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Testing the PEGR investment strategy
Empirical evidence from the Nordic stock market

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Traditional and widely utilized financial theories and asset-pricing models generally rely on assumptions and restrictions of the market and investors' behavioral characteristics. One of the essential assumptions is that the information is free and equally available for all market participants, and that in equilibrium conditions the security prices fully reflect the information available. Thus, in theory the securities are always correctly valued, and higher returns should only be achievable by increasing the risk simultaneously. However, the validity of the traditional theories and asset-pricing models have since been criticized, and various research have provided evidence of the existence of market anomalies. The anomalies suggest that it is, in fact, possible for investors to achieve abnormal returns from investment strategies and predictive patterns by investing in certain assets with specific characteristics or risk factors. Previous empirical evidence of the price-to-earnings-to-growth (PEG) ratio related investment strategies argues that generally the lowest PEG-ratio securities have outperformed the higher PEG-ratio securities, also indicating that the low PEG investment strategy has some anomalous characteristics beneficial for the investors.

This research pursues to examine whether abnormal stock returns can be achieved on the Nordic stock market by investing in low PEG-ratio securities. Generally, in previous related research the PEG-ratios have been defined with analyst estimates of the earnings growth rates. This research, however, provides further evidence of an alternative log-linear earnings growth rate estimation model initially presented by Wang et al. (2020). The log-linear method does not have similar constraints and deficiencies as the analyst estimates, and thus provides a functional approach for the PEG-related analysis on smaller markets. Three different portfolio types are annually composed, based on the companies' PEG-ratios and main operating industries, pursuing to provide further evidence of the companies' PEG-specific characteristics in different industries. The analysed portfolios are equally weighted and constructed of companies publicly listed on the OMX Nordic All-Share Index during years 2012-2022. The analyses are being conducted by utilizing the Fama-French three-factor regression model, and the robustness of the results is tested with the Carhart four-factor model, and with the alternative log-linear earnings growth rate estimation methods provided in this research.

The results indicated that the second lowest PEG portfolio was the only portfolio achieving excess returns on the market, suggesting that the low PEG investment strategy did not outperform all the higher PEG ratio portfolios on the Nordic stock market in its entirety, which is in contradiction to the previous evidence of the low PEG anomaly. However, the concerning anomaly was remarkably observable withing two individual industry groups, financials and real estate, and health care and utilities. To conclude, the Wang et al. method proved to be a functional tool for evaluating the earnings growth rate estimates of companies, as the method conducted similar PEG characteristics and scale of the PEG values in relation to the previous related research, which generally have been utilizing analyst estimates in defining the PEG-ratios. The alternative estimation methods presented in this research also provided interesting return characteristics, but further research and evidence is still necessary.

Key words: anomaly, excess returns, growth rate estimate, PEG

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Perinteisesti rahoituksessa hyödynnetyt teoriat ja arvopapereiden hinnoittelumallit ovat pohjautuneet vahvoihin oletuksiin markkinoista ja sijoittajien toimintamalleista. Keskeisimmät oletukset teorioiden taustalla liittyy taloudellisen informaation saatavuuteen sekä siihen, että arvopapereiden hinnoittelu teoreettisessa tasapainotilassa perustuu täysin saatavilla olevaan taloudelliseen informaatioon. Tällöin arvopapereiden hinnoittelun tulisi olla aina täysin oikeellinen, ja sijoittajien tulisi voida saavuttaa korkeampia tuottoja ainoastaan korottamalla sijoitustensa riskiä. Tätä on kuitenkin kritisoitu laajalti ja useat tutkimukset ovat jälkeenpäin osoittaneet, että sijoittajat voivat saavuttaa ylituottoja hyödyntämällä havaittuja markkinapoikkeamia, eli anomalioita. Empiiriset tulokset ovat osoittaneet, että matalimman price-to-earnings-to-growth (PEG) -luvun arvopaperit ovat suoriutuneet paremmin kuin korkeamman PEG-luvun arvopaperit, minkä pohjalta voidaan olettaa, että sijoittajien on matalan PEG-luvun sijoitusstrategialla mahdollista saavuttaa poikkeavia ylituottoja markkinoilta.

Tämän tutkimuksen tarkoituksena on selvittää, onko matalimman PEG-luvun sijoitusstrategiaa hyödyntämällä mahdollista saavuttaa ylituottoja pohjoismaisilla osakemarkkinoilla. Pääsääntöisesti aikaisemmissa tutkimuksissa PEG-luku on määritetty pohjautuen analyytikoiden estimaatteihin tulevien osinkotuottojen kasvuvauhdista. Tässä tutkimuksessa tulevien osinkotuottojen kasvuvauhti määritetään vaihtoehtoisesti log-lineaarisella menetelmällä, pohjautuen Wang ym. (2020) esittämään estimaatiomalliin. Log-lineaarinen malli soveltuu erityisesti pienemmillä markkinoilla käytettäväksi, sillä se ei sisällä samankaltaisia rajoituksia ja haasteita kuten analyytikoiden asettamat estimaatit. Tutkimuksessa analysoidaan kolmea erityyppistä portfoliomallia, jotka perustuvat määritettyihin PEG-lukuihin ja yritysten pääasiallisiin toimialoihin. Analysoidut portfoliot koostetaan ja tasapainotetaan vuosittain OMX Nordic All-Share indeksissä julkisesti listatuista yrityksistä vuosina 2012–2022. Lopulliset analyysit suoritetaan Fama-French kolmifaktorimallilla. Tulosten jatkuvuutta tarkastellaan Carhartin nelifaktorimallin sekä tässä tutkimuksessa esitettyjen vaihtoehtoisten log-lineaaristen estimaatiomallien tulosten avulla.

Tulokset osoittavat, että toiseksi matalimman PEG-luvun portfolio saavutti ainoana portfoliona tilastollisesti merkitsevää ylituottoa koko pohjoismaisilla osakemarkkinoilla mitattuna vuosina 2012–2022. Tulosten pohjalta voidaan siis todeta, että kaikista matalimman PEG-luvun portfolio ei saavuttanut ylituottoja, eikä suoriutunut korkeamman PEG-luvun portfolioita paremmin. Tulokset ovat siis poikkeavia aikaisempiin tutkimustuloksiin verrattuna, missä matalan PEG-luvun anomalia on ollut havaittavissa. Toimialakohtaisessa tarkastelussa kuitenkin osoittautui, että matalimman PEG-luvun portfoliot saavuttivat ylituottoja kahdessa toimialajoukossa – rahoitus- ja kiinteistöalalla, sekä terveydenhuolto- ja yleishyödyllisellä alalla. Wang ym. (2020) esittämä log-lineaarinen estimaatiomalli osoittautui toimivaksi tulevien osinkotuottojen kasvuvauhdin ja PEG-luvun määrityksessä, tuottaen myös aikaisempiin tutkimustuloksiin nähden vertailukelpoisia tuloksia. Tutkimuksessa esitetyt vaihtoehtoiset log-lineaariset estimaatiomallit tarjoavat myös mielenkiintoisia tuloksia sekä tuotto-ominaisuuksia, mutta jatkotutkimukset sekä menetelmien testaukset ovat kuitenkin edelleen tarpeellisia.

Avainsanat: anomalia, ylituotto, kasvutahdin estimaatti, PEG

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1 INTRODUCTION

1.1 Background

The traditional and widely utilized financial theories, such as the modern portfolio theory by Markowitz (1952), the efficient market hypothesis by Fama (1970), and the Capital Asset Pricing Model by Sharpe (1964) and Lintner (1965), all rely on significant assumptions and restrictions of the market and investors' behavioral characteristics. One of the central theoretical presumptions is that the market is always efficient, as the stock prices fully reflect all the information available. Therefore, it should be impossible for any participant on the market to predict future stock prices or returns with either technical or fundamental analysis, and thus systematically profit from the concerning methods without simultaneously increasing the risk considerably. (Fama 1970.) Hence, the traditional financial theories and asset-pricing models argue, that in equilibrium conditions the only possibility for the investors to achieve higher investment returns is to increase the risk accordingly, and no other possibilities should exist.

However, the validity of the traditional theories have since been criticized comprehensively due to their strong presumptions and theoretical problems (Ross 1976; Basu 1977, 1983; Banz 1981; Schwert 2003). The arbitrage pricing theory by Ross (1976) approaches the efficiency of the market from another angle, by assuming that market inefficiencies and arbitrage pricings of the assets occur on the market occasionally, causing the market to not be efficient and correctly valued at all times. Thus, it is possible for investors to capture the mispricing of the securities by utilizing the various related risk factors as predictable patterns, and accordingly achieve abnormal stock returns on the market (Ross 1976). The theoretical approach by Ross (1976) has since been the foundation to various market efficiency and anomaly-based research, also indicating that either the market inefficiencies could occur in contradiction to the traditional literature, or that the utilized asset-pricing models simply are deficient, which is in line with the joint hypothesis problem (Fama 1970; Jensen 1978). Although the inadequacies of the traditional financial theories and asset-pricing models are well known, and comprehensively researched and criticized, they still are considered to be the foundation for various financial research and findings.

Various research have since produced further evidence of the non-explainable market phenomena, also being referred to as the market anomalies. The anomalies have proved that it is, in fact, possible for all market participants to profit from investment strategies and predictive patterns by preferring certain asset specific characteristics or risk factors (Malkiel 2003; Schwert 2003). Thus, investment strategies preferring risk factors, such as the size, value, and momentum factors, have been proved to systematically outperform other assets on the market, at least for some time before the anomaly possibly disappears (Basu 1977, 1983; Banz 1981; Jegadeesh – Titman 1993; Fama – French 1993, 1998; Malkiel 2003; Wang et al. 2020). Accordingly, the certain risk factors are being notified on several different asset pricing models, such as in the Fama-French three-factor model and the Carhart four-factor model, as the explanatory power of these factors in relation to the securities' price fluctuation is empirically proved to be relatively significant (Fama – French 1993; Carhart 1997).

In addition to the previous anomalistic findings of the value effect by Basu (1977; 1983) and Fama and French (1992; 1993; 1998), Peters (1991) initially developed the Price-to-Earnings-to-Growth (PEG) ratio to further evaluate the relationship between a company's price-to-earnings ratio, and the estimated earnings growth rate. The results by Peters (1991) suggested that the low PEG-ratio companies remarkably outperformed the higher PEG-ratio companies. Afterwards, the issue has mainly been researched on the US, with results similar to the Peters', indicating that the low PEG-ratio companies have anomalistic return characteristics, and investment strategies preferring these companies could result in positive abnormal returns (Chahine – Choudhry 2004; Schatzberg – Vora 2009; Wang et al. 2020).

1.2 Purpose and limitations

The main purpose of this research is to examine whether abnormal stock returns can be achieved on the Nordic stock market by investing in low PEG-ratio securities. This issue has been previously researched mainly on the US markets, and the research suggests that securities with lower PEG-ratios outperform securities with higher PEG-ratios (Peters 1991; Schatzberg – Vora 2009; Wang et al. 2020). This phenomenon is also being referred to as the PEGR effect. This research pursues to provide further evidence of the PEGR effect by using an alternative estimate method of the earnings growth rate for the PEG-ratio; a log-linear regression model by Wang et al. (2020).

In previous research the calculation of the PEG-ratio has almost without exception been based on the I/B/E/S (Institutional Brokers' Estimate System) estimates of the earnings growth rates. The downside with the I/B/E/S estimates is that they are only accessible via Refinitiv, a financial database subject to a charge. Thus, the estimates are not equally accessible for individual investors, which in contradiction to the theory of market efficiency (Sharpe 1964; Fama 1970). Also, the concerning long-term earnings growth rate estimates are not available for all companies or all periods of time. These deficiencies occurs especially on smaller markets, such as the Nordic stock market, which clearly is not ideal for investors, and might cause inefficiencies on the market. Naturally, as the I/B/E/S estimates of the growth rates are forecasts, data distortions and inaccuracies are relatively likely to occur (Bauman – Miller 1997). As for the log-linear model presented, it can be beneficial for both investors and analysts, as it does not have similar constraints as the I/B/E/S estimates, and could be equally utilized on all markets (Wang et al. 2020).

It would be highly beneficial for investors and analysts to acknowledge whether the PEGR effect occurs on the Nordic stock market or not, as the matter has not been previously researched specifically on this market. In addition, the industry specific PEG-ratio characteristics, and the validity of the traditional benchmarking of the PEG-ratio are also further investigated on the Nordic stock market, to provide more comprehensive results (Arak – Foster 2003; Trombley 2008; Schnabel 2009). If the log-linear earnings growth rate estimate model by Wang et al. (2020), and the concerning low PEG-ratio investment strategy proves to be robust also on other markets outside the US, it could be highly advantageous to gather further empirical evidence of the phenomenon. Also, three other log-linear estimation methods are being constructed in addition to the Wang et al. - method, pursuing to test the robustness of the results and to provide additional empirical evidence of alternative and possibly more adjustable estimation models.

In this research the PEGR effect is being investigated on the Nordic stock market during years 2010-2022, pursuing to minimize the possible short-term deviations and distortions of the return data. However, the required companies' earnings-per-share (EPS) data needed for the log-linear estimation model is collected from years 1998-2010. The Nasdaq OMX Nordic All-Share Index is considered the benchmark portfolio of the research, and the further portfolio specific analyses are made with companies publicly listed on the concerning index. Also, the total return index is utilized in all further analyses, to enhance the accuracy of the results, and to enable more reliable comparison between the investigated portfolios (Vaihekoski 2003, 191-193). The regression model utilized for the final analyses is the Fama-French three-factor model, as it has been used in previous anomaly related research (Fama – French 1993, 1998). However, as the Fama-French three-factor model is not able to explain the returns' momentum characteristics properly, the robustness of the acquired results are being tested with the Carhart four-factor model (Carhart 1997; Schwert 2003, 951). The further requirements and limitations, as well as the portfolio definition, are discussed more specifically in chapter 3.

Accordingly, the research question and the sub-questions (2.1 & 2.2) are as follows:

Does the low PEG-ratio anomaly occur on the Nordic stock market?

2.1) Is the low PEG-ratio anomaly more visible on certain industries?

2.2) Is the PEG-ratio's traditional benchmark value of 1 for all companies across-the-board still valid?

1.3 Structure

In chapter 2, the literature review and the hypothesis details are presented. In the beginning, the market equilibrium models, the efficient market hypothesis and the CAPM, are covered. Next, the multi-factor asset-pricing models are defined, and related anomalistic research are introduced. In addition, the PEG-ratio is defined, and previous related literature and limitations of it are discussed. At last, the hypothesis details of this research are formed and described.

