-0.0025	-0.0028	-0.0029
t-stat	-1.96 **	-0.27	-0.74	-0.55	-1.03	-0.93	-0.81	-0.93	-0.85	-0.77	-0.89	-0.99	-1.04
6	-0.0042	-0.0002	-0.0027	-0.0043	-0.0057	-0.0053	-0.0044	-0.0048	-0.0044	-0.0042	-0.0044	-0.0046	-0.0045
t-stat	-0.78	-0.03	-0.57	-0.97	-1.33	-1.28	-1.11	-1.23	-1.13	-1.09	-1.16	-1.22	-1.18
9	-0.0077	-0.0043	-0.0069	-0.0077	-0.0088	-0.0075	-0.0069	-0.0072	-0.0067	-0.0065	-0.0066	-0.0067	-0.0064
t-stat	-1.37	-0.84	-1.48	-1.72 *	-2.02 **	-1.83 *	-1.78 *	-1.88 *	-1.81 *	-1.77 *	-1.80 *	-1.84 *	-1.75 *
12	-0.0035	-0.0026	-0.0057	-0.0073	-0.0074	-0.0078	-0.007	-0.0071	-0.007	-0.0069	-0.0071	-0.0071	-0.0067
t-stat	-0.56	-0.45	-1	-1.32	-1.39	-1.46	-1.36	-1.39	-1.4	-1.41	-1.44	-1.45	-1.37
							Medium-R&D						
3	-0.0045	-0.0015	-0.0004	-0.0005	-0.0012	-0.0012	-0.0008	-0.0006	-0.0006	-0.0006	-0.0005	-0.0004	-0.0004
t-stat	-1.01	-0.47	-0.16	-0.19	-0.54	-0.56	-0.39	-0.29	-0.32	-0.3	-0.25	-0.23	-0.22
6	-0.0018	0.0012	0.0015	-0.0002	-0.0012	-0.0014	-0.0007	-0.0012	-0.0015	-0.0012	-0.0011	-0.001	-0.001
t-stat	-0.39	0.29	0.37	-0.04	-0.33	-0.42	-0.21	-0.38	-0.45	-0.37	-0.33	-0.33	-0.3
9	-0.0029	-0.0013	-0.0014	-0.0029	-0.0038	-0.0035	-0.0025	-0.003	-0.0033	-0.0027	-0.0025	-0.0026	-0.0025
t-stat	-0.59	-0.3	-0.35	-0.74	-1.02	-0.98	-0.72	-0.91	-0.99	-0.84	-0.78	-0.83	-0.79
12	-0.0026	-0.002	-0.0025	-0.0038	-0.0038	-0.003	-0.0029	-0.0035	-0.0034	-0.0028	-0.0025	-0.0024	-0.0023
t-stat	-0.52	-0.42	-0.56	-0.9	-0.93	-0.76	-0.75	-0.93	-0.92	-0.77	-0.68	-0.67	-0.65

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							Low-R&D						
3	-0.0052	-0.0007	-0.0031	-0.0015	-0.0019	-0.0002	0.0009	0.0005	0.0004	0.0013	0.0014	0.0017	0.0017
t-stat	-0.87	-0.15	-0.68	-0.35	-0.46	-0.05	0.24	0.13	0.1	0.35	0.39	0.47	0.46
6	-0.002	-0.003	-0.0033	-0.0032	-0.0028	-0.0014	0.0006	0	0.0007	0.0015	0.0018	0.0021	0.0022
t-stat	-0.29	-0.48	-0.56	-0.59	-0.54	-0.27	0.11	0	0.15	0.33	0.39	0.45	0.47
9	-0.0091	-0.0084	-0.0097	-0.0078	-0.0068	-0.0048	-0.0034	-0.004	-0.0026	-0.0018	-0.0013	-0.0009	-0.001
t-stat	-1.46	-1.43	-1.80 *	-1.56	-1.39	-1.02	-0.79	-0.97	-0.65	-0.45	-0.32	-0.23	-0.25
12	-0.0103	-0.0115	-0.0113	-0.0098	-0.0082	-0.0071	-0.0064	-0.0066	-0.0054	-0.0047	-0.0042	-0.0037	-0.0038
t-stat	-1.48	-1.88 *	-2.01 **	-1.85 *	-1.63	-1.47	-1.45	-1.55	-1.29	-1.15	-1.03	-0.91	-0.92
							No-R&D						
3	-0.0161	-0.0075	-0.0063	-0.0055	-0.0056	-0.0048	-0.0033	-0.0033	-0.003	-0.0028	-0.0027	-0.0028	-0.0029
t-stat	-3.42 ***	-2.31 **	-2.17 **	-2.05 **	-2.20 **	-1.94 *	-1.38	-1.46	-1.33	-1.26	-1.22	-1.26	-1.31
6	-0.0119	-0.0074	-0.0064	-0.007	-0.0067	-0.0056	-0.0041	-0.004	-0.0036	-0.0034	-0.0033	-0.0034	-0.0034
t-stat	-2.59 ***	-1.78 *	-1.68 *	-1.97 **	-1.97 **	-1.70 *	-1.32	-1.33	-1.23	-1.16	-1.13	-1.17	-1.17
9	-0.0126	-0.0084	-0.0085	-0.008	-0.0074	-0.0058	-0.0048	-0.0047	-0.0041	-0.0039	-0.0039	-0.0041	-0.004
t-stat	-2.74 ***	-1.96 **	-2.16 **	-2.16 **	-2.10 **	-1.74 *	-1.53	-1.54	-1.37	-1.32	-1.32	-1.38	-1.36
12	-0.0132	-0.011	-0.0097	-0.0093	-0.0081	-0.0074	-0.0066	-0.006	-0.0054	-0.0053	-0.0054	-0.0055	-0.0056
t-stat	-2.66 ***	-2.35 **	-2.18 **	-2.15 **	-1.93 *	-1.82 *	-1.70 *	-1.6	-1.45	-1.42	-1.47	-1.5	-1.52

