Market anomalies in the Korean stock market

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Received 30 March 2020
Revised 23 April 2020
24 May 2020
Accepted 24 May 2020

Abstract

This paper aims to replicate 148 anomalies and to examine whether the performance of the Korean market anomalies is statistically and economically significant. First, the authors observe that only 37.8% anomalies in the universe of the KOSPI and the KOSDAQ and value-weighted portfolios have *t*-statistics that exceed 1.96. When the authors impose a higher threshold (an absolute value of *t*-statistics of 2.78), only 27.7% of the 148 anomalies survive. Second, microcaps have large impacts. The results vary significantly depending on whether the sample included stocks in the KOSDAQ and whether value-weighted or equal-weighted portfolios are used. The results suggest that data mining explains large portion of abnormal returns. Any tactical asset allocation strategies based on market anomalies should be applied very cautiously.

Keywords Data mining, Anomaly, Factor, Microcap stocks, Tactical asset allocation

Paper type Research paper

1. Introduction

The current asset management market is shifting from asset-based investments to factor-based investments, focusing on large institutional investors such as pension funds and insurance companies. In addition, the smart beta strategy has become one of the main strategies used by passive and enhanced index-based funds, which build portfolios based on multiple anomalies in the market. For example, there are currently about 1,000 smart beta ETFs in the USA, with a total market capitalization of $999bn exceeded (as of the end of 2017) [1]. Following this trend, smart beta-based ETFs in Korea are gradually expanding their shares, such that their market capitalization exceeded Korean â,©1.2tn as of March 2019. Therefore, both academically and practically, it has become more important to study which factor and strategy based on market anomalies actually provide premiums in the long-term.

In recent years, it has been argued that we need to examine whether the discovered factors would come from data mining. Harvey *et al.* (2016) argue that there are significant publication biases in which studies published in academia mostly report only results for significant factors. Then, Harvey *et al.* (2016) suggest that the standard for *t*-statistics should be raised to 3.00 for newly discovered factors because the standard threshold, for example, 2.00, cannot filter the data mining result. Harvey (2017) points out the behavior of empirical analysis in financial economics that is less likely to verify results through

This research was conducted with the support of the 2019 Korean Derivatives Association (sponsored by Mirae Asset Global Investments).

Journal of Derivatives and Quantitative Studies: 선물연구
Vol. 28 No. 2, 2020
pp. 3-50
Emerald Publishing Limited
p-ISSN: 1229-988X
e-ISSN: 2713-6647
DOI 10.1108/JDQS-03-2020-0004

replication than the norm in natural science. He also argues that researchers need to be cautious about data mining and P-hacking in empirical finance. Hou, Xue and Zhang (hereafter, Hou *et al.*, 2018) replicate and analyze 452 anomalies that are found to be significant in previous literature. In Hou *et al.* (2018), 65% of anomalies fail to exceed the *t*-statistic of 1.96 in the single test and 82% of anomalies fail to replicate if we adjust for multiple testing, the *t*-statistic of 2.78 suggested by Harvey *et al.* (2016). While such research on anomalies is increasing in other countries, research that comprehensively analyzes anomalies in the Korean market has not yet been conducted.

We replicate 148 anomalies in the Korean market drawn from the literature. We examine whether the return of each anomaly is statistically, as well as economically significant. Also, we investigate how the statistical significance of anomalies differs according to microcaps. To do this, we compare the result from the limited sample that includes only the KOSPI and the result from the total sample that covers both the KOSPI and KOSDAQ. Moreover, we test whether the value-weighted (hereafter, VW) method or the equal-weighted (hereafter, EW) method effects on replication rates.

The findings of our study are summarized as follows. First, with the VW portfolio, only 57 of the 148 anomalies (37.8%) exceed the single test hurdle of $|t - stat| \geq 1.96$ in the total sample that covers both of the KOSPI and the KOSDAQ. Additionally, only 41 out of 148 anomalies (27.7%) are replicated when we adopt the cutoff *t*-statistics of 2.78 presented by Harvey *et al.* (2016). Second, 44 of the 148 anomalies (29.7%) are replicated by the VW methods and the cutoff of 1.96, when we limit the sample to include only the KOSPI stocks. Meanwhile, if we increase the cutoff of *t*-statistics to 2.78, only 15 of the 148 anomalies (10.1%) are replicated. In particular, anomalies related to momentum are barely significant in the restricted sample to the KOSPI, unlike the results obtained when considering the total Korean market. Third, when comparing the results obtained by constructing a portfolio using VW and EW, the EW portfolio based on anomalies, on average, results in higher returns and higher *t*-statistics.

Our results have implications as follows. First, this study is the first to overview anomalies in the Korean market. Previous studies analyze at each anomaly alone, but this study would be the first to identify and analyze a large set of 148 anomalies. Among anomalies identified in the existing literature, we replicate only about 37% of 148 anomalies in Korea. Anomalies related to value, trading friction and momentum are well-replicated relatively. On the other hand, the estimated returns based on anomalies related to investment, profitability and intangible assets are not statistically and economically significant, and these categories are not properly replicated. Our results suggest that a significant number of anomalies identified by most studies might reflect "inevitable" data mining. This problem is also linked to the problem described in recent studies (Harvey *et al.*, 2016; Hou *et al.*, 2018).

Second, microcaps distort the result when we test the performance of anomalies. For example, the results for the limited sample that consists only of companies listed on the KOSPI can differ significantly to result in the total samples, also including companies listed on KOSDAQ. Therefore, if microcaps are not controlled correctly, the result can mislead us when we conduct to test which anomalies are significant or not. In addition, by constructing the EW portfolio that allocates more weight to microcaps, anomalies tend to earn higher returns and be statistically significant than the VW portfolio. These results also suggest a need to control for effects from microcaps in studies on anomalies.

Finally, our results provide the following practical implications. First, the results can be used for tactical asset *all*ocation by institutional investors. The traditional academic method of performing tactical asset allocation (TAA) is to use market anomalies. In other words, in industry, smart beta or factor investment is caused by these anomalies. In this study, we analyze 148 phenomena in the Korean market. We recommend industry practitioners to compile our list to investigate anomalies in Korea/overseas and stock/bonds. Our list of anomalies can be used to creatively combine strategies based on anomalies or to develop new strategies such as the factor rotation for selecting anomalies according to various aspects. For example, factor returns tend to become cyclical, so practitioners could allocate by predicting changes in a specific factor and betting on it tactically. In other words, experts need to focus on developing strategies that combine anomalies without reproducing existing market phenomena. Second, anomalies can be used to analyze and evaluate fund investment strategies and fund selection. In Korea, few institutions systematically manage anomalies and use anomalies actively for the fund evaluation. Institutions engaged in fund evaluation could use this factor-based performance evaluation model derived in our study.

2. Categorization for anomalies and portfolio construction

2.1 Data and categories

In this research, we replicate some of the anomalies found in existing academic papers using data for all companies listed on the KOSPI and KOSDAQ market. At first, the sample period runs from January 1995 to June 2019, and we obtain all stock price, trading and accounting information from FnGuide's Data guide. The final sample corresponds to the period from January 2000 to June 2019, as we estimate anomalies using data from the past five years. We limit the sample to companies outside of the financial industry and exclude companies that have suffered impairment of capital. We use stock return that adjusts dividends, splits and mergers.

Following Hou *et al.* (2018), we categorize anomalies into six groups as follows: value, momentum, investment, profitability, trading friction and intangibles. In Table 1, we present anomalies corresponding to each category and previous literature in which the anomaly is discovered. Information regarding how to estimate the return based on anomalies is presented in the Appendix. We analyze a total of 148 anomalies in this research: 13 anomalies related to value, 15 related to momentum, 29 related to investment, 20 related to profitability, 17 intangible anomalies and 54 related to trading friction.

2.2 How to construct a portfolio

To replicate anomalies, we form portfolios as follows. We construct decile portfolios by sorting based on the size of each variable related to anomalies, according to the rebalancing period for each anomaly. For example, in the case of $R^{11}1$, we rebalance the portfolio monthly. Then, decile portfolios are constructed based on the return for the past year at the end of each month (excluding the return for the last month). Then, at the end of the next month, rebalancing is carried out on the new portfolio and we continue to invest based on momentum, the past return. On the other hand, in the case of anomalies using accounting information, we conduct annual rebalancing. For example, when we estimate the return of Bm, we form portfolios by sorting the ratio of the book value of past fiscal year to the market value of past December at the end of each June. Therefore, we keep going with this portfolio until the end of June of the following year.

If the portfolio rebalancing is performed monthly, the holding periods are 1 month, 6 months and 12 months. This allows investors to evaluate the performance of the anomaly depending on the holding period.

To construct a portfolio, we use the VW method to reduce the impact of microcaps. Fama and French (2008) observe significant impacts when constructing EW portfolios using microcaps. Fama and French (2016) argue that the five-factor model shows irregular results

Panel A: Momentum			
$R^{6}1$	6 months momentum (1 months holding), Jegadeesh and Titman (1993)	$R^{6}6$	6 months momentum (6 months holding), Jegadeesh and Titman (1993)
$R^{6}12$	6 months momentum (12 months holding), Jegadeesh and Titman (1993)	$R^{11}1$	11 months momentum (1 months holding), Fama and French (1996)
$R^{11}6$	11 months momentum (6 months holding), Fama and French (1996)	$R^{11}12$	11 months momentum (12 months holding), Fama and French (1996)
52*w*1	52 week high momentum (1 month holding), George and Hwang (2004)	52*w*6	52 week high momentum (6 month holding), George and Hwang (2004)
52*w*12	52 week high momentum (12 month holding), George and Hwang (2004)	$\in^{6}1$	6-month residual momentum (1-month holding), Blitz *et al.* (2011)
$\in^{6}6$	6-month residual momentum (6-month holding), Blitz *et al.* (2011)	$\in^{6}12$	6-month residual momentum (12-month holding), Blitz *et al.* (2011)
$\in^{11}1$	11-month residual momentum (1-month holding), Blitz *et al.* (2011)	$\in^{11}6$	11-month residual momentum (6-month holding), Blitz *et al.* (2011)
$\in^{11}12$	11-month residual momentum (12-month holding), Blitz *et al.* (2011)		
Panel B: Value			
Bm	Book value-to-market value ratio, Rosenberg *et al.* (1985)	*Bmj*	Book value-to-end market value ratio, Asness and Frazzini (2013)
Dm	Debt-to-market value ratio, Bhandari (1988)	*Am*	Asset-to-market value ratio, Fama and French (1992)
Ep	Profit-to-stock ratio, Basu (1983)	*Cp*	Cash flow-to-stock ratio, Lakonishok *et al.* (1994)
Sr	5 year sales growth rate ranking, Lakonishok *et al.* (1994)	*Sg*	Sales growth rate, Lakonishok *et al.* (1994)
Sp	Sales-market value, Barbee *et al.* (1996)	*Ocp*	Operating cash flow to share price ratio, Desai *et al.* (2004)
Ebp	Total enterprise book value-market value, Penman *et al.* (2007)	*Ndp*	Net debt-to-market value ratio, Penman *et al.* (2007)
Em	EV/EBITDA ratio, Loughran and Wellman (2011)		
Panel C: Investment			
Aci	Excess corporate investment, Titman *et al.* (2004)	*I/A*	Investment-asset ratio, Cooper *et al.* (2008)
dpia	Changes in tangible assets and inventories, Lyandres *et al.* (2008)	*Noa*	Net operating assets, Hirshleifer *et al.* (2004)
dNoa	Net operating asset change, Hirshleifer *et al.* (2004)	*dLno*	Changes in long-term net operating assets, Fairfield *et al.* (2003)
Ig	1 year investment growth rate, Xing (2008)	2*Ig*	2 year investment growth rate, Anderson and Garcia-Feijoo (2006)
3*Ig*	3 year investment growth rate, Anderson and Garcia-Feijoo (2006)	*Nsi*	Net stock issuance, Pontiff and Woodgate (2008)
Cei	Comprehensive stock issuance, Daniel and Titman (2006)	*Cdi*	Comprehensive bond issuance, Lyandres *et al.* (2008)
Ivg	Inventory growth rate, Belo and Lin (2011)	*Ivc*	Inventory change, Thomas and Zhang (2002)
Oa	Operating accruals, Sloan (1996)	*Ta*	Total accrual, Richardson *et al.* (2005)

(*continued*)

Table 1.
Categories and definition of anomalies

dWc	Change in net non-cash working capital, Richardson *et al.* (2005)	*dCoa*	Change in current operation assets, Richardson *et al.* (2005)
dCol	Changes in current operating liabilities, Richardson *et al.* (2005)	*dNco*	Changes in net non-current operating assets, Richardson *et al.* (2005)
dNca	Changes in non-current operating assets, Richardson *et al.* (2005)	*dNcl*	Changes in non-current operating liabilities, Richardson *et al.* (2005)
dFin	Change in net financial assets, Richardson *et al.* (2005)	*dSti*	Changes in short-term investment assets, Richardson *et al.* (2005)
dLti	Changes in long-term investment assets, Richardson *et al.* (2005)	*dFnl*	Changes in financial debt, Richardson *et al.* (2005)
dBe	Change in book value, Richardson *et al.* (2005)	*Dac*	Discretionary accruals, Xie (2001)
Abs (*Dac*)	Absolute value of discretionary accruals	*Poa*	Percent operating accrual, Hafzalla *et al.* (2011)
Pta	Percent total accrual, Hafzalla *et al.* (2011)	*Pda*	Percent Discretionary Accruals
Panel D: Profitability			
Roe	Roe, Hou *et al.* (2015)	*dRoe*	Change in Roe, Hou *et al.* (2015)
Roa	Roa, Balakrishnan *et al.* (2010)	*dRoa*	Change in Roa
Rna	Net operating asset yield, Soliman (2008)	*Pm*	Profit margin, Soliman (2008)
Ato	Asset turnover, Soliman (2008)	*Cto*	Capital turnover, Haugen and Baker (1996)
Gpa	Gross profit-asset ratio, Novy-Marx (2013)	*Gla*	Gross profit-lagged asset ratio
Ope	Operating income-capital ratio, Fama and French (2015)	*Ole*	Operating income-lagged capital ratio
Opa	Operating income-asset ratio	*Ola*	Operating profit-lagged asset ratio
Cop	Cash-based operating profitability, Ball *et al.* (2016)	*Cla*	Cash-based operating profitability-lagged asset ratio,
F	Fundamental Score, Piotroski (2000)	*O*	O-Score, Ohlson (1980), Dichev(1998)
Z	Z-score, Altman (1968), Dichev (1998)	*Tbi*	Profit before tax-profit after tax, Lev and Nissim (2004)
Bl	Book value based leverage, Fama and French (1992)		
Panel E: Intangibles			
Adm	Advertising costs-market cap ratio, Chan *et al.* (2001)	*gAd*	Advertisement cost increase rate, Lou (2014)
Rdm	R&D expenditure-market capitalization ratio, Chan *et al.* (2001)	Rds	R&D cost-to-sales ratio, Chan *et al.* (2001)
Ol	Operating leverage, Novy-Marx (2011)	*Hn*	Employment rate, Belo *et al.* (2014)
Rca	R&D capital-asset ratio, Li (2011)	Age_{found}	Corporate age (based on found date), Jiang *et al.* (2005)
Age_{List}	Corporate age (based on listing date)	*dSi*	Difference between % change in sales and % change in inventory, Abarbanell and Bushee (1998)
dSa	Difference between % change in sales and % change in accounts receivable, Abarbanell and Bushee (1998)	*dGs*	Difference between % change in gross profit and % change in sales, Abarbanell and Bushee (1998)

(*continued*)

Table 1.

dSs	Difference between % change in sales and % change in SG&A, Abarbanell and Bushee (1998)	*Lfe*	Labor force efficiency, Abarbanell and Bushee (1998)
Tan	Asset tangibility, Hahn and Lee (2009)	*Ala*	Asset liquidity-to-total assets ratio, Ortiz-Molina and Phillips (2014)
Alm	Asset liquidity to market value ratio, Ortiz-Molina and Phillips (2014)		
Panel F: Trading frictions			
*Ivff*1	Idiosyncratic volatility – FF factor model (1 months holding), Ang and Hodrick (2006)	*Ivff*6	Idiosyncratic volatility – FF factor model (6 months holding), Ang and Hodrick (2006)
*Ivff*12	Idiosyncratic volatility – FF factor model (12 months holding), Ang and Hodrick (2006)	*Ivc*1	Idiosyncratic volatility – CAPM (1 months holding)
*Ivc*6	Idiosyncratic volatility – CAPM (6 months holding)	*Ivc*12	Idiosyncratic volatility – CAPM (12 months holding)
*Tv*1	Total volatility (1 months holding)	*Tv*6	Total volatility (6 months holding)
*Tv*12	Total volatility (12 months holding)	$\beta 1$	Market beta (1 months holding), Fama and MacBeth (1973)
$\beta 6$	Market beta (6 months holding), Fama and MacBeth (1973)	$\beta 12$	Market beta (12 months holding), Fama and MacBeth (1973)
$\beta^{FP}1$	Frazzini and Pedersen (2014) beta (1 months holding)	$\beta^{FP}6$	Frazzini and Pedersen (2014) beta (6 months holding)
$\beta^{FP}12$	Frazzini and Pedersen (2014) beta (12 months holding)	$\beta^{D}1$	Dimson (1979) beta (1 months holding)
$\beta^{D}6$	The Dimson (1979) beta (6 months holding)	$\beta^{D}12$	Dimson (1979) beta (12 months holding)
β^{-1}	Downside beta (1 months holding)	β^{-6}	Downside beta (6 months holding)
β^{-12}	Downside beta (12 months holding)	*Tur*1	Stock turnover (1 months holding)
*Tur*6	Stock turnover (6 months holding)	*Tur*12	Stock turnover (12 months holding)
*Cvt*1	Turnover volatility coefficient (1 months holding)	*Cvt*6	Turnover volatility coefficient (6 months holding)
*Cvt*12	Turnover volatility coefficient (12 months holding)	*Dtv*1	Dollar trading volume (1 months holding), Brennan *et al.* (1998)
*Dtv*6	Dollar trading volume (6 months holding)	*Dtv*12	Dollar trading volume (12 months holding), Brennan *et al.* (1998)
*Cvd*1	Dollar trading volume volatility coefficient (1 months holding), Chordia *et al.* (2001)	*Cvd*6	Dollar trading volume volatility coefficient (6 months holding)
*Cvd*12	Dollar trading volume volatility coefficient (12 months holding), Chordia *et al.* (2001)	*Srev*	Short term reversal, Jegadeesh (1990)
*Ami*1	Absolute return-to-volume ratio (1 months holding), Amihud (2002)	*Ami*6	Absolute return-to- volume ratio(6 months holding), Amihud (2002)
*Ami*12	Absolute return-to-volume ratio (12 months holding), Amihud (2002)	$Mdr^{5}1$	Monthly maximum daily returns (5 day average, 1 months holding), Bali *et al.* (2011)
$Mdr^{5}6$	Monthly maximum daily returns (5 day average, 6 months holding), Bali *et al.* (2011)	$Mdr^{5}12$	Monthly maximum daily returns (5 day average, 12 months holding), Bali *et al.* (2011)

Table 1.

(*continued*)

$Mdr^{10}1$	Monthly maximum daily returns (10 days average, 1 months holding), Bali *et al.* (2011)	$Mdr^{10}6$	Monthly maximum daily returns (10 days average, 6 months holding), Bali *et al.* (2016)
$Mdr^{10}12$	Monthly maximum daily returns (10days average, 12 months holding), Bali *et al.* (2011)	*Ts*1	Total skewness (1 months holding), Bali *et al.* (2016)
*Ts*6	Total skewness (6 months holding), Bali *et al.* (2016)	*Ts*12	Total skewness (12 months holding), Bali *et al.* (2016)
*Isc*1	Idiosyncratic skewness-CAPM (1 months holding)	*Isc*6	Idiosyncratic skewness-CAPM (6 months holding)
*Isc*12	Idiosyncratic skewness-CAPM (12 months holding)	*Isff*1	Idiosyncratic skewness-FF factor (1 months holding)
*Isff*6	Idiosyncratic skewness-FF factor (6 months holding)	*Isff*12	Idiosyncratic skewness-FF factor (12 months holding)

Notes: In this study, we categorize anomalies into six group following Hou *et al.* (2018): value, momentum, investment, profitability, trading friction and intangibles. Please see the Appendix for details regarding how the portfolio for each category are constructed. Finally, 148 anomalies are included in this study: 13 anomalies related to value, 15 related to momentum, 29 related to investment, 20 related to profitability, 17 related to intangible assets and 54 related to trading friction

Table 1.

in dealing with microcaps. Microcaps account for a large proportion of the total number of companies in the stock market, but their fraction of market capitalization is remarkably low. Moreover, as such companies have little liquidity and high transaction costs, we can be misled by the effect of microcaps when we form portfolios and test the performance of the portfolio. Therefore, we conduct the VW method to calculate the return of the portfolio. Then, the same analysis is carried out with the EW method and the results are compared to those obtained with the VW method.

