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FACTOR BASED PORTFOLIO PERFORMANCE IN HELSINKI STOCK EXCHANGE

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ABSTRACT

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The purpose of this research is to examine the returns of portfolios based on selected factors and the potential risk-adjusted excess returns compared to the market index. The target market is the Finnish stock market. The time-period under review is from 2001 to 2020. The benchmark index is the OMX Helsinki Growth Index. The portfolios constructed are based on four different factors, which are the company's market capitalization, P/B ratio, momentum and volatility. All companies on the Helsinki Stock Exchange are divided into small and large companies based on the market value at the end of each calendar year. After that, small and large groups are divided into 3x4 subgroups based on of P/B ratio, momentum and volatility, giving a total of 2x3x4 portfolios. The study has been carried out with both equally weighted and market value weighted portfolios, bringing the total number of portfolios to 48. First portfolios were formed at the beginning of 2002 based on 2001 figures. Since then, the companies in the portfolios have been updated annually on the first day of each calendar year. Portfolio performance was measured by absolute return, Jensen's alpha and Sharpe's ratio. The best return during the period under review was provided by the market cap weighted portfolio of small companies with the best momentum. A total of 29 of the 48 portfolios offered statistically significant excess return compared to the benchmark index.

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Tämän tutkielman tarkoituksena on tarkastella valittuihin faktoreihin perustuvien portfolioiden tuottoja ja mahdollisia riskikorjattuja ylituottoja verrattuna markkinaindeksiin. Kohdemarkkina on Suomen osakemarkkinat. Tarkasteltava aikahorisontti on vuodesta 2001 vuoteen 2020. Vertailuindeksinä toimii OMX Helsinki kasvuindeksi. Muodostetut portfoliot perustuvat neljään eri faktoriin, jotka ovat yrityksen markkina-arvo, P/B-luku, momentum ja volatiliteetti. Kaikki Helsingin pörssin yhtiöt on jaettu jokaisena kalenterivuonna pieniin ja suuriin yhtiöihin markkina-arvon perusteella. Tämän jälkeen kumpikin ryhmä on jaettu vielä 3x4 alaryhmään P/B-luvun, momentumin sekä volatiliteetin osalta, jolloin portfolioita on yhteensä 2x3x4. Tutkimus on toteutettu sekä yhtä suurilla painoilla että markkina-arvoon perustuvilla painoilla, jolloin portfolioiden kokonaismääräksi muodostuu 48. Ensimmäiset portfoliot on muodostettu vuoden 2002 alussa vuoden 2001 lukuihin perustuen. Tämän jälkeen portfolioiden yhtiöt on päivitetty vuosittain aina kalenterivuoden ensimmäisenä päivänä. Portfolioiden suoritusta mitattiin absoluuttisen tuoton, Jensenin alfan sekä Sharpen luvun perusteella. Tarkastelujakson parhaimman tuoton tarjosi pienistä, parhaan momentumin omaavista yhtiöistä koottu ja markkina-arvoin painotettu portfolio. Kaikkiaan 29 portfoliota 48:sta tarjosi tilastollisesti merkitsevän ylituoton verrattuna vertailuindeksiin.

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Doing this research has been a very interesting journey that ultimately proved to be really rewarding. Collecting data, editing, and finally seeing the results, made me think about ideas on how to use this information in real life. Applying the results to real life is often not easy due to, among other things, the limitations of the research carried out. However, the results of the study raise a lot of thoughts and perspectives on how the market works. I hope that the research will also provide the reader with something to think about and possibly ideas for further research.

I want to thank LUT for helping me to take the next steps in my career while making a bunch of new friends. I would also like to thank Sheraz Ahmed for providing great support and help in doing this research.

Helsinki, 5.12.2021

Anssi Raussi

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1 INTRODUCTION

1.1 Background

Market efficiency is one of the most debated and researched topics in financial theory. The main theme has been whether it is possible to earn a risk-adjusted excess return in stock markets, or whether stock prices are always pricing all the possible information. According to Sewell (2011), the theory of efficient markets traces back to the 16th century, but the most significant steps have been taken during the 20th century. Pearson (1905) introduced the theory of random walk, but more generally the theory came to the attention of economics and finance as presented by Malkiel (1973). Market efficiency is typically described with three different stages, which according to Fama (1970) are weak efficiency, semi-strong efficiency and strong efficiency.

Based on weak efficiency, security prices are reflecting all the prices from the past and thus it is impossible to gain risk-adjusted excessive returns with technical analysis. Semi-strong efficiency means that the stock markets have priced in all the publicly available information. In the markets of semi-strong efficiency, it would be impossible to reach risk-adjusted excess returns with technical or fundamental analysis. Strong efficiency claims that all the public and private information is priced in, which makes it impossible for anyone to gain risk-adjusted excess returns. (Fama, 1970).

1.2 The purpose of this study

The purpose of this research is to study whether an investor can gain risk-adjusted excess returns by factor-based portfolio investing in Finnish stock market. The factors to be studied are size, price-to-book ratio, momentum and volatility. All of these factors are related to well-known market anomalies, which have been studied widely around the world. However, the Finnish market has not been studied nearly as much as, for example, the US markets. There is a clear reasoning to test the mentioned anomalies also in Finnish stock markets. For example, Finnish private investors tend to favor their home country’s markets in their investments. Also, the investment universe of some Finnish institutional investors is limited to Finnish equities only.

The size effect means that the companies with smaller caps tend to produce better risk-adjusted returns than the larger ones. Banz (1981) published one of the first studies regarding the size effect, which proved that between 1936 and 1975, smaller companies had on average higher risk-adjusted returns than the companies with bigger market caps. Fama & French (2008) had similar kind of findings in their research. However, both of these studies recognized that the size effect and related excess returns were the most significant in the smallest companies and the effect weakened when middle-sized companies were compared to the bigger ones.

Price-to-book ratio relates to the anomaly called value effect, which suggests that the companies with small price-to-book ratios generate better risk-adjusted returns than the so-called growth companies with higher price-to-book-ratios. Rosenberg, Reid & Lanstein (1985) found the effect to be valid and statistically significant in the US markets.

The size and value effects are used to test the semi-strong form of efficiency market hypothesis, whereas the momentum and volatility effects are used to test the weak form market efficiency. The momentum anomaly refers to the theory that the best-performed stocks in recent history can be expected to perform best in the near future also. Jegadeesh and Titman (1993) found this phenomenon to be true between 1965 and 1989. The volatility effect of low volatility companies overperforming high volatility companies is supported by many studies. For example, Jensen, Black & Scholes (1972) and Haugen & Heins (1972) concluded the effect to be true.

There would be numerous other factors and anomalies to be tested, but this study is limited to the factors presented above. The limitation is based on the fact that these are one of the most well-known anomalies, but these have not yet been studied very comprehensively in the Finnish market. Size effect is also an interesting one when thinking one of the target groups who could benefit from this research, Finnish private investors. The liquidity of micro and small cap companies' shares is typically so limited that they are often not owned by large international institutional investors. This leads to a situation where the transactions of private investors largely determine the development of the share price.

The equity universe of this research includes all the Finnish listed companies. The time-period is 2001-2020, which includes many different market conditions and phenomena. The tech bubble, subprime crisis, European debt crisis and the trade war between the US and

China all fall within the time-period. The timeframe is also long enough to make reliable conclusions. Chan, Hamao & Lakonishok (1991), Zoghlami (2016) and Rosenberg et al. (1985) all used shorter than 20-year time-periods in their factor-based studies, which supports the assumption that the period is long enough to make meaningful conclusions.

The research is carried out so that all the listed companies are divided into two groups, small and large caps. Median value of the market caps is used to divide the groups. After that, three subgroups are formed within the groups of small and large caps. These subgroups are momentum, price-to-book and volatility. The final step is to sort these subgroups to quartiles. The limit values of these quartiles are 0-25% (1), 25-50% (2), 50-75% (3) and 75-100% (4) so that every group includes equal number of companies. Finally, every company belongs to three different groups. For example, if a company has the lowest market cap, the worst momentum, the lowest P/B ratio and the highest volatility, it belongs to groups Small + Momentum 1, Small + P/B 1 and Small + Volatility 4. This leads us to the situation where we have 2x3x4 portfolios. The study is done with equally weighted and market cap weighted portfolios, which raises the total number of portfolios to 48.

All the portfolios are rebalanced at the beginning of each calendar year based on the last year's data. The performance of these portfolios is measured by return, Sharpe ratio and Jensen's alpha. Jensen's alpha is accepted as statistically significant if the confidence level is at least 95 percent.

The cross section of factor-sorted portfolios is applied in this research, because it ensures that there is a sufficient number of portfolios to be studied. According to Harvey & Liu (2016), too few portfolios based on too few factors tend to push the results in favour of selected factors. Combining multiple factors also helps to avoid having a huge group of individual stocks or only a handful of portfolios to study (Feng, Giglio & Xiu, 2020). Splitting the data into smaller parts may also make it more accurate to trace the factors explaining the excess returns.

In order for research to have clear objectives, the following research questions are set to guide towards its goals:

1. Which of the selected factors have returned the most from 2002 to 2020?

2. Have any of the factor-based portfolios generated risk-adjusted excess returns compared to the market index?
3. Can we conclude that some of the market anomalies occur in the Finnish market?

This thesis consists of six different chapters. The first one is an introduction, which gives an overview of the researched anomalies and the methodology of this study. Literature review of the second chapter is followed by the theoretical background. Fourth chapter introduces the methodology applied in this research in more detail. The results are presented in the chapter 5. The final chapter summarizes the results and draws final conclusions.

2 Literature review

G. William Schwert (2003) listed in Handbook of the Economics of Finance some of the most known anomalies in markets: The size effect, the turn-of-the-year effect, the weekend effect, the value effect and the momentum effect. Schwert (2003) identified an anomaly as "an empirical result that seem to be inconsistent with maintained theories of asset-pricing behavior". Schwert (2003) stated though that anomalies change during the time and many of them do not hold in different time periods. Next, we take a look at some of the most common anomalies which are studied in this research.

2.1 The size effect

Banz (1981) found in his study that stocks of the smaller companies have had, on average, higher risk adjusted returns than big companies' stocks in NYSE common stocks. The study compared actual returns from 1936–1975 and predicted returns based on capital asset pricing model. According to Banz (1981), the size effect is evident for at least forty years prior to his study. One interesting finding in Banz' (1981) study was also that the size effect is not linear in the market value. The effect occurs for the smallest companies while the difference in excess returns between mid-size and large companies is smaller. The existence of size effect was also studied by Reinganum (1981), who stated that the simple capital asset pricing model (CAPM) is incorrectly specified or then the capital markets are inefficient. Reinganum (1981) found portfolios especially based on company size or earnings-to-price ratio to experience returns that were systematically different from the ones predicted by the CAPM. CAPM will be introduced in more detail in chapter 3.