Notes: We sort stocks into four groups based on R&D intensity (R&D/Sales), high-R&D, medium-R&D, low-R&D and No-R&D. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on previous 3-, 6-, 9- or 12-month returns using the Jegadeesh and Titman (1993) method. 16 trading strategies are considered based on look-back period and holding period, using equally-weighted method when forming portfolios. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

Table 5.6 Triple-sort Momentum Strategy: First by Size, Second by R&D, Third by Prior Returns

Panel A Large-Cap

						Holding Period							
Look-back Period	**3**	**6**	**9**	**12**	**15**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
							High-R&D						
3	-0.0082	0.0001	-0.0004	0.0006	-0.0005	-0.0003	-0.0003	-0.0007	0.0001	0.0003	0.0002	0	0
t-stat	-1.92 *	0.05	-0.15	0.26	-0.24	-0.13	-0.17	-0.37	0.04	0.18	0.11	0	0
6	-0.0039	-0.002	-0.0031	-0.004	-0.0055	-0.0056	-0.0047	-0.005	-0.0043	-0.004	-0.0038	-0.0041	-0.0041
t-stat	-0.88	-0.51	-0.84	-1.21	-1.85 *	-2.00 **	-1.80 *	-1.97 **	-1.71 *	-1.6	-1.55	-1.65 *	-1.64
9	-0.0027	-0.0004	-0.0028	-0.0049	-0.0055	-0.0048	-0.0048	-0.0047	-0.0039	-0.0034	-0.0033	-0.0035	-0.0034
t-stat	-0.56	-0.09	-0.69	-1.33	-1.58	-1.46	-1.53	-1.53	-1.31	-1.14	-1.12	-1.21	-1.15
12	-0.0011	-0.0018	-0.005	-0.006	-0.0049	-0.0057	-0.0055	-0.0049	-0.0037	-0.0034	-0.0035	-0.0038	-0.0035
t-stat	-0.21	-0.38	-1.1	-1.47	-1.29	-1.51	-1.53	-1.39	-1.08	-0.98	-1.03	-1.12	-1.03
							Low-R&D						
3	-0.0036	0.0004	-0.0023	-0.0007	-0.0006	0.0007	0.0013	0.0017	0.0019	0.0021	0.0023	0.0024	0.0027
t-stat	-0.65	0.11	-0.7	-0.24	-0.21	0.26	0.5	0.66	0.73	0.8	0.9	0.96	1.06
6	-0.0041	-0.0057	-0.004	-0.0019	-0.0016	-0.0012	0.0001	0.0006	0.0011	0.0009	0.0012	0.0011	0.0015
t-stat	-0.76	-1.22	-0.93	-0.48	-0.42	-0.33	0.03	0.17	0.3	0.26	0.34	0.3	0.42
9	-0.009	-0.0074	-0.005	-0.004	-0.0044	-0.003	-0.0013	-0.0007	0	0	0.0005	0.0005	0.0008
t-stat	-1.71 *	-1.53	-1.11	-0.91	-1.05	-0.71	-0.33	-0.17	-0.01	0.01	0.13	0.13	0.19
12	-0.0101	-0.0111	-0.0093	-0.0083	-0.0065	-0.0048	-0.0037	-0.0031	-0.0022	-0.0019	-0.0015	-0.0016	-0.0012
t-stat	-1.92 *	-2.51 **	-2.26 **	-2.06 **	-1.61	-1.21	-0.95	-0.79	-0.56	-0.51	-0.39	-0.42	-0.31