In chapter 3, the sample selection, the research design and data, and the preliminary tests and utilized methods are presented. Subsequently, in chapter 4, the empirical results, including the performance evaluation and the robustness checks, are discussed. Finally, in the chapter 5, the conclusions of the acquired results are presented and further discussed. Also, the contribution of this particular research is demonstrated, and further possible research topics are suggested.

2 LITERATURE REVIEW AND HYPOTHESIS DETAILS

2.1 Market equilibrium models

2.1.1 Efficient market hypothesis

The efficient market hypothesis (EMH) is a widely utilized, and somewhat controversial, financial theory, initially being presented in the late 1950's and early 1960's (Jensen 1978, 96). The efficient market hypothesis argues that all available security related information on the capital market should be responsible for securities' changing prices, in addition to the assumption of the security prices being identically distributed. Thus, according to the hypothesis, as the information reflects the security markets instantly, the markets and the individual securities should be correctly valued at all times, if the market is considered to be efficient. (Fama 1970.) Hence, in theory the investors should not be able to achieve abnormal returns on the market by utilizing either technical analysis or fundamental analysis in investment decision making, at least without significantly increasing the risk simultaneously.

The random walk is generally associated with the theory of the efficient market hypothesis. The theory of the random walk argues that the stock market prices follows a random walk, with the changes in securities' prices being random and independent at all times. As the market is expected to reflect the latest information available at all times, and the flow of information follows the latest news, then the yesterday's price changes reflect only the yesterday's news, and tomorrow's price changes reflect only tomorrow's news. As the latest information is always unpredictable, the security price changes must also be unpredictable, and follow the random walk. Thus, it is stated that the investors should not be able to predict the future stock prices with either technical theories or intrinsic value analysis procedures. Based on these assumptions, all amateur investors investing in well diversified portfolios should obtain similar returns than to the more specialised investors on the same market. (Fama 1970, 1995; Malkiel 2003).

The efficient market model requires some critical assumptions and adjustments of the prevailing market and its conditions to fully reflect the relation of the prices and the information available. Thus, Fama (1970) argued that the following assumptions are sufficient to be made for the market to be efficient, and for the security prices to fully reflect all the information available on the capital market:

1) The markets are frictionless and there are no transaction costs in security trading,
2) the information is free and equally available for all investors on the market,
3) the investors agree on the implications of the latest information reflecting the security prices and the distributions of prices of all securities in the future.

Fama (1970) also stated, that obviously the described presumptions do not reflect the real-world markets in practise. Even though the made presumptions are sufficient in terms of the market efficiency, they are not completely necessary. Thus, it is concluded that the transaction costs, possible information costs and availability challenges, and divergent investor behaviour compared to the theory of efficient markets, are all possible sources of market inefficiencies.

The market efficiency is categorized to three dimensions being based on the level of the available information on the market. The different market efficiency forms are the weak efficiency, the semi-strong efficiency, and the strong efficiency. The weak form is determined as a level in which the current security prices reflect only the historical security price data. Thus, the weak form of the market enables the investors to achieve abnormal returns by utilizing fundamental analysis, and hence making it possible to invest in undervalued securities. The semi-strong form occurs when all the previous information, such as the publicly announced financial reports and historical price data, is available for the investors. In these occasions, investors should not be able to achieve abnormal returns on the market with technical or fundamental analysis without information that is not equally available for all investors, such as insider information. The final strong form of the market efficiency occurs when the security prices fully reflect all information available, including both public and insider information, and the historical price data. In such cases, achieving abnormal returns should be impossible. (Fama 1970.)

Even though the strong form, or prices fully reflecting all available information, is the initial and ultimate hypothesis of the theory of the efficient markets, Fama (1991) retrospectively stated that the extreme form of efficiency is surely false. However, it still functions as a helpful theoretical benchmark by indicating the approximate level of available information on the market, and at what point the hypothesis of the market efficiency finally breaks. Thus, the final estimation of the reliability and the practicality of the market efficiency model simplifying the view of the worlds is up to the individuals, and the ambiguous characteristics of the model should always be acknowledged.

Most of the academic anomaly-based investment research have been strongly related to the theory of the efficient market hypothesis, either pursuing to evaluate the current efficiency level or to challenge and criticise the model and its assumptions. Accordingly, the efficient market hypothesis started to decrease in its popularity among financial economists and statisticians in the 21st century, as various anomalistic evidence had indicated that future security prices actually can be somewhat predicted based on the securities' fundamental characteristics and past performance (Basu 1977, 1983; Banz 1981; Jegadeesh – Titman 1993). Moreover, it was argued that the concerning predictable patterns of certain security characteristics could direct to investors achieving risk-adjusted abnormal returns on the market, which is controversial to the initial theory of the efficient market hypothesis and the random walk. (Jensen 1978; Malkiel 2003.)

In contradiction to the criticism, Fama (1970; 1991), Jensen (1978), and Ball (1978) all emphasized the fact that the market efficiency is not possible to test per se, and argued that it needs to be tested jointly with another model of equilibrium, or more specifically with an asset-pricing model. Thus, the tests of the market efficiencies were, in fact, more specifically tests of the joint hypothesis. It was argued that the possible abnormal returns achieved on the market, being the anomalous evidence against the efficient market hypothesis, were not purely the proof of market inefficiencies, but also proof of the inadequacies of the utilized asset-pricing models. Accordingly, as the models cannot be tested individually, it is impossible to specify whether the various obtained anomalous results are due to market inefficiencies or simply inadequacies of the utilized asset-pricing models, which should be acknowledged by individual investors and financial researchers.

2.1.2 Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) is a traditional asset-pricing model initially presented by Sharpe (1964) and Lintner (1965). The CAPM is frequently associated with the theory of efficient market hypothesis by Fama (1970) and the modern portfolio theory by Markowitz (1952), by sharing similar assumptions and constraints of the market and investor behaviour. As an asset-pricing model, the CAPM pursues to evaluate the correct valuation, or price for a security, based on its risk and return characteristics. Furthermore, purely based on the theory of the CAPM, higher rate of returns are only achievable by increasing the risk of the security simultaneously. Thus, it should be impossible for investors to achieve anomalous and abnormal security returns frequently on the market. (Pilbeam 2018, 176-182.)

The risk factor of the CAPM considered is the market's systematic risk, also being referred to as beta, which simply indicates the sensitivity of the security's price to the fluctuation of the market portfolio. Hence, the beta also indicates whether the security's returns are considered more or less volatile in comparison to the market. It is important to acknowledge that the theory of the CAPM does not consider the unsystematic risk of a security, and the beta only evaluates the undiversifiable systematic risk. This is due to the fact that the unsystematic risk of a security can be minimized or totally precluded with investment diversification (Markowitz 1952). The benchmarking value, or the market portfolio's beta, is considered to be 1. Hence, if the beta is valued under 1, the security can be considered less volatile and less risky than the market portfolio. Accordingly, if the beta is valued over 1, the security can be considered more volatile and more risky than the market portfolio. (Pilbeam 2018, 176-182.)

According to the modern portfolio theory and the theory of the CAPM, the market portfolio should be diversified with all types of different assets, such as bonds, consumer durables, stocks, and real estate (Markowitz 1952; Sharpe 1964). However, this rarely is the case, as the market portfolio generally is a limited proxy of the market. This is due to the fact, that in reality it is relatively hard for investors to completely diversify the portfolio with all types of different assets. Thus, the inconsistencies of the theoretical assumptions and the practical utilization of the model have also caused criticism towards the CAPM and the practical use of it in asset-pricing (Roll 1977; Fama – French 2004).

In equilibrium circumstances, rational investors pursue to maximize the expected returns at a certain risk level, with the risk being measured with standard deviation or variance of the returns, by optimally diversifying the efficient portfolio accordingly between the risk-free rate and the market portfolio. As a result, an efficient frontier, and a capital market line (CML) is constructed, with the capital market line being the tangency portfolio of the concerning efficient frontier. (Markowitz 1952, 1959; Sharpe 1964.)

The efficient frontier (EF) and the capital market line (CML) are presented in Figure 1. According to the capital market line, higher rate of return is possible to achieve only by simultaneously amplifying the perceived risk, or in this occasion the standard deviation, of the portfolio. Thus, the fluctuations of the efficient portfolios' returns should imitate the capital market line accordingly. Theoretically, the most effective portfolio (M), or the tangency portfolio, is the intercept point of the capital market line and the efficient frontier (Sharpe 1964).

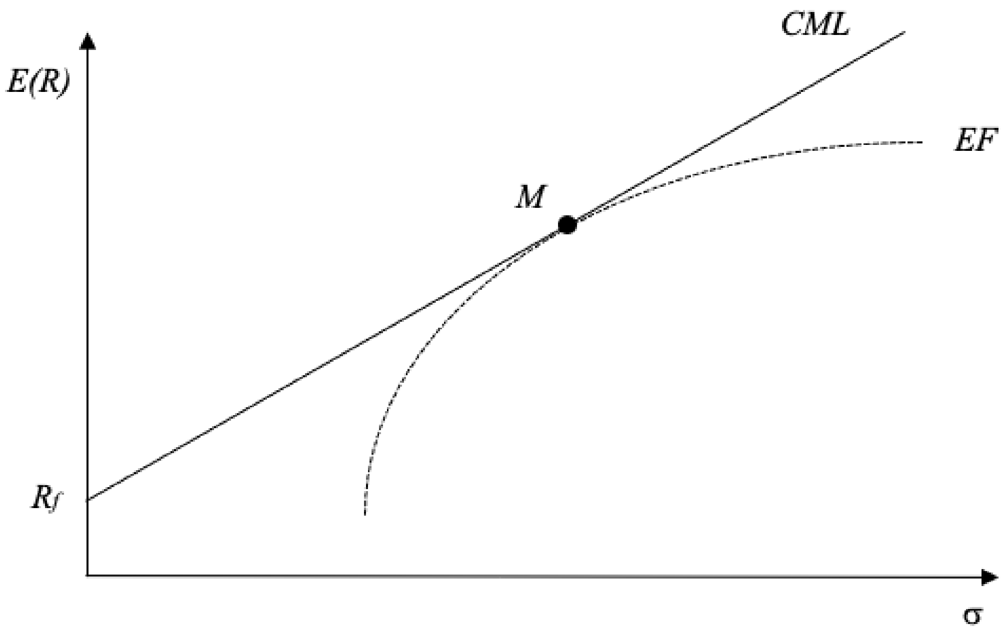

Figure 1. Efficient frontier and capital market line

As the capital market line describes the combination of the market portfolio and the risk-free rate and measures the total risk, or standard deviation, of the constructed portfolio, it cannot be utilized in defining individual assets or poorly diversified, and thus inefficient portfolios. As it is more frequent and ordinary for the investors to invest in individual securities or less broadly diversified portfolios, it is extremely beneficial for the investors to also evaluate the concerning assets' risk and return characteristics in relation to each other in equilibrium conditions. The concerning occasion can be illustrated with the security market line (SML), which describes more particularly the relation of the security's systematic risk, or beta, and the security's expected rate of return. (Pilbeam 2018.)

The security market line (SML) is presented in Figure 2. As illustrated, the fluctuation of the security's expected rate of return and the beta should imitate the security market line accordingly. Thus, higher rate of return should only be accessible by amplifying the systematic risk simultaneously, which is one of the main assumptions of the CAPM (Sharpe 1964). If the observed security's expected rate of return deviates from the security market line, the concerning asset either underperforms or overperforms in relation to the prevailing level of risk. The overperformance of the portfolio R_p in relation to the market portfolio R_m, or achieving abnormal excess returns on the market, is illustrated with the alpha (α) coefficient. Accordingly, on such occasion the security overperforms in relation to its prevailing risk level. If such occasions occurred frequently, it might be cause of some anomalistic characteristics of the security, which is in contradiction to the theories of the traditional equilibrium models (Markowitz 1952; Sharpe 1964; Fama 1970). Thus, most of the anomaly-based research focus on detecting and observing the factors causing the possible positive alpha, or positive abnormal returns, and to provide further evidence for investors to be able to profit from the observed phenomena (Pilbeam 2018).

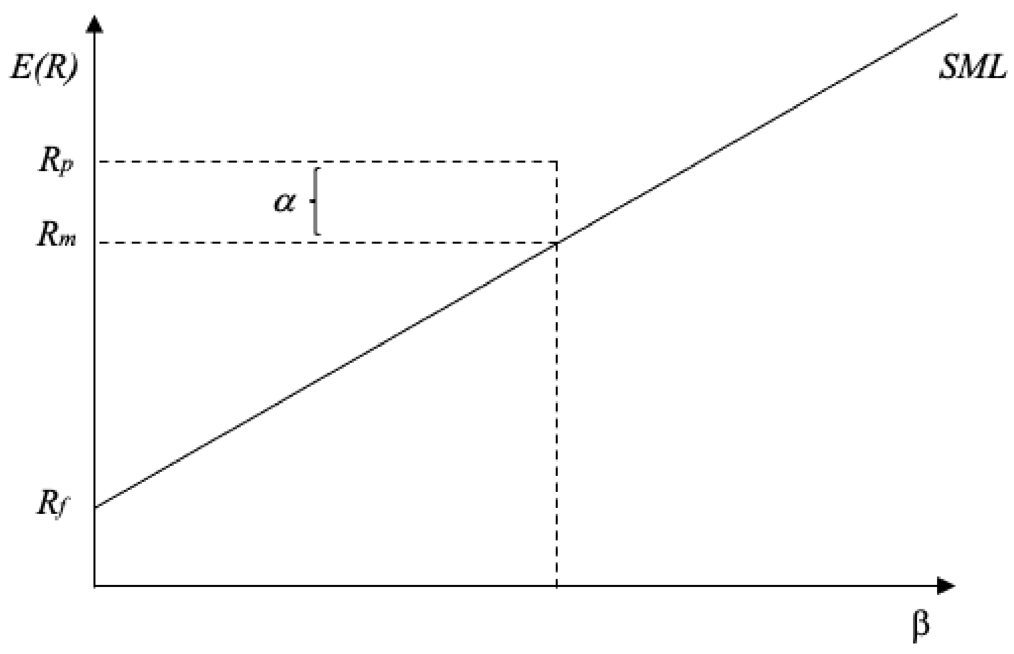

Figure 2. Security market line

The CAPM evaluates the security's expected rate of return as follows:

$$E(R_p) = R_f + \beta_p[E(R_m - R_f)] \quad (1)$$

where $E(R_p)$ = the security's expected rate of return, R_f = the risk-free rate, β_p = the beta coefficient, and $E(R_m - R_f)]$ = the market portfolio's expected rate of return. (Vaihekoski 2004, 204).