Fama & French (2008) mentioned Banz's (1981) research in their own paper about anomalies. Fama & French (2008) stated that usually two approaches are used to identify anomalies in overall, which are returns based on specific factors and regression analysis. Fama & French (2008) warn about potential problems in these methods, though. They use a common approach to form equal-weighted portfolios as an example, which can cause some microcap stocks to dominate the portfolio returns. Fama & French (2008) tested the size effect with more sorted portfolios, as they divided studied stock universe in microcaps, small caps and big stocks. They found that the excessive returns of smaller companies compared to larger companies consisted mainly of the microcap companies. The size effect and the excessive returns generated by the phenomenon weakened when comparing middle-sized companies to the biggest ones.

2.2 The value effect

Excess returns of value shares compared to growth shares is also one of the most commonly studied anomalies in the stock market. The phenomenon can be studied through a number of different approaches, like with price-to-earnings ratio (Basu, 1977) or price-to-book ratio. This research focuses on price-to-book-ratio.

Excess return anomaly regarding the price-to-book effect was probably most notably brought to public by Rosenberg et al. (1985). They studied the strategy where stocks were bought based on a low ratio of price-to-book value of a company. They found that these kinds of stocks have unusually high average returns compared to the market index in the US market. Rosenberg et al. (1985) concluded that despite the relatively short time-period through 1980, the phenomenon was evident and statistically significant.

Chan et al. (1991) studied the price-to-book, earnings yield and size effects in Japanese stock markets in a time-period from 1971 to 1988. Their research included manufacturing and non-manufacturing companies from the Tokyo stock exchange, and delisted stocks as well. Their results revealed a significant relationship between all these factors and expected excessive returns in Japanese market. They specifically underlined low price-to-book value and high cash flow yield to have the most significant positive impact on expected returns, low price-to-book value providing the best explanation for abnormal returns.

Du Toit & Krige (2014) published a paper in which they studied the relative performance of a value portfolio compared to growth portfolio. They divided the median price-to-book ratio of the growth portfolio with the median price-to-book ratio of the value portfolio and used this as a valuation difference multiple. Du Toit & Krige (2014) used monthly stock market data from 1991 to 2011. Their research found that the higher the quotient (growth portfolio P/B divided by value portfolio P/B), the higher the outperformance of the value portfolio versus growth portfolio over the five-year periods.

2.3 The momentum effect

Expected stock or portfolio performance based on the recent past has been researched multiple times during the past 35 years and interestingly, the results have been somewhat contradictory. Jegadeesh and Titman (1993) found trading strategies that buy past winners and sell past losers to produce significant abnormal returns during the time-period from 1965 to 1989. Jegadeesh and Titman (1993) used past 3 to 12 month-periods in their portfolio construction. These findings were also supported by Fama & French (1996) who stated that their 3-factor model, which does not include the momentum effect, could not explain short-term abnormal returns of the past winners. DeBondt's & Thaler's (1985) study found however the momentum effect to work the other way around, where past losers outperformed past winners.

Zoghlami (2016) studied the momentum effect and the possible excess returns of the best momentum stocks. The target market in this research was Tunisian stock market, the data was monthly price data, and the time frame was from January 1998 to December 2011. The methodology of this research was to clear the monthly returns from the inherent serial autocorrelations caused by investor's over and under reactions. The results showed momentum effect to be still profitable, but the excess returns achieved by the effect were fully explained by size effect and beta. Beta as a term is explained in chapter 3. However, the general consensus in the studies is that the momentum strategy has achieved risk-adjusted excess returns over history.

2.4 The volatility effect

The volatility effect is also well researched in the last decades. Several studies have shown evidence that stocks with lower volatility tend to produce risk-adjusted excess returns. For example, Haugen & Heins (1972) took a critical approach to, as they describe, unrealistic theoretical models, which described the relationship between higher return and higher risks. With these "unrealistic theories" they refer presumably to the assumption that the expected stock returns go up hand in hand with increasing risk level, i.e. volatility. Actually, they did not find a risk premium to exist at all. The results even proved that the stocks with lower variance in monthly basis provided greater average absolute returns than the ones with higher variance.

Blitz & van Vliet (2007) made same kind of findings in their own study as Haugen & Heins (1972). They found there to be empirical evidence that companies with low historical stock price variance have had higher risk adjusted return than those with higher variance. The annual spreads of returns were 12 percentage points globally between low and high volatility stocks, in favour of low volatile stocks. The time-period in research was from 1986 to 2006. Blitz and van Vliet (2007) concluded that based on their findings, the importance of volatility effect was similar to other most common effects, momentum, value and size.

2.5 Combining factors

As described by the theories presented in the previous paragraphs, the general consensus in financial theory is that the higher risk-adjusted returns can be achieved by investing in companies with small market caps, high momentum in the past, low price-to-book value or low volatility. However, research in the last decades argue that it would be the best to combine these factors to reach better explanatory power of excess returns. For example, Fama & French (1992) introduced a three-factor model, which combined size, value and market risks to have better explanatory power than the capital asset pricing model, which consists solely of market risk. Carhart's (1997) four-factor model claimed that adding momentum as a fourth factor to the Fama & French (1992) three-factor model improves the explanatory power even more.

Combining factors also avoids the problems that too few portfolios can cause. Too few portfolios typically make the results look too good for the factors being studied (Harvey & Liu, 2016). According to Feng et al. (2020), the combination of factors prevents a situation where the study consists of large number of individual securities or an insufficient number of portfolios. Too few portfolios could also lead to a loss of efficiency (Feng et al. (2020).

3 Theoretical background

This chapter gives the reader an overview of the finance theory, which is the backbone of this research.

3.1 Efficient Market Hypothesis

Most of the stock market analysis and research are based on Efficient Market Hypothesis (EMH). Eugene Fama (1991) describes hypothesis "to be the simple statement that security prices fully reflect all available information". One could explain the hypothesis to mean that it is impossible for any investor to be able to reach risk-adjusted excessive returns from the stock market since she could not have any new information, which the stock prices do not reflect already. Grossman and Stiglitz (1980) point out though that the real-life technical limitations, like costs for example, make it basically impossible for markets to be fully efficient.

EMH's history and the first theoretical publications could be traced all the way back to the 16th century at least, when Italian mathematician Girolamo Cardano wrote about gambling's equal conditions of opponents, money etc. (Sewell, 2011). The next big step in the development of EMH is considered to be taken in the early 1900's when Professor Karl Pearson (1905) introduced the term "random walk" in an article published in Nature. In this theory Pearson (1905) basically explains that if a man starts his walk from point X and walks Y yards, then he turns through any angle and walks another Y yards, his path will not form any kind of pattern or trend about his movement and so his walk is totally random. The random walk theory was widely popularized in economics by Burton G. Malkiel (1973) in his book called "A Random Walk Down Wall Street". Like Pearson (1905) described a man walking random path, Malkiel (1973) applied the same theory in stock markets. According to his theory, stock prices move according to random walk, and it is not possible to forecast future movements.

Austrian economist Friedrich Hayek (1945) wrote about using markets in taking advantage of all the knowledge available in the world. Hayek (1945) wrote that "in a system where the knowledge of the relevant facts is dispersed among many people, prices can act to coordinate the separate actions of different people in the same way as subjective values help the individual to coordinate the parts of his plan". When individual investors use the knowledge they have, the markets start to price in all these pieces, which leads to a situation where no one knows any information which is not priced in the markets.

The most important contribution and deeper understanding of Efficient Market hypothesis was provided by Eugene Fama (1970) when he introduced three stages of market efficiency in his publication “Efficient Capital Markets: A Review of Theory and Empirical Work”. The three stages were weak efficiency, semi-strong efficiency and strong efficiency.

Weak form efficiency hypothesis claims that all the past security prices are reflected in current price and thus one cannot predict the stock price based on its pricing history. Since there are no price patterns in weak form, it is impossible to gain abnormal returns with technical analysis. In this case there would be also no price momentum. In Fama’s (1970) research, weak form tests were the most voluminous and the results of weak form’s validity were strongly supported by the findings. (Fama, 1970).

In semi-strong efficiency, security prices are reflecting all the publicly available information. This form of efficiency makes it impossible to achieve any superior returns with technical or fundamental analysis. In overall, semi-strong form is often considered to be the most practical form of different type of efficiencies, and probably the form closest to reality. (Fama, 1970).

Strong-form efficiency hypothesis states that all available information, including public and private, is completely priced in current security prices. In this kind of market, it is impossible for anyone to gain any advantage and thus impossible to reach abnormal returns. There has been some research though, which claims corporate insiders, unexpectedly, to have monopolistic access to information regarding the company. This makes the strong form difficult to realize in real life. (Fama, 1970).

Grossman’s (1976) research concluded that when there are different kind of trades with different kind of information, these traders reveal their information to each other and this combines all the information, as it all becomes publicly known through the price. The result of this is that the competitive system aggregates all the market’s information so that the current market price includes all the available information. The other result of this “cumulating information” is that a trader who does nothing to receive any information or observe the market, can achieve the same returns as traders who pay for the information.

As stated earlier in this chapter, there have been also a fair amount of criticism towards the efficient market theory. Grossman and Stiglitz (1980) concluded that the assumptions of all markets to be in equilibrium and perfectly arbitrary all the time are inconsistent when taking the advantage of arbitrage is costly. Their model suggests that the prices reflect the information of informed traders but only partially. This will allow investors who use resources to access information to receive a reward in the form of excess returns.

3.2 Risk and return

The tradeoff between risk and return means that usually the risk increases when expected return rises. Modern portfolio theory (MPT) by Markowitz (1952) is based on an idea that risk-averse investors can construct portfolios with maximized expected returns based on a certain level of market risk. An investor can reduce his level of risk by allocating capital to different kind of financial assets. Risk can be further reduced by diversifying investments within the asset classes, in different stocks for example. The expected return of the whole portfolio is proportion-weighted combination of individual assets' expected returns. (Kallunki, Martikainen & Niemelä, 2019).

Portfolio's expected return is given as follows:

$$E(R_p) = \sum_{i=1}^{N} w_i \, \mathrm{E}(R_i)$$

where $E(R_p)$ is portfolio's expected return, $\mathrm{E}(R_i)$ is security i's expected return, w_i is security i's weight in the portfolio and N is the number of securities in the portfolio.

The risk of a portfolio, as well as an individual security, can be measured by standard deviation. The standard deviation describes the amount of variation in the return of an investment. According to MPT, the standard deviation of the whole portfolio is smaller than the average of standard deviations of individual stocks. The reason for this is that the movements of security prices do not correlate perfectly, and they move always somewhat differently. This leads to a situation where an investor can reduce his risk without losing any expected return. (Kallunki et al. 2019).

The following formula is used to calculate the standard deviation of the portfolio:

$$Std(R_p) = \sqrt{\sum_{i=1}^{N} w_i^2 \sigma_i^2 + \sum_{i=1}^{N} \sum_{j=1}^{N} w_i w_j cov_{ij} i \neq j}$$

Where w_i and w_j are securities' i and j weights in the portfolio, σ is security i's standard deviation, cov_{ij} is covariance between the returns of securities i and j and N is the number of securities in the portfolio.