Continued-

							No-R&D						
3	-0.0125	-0.0046	-0.0032	-0.0023	-0.0023	-0.0017	-0.0005	-0.0005	-0.0004	-0.0006	-0.0005	-0.0005	-0.0005
t-stat	-3.27 ***	-1.68 *	-1.26	-1.04	-1.09	-0.82	-0.24	-0.24	-0.21	-0.29	-0.26	-0.25	-0.27
6	-0.0074	-0.0028	-0.0025	-0.0033	-0.0035	-0.0026	-0.0014	-0.0012	-0.0011	-0.0013	-0.001	-0.0011	-0.001
t-stat	-2.09 **	-0.83	-0.83	-1.25	-1.43	-1.11	-0.63	-0.54	-0.54	-0.6	-0.49	-0.52	-0.46
9	-0.0089	-0.0048	-0.0045	-0.0051	-0.0044	-0.0032	-0.0019	-0.0017	-0.0015	-0.0016	-0.0015	-0.0015	-0.0015
t-stat	-2.52 **	-1.44	-1.49	-1.90 *	-1.73 *	-1.31	-0.83	-0.75	-0.7	-0.74	-0.69	-0.72	-0.72
12	-0.008	-0.0054	-0.0049	-0.0051	-0.0043	-0.0038	-0.003	-0.0028	-0.0026	-0.0026	-0.0026	-0.0026	-0.0027
t-stat	-2.04 **	-1.44	-1.38	-1.5	-1.33	-1.19	-0.97	-0.92	-0.87	-0.88	-0.89	-0.88	-0.91
Panel B Small-Cap													
							Holding Period						
Look-back Period	**3**	**6**	**9**	**12**	**15**	**18**	**24**	**30**	**36**	**42**	**48**	**54**	**60**
							High-R&D						
3	-0.0027	0.0027	0.0027	0.0023	0.0005	0.0006	0.0011	0.0009	0.0005	0.0008	0.0008	0.0006	0.0006
t-stat	-0.49	0.63	0.7	0.63	0.15	0.19	0.36	0.3	0.18	0.3	0.29	0.21	0.21
6	0.0075	0.0097	0.0071	0.0039	0.002	0.0016	0.0022	0.0008	0.0004	0.001	0.0011	0.0009	0.001
t-stat	1.28	1.77 *	1.39	0.79	0.43	0.37	0.54	0.2	0.12	0.26	0.29	0.25	0.28
9	0.0059	0.0057	0.0015	-0.0009	-0.0029	-0.0024	-0.0017	-0.0027	-0.0031	-0.0024	-0.0024	-0.0025	-0.0023
t-stat	0.99	1	0.29	-0.19	-0.64	-0.57	-0.46	-0.74	-0.89	-0.7	-0.71	-0.75	-0.68
12	0.0024	0.0036	0.0009	-0.0014	-0.0022	-0.0016	-0.002	-0.0027	-0.0027	-0.0022	-0.002	-0.002	-0.0018
t-stat	0.37	0.55	0.14	-0.24	-0.41	-0.32	-0.42	-0.58	-0.6	-0.48	-0.45	-0.44	-0.4

