Lappeenranta-Lahti University of Technology

School of Business and Management

Strategic Finance and Business Analytics

Momentum – Volatility – Asset Growth in Helsinki Stock Exchange

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ABSTRACT

Author:	Niko Korhonen
Title:	Momentum – Volatility – Asset Growth in Helsinki Stock Exchange
Faculty:	School of Business and Management
Master's program:	Strategic Finance and Business Analytics
Year:	2021
Master's thesis:	Lappeenranta-Lahti University of Technology LUT 56 pages, 24 tables and 18 figures
Examiners:	Professor Eero Pätäri
Keywords:	Helsinki stock exchange, momentum, volatility, asset growth, CAPM, market efficiency, stock market anomalies

The purpose of this thesis is to research the relationship between momentum, volatility and firm-specific asset growth expansion in Helsinki stock exchange. In addition, this thesis is motivated by the idea to challenge the strongest form of efficient market hypothesis. The study focuses on the univariate and multivariate portfolio analysis.

The literature review of this study introduces the most relevant concepts of financial theory, efficient market hypothesis (EMH) and capital asset pricing model (CAPM). This chapter also introduces momentum, volatility and asset growth anomaly theories and previously made anomaly studies. The empirical part of the study follows portfolio construction methodologies used by Jegadeesh & Titman, Baker & Haugen and Cooper, Gulen & Schill.

The results of this study show that momentum and volatility anomaly based trading strategies have offered interesting opportunities to beat the market. High momentum combined with low volatility seems to be a key to deliver persistent excess returns as this multi-factor based combination has annualized excess return of 15.06 % and superior sharpe-ratio in 1991-2019.

In addition, this study found a non-linear relationship between risk and return, which challenges CAPM, as it is an insufficient pricing model to explain asset price returns. Moreover, as these multi-factor portfolio excess returns have not disappeared, we can conclude that the stock market in Helsinki stock exchange is not strongly efficient.

TIIVISTELMÄ

Tekijä:	Niko Korhonen
Otsikko:	Momentum – Volatility – Asset Growth Helsingin pörssissä
Tiedekunta:	School of Business and Management
Maisteriohjelma:	Strategic Finance and Business Analytics
Vuosi:	2021
Pro gradu – tutkielma:	Lappeenrannan-Lahden teknillinen yliopisto LUT
	56 sivua, 24 taulukkoa ja 18 kuvaa
Tarkastajat:	Eero Pätäri
Hakusanat:	Helsingin pörssi, momentum, volatiliteetti, taseen kasvu, CAPM, markkinatehokkuus, osakemarkkina-anomaliat

Tämän tutkielman tavoitteena on tutkia momentumin, volatiliteetin ja taseen kasvun välistä yhteyttä Helsingin pörssissä. Tutkielma haastaa tehokkaan markkinan määritelmän keskittyen yhden ja useamman muuttujan portfolioanalyysiin.

Tutkielman kirjallisuuskatsaus esittelee työn kannalta olennaisimmat rahoitusteorian käsitteet, markkinatehokkuuden määritelmän ja capital asset pricing- mallin. Kirjallisuuskatsaus tuo esiin myös momentumiin, volatiliteettiin ja taseen kasvuun liitännäiset anomaliateoriat ja aikaisemmat tutkimukset. Tutkielman empiirinen osa hyödyntää portfolioiden muodostus metodologiana Jegadeesh & Titman, Baker & Haugen ja Cooper, Gulen & Schill tutkimuksia.

Tutkielman tulokset osoittavat, että momentum- ja volatiliteettipohjaiset sijoitusstrategiat ovat tarjonneet mielenkiintoisia mahdollisuuksia ylituottoon. Korkean momentumin ja alhaisen volatiliteetin yhdistelmä näyttää tarjonneen ylivertaisia tuottomahdollisuuksia annualisoidun ylituoton ollessa 15.06 % tarkasteluperiodilla 1991-2019.

Lisäksi tutkielma löysi epälineaarisen suhteen tuoton ja riskin välillä. Tämä haastaa nykymuotoisen CAPM teorian ja sen oikeutuksen toimia osaketuottojen selittäjänä. Anomalioihin pohjautuvat ylituotot eivät kadonneet tarkasteluperiodilla. Näin voimme todeta, että Helsingin pörssi ei saavuta markkinatehokkuuden tehokkainta määritelmää.

Acknowledgements

This has been an amazing journey and I'm more than happy I decided to spend it at the LUT School of Business and Management. I would like to express my gratitude to my supervisor, Professor Eero Pätäri, who gave me many beneficial ideas along my master's thesis journey.

I wish to extend my special thanks to all wonderful people I met during my time in Lappeenranta. I'm more than happy to see that many of those relationships have become to stay.

Lastly, I would like to thank my lovely girlfriend Linda. I love you. You make me happy every day.

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List of Abbreviations

AMEX	American Stock Exchange
AG	Asset Growth
CAPM	Capital Asset Pricing Model
EMH	Efficient Market Hypothesis
MOM	Momentum
NYSE	New York Stock Exchange
SML	Security Market Line
VOL	Volatility

Introduction

Background

Few stock market anomalies are documented as comprehensively as momentum effect. Even after broad academic research the momentum effect has not disappeared. Momentum effect is a tendency for assets that have performed well (poorly) in the recent past to continue perform well (poorly) in near future. The momentum effect was first documented by Jegadeesh and Titman (1993) in strategy which buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generating significant positive returns over 3 to 12 month holding periods.

Academic world has found that the relationship between risk and return is not as positive as Sharpe (1964) and Lintner (1965) researched when Capital Asset Pricing Model (CAPM) was broadly accepted to present the linear relationship between risk and expected return. Already Black, Jensen and Scholes (1972) found that low risk assets provide better returns than CAPM security market line (SML) suggest and the empirical CAPM has higher intercept and less steep SML slope than CAPM theory says. The low-volatility anomaly has been proved to exist globally over the last five decades. Defensive stocks with lower-betas tend to outperform aggressive stocks with higher-betas. This assumption is a challenge for CAPM as higher risk should be compensated by higher return.

In this study, we will research the relationship between momentum, volatility and firm-specific asset growth expansion. Cooper, Gulen and Schill (2008) were the first to study firm-level asset investment effects in returns by studying the cross-sectional relation between firm asset growth and subsequent stock performance. They found a strong evidence predicting that companies with low asset growth tend to overperform companies with high asset growth. After the publication, asset growth (AG) has received substantial attention and has become significant and recognized anomaly in academic research.

This research is motivated by the idea to challenge the strongest form of efficient market hypothesis (EMH). Anomalies are empirical results that are inconsistent with financial theories of asset-pricing behavior. They indicate either that market is not efficient or the underlying asset-pricing model is insufficient to explain stock returns. Anomalies often tend to disappear, reverse or attenuate after research and documentation. This raises the question of whether these anomalies existed in the past and offered excess returns. Under the strongest form of EMH, fundamental analysis is useless, because the stock price is already reflecting all projected future cash flows. Thus, changes in asset growth should not provide systematic excess returns. In my knowledge, this is the first study to investigate the relationship between momentum, volatility and asset growth anomaly in Helsinki Stock Exchange.

Purpose of the study and research questions

The purpose of the study is to examine whether the momentum – volatility – asset growth multi-factor portfolio have been profitable in the Helsinki stock exchange.

The first research question is to see whether the winners keeps winning and whether long-only momentum strategies have generated economically and statistically significant excess returns during 1991-2019. Statistical significance is measured in a sense of Capital asset pricing model (CAPM) theory and regression statistics.

H0: Long-only high momentum strategies have generated economically and statistically significant excess return during 1991-2019.

As higher risk should be compensated with higher return, the second research question assumes that high volatility long-only strategies have outperformed low volatility long-only strategies.

H1: Long-only high volatility strategies have outperformed low volatility long-only strategies.

Lastly, the main interest behind of this thesis is to find out how multi-factor portfolios have performed in Helsinki stock exchange. As the academic consensus seems to be that high momentum – low volatility and low asset growth anomalies do exist individually, the third research question tests whether multi-factor portfolios based on these assumptions together have generated economically and statistically significant excess returns during 1992-2019.

H2: Long-only high momentum – low volatility and low asset growth multi-factor portfolios have generated economically and statistically significant excess returns during 1992-2019.

Structure of the study

The study is organized as follows. The Literature review will go through most relevant concepts of financial theory, efficient market hypothesis (EMH) and capital asset pricing model (CAPM). Both of these are the foundation of this study. This chapter will also introduce momentum, volatility and asset growth theories and previously made anomaly studies. After that, data and methodology chapter will give more insight before univariate anomaly calculations are computed. In addition, multivariate portfolios are formed. Finally, research questions are answered and conclusions conclude the study with limitations.

Literature review

The idea that financial markets follow random-walk hypothesis and exclude the opportunity to make excess returns has been the foundation of modern economics. One of the most influential moments in financial theory happened when Eugene Fama introduced The efficient market hypothesis (EMH) in the early 1960s.

The capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) states that there is a linear relationship between the return on a security and the security's beta measured relatively to the market portfolio. However, according to Basu (1977), Banz (1981), Jagedeesh (1990) and Fama and French (1992) cross-sectional differences in average returns are not only determined by the market risk, but also by prior return, book-to-market and firm-level market capitalization.

The Efficient Market Hypothesis

Random-walk theory

The concept of market efficiency has been known since Bachelier (1900) recognized in his dissertation, that past, present and discounted future events are reflected in market prices, but often are not related to price changes. He also continued that if the market does not predict its fluctuations, it assumes them being more or less likely, and this probability can be mathematically estimated. Studies by Working (1934) and Cowles and Jones (1937) came also to conclusion that US stock prices and other economic series share these features.

Cowles (1933) also found that there was no apparent evidence to outperform the market. These insights gave significant contribution for the second half of the century, where many analytical theories and results were discovered. The assumption of economists was that “economic time series could be analyzed by extracting from it a long-term movement or trend for separate study and then scrutinizing the residual portion for short-term oscillatory movements and random fluctuations” (Kendall, 1953). Kendall examined stock and commodity prices and was surprised that his observations came together with not yet known Random-walk theory.

Roberts (1959) challenged practitioners when he examined that a time series generated from a sequence of random numbers was indistinguishable in US stock prices. Osborne (1959) applied the methods of statistical mechanism to stock market, after analyzing that common stock prices have properties analogous to the movement of molecules as in physics. Despite all the emerging evidence on behalf of randomness of stock price changes, there were occasional patterns of anomalous price behavior (Dimson & Mussavian 2000). Working (1960) and Alexander (1961) discovered that autocorrelation could be induced into returns series as a result of using time-averaged security prices. Fama (1965) concludes in his doctoral dissertation that “it seems to safe to say that this paper has presented strong and voluminous evidence in favour of the random walk hypothesis”. Samuelson (1965) emphasized that in competitive markets if someone assumes that the price is going to rise, it would have already risen and there is a buyer for every seller. He continued, that people should be expected in a sense of rationality to forecast future events before they happen and was surprised that the theorem is so obvious and simple.

Harry Roberts (1967) identified and divided efficient market to weak and strong form and Fama (1970) defined an efficient market as one where on available information fails to provide excess returns, therefore, efficiency needs to be proved by testing a model. He assembled an extensive review of the evidence and theory of market efficiency.

The strongest form of market efficiency is valid, when all information is reflected to stock prices instantaneously. It is impossible to beat the market and the area of portfolio management is fruitless after transaction costs has been noticed. Adaptive market hypothesis offers a new framework to explain, why several previous studies have proved market inefficiency in financial markets. It provides behavioral alternatives to market efficiency by applying the principles of evolution. Andrew Lo (2004) argued that much of what behavioralists cite as counterexamples to economic rationality – loss aversion, overconfidence and other behavioral biases are in fact, consistent with evolutionary model of individuals who are trying to adapt in to changing environment via heuristics.

Grossman and Stiglitz (1980) argues that if competitive equilibrium is situation where all arbitrage profits are eliminated, it is not clear whether the competitive economy will always be in equilibrium. Those who spend resources to obtain information do receive a compensation and when informed individuals observe information, they maintain the price system. Lo and MacKinlay (1987) strongly rejected the random walk model and papers by De Bondt and Thaler (1985, 1987) show that stock prices overreact to information. Buying past losers and selling past winners based on stock return in the previous week or month generate significant abnormal returns.

Principles of Corporate Finance is a book that describes the theory and practice of corporate finance. The latest published edition is number 12. Professor Robert Shiller told an interesting fact about the book during his lecture in Yale University in 2011. The opinion of market efficiency has totally changed over years. In the first editions Stuart Myers described market efficiency to be in form when security prices accurately reflect the available information and respond rapidly to new information as soon it becomes available. This definition has changed to “Much more research is needed before we have a full understanding of why asset prices sometimes get so out of line with what appears to be their discounted future payoffs (Brealey et al. 2011, 871). These findings attract a great deal of interest to research, what is the role of heuristic behavior in stock markets.

Capital asset pricing model (CAPM)

The capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965) is the most known asset pricing theory. CAPM is based on the Markowitz’s (1959) mean-variance model, where investors 1) minimize the portfolio variance on a given level of expected return and 2) maximize the expected return on given level of variance. The CAPM is still widely used and the most common and well-known asset pricing model. Still, it has never managed successfully explain the relationship between risk and return. Fama and French (2004) concluded that even though old and new empirical studies fail to capture expected returns estimated by CAPM, it is still a good base to be built on more complicated asset pricing models and fundamental based concepts of portfolio theory. But they also warn that despite its relatively easy to understand, CAPM's empirical problems most likely prevent its reliable use in practice.

The theory of CAPM is based on a positive relationship between risk and return. Higher risk provides higher return. Beta coefficient (β) is a measure of volatility i.e. it demonstrates a systematic part of risk. Market portfolio beta equals 1. If an individual stock beta is over 1, it goes up more than its benchmark when the benchmark goes up. Thus, the investment has more systematic risk than the market portfolio. Contrariwise, if an individual stock beta is lower than 1, it rises less than its benchmark when the benchmark is having upside. Thus, the investment has less systematic risk than the market portfolio. If an individual stock has the same beta of 1 as the market portfolio, it has the same the amount of systematic risk and fluctuates hand in hand with the benchmark. If we assume that the unsystematic risk can be fully minimized by diversification, then based on capital asset pricing model, higher portfolio beta and volatility is the only measure for explaining higher expected returns.

The CAPM equation:

$$ER_i = R_f + \beta_i (ER_m - R_f)$$

Where:

ER_i = *Expected return*

R_f = *Risk-free rate*

β_i = *Beta*

$(ER_m - R_f)$ = *Market risk premium*

Financial market anomalies

Momentum anomaly

By definition, momentum anomaly refers to the empirically proved tendency of rising asset prices to continue outperforming, whereas falling asset prices continue underperforming in the near term.

Jegadeesh and Titman (1993) showed that profitability of momentum strategies are not due to their systematic risk or to delayed stock price movements to common factors. They also documented that part of these returns generated within the first year after portfolio formation disappear during the following two years. Their paper analyzed NYSE and AMEX stocks trading strategies over 3 to 12 month horizons from 1965 to 1989 and the most examined trading strategy which selects stocks based on their past 6 month return and holds them for the next 6 months, realized a compounded excess return of 12.01% yearly on average. Earlier Jegadeesh (1990) and Lehmann (1990) evidenced shorter-term return reversals. Their papers proved contrarian strategies in stock selection based on previous week or month performance to generate significant returns. However, based on the relatively small time period and transaction intensity, these abnormal returns were more likely caused by lack of liquidity or short-term price pressure rather than overreaction. Momentum profits continued existing in the 1990s, when Jegadeesh and Titman (2001) suggested, that their earlier paper results were not biased by data snooping.