Modern portfolio theory suggests that an investor can choose the portfolio, which has the highest expected return with certain amount of risk. In other words, of the portfolios offering the same expected return, an investor can select the one with the lowest risk. This situation can be described with graph (figure 1) of the possibilities investor has to choose from. The line from point A to point B includes all the possible portfolios in an investing universe. Points A and B are individual stocks with the lowest and highest expected returns and standard deviations. Point C is the portfolio with the lowest volatility. From the figure 1 we can see that the portfolios located on a dotted line are not the optimal ones, since an investor can choose portfolios from point C upwards with the same volatility, but higher expected return. This is so called efficient frontier. (Kallunki et al. 2019).

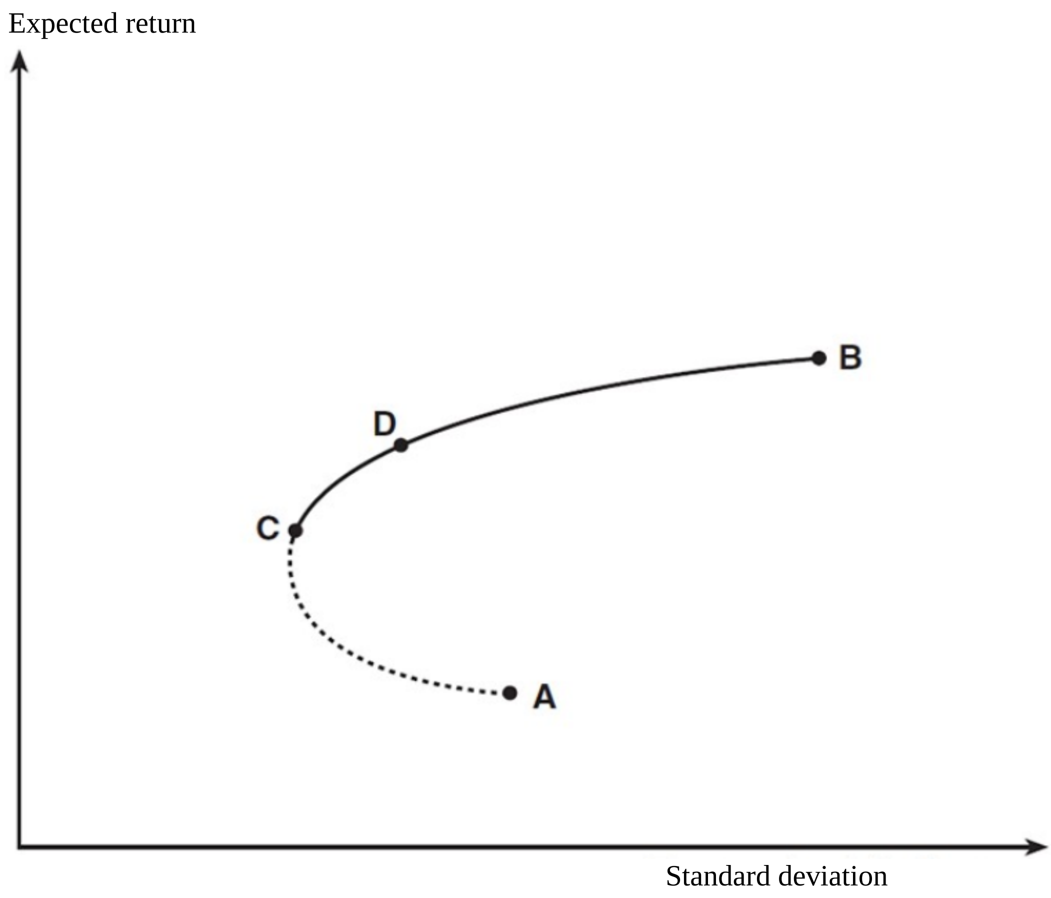

Figure 1. Efficient frontier (Kallunki, Martikainen & Niemelä, 2019).

To conclude, the main idea of efficient frontier is that an investor can reduce his risk by diversifying his portfolio without sacrificing the expected return. However, an investor can only reduce the risk of his portfolio until certain point by diversifying investments. There is a lot of academic research which suggest that the most effective risk reducing happens between 1 and 10 stocks, but after that the slope clearly decelerates between 10 and 20 stocks.

An investor cannot diversify all the risk away from his portfolio. The risk which is left after optimal diversification is called systematic risk. This part of the risk is caused by the general variation in stock markets. The other part, unsystematic risk, is the one related to the individual company. This part of risk is possible to diversify away in portfolio almost to the full amount. Systematic and unsystematic risks are described in figure 2 on the next page. Systematic risk is measured with beta coefficient, which is introduced in the next chapter. (Kallunki et al. 2019; Knüpfer & Puttonen, 2018).

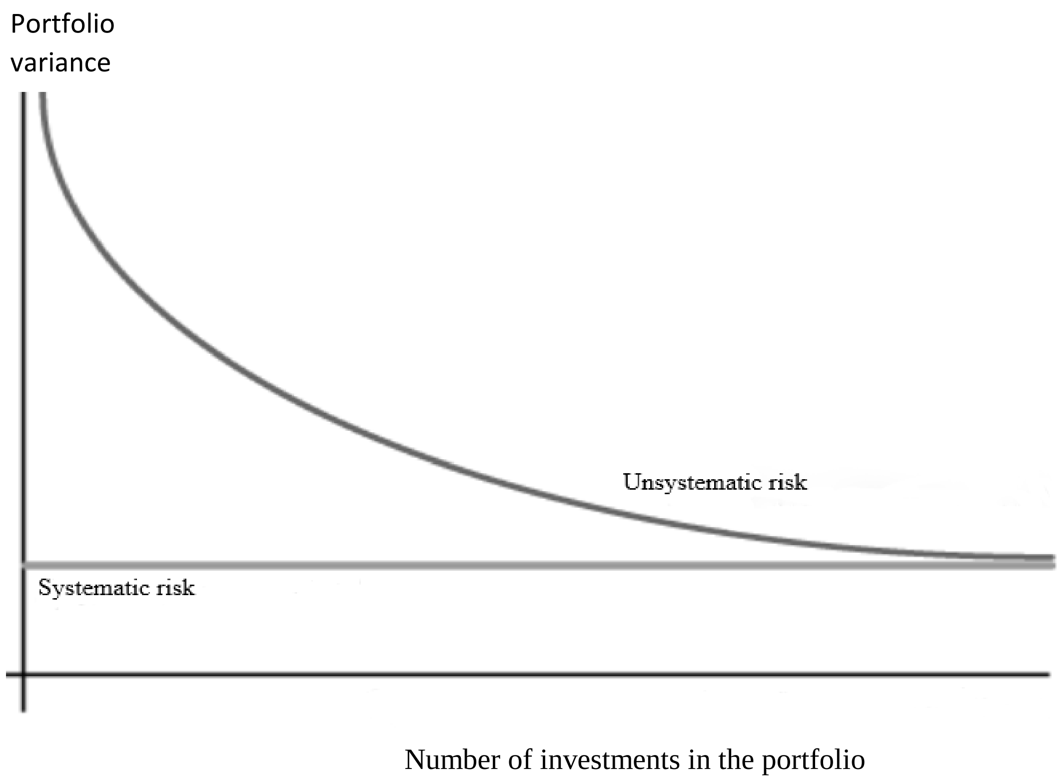

Figure 2. Systematic and unsystematic risk (Puttonen & Knüpfer, 2018).

3.3 Capital Asset Pricing Model

As we summarized in earlier paragraphs, there is a strong link between the expected return and risk level of certain stock or investment instrument according to financial theory. In fixed income asset class, it is rather easy for an investor to understand the expected return and even the level of risk, but it gets trickier when the investor has to make these assumptions regarding equities. It is one of the most discussed challenges in finance theory to estimate the relation between the risk and expected return of an equity.

The most common theory to approach this question is Capital Asset Pricing Model (CAPM), which was first introduced by William F. Sharpe (1964). CAPM is used to describe the company-related risk in relation to the market. Based on CAPM, this relationship can be described by the following formula (Kallunki et al. 2019):

$$E(R_i) = R_f + \beta_i[E(R_m) - R_f]$$

Where

$E(R_i)$ = expected return of security *i*

R_f = risk-free rate

β_i = beta coefficient of security *i*

$E(R_m)$ = expected return of market portfolio

Based on this equation, the expected return of an individual stock is a risk-free rate, usually government bond, plus a company-specific risk premium. Expected market return minus risk-free rate is the so-called market risk premium. This premium shows how much more the stock market is expected to return compared to risk-free rate. Beta is a multiple, which describes the systematic risk of a certain security. In other words, beta reflects the sensitivity of a change in the price of an individual security or portfolio in relation to price changes in market index. The beta multiple of the risk-free investment is always zero and the beta multiple of the market portfolio is 1. (Kallunki et al. 2019; Knüpfer & Puttonen, 2018).

Beta multiple of a security can be calculated with the following equation (Knüpfer & Puttonen, 2018):

$$\beta_i = \frac{\sigma_{im}}{\sigma_m^2}$$

Where

β_i= Beta coefficient of security *i*

σ_{im}= Covariance between security *i* and market portfolio

σ_m^2 = Variance of market portfolio return

The Capital Market Line (CML) is used to describe an efficient portfolio based on the theory of CAPM, which combines optimally risk and return. CML is showed as a straight line in figure 3on the next page. The CML applies the idea that the expected return increases together with risk. The most optimal portfolio regarding the mix of risk and return can be found in the middle of the line, which is so called tangency portfolio. (Campbell & Viceira, 2001).

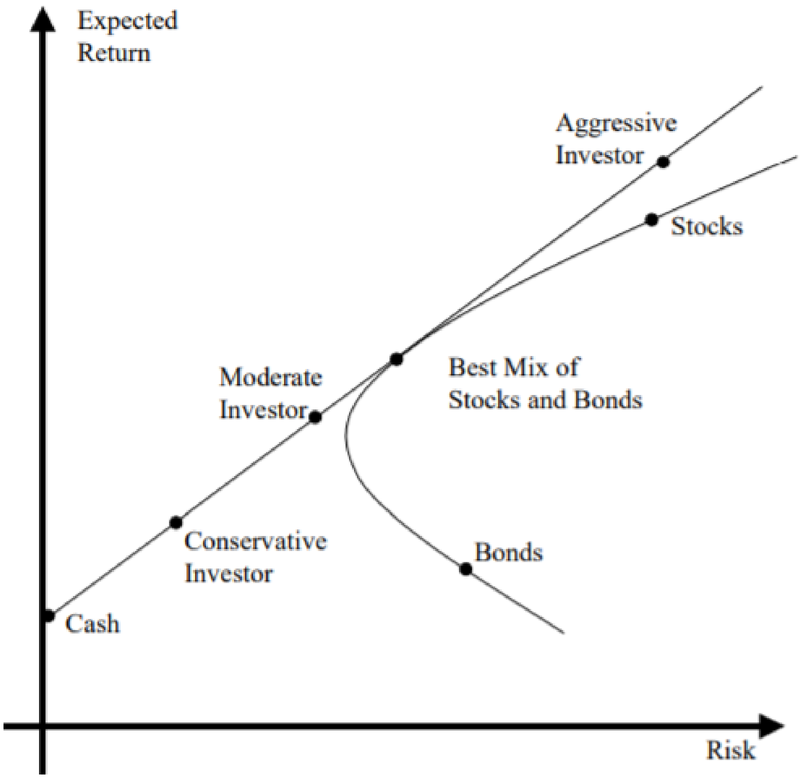

Figure 3. Capital Market Line (Campbell & Viceira, 2001).