3. Anomaly-related research in the Korean market

In this section, we outline trends in research related to anomalies conducted in the Korean market. Then, following Harvey *et al.* (2016), we verify whether the publication bias exists in Korea. Besides, we examine which stock markets, the KOSPI and KOSDAQ, are considered in each literature. Panel A in Table 2 summarizes Korean anomaly studies. The meaning of the numbers next to each literature is as follows. If the anomaly shows a significantly positive (+) performance, it is represented by [1]. Meanwhile, if the anomaly earns a negative (−) significant return, it is represented by [2]. We assign [3] to anomalies that are significant but change with time. [4] means that the anomaly is not statistically significant. We indicate whether the sample includes only the KOSPI [KOSPI], both the KOSPI and KOSDAQ market [KOSPI + KOSDAQ] or only the KOSDAQ market [KOSDAQ]. Panel B outlines the number and significance of previous literature according to categories.

Studies of anomalies in the US market have been based on a wide variety of anomalies. For example, according to Hou *et al.* (2018), for a total of 452 anomalies, 57 are related to momentum, 69 to value and growth, 38 to investment, 79 to profitability, 103 to intangible and 106 to trading friction. These results indicate that research in the USA is not heavily weighted to particular anomalies. However, the existing research for the Korean market has so far been biased toward specific anomalies, for instance, with 23 related to values, 18 to trading frictions and 12 to momentum (Panel A, Table 2). In particular, only two studies examine anomalies based on intangibles and many anomalies studied overseas have not yet been studied in the Korean market.

Panel A: Anomalies research	
Momentum	
Momentum	Sim (2018) [1] [KOSPI], Yoon and Kim (2009) [1] [KOSPI], Lee (2019) [3] [KOSPI], Jang (2017) [1] [KOSPI], Kim and Eom (1997) [2] [KOSPI], Kim (2000) [2] [KOSDAQ], Park and Jee (2006) [3] [KOSPI], Kim (2012) [3] [KOSPI], Lee and Ahn (2002) [3] [KOSPI], Hwang (2015) [2] [KOSPI], Park and Son (2012) [3] [KOSPI], Eom (2013) [3] [KOSPI+KOSDAQ]
Value	
Book to market	Kim and Kim (2001) [1] [KOSPI], Kam (1997) [1] [KOSPI], Lee *et al.* (2008) [1] [KOSPI+KOSDAQ], Kim and Yun (1999) [1] [KOSPI], Kim (2010) [1] [KOSPI], Kim *et al.* (2012) [KOSPI+KOSDAQ] [1], Jang and Kim (2003) [1] [KOSPI+KOSDAQ], Kim (1999) [1] [KOSPI], Kim and Kim (2015) [1] [KOSPI+KOSDAQ]
Earning to price	Kim (1999) [1] [KOSPI], Jang and Kim (2003) [1] [KOSPI+KOSDAQ], Kim and Lee (2006) [1] [KOSPI], Son and Yoon (2011) [1] [KOSPI+KOSDAQ], Kim and Yeo (2017) [4] [KOSPI+KOSDAQ]
Cashflow to price	Kam (1997) [1] [KOSPI], Kim (1999) [1] [KOSPI], Jang and Kim (2003) [1] [KOSPI+KOSDAQ], Kim and Lee (2006) [1] [KOSPI+KOSDAQ]
Operating cashflow -to price	Lee and Ohk (2015) [1] [KOSPI]
Sales growth	Kim and Lee (2006) [1] [KOSPI+KOSDAQ]
Sales to price	Kim (1999) [1] [KOSPI], Jang and Kim (2003) [1] [KOSPI+KOSDAQ], Kim and Lee (2006) [1] [KOSPI+KOSDAQ]
Investment	
Abnormal corporate investment	Chang and Kim (2016) [2] [KOSPI], Lee and Choi (2013) [2] [KOSPI], Son (2012) [2] [KOSPI]
Investment to asset	Uk Chang and Yibae Kim (2016) [2] [KOSPI], Jae Kyu Lee and Hyung Suk Choi (2013) [2] [KOSPI], Pan Do Son (2012) [2] [KOSPI]
Changes in PPE	Kim and Kim (2010) [2] [KOSPI]
Inventory to asset	
Stock issuance	Son and Yoon (2011) [1] [KOSPI+KOSDAQ]
Inventory growth inventory changes	Kim and Kim (2010) [2] [KOSPI+KOSDAQ], Kim and Lee (2013) [2] [KOSPI]
Accruals	Kho and Kim (2009) [2] [KOSPI], Im and Sonu (2015) [2] [KOSPI+KOSDAQ]
Profitability	
ROE and ROA and gross profit to asset	Lee and Ohk (2015) [4] [KOSPI], Kim Jeong and Kim (2018) [1] [KOSPI+KOSDAQ] Minki Kim, Jin Soo Jeong and Tong Suk Kim (2018) [1] [KOSPI + KOSDAQ]
Financial constraints (O score and Z score)	Kim and Kim (2016) [2] [KOSPI+KOSDAQ], Kim *et al.* (2013) [2] [KOSPI]
Intangibles	
	Woo and Kwak (2004) [4] [KOSPI+KOSDAQ], Ha and Park (2019) [1] [KOSPI+KOSDAQ]
Trading frictions	
Idiosyncratic volatility	Kim and Byun (2011) [2] [KOSPI], Eom *et al.* (2014) [2] [KOSPI], Chang *et al.* (2016) [2] [KOSPI], Chung (2018) [2] [KOSPI], Ok *et al.* (2018) [4] [KOSPI]
Total volatility	Kho and Kim (2014) [2] [KOSPI], Yun *et al.* (2011) [2] [KOSPI]
Beta	Kim and Kim (2001) [4] [KOSPI+KOSDAQ], Eom (2012) [3] [KOSPI]
Stock turnover	Yun *et al.* (2009) [2] [KOSPI], Ko *et al.* (2009) [2] [KOSPI+KOSDAQ]
Illiquidity (Amihud)	Kang and Jeong (2018) [1] [KOSPI+KOSDAQ]
Total skewness	Jang (2016) [2] [KOSPI], Sim (2016a) [2] [KOSPI], Sim (2016b) [2] [KOSPI]
Idiosyncratic skewness	Byun and Kim (2012) [2] [KOSPI]
Mdr	Kang and Sim (2014) [2] [KOSPI], Kho and Kim (2017) [2] [KOSPI+KOSDAQ]

Panel B: The significance of Korean anomalies-related studies and categories, samples

Categories	Number of literature	KOSPI+KOSDAQ		KOSPI		KOSDAQ
		Significant	Insignificant	Significant	Insignificant	Significant
Momentum	14	0	1	11	0	1
Trading friction	18	3	1	13	1	0
Value	23	11	1	11	0	0
Investment	8	2	0	6	0	0
Profitability	4	2	0	1	1	0
Intangible	2	1	1	0	0	0

Notes: Panel A is a summary of anomalies studies conducted in the Korean market. If the anomaly shows a significantly positive (+) performance, it is represented by [1]. Meanwhile, if the anomaly earns a negative (–) significant return, it is represented by [2]. We assign [3] to anomalies that are significant but change with time. The [4] means that the anomaly is not statistically significant. We indicate whether the sample includes only the KOSPI [KOSPI], both the KOSPI and KOSDAQ market [KOSPI + KOSDAQ] or only the KOSDAQ market [KOSDAQ]. Panel B shows the total number and significance of previous literature according to the categories

Table 2.
Korean research related to anomalies

In Korea, most literature reports that the return of anomalies-based portfolios is statistically significant (Panel A, Table 2). In terms of the sample in literature, most studies include only the KOSPI than the KOSDAQ. Panel B in Table 2 shows details. Of all 67 anomalies-related studies, 62 (92.5%) report that the return of anomalies-based strategies is statistically significant. Out of 67 studies, 42 (62.7%), the majority of studies focus on the KOSPI market. Studies that analyze both the KOSPI and KOSDAQ market, mostly focus on anomalies related to value (11 of 19 studies). The existing literature on the KOSDAQ mark *et al.* one has not included anomalies related to momentum, trade friction or investment. In other words, studies of anomalies for the Korean market tend to include only the KOSPI, so there is concern that the results may not be generalizable to microcaps.

4. Empirical analysis

4.1 The analysis of replication rates for all anomalies

In this study, following Hou *et al.* (2018), we assume that we have successfully replicated the results of previous research if our results are statistically significant. Panel A in Table 3 shows the proportion of anomalies that are found to be statistically significant for each category. The return of anomalies is the differentials between the *High* decile portfolio return and the *Low* decile portfolio return(the *High* minus *Low*). Then, we adopt two criteria that test whether the High minus Low portfolio return is significantly different to zero. The

Categories	Numbers of anomalies	KOSPI + KOSDAQ Cutoff 1.96 (%)	KOSPI + KOSDAQ Cutoff 2.78 (%)	KOSPI Cutoff 1.96 (%)	KOSPI Cutoff 2.78 (%)
Panel A: High minus Low return					
Momentum	15	66.67	26.67	20.00	0.00
Trading Friction	54	48.15	42.59	33.33	7.41
Value	13	69.23	53.85	46.15	38.46
Investment	29	24.14	10.34	27.59	0.00
Profitability	20	5.00	0.00	0.00	0.00
Intangible	17	23.53	23.53	23.53	11.76
Panel B: The intercept from FF (1993) three-factor model					
Momentum	15	46.67	20.00	6.67	0.00
Trading Friction	54	53.70	44.44	48.15	31.48
Value	13	30.77	7.69	7.69	0.00
Investment	29	17.24	13.79	17.24	6.90
Profitability	20	20.00	5.00	15.00	0.00
Intangible	17	41.18	29.41	35.29	11.76

Notes: This table shows the proportion of statistically significant anomalies in each category among a total of 148 anomalies observed from January 2000 to June 2019. The returns of anomalies are estimated for all companies listed on the KOSPI and KOSDAQ, except for those in the financial industry, and the portfolio returns are calculated using a value-weighted method. In this study, following Hou *et al.* (2018), it is assumed that the previous study result is replicated when our result is also statistically significant. The sample is divided into the subsample including all companies listed in the KOSPI and the KOSDAQ market, and another in which only the KOSPI are considered. Panel A shows the differential between the high and low decile portfolio returns and panel B shows the intercept obtained from the Fama and French (1993) factor model. The t-statistic for a single test is the absolute value of 1.96 and the t-statistic for multiple tests is the absolute value of 2.78 (Harvey *et al.*, 2016). We calculate the proportions on how many anomalies exceed the cutoff of 1.96 and 2.78 in each category and the sample construction For example, among the 15 anomalies related to momentum, 66.67% exceed the cutoff of 1.96 in the sample that covers the KOSPI and the KOSDAQ. All t-statistics are adjusted using standard error that controls for heteroscedasticity and autocorrelation following Newey and West (1987)

Table 3. Numbers of replicated anomalies that are statistically significant (January 2000–June 2019)

first cutoff is the single test absolute t-statistics, 1.96 (5% significance level). Following Harvey *et al.* (2016), we adjust for multiple testing by adopting the absolute value of t-statistics of 2.78 (5% significance level).

In the sample that covers all companies listed on the KOSPI and KOSDAQ, replication rates that the proportion of anomalies exceeding the cutoff of 1.96 are as follows. We replicate anomalies related to value (69.23%), momentum (66.67%) and trade friction (48.15%) well, while fail to replicate anomalies related to investments (24.14%), intangible assets (23.53%) and profitability (5%). In the case of profitability, only one of the 20 anomalies is statistically significant. Second, if we raise the cutoff to the absolute value of t-statistics of 2.78, only value (53.85%) and trading friction (42.59%) are replicated more than 40%. We do not replicate well the rest of categories: momentum (26.27%), investment (10.34%), profitability (0%), intangible assets (23.53). Compared to the cutoff of t-statistics of 1.96, anomalies related to momentum shows significantly low replication rate.

We can verify that replication rates are deteriorated when we limit the sample to only the KOSPI. For example, with the single test of the absolute t-statistics of 1.96, replication rates are 46.15%, 33.33%, 27.59%, 23.53%, 0% across the value, trading friction, investment, intangibles and profitability, respectively. In particular, 66.67% of the momentum related anomalies are exceeding the cutoff of the single test. In comparison, only 26.27% of the momentum category are replicated when we adjust for multiple testing with the cutoff of 2.78.

These results indicate that studies of anomalies in the Korean market might have different results depending on samples. In particular, whether the sample covers the KOSDAQ or not might affect the outcome because many microcaps are likely to belong to the KOSDAQ market.

Panel B in Table 2 shows the results of the Fama and French (FF, 1993) three-factor model regression to verify whether many anomalies are statistically significant. First, the FF (1993) model does not explain anomalies on investment and profitability and intangibles. For example, in the case of profitability-related anomalies, the High minus Low decile portfolio return is often not statistically significant (only 5% exceed the cutoff of 1.96 for the absolute value of t-statistics). Only 20% in profitability-related anomalies are significant for the intercept from the FF (1993) model. Second, in the case of the intercept from the FF (1993) model, we can verify that replication rates decrease when we limit our sample to the KOSPI. In other words, we should be cautious because our results can be affected from how the sample is defined.

4.2 Statistically significant anomalies

In an analysis of companies listed on the KOSPI and KOSDAQ market, we examine statistically significant anomalies in more detail. Table 4 presents multiple statistics for statistically significant anomalies. First, $\overline{R}$ is the mean of differential returns between the *High* decile portfolio and *Low* decile portfolio and $|t|$ is the absolute value of the t-statistic. α_{FF3} is the intercept in a regression of the FF (1993) model and t_{FF3} is the t-statistic for α_{FF3}. *GRS* represents the F-test test statistic of Gibbons *et al.* (1989) and $p(GRS)$ is the p-value for GRS F-test.

In this study, to understand in more detail whether the FF (1993) model explains anomalies, we examine several measures on asset pricing models, following Fama and French (2015, 2016). First, $A(|a_i|)$ is the average absolute value of intercepts from the FF (1993) model for anomalies. $A(|r_i|)$ is the average absolute value of market portfolio excess return. We use the KOSPI as the value-weighted market portfolio in the Korean stock market. We compare the distribution of $A(|a_i|)$ to $A(|r_i|)$. For example, if the FF (1993) model

Anomaly	$\overline{R}$	$\lvert t \rvert$	α_{FF3}	t_{FF3}	$A(a_i)$	$\frac{A(\lvert a_i \rvert)}{A(\lvert r_i \rvert)}$	$\frac{A(a_i^2)}{A(r_i^2)}$	GRS	$p(GRS)$	R^2
Value										
Ocp	2.067	4.843	1.342	3.242	0.363	0.802	0.574	2.033	0.031	0.703
Bmj	1.698	4.251	0.730	2.168	0.178	0.403	0.163	0.590	0.821	0.736
Bm	1.488	4.152	0.395	1.397	0.232	0.495	0.234	0.923	0.513	0.743
Am	1.578	4.047	0.370	1.205	0.244	0.586	0.350	1.184	0.303	0.743
Sp	1.546	3.545	0.355	1.118	0.244	0.457	0.265	0.977	0.465	0.731
Ebp	1.006	2.824	0.317	1.071	0.228	0.523	0.260	0.760	0.667	0.739
Dm	1.036	2.799	0.076	0.232	0.265	0.778	0.606	1.133	0.339	0.719
Cp	1.200	2.747	0.754	1.979	0.296	0.760	0.680	1.089	0.372	0.714
Em	−1.230	2.461	−1.148	−2.226	0.301	1.119	1.000	1.857	0.053	0.714
Profitability										
Ola	1.144	2.189	1.448	2.886	0.290	1.258	0.880	1.617	0.103	0.743
Investment										
Pta	−1.208	4.125	−1.170	−4.662	0.225	1.021	0.981	2.384	0.011	0.729
Cei	−1.657	3.355	−1.681	−4.136	0.306	0.954	1.025	1.447	0.161	0.655
Oa	−1.149	2.828	−1.243	−3.095	0.279	1.066	1.060	1.946	0.041	0.746
Pda	−0.854	2.625	−0.617	−2.060	0.169	0.603	0.384	0.578	0.831	0.750
dBe	−1.144	2.526	−0.846	−1.514	0.267	0.840	0.731	1.373	0.194	0.713
dWc	−1.060	2.380	−0.872	−1.719	0.314	0.874	0.848	2.068	0.028	0.730
Abs(*Dac*)	−0.873	2.047	−1.066	−2.840	0.296	0.923	0.877	1.947	0.040	0.750
Intangible										
Adm	1.608	3.810	1.224	3.062	0.297	1.070	0.894	1.453	0.159	0.719
Rdm	1.636	3.664	1.091	2.174	0.406	0.965	1.068	2.350	0.012	0.693
Age_{List}	1.233	3.629	1.193	3.582	0.342	1.093	1.088	2.358	0.012	0.715
dSa	1.074	3.044	0.944	2.796	0.226	1.127	1.233	1.845	0.055	0.732
Momentum										
$R^6 6$	1.749	3.467	1.475	3.275	0.317	0.784	0.890	2.790	0.003	0.816
52*w*12	1.896	3.444	1.840	3.791	0.389	0.965	1.010	2.735	0.004	0.853
$\in^6 6$	1.048	3.290	0.664	2.143	0.148	0.792	0.439	1.504	0.140	0.850
52*w*6	1.824	3.268	1.706	3.544	0.460	0.964	1.048	1.786	0.065	0.824
$\in^{11} 1$	1.118	2.610	0.790	2.020	0.238	0.726	0.464	0.804	0.625	0.684
$R^6 12$	1.094	2.446	0.876	2.255	0.249	0.920	0.916	3.068	0.001	0.861
52*w*1	1.477	2.326	1.139	1.875	0.537	0.996	0.928	1.642	0.096	0.710
$\in^6 12$	0.528	2.269	0.255	1.026	0.085	0.789	0.488	1.120	0.349	0.903
$R^{11} 1$	1.593	2.222	1.330	2.109	0.414	0.831	0.846	1.458	0.157	0.678
$\in^{11} 6$	0.661	1.965	0.395	1.252	0.108	0.794	0.530	0.946	0.492	0.839
Trading friction										
*Dtv*1	−2.102	5.100	−1.743	−8.399	0.529	0.888	0.722	4.146	0.000	0.760
*Tur*12	−2.245	4.833	−2.089	−5.140	0.570	1.074	0.945	2.989	0.002	0.792
*Tur*1	−2.616	4.361	−2.505	−4.538	0.642	1.068	0.946	3.479	0.000	0.703
*Ivc*1	−2.341	4.267	−2.558	−5.406	0.595	1.092	1.055	3.331	0.000	0.721
*Ivff*1	−2.228	4.234	−2.444	−5.501	0.642	1.082	1.074	3.584	0.000	0.725
*Ivc*6	−1.891	4.144	−2.267	−5.702	0.443	1.113	1.135	4.341	0.000	0.829
$Mdr^{10} 12$	−1.282	4.128	−1.353	−4.970	0.250	1.062	1.104	5.321	0.000	0.888
*Ivff*6	−1.826	4.059	−2.198	−5.615	0.438	1.095	1.135	4.177	0.000	0.829
Tv6	−1.744	3.900	−1.871	−4.768	0.423	1.070	1.162	3.496	0.000	0.826

(*continued*)

Table 4. Numbers of replicated anomalies which statistically significant (KOSPI KOSDAQ, value-weighted, continue)

Anomaly	$\overline{R}$	$\|t\|$	α_{FF3}	t_{FF3}	$A(a_i)$	$\frac{A(\|a_i\|)}{A(\|r_i\|)}$	$\frac{A(a_i^2)}{A(r_i^2)}$	*GRS*	*p(GRS)*	R^2
*Ivc*12	−1.690	3.845	−1.895	−5.186	0.415	1.052	1.030	3.552	0.000	0.862
*Tv*12	−1.616	3.747	−1.628	−4.229	0.387	1.080	1.067	3.322	0.001	0.867
$Mdr^5$6	−1.560	3.708	−1.751	−4.958	0.319	1.133	1.240	4.016	0.000	0.845
$Mdr^5$12	−1.398	3.703	−1.466	−4.483	0.299	1.098	1.117	3.700	0.000	0.880
Mdr^{10}6	−1.347	3.618	−1.502	−4.692	0.275	1.107	1.242	4.279	0.000	0.855
*Ivff*12	−1.580	3.586	−1.835	−5.052	0.399	1.081	1.062	3.726	0.000	0.863
$Mdr^5$1	−2.411	3.573	−2.519	−4.438	0.573	1.098	1.175	3.328	0.000	0.709
*Tur*12	−2.037	3.432	−1.961	−3.359	0.496	1.117	1.021	2.046	0.030	0.755
*Dtv*6	−1.360	3.402	−1.046	−5.053	0.408	0.845	0.610	4.574	0.000	0.808
*Ami*1	1.383	3.248	1.159	4.823	0.271	0.843	0.748	1.551	0.123	0.756
Mdr^{10}1	−1.919	3.226	−1.998	−3.791	0.429	1.223	1.178	2.099	0.026	0.710
*Srev*1	0.608	3.054	0.434	2.568	0.193	0.940	1.070	2.541	0.007	0.912
*Tv*1	−1.884	3.053	−1.952	−3.942	0.624	1.155	1.119	3.576	0.000	0.704
*Dtv*12	−1.205	2.907	−1.034	−5.307	0.431	0.950	0.799	5.491	0.000	0.830
*Cvd*12	−1.081	2.631	−1.336	−3.729	0.274	1.120	1.233	2.017	0.033	0.863
*Cvd*6	−1.005	2.288	−1.403	−3.348	0.277	1.114	1.401	2.211	0.018	0.830
*Ami*6	0.857	1.990	0.609	2.572	0.249	0.784	0.509	2.040	0.031	0.804

Notes: This table shows the statistics of anomalies that are statistically significant, for which the absolute value of the *t*-statistic exceeds 1.96, out of a total of 148 anomalies observed from January 2000 to June 2019. The returns from anomalies are estimated for all companies listed on the KOSPI and KOSDAQ, excluding the financial industry, and portfolio returns are calculated using a value-weighted method. $\overline{R}$ is the average differential between the *High* decile portfolio and *Low* decile portfolio returns, and $|t|$ is the absolute value of the *t*-statistics. α_{FF3} is the intercept in a regression of the FF (1993) model, and t_{FF3} is the *t*-statistic for α_{FF3}. *GRS* represents the F-Test test statistic of Gibbons *et al.* (1989), and $p(GRS)$ is the *p*-value for GRS *F*-test. $A(|a_i|)$ is the average absolute value of intercepts from the FF (1993) three-factor model for anomalies. $A(|r_i|)$ is the average absolute value of market portfolio excess return. We use the KOSPI as the value-weighted market portfolio in the Korean stock market. $\frac{A(|a_i|)}{A(|r_i|)}$ is the ratio of $A(|a_i|)$ and $A(|r_i|)$. $A\left(a_i^2\right)$ is the average squared intercept and $A\left(r_i^2\right)$ is the average squared market portfolio excess return. R^2 is the average of the FF (1993) model regression. The unit of monthly return is %. We report adjusted *t*-statistics for heteroscedasticity and autocorrelation following Newey and West (1987)

Table 4.

works well to explain the anomaly, the distribution of $A(|a_i|)A(|r_i|)$, would be near zero. If not, the relative dispersion appears relatively large. The second measure is $A\left(a_i^2\right)/A\left(r_i^2\right)$. $A\left(a_i^2\right)$ is the average squared intercept and $A\left(r_i^2\right)$ is the average squared market portfolio excess return. If the FF (1993) model explains anomalies well, $A\left(a_i^2\right)/A\left(r_i^2\right)$ would be close to zero. Otherwise, $A\left(a_i^2\right)/A\left(r_i^2\right)$ might be relatively high.