Substantial amount of evidence has been found to support that stock prices do not follow random walk theory. The momentum effect has been strongly researched theme in academic world, after Jegadeesh and Titman (1993) first published their paper. Moskowitz and Grinblatt (1999) documented that momentum strategies are significantly less profitable after controlling industry momentum and industry momentum strategies outperform individual stock momentum strategies. Thus, individual stock returns would be driven by the industry momentum. Barberis, Shleifer and Vishny (1998) researched how investors form beliefs. Their model proves how an individual fails to make judgements under uncertainty. Their findings are also related to behavioral biases and conservatism. News are incorporated slowly into prices and people tend to underreact to the news over short horizon of for example 1-12 months and overreact to the news over longer horizon.

Daniel, Hirshleifer and Subrahmanyam (1998) proposed that market under- and overreactions are based on investor overconfidence to private information and biased self-attribution. Based on their theory, an overconfident investor overestimates his own ability to analyze information and contrary, underestimates publicly available information. They found that overconfident investor causes the stock price overreaction and when the publicly available information arrives, the price does get normalized on average at least partially.

Also in Hong and Stein (1999) traders slowly adjust their opinions when the new information comes. Their model assumes that there are two type of investors in the markets; "Newswatchers" and "Momentum Traders". Neither one is fully rational. Newswatchers are trying to get an edge by trying to fundamentally benefit from the coming information. Thus, they have their own private opinions which diffuses gradually. They act first before momentum traders and because of different opinions, prices adjust slowly when the new information occurs. Consequently, market behavior is always underreaction and never overreaction. Momentum traders base their conditions on past price changes. Thus, when the market reaction is underreaction, momentum traders arbitrage away any remaining underreaction. Early momentum buyers get excess returns before trading moves prices over long-run equilibrium, and consequently late momentum cycle buyers face downside as the price is already above its long-run equilibrium.

Hong, Lim and Stein (2000) tested momentum stock returns and found that once firm size increases from the smallest one, the profitability of momentum strategies face a great decline. According to them, momentum strategies are most valuable among stocks with less analyst research coverage. George and Hwang (2004) argued stock's current price explains a major part of the profits in momentum anomaly. Nearness to the 52-week high level is more dominant factor than past returns. They compared three different momentum strategies. The first strategy measured individual past stock price performance and took long position in the top 30 % performance stocks and short position in the bottom 30 % performance stocks. This strategy was the same as used by Jegadeesh et al. (1993) when they made the first academic research related to momentum anomaly. The second strategy measured past industry price performance and took long position in the top 30 % performance industries and short position in the bottom 30 % performance industries. Industry momentum was earlier documented as an outperforming strategy against individual momentum anomaly by Moskowitz et al. (1999). The third strategy developed by George et al. (2004) measured stock price distance to its 52-week high and took long position in stocks whose current price was close to its 52-week high and short position in stocks whose current price was far from the 52-week high. Returns from the third strategy were about twice as much as returns from the individual or industry sample. Moreover, George et al. (2004) argued that traders anchor themselves in certain price levels and 52-week high is a great reference point to this assumption. When positive information arrives and pushes stock price to a new 52-week high or near to it, the price is reluctant to rise further even though the information would encourage it to rise more. In the long run the information prevails and the stock price rises further. In contrary, when negative news pushes stock price far away from its 52-week high, traders resist to sell the stock and the price stays higher than the new information would encourage it stay. In the long run the information prevails again and the stock falls lower. In addition, Grinblatt and Keloharju (2001) found same kind of price level trading patterns in Finnish stock market. An investor wants to sell stocks that are historically high and keep or buy stocks that are historically low.

Grinblatt and Moskowitz (2004) found that being a consistent winner stock and the past pattern of returns has significant power in explaining the cross-section of future returns. Surprisingly being a consistent loser seemed to be irrelevant regarding to future returns. Moreover, being a consistent winner in top momentum decile can double up the firm specific future returns. Fama and French (2008) investigated separately microcaps, small stocks and large stocks to gather new insights. They found that the relation between momentum anomaly and average returns is equal to small stocks and large stocks but for microcaps it is just half as strong. Fama and French (2012) examined stock anomalies in North America, Europe, Japan and Asia Pacific and found momentum anomalies everywhere else except in Japan. In addition, they found that spreads in momentum returns are wider in small stocks than large stocks and that asset pricing models, even local ones are not successful explaining size or momentum returns.

Novy-Marx (2012) investigated that momentum anomaly is mainly driven by stocks past performance from 7-12 months before portfolio allocation. Shorter run momentum generates excess returns, but is less profitable, particularly among large cap stocks. Israel and Moskowitz (2013) examined U.S stock market using data from 1926 to 2011 and international markets and other asset classes from 1972 to 2011. They found momentum premium in different size groups, even in every 20-year subsample, and small amount of evidence momentum strategy being significantly stronger among small stocks in U.S market. In addition, they found that short selling becomes less profitable for momentum when firm size decreases.

Barroso and Santa-Clara (2015) studied that unconditional momentum has a huge risk to crash, but the risk is manageable. Even though Jegadeesh and Titman (1993) found that momentum winners outperform momentum losers by 1.49 % monthly, momentum faces incidental crashes that that makes a long recovery time. This happened in 1932 when the winners-minus-losers (WML) lost -91.59 % just in two months and in 2009 when the performance was -73.42 % in three months. Even the continuous excess returns do not compensate enough if almost investment capital is wiped off. Barroso and Santa-Clara (2015) found that hedging the momentum risk by analyzing variance of daily returns is predictable and manageable way that leads to economic gains. Managing the risk made a substantial decrease in the volatility and increased the sharpe ratio from 0.53 to 0.97. Moreover, Barroso and Santa-Clara (2015) found scaled momentum being robust both in subsamples and in all major international markets they examined. Risk managed momentum was needed to avoid bad crashes but it made a positive impact to sharpe ratio even without crashes. In addition, their results indicate that momentum anomaly is not dead, though last ten years had market movements that did not favor momentum anomaly. Gharaibeh (2016) attempted to enhance momentum effect by combining volatility effect in Arabic market over the period of 1990-2014. Ghareibeh found that volatility based momentum strategy proved to outperform traditional momentum strategy. Moreover, momentum strategy provided return of 1.16 % per month over the six months holding period as recent winners with low-volatility minus recent losers with high-volatility gained 2.60 % per month over the same six months holding period.

Pettersson (2015) studied the relationship between time series momentum returns found in Moskowitz, Ooi and Pedersen (2012) and current level of volatility. Moskowitz et al. (2012) documented significant time series momentum returns over 1-12 month holding periods in equity indexes, currencies, commodities and bond futures. In addition, they found that momentum in all asset classes has best performance when the market condition is extreme. Pettersson (2015) found that equity indexes in time series momentum strategy returns are dependent on current level of volatility. Assets in low volatility states have positive and significant momentum returns, whereas assets in high volatility states do not have positive momentum returns.

Daniel and Moskowitz (2016) investigated momentum crashes and found that market stress, high volatility and already fallen market coupled with an abrupt upside in marker returns together make an impact and cause momentum crashes. Cooper, Gutierrez and Hameed (2004) found that profits from momentum strategies are highly dependent on the state of the market and a six-months momentum strategy works only after following times of market upside. Their sample from 1929 to 1995 resulted for the mean monthly profits being 0.93 % following positive market and -0.37 % following negative market. In addition, Cooper et al. (2004) extended the overconfidence theory from Daniels et al. (1998) to predict momentum returns. As investors are overconfident concerning their private information against publicly available information, this overconfidence increases further when market condition is favorable and momentum returns are generated. Eventually overreaction is corrected and the prices are more likely closer to equilibrium. Thus, increased overconfidence drives short-run momentum returns and long-run reversal.

Volatility anomaly

The low-volatility anomaly has been proved to exist globally over the last five decades. Defensive stocks with lower-betas tend to outperform aggressive stocks with higher-betas. This anomaly is a challenge for CAPM, as there is non-linear relationship between higher volatility and higher expected return. Already Black, Jensen and Scholes (1972) found that low risk assets provide better returns than CAPM security market line (SML) suggest. They claimed that although the relationship between the risk and return is linear, the empirical CAPM has higher intercept and less steep SML slope than CAPM theory says. Fama and MacBeth (1973) found a little support to this view by assuming that if the market portfolio is efficient, the price of high beta stocks are too low and their expected returns are too high. Moreover, Haugen and Heins (1975) found that the relationship between risk and expected return is not only flat, it is even inverted. More empirical evidence has been found to support flatter SML. Fama and French (1992) found that during 1963-1990 a relation between Beta and average return disappeared and the empirical SML slope was zero.

Ang, Hodrick and Xing (2006) examined the cross-section of expected returns and found that stocks with high idiosyncratic volatility consistent with Fama and French (1993) have substantially low average returns. They also concluded that low-volatility anomaly exists even after controlling other factors, such as size, book-to-market, momentum and liquidity. In particular, stocks with most volatile quintile portfolio earned total monthly return of -0.02 %.

(2012) studied stock markets in 21 developed and 12 emerging markets. Their results show that on all of these 33 stock markets including 99.5 % of the capitalization counted in each market, every market yielded expected negative reward for risk bearing investor. In addition, interestingly they found that more volatile stocks are hold by financial institutions, analyst coverage is substantially greater for more volatile stocks and the same applies for news coverage. Moreover, Baker and Haugen (2012) also rationalized some decision making and agency problems related to low-volatility anomaly. Fund managers might have an incentive to prefer high-volatility stocks if fund fee structure compensates potential overperformance against benchmark. In this case as the high-volatility fund outperforms the low-volatility fund, fund manager gets his bonus when bull market is on. On the other side, losing substantially to low-volatility fund during bear market does not reduce the base salary. This framework is consistent with findings from Baker, Bradley and Wurgler (2011) as high-beta stocks earned higher returns than low beta-stocks in up markets. Nevertheless, low-volatility anomaly was robust and generated higher alphas in both environments. Furthermore, as more volatile stocks are easier to analyze because of greater analyst and news coverage, further research and recommendations are more executable.

Baker et al. (2011) sorted all U.S stocks in five groups by market capitalization from 1968 to 2008 in U.S stock markets. They found that one dollar invested in 1968 in the lowest volatility portfolio was 59.55 dollars in 2008. One dollar invested in the highest volatility portfolio decreased to 0.58 dollars. Blitz and van Vliet (2007) researched globally differences between low-volatility decile portfolios and high-volatility decile portfolios and found annual alpha spread favoring low-volatility decile by 12 % annually between years of 1986-2006 time period. The relationship between risk and return is not only negative in U.S stock market but also in Europe and Japan. In addition, the results were even more robust when measured by volatility instead of beta. Moreover, they found possible explanations for low-volatility anomaly being not arbitraged away because of a need of using leverage, inefficient decision-making process within the industry and biased individual investors. Blitz, Pang and van Vliet (2012) found that consistently with earlier findings from developed markets, the relation between risk and return in emerging stock markets is also flat or negative.

Frazzini and Pedersen (2014) presented a betting against beta (BAB) factor, which goes long on leveraged low-beta assets and short on high-beta assets. This is because constrained investors (i.e. investors, pension funds, mutual funds) hold high-beta assets and bid-up their prices reducing the alpha. As these investors are unable to leverage their holdings, they overweight riskier assets. In addition, they found that high-beta assets have lower alphas as low-beta assets, as well as sharpe ratios. Moreover, Frazzini and Pedersen (2014) agreed with Black et al. (1972) as they concluded that standard CAPM SML is not only flatter for US stock markets, it is also relatively flat in 18 of 19 international equity markets, in treasuries, in corporate bonds and in future markets. The low-volatility anomaly has been widely researched and its disagreement with core concept of financial theory and CAPM has for sure further contributed research motivation to strengthen findings to support outperformance of low-volatility asset classes.

Asset Growth anomaly

Academic research has shown that changes in the book value of assets could be valuable way to analyze future returns in a firm-specific level. Asset growth anomaly is based on an idea that stocks with low asset growth outperform stocks with high asset growth. Cooper et al. (2008) documented the asset growth anomaly in the U.S stock returns simply by comparing changes in total assets on a yearly basis. They found a strong support for firm's asset growth being statistically significant stock return predictor in the U.S markets. These finding have received a great amount of attention and since then the asset growth anomaly has been more extensively researched.

Much research is documented before Cooper et al. (2008) simplified the asset growth anomaly by measuring year-on-year change in firm's total assets. Correlation between asset expansion (contraction) is identified by a wide range of studies. Negative correlation between different corporate investments and cross-section of future stock returns has been studied for example in accruals (Sloan 1996) when found that stock prices fail to reflect information in the accruals and cash flow components and investors tend to "fixate" on earnings. Titman et al. (2004) found negative relation between increase in capital investments and stock returns. The relation is even stronger when firms have higher cash flows and less debt in their balance sheet. Pontiff and Woodgate (2008) examined whether share issuances could explain and forecast stock returns. They found strong relation between share issuances and future stock price returns after 1970 time period. In addition, Pontiff and Woodgate (2008) found that share issuance anomaly is statistically more significant than book-to-market, size and momentum anomalies. These findings are consistent with an idea that insiders tend to repurchase or sell shares in order to take advantage from the fundamentally miscalculated stock price fluctuations. The finding suggest also that public equity offerings (Ibbotson 1975), acquisitions (Rau and Vermaelen 1998) and bank loan initations (Billett, Flannery and Garfinkel 2006) tend to generate abnormally low future stock price returns.

Contrarily, corporate actions associated with asset contractions tend to be followed abnormally high future stock price returns. McConnell and Ovtchinnikov (2004) showed that after spinoff, both subsidiary and parent company gain excess returns measured in almost all holding periods. Their sample consisted of 311 spinoffs between 1965 and 2000. Ikenberry, Lakonishok and Vermaelen (1995) examined share repurchase announcements in 1980-1990. They found that buying and holding shares after initial share repurchase announcement obtained for the next 4 years abnormal excess returns of over 12 %. Michaely, Thaler and Womack (1995) investigated market share price reactions to initiations and omissions of cash dividend payments. They found that short-run price movement is greater for omissions than initiations. Omission announcements were associated with a mean price fall of 7 %, whereas initiation announcements were associated with a mean price increase of over 3 %. Affleck-Graves and Miller (2003) examined both straight and convertible debt-prepayments from 1945 to 1995. They found abnormal stock price returns of 0.16-0.34 % monthly followed by next 5 years after debt-prepayment. Their evidence also found long-run overperformance related to stock repurchases, whereas both issues of debt and equity were followed by long-term underperformance. Lyandres, Sun and Zhang (2008) tested investment factor, going long in low-investment stocks and short in high-investment stocks. The investment factor made an excess return of 0.57 % per month.