4 Data and methodology

4.1 Description of data

The data used in this research includes all the stocks listed in Helsinki's stock exchange in selected time-period, which starts from the beginning of 2001 and ends at end of 2020. This time-period has been chosen because 20 years provides a sufficient sample size and time horizon for a monthly review. Also, several exceptional events and circumstances have occurred during this period, for example the dot-com bubble (from late 1990s to early 2000s), subprime crisis (2007–2008), European debt crisis (2010–2012) and the latest trade war between China and the USA (2018–2020). 20 years (+- few years) is also the time-period used in MSCI's (2013) Barra Equity Model, which is widely used global multi-factor equity model to screen different stock markets based on different factors (Bender, Briand, Melas, & Subramanian, 2013; MSCI, 2021). Fama & French (1992) used 28 years of data in their study about factors in stock markets, but the ballpark in the time horizon is roughly the same. Fama & French (2021) provide stock market data for 31 years in their website, but Finnish market is not separated from the European factor group, so Fama & French (2021) data is not usable in this research.

The number of studied companies varies during the research period, as the data used in this study includes all the listed companies, even if the company would have been listed only for a month. There are 195 different companies in total between 2001 and 2020. In the first year there are 136 companies and in the last year there are 132 companies.

The source of the research data is the FactSet database (2021), and every modification and portfolio construction is based on this dataset. The data takes into account dividends and treats them as if the dividends paid had been reinvested in the shares of the company that paid the dividend. Using price price data alone would lead to misinterpretations, as the share price typically decreases by the amount of dividend paid per share at the time the dividend is paid, ceteris paribus.

Dividends must also be taken into account when selecting an appropriate benchmark index. The stock universe and every constructed portfolio used in this research is limited to Finland and Helsinki stock exchange, so the suitable benchmark index is OMX Helsinki index, which includes every stock listed in Finland. OMX Helsinki Growth Index (OMXHGI) treats dividends in the same way as our dataset extracted from FactSet (2021), as it assumes that all the dividends had been invested back in the shares of the company who paid the dividend.

One could argue that the Finnish stock market is not big enough to make any meaningful assumptions, but many of the professional investors and fund managers, especially those who invest public money, are limited to Finnish stocks. They have to compare their performances against the OMXH indices, so there is an obvious reason to understand the local market also in addition to global markets.

Risk-free rate is also an essential part of this research. There are many issues associated with a term "risk-free", as one could argue that there are no risk-free investments in the known investing universe. The risk-free rate used in this research is Germany 10-year bond yield. It would be possible to use bonds of other countries also, such as Finland's since that is the target market of the study, but both of these countries have been part of the Eurozone for the whole research period and Germany can be considered as more stable and larger economy than Finland.

There are also different opinions and studies about the best possible government bond maturity to be used. For example, Feldhütter & Lando (2007) stated that swap rates are better proxies for risk-free rate than any maturity of treasury rates. However, 10-year treasuries are often used and since the purpose of this research is to study Finnish stock markets with a long-term mindset of 20 years, 10 years is a valid time horizon in author's opinion. Officer & Bishop (2008) argued in their study that they do not see any problem in continued usage of 10-year maturing proxy for the risk-free rate when assessing the cost of equity. They also underlined that preserving consistency in variables is maybe more important than the length of the maturity itself.

4.2 Methodology

As stated before, the purpose of this study is to compare returns of companies with different factors and elements by constructing multiple portfolios based on these factors and then study, how each of these portfolios performed over the time. As also mentioned before, the selected criteria for portfolios are size, momentum, price-to-book ratio and volatility. Firstly, the portfolios are constructed at the beginning of 2002 based on the numbers at the end of 2001. The companies in all portfolios are updated at the beginning of each calendar year based on previous calendar year's figures and performance. Portfolio performances are reviewed at the end of each calendar month and the final results are calculated for the time period between 2002 and 2020. Results show, how much each of these portfolios returned between this time-period and did any of these portfolios generate risk-adjusted excessive returns compared to the market index.

The first criterion in portfolio construction is the size, which is either "Small" or "Big". The companies are divided in these groups by their market caps. Every company with a market cap less than the median value of the whole group of OMXH companies is small and every company with a greater than the median market cap value is big. Market cap at the end of calendar year *t* determines if that company belongs to small or big companies in calendar year *t+1*. Small and big companies are handled separately during the whole research. Median values of market caps varied between 80 and 274 million euros 2001–2020, which tells us that the group of small caps consists of more like micro caps than small caps in global perspective.

All the other criteria, momentum, price-to-book ratio and volatility are used to divide the companies in four groups. The limit values are 25%, 50% and 75%. Companies with the lowest values/rankings belong to group 1 (0-25%) and companies with the highest values in group 4 (75-100%). Just like "small" and "big" criterion, all these factors are also based on the year-end or previous year's values.

Momentum ranking is based on the company's market value increase or decrease from the beginning of the calendar year to the end of the calendar year. The higher the relative market cap increase, the higher the momentum number. Price-to-book values are static numbers at the end of each year. Price-to-book stands for the market value of the company divided by the book value of the balance sheet. These values are downloaded from the FactSet (2021) database. According to FactSet (2021), price-to-book values are based on the latest available market caps and the latest published book values. Basically, this means that the price-to-book values used in this research are market caps at the end of each calendar year's last trading day divided by the book values of Q3 reports. This is because typically the latest published book values at the end of each calendar year are the ones from Q3 reports, since Q4 reports are usually published between late January and March.

Volatility ranking for each year is based on the market cap fluctuation during the previous calendar year. Market cap fluctuation is measured with annualized standard deviation. The market cap and market cap movement of each company is reviewed on a monthly basis and the annual volatility of each company is calculated with the following formula:

$$Annualized\ volatility = \sqrt{12}\left(\sqrt{\frac{\sum|x-y|^2}{N}}\right)$$

where

x = monthly market cap movement of the company

y = mean of the calendar year's market cap movement

N = the number of data points (12 months)

One could argue that volatility could or should be measured with annualized standard deviation derived from daily rather than monthly market cap movements. However, Schwert (2011) concluded in his research regarding volatility, that his findings from the stock market price data between 1802 and 2010 were not sensitive to whether volatility was measured on a monthly or shorter basis.

Constructed portfolios are named based on size and factor group:

Lowest quartile (0-25%) = 1, lower middle quartile (25-50%) = 2, upper middle quartile (50-75%) = 3 and the highest quartile (75-100%) = 4.

For example, a small company with momentum better than 75% of the universe of small caps belongs to portfolio Small + Momentum 4. A company with a bigger than median market cap and volatility in the second-highest quartile (50-75%) in the group of big market cap companies belongs to portfolio Big + Volatility 3. Small company with the highest price-to-book value among small companies belongs to portfolio Small + P/B 4 and so on. Something to point out here is that numbers 1, 2, 3 and 4 do not automatically tell, if the higher number is better or worse than the lower number. For instance, higher momentum number means that the development of the market cap of specific company has been better than those with lower number previous calendar year. Higher volatility number, on the other hand, means that the volatility of the stock has been greater than for companies with lower numbers, which can be seen as a negative thing.

At the end of portfolio construction process, we have 2x3x4 portfolios in total. However, all the portfolios presented in previous paragraphs are constructed with equal weights, but also with market cap weights. This means that, in total, there are 48 portfolios which are reviewed in this study: 24 with equal weights and 24 with weights based on market caps.

4.3 Jensen's alpha

Jensen's alpha is a measurement introduced by Michael Jensen (1967). The purpose of Jensen's alpha is to estimate how well the portfolio has performed on a risk-adjusted basis. The theory is based on the validity of the capital asset pricing model. As we concluded earlier, higher returns require higher risk according to the CAPM. If the value of Jensen's alpha is zero, it means that the portfolio has produced returns which are expected based on the risk level of the portfolio according to CAPM. Value greater than zero means that the portfolio has performed better than one could expect based on its risk level. Value less than zero means that the portfolio has underperformed on a risk-adjusted basis. According to Jensen (1967), the measurement of alpha can be defined with the following formula:

$$\alpha = R_i - [r_f + \beta_i(r_m - r_f)]$$

Where

α = the alpha measure i.e. excess return

R_i = the return of portfolio

r_f = the risk-free rate of return

β_i = the beta coefficient of the portfolio

r_m = the return of the market index

However, Jensen (1967) highlights that the measure of performance, alpha, can be greatly affected by pure randomness and luck. To be able to evaluate the results with more confidence, it is important to find out the statistical significance of the results. Therefore, the least squares regression model should be applied. Regression analysis and its methodology is introduced later in this chapter.

4.4 Sharpe ratio

Sharpe ratio is another measurement to evaluate the performance of a portfolio on a risk-adjusted basis. Sharpe ratio was developed by economist William F. Sharpe (1966). The purpose of the ratio is to measure portfolio's risk-adjusted return compared to the risk-free rate. Sharpe ratio is calculated by subtracting the return of risk-free rate from the return of portfolio and dividing the remainder by the volatility of portfolio's excess return. The higher the Sharpe ratio, the better the performance of the fund relative to its risk. (Kallunki et al. 2019).

According to Sharpe (1966), the ratio can be defined with the following formula:

$$Sharpe\ ratio = \frac{R_i - r_f}{\sigma_i}$$

Where

R_i = the return of the portfolio i

r_f = the risk-free rate

σ_i = the standard deviation of the portfolio i's excess return

4.5 Linear regression

Linear regression is used in this research to evaluate the relative performance of constructed portfolios compared to the market index. The main purpose is to find, which portfolios have performed better than the market index (OMX Helsinki growth index) on a risk-adjusted basis. This is done using Jensen's alpha, which was introduced in chapter 4.3. As stated earlier, Jensen's alpha is based on an expectation that capital asset pricing model is valid, which would mean that the risk and return go up and down hand in hand. If the value of Jensen's alpha is positive, then the portfolio in question has returned better than the level of risk would suggest.

The applicable regression formula can be derived directly from the previously presented formula for calculating Jensen's alpha:

$$R_i - r_f = \alpha + \beta_i(r_m - r_f) + u_i$$

Where

R_i = the return of the portfolio

r_f = the risk-free rate

α = alpha, i.e. excess return

β_i = the beta coefficient of portfolio i

r_m = the return of the market index

u_i = error term, which have a value of 0 and should be serially independent.