4.2.1 Anomalies related to value. First, among the value-related anomalies, 9 of 13 cases exceed the absolute value of *t*-statistics of 1.96 and are statistically significant. As we can check from Table 2, this is relevant to the existence of many studies of value-related anomalies in the Korean market. The highest performance anomaly is operating cash flow-to-price (*Ocp*), which shows an average return of about 2.067% per month and is statistically significant with the *t*-statistic of 4.843. Along with *Bmj* (book to June-end market; Asness and Frazzini, 2013), *Bm* (book to market), *Am* (asset to market) are also statistically significant with the absolute value of the *t*-statistic exceeding 4.00. Because the FF (1993) model contains the value factor, value anomalies are well-explained by the FF (1993) model on average. For example, the intercepts from the FF (1993) model tend to be lower than the high minus low return. Besides, in the case of the GRS F-test, only one anomaly is statistically significant at 5% and the rest are not significant.

4.2.2 Anomalies related to profitability and investment. Among the profitability-related anomalies, only operating profits-to-lagged assets (*Ola*) are replicated by exceeding the cutoff of the t-statistic of 1.96. Among investment-related anomalies percent total accruals (*Pta*), composite equity issuance (*Cei*), operating accruals (*Oa*), percent discretionary accruals (*Pda*), change in book value (*dBe*), change in working capital (*dWc*) and *Abs* (*Dac*) (absolute value of discretionary accruals) are statistically significant. Especially, *Cei* exhibits the highest performance in investment-related anomalies, with an average monthly return of about 1.657%. *Pta* takes second place with a return of 1.208%. *Oa* and *dBe* record −1.149%, −1.144%, respectively. Meanwhile, anomalies based on discretionary accruals, which are *Abs*(*Dac*) (−0.873%) and *Pda* (−0.854%) have relatively low returns. Compared to anomalies related to value, profitability and investment-related anomalies $\frac{A(|a_i|)}{A(|r_i|)}$ or $\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$ are higher. Our results suggest that many profitability and investment-related anomalies are not explained by the FF (1993) model.

4.2.3 Anomalies related to intangible assets. Among anomalies related to intangible assets, *Adm* (advertising expense-to-market), *Rdm* (R&D expense-to-market), Age_{List} (firm age), *dSa* (% change in sales minus % change in accounts receivable) are statistically significant. The most profitable anomaly is *Rdm*, which has an average monthly performance of 1.636%. *Adm* attains the return of 1.608% and Age_{List} has an average monthly performance of 1.233%. *dSa* is the lowest performance anomaly with the return of 1.074%. $\frac{A(|a_i|)}{A(|r_i|)}$ and $\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$ are higher than anomalies related to value but are similar to anomalies related to investment.

4.2.4 Anomalies related to momentum. Among anomalies related to momentum, 10 of 15 are statistically significant: $R^6 6$ (6 months momentum, 6 months holding), $52w12$ (52-week high price momentum, 12 months holding), $\epsilon^6\,6$ (6 months residual momentum, 6 months holding), $52w6$ (52-week high price momentum, 12 months holding), $\epsilon^{11}1$ (11 months residual momentum, 1 month holding), $R^6 12$ (6 months momentum, 12 months holding), $52w1$ (52-week high price momentum, 1 month holding), $\epsilon^6 12$ (6 months residual momentum, 12 months holding), $R^{11}1$ (11 months momentum, 1 month holding) and $\epsilon^{11}6$ (11 months residual momentum, 6 months holding). The highest performance among these anomalies is exhibited by $52w12$, which shows an average monthly performance of 1.896% per month. $52w6$ takes second place by attaining the average return of 1.824% and $R^6 6$ earns an average monthly return of 1.794%. Overall, 52-week high price momentums show the highest values of $\overline{R}$ and α_{FF3}, $\frac{A(|a_i|)}{A(|r_i|)}$,$\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$. This result shows that 52-week high price momentums are not explained by the FF(1993) model. On the other hand, the residual momentums (Blitz *et al.*, 2011; $\epsilon^6\,12$, $\epsilon^6 6$,$\epsilon^{11}6$), which are calculated from the residual of the FF (1993) model, have relatively low levels of α_{FF3}, $\frac{A(|a_i|)}{A(|r_i|)}$ and $\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$ compared to other momentum anomalies.

4.2.5 Anomalies related to trading friction. Among anomalies related to trading friction, 29 of 54 anomalies produce a statistically significant return. Moreover, trading friction anomalies generally have higher average returns than other categories of anomalies. For example, *Tur*1 (share turnover) earns on average −2.616%. In addition, $Mdr^5 1$ (maximum daily return) yields the average return of −2.411%. In other words, the overall performances based on anomalies related to trading frictions are higher than those of other anomalies. On the other hand, α_{FF3}, $\frac{A(|a_i|)}{A(|r_i|)}$ and $\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$ have higher than other anomalies. Of course, basically, most anomalies related to trading friction are rebalanced monthly. Thus, the transaction costs of the portfolio strategy would be high. Therefore, as suggested by Novy-Marx and Velikov (2016), high excess returns of anomalies related to trading friction are likely to decrease when we consider actual transaction costs.

4.3 Impact of microcap to the anomaly estimation: equal-weighted portfolio and the sample that includes only the KOSPI stocks

In this section, we examine the effects of microcaps on estimating the return of anomalies. To do this, we use two main methods. First, we estimate the anomaly return using only companies listed on the KOSPI. Because the KOSDAQ market tends to include more microcaps, if we limit the sample to the KOSPI alone, results might be influenced by the microcaps. Second, we compare the returns of anomalies with different portfolio compositions by applying the EW method and the VW method. When we use the EW portfolio, larger weights are allocated to the microcaps and the effect of the microcaps would be substantial. Therefore, if the return of anomalies estimated by the EW method could differ to the results from that estimated by the VW method, we can conclude that this difference comes from the inclusion of microcaps.

Table 5 presents the anomaly return for the sample that includes only the KOSPI stocks. Compared with the entire sample contains both of the KOSPI and the KOSDAQ, the difference of results can be summarized as follows. First, overall, anomaly returns that are estimated the KOSPI sample lower than the total sample. For example, *Bmj* earns 1.698% in the total sample that also includes the KOSDAQ, but decrease to 1.449% in the restricted sample that contains the KOSPI alone. *Tur*1 or anomalies related to trading friction, also decrease from −2.616% to −2.008%. In addition, the absolute intercept from the FF (1993) model is reduced. Second, in the case of anomalies related to momentum and trading friction that rebalance their portfolio monthly, the statistical significance greatly reduces. For example, only 3 out of 15 anomalies related to momentum are statistically significant with the restricted sample. In particular, if we increase the criterion for the absolute value of the *t*-statistic to 2.78, no momentum anomalies exceed the cutoff. These results are similar to Eom (2013), who showed that the momentum effect is mainly found in small caps. Third, compared to the total, the unexplained portion of the FF (1993) model is decreased. Excepting anomalies related to trading frictions, $\frac{A(|a_i|)}{A(|r_i|)}$ and $\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$ decreases on average. The GRS *F*-test also fails to reject the null hypothesis. For example, for investment-related anomalies, the average $\frac{A(|a_i|)}{A(|r_i|)}$ and $\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$ is 0.941 and 0.896, respectively in the total sample that includes both of the KOSPI and the KOSDAQ. While averaged $\frac{A(|a_i|)}{A(|r_i|)}$ and $\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$ is, respectively, 0.827, 0.679 in the restricted sample. In other words, the estimated returns based on anomalies within the KOSPI increase the explanatory power of FF (1993) model.

Table 6 shows the returns based on anomalies that estimated by the EW method in portfolio composition. Table 6 reports statistics for significant anomalies (the absolute value of *t*-statistic is higher than 1.96) from the total sample that also includes the KOSDAQ. Compared with the VW method, the notable differences are summarized as follows. First, on average, the returns increase. For example, Bmj earns the average return of 1.698% in the VW method, but the average return significantly increases to 2.382%, when we apply the EW method. We can interpret these results as follow. Because the EW method allocates

Table 5. Numbers of replicated anomalies that are statistically significant (only KOSPI, value-weighted, continue)

Anomaly	$\overline{R}$	$\|t\|$	α_{FF3}	t_{FF3}	$A(\|a_i\|)$	$\frac{A(\|a_i\|)}{A(\|r_i\|)}$	$\frac{A(a_i^2)}{A(r_i^2)}$	*GRS*	*p(GRS)*	R^2
Value										
Bmj	1.449	3.527	0.28	0.864	0.204	0.395	0.136	0.81	0.619	0.707
Sp	1.64	3.503	0.298	0.925	0.186	0.344	0.115	0.592	0.82	0.714
Am	1.444	3.149	−0.041	−0.113	0.217	0.421	0.212	1.482	0.148	0.723
Ocp	1.518	3.128	0.681	1.461	0.265	0.541	0.525	1.568	0.118	0.652
Bm	1.188	2.943	−0.012	−0.037	0.162	0.288	0.132	0.55	0.853	0.712
Em	−1.075	2.521	−1.024	−2.462	0.22	1.061	0.956	0.931	0.505	0.674
Trading friction										
*Dtv*1	−1.673	3.79	−1.158	−5.626	0.403	0.61	0.414	3.569	0	0.751
*Dtv*6	−1.491	3.268	−1.058	−4.445	0.363	0.566	0.374	2.842	0.002	0.761
*Tur*1	−2.008	3.105	−2.317	−3.417	0.411	1.294	1.431	2.709	0.004	0.675
*Dtv*2	−1.389	3.054	−1.029	−4.097	0.364	0.596	0.396	2.695	0.004	0.77
*Ami*6	1.258	2.573	0.789	2.874	0.273	0.484	0.273	1.827	0.057	0.766
*Ivff*6	−1.129	2.549	−1.719	−4.418	0.295	1.081	1.454	3.255	0.001	0.837
*Ami*1	1.2	2.543	0.697	2.967	0.228	0.431	0.238	1.195	0.295	0.757
*Tur*12	−1.443	2.485	−1.592	−2.73	0.394	1.183	1.328	2.055	0.029	0.762
$Mdr^5$1	−1.728	2.466	−2.093	−3.429	0.366	1.137	1.54	2.04	0.031	0.651
*Tv*6	−1.184	2.409	−1.427	−3.347	0.292	1.074	1.593	2.211	0.018	0.826
*Tv*12	−1.093	2.382	−1.259	−2.985	0.258	1.038	1.548	2.553	0.006	0.866
*Ivc*6	−1.068	2.373	−1.629	−3.905	0.305	1.121	1.532	2.595	0.005	0.838
*Ami*12	1.155	2.311	0.712	2.38	0.276	0.522	0.286	1.809	0.061	0.769
$Mdr^5$12	−0.857	2.24	−1.115	−3.261	0.223	1.184	1.737	3.104	0.001	0.881
$Mdr^5$6	−0.945	2.211	−1.306	−3.673	0.261	1.19	1.807	3.376	0	0.847
*Ivff*12	−0.954	2.197	−1.46	−3.853	0.283	1.236	1.634	2.218	0.018	0.863
*Ivc*12	−0.964	2.175	−1.414	−3.487	0.299	1.12	1.499	2.974	0.002	0.865
*Tur*6	−1.27	2.111	−1.512	−2.438	0.379	1.226	1.482	1.977	0.037	0.729
Momentum										
$\epsilon^6$6	0.803	2.364	0.435	1.323	0.165	0.944	0.595	1.423	0.171	0.839
$R^6$6	1.203	2.292	1.117	2.129	0.212	0.794	0.778	1.539	0.127	0.803
ϵ^{11}1	1.069	2.264	0.738	1.595	0.205	0.671	0.377	0.716	0.709	0.638

(*continued*)

Table 5.

Anomaly	$\overline{R}$	$\lvert t \rvert$	α_{FF3}	t_{FF3}	$A(\lvert a_i \rvert)$	$\frac{A(\lvert a_i \rvert)}{A(\lvert r_i \rvert)}$	$\frac{A(a_i^2)}{A(r_i^2)}$	*GRS*	*p(GRS)*	R^2
Investment										
Cei	−1.332	2.761	−1.287	−2.861	0.299	0.832	0.686	1.053	0.4	0.636
Pta	−0.966	2.677	−0.924	−2.836	0.288	0.862	0.657	1.911	0.045	0.68
dWc	−1.136	2.567	−1.003	−2.094	0.278	0.935	0.723	1.578	0.115	0.68
dSti	0.725	2.535	0.87	2.645	0.303	1.075	1.073	2.054	0.029	0.682
Pda	−0.886	2.378	−0.572	−1.556	0.183	0.579	0.309	1.148	0.329	0.707
Dac	−0.789	2.284	−0.627	−1.812	0.203	0.7	0.682	1.562	0.121	0.695
Aci	0.639	2.166	0.409	1.391	0.25	0.781	0.541	1.413	0.176	0.705
dBe	−0.993	2.12	−0.723	−1.422	0.297	0.85	0.763	1.509	0.138	0.68
Intangible										
Adm	1.748	3.744	1.351	2.887	0.295	0.891	0.622	1.187	0.301	0.675
Age_{List}	1.08	3.269	0.747	2.534	0.344	1.027	1.03	1.873	0.05	0.673
Rdm	1.502	2.585	1.26	1.971	0.307	0.946	0.769	1.339	0.211	0.636
Ol	0.702	2.137	0.64	2.069	0.278	0.749	0.717	1.738	0.074	0.694

Notes: This table shows the statistics of anomalies that are statistically significant, for which the absolute value of the *t*-statistic exceeds 1.96, out of a total of 148 anomalies observed from January 2000 to June 2019. The returns from anomalies are estimated for all companies only listed on the KOSPI, excluding the financial industry, and the portfolio returns are calculated using a value-weighted method. $\overline{R}$ is the average differential between the *High* decile portfolio and *Low* decile portfolio returns and $\lvert t \rvert$ is the absolute value of the *t*-statistics. α_{FF3} is the intercept in a regression of the FF(1993) model, and t_{FF3} is the *t*-statistic for α_{FF3}. *GRS* represents the *F*-test statistic of Gibbons *et al.* (1989) and *p*(*GRS*) is the *p*-value for GRS *F*-test. $A(\lvert a_i \rvert)$ is the average absolute value of intercepts from the FF (1993) three-factor model for anomalies. $A(\lvert r_i \rvert)$ is the average absolute value of market portfolio excess return. We use the KOSPI as the value-weighted market portfolio in the Korean stock market. $\frac{A(\lvert a_i \rvert)}{A(\lvert r_i \rvert)}$ is the ratio of $A(\lvert a_i \rvert)$ and $A(\lvert a_i \rvert)$. $A\left(a_i^2\right)$ is the average squared intercept and $A\left(r_i^2\right)$ is the average squared market portfolio excess return. R^2 is the average of the FF (1993) model regression. The unit of monthly return is %. We report adjusted *t*-statistics for heteroscedasticity and autocorrelation following Newey and West (1987)

Anomaly	$\overline{R}$	$\lvert t\rvert$	α_{FF3}	t_{FF3}	$A(\lvert a_i\rvert)$	$\frac{A(\lvert a_i\rvert)}{A(\lvert r_i\rvert)}$	$\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$	*GRS*	*p(GRS)*	R^2
Value										
Bm	2.280	4.778	1.429	3.070	0.610	0.705	0.491	7.356	0.000	0.812
Ocp	1.681	4.619	1.018	3.091	0.601	0.717	0.496	5.600	0.000	0.832
Sp	2.305	4.438	1.441	2.887	0.574	0.704	0.484	5.358	0.000	0.811
Bmj	2.382	4.437	1.580	2.866	0.634	0.727	0.494	6.583	0.000	0.800
Am	2.170	4.303	1.217	2.508	0.572	0.686	0.464	6.365	0.000	0.811
Ebp	0.842	3.575	0.564	2.621	0.534	0.711	0.489	5.452	0.000	0.817
Dp	1.056	3.299	0.666	1.848	0.395	0.615	0.382	2.124	0.024	0.818
Dm	1.158	2.658	0.479	1.113	0.469	0.671	0.429	3.768	0.000	0.820
Sr	−0.882	2.649	−0.745	−2.634	0.503	0.654	0.459	4.278	0.000	0.859
Cp	0.910	2.622	0.558	1.793	0.498	0.721	0.466	3.992	0.000	0.814
m	−0.719	1.978	−0.340	−0.887	0.522	0.705	0.489	2.339	0.012	0.832
Trading friction										
*Dtv*12	−2.993	8.880	−2.956	−10.212	0.782	0.985	0.956	15.903	0.000	0.837
*Dtv*1	−3.785	8.800	−3.559	−9.376	0.861	0.928	0.842	10.415	0.000	0.763
*Dtv*6	−3.070	8.699	−2.895	−8.759	0.739	0.907	0.806	11.358	0.000	0.819
*Ami*1	3.150	7.314	3.035	8.127	0.732	0.942	0.849	6.355	0.000	0.772
*Ami*6	2.479	6.907	2.401	7.437	0.637	0.892	0.804	7.991	0.000	0.824
*Ami*12	2.419	6.749	2.481	8.651	0.669	1.014	1.007	12.214	0.000	0.844
*Cvd*12	−1.844	5.870	−1.595	−5.607	0.511	0.850	0.717	9.741	0.000	0.866
*Tur*1	−2.733	5.490	−2.316	−5.013	0.774	0.827	0.684	7.910	0.000	0.746
*Tur*12	−2.066	5.347	−1.685	−5.226	0.587	0.814	0.657	9.036	0.000	0.853
*Cvt*12	1.365	4.864	1.305	5.926	0.443	0.935	0.821	7.606	0.000	0.869
*Tv*12	−1.618	4.818	−1.314	−4.361	0.418	0.802	0.636	7.400	0.000	0.868
$Mdr^5 6$	−1.298	4.788	−1.054	−4.283	0.370	0.803	0.644	6.956	0.000	0.875
$Mdr^{10} 12$	−1.168	4.684	−0.944	−4.131	0.354	0.804	0.646	7.339	0.000	0.878
*Ivc*12	−1.592	4.609	−1.286	−4.117	0.404	0.793	0.630	7.433	0.000	0.867
*Ivff*12	−1.553	4.600	−1.259	−4.075	0.401	0.799	0.636	6.754	0.000	0.869
*Cvt*1	1.688	4.575	1.456	3.884	0.524	0.831	0.683	3.423	0.000	0.765
$Mdr^5 1$	−1.735	4.556	−1.588	−4.488	0.583	0.830	0.718	5.778	0.000	0.798
*Ivc*1	−1.752	4.288	−1.541	−3.987	0.601	0.832	0.730	7.554	0.000	0.801
*Cvd*6	−1.518	4.167	−1.271	−3.227	0.484	0.755	0.574	4.931	0.000	0.844
*Tv*1	−1.679	4.161	−1.464	−3.958	0.591	0.832	0.706	6.422	0.000	0.798
*Tur*6	−1.862	4.148	−1.541	−3.592	0.598	0.763	0.602	6.333	0.000	0.831
*Ivff*1	−1.675	4.137	−1.461	−3.711	0.580	0.824	0.716	6.456	0.000	0.805
*Tv*6	−1.493	4.022	−1.303	−3.742	0.484	0.767	0.604	7.515	0.000	0.848
*Cvt*6	1.159	4.014	0.955	3.188	0.422	0.794	0.605	6.075	0.000	0.844
*Cvd*1	−1.570	4.003	−1.245	−2.771	0.546	0.792	0.619	2.854	0.002	0.786
$\beta^{FP}1$	−1.443	3.995	−1.533	−4.312	0.556	0.789	0.677	3.176	0.001	0.755
$Mdr^{10} 6$	−1.169	3.986	−1.053	−3.857	0.442	0.744	0.591	7.409	0.000	0.860
*Ivff*6	−1.435	3.934	−1.250	−3.595	0.475	0.764	0.604	6.935	0.000	0.851
*Ivc*6	−1.477	3.923	−1.290	−3.613	0.479	0.761	0.608	7.518	0.000	0.849
$Mdr^5 6$	−1.192	3.878	−1.085	−3.796	0.453	0.774	0.597	7.259	0.000	0.856
$Mdr^{10} 1$	−1.493	3.854	−1.326	−3.665	0.536	0.808	0.687	4.479	0.000	0.794
*Srev*12	0.446	3.765	0.321	2.906	0.365	0.817	0.658	8.326	0.000	0.879
$\beta^{-}12$	−0.816	2.823	−0.747	−2.651	0.322	0.823	0.678	3.077	0.001	0.869
$\beta^{-}6$	−0.856	2.807	−0.821	−2.637	0.391	0.723	0.528	3.814	0.000	0.847
$\beta^{-}1$	−1.036	2.761	−0.847	−2.278	0.448	0.770	0.606	3.435	0.000	0.791
$\beta^{FP}6$	−0.872	2.751	−1.056	−3.224	0.456	0.739	0.567	3.751	0.000	0.826