As mentioned earlier, Cooper et al. (2008) were the first to study “The Asset Growth” anomaly as a one proxy, driven by the asset expansion (contraction) of firm’s total assets. They argued that aggregate measure of firm asset growth as sum of all major subcomponents would be better to predict future returns than a single balance sheet item. In addition, Cooper et al. (2008) showed that firms with low asset growth rates earn significantly higher subsequent annualized risk-adjusted returns of 9.1 % while high asset growth firms earn -10.4 % in cross-section of U.S stock returns. Moreover, they found that asset growth effect dominates other variables e.g. momentum and firm capitalization in predicting the cross-section of future stock price returns. These findings provide an empirical challenge for the market efficiency theory as an investor could benefit from the fundamental analysis.

Fama and French (2008) explored the size, asset growth, accruals, profitability, net stock issues and momentum anomaly return pervasiveness in different size groups. They found accruals, net stock issues and momentum being pervasive in all size groups. Asset growth and profitability factors were less robust, while asset growth anomaly was found being strong only in microcaps, weaker in small stocks and “probably nonexistent” in big stocks. However, Lipson, Mortal and Schill (2011) examined that study made by Fama and French (2008) distorts the asset growth anomaly effect measured in big stocks. The reason for this was that the measurement method failed to include external financing effect into calculations. This caused results that were dampened especially in big stocks group. In addition, Lipson et al. (2011) found that asset growth effect is heavily linked to idiosyncratic volatility of the company. Low volatility company portfolios do not face the same level of asset growth effect as higher volatility portfolios. In addition, positive correlation between increasing volatility and higher asset growth effect could also be explained by asset mispricing as assets with higher volatility tend to fluctuate more than assets with low volatility. Thus, asset growth effect could be due to asset mispricing.

Nyberg and Pöyry (2014) connected their results to those Cooper et al. (2008) found and add to this that asset expansion is also a strong predictor of momentum profits. In their study momentum profits are statistically significant and meaningful among companies that have faced large asset expansions or contractions. In addition, Nyberg and Pöyry (2014) found in their cross-sectional analysis that firm-level asset expansion is not just a predictor of future abnormal returns. It is also a strong price predictor in shorter time horizon. Furthermore, they found a positive time series relation between asset growth and momentum returns in markets where earlier studies have not found momentum opportunities. They also argue that existing literature does not fully explain why asset growth should be with future returns. Moreover, they conclude that any theory that tries to explain momentum anomaly, should also try to capture asset growth – momentum relation due to strong interaction between these anomalies. Karell (2018) studied in his doctoral thesis anomaly based trading strategies in Finnish and U.S stock markets and found a strong momentum effect for firms that have had either large expansion or contraction in their total assets. These finding were consistent with earlier study made by Nyberg and Pöyry (2014). Karell (2018) found the highest average returns for high momentum / low asset growth portfolio that yielded 17.79 % p.a. Zhongzhi (2016) studied relationship between firm’s asset growth and idiosyncratic stock return volatility and found that in cross-section, stocks with either high positive asset growth rate or low asset growth rate have high idiosyncratic return volatility. Thus, the relationship between asset growth and volatility could be described as a V-shaped. In addition, Zhongzhi (2016) found that the asset growth factor is the most important predictor of the idiosyncratic return volatility and V-shape relationship between volatility and asset growth was robust even after controlling many factors such as size, growth options and expected earnings growth.

Lam and Wei (2010) found results that support the idea of negative relationship between asset growth and stock returns are due to asset mispricing. They argued that there is a lack of evidence regarding connection of investor mis-reaction and asset mispricing and limits to arbitrage do drive away the asset growth anomaly. Moreover, if the negative relationship exists, it should be stronger when there are more severe limits to arbitrage. They found evidence that all of their tested limits of arbitrage; arbitrage risk, information risk and potential transaction costs plays a substantial part in the underperformance of high asset growth firms. In contrast, stocks with low limits to arbitrage do not underperform the market even though they are high asset growth stocks. In addition, Lam and Wei (2010) came to a conclusion that asset growth anomaly is not arbitraged away because of its nature of limits to arbitrage. This argument is consistent with Shleifer and Vishny (1997) as arbitrageurs do not arbitrage away arbitrage opportunities when arbitrage is risky and costly. Thus, mispricing last longer and asset growth anomaly is not arbitraged away.

Hou, Xue and Zhang (2016) studied 437 anomaly variables overall in U.S. They found investment (asset growth) factor being “one of the key driving forces of the broad cross section of average stock returns.” Slotte (2011) were first to study asset growth anomaly in UK stock market and the main results were consisted with Cooper et al. (2008) and Lipson et al. (2010) from the U.S. In addition, Slotte (2011) found asset growth anomaly only in large companies and only a short-term momentum effect related to asset growth. The latter one is contrary to findings that Nyberg and Pöyry (2010) found. Moreover, asset growth anomaly exists in UK stock market, but is not as strong and persisting as examined in the U.S stock market.

Data

Sample data

The sample data consists of publicly listed companies in Helsinki Stock Exchange between January 1991 and December 2019. All companies listed in Nasdaq First North Helsinki are excluded from the sample regarding relatively high level of illiquidity of these assets. In addition, all financial companies are excluded from the sample data due to differences of accounting principles on these companies. This is a normal process in studies that rely on accounting principles as financial firms have higher leverage ratio than nonfinancial firms without having increase in level of financial distress. (Fama and French, 1992) The final sample after exclusions consists of 190 individual companies from Helsinki Stock Exchange. The sample set consists of monthly historical stock total returns, and firm-specific book value of assets. Stock returns and accounting information are downloaded from Thomson Reuters Datastream and Yahoo Finance. Stock returns imported from data sources are total returns, which takes into account both capital gains as well as any cash distributions, such as dividends. The portfolios used in this study are equally weighted. In this way a variability in market capitalization is controlled. This is especially important in Helsinki Stock Exchange where the number of listed companies is relative low and a few large cap companies would have heavy value weight. The risk free rate is combined timeseries taken from the European Central Bank eurosystem and from the eurosystem of Bank of Finland. The data should be free of survivorship bias as it includes all the companies that have gone bankrupt during each observation period. Following the method of Tikkanen et al. (2018), the company gets value of zero if its delisted.

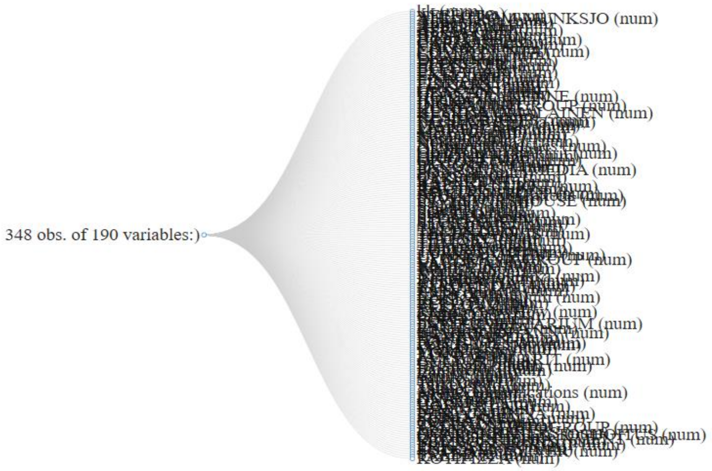

Figure 1: Sample size of 190 stocks(variables). Maximum 348 observations on each variable.

Risk free rate

The Euro Interbank Offered rate (Euribor) is an interest rate based on average interest rates at which a panel of European banks lend money to one another. Euribor rates are calculated on daily basis and made publicly at 11.00 Central European time (CET). As Finland is a part of European Union where European Central Bank takes monetary policy actions to achieve appropriate level of interest rates, 3-month Euribor interest rate is used as a risk free rate instead of US T-bill rate.

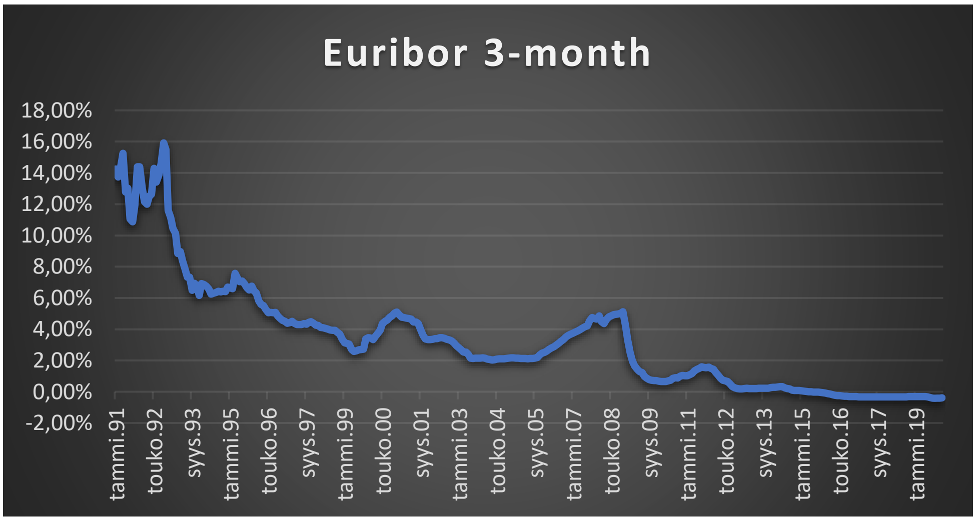

Figure 2: Euribor 3-month monthly development from Jan-1991 to Dec-2019.

Market index

The market index of this study is taken from Datastream. OMXHCAP is a value weighted index in which a maximum weight for one stock is 10 % of the index market value. Total return tracks all the sources of value that appreciates (depreciates) index value. OMXHCAP is used to represent stock market performance of Helsinki Stock Exchange. It is important to notice that all portfolios constructed in this study are equally weighted.

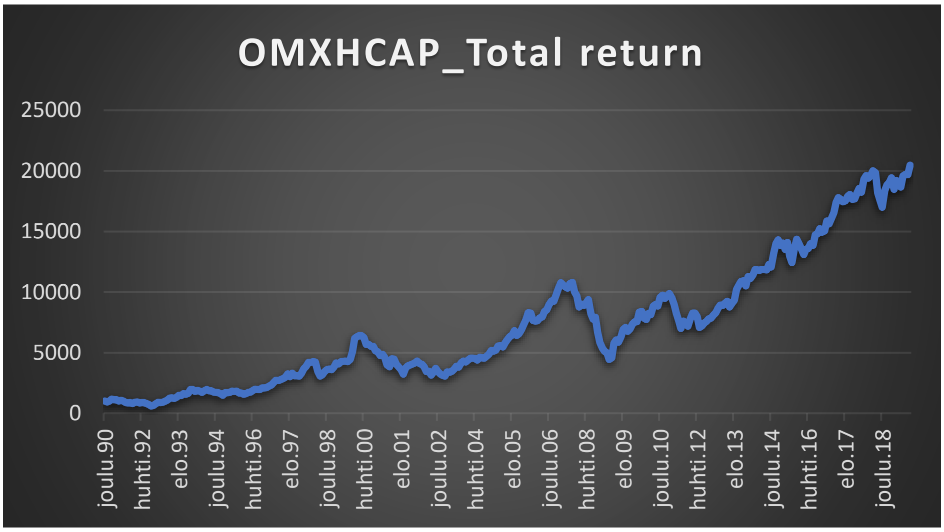

Figure 3: OMXHCAP total return 1991-2019.

Methodology and descriptive statistics

This chapter starts by briefly describing benchmarked studies used in each anomaly. After that descriptive statistics is presented regarding each dataset used in single anomaly calculations.

Momentum

The momentum effect was first documented by Jegadeesh and Titman (1993) in strategy which buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generating significant positive returns over 3 to 12 month holding periods.

Jegadeesh and Titman (1993) investigated momentum strategies based on stock returns over the past 1, 2, 3 and 4 quarters. They also conducted 16 strategies that skip a week between portfolio formation and portfolio holding periods to avoid effects as bid-ask spread, price pressure and lagged reactions. In addition, 10 decile portfolios were formed to rank the stocks from top decile called “losers“ to bottom decile called “winners”. Each strategy buys the winners and sells the losers. The profitability of buy and hold strategies compared to strategies that rebalances the portfolio weights monthly were almost equal.

The momentum strategy of this study takes account both 6 months and 12 months formation periods and combines these with 6 months ja 12 months holding periods with no lags between the formation and holding period. In this way total number of momentum portfolios is 3x6=18. 6F-6H, 6F-12H, 6F-12H, 12F-6H, 12F-12H, 12F-12H are each divided to tertiles M1, M2 and M3. At the beginning of each holding period, the securities are ranked in descending order on the basis of returns over formation period. Based on these rankings the best performed tertile is assigned to M1(winners) and the worst M3(losers).

Jegadeesh and Titman (1993) found that the most profitable zero-cost momentum strategy was 12-month / 3-month strategy which selects stocks based on their previous 12 month returns and then holds them for the next 3 months. This strategy was even profitable when there was 1-week lag between the formation period and holding period. The non-lag 12-3 strategy yielded 1.31 % per month whereas 1-week lag 12-3 strategy yielded 1.49 % month. 6-month formation strategy yielded 1 % per month for all holding periods.

Descriptive statistics Mom 6F-6H

Table 1 presents mom 6F-6H average monthly returns where the first holding period ends in 12/1991 and the second in 6/1992.

	Market	M1	M2	M3
Min.	-0.076123	-0.093453	-0.062472	-0.063979
1st Qu.	-0.003889	-0.005022	-0.004003	-0.014495
Median	0.011213	0.011895	0.009518	0.001528
Mean	0.009047	0.012251	0.009544	0.002734
3rd Qu.	0.027848	0.034071	0.027712	0.020825
Max.	0.064580	0.064505	0.067568	0.071080

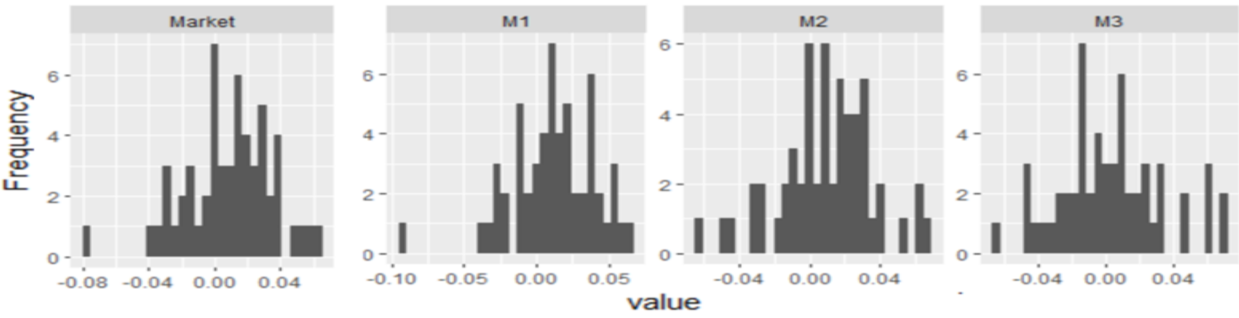

Table 1: Descriptive statistics Mom 6F-6H.

The most interesting finding from 6F-6H portfolios was the outperformance of M1 portfolio in 6/1991-6/2019. 1€ invested in 6/1991 gained to over 52€ in 6/2019. M2 portfolio and market portfolio both gained 20x initial investment while momentum losers portfolio M3 only just doubled its initial investment.