The purpose of linear regression is to give more evidence if any of the portfolios have produced excess returns. Jensen's alpha could be positive indicating risk-adjusted excess returns, but there would be also the possibility of pure luck and randomness. Thus, linear regression is used to measure the standard error of estimate of the performance measurement. The result of this analysis tells us if the efficient market hypothesis is valid or not based on the assumptions of capital asset pricing model. If none of the portfolios produce any excess returns, then the alpha is zero and the hypothesis of efficient markets can be seen as a valid. (Jensen, 1967).

Statistical significance of the results is measured with p-value, which describes the probability of outcome occurring randomly. If the p-value is under 0.05, it means that there is a less than five percent probability that the results are random and there is a so-called 95 percent confidence level. 0.05 is the most used limit value in statistics and results with p-value less than 0.05 are usually called statistically significant results.

4.6 Controlling the look-ahead and survivorship biases

To meet its objectives, research must handle and describe the data and phenomenon under study as accurately and unbiased as possible. The first obstacle to tackle for the author is extreme carefulness when manually handling the data. The second thing to consider during the study is that are there any biases which have gone unnoticed.

For example, look-ahead bias would occur if material or data had been used in the study at a time when information was not yet available. This bias has been prevented by the fact that all the information and data used in this study has been available at that time when different portfolio changes have been made. For example, using price-to-book values based on Q4 balance sheets would be typically impossible at the time of portfolio construction on 1 January, since Q4 results and balance sheets are usually published in Finland between January and March. FactSet (2021) data is based on the latest published information on any given date, so 1 January price-to-book values are typically based on the latest share prices and the book values of Q3 balance sheets.

Look-ahead bias had to be avoided also in other parts of portfolio construction, as there are many companies which have been delisted in the middle of calendar year. As described in the previous chapter, portfolios are constructed based on the factors at the end of each calendar year. If some company was delisted in the middle of the calendar year, this did not prevent the company to be included in some of the portfolios during that year.

Portfolio performances are reviewed at the end of each calendar month, so if some company has been delisted, for example, in June, the calculated return for that year is the one which the stock had cumulated until delisting point. One thing to consider is also that there is a possibility of bankruptcy or being acquired in the middle of the calendar month, in which case the final share value for that year is not registered in the data, but the value of the last month-end is used instead. The author does not see this as a major problem. First of all, bankruptcies usually do not happen overnight. Typically, this kind of company is already in a bad shape some time before the bankruptcy itself, so we could assume the stock price to be close to the final price already a few weeks before, which makes it very unlikely that there were any huge missing price movement in the middle of the calendar month.

Secondly, in the case of possible acquisition, the situation is even more simple. It is true that the publication of acquisition is usually a surprise to the markets leading to an immediate rise in share price. However, Finnish Securities Markets Act (2012) requires that the time allowed for the acceptance of a takeover bid may not be less than three nor more than ten weeks. It is typically not in the interest of acquiring party to make the timeframe too narrow for the target company's owners. Since the share price of the company being acquired moves typically close to the bid price fairly soon after the information comes public, there should be no major missing price movements due to completed acquisitions in the middle of calendar months.

The second common bias to be careful with is survival or survivorship bias, which means that the data would not take those samples into account which have not made it to the review point. This could lead to a too optimistic results when failed companies would not be considered part of the results. This is not the case in this study, because all the past and current companies are included for the time they have been listed. This leads to a realistic results, as those companies which have gone bankrupt end up close to the value of zero and acquired companies end up close to a takeover price.

Transaction costs are also something which could be taken into account. Usually, when there is a buy or sell transaction, the broker dealing the transaction takes a fee. As stated before, in this this research all the portfolios are updated and rebalanced at the beginning of each year. This does not mean necessarily that all the companies had to be bought or sold, because some of the companies in portfolios will continue from year *t* to year *t+1*, but there are typically over 130 companies in the data each year and each of these companies belong to 6/48 different portfolios every year. Such a massive rebalancing with buying and selling would cause naturally some transaction costs, but those are not included in this research. There are a few reasons: First, it is difficult to make any accurate estimates for the costs, since the portfolio construction is automated and the process does not highlight, how many companies have been bought or sold in each portfolio. Second, transaction costs have changed a lot during the review period of 2002–2020. Costs have also varied greatly between different brokers. There are some rough averages available for different decades and years, but since the number of transactions itself is not available, the decision to ignore transaction costs have been made in this study.

5 Results

This section includes all the results and statistics about the topics introduced earlier in this study. The first section introduces some basic statistics. The second section shows the portfolio returns. Third section focuses on the results of regression analyses. In addition, factors and issues that significantly affect the results have been highlighted.

5.1 Descriptive statistics and background

There are 48 portfolios studied in total, 24 different criterion combos with market cap weights and equal weights. The reviewed time-period is from the beginning of 2002, when the portfolios are constructed based on 2001 factors, to the end of 2020. This time-period contains a total of 228 data points, as the review is conducted on a monthly basis. The number of companies in each portfolio varies over time according to the number of companies on the Helsinki stock exchange at any given time. The lowest number of listed companies was in 2013, when there was a total of 124 of them. The highest number of companies were in 2003, when there were 139 listed companies. The average number of listed companies during the time-period was between 131 and 132, which means that each portfolio consists of an average of 16.4 companies.

Table 1. Benchmark index OMXHGI

Benchmark index	**Cum. return 2002-2020**	**Annual return**	**Standard deviation**	**Sharpe ratio**
OMXHGI	172%	5,4%	20%	0,16

As we start to take a closer loot at the performances of the portfolios, first, we look at the benchmark index. OMX Helsinki Growth Index returned cumulatively 172% between 2002–2020 and annually 5.4%. OMXHGI’s index value was 10804 at the end of 2001 and 29371 at the end of 2020. The lowest turn-of-the-month index value during the period was 6322 at the end of February 2003. The highest value was the one at the end of 2020. Standard deviation of the index was 20% and Sharpe ratio 0.16. (Nasdaq, 2021; table 1).

Something to highlight is that OMXHGI is market cap weighted index, and the weight of the companies is not limited. For example, Nokia's market cap was over 57% of the whole market cap of OMXHG index at the beginning of 2002. This means that changes in Nokia's share price are largely driving the index movements. Nokia's decline, especially from 2007 onwards, is also one major reason for such a modest OMXHGI return during the time-period. Nokia's price movements have not been adjusted or eliminated in the data used in this research.

Risk-free rate used in this research is German 10-year government bond yield. At the beginning of 2002, the annualized rate was close to five percent. As is well known, interest rates have been in decline after the financial crisis in 2007–2008. German 10-year bond was trading above 4 percent in 2008, but from that point the trend has been downwards. The rate turned negative for the first time in 2016. German 10-year government bond interest rate was at -0.6 percent at the end of 2020. (Figure 4).

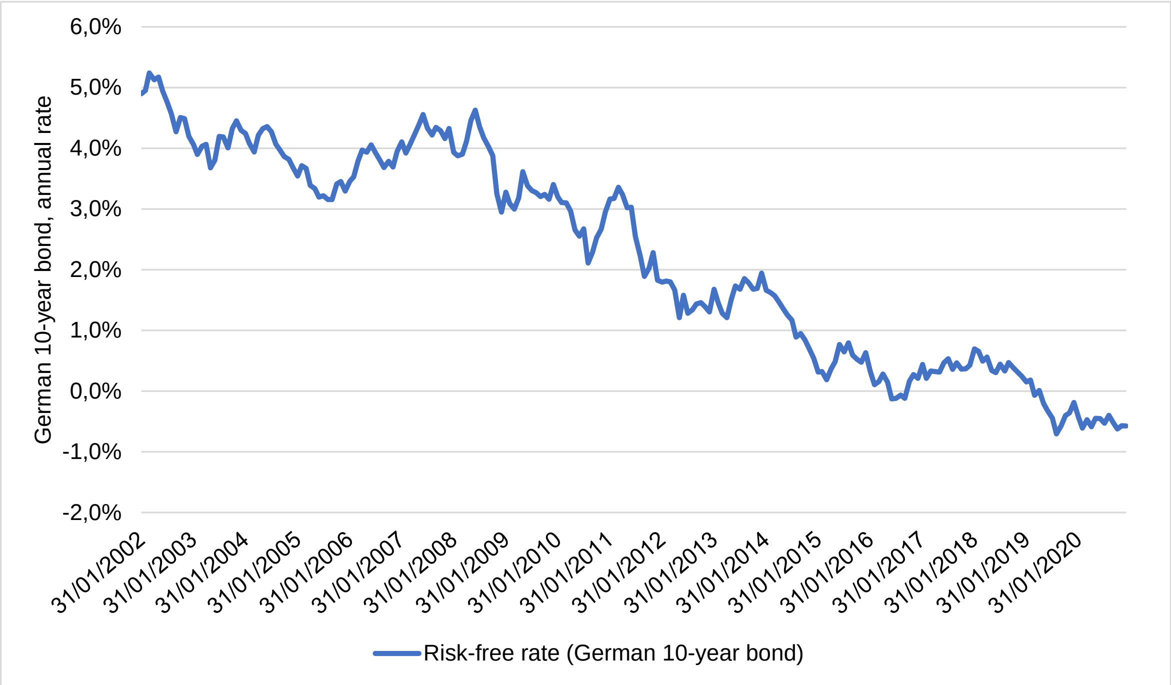

Figure 4. Risk-free rate, German 10-year government bond

5.2 Portfolio returns

Table 2. Small companies + Momentum

Equally weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Small + Momentum 1	144%	4,8%	27%	0,10
Small + Momentum 2	602%	10,8%	18%	0,47
Small + Momentum 3	580%	10,6%	16%	0,52
Small + Momentum 4	2640%	19,0%	20%	0,85

Market cap weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Small + Momentum 1	13%	0,6%	25%	-0,06
Small + Momentum 2	291%	7,4%	17%	0,30
Small + Momentum 3	760%	12,0%	16%	0,60
Small + Momentum 4	3179%	20,2%	20%	0,91

The performance of both, market cap and equally weighted, Small + Momentum 4 portfolios were especially strong. Annual return of market cap weighted Small + Momentum was 20.2% and the return of equally weighted Small + Momentum 4 was 19.0%. Both portfolios had a standard deviation of 20%, which is the same as OMXHGI. At this point we can conclude that these portfolios beat the index with a great margin, although volatility was at the same level as the index. (Table 2).

From the small companies divided by momentum, only the worst momentum portfolios (Small + Momentum 1) returned less than the market index. These portfolios, market cap and equally weighted, had also higher standard deviations. Market cap weighted Small + Momentum 1 was also the only portfolio in this study, which had a negative Sharpe ratio during the review period (-0.06). From these results it seems clear that the past momentum is a significant factor determining next year's returns, but we will get back to the statistical significance of the findings later in this chapter. (Table 2).