(*continued*)

Table 6. Numbers of replicated anomalies that are statistically significant (KOSPI KOSDAQ, equal-weighted, continue)

Anomaly	$\overline{R}$	$\lvert t \rvert$	α_{FF3}	t_{FF3}	$A(\lvert a_i \rvert)$	$\frac{A(\lvert a_i \rvert)}{A(\lvert r_i \rvert)}$	$\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$	*GRS*	*p(GRS)*	R^2
$\beta^D 12$	−0.270	2.524	−0.302	−2.715	0.357	0.792	0.635	8.274	0.000	0.893
Profitability										
Z	−0.861	2.051	−0.393	−0.869	0.503	0.698	0.484	3.935	0.000	0.815
Momentum										
$52w12$	1.801	4.490	1.512	4.202	0.463	0.807	0.700	6.053	0.000	0.857
$R^6 6$	1.292	4.330	1.086	3.999	0.460	0.812	0.705	7.557	0.000	0.849
$52w6$	1.609	3.795	1.336	3.456	0.477	0.733	0.565	3.568	0.000	0.832
$R^6 12$	1.033	3.473	0.825	2.912	0.457	0.925	0.789	9.691	0.000	0.863
$\epsilon^6 6$	0.682	3.220	0.537	2.700	0.336	0.751	0.544	2.547	0.006	0.889
$R^{11} 1$	1.232	3.180	0.993	2.826	0.537	0.855	0.710	6.949	0.000	0.813
$R^{11} 6$	1.205	3.100	1.008	2.793	0.473	0.887	0.783	7.495	0.000	0.842
$\epsilon^6 12$	0.492	2.850	0.405	2.615	0.299	0.904	0.806	2.214	0.019	0.906
$\epsilon^{11} 6$	0.624	2.740	0.542	2.711	0.314	0.838	0.698	2.470	0.008	0.891
$\epsilon^{11} 1$	0.616	2.320	0.429	1.721	0.325	0.727	0.546	2.830	0.003	0.849
$R^{11} 12$	0.872	2.177	0.724	1.825	0.484	0.867	0.748	9.986	0.000	0.847
$52w1$	1.169	2.149	0.753	1.350	0.447	0.737	0.515	2.069	0.028	0.790
Investment										
Cei	−1.797	4.996	−1.719	−4.904	0.624	0.724	0.526	5.597	0.000	0.826
3*Ig*	−0.989	4.686	−0.898	−4.640	0.503	0.729	0.560	4.538	0.000	0.835
I/A	−1.526	4.480	−1.249	−3.500	0.573	0.736	0.576	4.928	0.000	0.824
dBe	−1.435	4.076	−1.122	−3.041	0.567	0.733	0.564	5.779	0.000	0.821
Pta	−0.758	4.005	−0.896	−4.970	0.503	0.759	0.648	5.265	0.000	0.828
dCoa	−1.192	3.974	−1.065	−3.100	0.532	0.733	0.568	4.727	0.000	0.829
dCol	−0.749	3.895	−0.640	−3.402	0.500	0.742	0.554	3.715	0.000	0.837
dPia	−0.945	3.586	−0.766	−2.878	0.496	0.730	0.530	3.675	0.000	0.835
dNca	−0.813	3.553	−0.700	−2.928	0.502	0.738	0.556	6.114	0.000	0.831
Poa	−0.801	3.485	−0.611	−2.617	0.481	0.725	0.571	5.860	0.000	0.833
dLti	−0.735	3.379	−0.608	−2.780	0.488	0.736	0.549	4.255	0.000	0.836
Ig	−0.529	3.236	−0.450	−2.430	0.443	0.727	0.540	1.885	0.049	0.819
2*Ig*	−0.667	2.970	−0.443	−1.935	0.463	0.733	0.548	2.348	0.012	0.827
Noa	−0.838	2.925	−0.610	−1.983	0.478	0.725	0.529	3.048	0.001	0.831
Abs(*Dac*)	−0.729	2.879	−0.635	−3.068	0.568	0.780	0.619	4.595	0.000	0.855
Ivc	−0.778	2.805	−0.660	−2.396	0.479	0.710	0.521	3.191	0.001	0.837
dWC	−0.495	2.332	−0.361	−1.500	0.470	0.716	0.517	2.941	0.002	0.836
dFin	−0.547	2.260	−0.376	−1.386	0.506	0.733	0.547	4.044	0.000	0.834
dNco	−0.426	2.106	−0.276	−1.313	0.480	0.729	0.573	6.268	0.000	0.833
Oa	−0.545	2.050	−0.495	−1.571	0.512	0.737	0.548	4.327	0.000	0.833
Intangible										
Rdm	1.456	5.599	1.182	4.481	0.482	0.719	0.579	3.332	0.000	0.817
Adm	1.206	4.118	0.894	3.093	0.501	0.728	0.538	3.736	0.000	0.830
Hn	−0.898	3.961	−0.737	−3.303	0.533	0.732	0.530	4.354	0.000	0.832
Ala	−1.162	3.361	−0.862	−2.295	0.499	0.710	0.525	4.379	0.000	0.821
Ol	0.616	3.035	0.618	2.862	0.475	0.724	0.563	3.143	0.001	0.836
gAd	−0.640	2.591	−0.554	−2.094	0.399	0.656	0.462	2.398	0.010	0.818
Age_{List}	0.899	2.452	0.418	1.129	0.481	0.729	0.495	3.226	0.001	0.807

Table 6. (*continued*)

Anomaly	$\overline{R}$	$\|t\|$	α_{FF3}	t_{FF3}	$A(\|a_i\|)$	$\frac{A(\|a_i\|)}{A(\|r_i\|)}$	$\frac{A\left(a_i^2\right)}{A\left(r_i^2\right)}$	GRS	$p(GRS)$	R^2
Tan	0.515	2.271	0.332	1.471	0.482	0.715	0.527	3.735	0.000	0.838
Alm	0.607	2.133	0.443	1.646	0.508	0.694	0.483	2.972	0.002	0.839

Notes: This table shows the statistics of anomalies that are statistically significant, for which the absolute value of the t-statistic exceeds 1.96, out of a total of 148 anomalies observed from January 2000 to June 2019. The returns from anomalies are estimated for all companies listed on the KOSPI and the KOSDAQ, excluding the financial industry, and the portfolio returns are calculated using the equal-weighted method. $\overline{R}$ is the average differential between the *High* decile portfolio and *Low* decile portfolio returns and $|t|$ is the absolute value of the t-statistics. α_{FF3} is the intercept in a regression of the FF(1993) model and t_{FF3} is the t-statistic for α_{FF3}. *GRS* represents the F-test statistic of Gibbons *et al.* (1989), and $p(GRS)$ is the p-value for GRS F-test. $A(|a_i|)$ is the average absolute value of intercepts from the FF (1993) three-factor model for anomalies. $A(|r_i|)$ is the average absolute value of market portfolio excess return. We use the KOSPI as the value-weighted market portfolio in the Korean stock market. $\frac{A(|a_i|)}{A(|r_i|)}$ is the ratio of $A(|a_i|)$ and $A(|a_i|)$. $A\left(a_i^2\right)$ is the average squared intercept and $A\left(r_i^2\right)$ is the average squared market portfolio excess return. R^2 is the average of the FF (1993) model regression. The unit of monthly return is %. We report adjusted t-statistics for heteroscedasticity and autocorrelation following Newey and West (1987)

Table 6.

more weights on microcaps relatively, this can lead to higher performance of anomalies. Second, the number of statistically significant anomalies also increases. In particular, in the case of anomalies related to investment, 7 out of 29 anomalies are statistically significant (based on the absolute value of the t-statistic of 1.96) when we restrict the sample to include only the KOSPI stocks. However, in the total sample with the KOSDAQ, 20 out of 29 anomalies are statistically significant.

In summary, we validate that studies of anomalies in the Korean market should consider the effects of microcaps. In particular, researchers should be aware of the differences in outcomes that can occur depending on whether the sample includes the KOSPI and the KOSDAQ market. Portfolio composition should be designed to minimize the impact of microcaps by using VW methods.

4.4 Commonality of anomalies returns

In this section, to determine whether there are commonalities between anomalies, we perform principal component analysis to reduce dimensions.

Panel A of Table 7 presents the results of the principal component analysis for all 148 anomalies. We extract the first ten principal components from all anomalies. Panel A demonstrates that the first principal component, PC1, accounts for 22.41% of the variance of all anomalies. This result is a similar result to 25.93% for Hou *et al.* (2018) in the US market. On the other hand, there are slight differences in details. For instance, in the anomalies related to investment and intangible assets, PC1 accounts for less than 20% of the variance, but PC1 explains more than 30% for anomalies related to value, profitability, momentum and trading friction. In particular, for momentum, PC1 accounts for 59.36% of the variance. This finding is similar to that of Hou *et al.* (2018). In Hou *et al.* (2018), the share of variance explained by PC1 is greatest for value, trading friction, profitability, momentum, investment and intangible assets, in decreasing order. In this study, such as Hou *et al.* (2018), we can also verify that the share of variance explained by PC1 is low in the case of anomalies related to investment and intangible assets.

Categories	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Panel A: All anomalies										
ALL	22.41	9.58	6.89	5.43	4.81	3.38	2.73	2.52	2.46	2.14
Value	32.16	18.38	13.80	7.92	5.75	5.22	4.48	3.68	2.75	2.45
Profitability	49.16	11.08	7.41	5.33	4.85	3.69	3.32	2.97	2.17	1.78
Momentum	59.36	18.43	8.27	3.86	2.69	2.11	1.69	1.14	0.75	0.45
Trading Friction	39.06	19.25	6.41	5.82	4.06	3.39	2.65	2.35	2.17	1.83
Investment	15.96	10.36	9.11	7.08	6.94	6.16	5.12	4.54	3.98	3.58
Intangible	15.56	10.82	9.94	8.31	7.91	6.56	6.21	5.60	4.98	4.64
Panel B: Only significant anomalies										
ALL	37.18	12.32	7.79	6.85	3.95	3.19	2.69	2.48	2.38	2.00
Value	45.23	18.41	9.08	7.60	6.80	5.51	3.85	2.38	1.13	0.00
Momentum	64.21	21.36	4.13	3.58	2.95	1.44	1.00	0.66	0.41	0.25
Trading Friction	65.91	14.01	5.43	4.91	3.03	1.80	0.99	0.75	0.64	0.42
Investment	25.10	20.87	14.84	13.07	12.74	8.16	5.23	0.00	0.00	0.00
Intangible	33.70	26.67	22.66	16.96	0.00	0.00	0.00	0.00	0.00	0.00

Notes: This table shows the results of the principal component analysis in the sample covers both of the KOSPI and the KOSDAQ from January 2000 to June 2019, with all returns of 148 anomalies calculated by value-weighted methods. From the first to the tenth principal component, the table shows the percentage of variance accounted for by each principal component. Panel A shows the results of principal component analysis, including all 148 anomalies. Panel B shows the results of the principal component analysis of a subset of 58 out of 148 anomalies with the absolute values of *t*-statistics exceeding 1.96. All units are %. We report adjusted *t*-statistics for heteroscedasticity and autocorrelation following Newey and West (1987)

Table 7.
Principal component analysis of anomalies (continued)

Panel B of Table 7 shows the results of the principal component analysis from 58 anomalies that are statistically significant (the absolute value of the *t*-statistic exceed 1.96). Only one of the anomalies related to profitability is significant. PC1 accounts for 37.18% of all statistically significant high minus low decile portfolios. Overall, the share of variance explained by PC1 increases, but anomalies related to intangible assets and investments take also place the lowest.

5. Conclusion

We replicate 148 anomalies for the Korean stock market. Our results are summarized as follows. First, only 57 out of 148 anomalies (37.8%) are replicated with the cutoff of the *t*-statistics of 1.96, when we use the total sample that includes the KOSPI and KOSDAQ market and the value-weighted method to construct a portfolio. When we increase the cutoff for the absolute value of the *t*-statistic to 2.78, only 41 out of 148 anomalies (27.7%) are statistically significant. Second, we conclude that it is necessary for researchers to be aware of the effect of microcaps on estimating anomalies. For example, we can get different results from whether the value-weighted or the equal-weighted portfolio and whether the total sample that also contains the KOSDAQ and the restricted sample that only include the KOSPI. In addition, when we compare the results for value-weighted and equal-weighted portfolios, the equal-weighted anomalies result in higher returns and higher *t*-statistics than the value-weighted anomalies. Hence, future researchers who will study the market anomalies should be aware of the impacts of microcaps on results.

Practitioners that interest in TAA would be most benefited by our results, which guide how to undertake TAA scientifically, how to become cautious in managing risks in TAA, and what anomalies to use for TAA. This is an important practical contribution given that managers in practices do not well-know that market anomaly is the basis of TAA, let alone knowing how to use the anomalies for TAA.

Note

1. FTSE Russell, 2018, “Five-year trends and Outlook for smart beta.”

References

Abarbanell, J.S. and Bushee, B.J. (1998), “Abnormal returns to a fundamental analysis strategy”, *The Accounting Review*, Vol. 73, pp. 19-45.

Amihud, Y. (2002), “Illiquidity and stock returns: cross-section and time series evidence”, *Journal of Financial Markets*, Vol. 5 No. 1, pp. 31-56.

Anderson, C.W. and Garcia-Feijoo, L. (2006), “Empirical evidence on capital investment, growth options, and security returns”, *The Journal of Finance*, Vol. 61 No. 1, pp. 171-194.

Ang, A. and Hodrick, R.J. (2006), “The cross-section of volatility and expected returns”, *The Journal of Finance*, Vol. 61 No. 1, pp. 259-299.

Ang, A., Chen, J. and Xing, Y. (2006), “Downside risk”, *Review of Financial Studies*, Vol. 19 No. 4, pp. 1191-1239.

Asness, C. and Frazzini, A. (2013), “The devil in HML’s details”, *The Journal of Portfolio Management*, Vol. 39 No. 4, pp. 49-68.

Balakrishnan, K., Bartov, E. and Faurel, L. (2010), “Post loss/profit announcement drift”, *Journal of Accounting and Economics*, Vol. 50 No. 1, pp. 20-41.

Bali, T.G., Cakici, N. and Whitelaw, R.F. (2011), “Maxing out: stocks as lotteries and the cross-section of expected returns”, *Journal of Financial Economics*, Vol. 99 No. 2, pp. 427-446.

Bali, T.G., Robert, F. and Engle, S. (2016), *Empirical Asset Pricing: The Cross Section of Stock Returns Hoboken*, Wiley.

Ball, R., Gerakos, J., Linnainmaa, J. and Nikolaev, V. (2015), “Deflating profitability”, *Journal of Financial Economics*, Vol. 117 No. 2, pp. 225-248.

Ball, R., Gerakos, J., Linnainmaa, J. and Nikolaev, V. (2016), “Accruals, cash flows, and operating profitability in the cross section of stock returns”, *Journal of Financial Economics*, Vol. 121 No. 1, pp. 28-45.

Barbee, W.C., Jr, Mukherji, S. and Raines, G.A. (1996), “Do sales-price and debt-equity explain stock returns better than book-market and firm size?”, *Financial Analysts Journal*, Vol. 52 No. 2, pp. 56-60.

Basu, S. (1983), “The relationship between earnings yield, market value, and return for NYSE common stocks: further evidence”, *Journal of Financial Economics*, Vol. 12 No. 1, pp. 129-156.

Belo, F. and Lin, X. (2011), “The inventory growth spread”, *Review of Financial Studies*, Vol. 25 No. 1, pp. 278-313.

Belo, F., Lin, X. and Bazdresch, S. (2014), “Labor hiring, investment, and stock return predictability in the cross section”, *Journal of Political Economy*, Vol. 122 No. 1, pp. 129-177.

Bhandari, L.C. (1988), “Debt/equity ratio and expected common stock returns: empirical evidence”, *The Journal of Finance*, Vol. 43 No. 2, pp. 507-528.

Blitz, D., Huij, J. and Martens, M. (2011), “Residual momentum”, *Journal of Empirical Finance*, Vol. 18 No. 3, pp. 506-521.

Brennan, M.J., Chordia, T. and Subrahmanyam, A. (1998), “Alternative factor specifications, security characteristics, and the cross-section of expected stock returns”, *Journal of Financial Economics*, Vol. 49 No. 3, pp. 345-373.

Byun, Y. and Kim, T. (2012), "Firm-specific volatility, skewness and portfolio stock returns", *Journal of the Korean Data Analysis Society*, Vol. 14 No. 2, pp. 1003-1012.

Chan, L.K.C., Lakonishok, J. and Sougiannis, T. (2001), "The stock market valuation of research and development expenditures", *The Journal of Finance*, Vol. 56 No. 6, pp. 2431-2456.

Chordia, T., Subrahmanyam, A. and Ravi Anshuman, V. (2001), "Trading activity and expected stock returns", *Journal of Financial Economics*, Vol. 59 No. 1, pp. 3-32.

Chang, U. and Kim, Y. (2016), "The effect of asset growth on the expected stock return", *Joumal of Accounting and Finance*, Vol. 34 No. 4, pp. 293-312.

Chang, C., Eom, J. and Park, (2016), "The effect of arbitrage asymmetry on the idiosyncratic volatility puzzle: Korea stock market, The ", *Korean Journal of Financial Engineering*, Vol. 15 No. 1, pp. 21-44.

Chung, C. (2018), "Decomposition and evaluation on the determinants of the idiosyncratic volatility puzzle in Korea stock market", *The Korean Journal of Financial Engineering*, Vol. 17 No. 4, pp. 1-35.

Cooper, J.H., Gulen, M.J. and Schill, (2008), "Asset growth and the cross-section of stock returns", *The Journal of Finance*, Vol. 63 No. 4, pp. 1609-1652.

Daniel, K.D. and Titman, S. (2006), "Market reactions to tangible and intangible information", *The Journal of Finance*, Vol. 61 No. 4, pp. 1605-1643.

Dechow, P.M., Sloan, R.G. and Sweeney, A.P. (1995), "Detecting earnings management", *Accounting Review*, pp. 193-225.