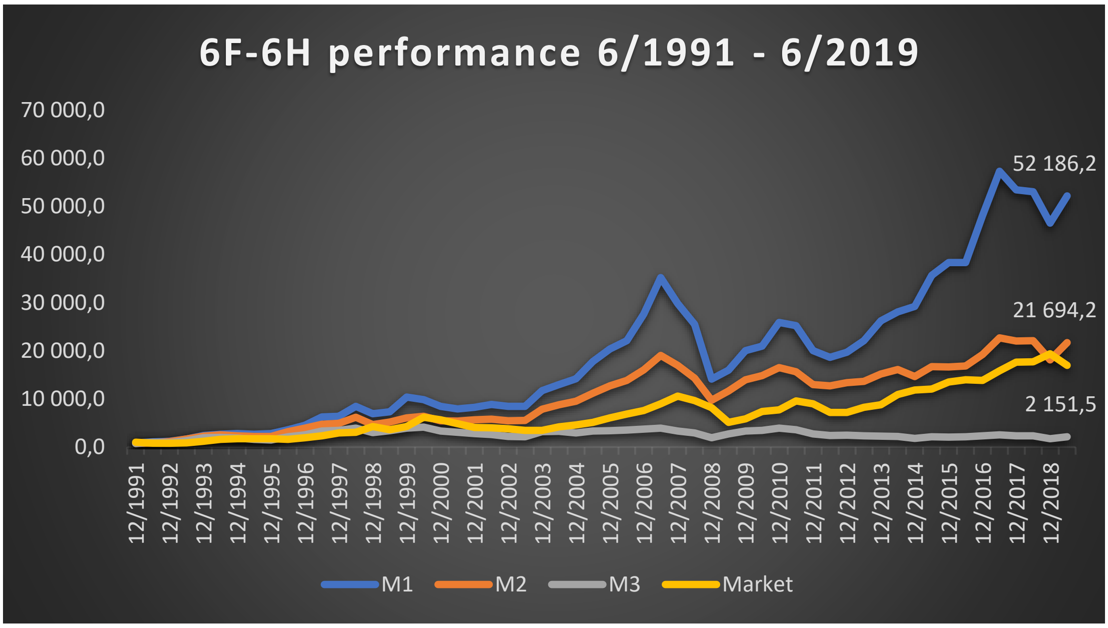

Figure 4: Mom 6F-6H performances. M1 clear winner.

Descriptive statistics Mom 6F-12H

Table 2 below shows 6F-12H Descriptive statistics and average monthly returns where the first holding period ends in 6/1992 and the second in 6/1993.

```
    Market                   M1                       M2                       M3
Min.   :-0.0314537   Min.   :-0.023630   Min.   :-0.032260   Min.   :-0.027796
1st Qu.:-0.0005782   1st Qu.:-0.003094   1st Qu.:-0.010680   1st Qu.:-0.001719
Median : 0.0156397   Median : 0.009373   Median : 0.003185   Median : 0.011856
Mean   : 0.0120902   Mean   : 0.009192   Mean   : 0.002902   Mean   : 0.009012
3rd Qu.: 0.0272620   3rd Qu.: 0.024142   3rd Qu.: 0.019057   3rd Qu.: 0.024155
Max.   : 0.0515944   Max.   : 0.042082   Max.   : 0.038989   Max.   : 0.036109
```

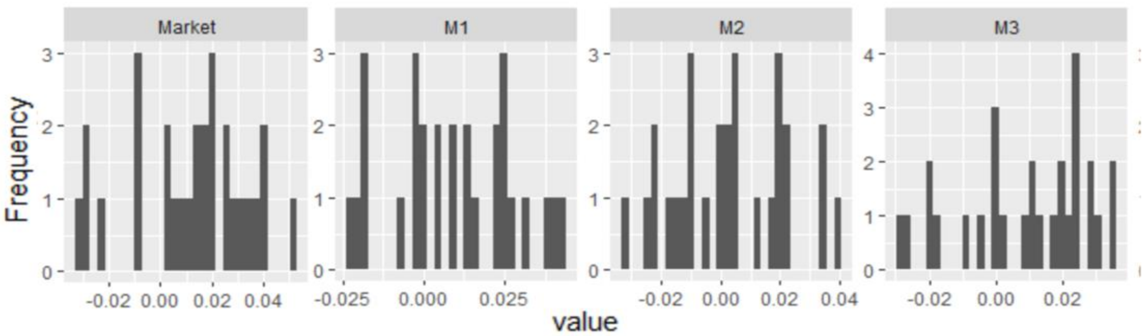

Table 2: Descriptive statistics Mom 6F-12H.

As we look figure 5 momentum performances, we can see that even though M1 has faced huge downside during market turmoil in financial crises, it has still outperformed M2 and M3. It is worth noting that M3 increased from 1000 to 2495 index points during the period.

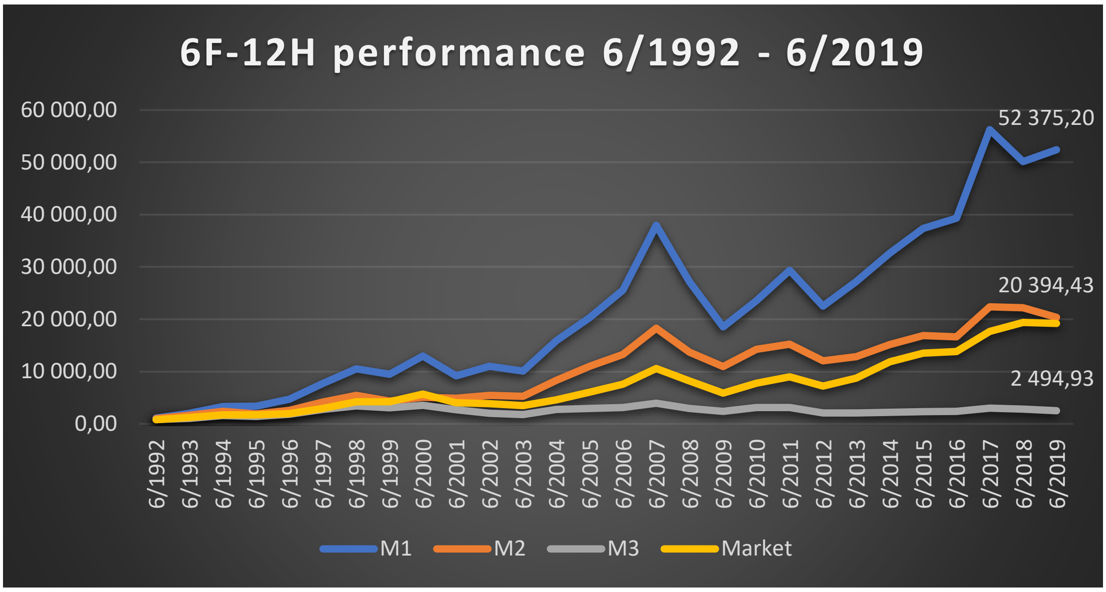

Figure 5: Mom 6F-12H performances. Worst M3 performance in all tests.

Descriptive statistics Mom 6F-12H

Table 3 below shows mom 6F-12H average monthly returns where the first holding period ends in 12/1992 and the second in 12/1993.

Market		M1		M2		M3	
Min.	:-0.052047	Min.	:-0.048875	Min.	:-0.0506837	Min.	:-0.052112
1st Qu.:	0.002621	1st Qu.:	0.003644	1st Qu.:	0.0007234	1st Qu.:	-0.009980
Median :	0.012219	Median :	0.009931	Median :	0.0145194	Median :	0.002324
Mean :	0.009918	Mean :	0.010498	Mean :	0.0120203	Mean :	0.006396
3rd Qu.:	0.022306	3rd Qu.:	0.024039	3rd Qu.:	0.0232702	3rd Qu.:	0.019107
Max. :	0.054578	Max. :	0.050701	Max. :	0.0628946	Max. :	0.070436

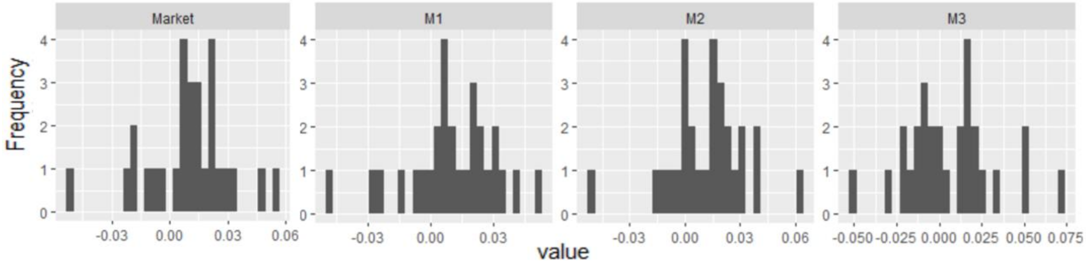

Table 3: Descriptive statistics Mom 6F-12H.

Figure 6 shows how M2 portfolio was a winner in 6F-12H momentums. This is really interesting as it seems that momentum based on longer holding period seems to be better performer.

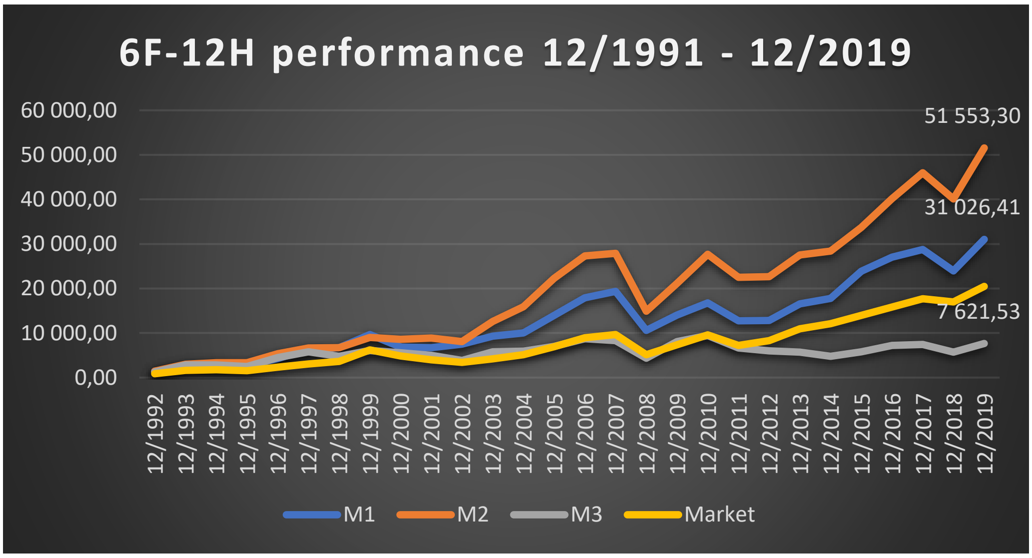

Figure 6: Mom 6F-12H performances. M2 is a winner. The best M3 score in 6F portfolios.

Descriptive statistics Mom 12F-6H

Table 4 below shows mom 12F-6H average monthly returns where the first holding period ends in 6/1992 and the second in 12/1992.

	Market	M1	M2	M3
Min.	-0.052047	-0.0783715	-0.067258	-0.072702
1st Qu.	-0.002008	-0.0005114	-0.005729	-0.012961
Median	0.012052	0.0144960	0.011186	0.005521
Mean	0.009353	0.0120527	0.010188	0.005976
3rd Qu.	0.023224	0.0255385	0.028229	0.021391
Max.	0.054578	0.0691223	0.063235	0.082868

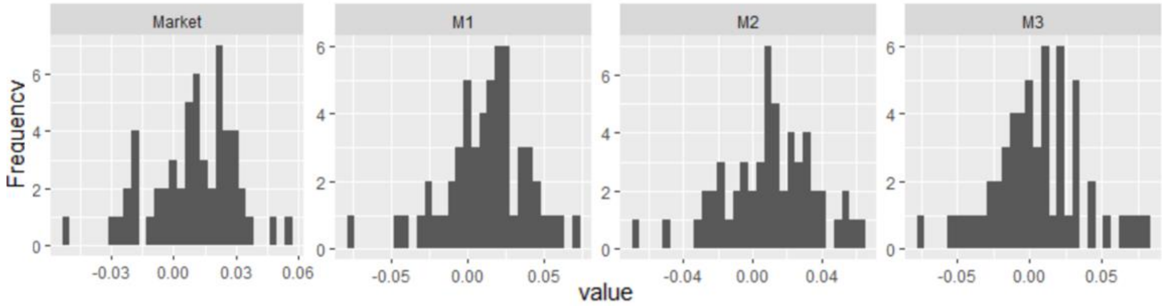

Table 4: Descriptive statistics Mom 12F-6H.

Figure 7 presents 12F-6H performance during 12/1991 – 6/2019. Market performance is quite close to M2. M3 continues to underperform.

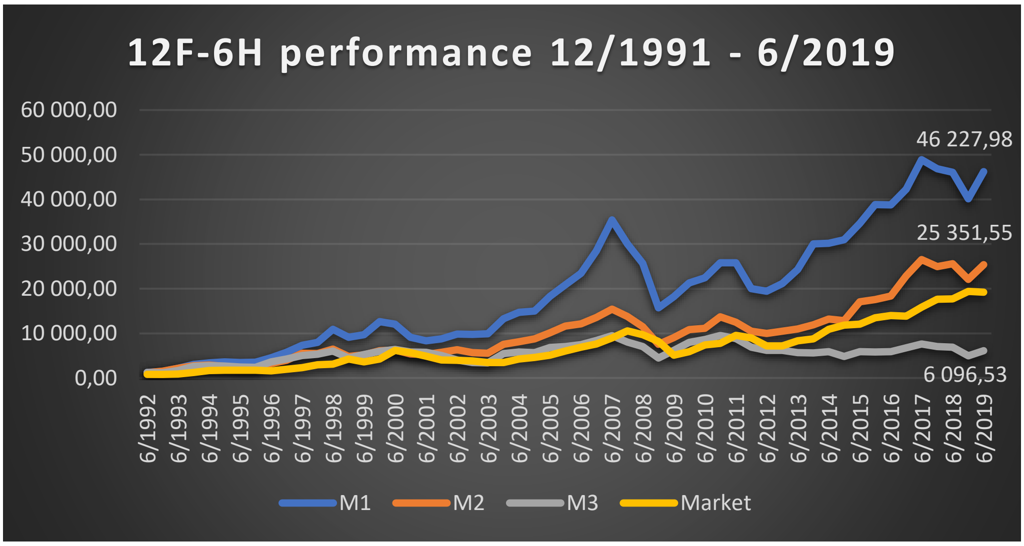

Figure 7: Mom 12F-6H performances.