Table 3. Small companies + Price-to-book ratio

Equally weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Small + P/B 1	895%	12,9%	19%	0,56
Small + P/B 2	708%	11,6%	20%	0,48
Small + P/B 3	925%	13,0%	19%	0,57
Small + P/B 4	803%	12,3%	20%	0,51

Market cap weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Small + P/B 1	915%	13,0%	18%	0,61
Small + P/B 2	371%	8,5%	19%	0,34
Small + P/B 3	879%	12,8%	19%	0,56
Small + P/B 4	910%	12,9%	20%	0,53

Small caps broken down by price-to-book ratio is a much more equal group than the one based on a momentum. Theory and previous research suggest that companies with small P/B would outperform the ones with a higher ratio, but this was not clear between 2002 and 2020. Annual return, standard deviation and Sharpe ratio were all close to each other between Small + P/B 1, Small + P/B 3 and Small + P/B 4. Only Small + P/B 2 was lagging the rest of the group. In equally weighted portfolios Small + P/B 2 was also closer to the rest of the subgroup than in market cap weighted portfolios. All the small + P/B portfolios outperformed the market index in annual return and Sharpe ratio. (Table 3).

Table 4. Small companies + Volatility

Equally weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Small + volatility 1	1265%	14,7%	14%	0,92
Small + volatility 2	598%	10,8%	17%	0,50
Small + volatility 3	700%	11,6%	21%	0,44
Small + volatility 4	484%	9,7%	28%	0,27

Market cap weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Small + volatility 1	1187%	14,4%	13%	0,92
Small + volatility 2	337%	8,1%	18%	0,33
Small + volatility 3	896%	12,9%	20%	0,53
Small + volatility 4	368%	8,5%	28%	0,22

Small caps with the lowest volatility (volatility 1) provided the best annual return in both equally and market cap weighted categories (14.7% and 14.4%). Standard deviation remained lower in those portfolios which had a lower price variance in previous year also. Small + Volatility 1 portfolios had the highest annual returns, lowest standard deviations and thus also the best Sharpe ratio of 0.92. Portfolios with the highest standard deviation produced annual returns of only 9.7% and 8.5%. These results are quite contrary to finance theory and capital asset pricing model, which are based on an assumption that higher returns are correlated with higher risk. Although, it is studied that companies with lower volatility produce better risk-adjusted returns than companies with higher volatility, it is still somewhat surprising to see that the gross annual return is also so much better. Sharpe ratios of Small + Volatility 4 portfolios were 0.27 and 0.22. All the small + volatility portfolios outperformed the OMXHG index in annual return and Sharpe ratio. (Table 4).

Table 5. Big companies + Momentum

Equally weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Big + Momentum 1	267%	7,1%	23%	0,21
Big + Momentum 2	647%	11,2%	18%	0,51
Big + Momentum 3	1197%	14,4%	16%	0,74
Big + Momentum 4	856%	12,6%	18%	0,58

Market cap weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Big + Momentum 1	158%	5,1%	29%	0,10
Big + Momentum 2	233%	6,5%	21%	0,21
Big + Momentum 3	1034%	13,6%	18%	0,63
Big + Momentum 4	744%	11,9%	21%	0,45

The momentum effect in large companies is somewhat visible in these results, but not as strongly as in small companies. Actually, the Big + Momentum 4 portfolios were not the best performers in terms of annual return, but Big + Momentum 1 portfolios were clearly the worst ones of this group. In market cap weighted portfolios, Big + Momentum 3 and 4 were clearly superior compared to 1 and 2. Market cap weighted Big + Momentum 1 was the only one to underperform compared to the market index in annual return and Sharpe ratio. (Table 5).

Table 6. Big companies + Price-to-book ratio

Equally weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Big + P/B 1	1115%	14,0%	19%	0,61
Big + P/B 2	466%	9,6%	18%	0,41
Big + P/B 3	861%	12,6%	17%	0,60
Big + P/B 4	426%	9,1%	18%	0,38

Market cap weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Big + P/B 1	845%	12,5%	23%	0,45
Big + P/B 2	263%	7,0%	22%	0,22
Big + P/B 3	380%	8,6%	20%	0,33
Big + P/B 4	141%	4,7%	25%	0,10

Big companies with the lowest price-to-book ratio returned annually (14.0% and 12.5%) more than their four-member subgroups. There is a somewhat visible downward trend from small P/B to bigger P/B portfolios in returns. The worst portfolio of all the Big + P/B ones was market cap weighted Big + P/B 4, which was the only one of this group to underperform compared to OMXHGI in annual return and in Sharpe ratio also. It is notable that some company or companies with a really large market cap was heavily underperforming, since equally weighted portfolio returns and Sharpe ratios were significantly higher than the market cap weighted portfolios had. (Table 6).

Table 7. Big companies + Volatility

Equally weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Big + volatility 1	555%	10,4%	13%	0,61
Big + volatility 2	1364%	15,2%	17%	0,76
Big + volatility 3	730%	11,8%	20%	0,49
Big + volatility 4	382%	8,6%	24%	0,27

Market cap weighted portfolio	Cum. return 2002-2020	Annual return	Standard deviation	Sharpe ratio
Big + volatility 1	643%	11,1%	17%	0,53
Big + volatility 2	435%	9,2%	20%	0,35
Big + volatility 3	391%	8,7%	23%	0,29
Big + volatility 4	128%	4,4%	28%	0,08

The same effect of market cap weighted portfolios lagging the equally weighted ones is obvious also in Big + Volatility portfolios as was in Big + P/B portfolios. All the equally weighted portfolios beat the market index in annual return and Sharpe ratio. Equally weighted Big + Volatility 2 was especially strong with 15.2% annual return and 0.76 Sharpe ratio. (Table 7).

In market cap weighted portfolios, Big + Volatility 4 returned only 4.4% with Sharpe ratio of 0.08. Both numbers lagged OMXHGI. Market cap weighted portfolios show a trend of declining returns and lower Sharpe ratios as the volatility increases. This effect in not as visible in equally weighted portfolios, although Big + Volatility 4 was the worst performer in that subgroup also. The theory about higher returns with higher risk is easy to question based on these results also. (Table 7).

When we look at the performances of all the portfolios studied in this research, two different portfolios pop up with especially strong returns. These are small cap companies that have had the best momentum in the previous year (Small + Momentum 4). This is true in both equally weighted and market cap weighted portfolios. Market cap weighted Small +

Momentum 4 portfolio returned cumulatively 3179% from the beginning of 2002 to the end of 2020. As an annual return this means 20.2%. The second-best portfolio, equally weighted Small + Momentum 4, returned cumulatively 2640% and annually 19.0%. The third one was equally weighted Big + Volatility 2, which returned cumulatively 1364% and annually 15.2%. (Figure 5).

The worst portfolios of the studied time-period were market cap weighted Small + Momentum 1 (the worst momentum in the previous year) and market cap weighted Big + Volatility 4, which is the portfolio consisting of large caps with the highest volatility in the previous year. Market cap weighted Small + Momentum 1 returned cumulatively only 13.0%, resulting in an annual return of 0.6%. Market cap weighted Big + Volatility 4 returned cumulatively 128% and annually 4.4%.

Small cap portfolios performed return-wise better than large cap portfolios. The average annual return of all the small cap portfolios was 11.4%, when the average annual return of large cap portfolios was 10.0% between 2002 and 2020. Average standard deviation of small cap portfolios was 20%. Large caps had also an average standard deviation of 20%. Small cap portfolios' average Sharpe ratio was 0.50, while large caps had an average Sharpe ratio of 0.41. One could sum up these findings so that the small cap portfolios have returned better than large cap portfolios with the same risk level.

At this point it is important to highlight though the problem with liquidity. Several small cap companies have very low liquidity, which makes their shares less volatile than those with better liquidity. It is also good to remember that volatility is used to measure risk in this research. It can be concluded that small caps could appear to be less risky than they actually might be.

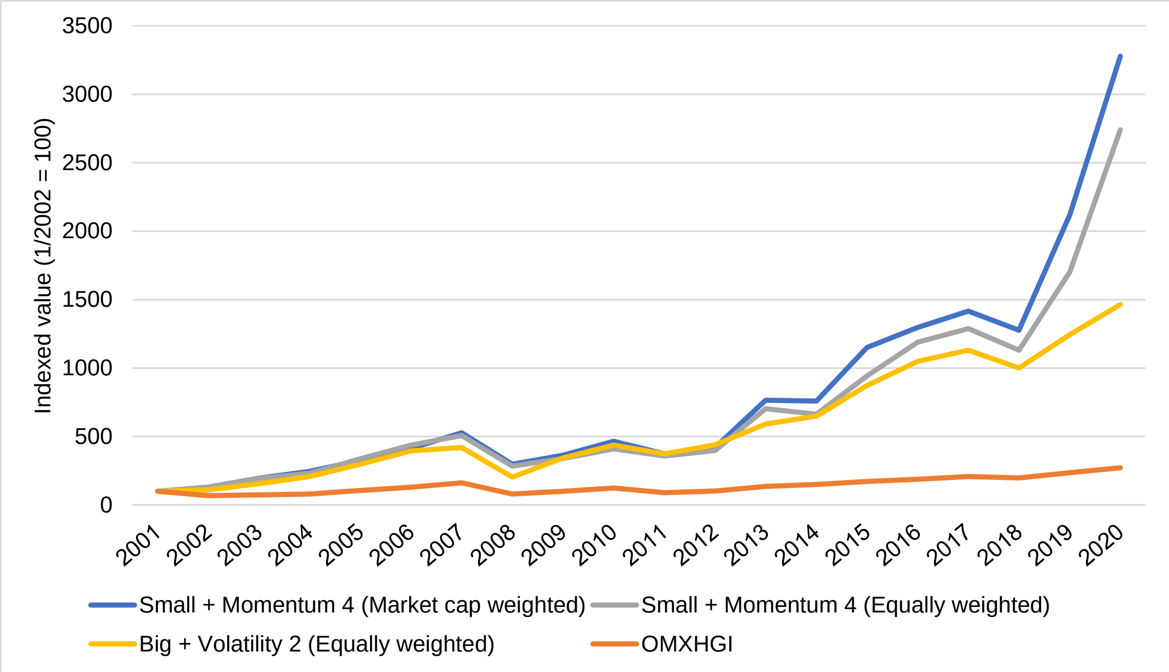

Figure 5. The best returned portfolios

5.3 Time-series regressions

This section reviews the results of time-series regressions. Earlier we found absolute returns and standard deviations of different portfolios, but now we look at the risk-adjusted excess and under returns, beta coefficients and their statistical significances as well. In the results section, alpha values with statistical significance are bolded for the sake of readability.