As mentioned, the CAPM shares relatively similar assumptions and constraints of the market and investor behaviour in relation to the efficient market hypothesis and the modern portfolio theory. As argued with the equilibrium conditions of the efficient market hypothesis, the highly restrictive and unrealistic assumptions necessary for the CAPM do not fully reflect the real-world and actual markets, but rather provides a relatively simple and versatile tool for investors to evaluate the financial characteristics of different securities from a theoretical point of view (Sharpe 1964, 434). The concerning assumptions and restraints are as follows (Sharpe 1964; Pilbeam 2018, 176):

1) A common pure interest rate is available on the market for all investors, with the investors having equal terms and possibilities to borrow and lend at that rate,
2) all required information is equally available for all individual investors,
3) transaction and taxation costs do not exist, all securities are infinitely divisible and liquid, and investors are able to short-sell securities,
4) the homogeneity of rational and risk-averse investors, and their expectations in terms of being fully aware of the return and risk factors of the concerning securities,
5) the varying risk preferences among investors is the pure explaining reason of different investor specific investment decisions.

As the CAPM is one of the most researched and discussed asset-pricing models in the financial field, it also has been empirically tested and criticized quite comprehensively. Roll (1977) stated that the two-parameter asset pricing theory, such as the CAPM, is testable in principle, but the model's necessary assumptions and problems with the definition and construction of the market portfolio, or more specifically its proxy, contaminates the validity of the whole model. Thus, the theoretical problems of the

CAPM makes it impossible to conduct unambiguous and correct tests in the future, making the whole theory of the model unreliable.

Reinganum (1981) further researched the relation between the securities' betas and their average rates of returns, also pursuing to estimate the cross-sectional importance of the beta, and hence reflect the obtained results to the theory of the CAPM. The results indicated that the betas were not systematically related to the securities' average returns, meaning that the fluctuations of the betas appeared to not have affected to the securities' average returns. To conclude, Reinganum argued that the betas that were estimated based on the standard market indices, did not appear to measure the systematic risk of the market reliably, which is supported by previous research by Fama and French (1992). The results also suggested that the empirical base of the theory of the CAPM can be concluded somewhat ambiguous or even faulty.

Supplementing the previous criticism of the CAPM, Fama and French (2004) discussed the empirical problems and theoretical failings of the model. More specifically Fama and French argued that the model's problems might be caused of its multiple simplifying assumptions, or alternatively the difficulties in implementing the correct tests based on the theory of the CAPM. Also, comparing the estimated risk of a security to the market portfolio, or the best possible proxy of it, is argued to be ambiguous and unreliable, which is in line with empirical evidence by Roll (1977). Fama and French concluded, that measuring the performance of portfolios and mutual funds with the CAPM is complicated. This is due to the fact that small stocks and value stocks or stocks with low betas tend to achieve abnormal rates of returns, simply because of their favourable characteristics in terms of the theoretical assumptions of the CAPM. However, the CAPM still functions as a simplistic approach for the theoretical concepts of the modern portfolio theory and other asset-pricing models (Fama – French 2004).

2.2 Multi-factor asset pricing models

2.2.1 Arbitrage pricing theory

Arbitrage pricing theory (APT) by Ross (1976) was initially proposed as an alternative to the CAPM. As the CAPM approaches the asset pricing with a single beta, the APT uses a multi-factor model. In other words, the APT includes several variables to asset pricing, pursuing to capture the systematic risk of an asset with multiple factors rather than with only one factor, and hence the model is expected to be more precise and reliable in comparison to the CAPM. Also, as the theoretical assumptions of the market efficiency and the CAPM are ambiguous, and thus relatively difficult to justify, the APT pursues to provide an alternative asset-pricing method with less restrictive assumptions.

The APT approaches the market efficiency from a different point of view, in comparison to the CAPM, by assuming that the markets are not efficient and correctly valued at all times. Accordingly, the APT assumes that arbitrage pricings, or market inefficiencies, of the assets occur on the market occasionally. Therefore, by utilizing the various systematic risk factors, it is possible for investors to capture the market inefficiencies and mispricing of the assets on the market, and also to profit from them. However, the correct risk factors are not defined in particular, which enables the model to be less restrictive and adjustable for the investors. (Ross 1976.)

The equation of the APT is defined as follows:

$$E(R_p) = R_f + \beta_1[E(r_1 - r_f)] + \beta_2[E(r_2 - r_f)] + \cdots + \beta_3[E(r_n - r_f)] + \varepsilon_p \qquad (2)$$

where $E(R_p)$ = the security's expected rate of return, R_f = the risk-free rate, $(r_1 - r_f), (r_2 - r_f), (r_n - r_f) =$ the risk premiums of the factors, $\beta_1, \beta_2, \beta_n =$ the security's sensitivities for the risk factors (factor loadings), and $\varepsilon_p =$ the security's idiosyncratic random shock with mean of zero (Ross 1976).

It is further researched, that the security prices are being exposed to various macroeconomic factors, with some of them having a greater effect on securities' prices than the others, such as the size and the value effects (Nai-Fu et al. 1986; Basu 1977; Banz 1981). Such factors should especially be taken into consideration when defining the possible risk factors for the asset-pricing model. Thus, various other multi-factor asset-pricing models have since been defined, pursuing to take the most significant macroeconomic factors effecting the stock prices into consideration on the asset valuation, and to enhance the explanatory power of the whole model (Fama – French 1993, 1996, 2015; Carhart 1997).

2.2.2 Fama-French three-factor model

The Fama-French three-factor model was initially presented by Fama and French (1992; 1993), by observing the size, leverage, earnings-to-price, and book-to-market (value) factors explanatory power in the cross-section of average stock returns. The results indicated that the size and value factors captured and explained most of the returns' fluctuation, instead of the more traditionally utilized beta coefficient on the US stock market during years 1941-1990, with the model remarkably explaining about 90 % of the returns of the diversified portfolios (Fama – French 1993). Additionally, Fama and French concluded, that the relation of the beta coefficient and the average returns on the market was weak, or even non-existent. As the empirical evidence further addressed the problems with the ambiguous theory of the CAPM, the three-factor model was defined, by expanding the initial asset-pricing model with the additional size (SMB) and value (HML) factors.

Accordingly, the equation of the Fama-French three-factor model is as follows:

$$(R_{pt} - R_{ft}) = \alpha_{pt} + \beta_1(R_{mt} - R_{ft}) + \beta_2(SMB_t) + \beta_3(HML_t) + \varepsilon_t \qquad (3)$$

where $R_{pt} - R_{ft}$ = the excess return of the portfolio, α_{pt} = the intercept, $R_{mt} - R_{ft}$ = (or MKT) the excess return of the market portfolio, SMB_t = the size premium (small minus big), HML_t = the value premium (high minus low), and $\beta_{1,2,3}$ = the factor coefficients (Fama-French 1993; 1996).

Further research addressed that the previous CAPM related anomalistic research and empirical evidence can also be captured with the Fama-French three-factor model, such as with the size effect related research by Basu (1983). However, Basu (1983) also argued, that the size factor is only beneficial in occasions when it is utilized simultaneously with other factors, and not when used independently due to possible robustness problems. Additionally, Fama and French (1996) discovered the reversal of the long-term average returns of a company also with the three-factor model, which is in line with previous research by De Bondt and Thaler (1985) and Jegadeesh and Titman (1993). The results indicated that the previous "loser companies" with lower past returns appeared to have higher average returns in the future, with positive size and value factor slopes. In contradiction, the previous "winner companies" with higher past returns appeared to have negative value factor slope and lower average returns in the future.

2.2.3 Carhart four-factor model

The Carhart four-factor model is an alternative extension for the Fama-French three-factor model, initially presented by Carhart (1997). The difference between the Fama-French three-factor and Carhart four-factor models is that the latter also includes the momentum factor in the asset valuation, in addition to the previous market, size, and value factors. The momentum factor was initially discovered by Jegadeesh and Titman (1983), as they gathered empirical evidence of the profitability of the investment strategies that buy previously well-performed companies and short-sell companies that have not performed well in the past, which is contrary to the investment strategies discussed by De Bondt and Thaler (1985) and Fama and French (1996). Thus, including the momentum factor to the model is also in line with the theory of the APT, as it has relatively significant effect on the securities' price fluctutation (Ross 1976).

The Carhart four-factor model is defined as follows:

$$\left(R_{pt} - R_{ft}\right) = \alpha_{pt} + \beta_1\left(R_{mt} - R_{ft}\right) + \beta_2(SMB_t) + \beta_3(HML_t) + \beta_4(PR1YR_t) + \varepsilon_t \quad (4)$$

where $R_{pt} - R_{ft}$ = the excess return of the portfolio, α_{pt} = the intercept, $R_{mt} - R_{ft}$ = (or MKT) the excess return of the market portfolio, SMB_t = the size premium (small minus big), HML_t = the value premium (high minus low), MOM_t = the momentum premium (the performance of the past 12-months), and $\beta_{1,2,3,4}$ = the factor coefficients (Fama-French 1993, 1996; Carhart 1997).

In addition, Carhart (1997) concluded that the model and the gathered evidence is consistent with the theory of the market efficiency, and with the utilization of the momentum factor and the acquired alpha, it is possible to estimate whether a mutual fund is over- or underperforming.

2.3 Market anomalies

Multiple previous research have produced evidence of anomalies, or non-explainable market phenomena, which are in contradiction to the utilized asset-pricing models and financial theories. The concerning anomalies indicate that it is possible for investors to achieve abnormal returns on the market by utilizing certain investment strategies, or alternatively by preferring certain security specific characteristics, which proves that there are either inadequacies with the maintained asset pricing models or with the market efficiency theories, which is also being referred to as the joint hypothesis problem. Hence, the anomalistic findings are in contradiction to the traditional financial theories, such as the efficient market hypothesis. (Fama 1970; Malkiel 2003; Schwert 2003).

As previously argued, the size effect, the value effect, and the momentum effect are examples of well-known anomalies in the financial literature, and each of them have been proved to have a significant effect on the securities' prices. Accordingly, these factors are also being considered on several asset pricing models as risk variables, such as in the Fama-French three-factor model or the Carhart four-factor model, to investigate the explanatory power of the factors in securities' price formation. (Ross 1976; Fama – French 1993, 1996; Carhart 1997.) Nevertheless, some of the observed anomalies have since disappeared, reversed, or attenuated on the market. It is questionable whether the changes with the anomalies have been due to the growing public awareness and various research of the phenomena, or just the fact that the discussed anomalies have simply been statistical deviations on the market at that time. (Schwert 2003, 941–942.)

2.3.1 The value effect

The value effect refers to an occasion where value companies have achieved higher average returns in comparison to the growth companies (Malkiel 2003, 68). Generally, a company is defined as a "value company" by identifying the companies' differences with various fundamental multiples, most commonly with the price-to-earnings ratios or the price-to-book-value ratios. Thus, relatively inexpensive companies, measured by the price-to-earnings ratio or the price-to-book-value ratio, are considered as value companies, and vice versa the more expensive companies as growth companies. (Malkiel 2003; Schwert 2003.)

Basu (1977) initially discovered the relationship between the common stocks' return performance and their price-to-earnings ratios on the US stock market during years 1957-1971. The results indicated that the low price-to-earnings portfolios remarkably outperformed the higher price-to-earnings portfolios on average, with the performance being measured with both absolute and risk-adjusted returns. Additionally, the returns were adjusted to several different factors, such as the transaction costs and differential taxes, which argued that the results were also in contradiction to the theory of the efficient market hypothesis and the CAPM (Sharpe 1964; Basu 1977). Furthermore, similar value effect research and equal evidence of the abnormal performance of the concerning anomaly on the US market has been presented by Reiganum (1981), Basu (1983), and Fama and French (1992; 1993).

Capaul et al. (1993) investigated the returns of the growth stock portfolios with high price-to-book ratios, and the returns of value stock portfolios with low price-to-book ratios, internationally during years 1981-1992. The concerning portfolios' returns were analyzed over 6 different countries, including France, Germany, the UK, the US, Japan, and Switzerland. The result indicated that the value effect was, in fact, observable on a global basis, as the portfolios with low price-to-book ratios gained higher risk-adjusted returns than the high price-to-book portfolios. The evidence of the superior performance of value companies on a global basis is in line with the research by Fama and French (1998), as they also investigated the international performance differences between the growth and value portfolios during years 1975-1995. The results argued that the value stocks outperformed the growth stocks on 12 out of 13 different major market, with the average yearly excess return being a remarkable 7.68 percent in favor of the value strategy (Fama – French 1998). The international evidence of the value effect also enhanced the robustness of the previous empirical evidence, which arguably has led to the value effect-based investment strategy still being preferred by large amount of investors all around the globe.

2.3.2 The size effect

The size effect, or the tendency of the smaller companies generating higher returns than large companies, is one of the most significant anomalies yet discovered (Malkiel 2003, 67-68). The size anomaly was initially presented by Banz (1981), who investigated the empirical relationship between the market values and the returns of securities listed on the New York Stock Exchange (NYSE) during years 1936-1975, by utilizing the CAPM as the predicting asset-pricing model for the analyses. The results argued that the smaller market-cap companies gained higher risk-adjusted returns in comparison to the higher market-cap companies over the analysed period of 40-years. Also, the size effect appeared to not be linear with the changing market value of the companies, as the effect appeared to be the strongest for the very small companies, and the differences between the average size companies' returns and the large size companies' returns were relatively small.

Further evidence of the size effect, as well as the value effect, was provided by Basu (1983). Basu researched the size factors' and earnings' yield relation to the returns of the common securities of the NYSE firms during years 1963-1979. The results indicated that as with the research by Banz (1981), the common stocks of smaller NYSE companies appeared to achieve substantially higher returns in comparison to the larger NYSE companies. However, the anomalistic evidence of the size effect disappeared when the returns were to be controlled for differences in earnings-to-price ratios and risks. Thus, it was argued that the value effect is not completely independent of the company size, and that both of the anomalistic phenomena are, in fact, more complicated than discussed and argued in previous literature.

Since the initial publications and discovering of the anomalistic characteristics of smaller companies' abnormal performance, it has been argued that the size effect has completely disappeared from the market. (Malkiel 2003, 68; Schwert 2003, 945). Malkiel (2003) concluded that from the mid-1980s to the 1990s, there has been no evidence presented of the smaller companies systematically outperforming the larger companies. This may be due to the fact, that the institutional investors prefer the more liquid and larger companies rather than the more risky and smaller companies. Also, it is stated that the possibility of the survivorship bias[1] could have somewhat affected the previous size effect studies (Malkiel 2003, 68).