Descriptive statistics Mom 12F-12H

Table 5 below shows mom 12F-12H average monthly returns where the first holding period ends in 12/1992 and the second in 12/1993

	Market	M1	M2	M3
Min.	-0.061854	-0.043210	-0.048407	-0.052047
1st Qu.	0.000351	0.000379	-0.007671	0.002621
Median	0.011369	0.013125	0.007174	0.012219
Mean	0.010754	0.011449	0.007426	0.009918
3rd Qu.	0.023744	0.023800	0.019205	0.022306
Max.	0.064967	0.059825	0.060172	0.054578

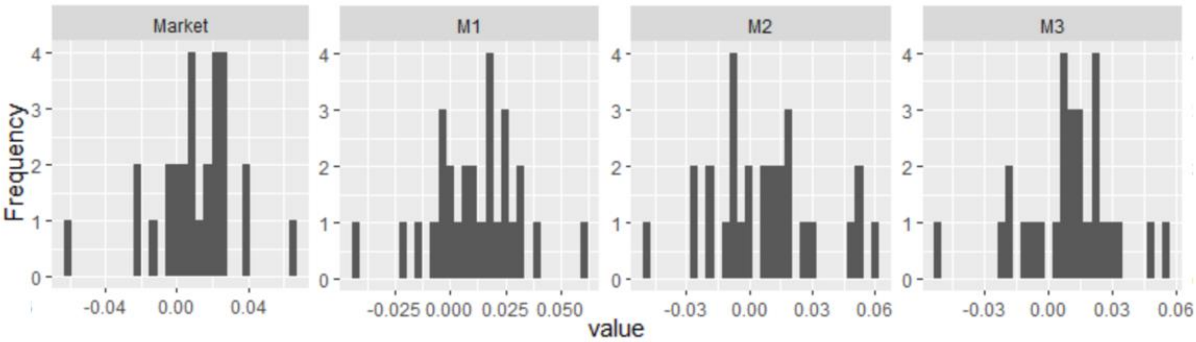

Table 5: Descriptive statistics Mom 12F-12H.

Figure 8 is a good example how M2 portfolio overall performs better when holding period increases. In addition, M3 has its best performance in all momentums but it still can’t compete with market return.

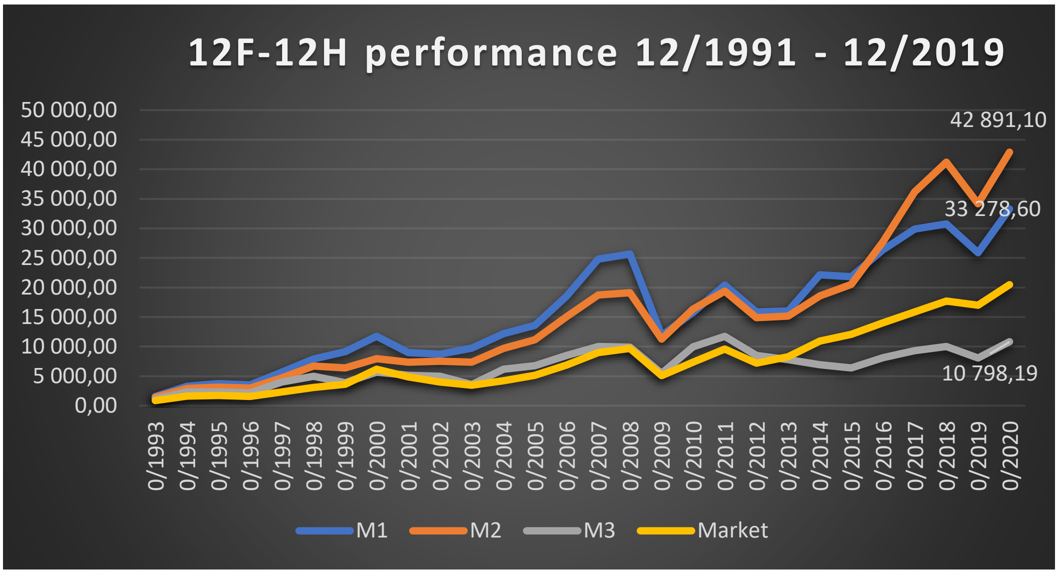

Figure 8: Mom 12F-12H performances. The best M3 performance.

Descriptive statistics Mom 12F-12H

Table 6 below presents mom 12F-12H average monthly returns where the first holding period ends in 6/1993 and the second in 6/1994

```
    Market              M1                  M2                  M3
Min.   :-0.043425   Min.   :-0.026205   Min.   :-0.031146   Min.   :-0.0277962
1st Qu.:-0.001779   1st Qu.:-0.007150   1st Qu.:-0.010075   1st Qu.:-0.0003518
Median : 0.012362   Median : 0.015453   Median : 0.003998   Median : 0.0124987
Mean   : 0.009530   Mean   : 0.009684   Mean   : 0.007103   Mean   : 0.0100441
3rd Qu.: 0.021317   3rd Qu.: 0.023492   3rd Qu.: 0.021478   3rd Qu.: 0.0242566
Max.   : 0.044739   Max.   : 0.049125   Max.   : 0.048016   Max.   : 0.0361091
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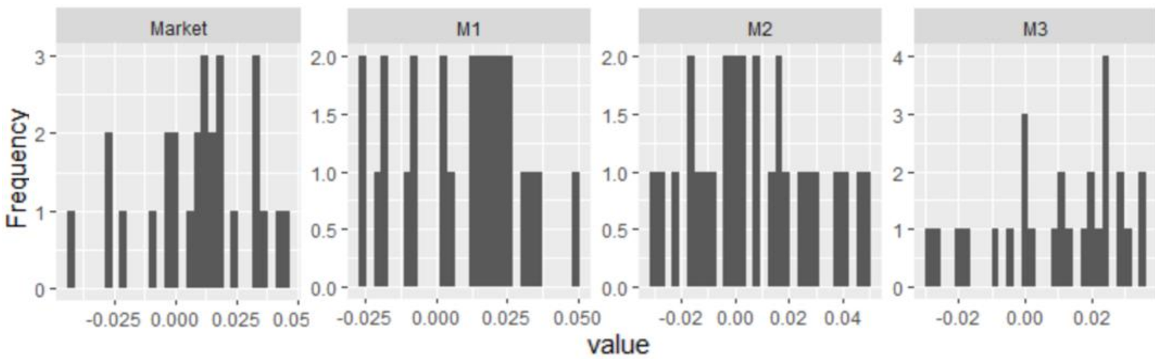

Table 6. Descriptive statistics Mom 12F-12H.

Figure 9 shows the closest battle between M1, M2 and M3. Still, one of the reasons for lower returns in each portfolio is that the first holding period starts in 6/1992. Thus, the compounded return is lower.

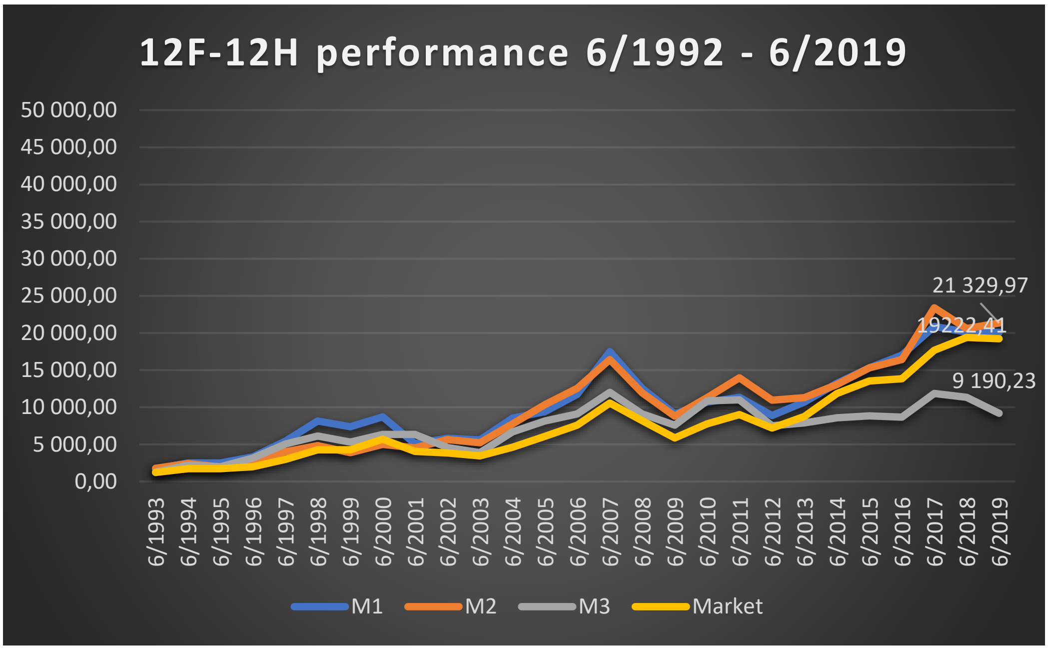

Figure 9: Mom 12F-12H performances. Market return close to M1 and M2.

Volatility

The low-volatility anomaly has been proved to exist globally over the last five decades. Baker and Haugen (2012) studied stock markets in 21 developed and 12 emerging markets over the time period from 1990 to 2011. They computed the volatility of total returns for each stock in every country for the T-24 months and then formed deciles, quintiles and halves to rank the stocks. The re-ranking was conducted for the next period and new returns were calculated. This process was continued for the whole 264 month period.

The volatility strategy of this study is based on 1 month formation and both 6 and 12 month holding periods. The stocks are ranked in descending order and assigned to tertiles.

Descriptive statistics Vol 1F-6H

```
     Market              V1                  V2                  V3
Min.   :-0.211393   Min.   :-0.102706   Min.   :-0.082021   Min.   :-0.062585
1st Qu.:-0.020015   1st Qu.:-0.016805   1st Qu.:-0.003611   1st Qu.:-0.002668
Median : 0.010255   Median : 0.007840   Median : 0.013166   Median : 0.010833
Mean   : 0.009529   Mean   : 0.006909   Mean   : 0.012206   Mean   : 0.011012
3rd Qu.: 0.043500   3rd Qu.: 0.026905   3rd Qu.: 0.028849   3rd Qu.: 0.026361
Max.   : 0.235762   Max.   : 0.114193   Max.   : 0.099887   Max.   : 0.073249
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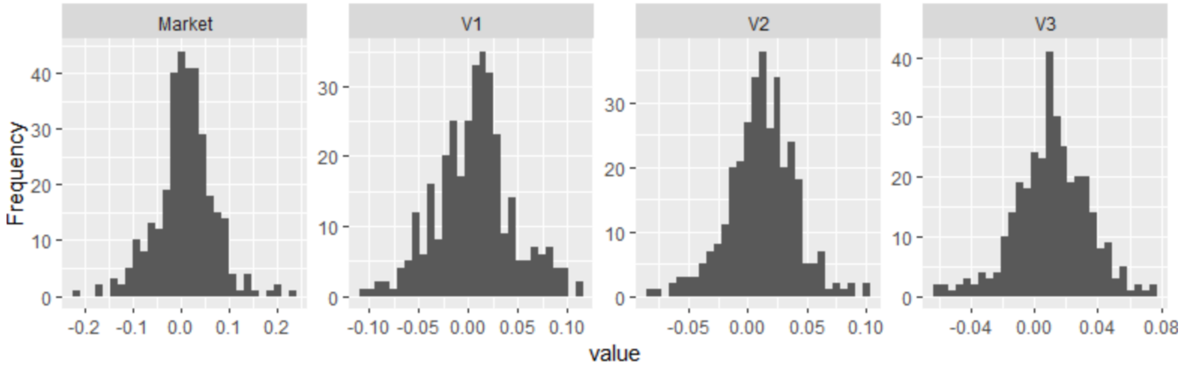

Table 7: Descriptive statistics Vol 1F-6H.

Figure 10 presents the first of two volatility comparisons. The middle portfolio V2 has the highest absolute returns. This is not the case when looking at risk-adjusted results on the next chapter.

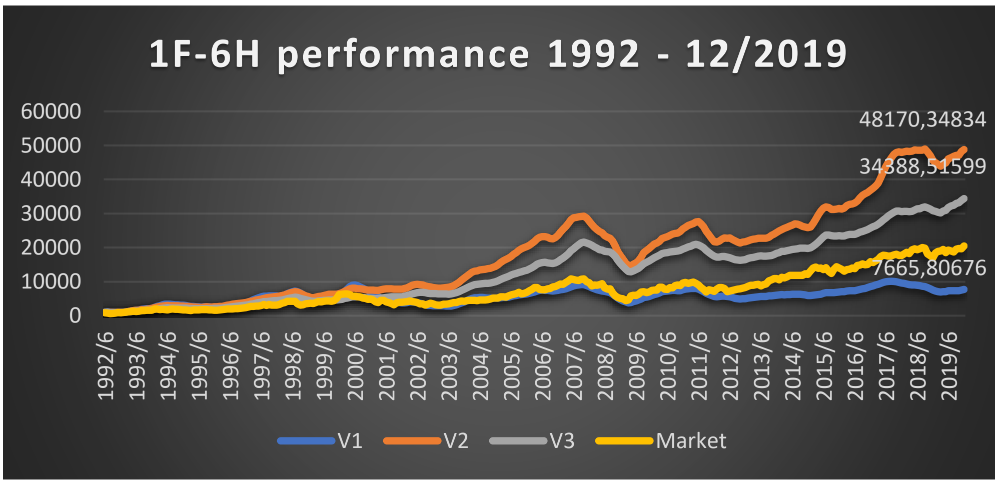

Figure 10: Vol 1F-6H performances. V2 has the best performance.