Table 8. Small companies + Momentum

Equally weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Small + Momentum 1	0,2%	0,658	2,3%	0,708	0,000	0,285
Small + Momentum 2	**0,6%**	0,035	**6,9%**	0,586	0,000	0,421
Small + Momentum 3	**0,5%**	0,021	**6,7%**	0,537	0,000	0,441
Small + Momentum 4	**1,2%**	0,000	**15,3%**	0,574	0,000	0,339

Market cap weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Small + Momentum 1	-0,2%	0,674	-2,0%	0,714	0,000	0,316
Small + Momentum 2	0,3%	0,237	3,6%	0,587	0,000	0,453
Small + Momentum 3	**0,7%**	0,007	**8,1%**	0,527	0,000	0,416
Small + Momentum 4	**1,3%**	0,000	**16,3%**	0,588	0,000	0,356

Market cap weighted Small + Momentum 4 portfolio produced the best return followed by equally weighted Small + Momentum 4, with annual returns of 20.2% and 19.0%. From table 8 we see that these portfolios had also monthly alpha values of 1,3% and 1,2%, which means 16.3% and 15.3% annualized risk-adjusted excess returns compared to the market index. Beta values of these portfolios were 0.588 and 0.574, which signals them to be significantly less risky than the market index. Findings of these two portfolios are statistically significant since the p-values of alphas and betas are <0.000. When taken into account also high alphas of Small + Momentum 3's in both subgroups, the existence of momentum effect can be seen to be supported by the results, even though the comparison to worse momentum portfolios is not possible due to their high p-values of alphas.

The worst performing portfolio of the whole reviewed portfolio universe was market cap weighted Small + Momentum 1, which returned only 0.6% annually. Alpha of this portfolio is negative and beta 0.674. However, alpha is not statistically significant, because the p-value is >0.05. The p-value of alpha was over 0.05 also in equally weighted Small + Momentum 1 and in market cap weighted Small + Momentum 2. All the beta values are statistically significant. (Table 8).

When looking at the results of small cap portfolios, it is good to note again the challenges in determining the risks for these companies. Standard deviations of these companies are naturally lower than big companies have, because the liquidity of small caps' shares is typically low. Therefore, the share prices can stay stagnated for a long period of times before making the move and so they look less volatile, which they statistically are, of course. But this raises the question about the risk and the relevance of standard deviation in measuring it. However, this research is based on capital asset pricing model and its definition of risk, which is volatility and thus we accept the results presented in this chapter with the selected criteria.

Table 9. Small companies + Price-to-book ratio

Equally weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Small + P/B 1	**0,7%**	0,013	**9,3%**	0,536	0,000	0,321
Small + P/B 2	**0,7%**	0,034	**8,2%**	0,559	0,000	0,326
Small + P/B 3	**0,7%**	0,008	**9,0%**	0,647	0,000	0,459
Small + P/B 4	**0,7%**	0,022	**8,5%**	0,620	0,000	0,394

Market cap weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Small + P/B 1	**0,8%**	0,008	**9,6%**	0,476	0,000	0,289
Small + P/B 2	0,4%	0,155	5,0%	0,562	0,000	0,366
Small + P/B 3	**0,7%**	0,008	**8,6%**	0,657	0,000	0,485
Small + P/B 4	**0,7%**	0,014	**9,1%**	0,652	0,000	0,421

All the Small + P/B portfolios produced positive alpha, although it was not statistically significant in case of market cap weighted Small + P/B 2. Market cap weighted Small + P/B 1 had the best alpha, 0,8% monthly and 9.6% annually, in this group. Market cap weighted Small + P/B 1 had also the lowest beta, 0.476. All the beta values were statistically significant in the group of Small + P/B portfolios, as the p-values were <0.000 for every portfolio. In general, the results show only a few differences within the Small + P/B portfolios when comparing to momentum and volatility, and the evidence of price-to-book effect is somewhat mixed in small market cap companies. (Table 9).

Table 10. Small companies + Volatility

Equally weighted portfolio	Monthly Alpha	P-value of alpha	Annualized Alpha	Beta	P-value of beta	Adjusted R-square
Small + volatility 1	**0,9%**	0,000	**10,8%**	0,442	0,000	0,426
Small + volatility 2	**0,6%**	0,031	**7,1%**	0,518	0,000	0,361
Small + volatility 3	**0,6%**	0,045	**7,8%**	0,679	0,000	0,413
Small + volatility 4	0,6%	0,193	7,0%	0,779	0,000	0,321

Market cap weighted portfolio	Monthly Alpha	P-value of alpha	Annualized Alpha	Beta	P-value of beta	Adjusted R-square
Small + volatility 1	**0,8%**	0,000	**10,4%**	0,435	0,000	0,433
Small + volatility 2	0,4%	0,173	4,5%	0,546	0,000	0,380
Small + volatility 3	**0,7%**	0,013	**8,9%**	0,679	0,000	0,457
Small + volatility 4	0,5%	0,291	5,7%	0,817	0,000	0,337

Small caps with the lowest volatility in the previous year produced the highest alphas in group of Small + Volatility portfolios. Equally weighted Small + Volatility 1 had a monthly alpha of 0.9% and an annual alpha of 10.8%. Market cap weighted Small + Volatility 1 had a monthly alpha of 0.8% and an annual alpha of 10.4%. Beta coefficients were 0.442 and 0.435, respectively. Both the alphas and betas of these portfolios were statistically significant as the p-values were <0.000. For other portfolios, the results were more even. The alpha values of equally weighted Small + Volatility 4 and market cap weighted Small + Volatility 2 and 4 were not statistically significant, as the p-values were >0.05. Strong performance of the lowest volatility portfolios supports the theory of volatility effect, but the weaker results of higher volatility portfolios are not statistically significant and thus cannot be considered. (Table 10).

Table 11. Big companies + Momentum

Equally weighted portfolio	Alpha	P-value of alpha	Annualized Alpha	Beta	P-value of beta	Adjusted R-square
Big + Momentum 1	0,2%	0,417	2,5%	0,951	0,000	0,681
Big + Momentum 2	**0,6%**	0,016	**6,9%**	0,643	0,000	0,538
Big + Momentum 3	**0,8%**	0,000	**9,9%**	0,636	0,000	0,600
Big + Momentum 4	**0,7%**	0,005	**8,3%**	0,661	0,000	0,539

Market cap weighted portfolio	Monthly Alpha	P-value of alpha	Annualized Alpha	Beta	P-value of beta	Adjusted R-square
Big + Momentum 1	0,1%	0,838	0,8%	1,205	0,000	0,691
Big + Momentum 2	0,2%	0,451	2,4%	0,764	0,000	0,558
Big + Momentum 3	**0,7%**	0,001	**9,2%**	0,677	0,000	0,565
Big + Momentum 4	**0,6%**	0,028	**7,6%**	0,776	0,000	0,535

As stated in earlier section, the momentum effect was not as visible in big companies as it was in small ones when looking at the returns generated by these portfolios. However, in big company portfolios momentum groups 3 and 4 produced higher alphas than portfolios 1 and 2 in their subgroups. Equally weighted Big + Momentum 3 and market cap weighted Big + Momentum 3 produced the highest alphas, 0.8% and 0.7% monthly, and 9.9% and 9.2% annually. These alphas were statistically significant. The momentum effect was thus visible that the weaker momentum groups of Momentum 1 and 2 were clearly behind of groups 3 and 4 in alphas. However, the alphas of Equally weighted Big + Momentum 1 and market cap weighted Big + Momentum 1 and 2 were not statistically significant. (Table 11).

Beta coefficients were statistically significant for every portfolio in Big + Momentum group. Market cap weighted Big + Momentum 1 was the only portfolio with beta value over 1 (1.205). The challenge in Helsinki stock exchange is its small size in terms of market cap. As mentioned earlier, the sample period of 2002-2020 includes the Nokia's last glamorous years and the downfall. In some years Nokia's weight was well over 50 percent of the whole market cap of Helsinki stock exchange. This might cause a situation, where over 60 or even 70 percent of the total market cap index is in one portfolio. This brings its own challenges when interpreting the results. (Table 11).

Table 12. Big companies + Price-to-book ratio

Equally weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Big + P/B 1	**0,8%**	0,003	**9,6%**	0,707	0,000	0,539
Big + P/B 2	0,4%	0,052	5,0%	0,712	0,000	0,629
Big + P/B 3	**0,7%**	0,003	**8,2%**	0,659	0,000	0,580
Big + P/B 4	0,4%	0,065	4,6%	0,730	0,000	0,661

Market cap weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Big + P/B 1	**0,7%**	0,032	**8,4%**	0,787	0,000	0,483
Big + P/B 2	0,2%	0,405	2,6%	0,838	0,000	0,608
Big + P/B 3	0,4%	0,153	4,4%	0,724	0,000	0,549
Big + P/B 4	0,0%	0,970	0,1%	1,083	0,000	0,754

All the Big + P/B portfolios produced positive alpha, although it was only 0.1% annually for market cap weighted Big + P/B 4. However, there are only 3 portfolios with p-values under accepted 0.05: Equally weighted Big + P/B 1, equally weighted Big + P/B 3 and market cap weighted Big + P/B 1. The lowest P/B portfolios had the highest alphas (9.6% and 8.4% annually) and these were also statistically significant results. (Table 12).

The only portfolio with higher beta than the market index was market cap weighted Big + P/B 4 with a beta of 1.083. Like in every other group of portfolios also, all the betas in Big + P/B portfolios were statistically significant. (Table 12).

Table 13. Big companies + Volatility

Equally weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Big + volatility 1	**0,5%**	0,004	**6,3%**	0,494	0,000	0,547
Big + volatility 2	**0,8%**	0,000	**10,7%**	0,646	0,000	0,575
Big + volatility 3	**0,6%**	0,014	**7,3%**	0,752	0,000	0,596
Big + volatility 4	0,3%	0,207	3,9%	0,990	0,000	0,692

Market cap weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Big + volatility 1	**0,6%**	0,014	**7,0%**	0,591	0,000	0,493
Big + volatility 2	0,4%	0,103	4,9%	0,769	0,000	0,600
Big + volatility 3	0,4%	0,185	4,3%	0,889	0,000	0,627
Big + volatility 4	0,0%	0,970	-0,1%	1,217	0,000	0,751

From the group of Big + Volatility portfolios, equally weighted Big + Volatility 1, 2 and 3, and market cap weighted Big + Volatility 1 returned risk-adjusted excess returns. i.e. positive alpha with p-value <0.05. The only portfolio with beta coefficient higher than the market index was market cap weighted Big + Volatility 4 with beta of 1.217. All the betas were statistically significant (p-value <0.000). (Table 13).

Again, it is somewhat hard to interpret the results, but basically, we can summarize that the low volatility portfolios produced excess risk-adjusted returns and the theory of volatility effect is holding. It is important though to emphasize again the importance of Nokia in the market index. If Nokia did not have its decline during the review period, the results could look very different than they do now. (Table 13).

6 Summary and conclusions

The last chapter of this thesis summarizes the background of the research, research process itself and the results of the research. The purpose is to open the results and interpret them so that we can draw conclusions regarding research topic and research questions. The author also wants to point out some details which could affect the findings. Finally, we will also suggest ideas for further research regarding the research topic and mention some of the limitations related to this research.

6.1 Research background

The theory of efficient markets and its testing has been at the heart of financial theory for several decades already. The modern portfolio theory (Markowitz, 1952) and the efficient market hypothesis (Fama & French, 1970) are the backbone of financial theory and focal points of financial studies. These theories are based on an assumption that investors cannot make an excess return, because the market is pricing the known information already. Numerous studies have been conducted on the subject for the sake of understanding the subject, but also for the eagerness of investors to reach higher returns for their money.