Desai, H., Rajgopal, S. and Venkatachalam, M. (2004), "Value-glamour and accruals mispricing: One anomaly or two?", *The Accounting Review*, Vol. 79 No. 2, pp. 355-385.

Dichev, I. (1998), "Is the risk of bankruptcy a systematic risk ?", *Journal of Finance*, Vol. 53, pp. 1141-1148.

Dimson, E. (1979), "Risk management when shares are subject to infrequent trading", *Journal of Financial Economics*, Vol. 7 No. 2, pp. 197-226.

Eom, C. (2012), "Re-examination on cross-section of expected stock returns under up/down market conditions", *Asian Review of Financial Research*, Vol. 25 No. 4, pp. 599-639.

Eom, Y. (2013), "Momentum profits and firm size", *Korean Journal of Financial Studies*, Vol. 42 No. 5, pp. 901-927.

Eom, C., Lee, W., Park, R., Chang, U. and Park, J. (2014), "A study on the relationship between idiosyncratic volatility and stock returns in the Korean stock markets", *Korean Journal of Financial Studies*, Vol. 43 No. 4, pp. 753-784.

Fairfield, P.M., Whisenant, J.S. and Lombardi Yohn, T. (2003), "Accrued earnings and growth: implications for future profitability and market mispricing", *The Accounting Review*, Vol. 78 No. 1, pp. 353-371.

Fama, E.F. and French, K.R. (1992), "The cross-section of expected stock returns", *The Journal of Finance*, Vol. 47 No. 2, pp. 427-465.

Fama, E.F. and French, K.R. (1993), "Common risk factors in the returns on stocks and bonds", *Journal of Financial Economics*, Vol. 33 No. 1, pp. 3-56.

Fama, E.F. and French, K.R. (1996), "Multifactor explanation of asset pricing anomalies", *The Journal of Finance*, Vol. 51 No. 1, pp. 55-84.

Fama, E.F. and French, K.R. (2008), "Dissecting anomalies", *The Journal of Finance*, Vol. 63 No. 4, pp. 1653-1678.

Fama, E.F. and French, K.R. (2015), "A five-factor asset pricing model", *Journal of Financial Economics*, Vol. 116 No. 1, pp. 1-22.

Fama, E.F. and French, K.R. (2016), "Dissecting anomalies with a five-factor model, The ", *Review of Financial Studies*, Vol. 29 No. 1, pp. 69-103.

Fama, E.F. and MacBeth, J.D. (1973), "Risk return, and equilibrium: empirical tests", *Journal of Political Economy*, Vol. 81 No. 3, pp. 607-636.

Frazzini, A. and Pedersen, L.H. (2014), "Betting against beta", *Journal of Financial Economics*, Vol. 111 No. 1, pp. 1-25.

George, T.J. and Hwang, C.-Y. (2004), "The 52-week high and momentum investing", *The Journal of Finance*, Vol. 59 No. 5, pp. 2145-2176.

Gibbons, M.R., Ross, S.A. and Shanken, J. (1989), "A test of the efficiency of a given portfolio", *Econometrica*, Vol. 57 No. 5, pp. 1121-1152.

Ha, S. and Park, S. (2019), "The effect of *r*&d expenditures on future earings and future abnormal returns", *Korean International Accounting Review*, Vol. 83, pp. 29-48.

Hafzalla, N., Lundholm, R. and Matthew Van Winkle, E. (2011), "Percent accruals", *The Accounting Review*, Vol. 86 No. 1, pp. 209-236.

Hahn, J. and Lee, H. (2009), "Financial constraints, debt capacity, and the cross section of stock returns", *The Journal of Finance*, Vol. 64 No. 2, pp. 891-921.

Harvey, C.R. (2017), "Presidential address: the scientific outlook in financial economics", *The Journal of Finance*, Vol. 72 No. 4, pp. 1399-1440.

Harvey, C.R., Liu, Y., Zhu, H. (2016), ". . . and the cross-section of expected returns", *Review of Financial Studies*, Vol. 29 No. 1, pp. 5-68.

Haugen, R.A. and Baker, N.L. (1996), "Commonality in the determinants of expected stock returns", *Journal of Financial Economics*, Vol. 41 No. 3, pp. 401-439.

Hirshleifer, D., Hou, K., Teoh, S.H. and Zhang, Y. (2004), "Do investors overvalue firms with bloated balance sheets?", *Journal of Accounting and Economics*, Vol. 38, pp. 297-331.

Hou, K. Xue, C. and Zhang, L. (2018), "Replicating anomalies, review of financial studies".

Hou, K., Xue, C. and Zhang, L. (2015), "Digesting anomalies: an investment approach", *Review of Financial Studies*, Vol. 28 No. 3, pp. 650-705.

Hribar, P. and Collins, D.W. (2002), "Errors in estimating accruals: implications for empirical research", *Journal of Accounting Research*, Vol. 40 No. 1, pp. 105-134.

Hwang, J. (2015), "Profit analysis of short term weekly momentum strategy in the Korean stock market", *Korean Journal of Futures and Options*, Vol. 23 No. 4, pp. 543-569.

Jang, J. (2016), "Idiosyncratic kurtosis and the cross-section of stock returns", *Korean Journal of Financial Studies*, Vol. 45 No. 5, pp. 1001-1034.

Jang, J. (2017), "Price momentum anomaly revisited: evidence in the Korean stock market", *Asian Review of Financial Research*, Vol. 30 No. 3, pp. 317-359.

Jegadeesh, N. (1990), "Evidence of predictable behavior of security returns", *The Journal of Finance*, Vol. 45 No. 3, pp. 881-898.

Jegadeesh, N. and Titman, S. (1993), "Returns to buying winners and selling losers: implications for stock market efficiency", *The Journal of Finance*, Vol. 48 No. 1, pp. 65-91.

Jiang, G., Lee, C.M.C. and Zhang, Y. (2005), "Information uncertainty and expected returns", *Review of Accounting Studies*, Vol. 10 Nos 2/3, pp. 185-221.

Kam, H. (1997), "An empirical study on the relationship between fundamental variables and stock return", *The Korean Journal of Financial Management*, Vol. 14 No. 2, pp. 21-55.

Kang, J. and Jeong, G. (2018), "Stock return predictability of the Amihud measure in the Korean stock market and trading volume", *Korean Journal of Financial Studies*, Vol. 47 No. 4, pp. 543-577.

Kho, B. and Kim, J. (2009), "Accrual anomaly and arbitrage trading opportunity", *Korean Journal of Financial Studies*, Vol. 38 No. 1, pp. 77-105.

Kho, B. and Kim, J. (2014), "Low volatility anomaly and its profitability in Korean stock markets", *Korean Journal of Financial Studies*, Vol. 43 No. 3, pp. 573-603.

Kho, B. and Kim, J. (2017), "Who drives return reversals of lottery stocks with extreme past returns in Korean stock market?", *The Korean Journal of Financial Management*, Vol. 34 No. 3, pp. 61-89.

Kim, C. (2000), "On the efficiency of the KOSDAQ market", *Korean Journal of Financial Studies*, Vol. 27 No. 1, pp. 331-361.

Kim, H. (1999), "An empirical study on the performance of contrarian investment in Korea stock market", *The Korean Journal of Financial Management*, Vol. 16 No. 2, pp. 157-178.

Kim, M. (2010), "A prediction of the returns for the low book-to-market stocks using financial statement analysis", *Korean International Accounting Review*, Vol. 30, pp. 1-18.

Kim, S. (2012), "A study on the profitability of the trading strategies using past returns", *Asian Review of Financial Research*, Vol. 25 No. 2, pp. 203-246.

Kim, T. and Eom, C. (1997), "Comparative study on the economic usefulness of reverse trading strategy and continuous trading strategy in Korean stock market", *The Korean Journal of Financial Management*, Vol. 14 No. 3, pp. 73-111.

Kim, H., Seo, J. and Cho, S. (2013), "Usefulness of credit ratings as a prediction of stock price returns", *The Korean Finance Association*, pp. 1052-1078.

Kim, M., Jung, J. and Kim, T. (2018), "Dissecting profitability premium in Korean stock markets", *The Korean Journal of Financial Management*, Vol. 35 No. 4, pp. 69-108.

Ko, H., Park, Y.S. and Lee, H. (2009), "The empirical analysis on the relation between volatility of liquidity and return", *Daehan Journal of Business*, Vol. 22 No. 5, pp. 2873-2893.

Kim, H. and Yeo, H. (2017), "An empirical test of stock return predictability in Korean stock market", *Journal of Money and Finance*, Vol. 31 No. 1, pp. 39-73.

Kim, I. and Kim, T. (2016), "Financial distress risk and stock returns", *The Korean Data Analysis Society*, Vol. 20 No. 6, pp. 319-330.

Kim, K. and Kim, Y. (2001), "What determines expected stock returns in the Korean stock market?", *Korean Journal of Financial Studies*, Vol. 28 No. 1, pp. 57-85.

Kim, M. and Kim, H. (2010), "The impacts of the abnormal inventory changes on market performance", *Daehan Journal of Business*, Vol. 23 No. 3, pp. 1555-1575.

Kim, S. and Kim, D. (2015), "Stock market anomalies and portfolio investment strategies", *The Korean Journal of Financial Engineering*, Vol. 14 No. 2, pp. 67-93.

Kim, T. and Byun, Y. (2011), "The relationship between idiosyncratic volatility and expected returns in the Korea stock markets", *Korean Journal of Financial Studies*, Vol. 40 No. 3, pp. 525-550.

Kim, B. and Lee, P. (2006), "An analysis on the long-term performance of value investment strategy in Korea", *Korean Journal of Financial Studies*, Vol. 35 No. 3, pp. 1-39.

Kim, C. and Lee, J. (2013), "An empirical study on market anomaly of over-inventory investment", *Journal of Accounting and Finance*, Vol. 31 No. 1, pp. 427-452.

Kim, C. and Song, D. (2008), "The effect of over-investment on earnings management", *Korean Management Review*, Vol. 37 No. 4, pp. 901-925.

Lakonishok, J., Shleifer, A. and Vishny, R.W. (1994), "Contrarian investment, extrapolation, and risk", *The Journal of Finance*, Vol. 49 No. 5, pp. 1541-1578.

Lee, K. (2019), "Price momentum in Korea and the effect of investors' trading", *Korean Journal of Futures and Options*, Vol. 27 No. 3, pp. 329-364.

Lee, J. and Ahn, Y. (2002), "Performance analysis of investment strategy in the Korean stock market", *Korean Journal of Financial Studies*, Vol. 30 No. 1, pp. 33-74.

Lee, J. and Choi, H. (2013), "Asset growth effect in Korean stock markets", *Daehan Journal of Business*, Vol. 26 No. 11, pp. 2815-2830.

Lee, M. and Ohk, K. (2015), "Market anomalies and multifactor models: comparison between the FF model and the CNZ model", *Korean Journal of Financial Studies*, Vol. 44 No. 5, pp. 855-885.

Lee, M., Lee, S. and Ohk, K. (2008), "An empirical test for Fama-French three factor model in the Korean stock market", *The Korean Data Analysis Society*, Vol. 19 No. 6, pp. 945-956.

Lev, B. and Nissim, D. (2004), "Taxable income, future earnings, and equity values", *The Accounting Review*, Vol. 79 No. 4, pp. 1039-1074.

Li, D. (2011), "Financial constraints, R&D investment, and stock returns", *Review of Financial Studies*, Vol. 24 No. 9, pp. 2974-3007.

Lou, D. (2014), "Attracting investor attention through advertising", *Review of Financial Studies*, Vol. 27 No. 6, pp. 1797-1829.

Loughran, T. and Wellman, J.W. (2011), "New Evidence on the relation between the enterprise multiple and average stock returns", *Journal of Financial and Quantitative Analysis*, Vol. 46 No. 6, pp. 1629-1650.

Lyandres, E. and Le Sun, L. (2008), "The new issues puzzle: testing the investment based explanation", *Review of Financial Studies*, Vol. 21 No. 6, pp. 2825-2855.

Newey, W.K. and West, K.D. (1987), "A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix", *Econometrica*, Vol. 55 No. 3, pp. 703-708.

Novy-Marx, R. (2011), "Operating leverage", *Review of Finance*, Vol. 15 No. 1, pp. 103-134.

Novy-Marx, R. (2013), "The other side of value: the gross profitability premium", *Journal of Financial Economics*, Vol. 108 No. 1, pp. 1-28.

Novy-Marx, R. and Velikov, M. (2016), "A taxonomy of anomalies and their trading costs", *The Review of Financial Studies*, Vol. 29 No. 1, pp. 104-147.

Ohlson, J.A. (1980), "Financial ratios and the probabilistic prediction of bankruptcy", *Journal of Accounting Research*, Vol. 18 No. 1, pp. 109-131.

Ok, Y., An, S. and Kim, J. (2018), "Robustness of idiosyncratic volatility puzzle in the Korean stock market", *Korean Journal of Financial Studies*, Vol. 47 No. 4, pp. 635-671.

Ortiz-Molina, H. and Phillips, G.M. (2014), "Real asset liquidity and the cost of capital", *Journal of Financial and Quantitative Analysis*, Vol. 49 No. 1, pp. 1-32.

Penman, S.H., Richardson, S.A. and Tuna, I. (2007), "The book-to-price effect in stock returns: accounting for leverage", *Journal of Accounting Research*, Vol. 45 No. 2, pp. 427-467.

Piotroski, J.D. (2000), "Value investing: the use of historical financial statement information to separate winners from losers", *Journal of Accounting Research*, Vol. 38, pp. 1-41.

Pontiff, J. and Woodgate, A. (2008), "Share issuance and cross-sectional returns", *The Journal of Finance*, Vol. 63 No. 2, pp. 921-945.

Richardson, S.A., Sloan, R.G., Soliman, M.T. and Tuna, I. (2005), "Accrual reliability, earnings persistence and stock prices", *Journal of Accounting and Economics*, Vol. 39 No. 3, pp. 437-485.

Rosenberg, B., Reid, K. and Lanstein, R. (1985), "Persuasive evidence of market inefficiency", *The Journal of Portfolio Management*, Vol. 11 No. 3, pp. 9-16.

Rosenberg, B., Reid, K. and Lanstein, R. (1985), "Persuasive evidence of market inefficiency", *The Journal of Portfolio Management*, Vol. 11 No. 3, pp. 9-16.

Sim, M. (2016a), "Realized skewness and the return predictability", *Korean Journal of Futures and Options*, Vol. 24 No. 1, pp. 119-152.

Sim, M. (2016b), "Higher moments and the cross-section of stock returns", *The Korean Journal of Financial Management*, Vol. 33 No. 1, pp. 71-102.

Sim, M. (2018), "Rank momentum strategies in the Korean stock market", *Asian Review of Financial Research*, Vol. 31 No. 1, pp. 117-155.

Sloan, R.G. (1996), "Do stock prices fully reflect information in accruals and cash flows about future earnings?", *The Accounting Review*, Vol. 71, pp. 289-315.

Soliman, M.T. (2008), "The use of DuPont analysis by market participants", *The Accounting Review*, Vol. 83 No. 3, pp. 823-853.

Son, P. (2012), "Asset growth and the cross-section of stock returns", *The Korean Journal of Financial Engineering*, Vol. 11 No. 2, pp. 45-70.

Son, S. and Yoon, B. (2011), "Anomaly tests in size groups in Korean stock market", *Korean Journal of Financial Studies*, Vol. 40 No. 2, pp. 315-345.

Thomas, J.K. and Zhang, H. (2002), "Inventory changes and future returns", *Review of Accounting Studies*, Vol. 7 Nos 2/3, pp. 163-187.

Titman, S., Wei, K.C.J. and Xie, F. (2004), "Capital investments and stock returns", *Journal of Financial and Quantitative Analysis*, Vol. 39 No. 4, pp. 677-700.

Woo, C. and Kwak, J. (2004), "An empirical study on the performance of portfolio strategy based on the firm`s *r*&d intensity", *The Korean Journal of Financial Management*, Vol. 21 No. 1, pp. 87-124.

Xie, H. (2001), "The mispricing of abnormal accruals", *The Accounting Review*, Vol. 76 No. 3, pp. 357-373.

Xing, Y. (2008), "Interpreting the value effect through the Q-theory: an empirical investigation", *Review of Financial Studies*, Vol. 21 No. 4, pp. 1767-1795.

Yoon, J. and Kim, S. (2009), "Reality check test on the momentum and contrarian strategy", *The Korean Journal of Financial Management*, Vol. 26 No. 1, pp. 189-220.

Yun, S., Ku, B. and Eom, Y. (2011), "Empirical investigation on the relationship of firm-volatility and the cross-section of stock returns", *Asian Review of Financial Research*, Vol. 24 No. 1, pp. 91-131.

Yun, S., Ku, B., Eom, Y. and Hahn, J. (2009), "The cross-section of stock returns in Korea: an empirical investigation", *Asian Review of Financial Research*, Vol. 22 No. 1, pp. 1-44.

Further reading

Banz, R.W. (1981), "The relationship between return and market value of common stocks", *Journal of Financial Economics*, Vol. 9 No. 1, pp. 3-18.

Chung, C., Kim, B. and Kim, D. (2012), "Re-examination of anomalies in Korea capital market", *The Korean Journal of Financial Engineering*, Vol. 11 No. 3, pp. 83-117.

Gwang, J. and Jongtaeg, K. (2003), "A value investment strategy: its performance and sources", *Korean Journal of Financial Studies*, Vol. 32 No. 2, pp. 165-208.

Johnson, B., Bioy, H. and Boyadzhiev, D. (2016), "Assessing the true cost of strategic beta ETFs", *The Journal of Index Investing*, Vol. 7 No. 1, pp. 35-48.

Kho, B. (1997), "Risk premium and profitability of relative strength strategies", *The Korean Journal of Financial Management*, Vol. 14 No. 1, pp. 1-21.

Kim, S. and Yun, Y. (1999), "Fundamental variables, marcroeconomic factors, risk characteristics and equity returns", *The Korean Journal of Financial Management*, Vol. 16 No. 2, pp. 179-213.

Lim, S. and Heyjung, S.C. (2015), "A predictive ability of accruals for future stock returns", *Korean International Accounting Review*, Vol. 62, pp. 305-342.

Park, J. and Son, S. (2013), "A study on the momentum profits corresponding to credit risk and business conditions: Korean stock market evidence", *Journal of Money and Finance*, Vol. 27 No. 1, pp. 1-28.

Park, K. and Jee, C. (2006), Contrarian strategy based on past stock return and volatility, *The Korean Journal of Financial Management*, Vol. 23 No. 2, pp. 1-25.

Sim, M. and Kang, J. (2014), "Lottery-Like stocks and the cross-section of expected stock returns in the Korean stock market", *Asian Review of Financial Research*, Vol. 27 No. 2, pp. 297-332.