2.3.3 The momentum effect

The momentum effect, or the momentum anomaly, can be divided into two different and diametrically opposed findings based on the previous empirical evidence; the long-term reversals and the short-term momentums (Fama – French 1996; Schwert 2003; Alwathainani 2012). The long-term reversal was initially discussed by De Bondt and Thaler (1985), as they researched whether the reactions caused by unexpected and dramatic news affected the market. The results remarkably indicated that the portfolios constructed with the previous "loser" companies systematically outperformed the portfolios constructed with previous "winner" companies with over 3-5-year holding period on the US market. In contradiction, Jegadeesh and Titman (1993) argued that

[1] The survivorship bias refers to a situation, in which the modern databases only include companies that have not gone bankrupt. Thus, the research that focus on the long-term performance of the companies are only able to evaluate the performance of the companies that have survived, and not the ones that have failed, which automatically causes a bias towards the companies with better performance in the analyses. (Malkiel 2003, 68.)

buying the past “winner” companies and short selling the past “loser” companies generated positive abnormal returns on the US market, but only over 3-12-month holding period. Thus, the short-term momentum of the returns is argued to be caused by investors’ biased expectations, also causing the returns to revert afterwards. This phenomenon is believed to be caused by market overreactions, that are being corrected later on after the investors’ erroneous expectations of the future performance are being acknowledged (Alwathainani 2012). Also, it is important to acknowledge that in most financial literature the phenomenon of the short-term overperformance of assets is generally described as the momentum anomaly.

Rouwenhorst (1998) further researched the momentum effect on the international markets, by testing the effect on 12 different European countries during years 1980-1995. The results were in line with the results by Jegadeesh and Titman (1993), as the “winner” portfolios systematically outperformed the “loser” portfolios, with the abnormal returns continuing approximately for 12 months before the beginning of the returns’ reversal. The results appeared to hold for both small and large companies, but the effect was argued to be stronger with smaller companies. The international momentum effect has been researched later on by Fama and French (2012), with the results indicating that the momentum effect has been visible during years 1989-2011 on all major regions except for Japan (thus referring to North America, Europe, and Asia Pacific). Similar to the evidence by Rouwenhorst (1998), the results by Fama and French (2012) also indicated that the momentum effect is stronger for the smaller companies than for the larger companies. To conclude, the empirical evidence of the momentum effect seems to be robust, but it is important to keep in mind that the results might also reflect to risk factors that are not yet to be acknowledged or understood completely (Schwert 2003, 951).

2.4 Price-to-Earnings-to-Growth ratio

The Price-to-Earnings-to-Growth (PEG) ratio is a widely utilized investment metric to evaluate whether a company is correctly valued in relation to its estimated earnings per share (EPS) growth rate. The majority of the traditional investment evaluation metrics, such as the Price-to-Book (P/B), Price-to-Sales (P/S), and Price-to-Earnings (P/E) ratios, generally evaluate the companies’ performance based on the past key figures, such as the realized sales or stock prices. Thus, the PEG-ratio pursues to provide a more forward-looking investment metric by considering the company’s forecasted growth rate, which also has a relatively comprehensive impact on the company's potential performance and expected returns. (Trombley 2008; Fafatas – Shane 2011; Pilbeam 2018, 222)

The PEG-ratio is traditionally calculated as follows:

$$PEG_t = \frac{P_t/E_t}{EPS_{Gt}} \tag{5}$$

where PEG_t = the Price-to-Earnings-to-Growth rate, P_t/E_t = the Price-to-Earnings ratio of the company, and EPS_{Gt} = the company's earnings per share growth rate.

The PEG-ratio is traditionally utilized as a stock screener metric, as it provides a benchmark for different companies' performance evaluation, also including the forecasted growth rate into the consideration (Trombley 2008; Fafatas – Shane 2011). Thus, in comparison to most of the other traditional investment metrics, the PEG-ratio enables the investors to compare companies with different growth rates to each other. Analyst estimates, such as the I/B/E/S estimates for forecasted EPS growth rate, are commonly utilized for calculating the PEG-ratio, or more specifically the growth factor of the company. However, as the analyst estimates arguably might be unambiguous, alternative estimation methods for the growth factor and the PEG-ratio have been additionally presented (Wang et al. 2020; Chan 2023).

The suggested benchmark value of the PEG-ratio is traditionally set as follows: for correctly valued companies PEG equals 1, for undervalued companies PEG is under 1, and for overvalued companies PEG is over 1 (Fafatas – Shane 2011; Pilbeam 2018, 222). In other words, for a company to be fairly valued, the dividend growth rate should be equal to the company's PE-ratio (Fafatas – Shane 2011; Lajevardi 2014). However, the traditional benchmarking of the PEG-ratio has also encountered criticism in several related studies, arguing that the equal benchmarking value of 1 for all companies or stocks is ambiguous. Accordingly, the correct PEG-ratio values for fairly valued companies should be defined and calculated separately, based on the company specific growth rates and financial characteristics. (Arak – Foster 2003; Trombley 2008; Schnabel 2009.)

2.4.1 Limitations of the PEG-ratio

Calculating the PEG-ratio might be demanding for individual investors, as there is no unambiguous measure for defining the earnings growth rate. In most of the previous related studies, such as with research by Peters (1991), Schatzberg and Vora (2009), and Fafatas and Shane (2011), the PEG-ratio is calculated with the forward-looking earnings growth rate forecasts, provided by the I/B/E/S analysts. As the PEG-ratio is significantly dependent on the growth factor of a company's prospected earnings, thus being based on analyst estimates and forecasts, inadequacies and distortions are relatively likely to occur (Bauman – Miller 1997). Therefore, investors should acknowledge the possible deficiencies of the PEG-ratio before making any investment decisions.

Bauman and Miller (1997) researched the performance of value and growth stocks on the US stock market during years 1980-1993. Bauman and Miller argued that in most cases the performance evaluation and forecasting of the growth stocks, and accordingly the companies' growth rates, are being relied too much on the historical trends. Hence, the behavioural and psychological influences on human-based decision making, such as estimates generated by analysts, could lead to biased forecasts of future performance, also influencing the growth rate forecasts. The results indicated that the value stocks, or stocks with low PE-ratios, performed better than the growth stocks. However, Bauman and Miller discussed that the growth stocks' worse returns were associated with analysts extrapolating the former growth rates into the future, and thus causing exaggerated earnings forecasts and greater negative earnings surprises. Thus, the results supported the fact that the analysts' systematically overestimated the companies' forecasted growth factors during the entire research period.

Arak and Foster (2003) examined the benchmarking of the PEG-ratio, and whether the traditional value of 1 for correctly valued companies across-the-board is justified. Arak and Foster utilized two different company valuation models, the dividend discount, and the free cash flow model, to evaluate the appropriate stock prices and the different growth phases for the companies. Also, different financial factors such as the profitability and the required rate of return of a company, were utilized to determine the correct PEG-ratio values for different companies. The results indicated that the PEG-ratio's traditional benchmark of 1 might be justified for companies with relatively high growth and profitability, presuming that the growth continues for a couple of years, but not for companies with only moderate growth rates. However, the relationship between high growth rates and high PEG-ratios is not linear, but rather convex. Additionally, Arak and Foster argued that the companies' growth-cycles should be acknowledged and appraised when evaluating the fair company specific PEG-ratios.

Trombley (2008) explored the relationship of the PEG-ratio and companies' financial characteristics, such as the cost of capital of the company. Trombley particularly pursued to observe whether correctly valued companies' PEG-ratios could differ from the traditional benchmark valuation, with the ratio approximating the value of 1. The results were concluded in three main observations. First, Trombley argued that higher PEG-ratios are consistent for correctly valued companies with relatively low growth, which is also in line with the empirical evidence by Easton (2004). Second, higher PEG-ratios also occur for companies with relatively high and persistent growth rate. Third, higher PEG-ratios are consistent for companies with lower cost of capital. The results indicated that the PEG-ratio should frequently exceed the valuation of 1 for correctly valued companies, especially with the ones with lower cost of capital. Trombley discussed that the PEG-ratio of 1 could, however, be the appropriate benchmark for certain type of companies, such as companies with high growth and risk characteristics. To conclude, Trombley suggested that the PEG-ratio should not be individually utilized to compare companies in different industries, due to the discrepancies of the company and industry specific characteristics.

Schnabel (2009) researched the benchmarking of the PEG-ratio and the possible discrepancies with the concerning valuations of the ratio, by using the Gordon's constant growth model for share valuation. Schnabel argued that the similar benchmark value for all different companies across-the-board, is inappropriate. Thus, in some cases the benchmark value of 1 for correctly valued companies is too high, and vice versa in some cases too low. Therefore, the benchmarking of the PEG-ratio should be company specific, and being based on company specific financial figures, such as the cost of capital and the growth rate, which is in line with previous related research by Arak and Foster (2003) and Trombley (2008). In conclusion, Schnabel (2009) argued that the benchmark value of the PEG-ratio is in fact a declining function of the cost of capital and convex function of the earnings growth rate, which supports the proposition that the benchmark value of 1 is not constant for all companies and industries.

2.4.2 Previous PEGR effect research

Peters (1991) initially presented the low PEG-ratio based investment strategy, and researched the performance of it by analysing growth stocks on the US stock market during years 1982-1989. The PEG-ratios were calculated with the I/B/E/S analyst estimates of the forecasted earnings growth rates. The results argued that the lowest PEG-ratio companies performed better than the higher PEG-ratio securities systematically during the analysed years. Also, the lowest PEG-ratio portfolio remarkably performed better than the S&P 500 in 21 out of 30 quarters considered. To conclude, Peters argued that the PEG-ratio is a valuable investment tool on evaluating the performance of growth stocks, the results also showing further proof of the undervalued growth stocks outperforming those with relatively high expectations.

Sun (2001, as cited in Chahine – Choudhry 2004; Lajevardi 2014; Wang et al. 2020) researched the PEG-ratio based investment strategy during years 1983-2000. The main finding of the research was that the average returns of different PEG-ratio portfolios were in fact hump-shaped, indicating that the medium PEG-ratio portfolios remarkably achieved the highest returns of all portfolios. Hence, the results casted doubts on the low PEG-ratio preferring investment strategies, and previous empirical evidence of the PEGR effect. Additionally, the ambiguous characteristics of forecasting the earnings growth rates for companies was being discussed, with a conclusion that the analyst estimates of company specific earnings growth rates also partially explain the obscure PEG-ratio specific return characteristics and patterns.

Chahine and Choudhry (2004) further studied whether the previous empirical evidence of value stocks outperforming the growth stocks has changed on the European market during years 1988-2002, and whether the strategy is sensitive to specific country, industry, and earnings growth rate factors. The results indicated that preferring value companies with high earnings growth rates, and by short selling securities with PEG-ratios over 1 and buying securities with PEG-ratios under 1, overperformed all other trading strategies on the European market. The results also hold up with all different time periods, and individual industries and countries, which indicates that the low PEG-ratio companies overperform the high PEG-ratio companies regardless of the industry or country specific factors.

Schatzberg and Vora (2009) examined the robustness of the extraordinary performance of the low PEG-ratio based investment strategy with the growth stocks on the US stock market during years 1990-2003, based on the empirical evidence by Peters (1991). Also, the risk and return characteristics of such investment strategies were further investigated. As with most of the previous related research, the PEG-ratios were calculated based on the I/B/E/S analyst estimates of the forecasted earnings growth rates. The findings of the research suggested, that the overperformance of low PEG-ratio companies also extends to the value stocks in addition to the growth stocks, also arguing that the differences in performance of varying PEG-ratios are robust to controls for differential risk and the employment of forecasted or historical EPS measures. Additionally, the results indicated that the PEG-ratio based value investing strategy had enhanced risk characteristics, that are counterintuitive for most value stock preferring investors.

Fafatas and Shane (2011) investigated the utilization of the PEG-ratio as an intrinsic value model, or a trading heuristic, in relation to the value stocks on the US stock market during years 1990-1994. To identify the inefficiencies of the market is conducted by comparing fairly valued PEG-ratio companies' one-year-ahead performance, taking both long and short positions based on the ratios of intrinsic values and current prices (V/P), to a hedge-fund's performance with an identical approach on the market. The PEG-ratios were calculated with one-year-ahead EPS and long-term growth forecasts, with the data being collected from the I/B/E/S database. The results indicated that the returns of the V/P trading strategy with fairly valued companies based on their PEG-ratios, with the values being close to the traditional benchmark of 1, were in fact greater in comparison to the whole market. To conclude, the utilization of the PEG-ratio as an investment tool, and more specifically by preferring the fairly valued companies, or companies with medium PEG-ratios, seems to result in abnormal excess returns on the US stock market.

Wang et al. (2020) estimated an alternative method to forecast the companies' earnings growth rates and the PEG-ratios, with a log-linear regression model. Accordingly, the performance of the low PEG-ratio investment strategy was analysed on the US stock market during years 1968-2009. The results indicated that all again the low PEG-ratio securities performed better than the high PEG-ratio securities, also achieving abnormal returns and hence overperforming the market, over the analysed period of 42-years. The obtained results are in line with previous empirical evidence and research by Peters (1991), Chahine and Choudhry (2004), and Schatzberg and Vora (2009). To conclude, the presented log-linear estimation model could arguably benefit the investors in constructing the PEG-ratio based portfolios, and also the analysts by providing an alternative tool for defining growth estimates and forecasts in the future. As the results were in line with previous low PEG-ratio investment strategy research, it would be interesting to analyse whether this method could also provide further evidence of the

PEGR effect on other markets. Thus, the concerning method is utilized and tested in this particular research.

2.5 Hypothesis details

The hypotheses of this research are being formed based on the previous related research. As the low PEG-ratio anomaly has not been previously researched on the Nordic stock market, the hypothesis 1) and 2) rest upon the empirical evidence of the low PEG investment strategy's performance on the other markets (Peters 1991; Chahine – Choudhry 2004; Schatzberg – Vora 2009; Wang et al. 2020). Furthermore, the hypothesis 3) is formed based on the empirical evidence of the benchmarking problems of the PEG-ratio (Arak – Foster 2003; Trombley 2008; Schnabel 2009). Accordingly, the hypotheses for the research questions are as follows:

1) The low PEG-ratio anomaly, or the PEGR effect, is observable on the Nordic stock market,

2) the low PEG-ratio anomaly, or the PEGR effect, is more visible in certain industries,

3) and the traditional PEG-ratio's benchmark value of 1 for all companies across-the-board is not valid.

3 RESEARCH DESIGN

3.1 Data and sample selection

The company specific data of the research is consisting of companies listed on Nasdaq OMX Nordic All-Share Index, including all publicly listed companies on Nasdaq OMX Copenhagen, Nasdaq OMX Helsinki, and Nasdaq OMX Stockholm (Nasdaq 2023). The Nasdaq OMX Nordic All-Share Index will also be the benchmark index, or market portfolio, in this research, to provide as reliable benchmark for the portfolio specific performance analysis as possible, concerning only the Nordic stock market. Although the market portfolio is being diversified with only one asset class, in this occasion with publicly listed stocks, and thus does not satisfy the presumptions of the modern portfolio theory and the CAPM, the utilization of a single asset class is justified as it is pursued to comply with the procedures of the previous related research.