Continued-

							Low-R&D						
3	-0.0006	0.0023	0.0012	0.0008	0.0002	0.0017	0.0031	0.0027	0.0026	0.0034	0.0035	0.0038	0.0039
t-stat	-0.1	0.45	0.26	0.19	0.04	0.41	0.8	0.7	0.69	0.92	0.93	1.02	1.04
6	-0.0006	-0.0013	-0.0012	-0.0017	-0.0014	0.0004	0.002	0.0011	0.0016	0.0029	0.0029	0.0033	0.0034
t-stat	-0.1	-0.23	-0.23	-0.37	-0.31	0.1	0.53	0.3	0.45	0.81	0.84	0.95	0.96
9	-0.0047	-0.0045	-0.006	-0.0043	-0.0029	-0.0013	0	-0.001	-0.0001	0.0011	0.0013	0.0018	0.0019
t-stat	-0.75	-0.78	-1.1	-0.87	-0.62	-0.3	0.01	-0.28	-0.03	0.31	0.38	0.52	0.54
12	-0.0072	-0.0077	-0.0071	-0.0057	-0.0043	-0.0031	-0.0026	-0.0031	-0.002	-0.0014	-0.0009	-0.0003	-0.0002
t-stat	-1.1	-1.36	-1.36	-1.19	-0.96	-0.73	-0.69	-0.89	-0.58	-0.41	-0.26	-0.09	-0.05
							No-R&D						
3	-0.0136	-0.0068	-0.0052	-0.0046	-0.0048	-0.0042	-0.0022	-0.0023	-0.0019	-0.0015	-0.0013	-0.0016	-0.0016
t-stat	-2.68 ***	-1.92 *	-1.77 *	-1.77 *	-1.97 **	-1.81 *	-1.07	-1.17	-1	-0.82	-0.71	-0.84	-0.87
6	-0.0093	-0.0064	-0.0056	-0.0061	-0.0057	-0.0048	-0.0032	-0.003	-0.0025	-0.0019	-0.0019	-0.0021	-0.0021
t-stat	-1.90 *	-1.52	-1.52	-1.77 *	-1.76 *	-1.53	-1.12	-1.13	-0.94	-0.75	-0.76	-0.84	-0.84
9	-0.0108	-0.0075	-0.0079	-0.0073	-0.0065	-0.005	-0.0039	-0.0036	-0.0029	-0.0024	-0.0024	-0.0026	-0.0025
t-stat	-2.24 **	-1.68 *	-1.93 *	-1.89 *	-1.79 *	-1.46	-1.24	-1.21	-0.99	-0.84	-0.86	-0.93	-0.89
12	-0.0117	-0.01	-0.0089	-0.0082	-0.0067	-0.0058	-0.005	-0.0043	-0.0034	-0.0029	-0.003	-0.0032	-0.0031
t-stat	-2.28 **	-2.07 **	-1.95 *	-1.87 *	-1.61	-1.49	-1.4	-1.28	-1.04	-0.91	-0.95	-0.99	-0.96

Notes: We sort stocks into six groups based on market capitalization and R&D intensity (R&D/Sales), including Large-cap: high-R&D, low-R&D and no-R&D, and Small-cap: high-R&D, low-R&D and no-R&D. Within each group, stocks are assigned into 5 quintiles, from winner to loser, based on previous 3-, 6-, 9- or 12-month returns using the Jegadeesh and Titman (1993) method. 16 trading strategies are considered based on look-back period and holding period, using equally-weighted method when forming portfolios. The data reported are the average portfolio monthly returns of buying Winners and selling Losers.

Chapter 6 Conclusion

This dissertation studies the sources of abnormal returns produced by momentum strategy, value strategy and R&D investment. The first essay examines the difference of value premium and R&D premium. Research and development represents the value of intangible asset not captured by book value under current GAAP accounting regulations. Controlling R&D helps to distinct the valuable growth firms, which invest actively in R&D, from growth firms, measured by book-to-market ratio. In R&D quintiles, value strategies on average outperform the non-R&D portfolio and univariate value strategy. The most profitable value strategy is the stocks most actively investing in research and development. This study indicates that R&D factor is an independent risk proxy and not dominated by book-to-market, conversely, the R&D factor does not dominate book-to-market factor. The empirical results are consistent with the theoretical framework built on the dividend discount model, investment-asset pricing theory and q-theory. These findings suggest that R&D strategy provides a hedge to value strategy. It provides new evidence to the literature about the value of R&D investment.

The second essay demonstrates that growth options and firm size play an important role in explaining stock returns. Building on a theoretical explanation of return premium to different firm characteristics, it identifies relevant firm characteristic, like firm size, book-to-market ratio, R&D level, industry requirement and time period. Based on all stocks obtained from CRSP/Compustat database, this study explores the historic market risk premium, size premium, value premium, R&D premium, industry premium

and momentum premium. The enhanced momentum strategies by first sorting on market equity, book-to-market ratio, R&D level and industry requirement. The results show 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.

The third essay employs similar methods with second essay, and focuses on Chinese stock market. Based on the most up-to-date Chinese data, it provides new evidence to the debate of Chinese momentum and reversal phenomenon.

The returns of JT momentum strategies are close to zero in the short horizon, but long-horizon contrarian strategies generate pervasive returns for holding periods of 12-60 months. Moreover, this study indicates that firm size and R&D investment help to explain momentum and reversal patterns in China. On the one hand, it reveals that large firms experience weak momentum effect in first decade of Chinese stock development, while small firms are more likely to reverse and the reversal effect is stronger in the recent decade. On the other hand, R&D investment reduces reversal effect, and this pattern is robust to both large and small firms. In sum, both firm size and R&D investment contribute to the momentum and reversal patterns in Chinese stock markets.