The most typical way to test the theory of efficient markets has been to find different factors that explain the excess return of certain investing instrument. For example, Fama & French (1991) have studied how the size, operating profit, price-to-book ratio or company's investing activity affects the return of the stock and how much these factors explain the performance of a certain stock. Jegadeesh & Titman (1993) studied how past performance, in other words momentum, affects the future return and how much past momentum explain the future performance.

This research is also based on different factors. Size, momentum, price-to-book ratio and volatility are the chosen factors which are studied, how they affect the returns and is there a possibility to gain excess returns compared to market index. As mentioned earlier, these factors have been the subject of several studies in the past already. However, we use Finnish stock exchange as a target market, which is not that popular subject of research due to its small market value and kind of limited number of industries within its companies. Different countries and their stock markets have different characteristics and dynamics, and therefore it is important to extend research to multiple geographical areas.

The time-period used in this research is 2002–2020. We study 48 different portfolios in total, which are constructed based on the previous year's factors presented in the previous paragraph. Companies are divided in two possible groups, either small or big, depending on if the market capitalization is higher or lower than the median market capitalization of the whole studied company universe. These small and big companies are divided further into four equal numbered subgroups under each factor, momentum, price-to-book ratio and volatility. This operation leads us to 2x3x4=24 different portfolios, but the review is done with both equal and market cap weighted portfolios, which doubles the number of portfolios to 48.

As a result, we see how each of these portfolios performed compared to the market index during the chosen time-period. We also calculated the standard deviation, i.e. volatility, for each portfolio to see how they performed compared to their risk. This shows us already the best portfolios in the review period, but to make sure that the results are not random or based on a luck within certain groups, we also applied regression analysis to see if there are portfolios which have produced risk-adjusted excess returns compared to the market index with statistical significance.

The regression analysis and the whole research is based on the assumption that the risk of a stock is determined by its price volatility. This assumption has its roots in a theory called capital asset pricing model (CAPM). CAPM was most notably introduced by William Sharpe (1964). The model was created to describe the relation of a stock price and its risk. According to CAPM, the expected return of a security is possible to conclude from the risk-free rate, the expected market return and the beta coefficient of the security. Beta coefficient tells us how much the price of the security changes relative to the market index. From the CAPM we can derive alpha, also called Jensen's alpha, which measures the risk-adjusted performance of the security in relation to its expected, theory-based performance.

6.2 Results

The first research question was to find out, which factors have returned the most between 2002 and 2020. Clearly the best portfolios return-wise were those ones, which consisted of companies with small market caps and the best momentum in previous years. Market cap weighted portfolio of small companies with the best momentum (Small + Momentum 4) returned over 20 percent annually and equally weighted portfolio with small market caps and the best momentum returned also 19 percent annually. The difference is clear, since the third in gross returns was the portfolio of big market cap companies with volatility in the second lowest quartile (Big + Volatility 2), which returned annually a bit over 15 percent.

To give these returns some perspective, we have to compare them to the market index, of course. In this research the main point was to study Finnish stock market, so the chosen market index is OMX Helsinki general index. To make it as accurate as possible, dividends are included in constructed portfolios and in market index also. This leads us to use OMX Helsinki Growth Index, OMXHGI, which includes the dividends. OMXHG index had an annual return of only 5.4 percent during the review period, so the best constructed portfolio of small companies with the best momentum had almost four times the annual return of market index.

The worst performing portfolio of the study was market cap weighted portfolio of small companies with the worst momentum (Small + Momentum 1), which returned only under one percent annually. From the bottom, next in raking was the market cap weighted portfolio of big companies with the highest volatility (Big + Volatility 4), followed by the market cap weighted portfolio of big companies with the highest price-to-book ratio (Big + P/B 4). Both of these portfolios returned under 5 percent annually. In general, small cap portfolios performed better than the portfolios of bigger companies. Small cap portfolios' average annual return was 11.4 percent, when the big company portfolios had an annual average return of 10.0 percent between 2002 and 2020.

A mere review of returns would be rather pointless if the risk had not been taken into account at all. The statistical significance of the results plays a key role in eliminating the effect of luck on the results. Therefore, regression analysis has been applied in this research to find out, which portfolios produced risk-adjusted excess returns and which of these results were statistically significant.

The best portfolios in terms of risk-adjusted excess return were also the ones with the highest gross returns, i.e. market cap weighted Small + Momentum 4 and equally weighted Small + Momentum 4. Monthly alpha of market cap weighted Small + Momentum 4 was 1.3%, while equally weighted had a monthly alpha of 1.2%. As we use monthly data, the results mean that these portfolios had an annual risk-adjusted excess returns of 16.3% and 15.3%. The alphas of these portfolios were also statistically significant. (Table 14).

Table 14. Portfolios with the highest alphas

Equally weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Small + Momentum 1	0,2%	0,658	2,3%	0,708	0,000	0,285
Small + Momentum 2	**0,6%**	0,035	**6,9%**	0,586	0,000	0,421
Small + Momentum 3	**0,5%**	0,021	**6,7%**	0,537	0,000	0,441
Small + Momentum 4	**1,2%**	0,000	**15,3%**	0,574	0,000	0,339

Market cap weighted portfolio	**Monthly Alpha**	**P-value of alpha**	**Annualized Alpha**	**Beta**	**P-value of beta**	**Adjusted R-square**
Small + Momentum 1	-0,2%	0,674	-2,0%	0,714	0,000	0,316
Small + Momentum 2	0,3%	0,237	3,6%	0,587	0,000	0,453
Small + Momentum 3	**0,7%**	0,007	**8,1%**	0,527	0,000	0,416
Small + Momentum 4	**1,3%**	0,000	**16,3%**	0,588	0,000	0,356

In total, 17 of 24 small cap portfolios returned risk-adjusted excess return with statistical significance (p-value <0.05). 12 of 24 large cap portfolios did the same thing. With these results, we can get back to the research questions 2 and 3:

2. Have any of the factor-based portfolios generated risk-adjusted excess returns compared to the market index?
3. Can we conclude that some of the market anomalies occur in the Finnish market?

Simply looking at the results, we can conclude that actually many of the portfolios generated risk-adjusted excess returns compared to the market index of OMXHGI. When looking at the anomalies and if they occur in Helsinki stock exchange, the answer would be yes, if we look at the results of regression analysis again. Especially the momentum effect seems to be quite strong, most notably in small companies, but risk-adjusted excess returns could be identified in every portfolio category.

Although, there are some things the author wants to highlight regarding the results. Small and big companies are those which have the market cap under or over the median value. In Helsinki stock exchange, this median value is really low, around 100 million euros in many years. This leads us to the situation where small caps are extremely small, and shares are also extremely illiquid. There is so little trading and transactions in some companies' shares, that sometimes the stock price does not move for long times. This makes volatility appear really low, and since the volatility is the measure of risk in our research, these companies could appear maybe less risky than they are in a real life. This in turn leads us to the situation, where we have to think the term risk and if volatility is the right method to measure it. The author does not want to reject the results of this research, but this is more about highlighting something, which probably makes the results more extreme, especially in case of small cap companies.

When examining the size factor, it is important to use market cap weights when constructing the portfolios in the research. Fama & French (2008) underlined the problems with equally weighted portfolios, since the existence of the size anomaly and excess returns related to the phenomenon relies heavily on the smallest, so-called micro companies. Market cap weights reduce the importance of micro caps in constructed portfolios.

Small companies also pose another challenge. The momentum effect is largely based on small firms, as also observed in this study. One of the limitations of this thesis is the lack of trading costs, which could be higher in small companies due to illiquid shares. This may limit the arbitrage associated with the momentum effect (Liu, 2012). Zoghlami (2016) also found that the excessive returns of momentum stocks were fully explained by size and beta.

The other thing to consider also is the impact of Nokia and some other big market cap companies also, but Nokia as the most extreme one. The market cap of Nokia was at the beginning of the reviewed time-period close to 60 percent of the whole OMX Helsinki index. OMXHGI was used as a benchmark index in this research, and this index does not cap any company's market cap. As noted before, the OMXHGI returned only 5.4 percent annually from 2002 to 2020 and Nokia's decline at the end of 2000's had a big impact on this rather poor performance of the index. When we compare the returns of portfolios to the market index, we are comparing the results to a great extent to the returns of Nokia. If one company is such a dominant with its market share, it is possible in theory that one company is declining and every other company seems to beat the market. Again, this is not something which would wipe out the results of this research, but it is something to consider and maybe makes the results look a bit exaggerated.

6.3 Future research and suggestions

There has been a lot of research about factor investing and the possible risk-adjusted excess return linked to that. This is why the future research should probably be more about diving deeper in the details and factors itself. With this the author points, for example, to the challenges explained in the previous paragraphs.

One obvious, but not that easy, subject of further examination is risk and how to measure it. Risk is an age-old headache for the financial theory, and so far volatility has been the most used and widely regarded as the best way to measure it. Volatility is in no way bad way to measure risk, quite opposite. It is probably the best way to measure risk, but it has its shortcomings, as explained earlier. One idea to apply in research of factor investing could be to look at the risk from different angle. If there was a way to measure the risk with, for example, a combination of volatility, balance sheet risk, business risk (subjective evaluation), valuation metrics or other things, it could give a totally new approach. To modify the database to create these criteria would be quite a work and not an easy task to do, but an idea for research with larger extent.

Finnish stock market has not been studied that much due to its low market cap, low number of companies and low liquidity, but if there was further research regarding factor investing, one could consider adjusting the index. With this the author means the dominant role of big companies, especially Nokia in 2000's, and capping their share in the market index. The easiest way to do this would be to run all the regression analyses against the market index, which caps the proportion of one company to the maximum of 10 percent. These so-called cap indices are widely followed and the data is easy to extract.

One specific thing to follow in the coming years and decades is the evolvement of price-to-book effect. The theory now suggests that the companies with low price-to-book ratios produce higher risk-adjusted returns than the ones with higher ratios. There were some differences in favor of smaller P/B value portfolios in this research, but the results were not as clear as in the case of momentum effect. Price-to-book ratio is highlighted here because it has been a trend for some time already to outsource a lot of companies' own production. Usually, the outsourcing is done by large companies and often the subcontractor is not listed company. This moves assets out of the book value of listed companies and might have an effect to price-to-book ratios. The other thing affecting price-to-book effect is the rise of technology companies, which have usually a lot lighter balance sheet than companies operating in manufacturing industry. The same goes with service companies. Technology and services become more and more important in the western countries, so it is interesting to see how it affects valuation metrics and key figures.

This research has just scratched the surface of the factor investing in Finnish markets and the author hopes to see many other studies regarding the topic. It is especially useful for small and private investors to understand, where to look at in hopes of excess returns, since illiquid markets tend to favor and offer opportunities for those with smaller amounts of capital.

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