Descriptive statistics Vol 1F-12H

```
     Market                V1                  V2                   V3
 Min.   :-0.211393   Min.   :-0.054830   Min.   :-0.0505688   Min.   :-0.0370728
 1st Qu.:-0.018419   1st Qu.:-0.011819   1st Qu.:-0.0008147   1st Qu.: 0.0007697
 Median : 0.010255   Median : 0.010305   Median : 0.0130904   Median : 0.0120783
 Mean   : 0.009627   Mean   : 0.007763   Mean   : 0.0125802   Mean   : 0.0112768
 3rd Qu.: 0.042894   3rd Qu.: 0.024233   3rd Qu.: 0.0247733   3rd Qu.: 0.0223343
 Max.   : 0.235762   Max.   : 0.093236   Max.   : 0.0811458   Max.   : 0.0703194
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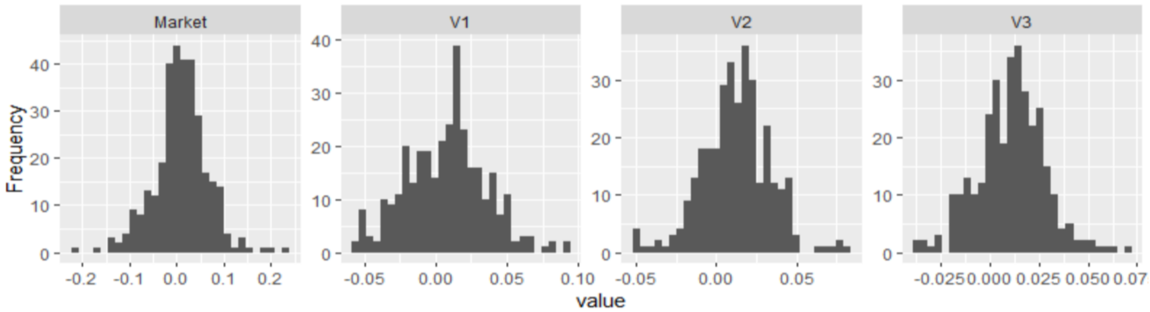

Table 8: Descriptive statistics Vol 1F-12H.

Figure 11 presents 1F-12H volatility statistics. V2 has the best performance also in 1F-12H and the highest volatility portfolio is a loser again.

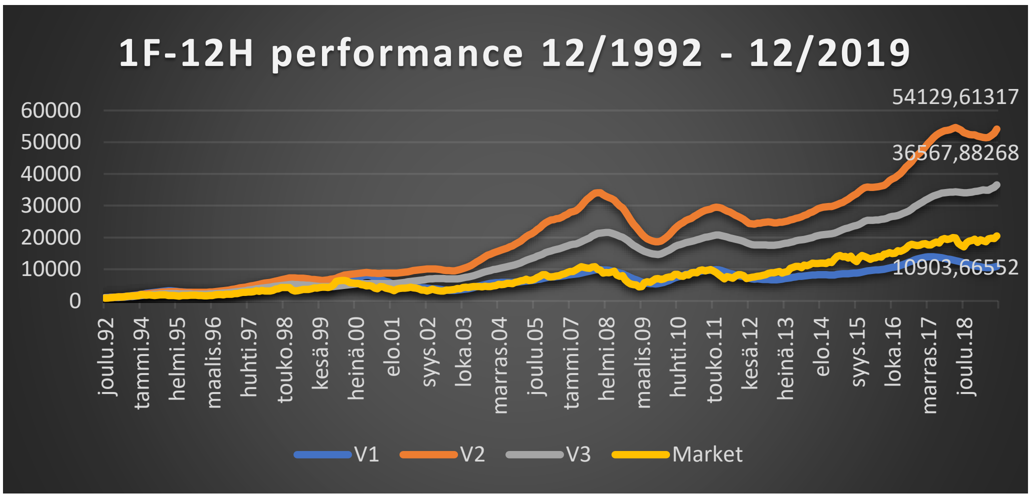

Figure 11: Vol 1F-12H performances. The same ranking as in Vol 1F-6H.

Asset Growth

Cooper, Gulen and Schill (2008) were the first to study firm-level asset investment effects in returns by studying the cross-sectional relation between firm asset growth and subsequent stock performance. They found a strong evidence predicting that companies with low asset growth tend to overperform companies with high asset growth. Their data consisted of all NYSE, Amex and Nasdaq nonfinancial firms from 1963 to 2003.

In this study asset growth strategy is calculated as in Cooper et al. (2008). The argument behind their simplified asset growth measurement was that this simple pure measurement of company's total assets is capable to capture the same effect as changes in firm's total investment and financing activities. The first holding period starts in July 2002. In this way we secure that the accounting information is publicly available.

Descriptive statistics Ag 12F – 12H

Table 9 below are Ag 12F-12H average monthly returns where the first holding period ends in 6/1993 and the second in 6/1994.