All return data and further analysis are conducted by utilizing the total return index of the returns. This is due to the fact, that the total return index acknowledges all changes in securities' prices in the valuation, such as dividends, stock splits, share issues, and other possible price distributions of the asset. Also, all the available and realized cash distributions are assumed to be reinvested, which enhances the accuracy of the security specific pricing, enabling the investors to compare the results of different securities' overall performance more reliably to each other. (Vaihekoski 2004, 191–193.)

The more specific data requirements are set by pursuing to comply with the previous anomaly-based research by Basu (1977), Schatzberg and Vora (2009), Fafatas and Shane (2011), and Wang et al. (2020). The sample period of this research is years 2010-2022, pursuing to minimize possible short-term deviations and distortions of the data, and to estimate whether the PEGR effect have been occurring in a long term during the sample period, which is also supported by the theory of the efficient market hypothesis and the random walk of returns (Fama 1970; Jensen 1978; Malkiel 2003). Accordingly, the set requirements are as follows (see Basu 1977; Peters 1991; Wang et al. 2020):

1) The company has reported positive earnings per share (EPS) for the current year,

2) the fiscal year of the company ends on December 31,

3) the company's log-linear earnings (EPS) growth rate is positive,

4) the company’s financial statement data and related essential information are not missing,

Additionally, only PEG-ratio values in between 0-10 are included in the sample. If the PEG-ratio data are missing or the values exceed the set limits, the observations are excluded from the observed sample and analysis. Also, companies operating in financials and utilities industries are included in the sample to provide as wide-ranging empirical evidence as possible, and to observe the industry specific characteristics across-the-board. It is interesting to observe whether the divergent leverage structure of financial firms, as argued by Fama and French (1992), possibly have an impact on the PEG-characteristics and performance of the concerning portfolios, or not.

The financial data in this research is being collected from the Datastream service by Thomson Reuters. The Fama-French factors from the Data Library of French (2023) are utilized to conduct the Fama–French three-factor regressions. The company specific EPS growth rates, and accordingly the calculations of the PEG-ratios are executed by using Microsoft Excel (version 16.72). All further statistics and analysis are carried out with the statistical computing and graphics software R-studio (version 2023.06.01+524).

3.1.1 Calculating the PEG-ratios

Conducting the log-linear regression model to estimate the earnings growth rate of a company is being based on the methods used by Wang et al. (2020). The initial intention of utilizing the log-linear regression model is to provide investors an alternative tool for estimating the earnings growth rate, and more specifically the PEG-ratio, of a company. The analyst estimates, such as the I/B/E/S estimates commonly utilized for calculating the PEG-ratio, are generally not equally available for all investors. Also, based on previous research by Bauman and Miller (1997), the estimates set by analysts could lead to biased forecasts and exaggeration of companies’ growth rates and future performance, and thus could cause data distortions and reliability issues with heuristics such as the PEG-ratio. Hence, the alternative earnings growth rate estimation method could be in high value for investors and analysts in the future, and further research is needed.

The Wang et al. -method log-linear regression initially uses 12 historical annual observations of EPS to estimate the first coefficients for the companies in the sample, in this case for the year 2010 the EPS observations are collected from the years 1998-2009.

Next year all the historical EPS information, from 1998-2010, is being used, in total having 13 observations. For the final sample year of this research, being 2022, historical EPS information from 1998-2021 is utilized, having 24 observations in total. The equation for the log-linear estimation model is as follows:

$$\ln EPS_t = \beta_1 + \beta_2 t + \varepsilon_t \tag{6}$$

where EPS = the earnings per share, and β_1 *and* β_2 are coefficients (Wang et al. 2020).

In this case, the regressor is time, taking values 1, 2, 3, etc. The coefficients can be obtained simply by the ordinary least squares (OLS) method. Hence, the compound growth rate of EPS (g), can finally be obtained by taking antilog of the estimated coefficient β_2, and subtracting 1 from it. An example of the EPS growth rate calculation is presented in Appendix 1. The obtained growth rate is then utilized to calculate the PEG-ratio for each sample company.

The Wang et al. -method is the main method to calculate the concerning EPS growth rates in this research. In addition, three alternative methods are presented and tested, to estimate whether they could provide more adaptable approach for estimating the EPS growth rate and to test the robustness of the acquired results. This is due to the fact that the Wang et al. -method acknowledges the whole history of EPS values through all years, and thus possibly is not as adaptable for the latest changes in the market or companies' characteristics. Thus, the alternative presented methods are R12-method, R9-method, and R6-method.

The R12-method refers to a log-linear regression, that utilizes the 12 latest annual observations of EPS in a rolling fashion. Thus, the method is similar to the Wang et al. -method at its starting point, by observing the years 1998-2009. However, next year the EPS value of 1998 is not observed anymore as it is replaced by the EPS value of 2010, the observable sample now being years 1999-2010, and so on. The rest of the methods work identically, as the R9-method utilizes the nine latest annual observations of EPS in a rolling fashion, and the R6-method the six latest annual EPS observations in a rolling fashion. If these alternative methods could be exploited in estimating the EPS growth rate and be utilized in calculating PEG-ratios of individual companies, it could provide investors a great and more adaptable tool for analysing possible investments in the future.

After defining the EPS growth rates with each of the presented methods for all companies and each year of the sample, the final PEG-ratios are calculated by dividing the companies' year specific PE-ratios by the acquired EPS growth rates.

3.1.2 Defining the portfolios

Portfolios are being constructed in three different ways. The first practise is to observe PEG-ratio specific characteristics and build the portfolios accordingly to compare how lower PEG-ratio companies' performance compares to higher PEG-ratio companies' performance. Thus, four PEG specific portfolios are being annually constructed with P1 being the lowest PEG-ratio portfolio, and P4 the highest PEG-ratio portfolio. This manner is repeated for all four different PEG-ratio calculation methods, the Wang et al. -method, the R12-method, the R9-method, and the R6-method. In total there are 16 different PEG specific portfolios being constructed annually.

The second practise is to observe industry specific PEG-ratio characteristics and performance based on the PEG-based share-picking. This is executed by grouping the companies into five different portfolios based on their main operating industry. The industry separation is executed as follows: IP1) industrials and basic materials, IP2) consumer discretionary and consumer staples, IP3) financials and real estate, IP4) technology and telecommunications, and IP5) health care and utilities. The concerning industry groups are also observable in a table form in Appendix 2. Hence, five different industry specific portfolios will be annually constructed, and being repeated for all different PEG-ratio calculation methods mentioned above. In total there are 20 different industry specific portfolios being constructed annually. The third practise is to combine the PEG- and industry-specific portfolios, by creating the PEG portfolios for all industries, and all different methods. Hence, in total 80 different combined portfolios are annually constructed.

All portfolios are being constructed annually for a one-year time period ahead until the process is repeated, and the portfolios are being rebalanced, complying with previous related research by Basu (1977), Schatzberg and Vora (2009), Fafatas and Shane (2011), and Wang et al. (2020). Also, all companies included in the portfolios are being equally weighted. The next year's investment decisions, or company selections, are being made at the final day of the year based on the latest prevailing financial data. The portfolios are always being constructed on the first day of the following year, and being analysed until the last day of that year. Thus, the time period for the portfolios' analyses is 1st of January to 31st of December for each year of the sample period of the research.

The portfolio data are presented in Table 1. The total amounts of observations of the PEG specific and industry specific portfolios differ with some observations, as some of the companies included in the PEG specific sample do not have an industry dimension in the data. As noticeable, in total the R6-method has more observations in comparison to other methods, which indicates that the utilization of this method might benefit investors and analysts in terms of broader samples. It is noteworthy, that with the industry specific results, IP4 and IP5 have significantly smaller number of observations in comparison to other industry separated groups, which could cause some challenges when comparing the results to each other. Even though IP4 (Wang et al.) has the smallest number of individual company observations (N=181), the results can be still held somewhat reliable.

Of all the PEG specific portfolios, P1 portfolios includes the lowest PEG-ratios and P4 portfolios includes the highest PEG-ratios. Also, P1 (R9) obtains the lowest PEG value (0.20) of all portfolios, and P4 (Wang et. al) obtains the highest PEG value (5.44).[2] The average PEG-ratios for all methods are 2.47 (Wang et al.), 2.08 (R12), 1.56 (R9), and 1.58 (R6). This indicates that the shorter the time period for defining the EPS growth rate, in this case covering the R9-method and the R6-method, the lower the PEG-ratio. However, it is still unclear whether the calculation method affects to the interpretation of the PEG-ratio, and its traditional benchmark of 1 for correctly valued companies.

The R9-method (482 %) achieved the highest cumulative percentual returns for the whole method-based sample. The R6-method (476 %) achieved the second highest returns, and the R12-method (394 %) and Wang et al. -method (374 %) the lowest cumulative returns of the observation group. P4 (R9) has the highest cumulative returns (564 %), and P4 (Wang et al.) has the lowest cumulative returns (273 %) of all single portfolios. It is noteworthy, that with the Wang et al. - and R12-methods the two best performing portfolios over time are P2 and P3, and with R9- and R6-methods the best performing portfolios are P3 and P4. This indicates that with the R9- and R6-methods the higher

[2] The PEG-ratio calculation method is presented in the parenthesis. E.g., P1 (Wang et al.) refers to the Wang et al. -method based portfolio P1. These kinds of markings are being used through this paper, when analysing different portfolios' results.

PEG-ratio value is not a restraint for greater returns but vice versa, which is in contradiction to the results of Wang et al. – and R12-methods and previous research.

Of all the industry specific portfolios, IP3 portfolios includes all the lowest PEG-ratio values, and IP4 portfolios includes all the highest PEG-ratio values of the sample. Of all individual portfolios, IP3 (R9) obtains the lowest PEG-ratio value (1.07) of all industry groups. Accordingly, IP4 (Wang et al.) obtains the highest individual PEG-ratio value (2.79). The variation of the PEG-ratios between different portfolios is most likely due to industry specific characteristics.

IP4 (R6) has the highest cumulative returns (626 %), and IP2 (R12) has the lowest cumulative returns (196 %) of all single portfolios. In total, IP2 seems to have strongly underperformed in comparison to all other individual portfolios, with the cumulative returns varying only between 186 % - 216 %. This might indicate that the company investment decisions being based on PEG-ratio do not perform well in the consumer discretionary and consumer staples industries. With the Wang et al. –method IP4 has performed the best (491 %), even though having the highest PEG-ratio (2.79) of the industry groups. The two best performing portfolios of the R12-method are IP1 (474 %) and IP3 (464 %). IP4 is the best performing portfolio with the R9- (616 %) and the R6-methods (626 %). What is remarkable is that all other portfolios of the R9- and the R6-methods, excluding the underperformed portfolio IP2, yielded higher cumulative returns than any of the constructed portfolios of Wang et al. – and R12 -methods.

Table 1. Portfolio data

*Note: N = number of companies included in the portfolio. Return data consists of 12 monthly observations for each company and for each year during 31.1.2010 – 31.12.2022 (e.g., for R12-method the total amount of observations is 2 766 * 12 = 33 192).*

Statistics		**PEG portfolios (P1-P4)**			**Industry portfolios (IP1-IP5)**		
		N	**PEG (mean)**	**Cumulative %-return**	***N***	**PEG (mean)**	**Cumulative %-return**
Wang et al.	(I)P1	*672*	0.63	362 %	*905*	2.74	448 %
	(I)P2	*667*	1.41	486 %	*554*	2.58	196 %
	(I)P3	*663*	2.45	382 %	*763*	1.96	409 %
	(I)P4	*661*	5.44	273 %	*181*	2.79	491 %
	IP5	-	-	-	*255*	2.53	384 %
	Total	*2 663*	2.47	374 %	*2 658*	2.47	374 %
R12	(I)P1	*695*	0.44	369 %	*964*	2.25	474 %
	(I)P2	*694*	1.06	474 %	*525*	2.17	186 %
	(I)P3	*691*	1.96	463 %	*730*	1.55	464 %
	(I)P4	*686*	4.88	279 %	*247*	2.56	343 %
	IP5	-	-	-	*295*	2.24	417 %
	Total	*2 766*	2.08	394 %	*2 761*	2.08	394 %
R9	(I)P1	*684*	0.20	464 %	*964*	1.69	572 %
	(I)P2	*681*	0.63	418 %	*516*	1.66	216 %
	(I)P3	*679*	1.41	469 %	*665*	1.07	512 %
	(I)P4	*674*	4.04	564 %	*273*	1.88	616 %
	IP5	-	-	-	*294*	1.81	577 %
	Total	*2 718*	1.56	482 %	*2712*	1.56	482 %
R6	(I)P1	*743*	0.21	443 %	*1050*	1.70	573 %
	(I)P2	*738*	0.71	401 %	*564*	1.66	209 %
	(I)P3	*734*	1.46	520 %	*703*	1.09	532 %
	(I)P4	*731*	3.96	534 %	*301*	1.89	626 %
	IP5	-	-	-	*320*	1.85	517 %
	Total	*2 946*	1.58	476 %	*2 938*	1.58	476 %

3.2 Return data

The market portfolio's, or the Nasdaq OMX Nordic All-Share Index's, returns are presented in Figure 3. The returns presented are calculated with the total return index to provide as realistic observations of the total performance of the portfolio as possible. Also, it is strived to minimize all distortions of the return data, and to make the results comparable to other analysed portfolios. The left-hand graph illustrates the monthly total returns through years 2010-2022. As noticeable towards the end of the sample period in 2022, the monthly returns seem to be more lower and more volatile in comparison to the previous years, increased interest rates and the uncertainties of the market.

The right-hand graph presents the market portfolio's cumulative returns through years 2010-2022, ending up with total profits of 310 %. The negative progress of the market portfolio's returns starting from February of 2022 is also noticeable in this graph, with the highest value of 407 % being observed in January of 2022.