Appendix. The construction of portfolio

Anomaly	$\overline{R}$	$\lvert t\rvert$	α_{FF3}	t_{FF3}	$A(\lvert a_i\rvert)$	$\frac{A(\lvert a_i\rvert)}{A(\lvert r_i\rvert)}$	$\frac{A(a_i^2)}{A(r_i^2)}$	*GRS*	*p(GRS)*	R^2
Value										
Dp	0.670	1.660	0.287	0.797	0.266	0.719	0.678	1.340	0.210	0.652
Ep	0.583	1.200	0.327	0.734	0.340	0.915	0.819	1.546	0.125	0.722
Sg	−0.197	0.483	−0.055	−0.120	0.157	0.771	0.747	0.445	0.923	0.723
Sr	0.201	0.460	0.543	1.344	0.235	0.888	0.897	1.750	0.072	0.715
Trading friction										
Cvd1	−0.895	1.784	−1.108	−2.259	0.328	1.063	1.187	1.487	0.145	0.701
β^{-1}	−0.828	1.749	−0.688	−1.518	0.243	0.908	0.969	1.140	0.333	0.676
Ami12	0.755	1.646	0.632	2.571	0.286	0.956	0.802	2.987	0.002	0.830
Srev6	0.365	1.392	0.119	0.471	0.160	1.069	1.121	1.329	0.216	0.879
β^{-6}	−0.532	1.222	−0.451	−1.175	0.197	0.954	0.926	0.978	0.464	0.779
$\beta^{FP}12$	0.539	1.089	0.250	0.666	0.103	0.776	0.590	0.398	0.946	0.735
$\beta^{D}6$	0.251	1.073	0.249	1.289	0.165	1.079	1.351	3.074	0.001	0.876
β^{-12}	−0.422	1.056	−0.352	−1.173	0.179	0.976	0.892	1.223	0.278	0.815
$\beta 1$	0.515	1.053	0.363	0.774	0.263	1.229	1.269	1.312	0.225	0.667
$\beta^{FP}1$	0.538	1.049	0.259	0.553	0.184	0.964	0.785	0.668	0.753	0.634
$\beta^{FP}6$	0.496	1.016	0.161	0.377	0.127	0.690	0.485	0.406	0.943	0.694
$\beta^{D}12$	0.236	1.010	0.191	1.027	0.132	1.078	1.217	2.481	0.008	0.903
*Ts*1	−0.287	0.986	−0.449	−1.466	0.293	1.145	1.375	1.441	0.164	0.734
*Cvt*1	0.407	0.963	−0.010	−0.031	0.349	1.305	1.710	1.615	0.104	0.719
*Ts*6	−0.134	0.930	−0.304	−2.242	0.128	1.727	3.776	1.104	0.360	0.904
*Cvt*6	0.263	0.829	−0.206	−0.920	0.216	1.249	1.795	1.523	0.133	0.823
*Isff*12	0.099	0.721	−0.011	−0.100	0.091	1.511	2.183	0.883	0.550	0.931
*Isff*6	0.111	0.680	−0.014	−0.092	0.128	1.425	1.823	0.981	0.461	0.903
*Cvt*12	0.198	0.634	−0.089	−0.426	0.175	1.411	1.764	1.353	0.205	0.856
$I_{SC}12$	0.083	0.550	−0.014	−0.120	0.095	1.692	2.416	0.844	0.587	0.931
$I_{SC}6$	0.087	0.544	0.015	0.096	0.140	1.713	3.225	1.333	0.215	0.904
$I_{SC}1$	0.185	0.480	0.032	0.079	0.333	1.227	1.419	1.816	0.059	0.731
$\beta^{D}1$	0.125	0.282	0.224	0.561	0.320	1.334	1.875	1.542	0.126	0.699
*Isff*1	0.041	0.122	−0.156	−0.434	0.314	1.252	1.601	1.429	0.169	0.726
$\beta 12$	0.028	0.061	−0.057	−0.159	0.160	1.040	1.486	1.035	0.416	0.744
*Srev*1	−0.029	0.055	−0.413	−0.764	0.319	1.230	1.363	1.225	0.276	0.706
*Ts*12	−0.006	0.046	−0.114	−1.083	0.105	1.435	2.419	1.598	0.109	0.932
$\beta 6$	0.018	0.039	−0.136	−0.347	0.208	1.075	1.319	1.141	0.333	0.716
Profitability										
Bl	0.643	1.533	0.185	0.530	0.222	1.026	0.949	1.186	0.301	0.726
O	−0.685	1.487	−1.022	−2.666	0.282	0.858	0.924	1.437	0.166	0.762
Ole	0.662	1.347	0.964	2.234	0.241	0.812	0.817	1.056	0.398	0.738
F	0.642	1.201	0.376	0.765	0.215	1.188	1.452	0.934	0.481	0.760
Cla	0.555	1.185	0.862	2.025	0.275	1.139	1.386	1.567	0.118	0.729
Pm	0.576	1.133	0.686	1.592	0.203	0.693	0.570	0.986	0.457	0.747
Z	−0.457	1.040	0.258	0.713	0.281	1.064	0.957	1.854	0.053	0.733
Ope	0.478	0.977	0.716	1.721	0.230	0.939	0.895	0.957	0.482	0.749
Roa	0.397	0.750	0.738	1.424	0.236	0.879	0.864	1.005	0.440	0.732
Roe	0.329	0.698	0.750	1.651	0.217	0.860	0.978	0.749	0.678	0.735
Cop	0.266	0.550	0.487	1.001	0.252	2.212	4.557	1.004	0.441	0.733

(*continued*)

Table A1. Statistics of anomalies that are not statistically significant (KOSPI KOSDAQ, value-weighted, continue)

Anomaly	$\overline{R}$	$\|t\|$	α_{FF3}	t_{FF3}	$A(\|a_i\|)$	$\frac{A(\|a_i\|)}{A(\|r_i\|)}$	$\frac{A(a_i^2)}{A(r_i^2)}$	GRS	$p(GRS)$	R^2
Tbi	0.222	0.525	0.221	0.578	0.281	1.038	1.053	1.190	0.299	0.645
Gpa	−0.235	0.490	0.249	0.641	0.263	1.619	3.559	1.230	0.273	0.742
dRoe	−0.211	0.458	−0.018	−0.037	0.232	1.063	0.891	0.923	0.512	0.728
Rna	−0.123	0.379	0.190	0.661	0.184	0.991	0.669	1.169	0.313	0.766
Cto	−0.099	0.265	−0.055	−0.148	0.284	1.195	1.604	1.702	0.082	0.731
Ato	0.110	0.214	0.217	0.484	0.255	1.061	0.937	1.079	0.380	0.756
Opa	−0.101	0.186	−0.011	−0.023	0.152	1.113	1.182	0.652	0.768	0.732
dRoa	0.050	0.114	0.109	0.251	0.216	1.231	1.049	0.576	0.833	0.721
Momentum										
$\epsilon^{11}12$	0.559	1.857	0.345	1.177	0.093	0.742	0.512	1.067	0.390	0.875
$R^{11}12$	1.161	1.824	1.019	1.694	0.228	0.986	1.087	1.718	0.079	0.817
$R^{11}6$	1.088	1.731	0.927	1.633	0.277	0.869	0.963	1.508	0.139	0.788
$\epsilon^{6}1$	0.668	1.608	0.346	0.804	0.267	0.999	1.092	1.462	0.155	0.693
$R^{6}1$	0.888	1.472	0.470	0.752	0.356	0.968	1.029	2.043	0.030	0.678
Investment										
2Ig	−0.676	1.877	−0.471	−1.374	0.217	0.992	1.102	0.923	0.513	0.711
I/A	−0.798	1.848	−0.456	−0.881	0.190	0.818	0.527	0.581	0.829	0.706
Cdi	−0.573	1.842	−0.460	−1.573	0.238	0.920	0.835	1.325	0.218	0.708
Noa	−0.756	1.831	−0.328	−0.802	0.234	0.924	0.963	1.792	0.063	0.734
Dac	−0.618	1.792	−0.520	−1.624	0.252	0.902	0.814	1.720	0.078	0.755
dPia	−0.527	1.628	−0.231	−0.741	0.206	0.966	0.862	0.672	0.750	0.736
dFin	−0.548	1.459	−0.425	−1.064	0.243	0.989	0.889	1.190	0.299	0.734
dNcl	−0.406	1.414	−0.538	−1.924	0.176	1.211	1.244	1.016	0.431	0.733
dCoa	−0.589	1.318	−0.485	−0.977	0.289	1.116	1.070	1.449	0.161	0.716
Ig	−0.386	1.286	−0.138	−0.395	0.168	0.915	1.081	0.554	0.850	0.713
Aci	0.317	1.276	0.175	0.732	0.189	1.344	1.417	0.722	0.703	0.741
Poa	−0.447	1.024	−0.286	−0.716	0.268	1.077	1.333	1.738	0.074	0.743
dLti	−0.354	0.975	−0.346	−0.939	0.178	0.757	0.703	1.087	0.374	0.732
3Ig	−0.390	0.918	−0.249	−0.584	0.184	1.052	1.440	1.042	0.409	0.712
dFnl	0.327	0.903	0.362	0.952	0.190	1.066	1.058	0.962	0.478	0.737
Ta	−0.306	0.877	−0.606	−1.520	0.280	1.125	1.126	2.148	0.022	0.714
dNca	−0.243	0.662	−0.011	−0.028	0.135	0.744	0.481	0.394	0.948	0.751
dCol	0.191	0.481	0.175	0.383	0.142	1.490	2.069	0.526	0.871	0.736
dSti	0.144	0.458	0.229	0.674	0.222	1.080	1.198	1.045	0.406	0.734
dNoa	0.147	0.452	0.239	0.716	0.247	1.012	1.237	1.165	0.316	0.728
Ivc	−0.138	0.398	−0.279	−0.777	0.208	1.135	1.339	0.837	0.593	0.735
dNco	−0.054	0.178	0.013	0.038	0.195	1.006	0.910	1.054	0.399	0.748
Intangible										
Lfe	0.773	1.875	0.840	2.133	0.272	0.971	1.017	1.927	0.043	0.729
Hn	−0.797	1.873	−0.597	−1.462	0.215	0.922	0.912	1.046	0.406	0.729
Rds	0.815	1.642	1.499	3.142	0.325	1.235	1.491	1.482	0.148	0.691
Age_{FOUND}	0.381	1.453	0.026	0.085	0.222	0.746	0.670	0.894	0.539	0.692
Alm	0.581	1.349	0.070	0.179	0.268	0.658	0.494	1.968	0.038	0.740
dGs	−0.592	1.331	−0.605	−1.363	0.205	0.962	1.243	0.980	0.462	0.720
Rca	0.655	1.325	1.557	3.316	0.289	1.167	1.946	1.326	0.218	0.695
Ol	0.369	1.042	0.332	1.032	0.277	1.004	0.903	1.495	0.143	0.738
Tan	0.249	0.700	−0.127	−0.388	0.185	0.741	0.730	1.058	0.396	0.754

(*continued*)

Table A1.

Anomaly	$\overline{R}$	$\lvert t \rvert$	α_{FF3}	t_{FF3}	$A(\lvert a_i \rvert)$	$\frac{A(\lvert a_i \rvert)}{A(\lvert r_i \rvert)}$	$\frac{A(a_i^2)}{A(r_i^2)}$	*GRS*	*p(GRS)*	R^2
dSi	−0.266	0.648	−0.002	−0.004	0.254	1.065	0.983	1.146	0.329	0.727
gAd	−0.252	0.633	−0.275	−0.650	0.202	1.154	1.205	0.756	0.671	0.713
dSs	−0.202	0.502	−0.254	−0.674	0.192	1.181	1.304	0.950	0.488	0.730
Ala	−0.152	0.407	−0.078	−0.206	0.222	0.702	0.580	0.942	0.495	0.729

Notes: This table shows the statistics of anomalies that are not statistically significant, for which the absolute value of the *t*-statistic exceeds 1.96, out of a total of 148 anomalies observed from January 2000 to June 2019. The returns from anomalies are estimated for all companies listed on the KOSPI and KOSDAQ, excluding the financial industry, and portfolio returns are calculated using the value-weighted method. $\overline{R}$ is the average differential between the *High* decile portfolio and *Low* decile portfolio returns and $\lvert t \rvert$ is the absolute value of the *t*-statistics. α_{FF3} is the intercept in a regression of the FF (1993) model and t_{FF3} is the *t*-statistic for α_{FF3}. *GRS* represents the *F*-test statistic of Gibbons *et al.* (1989) and *p*(*GRS*) is the *p*-value for GRS F-test. $A(\lvert a_i \rvert)$ is the average absolute value of intercepts from the Fama and French (1993) three-factor model for anomalies. $A(\lvert r_i \rvert)$ is the average absolute value of market portfolio excess return. We use the KOSPI as the value-weighted market portfolio in the Korean stock market. $\frac{A(\lvert a_i \rvert)}{A(\lvert r_i \rvert)}$ is the ratio of $A(\lvert a_i \rvert)$ and $A(\lvert r_i \rvert)$. $A\left(a_i^2\right)$ is the average squared intercept, and $A\left(r_i^2\right)$ is the average squared market portfolio excess return. R^2 is the average of the FF(1993) model regression. The unit of monthly return is %. We report adjusted *t*-statistics for heteroscedasticity and autocorrelation following Newey and West (1987)

Table A1.

A.1 Momentum

A.1.1 R^61, R^66, R^612 (6 months momentum, Jegadeesh and Titman, 1993)

We construct a decile portfolio based on returns over the past six months, cumulative returns from $t-7$ to $t-2$ month. The $t-1$ month is skipped and each portfolio starts from the beginning of *t*-month. The holding period for the decile portfolio is 1 month (from the end of *t* month), 6 months (from *t* to end of $t+5$) and 12 months (from *t* to end of $t+12$). At this time, the decile portfolio is rebalanced at the beginning of $t+1$ month. If the holding period is longer than one month, the portfolio return is calculated as follows. For example, using the six months holding period strategy (R66), the return of each decile portfolio for each month uses the simple average of the returns of the six decile portfolios starting in different months.

A.1.2 $R^{11}1$, $R^{11}6$, $R^{11}12$ (11 months momentum, Fama and French, 1996)

We construct a decile portfolio based on returns over the past eleven months, cumulative returns from $t-12$ to $t-2$ month. The $t-1$ month is skipped, and each portfolio starts from the beginning of *t*-month. The holding period for the decile portfolio is 1 month (from the end of *t* month), 6 months (from *t* to end of $t+5$) and 12 months (from *t* to end of $t+12$). At this time, the decile portfolio is rebalanced at the beginning of $t+1$ month. If the holding period is longer than one month, the portfolio return is calculated as follows. For example, using the six months holding period strategy ($R^{11}6$), the return of each decile portfolio for each month uses the simple average of the returns of the six decile portfolios starting in different months.

A.1.3 52w1, 52w6, 52w12 (52 week high momentum, George and Hwang, 2004)

At the end of every $t-1$ month, we construct a decile portfolio based on the ratio of the current adjusted share price to the highest adjusted share price (divided adjusted) for the past 52 weeks. The holding period for the decile portfolio is 1 month (from the end of *t* month), 6 months (from *t* to t + end of 6) and 12 months (from *t* to t + end of 12). At this time, the decile portfolio is rebalanced at the beginning of

$t+1$ month. If the retention period is longer than 1 month, the portfolio return is calculated as follows. For example, when using a strategy of six months holding period (526), the return of each decile portfolio for each month uses the simple average of the returns of the six decile portfolios starting in different months. In many cases, stocks hit a 52-week high at the same point in time, so $52w$ would be 1 at the same time. In this case, if $52w$ is 1 as a breakpoint constituting the decile portfolio, a problem may occur in the number of observations when constructing the portfolio. Therefore, in this study, we use $52w$ less than 1 as a breakpoint required for portfolio construction.

A.1.4 $\epsilon^6 1$, $\epsilon^6 6$, $\epsilon^6 12$ (6 months residual momentum, Blitz et al., 2011)

We construct a decile portfolio based on the average residual return from $t-7$ to $t-2$ month divided by the standard deviation of the residual returns for past six months. We construct the portfolio at the end of every $t-1$ month. That is, $t-1$ month is skipped and each portfolio starts from the beginning of t month. The holding period of the decile portfolio is 1 month (from the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). The residual return is calculated as follows. First, for 36 months from t-36 month to $t-1$ month, the residual return is calculated through regression analysis of Fama and French (1993) factors. To minimize the noise in the estimation, in this study we calculate the residual return only if the past return observations exist for the past 36 months. At this time, the decile portfolio is rebalanced at the beginning of $t+1$ month. If the retention period is longer than 1 month, the portfolio return is calculated as follows. For example, when using a strategy of 6 months holding period ($\epsilon^6 6$), the return of each decile portfolio for each month uses the simple average of the returns of the six decile portfolios starting in different months.

A.1.5 $\epsilon^{11} 1$, $\epsilon^{11} 6$, $\epsilon^{11} 12$ (11 months residual momentum, Blitz et al., 2011)

We construct a decile portfolio based on the average residual return from $t-12$ to $t-2$ month divided by the standard deviation of the residual returns for past eleven months. We construct the portfolio at the end of every $t-1$ month. That is, t-1 month is skipped and each portfolio starts from the beginning of t month. The holding period of the decile portfolio is 1 month (from the end of t month), 6 months (from t month to the end of $t+5$ month) and 12 months (from t month to the end of $t+11$ month). The residual return is calculated as follows. First, for 36 months from t-36 month to $t-1$ month, residual return is calculated through regression analysis of Fama and French (1993) factors. To minimize the noise in the estimation, in this study we calculate the residual return only if the past return observations exist for the past 36 months. At this time, the decile portfolio is rebalanced at the beginning of $t+1$ month. If the retention period is longer than 1 month, the portfolio return is calculated as follows. For example, when using a strategy of 6 months holding period ($\epsilon^{11} 6$), the return of each decile portfolio for each month uses the simple average of the returns of the six decile portfolios starting in different months.

A.2 Value

A.2.1 Book value-to-market value ratio (Rosenberg et al., 1985)

Book-to-market ratio (Bm) is the book value of the fiscal year divided by the market cap at the end of December $t-1$ year. We construct a decile portfolio at the end of June of every t year with the book-to-market ratio. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$. In this study, we calculate the book value by subtracting the capital stock of preferred stock from the total amount of capital by referring to a past study (Davis *et al.*, 2000).

A.2.2 Book value to june-end market value ratio (Asness and Frazzini, 2013)
Following Asness and Frazzini (2013), we calculate the book to June-end market (Bmj) by dividing the book equity of the last $t-1$ fiscal year by the market equity of the end of June t. We construct a decile portfolio at the end of June of every t year with book to June-end market ratio. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$. In this study, we calculate the book value by subtracting the capital stock of preferred stock from the total amount of capital by referring to a past study (Davis *et al.*, 2000).

A.2.3 Debt to market value ratio (Bhandari, 1988)
We construct a decile portfolio with the debt-to-market value ratio at the end of June of every t year. The ratio is the total debt for the last $t-1$ fiscal year divided by the market equity at the end of December $t-1$. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.4 Asset to market ratio (Fama and French, 1992)
We construct a decile portfolio with the asset-to-market value ratio at the end of June of every t year. The ratio is the total assets of the last $t-1$ fiscal year divided by the market equity at the end of December $t-1$. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.5 Earnings to price ratio (Basu, 1983)
We construct a decile portfolio with the earnings to price ratio at the end of June of every t year. The ratio is calculated by dividing continued operating profit for the last $t-1$ fiscal year by market equity at the end of December $t-1$. Companies that do not make positive profits are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.6 Cashflow to price ratio (Lakonishok et al., 1994)
We construct a decile portfolio with the earnings to price ratio at the end of June of every t year. The ratio is the total cash flow of the last t-1 fiscal year divided by the market equity at the end of December $t-1$. Companies that do not make positive profits are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.7 Sr (five-year sales growth rank, Lakonishok et al., 1994)
Following Lakonishok e***t al.*** (1994), at the end of June of t, we measure the weighted average sales growth over the past five years. The sales ranking is calculated as follows: $\sum_{j=1}^{5}(6-j)\times Rank(t-j)$. The sales growth rate in the t–j year uses the sales growth rate from the $t-\mathrm{j}-1$ fiscal year to the $t-\mathrm{j}$ fiscal year. Only companies with rankings of sales growth over the past five years are included in the portfolio composition process, and excluded those with negative sales (–). Then, in each year from $t-5$ to $t-1$, ranks from 1 to 10 are assigned based on the sales growth rate, and a decile portfolio is allocated. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.8 Sales growth rate (Lakonishok et al., 1994)

At the end of June every t year, the growth rate from the sales in the $t-2$ fiscal year to the sales in the last $t-1$ fiscal year is calculated, and based on this growth rate, we construct a decile portfolio. Companies that fail to generate positive sales are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.9 Sales to price (Barbee et al., 1996)

At the end of June of each t year, we construct a decile portfolio based on the cash flow-to-share ratio which is the sales for the last $t-1$ fiscal year divided by the market equity at the end of $t-1$ December. Companies that fail to record positive sales are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.10 Operating cash flow-to-price (Desai et al., 2004)

At the end of June of every t year, we construct a decile portfolio based on the cash flow-to-stock ratio which is the operating cash flows of the last $t-1$ fiscal year divided by the market equity at the end of $t-1$ December. Companies that fail to record positive operating cash flows are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.11 Enterprise book-to-price, net debt-to-price (Penman et al., 2007)

Following Penman *et al.* (2007), in this study, the total enterprise book-to-price (*Ebp*) is defined as the book value of net operating capital (net debt + total capital - preferred stock) divided by the market value of net operating capital (net debt + market capitalization). Net debt-to-price (*Ndp*) is the net debt divided by the market cap. Net debt is the financial debt minus financial assets. Financial liabilities are calculated as non-current liabilities + liquid long-term liabilities + preferred stock capital. On the other hand, financial assets are cash and cash equivalents plus short-term financial assets. The book value is the capital stock minus the preferred stock capital. After calculating *Ebp* and *Ndp*, at the end of June of each t year, the book value and net liabilities of the net operating capital of the last $t-1$ fiscal year are divided by the market equity at the end of December $t-1$, respectively. We then construct a decile portfolio based on percentage. Companies that fail to record positive book value or market value are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.2.12. Em (EV/EBITDA (enterprise multiple), Loughran and Wellman, 2011)

EV (enterprise value) is calculated by adding the market cap, total debt and preferred stock capital, and excluding cash and cash equivalents and short-term financial assets. *Em* is *EV* divided by *EBITDA* (earnings before interest, tax, depreciation and amortization). All accounting information used to calculate *Em* uses the value of fiscal year $t-1$, and the market cap uses the value of the end of December of fiscal year $t-1$. Subsequently, at the end of June of every t year, we construct a decile portfolio based on *Em*. Companies with negative *EV* or *EBITDA* are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3 Investment

A.3.1 Abnormal corporate investment (Titman et al., 2004)