```
    Market                AG1                AG2                AG3
Min.   :-0.0277962   Min.   :-0.029495   Min.   :-0.019356   Min.   :-0.025635
1st Qu.:-0.0003518   1st Qu.:-0.001788   1st Qu.:-0.002796   1st Qu.:-0.005813
Median : 0.0124987   Median : 0.012548   Median : 0.013644   Median : 0.010101
Mean   : 0.0100441   Mean   : 0.010981   Mean   : 0.011403   Mean   : 0.009780
3rd Qu.: 0.0242566   3rd Qu.: 0.028281   3rd Qu.: 0.021244   3rd Qu.: 0.024303
Max.   : 0.0361091   Max.   : 0.040296   Max.   : 0.042450   Max.   : 0.042431
```

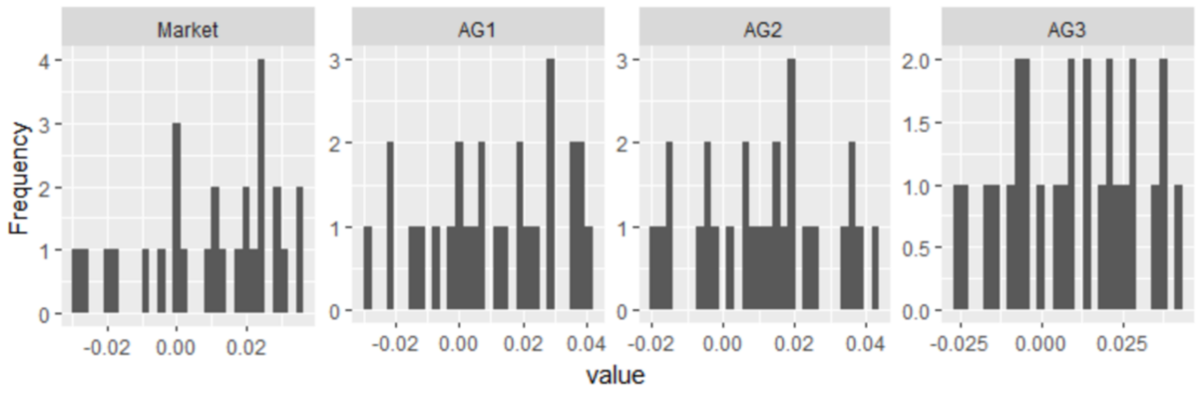

Table 9: Descriptive statistics Ag 12F-12H.

As seen in figure 12 the best performing asset growth portfolio has been AG2 while AG1 was in second place. Lowest asset growth (AG3) indicates also lowest absolute return.

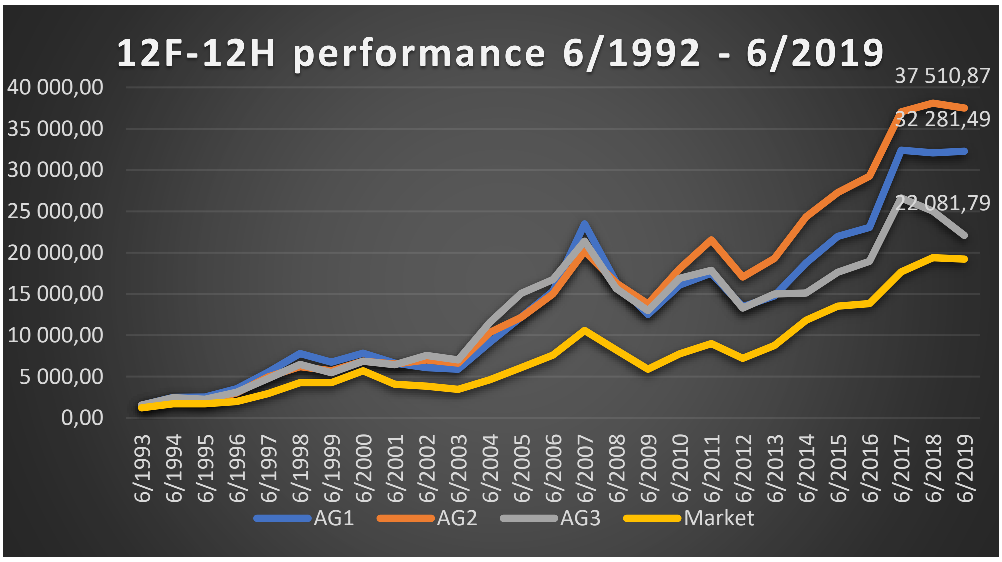

Figure 12: Ag 12F-12H performances. AG2 with best performance.

Risk-adjusted performance results

This chapter presents risk-adjusted performance results for each Momentum – Volatility and Asset Growth portfolio. This section also provides answers to first and second research questions presented in chapter 1.2. Summary statistic tables presents regression results and risk-adjusted performance measures.

The first research question asks whether Long-only high momentum strategies have generated economically and statistically significant excess return during 1991-2019. Tables 10 to 16 presents how long-only momentum strategies have statistically performed.

Momentum

The evidence in table 10 tells that M1 and M2 portfolios do gain excess returns during the period of 1991-2019. M1 portfolio has relatively high adjusted R square figure which means that M1 portfolio has explained significant amount of market price movements. Both M1 and M2 portfolios do have positive sharpe-ratio which means that these investments have performed better than risk free return if excess risk is not counted. M3 portfolio with annual excess return of -2.82% and higher annualized standard deviation of 45.44% has negative sharpe-ratio(-0.06). Intercepts are not significant with risk level of 5%. Slope (Beta) is strongly significant in every portfolio. The spread of annualized excess returns is widest within Momentums as it is here 11.72%.

This table shows Momentum 6F-6H porfolio returns. Stocks in each portfolio are ranked in descending
order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles.
Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns,
CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes.
Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation).
Adjusted R squared is used as it accounts the sample size.

Momentum 6F-6H

Portfolio	M1	M2	M3
Excess return	8.90%	5.44%	-2.82%
Intercept	-0.0014	0.0007	0.0072
Beta	0.85	0.87	0.69
Standard deviation	37.06%	27.56%	45.44%
Sharpe-ratio	0.24	0.20	-0.06
Adjusted R Squared	0.85	0.75	0.61

Table 10: Momentum 6F-6H risk-adjusted returns.

Table 11 presents Momentum 6F-12H returns. M1 winners portfolio outperformed M2 and M3 portfolio when considering annualized excess returns. The spread between annualized excess returns of M1 and M3 was 11.34%. M1 portfolio has high standard deviation(80.06%). This makes it more risky versus M2 portfolio when comparing sharpe-ratios. Intercepts for M1 and M3 are not significant with risk level of 5%. Slope (Beta) is strongly significant in each portfolio. M1 has again highest Adjusted R squared(0.83) and seems to be the best explanatory variable in this model.

This table shows Momentum 6F-12H porfolio returns. Stocks in each portfolio are ranked in descending order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles. Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns, CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes. Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation). Adjusted R squared is used as it accounts the sample size.

Momentum 6F-12H

Portfolio	**M1**	**M2**	**M3**
Excess return	8.94%	5.24%	-2.40%
Intercept	0.0023	0.0092	0.0027
Beta	1.06	1.01	1.05
Standard deviation	80.06%	29.60%	46.00%
Sharpe	0.11	0.18	-0.05
Adjusted R Squared	0.83	0.74	0.80

Table 11: Momentum 6F-12H risk-adjusted returns.

The evidence in table 12 shows Momentum 6F-12H portfolio returns. The difference between table 11 and table 12 Momentum 6F-12H portfolios is that in table 11 portfolio weights are rebalanced in January whereas in table 12 portfolio weights are rebalanced in July.

In table 12 M2 portfolio has the best annualized excess return. M2 outperforms M1 even after controlling the volatility as its sharpe(0.36) is greater than M1 sharpe(0.29). Intercepts for M1 and M2 are not significant with risk level of 5%. Slopes (Betas) are again highly significant. R squared value for M1(0.8) and M2(0.78) indicates that both of these variables have high correlation with market return.

This table shows Momentum 6F-12H porfolio returns. Stocks in each portfolio are ranked in descending
order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles.
Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns,
CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes
Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation).
Adjusted R squared is used as it accounts the sample size.

Momentum 6F-12H			
Portfolio	**M1**	**M2**	**M3**
Excess return	7.38%	9.35%	2.24%
Intercept	0.0003	-0.0011	0.0055
Beta	0.92	0.91	0.69
Standard deviation	25.44%	25.65%	101.49%
Sharpe	0.29	0.36	0.02
Adjusted R Squared	0.80	0.78	0.68

Table 12: Momentum 6F-12H risk-adjusted returns.

Table 13 presents 12F-12H portfolio returns when portfolios are rebalanced on yearly basis in July. Compared to the previous table, M1 is a winner in absolute excess return terms as well as in risk-adjusted basis measured by sharpe(0.27). M2 did dominate when portfolios were rebalanced in January. M1 portfolio is also much less risky when formed in July compared to table 12 when rebalanced in January. Intercepts for M1 and M2 are not significant with risk level of 5%. Even though M2 Intercept is really close (p-value 0.054434). Slopes (Betas) are again significant. Adjusted R squared values do not represent the variance of dependent variable as well as with other Momentums.

This table shows Momentum 12F-6H porfolio returns. Stocks in each portfolio are ranked in descending
order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles.
Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns,
CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes.
Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation).
Adjusted R squared is used as it accounts the sample size.

Momentum 12F-6H			
Portfolio	**M1**	**M2**	**M3**
Excess return	9.01%	6.62%	1.38%
Intercept	0.0031	0.0048	0.0073
Beta	0.52	0.44	0.34
Standard deviation	33.88%	31.94%	47.86%
Sharpe	0.27	0.21	0.03
Adjusted R Squared	0.47	0.31	0.25

Table 13: Momentum 12F-6H risk-adjusted returns.

Table 14 and Table 15 represent Momentum 12F-12H portfolios where table 14 portfolios are rebalanced in January and table 15 portfolios are rebalanced in July. In table 14 M2 portfolio has highest excess return, whereas the lower volatility in M1 leads to lower sharpe(0.3) compared to M2 sharpe(0.26). Intercepts are not significant with risk level of 5%. Betas(slopes) are once again highly significant and specially M1 portfolio seems to have strong correlation with market portfolios as adjusted R squared is 0.88.

This table shows Momentum 12F-12H porfolio returns. Stocks in each portfolio are ranked in descending order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles. Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns, CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes. Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation). Adjusted R squared is used as it accounts the sample size.

Momentum 12F-12H

Portfolio	**M1**	**M2**	**M3**
Excess return	7.71%	8.60%	3.51%
Intercept	-0.0017	0.0054	0.0013
Beta	1.09	0.72	0.96
Standard deviation	25.75%	32.79%	44.63%
Sharpe	0.30	0.26	0.08
Adjusted R Squared	0.88	0.62	0.78

Table 14: Momentum 12-12H risk-adjusted returns.

The evidence in table 15 shows that the annualized excess return spread between M1 and M3 is lowest within Momentums as it is only 3.05%. Surprisingly, M3 has the highest Adjusted R Squared value(0.85) whereas M1 has the highest excess return(6.43%) and risk-adjusted value(0.23). Intercepts are not significant with risk level of 5%. Betas(slopes) are significant.

This table shows Momentum 12F-12H porfolio returns. Stocks in each portfolio are ranked in descending order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles. Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns, CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes. Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation). Adjusted R squared is used as it accounts the sample size.

Momentum 12F-12H			
Portfolio	**M1**	**M2**	**M3**
Excess return	6.43%	6.62%	3.38%
Intercept	0.001	0.004	-0.001
Beta	0.93	0.73	1.08
Standard deviation	28.08%	41.27%	49.34%
Sharpe	0.23	0.16	0.07
Adjusted R Squared	0.73	0.53	0.85

Table 15: Momentum 12F-12H risk-adjusted returns.

Volatility

Table 16 presents portfolio returns based on Volatility 1F-6h. V1 portfolio has the highest volatility and the lowest excess returns. This combination makes it sharpe fall close to zero(0.08). V2 portfolio has the highest excess return but considering the risk-adjustments, V3 has the highest sharpe(0.6) as its standard deviation(18.07%) falls below V2 standard deviation(26.69). Low Adjusted R squared values tell that these individual portfolios or independent variables are not that great explanatory variables. Betas(slopes) are again highly significant whereas all intercepts are not.

This table shows Volatility 1F-6H porfolio returns. Stocks in each portfolio are ranked in descending order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles. Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns, CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes. Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation). Adjusted R squared is used as it accounts the sample size.

Volatility 1F-6H			
Portfolio	**V1**	**V2**	**V3**
Excess return	5.62%	12.50%	10.92%
Intercept	0.0055	-0.0002	0.0001
Beta	0.58	0.80	0.85
Standard deviation	73.18%	26.69%	18.07%
Sharpe	0.08	0.47	0.60
Adjusted R Squared	0.14	0.14	0.11

Table 16: Volatility 1F-6h risk-adjusted returns.

The evidence in table 17 confirms that V1 with highest volatility has the worst performance on risk-adjusted basis whereas low volatility portfolio V3 has highest sharpe(0.71). V3 excess return of 11.48% is superior compared to V1 excess return 6.91% even when not considering risk-adjustments. The model itself does not predict well market returns as all adjusted R squared values are as well in this volatility comparison too low(0.11-0.14). Intercepts are not significant with a risk level of 0.05%. All betas(slopes) are significant.

It is interesting to see that in both 1F-6H and 1F-12H, V2 portfolio has the highest absolute excess return. Still, the most fundamental finding is that risk and return do not fluctuate hand in hand.

This table shows Volatility 1F-12H porfolio returns. Stocks in each portfolio are ranked in descending order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles. Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns, CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes. Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation). Adjusted R squared is used as it accounts the sample size.

Volatility 1F-12H

Portfolio	**V1**	**V2**	**V3**
Excess return	6.91%	13.22%	11.48%
Intercept	0.0055	-0.0002	0.0003
Beta	0.53	0.78	0.83
Standard deviation	63.19%	24.50%	16.19%
Sharpe	0.11	0.54	0.71
Adjusted R Squared	0.06	0.09	0.06

Table 17: Volatility 1F-12H risk-adjusted returns.

Asset Growth

The statistics in table 18 presents Asset Growth returns. The excess return spread between high AG1 and low AG3 is the lowest within Momentum-Volatility and Asset Growth.

This table shows Asset Growth 12F-12H porfolio returns. Stocks in each portfolio are ranked in descending
order at the beginning each holding period based on the formation period return.The ranked stocks are assigned to tertiles.
To avoid look-ahead bias Asset Growth portfolios are formed when the year end balance sheet figures are publickly available.
Re-ranking is done after holding period ends. All stocks are equally weighted. Average annual excess returns,
CAPM intercept(Alpha) and slope(Beta) are calculated from regressions. Annualized standard deviation is calculated from monthly changes.
Sharpe-ratio helps to understand the return earned in excess of the risk-free rate per unit of volatility(standard deviation).
Adjusted R squared is used as it accounts the sample size.

Asset Growth 12F-12H

Portfolio	AG1	AG2	AG3
Excess return	8.28%	8.83%	6.74%
Intercept	0.001	0.000	0.002
Beta	0.85	0.90	0.80
Standard deviation	36.29%	47.75%	28.60%
Sharpe	0.23	0.18	0.24
Adjusted R Squared	0.85	0.72	0.68

Table 18: Asset Growth 12F-12H risk-adjusted returns.

Multi-factor portfolios

Construction

The multi-factor strategy of this study is based on univariate anomaly calculations and then combined together based on ranking points. First, momentum portfolios with 6 month formation and 12 month holding are used to present momentum anomaly, formation 1 month and holding 12 month portfolios are used to present volatility anomaly and formation 12 month and holding 12 month portfolios are used present asset growth anomaly. Each data set formation is chosen in a way that respectively following holding period will be the next full calendar year. The first holding period starts from the January of 1991 and the last from the January of 2019. Portfolios are formed once in a year based on previous year formation scores. If a stock is missing in one variable, it is excluded from the portfolios.

Ranking points are calculated as follows: Based on formation period the best stock (highest momentum) performer in momentum gets max points and the worst stock(lowest momentum) performer gets min points.

Based on formation period the stock with lowest volatility gets max points and the stock with highest volatility gets min points.

Based on formation period the stock with lowest asset growth gets max points and the stock with highest asset growth gets min points.

Ranking points are summed together and P1, P2 and P3 multi-factor portfolios are formed. These portfolios are examined by using regression models.

Descriptive statistics

Descriptive statistics of Multi-factor portfolios; Time frame from 1991 to 2019, total 336 months. Minimum number of stocks in 1991 (35) and maximum number of stocks in 2003 (125).

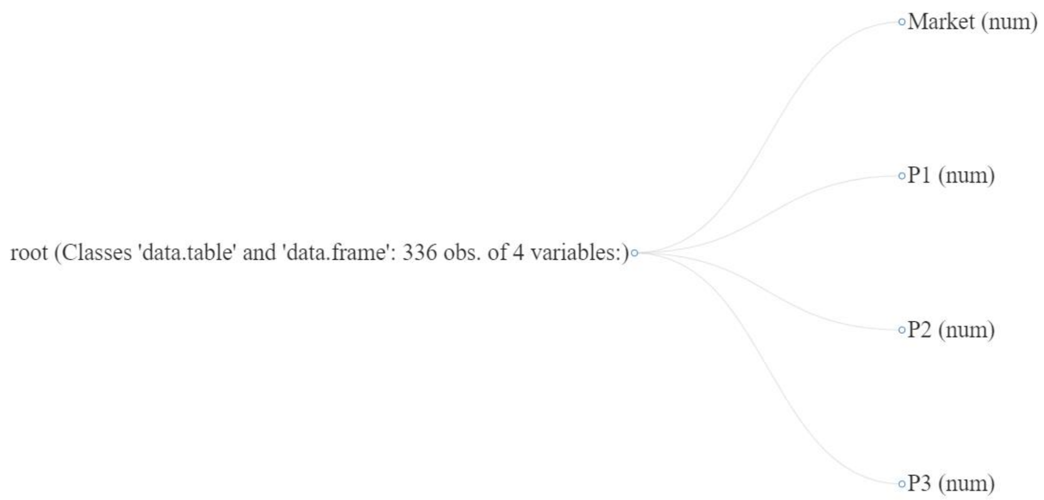

Figure 13: 4 variables and 336 observations on each variable.

Table 19 below presents minimum and maximum monthly returns on each Market, P1, P2 and P3 portfolio. The lowest monthly return have been in Market portfolio (-21.1%) and the highest monthly return have been with P3 portfolio (49.8 %). The median return is highest in P1 portfolio (1.1 %). The highest mean score is with P1 (1.42%) and P2 (1.41%). The frequency of monthly returns is also displayed in table 19. The returns seems to be within a range of normal distribution.

	Market	P1	P2	P3
Min.	:-0.211393	:-0.16492	:-0.192415	:-0.260076
1st Qu.	:-0.019601	:-0.01117	:-0.018409	:-0.030483
Median	: 0.010893	: 0.01125	: 0.009289	: 0.005297
Mean	: 0.009641	: 0.01422	: 0.014123	: 0.011289
3rd Qu.	: 0.043414	: 0.04073	: 0.041163	: 0.050064
Max.	: 0.235762	: 0.31628	: 0.309621	: 0.497530

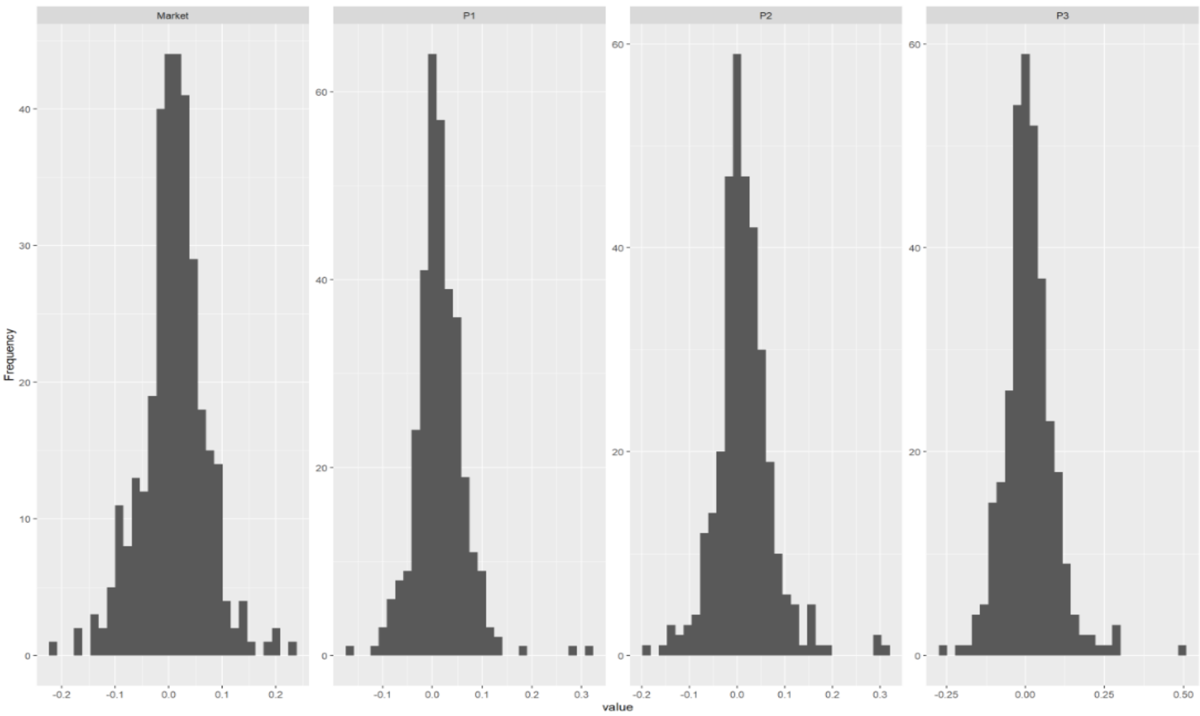

Table 19: Min and max monthly returns. And frequency and variability of monthly returns.

Figure 14 shows multi-factor correlations. All multi-factor portfolios have high positive correlation with Market portfolio. The highest positive correlation is with P2 and Market (0.85) while the lowest correlation is among P1 and P3 (0.74).

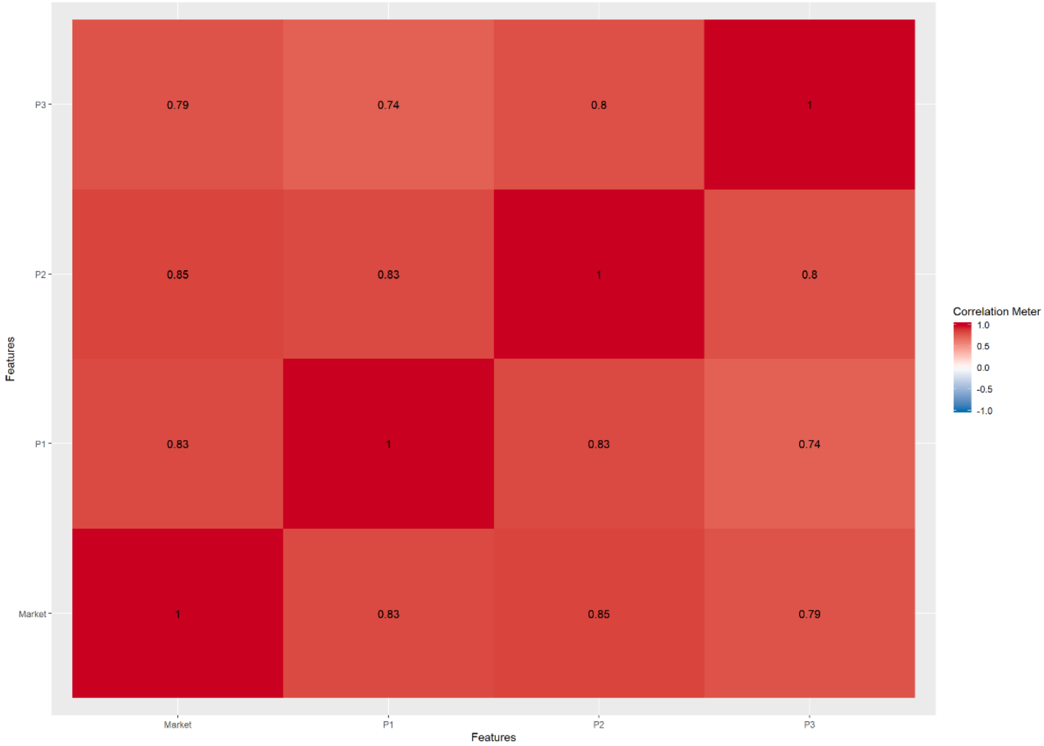

Figure 14: Multi-factor correlation matrix.

Figure 15 shows multi-factor portfolio performance. The starting point in January 1992 was 1000 index points for each portfolio. The best performers, P1 yielded almost 78x initial investment during the holding period while P2 had also great success as it yielded more than 63x initial investment.

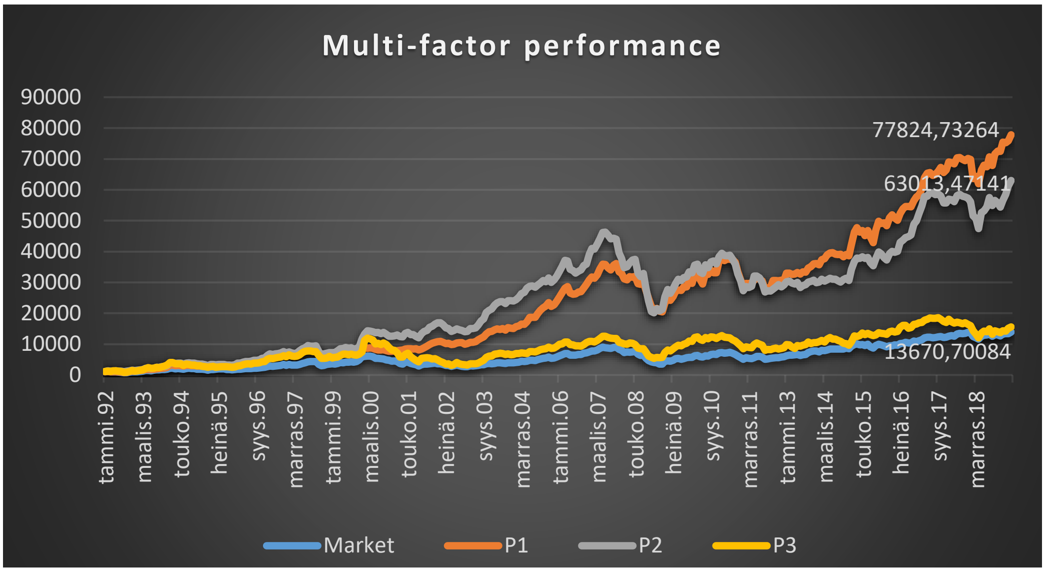

Figure 15: Multi-factor performance. P1 and P2 superior returns.

Univariate linear regressions

When comparing P1, P2 and P3 portfolios against Market return we can see interesting results. This is done with regression analysis. Table 20 shows that P1 portfolio has annualized excess return (15.06 %) and lowest standard deviation (17.09 %). This combination makes its risk-adjusted performance (sharpe 0.88) superior compared against P3 portfolio (sharpe 0.40).

Multi-factor

Portfolio	P1	P2	P3
Excess return	15.06%	14.94%	11.13%
Intercept	-0.0046	-0.0024	0.0030
Beta	1.00	0.85	0.59
Standard deviation	17.09%	20.68%	27.84%
Sharpe-ratio	0.88	0.72	0.40
Adjusted R Squared	0.68	0.72	0.63

Table 20: Multi-factor portfolios.

As we look at the linear relation between Market and P1 can be seen in figure 16. For further analysis in table 21, we can see that the Beta value for P1 equals 1 and it is significant with risk level of 5 percent. N values (334) seems to be enough to make adjusted R-squared values

(0.6834) almost equal multiple s-squared values (0.6843). R-squared values tell us that approximately 68 % of the variability of market returns are explained by P1 returns. On the bottom of the table we can see that our regression residuals follow normal distribution.

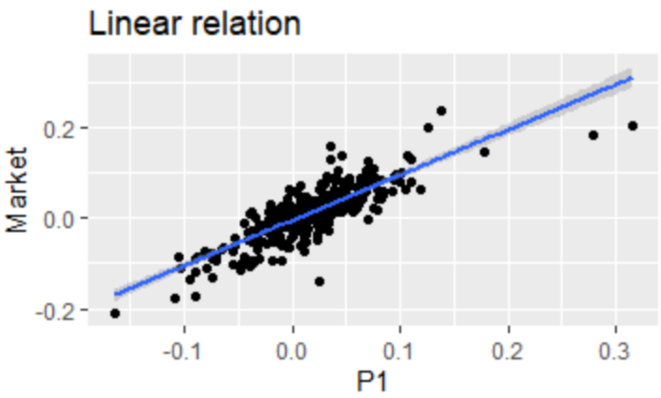

Figure 16: Relation between P1 and Market portfolio.