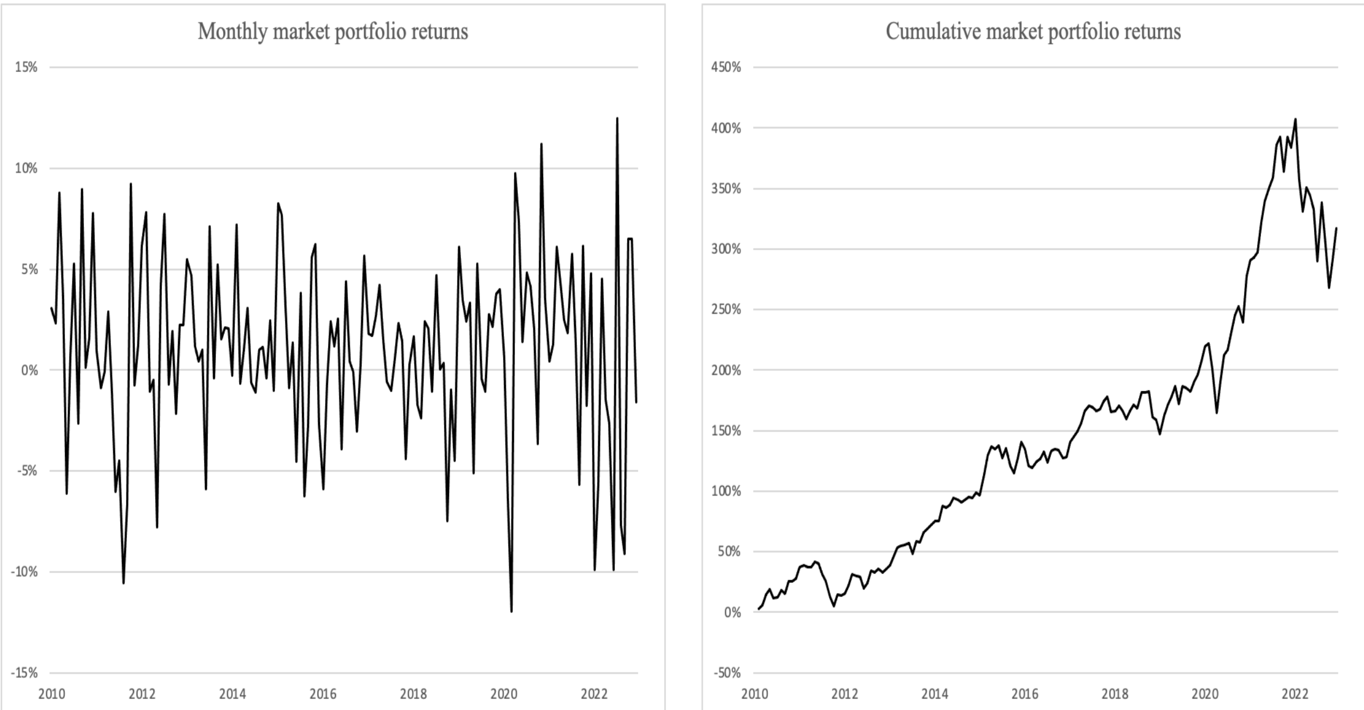

Figure 3. Market portfolio returns

Note: The market portfolio describes the total returns of the Nasdaq OMX Nordic All-Share Index. The return data are calculated with the total return index, which includes all realized distributions, such as dividends and stock splits, into the valuation.

The PEG and industry specific portfolios' individual monthly returns are presented in Figure 4. The PEG specific portfolios are observable on the left-hand side of the figure. Accordingly, the industry specific portfolios are observable on the right-hand side of the figure, being labelled as e.g., *"P1_ind_Wang et al."*.

All observed portfolios have positive median returns over the time period of 2010-2022. Furthermore, the PEG specific portfolios appears to have quite stabile average variances, although the average PEG-ratio of the portfolio varies quite drastically between different portfolios. However, there seems to be some differences between the industry specific portfolios, as P3 portfolios appears to have the lowest variances, and P4 portfolios the highest variances of all the groups, which may be due to industry specific characteristics. In total, it appears that with all the observed portfolios the outlying observations are more biased to the negative side, which indicates that the sample companies are more sensitive to generate higher negative returns rather than higher positive returns.

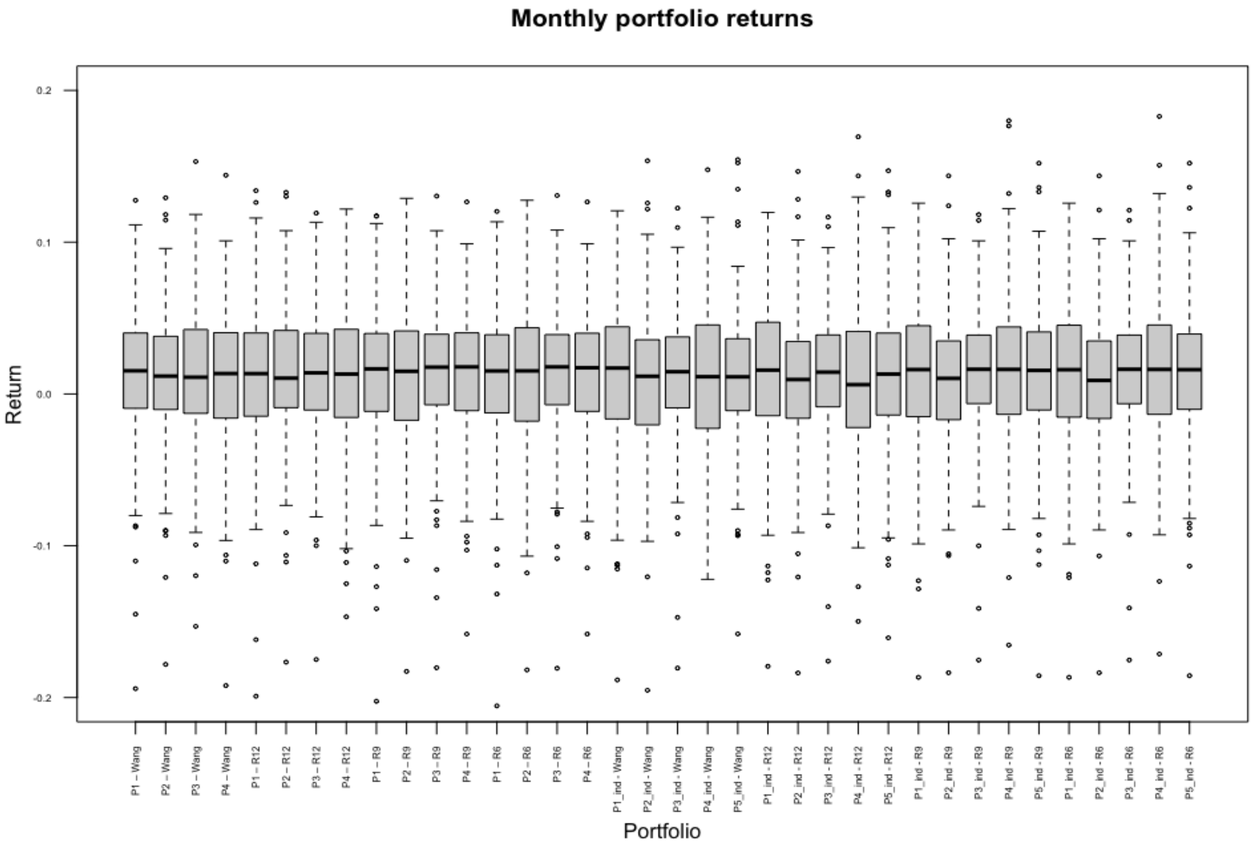

Figure 4. PEG and industry specific portfolio returns

Note: The return data are calculated with the total return index, which includes all realized distributions, such as dividends and stock splits, into the valuation. Values presented = monthly returns – risk-free rate.

3.2.1 Descriptive statistics

Table 2 presents the PEG specific portfolios' descriptive statistics. All the portfolios return data consist of a total of 156 monthly observations. The market portfolio's average monthly returns (0.0091) and standard deviation (0.0455) are both the third lowest of all PEG specific portfolios. P4 (R9) has the highest average monthly returns (0.0121) of the group, and in contradiction P4 (Wang et al.) has the lowest average monthly returns (0.0085). Furthermore, P2 (R6) has the highest standard deviation (0.0505), and P4 (R6) has the lowest standard deviation (0.0444) of all observed portfolios.

Based on the descriptive statistics, the best performing portfolios of the Wang et al. – and R12-methods are P2 with average returns of 0.0115 (Wang et al.) and 0.0013 (R12). Accordingly, the standard deviations are 0.0470 (Wang et al.) and 0.0471 (R12). Vice versa, the worst performing portfolios are P4 with average returns of 0.0085 (Wang et al.) and 0.0087 (R12), and standard deviations of 0.0474 (Wang et al.) and 0.0479 (R12). With both Wang et al. – and R12-methods the lowest PEG-ratio portfolio P1 underperformed in comparison to the second lowest portfolio P2, which indicates that the previous benchmarking value of 1 for the PEG-ratio might not be valid in this occasion. However, the highest PEG-ratio portfolio P4 is the worst performing portfolio of both of the groups, which indicates that with these two methods the higher the PEG-ratio, the lower the portfolios' returns seems to be.

The two best performing portfolios of the R9- and R6-methods surprisingly are P3 and P4, with the average monthly returns being as follows: P3 (R9) 0.0113, P4 (R9) 0.0121, P3 (R6) 0.0188, and P4 (R6) 0.0118. The lowest standard deviations of the concerning portfolios are with portfolios P4 (R9) 0.0447, and P4 (R6) 0.0444. The results surprisingly indicate that in contradiction to the Wang et al. – and R12-methods, the higher the PEG-ratio of the portfolios defined with R9- and R6-methods, the better the overall performance and the lower the volatility of the portfolios' returns are. Thus, it can be concluded that the previous benchmark and value definition of the PEG-ratio is not valid with the R9- and R6-methods, and more related research would be beneficial. Also, it is noteworthy that the P4 (R9) and P4 (R6) were the two best performing portfolios, also with the least amount of volatility or risk, of the whole observation group.

Table 2. PEG portfolios' descriptive statistics

Note: Table includes PEG-ratio specific portfolios (P1=low PEG, P4=high PEG). Return data consists of 156 monthly observations during 31.1.2010 – 31.12.2022. Values presented = monthly returns – risk-free rate. N=number of monthly observations.

Statistic		***N***	**Min**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max**	**St. dev.**
Market portfolio		*156*	-0.1211	-0.0123	0.01233	0.0091	0.0408	0.1226	0.0455
Wang et al.	P1	*156*	-0.1905	-0.0123	0.0165	0.0099	0.0404	0.1329	0.0468
	P2	*156*	-0.1745	-0.0126	0.0133	0.0115	0.0394	0.1210	0.0470
	P3	*156*	-0.1494	-0.0164	0.0105	0.0102	0.0418	0.1584	0.0482
	P4	*156*	-0.1885	-0.0182	0.0133	0.0085	0.0416	0.1469	0.0474
	Total	*624*	-0.1758	-0.0142	0.0149	0.0100	0.0386	0.1245	0.0459
R12	P1	*156*	-0.1955	-0.0146	0.0148	0.0101	0.0378	0.1392	0.0482
	P2	*156*	-0.1731	-0.0108	0.0121	0.0113	0.0450	0.1329	0.0471
	P3	*156*	-0.1713	-0.0102	0.0153	0.0111	0.0384	0.1219	0.0463
	P4	*156*	-0.1432	-0.0167	0.0111	0.0087	0.0431	0.1246	0.0479
	Total	*624*	-0.1709	-0.0128	0.0139	0.0103	0.0410	0.1203	0.0462
R9	P1	*156*	-0.1988	-0.0136	0.0176	0.0113	0.0401	0.1225	0.0484
	P2	*156*	-0.1792	-0.0163	0.0150	0.0107	0.0412	0.1341	0.0493
	P3	*156*	-0.1767	-0.0092	0.0142	0.0113	0.0398	0.1331	0.0475
	P4	*156*	-0.1545	-0.0139	0.0170	0.0121	0.0435	0.1293	0.0447
	Total	*624*	-0.1774	-0.0085	0.0172	0.0113	0.0414	0.1217	0.0461
R6	P1	*156*	-0.2019	-0.0151	0.0158	0.0110	0.0402	0.1255	0.0478
	P2	*156*	-0.1782	-0.0165	0.0154	0.0106	0.0417	0.1322	0.0505
	P3	*156*	-0.1171	-0.0096	0.0145	0.0118	0.0412	0.1335	0.0466
	P4	*156*	-0.1545	-0.0139	0.0165	0.0118	0.0414	0.1293	0.0444
	Total	*624*	-0.1780	-0.0109	0.0171	0.0113	0.0408	0.1221	0.0460

Table 3 presents the industry specific portfolios' descriptive statistics. The return data for all portfolios consist of a total of 156 monthly observations. The average monthly returns varies between 0.0071–0.0131, with the lowest value for IP2 (R12) and the highest for IP4 (R6). The portfolio specific standard deviations are in between 0.0444–0.0535, with the lowest value for IP3 (Wang et al.) and the highest for IP4 (R6). In total, all IP2 portfolios seem to have significantly underperformed, with the average monthly returns being only valued in between 0.0068–0.0074, and thus being the worst performers in each industry groups. As mentioned previously, this may indicate that the utilization of PEG-ratio based methods might not work well with consumer discretionary - and consumer staples -industries. However, this issue would need more related research and testing to make more reliable conclusions.

The descriptive statistics argue that the best performing portfolios of the Wang et al. – and R12-methods are IP4 (Wang et al.) 0.0116 and IP1 (R12) 0.0116. The concerning standard deviations are IP4 (Wang et al.) 0.0492 and IP1 (R12) 0.0522. The obtained results seem to be relatively similar between the two different methods, except for the average performance of IP4 (Wang et al.) 0.0116 and IP4 (R12) 0.0098. Also, the volatilities differ between the two groups, as for IP1-IP2 the standard deviations are a bit higher with the Wang et al. -method, and for IP3-IP4 they are higher with the R12-method.

The best performing portfolios of the R9- and R6-methods are IP1 and IP4, with the average monthly performance being as follows: IP1 (R9) 0.0126, IP4 (R9) 0.0130, IP1 (R6) 0.0126, and IP4 (R6) 0.0131. The standard deviations for the portfolios mentioned above are on the upper portion of all concerning portfolios, and varies in between 0.0521–0.0535. It appears that similar to the PEG specific regression results, the R9- and R6-method portfolios performed overall stronger than the Wang et al. – and R12-method portfolios. It is arguable whether the method specific sample selection with the set criteria simply works better with the R9- and R6 methods than with the Wang et al – and R12 methods, or could the R9- and R6-methods work as a possible screening tool for investors trying to achieve abnormal returns on the Nordic stock market. The findings are relatively interesting and could be in high value, but further research is highly necessary.

Table 3. Industry portfolios' descriptive statistics

Note: Table includes industry specific portfolios. Return data consists of 156 monthly observations during 31.1.2010 – 31.12.2022. Values presented = monthly returns – risk-free rate. N=number of monthly observations.