At the end of June every t year, we estimate abnormal corporate investment (Aci) as follows and construct a decile portfolio based on Aci. Aci is $Ce_{t-1}/[(Ce_{t-2}+Ce_{t-3}+Ce_{t-4}/3]-1$. Ce is capital expenditure divided by $t-$ j fiscal year sales. For example, Ce_{t-1} is the ratio of capital expenditure in fiscal year $t-1$ divided by sales. In this study, if sales are less than 10 billion, they are excluded from portfolio composition. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.2 Investment-to-assets (Cooper et al., 2008)

At the end of June of every t year, divide the total assets in fiscal year t-1 by the total assets of fiscal year $t-2$ minus 1, and then construct a decile portfolio based on the investment-asset ratio I/A. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.3 dPia (change in PPE and inventory-to-assets, Lyandres et al., 2008)

The rate of change of tangible assets and inventories is calculated as follows. First, the amount of change between tangible assets for each t-1 fiscal year and tangible assets for $t-2$ fiscal year is calculated. Similarly, we calculate the amount of change in inventories for $t-1$ fiscal year and inventories for $t-2$ fiscal year. Then, after adding the two changes, we calculate the $dPia$ by dividing by the total assets for the fiscal year $t-2$. Subsequently, at the end of June of every t year, we construct a decile portfolio based on the $dPia$ of $t-1$ year. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.4 dNoa (net operating asset and change in net operating asset, Hirshleifer et al., 2004)

In this study, we cacluate net operating assets as the difference between operating assets and operating liabilities as follows. Operating assets are total assets excluding cash and cash equivalents and short-term financial assets. Operating liabilities are total assets excluding liquid long-term liabilities and non-current liabilities, minority shareholder equity, and preferred stocks and common stocks. Noa is the net operating assets divided by the total asset one year prior. For example, if we calculate the net operating assets using information from fiscal year $t-1$, it is divided by the total assets in fiscal year $t-2$. $dNoa$ is the annual change in net operating assets and is calculated by dividing by the total assets from one year prior. After that, at the end of every t year, we construct each decile portfolio based on Noa and $dNoa$. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.5 dLno (change in long-term net operating assets, Fairfield et al., 2003)

We cacluate changes in long-term net operating assets by adding changes in tangible assets, changes in intangible assets, changes in other non-current assets and depreciation, and subtracting changes in other non-current assets. $dLno$ is use by dividing the change in the long-term net operating balance by the average of the total assets of the same fiscal year and the total assets of the previous year. For example, if the information in the t-1 fiscal year is used to determine the change in the long-term net operating assets, divide it by the total assets in $t-1$. Subsequently, at the end of June every t, we construct a decile portfolio based on $dLno$. Each decile portfolio is invested from the beginning of July t year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.6 Investment growth (Xing, 2008)

At the end of June of every *t*-year, we construct a decile portfolio based on the rate of increase in capital expenditures from fiscal year *t*-2 to fiscal year $t-1$. For example, capital expenditure in $t-1$ fiscal year divided by capital expenditure in *t*-2 fiscal year is use as the rate of increase in investment (*Ig*). Each decile portfolio is invested from the beginning of July *t* year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.7 Two-year investment growth (Anderson and Garcia-Feijoo, 2006)

At the end of June of each *t*-year, we construct a decile portfolio based on the rate of increase in capital expenditures from fiscal year *t*-3 through fiscal year $t-1$. For example, the capital expenditure in $t-1$ fiscal year divided by the capital expenditure in *t*-3 fiscal year is use as a two-year growth rate (2*Ig*). Each decile portfolio is invested from the beginning of July *t* year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.8 Three-year investment growth (Anderson and Garcia-Feijoo, 2006)

At the end of June of each *t* year, we construct a decile portfolio based on the rate of increase in capital expenditure from the $t-4$ fiscal year to the *t*-1 fiscal year. For example, the capital expenditure of $t-1$ fiscal year divided by the capital expenditure of $t-4$ fiscal year is use as a three-year growth rate (3*Ig*). Each decile portfolio is invested from the beginning of July *t* year to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.9 Net stock issuance (Pontiff and Woodgate, 2008)

Net stock issuance (*Nsi*) is calculated as follows. This is the natural log of the ratio of the number of listed stocks in $t-1$ fiscal year (divided adjusted) divided by the number of listed stocks in $t-2$ fiscal year. At the end of every *t* year of June, companies with negative *Nsi* are sent to portfolios 1 and 2 to classify them as the size of *Nsi*, and if *Nsi* is 0, they are classified as portfolio 3. Companies with the remaining positive Nsi are ranked by size from 4 to 10 in the portfolio. Each portfolio is invested from the beginning of July *t* to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.10 Composite equity issuance (Daniel and Titman, 2006)

At the end of every *t* of June, we construct a decile portfolio based on *Cei*, which represents the composite equity issuance. *Cei* is the rate of increase in market capitalization that is not affected by stock returns, and is calculated as follows. $Log(ME_t/Me_{t-5})$–$r(t-5,t)$ where $r(t-5,t)$ is the cumulative log stock return from the end of June of $t-5$ to the end of June of t. Each portfolio is invested from the beginning of July *t* to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.11 Composite debt issuance (Lyandres et al., 2008)

At the end of every *t* of June, we construct decile portfolio based on the *Cdi* representing the composite debt issuance. *Cdi* is the logarithmic growth rate from fiscal year $t-6$ to fiscal year $t-1$ of the sum of liquid long-term and non-current liabilities. Each portfolio is invested from the beginning of July *t* to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.12 Inventory growth (Belo and Lin, 2011)

At the end of every *t* year of June, we construct a decile portfolio based on the growth rate of inventories from fiscal year $t-2$ to fiscal year $t-1$. Each portfolio is invested from the beginning of July *t* to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.13 Inventory change (Thomas and Zhang, 2002)

At the end of every t year of June, we construct a decile portfolio based on the ratio of the change in inventories from fiscal year $t-2$ to fiscal year t-1 divided by the average total assets over the two periods. In this study, companies that did not have inventory in both $t-1$ and $t-2$ are excluded from portfolio composition. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.14 Operating accruals (Sloan, 1996)

We calculate the operating accruals by subtracting operating cash flows from net income (Hribar and Collins, 2002) and dividing it by total assets of the previous year. For example, if you use operating accruals for fiscal year $t-1$, divide by total assets for fiscal year $t-2$. At the end of every t of June, we construct a decile portfolio based on the operating accruals (*Oa*). Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.15 Total accruals

The total accruals is the net income from the total cash flow minus all cash flows from operating activities, investment activities, and financial activities, and the excess of stock issuance (if 0 is absent) added, treasury stock purchases and dividends (if 0 is absent). The value obtained by subtracting the value divided by the total assets of the previous year is used. For example, if you use the total accruals for fiscal year t-1, divide it by the total assets for fiscal year $t-2$. At the end of June every t, we construct a decile portfolio based on the total accruals (*Ta*). Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.16 dWc (change in net non-cash working Capital), dCoa (change in current operating assets), dCol (change in current operating liabilities)

dWc is the change in net non-cash working capital. Net non-cash working capital excludes current operating liabilities from current operating assets. Current operating assets are current assets minus cash, cash equivalents and short-term financial assets. Current operating liabilities are current liabilities minus long-term liquidity liabilities. *dCoa* is the amount of change in current operating assets, *dCol* is the amount of change in current operating liabilities. Of the changes in the long-term liquidity liabilities, the missing value is converted to zero. *dWC,dCoa,dCol* is divided by the total assets of the previous year, and for example, if the value of fiscal year t-1 is used, it is divided by the total assets of fiscal year t-2. At the end of every t year of June, we construct each decile portfolio based on *dWC, dCoa, dCol*. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.17 dNco (changes in net non-current operating assets), dNca (changes in non-current operating assets), dNcl (changes in non-current operating liabilities)

dNco is the change in net non-current operating assets. Net non-current operating assets are non-current operating assets minus non-current operating liabilities. In addition, non-current operating assets are total assets minus current assets and long-term investments (required confirmation). Non-current operating liabilities are total liabilities minus current and non-current assets. *dNca* represents the change in non-current operating assets, and *dNcl* represents the change in non-current operating liabilities. Missing values in long-term investments and changes in non-current liabilities are converted to zero. *dNco*, *dNca* and *dNcl* are divided by the total assets of the previous year, for example, if the value of fiscal year t-1 is used, it is divided by the total assets of fiscal year t-2. At the end of every t year of June, we construct each decile portfolio based on *dNco*, dNca and *dNcl*. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.18 dFin (changes in net financial assets), dSti (changes in short-term investments), dLti (changes in long-term investments), dFnl (changes in financial liabilities), dBe (changes in book value)

dFin is the amount of change in net financial assets. Net financial assets are financial assets minus financial liabilities. Financial assets are short-term financial assets plus long-term financial assets and financial liabilities are non-current liabilities, liquid long-term debts and preferred stock capital. *dSti* is the change in short-term investment, *dLti* is the change in long-term investment. *dFnl* is the amount of change in financial debt and *dBe* is the amount of change in total capital. When constructing a portfolio based on *dSti* and *dLti*, we exclude companies that have not had long-term or short-term investments in the past two years (fiscal year). *dFin*, *dSti*, *dLti*, *dFnl* are divided by the total assets of the previous year, for example, if the value of t-1 fiscal year is used, it is divided by the total assets of t-2 fiscal year. At the end of June every t, we construct a decile portfolio based on *dFin*, *dSti*, *dLti*, *dFnl* and *dBe*. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.19 Discretionary accruals, abs(dac), (absolute value of discretionary accruals), Xie (2001)

Following Dechow *et al.* (1995), we calculate discretionary accruals as follows:

$$\frac{Oa_{i,t}}{AT_{i,t-1}} = \alpha_1 \frac{1}{AT_{i,t-1}} + \alpha_2 \frac{dSALE_{i,t} - dREC_{i,t}}{AT_{i,t-1}} + \alpha_3 \frac{PPE_{i,t}}{AT_{i,t-1}} + e_{i,t}$$

Here, *Oa* is the operating accrual and *At* is the total assets of t-1. dSALE represents the amount of change from $t-1$ to t in sales, and dREC is the amount of change in sales receivables. PPE represents tangible assets. For discretionary accruals, the above regression analysis is performed for each year and for each industry to obtain the residual term, that is, the discretionary accruals. In regression analysis, discretionary accruals are calculated only when each sample includes at least 10 companies. Abs(*Dac*)) is the absolute value of the discretionary accrual due to the logic that the absolute size, rather than the direction of discretionary accruals, can be used as a proxy for earnings adjustment. At the end of June every t, we construct a decile portfolio based on discretionary accruals. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.20 Percent operating accruals, (Hafzalla et al., 2011)

The percent operating accruals (*Poa*) is the operating accruals (*Oa*) divided by the absolute value of the profit, not the total assets (Hafzalla *et al.*, 2011). At the end of every t year of June, we construct a decile portfolio based on the ratio of the operating accruals (*Oa*) for fiscal year t divided by the absolute value of net income for fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.21 Percent total accruals (Hafzalla et al., 2011)

The percent total accruals (*Pta*) is the total accruals (*ta*) divided by the absolute value of the profit, not the total assets. At the end of every t year of June, we construct a decile portfolio based on the ratio of the total accruals (*ta*) for the fiscal year $t-1$ divided by the absolute value of the net income for the fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.3.22 Percent discretionary accruals

The percent discretionary accruals (*Pda*) is the discretionary accrual (*Dac*) multiplied by the total assets of fiscal year $t-1$ and divided by the absolute value of net income for fiscal year $t-2$. At the end of every t year, we construct a decile portfolio based on the ratio of the percentage discretionary accrual (*Pda*) of fiscal year $t-1$ divided by the absolute value of net income for fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4 Profitability

A.4.1 Return on equity (Hou et al., 2015)

We calculate *Roe* as dividing continuous operating profit by book equity one year prior. The book value is the capital stock minus the preferred stock capital. At the end of every t year, we construct each decile portfolio based on the *Roe* of fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.2 dRoe (change in return on equity)

dRoe represents the change amount of *Roe*. For example, *dRoe* in fiscal year $t-1$ is the difference between *Roe* in $t-1$ and Roe in $t-2$. *Roe* uses continued operating profit divided by book equity one year prior. The book value is the capital stock minus the preferred stock capital. At the end of every t year, we construct each decile portfolio based on the *dRoe* of fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.3 Return on assets (Balakrishnan et al., 2010)

We calculate *Roa* as continuing operating profit divided by book equity one year prior. The book value is the capital stock minus the preferred stock capital. At the end of every t year of June, we construct each decile portfolio based on the *Roa* of fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.4 dRa (change in return on assets)

dRoa represents the change amount of *Roa*. For example, *dRoa* in fiscal year $t-1$ is the difference between Roe in $t-1$ and *Roa* in $t-2$. *Roa* uses continuing operating profit divided by book equity one year prior. The book value is the capital stock minus the preferred stock capital. At the end of every t year of June, we construct each decile portfolio based on the *dRoa* of the *t*-1 fiscal year. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.5 rna (net operating asset return), Pm (profit margin), ato (asset turnover), Soliman (*2008*)

Roe can be degraded to *Rna* + FLEV ∗ SPREAD following the Dupont analysis method (Soliman, 2008). Where *Rna* is the net operating asset return, FLEV is the financial leverage, and SPREAD is the difference between the net operating asset return and borrowing cost. Hou *et al.* (2018) again composed *Rna* by the product of profit margin (*Pm*) ∗ asset turnover (*Ato*). *Rna* uses *EBIT* (*Earnings before interest and tax*) divided by net operating asset (*Noa*) one year prior. For example, *EBIT* for fiscal year $t-1$ is divided by net operating assets for *t*-2 years. Net operating assets are calculated as the difference between operating assets and operating liabilities as follows. Operating assets are total assets excluding cash and cash equivalents and short-term financial assets. Operating debt is the total assets excluding liquid long-term liabilities (treated as 0 if not present) and non-current liabilities (treated as 0 if not present), minority shareholders' equity (treated as 0 if not), and preferred capital (treated as 0 if not) and common stock capital. *Noa* uses net operating assets divided by total assets from one year prior. *Pm* is calculated by dividing the *EBIT* for $t-1$ fiscal year by the sales for

$t-1$ year. *Ato* is the sales of $t-1$ fiscal year divided by the net operating assets of *Noa* of $t-2$. At the end of every t year of June, we construct each decile portfolio based on *Rna*, *Pm* and *Ato* of fiscal year $t-1$. Each portfolio is invested from the beginning of July of t to the end of June of $t+1$, and rebalanced in June of $t+1$. In the portfolio composition, companies with no positive net operating assets (*Noa*) in *t*-2 are excluded.

A.4.6 Capital turnover (Haugen and Baker, 1996)
At the end of every t year of June, we construct a decile portfolio based on the ratio of sales in fiscal year $t-1$ divided by total assets in fiscal year $t-2$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.7 Gross profits-to-assets (Novy-Marx, 2013)
We calculate *Gpa* by subtracting the cost of sales from the sales in $t-1$ fiscal year and dividing by the total assets in $t-1$ fiscal year (Novy-Marx, 2013). At the end of June of each year, a decile portfolio is constructed based on *Gpa* calculated based on information from $t-1$ fiscal year. Each portfolio is invested from the beginning of July of t to the end of $t+1$ of June, and rebalanced in $t+1$ of June.

A.4.8 Gross profits-to-lagged assets
We calculate *Gla* by subtracting the cost of sales from the sales in $t-1$ fiscal year, and dividing it by the total assets in $t-2$ fiscal years one year prior (Novy-Marx, 2013). At the end of June of each year, we construct a decile portfolio based on *Gla* calculated based on information from $t-1$ fiscal year. Each portfolio is invested from the beginning of July of *t*to the end of $t+1$ of June, and rebalanced in $t+1$ of June.

A.4.9 Operating profits to equity (Fama and French, 2015)
The operating profits (*Ope*) is the total amount of sales minus the cost of sales (processed as 0 if absent), *SG&A* (processed as 0 if absent), and interest expenses (processed as 0 if absent) divided by the book equity. (Fama and French, 2015). At the end of every t year of June, we construct a decile portfolio based on the *Ope* calculated based on the information in the fiscal year $t-1$.Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.10 Operating profits to lagged equity
The operating profits (*Ope*) is the total amount of sales minus the cost of sales (processed as 0 if absent), *SG&A* (processed as 0 if absent), and interest expenses (processed as 0 if absent) divided by the one year prior book equity. (Fama and French, 2015). For example, if the sales, *SG&A* expenses and interest expenses for the fiscal year *t*-1 are used, it is divided by the total capital of *t*-2 minus the capital stock of preferred stock. At the end of every t year of June, we construct a decile portfolio based on the *Ole* calculated based on the information in fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.11 Operating profits-to-assets
We calculate *Opa* by subtracting the cost of sales (processed as 0 if absent) and SG and A (processed as 0 if absent), and adding R&D costs (processed as 0 if not), divided by total assets for the same fiscal year. At the end of every t year of June, we construct a decile portfolio based on the *Opa* calculated based on the information in the fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.12 Operating profits-to-lagged assets

Ola is the total sales minus the cost of sales (processed as 0 if absent) and SG and A (processed as 0 if absent), plus the R&D cost (processed as 0 if not), divided by the total assets for the fiscal year one year prior. At the end of every t year of June, we construct a decile portfolio based on *Ola* (divided by total assets for $t-2$) calculated based on the information in fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.13 Cash-based operating profitability (Ball et al., 2016)

Cop is the cash-based operating profitability, calculated as follows. First, excluding the cost of sales and SG and A expenses from the total sales, R and D expenses (if zero) are added, the amount of changes in the receivables, changes in inventories, and changes in prepaid costs are subtracted. Add the amount of change in deferred cost. Subsequently, this value is divided by total assets, where total assets use the same fiscal year values as other accounting variables.

$$\begin{aligned}&\text{Total Sales} - \text{Cost of Sales} - \text{SG \& A Cost} + \text{R \& D Cost} - \Delta\ \text{Receivables}\\&\quad - \Delta\ \text{Inventory Assets} - \Delta\ \text{Upfront Cost} + \Delta\ \text{Earnings}\\&\quad + \Delta\ \text{Trade Payables} + \Delta\ \text{Deferred Costs}\end{aligned}$$

All of the above changes are treated as zero if there are missing values. At the end of every t year, we construct a decile portfolio based on the *Cop* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.14 Cash-based operating profits-to-lagged assets

Cla is the cash-based operating profitability, calculated as follows. First, excluding the cost of sales and SG and A expenses from the total sales, R&D expenses (if zero) are added, the amount of changes in the receivables, changes in inventories, and changes in prepaid costs are subtracted. Add the amount of change in deferred cost. Then, this value is divided into total assets, where the total assets use the value of the fiscal year one year earlier than other accounting variables. For example, if the operating profit of $t-1$ is used, it is divided by the total assets of $t-2$.

$$\begin{aligned}&\text{Total Sales} - \text{Cost of Sales} - \text{SG \& A Cost} + \text{R \& D Cost} - \Delta\ \text{Receivables}\\&\quad - \Delta\ \text{Inventory Assets} - \Delta\ \text{Upfront Cost} + \Delta\ \text{Earnings}\\&\quad + \Delta\ \text{Trade Payables} + \Delta\ \text{Deferred Costs}\end{aligned}$$

All of the above changes are treated as zero if there are missing values. At the end of every t year, we construct a decile portfolio based on the *Cla* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.15 F (fundamental score, Pitroski, 2000)

The ***F* score** of Piotroski (2000) is calculated as follows:

$$\begin{aligned}F &= F_{Roa} + F_{dRoa} + F_{Cf/A} + F_{Acc} + F_{dMargin} + F_{dTurn} + F_{dLever}\\&\quad + F_{dLiquid} + Eq\end{aligned}$$

The signals for each fundamental are divided into 1 and 0, depending on the impact on future stock prices and profitability. That is, the scores of the individual signals are both 1 and 0. The F-score appears as a sum of nine signals and measures the overall level of the company's financial position. Nine signals measure profitability, liquidity and operating efficiency of a company's financial condition.

To measure profitability, the following four signals are used.

(1) *Roa* is continuous operating profit divided by book value. F_{Roa} is a dummy variable that has a value of 1 if *Roa* is positive.

(2) d*Roa* is the change amount of *Roa* compared to the previous year. *FdRoa* is a dummy variable that is 1 if d*Roa* is positive (+), or 0 otherwise.

(3) *Cf/A* is the operating cash flow divided by the book value. $F_{Cf/A}$ is a dummy variable with 1 if *Cf/A* is positive and 0 otherwise.

(4) F_{Acc} is a dummy variable that is 1 if *Cf/A* lager than *Roa* else 0.

Two signals are used to measure operating efficiency.

(1) The gross profit ratio is the gross profit divided by sales. *dMargin* is the amount of change in the gross profit ratio compared to the previous year. $F_{dMargin}$ is 1 if *dMargin* is positive and 0 if not.

(2) The turnover of assets is the total sales divided by the total assets of the previous year. *dTurn* is the amount of change in asset turnover compared to the previous year. F_{dTurn} is 0 if the asset turnover is 1 if it is positive.