```
Residuals:
      Min        1Q    Median        3Q       Max
-0.161317 -0.018313  0.002516  0.018692  0.127285

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.004571   0.001907  -2.397   0.0171 *
P1           0.999733   0.037152  26.909   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.03359 on 334 degrees of freedom
Multiple R-squared:  0.6843,    Adjusted R-squared:  0.6834
F-statistic: 724.1 on 1 and 334 DF,  p-value: < 2.2e-16
```

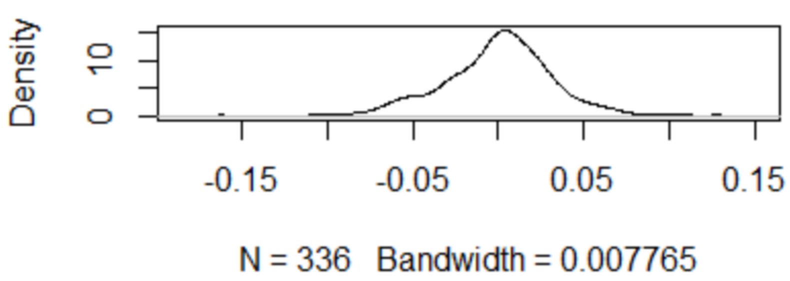

Table 21: P1 Regression statistics and residual density.

The regression analysis for P2 shows that the Beta for P2 equals 0.85. This relation can also be seen on the figure 17. Multiple R-squared value (0.725) tells us that this regression is the best model to explain market returns. The beta is also highly significant as its p-value is below our risk level 5 %. From the table 22, we can also see that residuals are normally distributed.

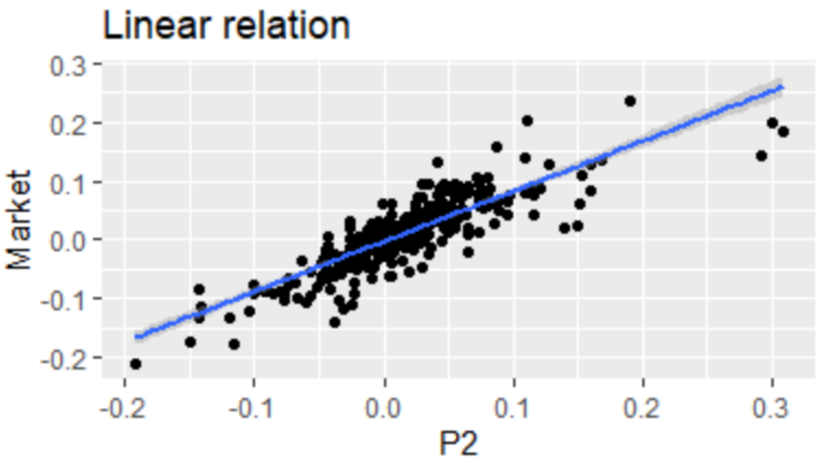

Figure 17: Relation between P2 and Market portfolio.

```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.10599 -0.01504  0.00239  0.01883  0.11199 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)    
(Intercept) -0.002368   0.001758  -1.347    0.179    
P2           0.850329   0.028657  29.672   <2e-16 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.03135 on 334 degrees of freedom
Multiple R-squared:  0.725,	Adjusted R-squared:  0.7242 
F-statistic: 880.4 on 1 and 334 DF,  p-value: < 2.2e-16
```

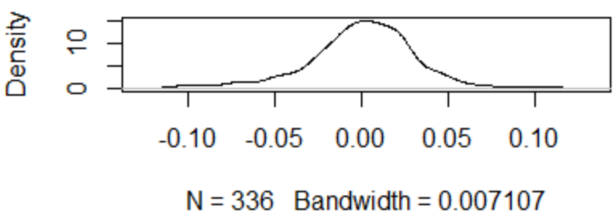

Table 22: P2 Regression statistics and residual density.

The relation between Market returns and P3 portfolio can be seen in figure 18. Regression analysis in table 23 for P3 shows that multiple R-squared value (0.6283) ranks between P1 and P3 as a model when trying to explain market returns. The beta value (0.587) is significant on risk level of 5 %. Residual density seems to be as well normally distributed.

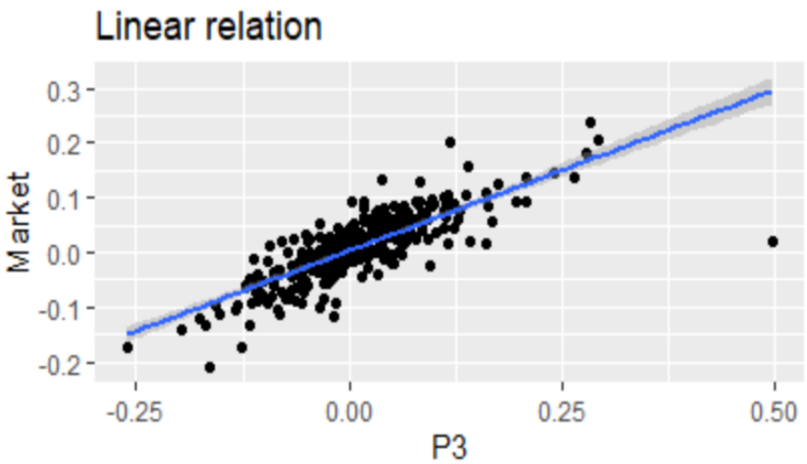

Figure 18: Relation between P3 and Market portfolio.

```
Residuals:
      Min        1Q    Median        3Q       Max 
-0.274155 -0.020059  0.002482  0.020494  0.128245 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 0.003005   0.002008   1.496    0.135    
P3          0.587887   0.024740  23.763   <2e-16 ***
---
Signif. codes:  
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.03645 on 334 degrees of freedom
Multiple R-squared:  0.6283,	Adjusted R-squared:  0.6272 
F-statistic: 564.7 on 1 and 334 DF,  p-value: < 2.2e-16
```

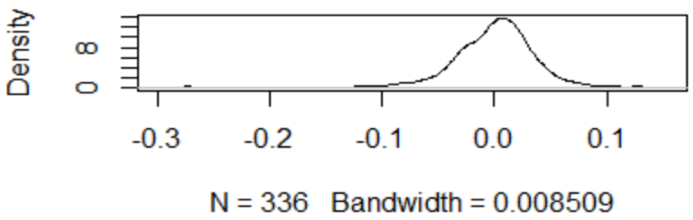

Table 23: P3 Regression statistics and residual density.

Multivariate linear regression

Multivariate regression analysis in table 24 shows that P1,P2 and P3 together as a model are able to better explain dependent market returns than any univariate regression itself. Multiple R-squared value (0.7904) is higher than in univariate regressions. All coefficients (Betas) are significant with risk level of 5 %. Residuals seems to follow the same path as with univariate regressions, being normally distributed.

```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.003471   0.001569  -2.212   0.0277 *
P1           0.401453   0.055899   7.182 4.55e-12 ***
P2           0.382835   0.052373   7.310 2.01e-12 ***
P3           0.177012   0.032120   5.511 7.17e-08 ***
---
Signif. codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.02745 on 332 degrees of freedom
Multiple R-squared:  0.7904,    Adjusted R-squared:  0.7885
F-statistic: 417.3 on 3 and 332 DF,  p-value: < 2.2e-16
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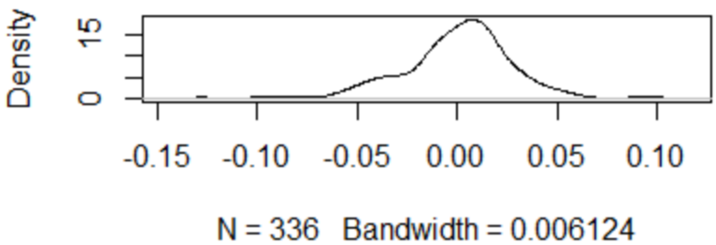

Table 24: Multivariate regression statistics and residual density.

Results

The first research question was to find out whether the winners keeps winning and whether long-only momentum strategies have generated economically and statistically significant excess returns during 1991-2019.

The single anomaly calculation results show that long only M1 portfolios have generated economically significant excess returns during 1991-2019. Due to high level of volatility the sharpe-ratio has been maximum 0.30 for M1's. The highest yearly drawdown happened in 2008 when the global financial crisis destroyed almost 54% of F12-12H M1 market value. The most profitable momentum portfolios seems to be based on 6 months formation winners. It is interesting to see that momentum losers (M3) portfolios do have overall better performance when the holding period is 12 months compared to 6 months holding period. As we look into our regression results, we can conclude that momentum regressions do have significant explanatory power as independent variable. Thus, momentum strategies based on buying recent winners have generated economically and statistically significant excess returns on our sample period.

The second research questions was to find out whether long-only high volatility strategies have outperformed low volatility long-only strategies. This assumption is based on the theory that higher risk should be compensated with a higher return. This hypothesis is also one of the cornerstones of financial theory.

There is no doubt that this hypothesis is rejected in Helsinki stock exchange. Low-volatility portfolio outperformance is highly significant as it has constantly gained excess returns compared to portfolios with higher volatility. When taking account risk-adjusted performances the spread between low-volatility and high-volatility asset returns is even higher. Higher volatility destroys portfolio sharpe-ratios. Still, it is interesting to see that based on absolute yearly excess returns, the middle portfolio V2 made most excess returns in both 1F-6H and 1F-12H portfolios. After risk-adjustments, V3 had the best sharpe-ratio.

The third research question and our main interest was to find out how multi-factor portfolios have performed in Helsinki stock exchange. As we see strong evidence that high momentum and low volatility have performed well itself. Asset growth results are more contradictory. Low asset growth (AG3) has the best risk-adjusted return, whereas AG2 has the best performance.

Multi-factor portfolios were ranked based on ranking points where high momentum, low volatility and low asset growth stocks formed preferred P1 portfolio. The most interesting finding was to see that this P1 portfolio skyrocketed from 1000 index points to almost 78000 index points during 1992-2019 as non-preferred P3 portfolio rose from 1000 index points to 15500 index points. Based on portfolio performance, risk-adjusted returns and regression statistics, we can conclude that long-only high momentum – low volatility and low asset growth multi-factor portfolios have generated economically and statistically significant excess returns during 1992-2019.

Conclusions

This research was motivated by the idea to challenge the strongest form of market efficiency. Eugene Fama (1970) defined an efficient market as one where on available information fails to provide excess returns. When all information is priced in to stock prices instantaneously the market is strongly efficient and after transaction costs it is impossible to beat the market return. Some form of market inefficiency have been found when concluding this study results together.

The theory of capital asset pricing model is based on assumptions that higher risk should be compensated with higher return. This study comes to the conclusion that already in 1972 when Black, Jensen and Scholes found non-linear relationship between risk and returns is also relevant point in Helsinki stock exchange during 1991-2019. This is a strong challenge for CAPM, as it is insufficient pricing model to explain asset price returns.

The results show that, on average high momentum and low volatility portfolios have been the best outperformers. High asset growth portfolio surprisingly outperformed low asset growth portfolio when looking at absolute non risk-adjusted returns. When comparing volatility portfolios, it is extremely interesting to see that V2 portfolio outperformed both V1 and V3 portfolios when it comes to absolute returns. This happened in both 6 months and 12 months holding period. These study results are consistent with Frazzini and Pedersen (2014) as CAPM SML seems to be also flatter in Helsinki stock exchange. In addition, low volatility portfolios had superior sharpe-ratios. The momentum effect was strong in all models. This is in line what Jegadeesh and Titman found in 1993 and confirmed in 2001 not being due to data snooping. Low momentum portfolios (M3) were losers in all 6 comparisons. It was quite unexpected to see significant differences between two momentum 6F-12H portfolio returns. Despite of similar formation and holding periods, the momentum effect was much stronger when the rebalancing was done in January. Moreover, when the rebalancing was done in July, actually M2 portfolio had better excess return than M1. The asset growth effect finding are in contrast with Nyberg and Pöyry (2014) where they found that firm-level asset expansion (contraction) is strong stock price predictor in shorter time horizon. Asset growth results are more mixed as highest asset growth companies had also the best returns. In addition, the risk-adjusted returns seems to favor low asset growth portfolio. Still, we can conclude that there is no asset growth effect in our sample.

When comparing multi-factor portfolio returns, we can see that preferred P1 portfolio had stronger return that any single anomaly (annualized excess return of 15.06 %) and also superior sharpe-ratio. The improvement in sharpe is driven by relative stable and moderate standard deviation in low volatility stocks. High momentum combined with low volatility seems to be a key to deliver persistent excess returns. However, despite overperformance of P1, non-preferred P3 multi-factor portfolio returned similar results with market portfolio. Both P1 and P3 portfolios faced huge downside during the period of financial crisis (May-07 – Dec-08) and it took almost 8 years to recover these losses. In that sense, one could argue that the timing is one of key variables when constructing momentum based multi-factor portfolios.

Overall, the results of this study show that momentum and volatility anomalies do exist in Helsinki stock exchange during 1991-2019. These anomaly based trading strategies have offered interesting opportunities to beat the market. As these multi-factor portfolios seems to continue market outperformance and these excess returns have not disappeared, we can conclude that the stock market in Helsinki might be efficient but it is not strongly efficient.

The finding of this study are useful for investors who are keen to challenge efficient market hypothesis and random walk theory. In addition, these results could be a way to enhance equity portfolio returns and risk-adjusted returns. This study had certain limitations. As acknowledged, the number of listed companies is relative low in Helsinki stock exchange. This affected the scope of study as the highest n = 190 and the lowest n = 35 companies in one period. Thus, the diversification benefits are not achieved in a way that modern portfolio theory suggest. This also led to portfolio ranking style used when multi-factor portfolios were formed. In addition, some companies other than intended, were removed due to them not having both total assets and price index values in some periods. For further studies it would be interesting to explore how multi-factor portfolios have been performing in Nordic stock exchange. Another idea would be to compare different multi-factor portfolios in industry level as some momentum based studies suggest that momentum returns would be driven by the industry momentum.

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