Statistic		***N***	**Min**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max**	**St. dev.**
Wang et al.	IP1	*156*	-0.1848	-0.0166	0.0167	0.0113	0.0439	0.1234	0.0527
	IP2	*156*	-0.1916	-0.0190	0.0098	0.0071	0.0378	0.1563	0.0489
	IP3	*156*	-0.1770	-0.0089	0.0140	0.0104	0.0373	0.1277	0.0444
	IP4	*156*	-0.1301	-0.0233	0.0124	0.0116	0.0449	0.1473	0.0492
	IP5	*156*	-0.1544	-0.0123	0.0121	0.0101	0.0348	0.1571	0.0454
	Total	*780*	-0.1758	-0.0142	0.0149	0.0100	0.0386	0.1245	0.0459
R12	IP1	*156*	-0.1758	-0.0149	0.0156	0.0116	0.0458	0.1223	0.0522
	IP2	*156*	-0.1802	-0.0161	0.0091	0.0068	0.0351	0.1494	0.0471
	IP3	*156*	-0.1724	-0.0081	0.0139	0.0111	0.0380	0.1218	0.0447
	IP4	*156*	-0.1462	-0.0207	0.0071	0.0098	0.0420	0.1742	0.0512
	IP5	*156*	-0.1570	-0.0148	0.0127	0.0107	0.0390	0.1498	0.0478
	Total	*780*	-0.1709	-0.0128	0.0139	0.0103	0.0410	0.1203	0.0462
R9	IP1	*156*	-0.1831	-0.0138	0.0156	0.0126	0.0471	0.1284	0.0522
	IP2	*156*	-0.1800	-0.0167	0.0099	0.0074	0.0366	0.1464	0.0465
	IP3	*156*	-0.1717	-0.0084	0.0182	0.0116	0.0368	0.1197	0.0451
	IP4	*156*	-0.1618	-0.0166	0.0151	0.0130	0.0435	0.1848	0.0534
	IP5	*156*	-0.1820	-0.0135	0.0139	0.0125	0.0394	0.1548	0.0490
	Total	*780*	-0.1774	-0.0085	0.0172	0.0113	0.0414	0.1217	0.0461
R6	IP1	*156*	-0.1831	-0.0136	0.0158	0.0126	0.0464	0.1284	0.0521
	IP2	*156*	-0.1800	-0.0165	0.0095	0.0073	0.0361	0.1464	0.0461
	IP3	*156*	-0.1717	-0.0079	0.0182	0.0118	0.0368	0.1197	0.0450
	IP4	*156*	-0.1677	-0.0166	0.0151	0.0131	0.0440	0.1856	0.0535
	IP5	*156*	-0.1820	-0.0129	0.0134	0.0118	0.0392	0.1548	0.0488
	Total	*780*	-0.1780	-0.0109	0.0171	0.0113	0.0408	0.1221	0.0460

Table 4 shows the monthly descriptive statistics of the Fama-French three-factors and the risk-free rate. As seen, the SMB-factor has yielded positive average returns on the observed time period. Vice versa, the HML-factor has yielded negative average returns on the same time period. The MKT factor has the highest standard deviation (0.0455) and the highest average returns (0.0091) of the group. However, in comparison to the PEG and industry specific portfolios, the MKT factor's returns underperforms most of the other portfolios' returns. The risk-free rate has yielded relatively small monthly returns (0.0010), also the standard deviation being the lowest of the Fama-French three factor group (0.0063), as expected. Also, the variance inflation factor (VIF) values are presented in the table. The values are relatively small, with the values varying in between 1.0428 – 1.4549, which indicates that with the utilized variables, there is no problematic multicollinearity observable.

Table 4. Carhart four-factors' descriptive statistics

Note: Data consists of 156 monthly observations during 31.1.2010 – 31.12.2022. The risk-free rate presented is Euribor 3M.

Statistic	***N***	**Min**	**1st Qu.**	**Median**	**Mean**	**3rd Qu.**	**Max**	**St. dev.**	**VIF**
MKT	*156*	-0.1211	-0.0124	0.0133	0.0091	0.0408	0.1226	0.0455	1.0903
SMB	*156*	0.0462	-0.0109	0.0011	0.0012	0.0123	0.0503	0.0174	1.0428
HML	*156*	-0.1130	-0.0200	-0.0042	-0.0016	0.0148	0.1209	0.0291	1.3972
MOM	*156*	-0.1839	-0.0073	0.0085	0.0087	0.0258	0.0894	0.0325	1.4549
Rf	*156*	-0.0057	-0.0033	-0.0015	0.0010	0.0030	0.0213	0.0063	

Table 5 presents the correlation matrix of Carhart four-factors, aiming to evaluate whether the concerning variables could be effectively utilized together in the regressions later on. The MKT factor is positively correlated with both the SMB and the HML factor. However, the SMB and the HML factors are negatively correlated with each other, which indicates that the smaller the company, such as most of the growth companies, the lower the value premium is, which is in line research by Basu (1977) and Bauman and Miller (1997). The MOM factor is positively correlated only with the SMB factor, and with the MKT and the HML factors, it is negatively correlated. It is noteworthy, that by excluding the MOM factor, the correlations are relatively low with the Fama-French three-factors, with the absolute values varying between -0.1493 – 0.1295. This is ideal for the analysis, as the factors can be considered more effective when utilized together in the regressions later on.

Table 5. Carhart four-factors' correlation matrix
Note: Data consists of observations during 31.1.2010 – 31.12.2022.

Carhart four-factors	MKT	SMB	HML	MOM
MKT	1.0000			
SMB	0.1295	1.0000		
HML	0.0438	-0.1493	1.0000	
MOM	-0.2384	0.0585	-0.5157	1.0000

3.3 Preliminary tests and methods

Before the final regressions, the data are being tested with the Breusch-Pagan test and the Durbin-Watson test, and adjusted accordingly to improve the significance and the reliability of the regression results. Also, the Jarque-Bera normality test is performed, and the skewness and kurtosis characteristics are being presented to interpret the possible differences between the individual PEG and industry specific portfolios.

3.3.1 Preliminary test statistics

Linear regression models, such as the Fama-French three-factor model utilized in this case, assume that there is no observable heteroscedasticity among the analysed observations. This is due to the fact that the possible heteroscedasticity in the data are detrimental for the significance of the acquired regression results. (Greene 2003.) If the heteroscedasticity prevails in the analysed data, the standard errors of the regressions cannot be considered reliable anymore. In this kind of situation, the initial standard errors need to be replaced with robust standard errors, such as White's heteroskedasticity-consistent (HC) standard errors, to enhance the reliability and the significance of the acquired results. Therefore, the possible prevailing heteroscedasticity is being tested with the Breusch-Pagan test, which indicates whether the observations are homoscedastic or problematically heteroscedastic. (Breusch – Pagan 1979; Greene 2003; Wooldridge 2020, 270–271.)

The second test conducted is the Durbin-Watson test, which tests for the possible serial correlation in the regression residuals. The serial correlation, or autocorrelation, occurs when the concerning regression residuals are correlated across time. This can cause the standard errors to be underestimated, and hence the significance of the results can be inaccurate. (Wooldridge 2020, 342–343.) The Durbin-Watson test is conducted as follows:

$$DW = \frac{\sum_{t=2}^{n}(\hat{u}_t - \hat{u}_{t-1})^2}{\sum_{t=1}^{n}\hat{u}_t^2} \tag{7.1}$$

where DW = Durbin-Watson test statistic, and $\hat{u}_t$ = the residuals of an OLS regression (Wooldridge 2020, 403–404).

The Durbin-Watson test statistic value varies between 0–4. Value of 2 indicates that there is no autocorrelation observable, values < 2 indicates positive autocorrelation, and values > 2 indicates negative autocorrelation. However, test statistic values are considered relatively normal when varying between the values of 1.5–2.5. In such situations, in which both the Breusch-Pagan test statistic value and the Durbin-Watson test statistic values are statistically significant, implying that the observations are heteroscedastic and autocorrelated at the same time, the Newey-West heteroscedasticity and autocorrelation corrected (HAC) standard errors could be utilized instead of the White's heteroskedasticity-consistent standard errors (Newey – West 1987; Greene 2003).

The Jarque-Bera normality test is performed to observe the normality of the observations, and to illustrate the portfolio specific skewness and kurtosis characteristics. The normality of the data are commonly assumed in most statistical tests and in financial research, and thus impacts the interpretation and reliability of the results. The Jarque-Bera test result value of 0 indicates that the data are normally distributed. Also, a normally distributed data has a skewness of 0 and a kurtosis of 3. The Jarque-Bera test's equation is formulated as follows:

$$JB = n[\frac{(\sqrt{\hat{b}_1})^2}{6} + \frac{(\hat{b}_2 - 3)^2}{24}] \tag{7.2}$$

where JB = Jarque-Bera test statistic, n = the sample size, $\sqrt{\hat{b}_1}$ = the skewness coefficient, and $\hat{b}_2$ = the kurtosis coefficient (Jarque – Bera 1987).

As mentioned, the normal distribution is assumed in plenty of financial theories and related research, but in reality, the return data are in most cases skewed. Positively skewed data, or right-tailed data, indicates that most of the observations are lower than the mean, and the largest values and possible distortions are on the right-hand side of the distribution. Thus, in financial return context, the smaller negative returns, or losses, are more frequent than the higher positive returns, or gains. Vice versa, negatively skewed data, or left-tailed data, indicates that most of the observations are higher than the mean, which may mean in financial return context that smaller positive returns, or gains, are more frequent than the higher negative returns, or losses. Hence, negatively skewed data are more commonly preferred by risk-averse investors due to its characteristics of producing more stable profits, instead of the positively skewed data, which relies more on the few possible higher gains covering the more frequent small losses.

Both the PEG specific and industry specific portfolios' preliminary test statistics are presented in Table 6. The PEG specific portfolios' Breusch-Pagan test statistics indicate that in 10 out of 16 portfolios there is statistically significant heteroscedasticity observable. Also, in 5 out of 16 portfolios there is statistically significant autocorrelation detectable. Based on the Jarque-Bera test values, the null hypothesis of normally distributed data are rejected for all portfolios. More specifically, all the PEG specific portfolios are negatively skewed, with the values varying in between -0.953 – -0.333, which indicates that the portfolios are producing more stable profits as discussed previously. Also, all the kurtosis values are over 3, which argues that the distributions are heavy tailed in relation to the normal distributions, meaning that the portfolios have more data outliers observable.

The industry specific portfolios' Breusch-Pagan test statistics indicate that 11 out of 20 portfolios has statistically significant heteroscedastic characteristics, and 8 of those observations were of R9- and R6-method portfolios. The Durbin-Watson test statistic values indicate that with three portfolios there is statistically significant autocorrelation observable. It is noteworthy, that the Jarque-Bera test statistic values are not statistically significant with IP4 (Wang et al.) and IP4 (R12) portfolios, arguing that with these two portfolios the data are somewhat normally distributed, which is contrary to all other concerning portfolios. Of all industry specific portfolios, 17 out of 20 are negatively skewed, again arguing that most of the portfolios produce more frequent low profits and just relatively few larger losses, and thus being more stable as discussed previously. In contradiction, portfolios IP5 (Wang et al.), IP4 (R12) and IP4 (R9) are positively skewed, which indicates that with these portfolios the smaller losses are more frequent than the higher profits. With both IP4 (R12) and IP4 (R9) portfolios being constructed from companies with main operating industries of technology and telecommunication, it can be discussed and researched further, whether these results indicate some industry specific characteristics, or are the results only incidental. As with the PEG specific portfolios, all the kurtosis values are over 3, suggesting that the portfolios have more data outliers observable in comparison to the normal distribution.

To conclude, the Breusch-Pagan test statistic results indicate that heteroscedasticity is observable in the majority of the portfolios. Thus, it is reasonable to utilize the robust standard errors, or White's heteroskedasticity-consistent standard errors, instead of the conventional standard errors in the upcoming regressions. By this procedure it is aimed to increase the significance and the reliability of the standard errors, and the overall regression results as well. In addition, there is observable autocorrelation with 8 of the portfolios according to the Durbin-Watson test results. Thus, it is necessary to also consider using the Newey-West heteroscedasticity and autocorrelation corrected standard errors with the concerning portfolios, again to diminish the problematic characteristics of autocorrelation, and to increase the significance and reliability of the results.

Table 6. Preliminary test statistics

*Note: p-values are presented in the parenthesis, *** p < 0.01, ** p < 0.05, * p < 0.1*