Three signals are used to measure liquidity.

(1) *dLever* is the total debt divided by the average of current assets and total assets one year prior. F_{dLever} is 1 or 0 if *dLever* is negative.

(2) *dLiquid* is the amount of change in the flow rate compared to the previous year. The current ratio is calculated by dividing current assets by current liabilities. $F_{dLiquid}$ is 0 if *dLiquid* is positive and 1 if not.

(3) *Eq* is 0 if not issued for common stock in the year.

At the end of June every t year, we construct a decile portfolio based on the F Score of year $t-1$. Extreme values have low specific gravity, so extreme values such as Low (F = 0,1,2), 3, 4, 5, 6, 7, and High (F = 8,9) are grouped to form a portfolio. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.16 O (O-score, Dichev, 1998; Ohlson, 1980)

Ohlson's (1980) O-Score is calculated as follows:

$$O = -1.32 - 0.407\log(AT) + 6.03\frac{DEBT}{AT} - 1.43WC + 0.076\frac{CL}{CA} - 1.720ENEG$$

$$-2.37\frac{NI}{AT} - 1.83\frac{FU}{TL} + 0.285\,INTWO - 0.521CHIN$$

Where AT represents total assets, *DEBT* represents total debt, and *WC* represents working capital. *CL* is current liability and *CA* is current assets. *OENEG* is a dummy variable that is 1 if the total debt exceeds the total asset, or 0. *NI* is net income and *FU* is operating cash flow. *INTWO* is a dummy variable with 1 or 0 if the net profit is less than 0 in the last 2 years, and *CHIN* is $\frac{(\mathrm{NI}_t - NI_{t-1})}{(|NI_t| - |NI_{t+1})}$. For each independent variable except dummy variable, Windsorization is applied at the upper and lower

1% level by year. At the end of every t year, we construct a decile portfolio based on the O-Score of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.17 Z (Z-score, Dichev, 1998; Altman, 1968)
The Z-Score of Altman (1968) is calculated as follows:

$$Z = 1.2\frac{WC}{AT} + 1.4\frac{RE}{AT} + 3.3\frac{EBIT}{AT} + 0.6\frac{ME}{TL} + \frac{SALE}{AT}$$

Here, AT represents total assets and WC represents working capital. RE is the retained earnings, ME is the market cap, and TL is the total liability. $SALE$ means sales. For each independent variable except the dummy variable, Windsorization is applied at the upper and lower 1% level by year. At the end of every t year, we construct a decile portfolio based on the *Z–Score* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.18 Taxable income-to-book income (Lev and Nissim, 2004)
At the end of every t year, we construct a decile portfolio based on the ratio of the pre-tax continuing business profit for the $t-1$ fiscal year divided by the net income for the $t-1$ fiscal year. If the profit before continuing business or net profit is negative (-), it is excluded from portfolio composition. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.4.19 Book leverage (Fama and French, 1992)
Bl is the book value-based leverage, which is the total asset divided by the capital stock minus preferred stock capital. At the end of every t year of June, we construct a decile portfolio based on *Bl* in fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5 Intangibles
A.5.1 Advertising expense-to-market (Chan et al., 2001)
At the end of every t year, we construct a decile portfolio based on the ratio of the advertising expenses for the fiscal year t-1 divided by the market cap in December $t-1$. Only companies that recorded positive advertising expenses are included in the portfolio composition. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.2 Growth in advertising expense (Lou, 2014)
At the end of every t year of June, we construct a decile portfolio based on the growth rate of advertising expenses from fiscal year t-2 to fiscal year $t-1$. Only companies that have recorded at least 100 million advertisement expenses are included in the portfolio composition. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.3 rdm (R&D expense-to-market, Chan et al., 2001)
At the end of every t year of June, we construct a decile portfolio based on the ratio of the research and development expenses for the fiscal year $t-1$ divided by the market cap in December t-1. Only companies with positive R&D expenses are included in the portfolio composition. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.4 rds (R&D expenses-to-sales, Chan et al., 2001)

At the end of June of every t year, we construct a decile portfolio based on the ratio of R&D expenditure in fiscal year t divided by sales in $t-1$ year. Only companies with positive R&D expenses are included in the portfolio composition. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.5 Operating leverage (Novy-Marx, 2011)

Operating leverage (*Ol*) is calculated by dividing operating expenses by total assets for the same fiscal year (Novy-Marx, 2011). The operating cost is the cost of sales plus the SG and A cost. At the end of every t year of June, we construct a decile portfolio based on operating leverage (*Ol*) for the fiscal year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.6 Hn (hiring rate, Belo et al., 2014)

The employment rate (*Hn*) is calculated as follows. $Hn = (N_{t-1} - N_{t-2})/(0.5N_{t-1} + 0.5N_{t-2})$, Here, N_{t-j} represents the number of employees in the t-j year. At the end of every t year of June, we construct a decile portfolio based on the employment rate (*Hn*) of year t-1. In this case, companies with zero employment rate (*Hn*) are excluded. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.7 rca (R&D Capital-to-assets, Li, 2011)

Following the method suggested by Li (2011), the R&D capital $R\&DC_{i,t}$) is estimated as follows.

$$R\&DC_{i,t} = R\&DX_{it} + 0.8R\&DX_{it-1} + 0.6R\&DX_{it-2} + 0.4R\&DX_{it-3} + 0.2R\&DX_{it-4}$$

$R\&DX_{i,t-j}$ denotes the research and development expenses of the company t-j year. In other words, R&D expenditure is accumulated by decreasing by 20% in the past 5 years as R&D capital. *Rca* is the estimated $R\&DC_{i,t}$ divided by total assets. At the end of June of every t year, we construct a decile portfolio based on the *Rca* of year $t-1$. We include only companies with positive $R\&DC_{i,t\text{-values}}$. In addition, only those companies with R&D expenditures for the fiscal year $t-1$ are included, because the most recent R&D expenditure is the largest. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.8 Age_{Found}, Age_{List} (firm age, Jiang et al., 2005)

The age of the company (Age_{Found}) is the number of months from the date of composing the portfolio to the date of establishment of the company (Jiang *et al.*, 2005). Age_{List} is the number of months from the date of composing the portfolio to the date of listing on the company. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.9 dSi (per cent change in sales minus per cent change in inventory, Abarbanell and Bushee, 1998)

dSi is the difference between per cent change in sales over two years and per cent change in inventory. The percent change in sales $(SALE_t - E[SALE_t])/E[SALE_t]$, E[SALE_t] $=(SALE_{t-1} + SALE_{t-2})/2$. The change in per cent of inventory is similar $(INVENTORY_t - E[INVENTORYt])/E[INVENTORY_t]$, $E[INVENTORY_t] = (INVENTORY_{t-1} + INVENTORY_{t-2})/2$. *SALE* is sales, *INVENTORY* is inventory. For portfolio composition, companies with negative average sales or average inventory over the past two years are excluded. At the end of every t year of June, we construct a deciles portfolio based on the *dSi* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.10 dSa (percent change in sales minus percent change in accounts receivable, Abarbanell and Bushee, 1998)
dSa is the difference between the percent change in sales over the two years and the percent change in sales receivables. The percent change in sales($SALE_t$–$E[SALE_t]$)/$E[SALE_t]$, $E[SALE_t]$=($SALE_{t-1}$+$SALE_{t-2}$)/2. The change in percent of receivables is similar (AR_t–$E[AR_t]$)/$E[AR_t]$, $E[AR_t]$=(AR_{t-1}+AR_{t-2})/2. *SALE* is sales, AR is a trade receivable. For portfolio composition, companies with negative average sales or average receivables over the past two years are excluded. At the end of every t year of June, we construct a deciles portfolio based on the dSa of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.11 Gs (percent change in gross margin minus percent change in sales), Abarbanell and Bushee, 1998)
dGs is the difference between the percent change in gross profit and the percent change in sales for two years. First, the percent change in sales is ($SALE_t$ – $E[SALE_t]$)/$E[SALE_t]$, $E[SALE_t]$= ($SALE_{t-1}$+$SALE_{t-2}$)/2. Percent (per cent) change in gross profit is calculated likewise (GM_t–$E[GM_t]$)/$E[GM_t]$, $E[GM_t]$=(GM_{t-1}+GM_{t-2})/2. *SALE* is sales, *GM* is gross profit, which is the cost of sales minus the cost of sales. When constructing a portfolio, companies with average sales or average gross profit in the past two years are excluded. At the end of every t year, we construct a declie portfolio based on the *dSa* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.12 dSs, (percent change in sales minus percent change in SG&A, Abarbanell and Bushee, 1998)
dSs is the difference between the percent change in sales over the two years and the percent change in SG and A expenses. First, the percent change in sales is ($SALE_t$–$E[SALE_t]$)/$E[SALE_t$, $E[SALE_t]$= ($SALE_{t-1}$+$SALE_{t-2}$)/2. The change in SG and A expenses is similar (SGA_t_$E[SGA_t]$)/$E[SGA_t]$, $E[SGA_t]$ = (SGA_{t-1}+SGA_{t-2})/2. *SALE* is sales, SGA is minus SG and A. When forming a portfolio, companies with average sales or average SG and A expenses for the past two years are excluded. At the end of every t year, we construct a decile portfolio based on the *dSs* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.13 lfe (labor force efficiency, Abarbanell and Bushee, 1998)
The workforce efficiency, *Lfe*, is calculated as follows. (Abarbanell and Bushee, 1998).

$$Lfe_t = \left[\frac{SALE_t}{EMPLOYEES_t} - \frac{SALE_{t-1}}{EMPLOYEES_{t-1}}\right] / \frac{SALE_{t-1}}{EMPLOYEES_{t-1}}$$

SALE indicates sales, while *EMPLOYEES* is the number of employees. At the end of June of every t year, we construct a decile portfolio based on the *Lfe* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.14 Tangibility, Hahn and Lee, 2009)
Tangibility (*Tan*) is calculated as follows according to Hahn and Lee (2009):

$$\text{Cash and cash equivalents } + 0.715 \times \text{Trade receivables } + 0.547 \times \text{Inventory assets} \\ + 0.535 \times \text{Tangible assets (PPE)}$$

Then, it is divided by total assets to calculate *Tan*. At the end of June of every t year, we construct a decile portfolio based on the *Tan* of year $t-1$. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.5.15 ala, alm (asset liquidity, Ortiz-Molina and Phillips, 2014)
Asset liquidity is estimated as follows:

$$CASH \ + 0.75 \times NON\ \ CASH\ \ CURRRENT\ \ ASSET + 0.5 \times TANGIBLE\ \ FIXED\ \ ASSET$$

CASH includes both cash and cash equivalents and short-term financial assets, and non-cash current assets (NON CASH CURRENT ASSET) are the current assets minus CASH. Tangible fixed assets (TANGIBLE FIXED ASSET) are the total assets minus current assets and goodwill (if not present, treated as 0), and intangible assets (if not present, treated as 0). *Ala* is the asset liquidity divided by the total asset one year prior. *Alm* divides asset liquidity by the market value of the asset one year prior. The market value of an asset is the sum of its market capitalization and the total capital (book value) minus it. At the end of every t year of June, we construct a decile portfolio based on *Ala* and *Alm* of $t-1$ year. Each portfolio is invested from the beginning of July t to the end of June $t+1$, and rebalanced in June $t+1$.

A.6 Trading frictions

A.6.1 Ivff1, Ivff6, Ivff12 (idiosyncratic volatility per the FF three-factor model)
Ivff is the standard deviation of the residual term calculated by regression analysis with the intrinsic volatility from the Fama and French three-factor model, the excess return of each month as a dependent variable, and the market factor, scale factor, and value factor return as independent variables. When estimating intrinsic volatility, include only stocks with observations of at least 15 days. At the end of each month, a decile portfolio is formed based on *Ivff*. Each portfolio is rebalanced monthly. If the retention period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period(*Ivff*6), The returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.2 Ivc1, Ivc6, Ivc12 (idiosyncratic volatility per the CAPM)
Ivc is the standard deviation of the residual term calculated by regression analysis using the intrinsic volatility from CAPM, the excess return of each month stock as a dependent variable, and the market excess return as an independent variable. When estimating intrinsic volatility, only stocks with observations for at least 15 days are included. At the end of every month, a decile portfolio is formed based on *Ivc*. Each portfolio is rebalanced monthly. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Ivc*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.3 Tv1, Tv6, Tv12 (total volatility)
Tv is the total volatility, which is the standard deviation of stock returns for every t month. When estimating total volatility, only stocks with observations of at least 15 days are included. At the end of every month, a decile portfolio is formed based on *Tv*. Each portfolio is rebalanced monthly. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of

$t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the retention period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period ($Tv6$), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

*A.6.4 **β1, β6, β12** (market beta, Fama and MacBeth, 1973)*

At the end of every t-1 month, market beta β is estimated as monthly returns from t-June to t-1 month five years and includes only stocks with at least 24 months of observations. Market beta β is the coefficient value of regression analysis, where the excess return of a stock is the number of dependent stars and the excess return of the market is an independent variable. At the end of every $t-1$ month, a decile portfolio is formed based on the market beta β. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period ($\beta 6$), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

*A.6.5 **β^{FP}**1, **β^{FP}**6, **β^{FP}**12 (Frazzini and Pedersen, 2014)*

β^{FP} is calculated as follows according to Frazzini and Pedersen (2014). β^{FP} is $\hat{\rho}\,\hat{\sigma}_l/\hat{\sigma}_m$, where $\hat{\sigma}_i$ and $\hat{\sigma}_m$ are the standard deviations of stock returns and market returns, respectively, and $\hat{\rho}$ is the correlation coefficient between the two. To estimate the volatility of the return, the standard deviation is estimated by using the rolling method of daily log return every 1 year. Only includes cases for which observations of at least 120 days are secured. To determine the return correlation, in this study, we overlap the log return for 3 days ($r_t^{3d} = \sum_{k=0}^{2} log\left(1 + r_{t+k}^{i}\right)$) and estimate using a rolling method with a 5-year window only if 750-day daily returns are available. At the end of every t-1 month, a decile portfolio is formed based on β^{FP}. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the retention period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period ($\beta^{FP}6$), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

*A.6.6 **β^{D}**1, **β^{D}**6, **β^{D}**12 (Dimson beta, Dimson, 1979)*

β^{D} is calculated as follows according to Dimson (1979):

$$\beta^{D} = \hat{\beta}_{i1} + \hat{\beta}_{i2} + \hat{\beta}_{i3}$$

$$r_{id} - r_{fd} = \alpha_i + \beta_{i1}(r_{md-1} - r_{fd-1}) + \beta_{i2}(r_{md} - r_{fd}) + \beta_{i3}(r_{md+1} - r_{fd+1}) + \epsilon_{id}$$

r_{id} is the return at point d of item i, r_{md} is the market return, and r_{fd} is the risk-free return. Based on β^{D} by the end of every t-1 month, we construct a decile portfolio only if at least 15 days of observations are obtained. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period ($\beta^{D}6$), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.7 $\boldsymbol{\beta}^{-1}$, $\boldsymbol{\beta}^{-6}$, $\boldsymbol{\beta}^{-12}$ (downside beta)

$\beta^{-}$is calculated as follows according to:

$$\beta^{-} = \frac{Cov(r_i, \ r_m \mid r_m < \mu_m)}{Var(r_m \mid r_m < \mu_m)}$$

r_i is the excess return of item i, r_m is the excess return of the market, μ_m is the average excess return of the market. Based on β^{-} for every $t-1$ month, 12 months from t-12 month to the end of t-1 month, a decile portfolio is constructed (only considering ($r_m < \mu_m$). Only cases for which at least 50 days of observations are available are included. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period ($\beta^{-}6$), The returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.8 Tur1, Tur6, Tur12 (share turnover)

The share turnover (*Tur*) uses the average daily turnover over the past six months and is calculated only if there are at least 50 observations. The daily turnover is calculated by dividing the trading volume by the number of listed shares. Every t-1 month, we construct a decile portfolio based on the *Tur* from the end of t-6 month to the end of t-1 month. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Tur*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.9 Cvt1, Cvt6, Cvt12 (coefficient of variation of share turnover)

Cvt uses the coefficient of volatility of the daily turnover over the past 6 months (the ratio of the standard deviation to the mean) and is calculated only if there are at least 50 observations. The daily turnover is calculated by dividing the trading volume by the number of listed shares. Every $t-1$ month, we construct a decile portfolio based on the *Cvt* from the end of $t-6$ month to the end of $t-1$ month. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Cvt*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.10 Dtv1, Dtv6, Dtv12 (dollar trading volume, Brennan et al., 1998)

Dtv uses the average daily trading volume for the past 6 months, and is calculated only when there are at least 50 observations. Every $t-1$ month, we construct a decile portfolio based on the *Dtv* from the end of $t-6$ month to the end of $t-1$ month. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Dtv*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.11 Cvd1, Cvd6, Cvd12 (coefficient of variation of dollar trading volume)

Cvd uses the coefficient of volatility of the transaction value over the past 6 months (the ratio of the standard deviation to the mean) and is calculated only if there are at least 50 observations. The daily trading volume is the stock price multiplied by the number of shares. Every *t*-1 month, we construct a decile portfolio based on the *Cvd* from the end of $t-6$ month to the end of $t-1$ month. The holding period of the decile portfolio is 1 month (until the end of *t* month), 6 months (from *t* month to the end of $t+5$ month), and 12 months (from *t* month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Cvd*6), The returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.12 Short-term reversal (Jegadeesh, 1990)

Srev uses a return of $t-1$ month. To be used in the decile portfolio every *t* month, it must have a valid price of $t-2$ months and a valid return of $t-1$ months. The monthly decile portfolio returns are calculated as the returns in *t* month and are rebalanced at the end of every *t* month.

A.6.13 Ami1, Ami6, Ami12 (absolute return-to-volume, Amihud, 2002)

Non-liquidity indicators by Amihud (2002), *Ami* is used by averaging the ratio of the absolute value of daily returns over the past six months divided by the daily trading volume. At this time, *Ami* is calculated only when there are at least 50 observations. Every $t-1$ month, we construct a decile portfolio based on the *Ami* from the end of $t-6$ month to the end of $t-1$ month. The holding period for the decile portfolio is 1 month (from the end of *t* month), 6 months (from *t* to end of *t* +5 month), and 12 months (from *t* to end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Ami*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.14 $Mdr^5$1, $Mdr^5$6, $Mdr^5$12, Mdr^{10}1, Mdr^{10}6, Mdr^{10}12 (average maximum daily return, Bali et al., 2011)

Mdr^5 represents the highest five−day average of the maximum daily returns during $t-1$ month and is calculated only when there are at least 15 observations. Mdr^{10} Represents the highest five-day average of the maximum daily returns during $t-1$ month and is calculated only when there are at least 15 observations. Every $t-1$ month, we construct a decile portfolio based on the *Mdr* from the end of *t*-6 month to the end of *t*-1 month. The holding period for the decile portfolio is 1 month (from the end of *t* month), 6 months (from *t* to end of $t+5$ month), and 12 months (from *t* end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Mdr*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.15 Ts1, Ts6, Ts12 (total skewness, Bali et al., 2016)

Ts represents the total skewness of the returns during $t-1$ month, and is calculated only when there are at least 15 observations. Every *t*-1 month, we construct a decile portfolio based on the *Ts* from the end of $t-6$ month to the end of *t*-1 month. The holding period of the decile portfolio is 1 month (until the end of *t* month), 6 months (from *t* month to the end of $t+5$ month), and 12 months (from *t* month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period(*Ts*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.16 Isc1, Isc6, Isc12 (idiosyncratic skewness – CAPM, idiosyncratic skewness per the CAPM)
Isc is the Idiosyncratic skewness from the CAPM, and is the skewness of the residual term calculated by regression analysis using the excess return of each month as a dependent variable and the market excess return as an independent variable. When estimating idiosyncratic skewness, only stocks with observations for at least 15 days are included. At the end of every month, a decile portfolio is formed based on *Isc*. Each portfolio is rebalanced monthly. The holding period of the decile portfolio is 1 month (until the end of t month), 6 months (from t month to the end of $t+5$ month), and 12 months (from t month to the end of $t+11$ month). If the holding period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Isc*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

A.6.17 Isff1, Isff6, Isff12 (idiosyncratic skewness per the FF three-factor model)
Isff is the Idiosyncratic skewness from the Fama and French three-factor model, and is the skewness of the residual term calculated by regression analysis using the excess returns of each month as dependent variables, and market factors, scale factors, and value factors returns as independent variables. Estimates of idiosyncratic skewness include only stocks with at least 15 days of observations. At the end of every month, a decile portfolio is formed based on *Isff*. Each portfolio is rebalanced monthly. If the retention period is longer than 1 month, the portfolio return is calculated as follows. For example, using a strategy of 6 months holding period (*Isff*6), the returns for each decile portfolio for each month use the simple average of the returns for the six decile portfolios starting in different months.

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