		PEG portfolios (P1-P4)					Industry portfolios (IP1-IP5)				
Statistics		**Breusch-Pagan**	**Durbin-Watson**	**Jarque-Bera**	**Skewness**	**Kurtosis**	**Breusch-Pagan**	**Durbin-Watson**	**Jarque-Bera**	**Skewness**	**Kurtosis**
Wang et al.	(I)P1	12.158*** (0.007)	1.691* (0.060)	48.068*** (0.000>)	-0.867	5.096	2.486 (0.478)	1.790 (0.178)	11.532*** (0.003)	-0.547	3.759
	(I)P2	1.664 (0.645)	1.856 (0.354)	18.272*** (0.000>)	-0.574	4.221	6.164 (0.104)	1.866 (0.376)	24.199*** (0.000>)	-0.457	4.699
	(I)P3	2.790 (0.425)	2.248 (0.136)	6.845** (0.033)	-0.331	3.783	9.772** (0.021)	1.861 (0.348)	51.423*** (0.000>)	-0.845	5.248
	(I)P4	8.289** (0.040)	2.008 (0.966)	29.265*** (0.000>)	-0.673	4.641	1.461 (0.691)	2.223 (0.160)	0.691 (0.708)	-0.159	3.074
	IP5	-	-	-	-	-	3.452 (0.327)	2.259* (0.096)	18.118*** (0.000>)	0.050	4.667
R12	(I)P1	6.640* (0.084)	1.721* (0.068)	52.747*** (0.000>)	-0.800	5.347	5.326 (0.149)	1.814 (0.232)	11.460*** (0.003)	-0.559	3.716
	(I)P2	3.719 (0.293)	1.819 (0.270)	16.279*** (0.000>)	-0.527	4.180	10.112** (0.017)	1.916 (0.566)	24.680*** (0.000>)	-0.454	4.724
	(I)P3	6.331* (0.097)	2.067 (0.700)	12.715*** (0.002)	-0.477	4.023	10.543** (0.014)	1.777 (0.182)	36.419*** (0.000>)	-0.762	4.811
	(I)P4	1.431 (0.698)	1.998 (0.946)	12.018*** (0.002)	-0.608	3.607	1.856 (0.602)	2.100 (0.584)	3.884 (0.143)	0.057	3.764
	IP5	-	-	-	-	-	6.096 (0.107)	2.072 (0.72)	8.472** (0.014)	-0.180	4.083
R9	(I)P1	9.135** (0.028)	1.746 (0.102)	62.886*** (0.000>)	-0.953	5.458	6.369* (0.095)	1.776 (0.162)	14.310*** (0.000>)	-0.591	3.897
	(I)P2	7.066* (0.070)	1.963 (0.748)	11.330*** (0.003)	-0.465	3.938	7.071* (0.070)	1.674** (0.034)	26.590*** (0.000>)	-0.564	4.678
	(I)P3	3.149 (0.369)	1.945 (0.732)	26.940*** (0.000>)	-0.673	4.528	10.305** (0.016)	1.930 (0.662)	37.612*** (0.000>)	-0.781	4.830
	(I)P4	7.313* (0.063)	1.719* (0.080)	16.405*** (0.000>)	-0.629	3.970	6.838* (0.077)	1.914 (0.570)	7.123** (0.028)	0.059	4.040
	IP5	-	-	-	-	-	3.543 (0.315)	2.149 (0.338)	17.082*** (0.000>)	-0.282	4.520
R6	(I)P1	10.036** (0.018)	1.713* (0.076)	54.802*** (0.000>)	-0.873	5.319	6.223 (0.101)	1.753 (0.118)	12.869*** (0.002)	-0.566	3.835
	(I)P2	8.659** (0.034)	1.963 (0.806)	11.618*** (0.003)	-0.501	3.884	9.274** (0.026)	1.707* (0.068)	23.280*** (0.000>)	-0.505	4.601
	(I)P3	4.788 (0.188)	1.967 (0.860)	19.281*** (0.000>)	-0.568	4.295	10.859** (0.013)	1.930 (0.688)	36.786*** (0.000>)	-0.761	4.828
	(I)P4	6.757* (0.080)	1.702** (0.044)	19.065*** (0.000>)	-0.653	4.107	8.362** (0.039)	1.896 (0.496)	5.597* (0.061)	-0.035	3.925
	IP5	-	-	-	-	-	6.283* (0.099)	2.127 (0.374)	15.780*** (0.000>)	-0.292	4.445

3.3.2 Regression model and variable definition

The further analyses are being conducted by utilizing the Fama-French three-factor regression model. The Fama-French factors needed are downloaded from the Data Library of French (2023), except for the market portfolio returns and the risk-free rate, being three-month Euribor rate, which both are acquired from the Datastream service by Thomson Reuters. The concerning model developed by Eugene F. Fama and Kenneth R. French (1993) is an extension of the traditional asset pricing model in financial research, the CAPM by Sharpe (1964). The CAPM includes only one factor, the market risk or beta, in the regression model to explain the return performance of the asset. On contrary, the Fama-French three-factor model includes two additional factors in the regression model, the size, and the value risk. The aim is to adjust the model to the propensity of assets with certain size and value characteristics, or anomalistic characteristics, outperforming the market, which is also in line with the previous anomaly-based research (Basu 1977, 1983; Banz 1981; Fama – French 1992, 1993, 1998).

Due to the more comprehensive approach of the Fama-French three-factor model in comparison to the CAPM, it is regularly used in related anomaly-based financial research (Fama – French 1993; 1998). Therefore, is is also justified to use the Fama-French three-factor regression model in this research. Furthermore, the momentum factor of the Carhart four-factor-model is used to research the robustness of the acquired results, as the Fama-French three-factor model is not able to explain the systematic differences in average returns' momentum characteristics (Schwert 2003, 951).

The size risk factor SMB (small minus big) describes the size effect, which is based on the anomalistic characteristics of smaller companies, being grouped by market equity, outperforming the larger companies in the long run. Furthermore, the value risk factor HML (high minus low) describes the value effect, being based on the anomalistic characteristics of higher book-to-market (B/M) ratio companies, or value companies, outperforming the lower book-to-market ratio companies in the long run. (Fama-French 1993.)

The SMB and HML factors are accordingly constructed of six different size and book-to-market benchmark portfolios. The benchmark value for the grouping between small and big companies is the median market equity value of NYSE. Furthermore, the value-based grouping is conducted with the book-to-market value characteristics of NYSE, with the lowest 30 % of B/M values being the growth companies, the values between 30 – 70 % of B/M values being the neutral companies, and the highest 70 % of B/M values being the value companies. The benchmark portfolios are being quarterly rebalanced, and the portfolios do not acknowledge any transaction costs or include hold ranges. (French 2023.) The MOM factor is constructed of six value-weighted portfolios, based on the size and the 2-12 -month prior return performance. The breakpoints of the different portfolios are formed similarly to the SMB and HML portfolios, with the prior monthly return performance replacing the book-to-market as a measure. (French 2023.) Accordingly, the SMB factor value is being calculated of three different small portfolios' average returns minus three different big portfolios' average returns. Thus, the equation for the SMB factor is as follows:

$$SMB = \frac{1}{3}(SV_r + SN_r + SG_r) - \frac{1}{3}(BV_r + BN_r + BG_r) \tag{8.1}$$

where SMB = the small minus big factor, SV_r = small value, SN_r = small neutral, SG_r = small growth, BV_r = big value, BN_r = big neutral, and BG_r = big growth portfolio's returns (French 2023).

The HML factor value is being calculated of two different value portfolios' average returns minus two different growth portfolios' average returns. The HML factor's equation is as follows:

$$HML = \frac{1}{2}(SV_r + BV_r) - \frac{1}{2}(SG_r + BG_r) \tag{8.2}$$

where HML = the high minus low factor, SV_r = small value, BV_r = big value, SG_r = small growth, and BG_r = big growth portfolio's returns (French 2023).

The MOM factor value is being calculated of two high prior return portfolios' average returns minus the two low prior return portfolios' average returns. Thus, the MOM factor is defined as follows:

$$MOM = \frac{1}{2}(SH_r + BH_r) - \frac{1}{2}(SL_r + BL_r) \tag{8.3}$$

where MOM = the momentum factor, SH_r = small high prior, BH_r = big high prior, SL_r = small low prior, and BL_r = big low prior return portfolio's average returns (French 2023).

4 EMPIRICAL RESULTS

4.1 Performance evaluation

4.1.1 PEG portfolio regressions

The Fama-French three-factor regression results of the PEG specific portfolios are presented in Table 7. The results are presented for each of the utilized PEG-ratio calculation methods. The F-statistics for all portfolios are statistically significant at 0.01 % level, and thus it can be concluded that the utilized regression model fits the data well. Also, the adjusted R-squared statistic values are in between 0.8231 – 0.8886 for all PEG specific regressions, with the lowest value for P1 (Wang et al.) and the highest for P4 (R12). Thus, it can be interpreted that the utilized regression model explains the variance of all the included observations relatively well.

The Wang et al. -method results indicate that P2 is the only portfolio achieving statistically significant intercept (p=0.0486) at 5 % significance level. As the intercept coefficient is also positive (0.0028), it can be concluded that the medium PEG portfolio P2 gained positive excess returns on the market, which is in line with Sun (2001) and Fafatas and Shane (2011). Also, the intercept for both P1 and P3 are positive, but statistically insignificant. The P4 is the only portfolio that had negative intercept coefficient, but the result is highly insignificant. The MKT factor is statistically significant for all portfolios at 0.01 % level, and the coefficient value is in between 0.8953 – 0.9533, with the lowest value for P1 and the highest for P3. However, as the values are less than 1 for all portfolios, it can be concluded that all the portfolios' returns are less volatile, and hence less risky, than the average market portfolio's returns.

The SMB factor coefficient is positive and highly significant for all the portfolios, with P1 (0.3488, p=0.0012) being the lowest and P4 (0.6044, p<0.000) being the highest observation. Also, all the HML factor coefficients are positive and statistically significant at 5 % level, with P1 (0.2202, p=0.0021) being the highest and P3 (0.1240, p=0.0105) being the lowest observation. In this occasion, the obtained results indicate that the SMB factor coefficient value grows towards the higher PEG-ratio portfolios, and thus it can be concluded that the higher the PEG-ratio, the more it seems to be weighted towards small-cap companies. On the contrary, the HML factor coefficient values seem to lower towards the higher PEG-ratio portfolios, which indicates that the lower the PEG-ratio of the portfolio, the higher the value premium is, which is in line with results by Fama and French (1995).

The R12-method results illustrates that P1, P2 and P3 are the only portfolios obtaining positive intercept coefficients, but only P2 (0.0026, p=0.0590) and P3 (0.0026 p=0.0643) achieved statistically significant results at 10 % level. Again, for P4 the intercept is negative and statistically insignificant. Furthermore, the MKT coefficient values are in between 0.9096 – 0.9502. All the coefficients are significant at 0.01 % level. As the values are below 1 for all portfolios, the returns are on average less volatile than the market portfolio's returns.

The SMB coefficients are positive and significant at 0.01 % significance level for all the portfolios, with P3 (0.3879, p<0.000) being the lowest and P2 (0.5463, p<0.000) being the highest valued observation. Hence, the same phenomenon of SMB coefficient value growing towards higher PEG-ratio portfolios as in Wang et al. -method, is not observable in this occasion. Also, the variation between the different portfolios' SMB coefficient values is smaller in comparison to the Wang et al. -method results. The HML factor coefficients are positive for all portfolios, the values being in between 0.0409 – 0.2113. P1 and P2 values are statistically significant at 0.01 % level, P3 value at 10 % level, and P4 value being the only insignificant of the group. As with the Wang et al. -method, the HML coefficient value seems to lower towards the higher PEG-ratio portfolios.

The results of the R9-method demonstrates that all portfolios achieved positive intercept coefficients. However, P4 (0.0035, p=0.0057) is the only portfolio achieving statistically significant results at 1 % level, also having the highest excess returns of all corresponding regressions. Additionally, P1 (0.0027, p=0.0996) achieved significant results at only 10 % level. The MKT coefficient values are below value of 1, being in between values 0.8904 – 0.9439 with P4 being the lowest and P2 the highest. All results are significant at 0.01 % level. What is remarkable is that P4, the highest PEG-portfolio, achieved the highest statistically significant excess returns, and also has the second least volatile returns in comparison to all other analysed portfolios.

The SMB coefficients are all positive and statistically significant at 0.01 % level. The lowest SMB coefficient value is for P4 (0.4377, p<0.000) and the highest value is for P2 (0.6090, p<0.000). Thus, the phenomenon of SMB coefficient value growing towards higher PEG-ratio portfolios as observed with the Wang et al. -method, does not occur in this occasion. However, in comparison to the results of R12-method, the SMB coefficient value of P4 (R9) 0.4377 is relatively similar to the P1 (R12) value of 0.4312, although the PEG-ratios of the two portfolios differ drastically. The HML factor coefficients are positive for portfolios P1-P3, but negative for P4. All the values are in between -0.0074 – 0.2433, with P4 being the lowest and P1 the highest. P1 and P2 are the only portfolios with statistically significant results at 0.01 % level. Similar to the previous methods, the HML coefficient value seems to lower towards portfolios with higher PEG-ratios.

The R6-method results indicate that as in R9-method all portfolios achieved positive intercept coefficients. Nevertheless, P3 and P4 are the only portfolios achieving significant results at 1 % significance level. Additionally, P4 (0.0033, $p=0.0101$) has the second highest excess returns and P3 (0.0031, $p=0.0030$) has the third highest excess of all corresponding regressions. The MKT coefficient values are in between values 0.8812 – 0.9673 with again P4 being the lowest and P2 the highest. The results are significant at 0.01 % level. Once more P4, the highest PEG-portfolio, achieved the highest statistically significant excess returns, and additionally has the least volatile returns of the whole analysed sample.

The SMB coefficients values are positive and statistically significant at 0.01 % level, and complies with similar breakdown as with the results of R9-method. The lowest value of SMB coefficient is for P4 (0.4522, $p<0.000$) and the highest value is for P2 (0.6633, $p<0.000$). As seen, the phenomenon of SMB coefficient growing towards the higher PEG-ratio portfolios as illustrated in the results of Wang et al. -method, does not occur with any other methods. Nevertheless, the SMB coefficient value of P4 (R6) 0.4522 is reasonably close to the P1 (R12) value of 0.4312 and the P4 (R9) value of 0.4377. These results may indicate that the PEG-specific portfolio formation might perform the best with certain group of companies, that have similar SMB coefficient characteristics and reasonably high PEG-ratios. The HML factor coefficients are positive for all four portfolios. The coefficient values are in between 0.0073 – 0.2472, and similarly to previous results P4 has the lowest and P1 the highest coefficient value. P1 and P2 are the only portfolios with statistically significant results at 0.01 % level. Accordingly, the coefficient value of HML seems to lower towards portfolios with higher PEG-ratios.

Table 7. PEG portfolios' regression results

*Note: p-values are presented in the parenthesis, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.*

Statistic		Intercept	MKT	SMB	HML	Adjusted R^2	F-statistic
Wang et al.	P1	0.0017	0.8953***	0.3488**	0.2202***	0.8231	241.4***
		(0.3726)	(0.000>)	(0.0012)	(0.0021)		(0.000>)
	P2	0.0028**	0.9254***	0.3978***	0.1601**	0.8698	346.2***
		(0.0486)	(0.000>)	(0.000>)	(0.0108)		(0.000>)
	P3	0.0012	0.9533***	0.4417***	0.1240**	0.8775	371.2***
		(0.3602)	(0.000>)	(0.000>)	(0.0105)		(0.000>)
	P4	-0.0002	0.9072***	0.6044***	0.1568***	0.8651	332.5***
		(0.8905)	(0.000>)	(0.000>)	(0.0087)		(0.000>)
R12	P1	0.0014	0.9287***	0.4312***	0.2113***	0.8433	279.1***
		(0.4092)	(0.000>)	(0.000>)	(0.0021)		(0.000>)
	P2	0.0026*	0.9135***	0.5463***	0.1536***	0.8732	356.7***
		(0.0590)	(0.000>)	(0.000>)	(0.0039)		(0.000>)
	P3	0.0026*	0.9096***	0.3879***	0.1116*	0.8569	310.3***
		(0.0643)	(0.000>)	(0.000>)	(0.0503)		(0.000>)
	P4	-0.0005	0.9502***	0.4930***	0.0409	0.8886	413.1***
		(0.6921)	(0.000>)	(0.000>)	(0.2638)		(0.000>)
R9	P1	0.0027*	0.9154***	0.5020***	0.2433***	0.8347	261.9***
		(0.0996)	(0.000>)	(0.000>)	(0.000>)		(0.000>)
	P2	0.0018	0.9439***	0.6090***	0.1994***	0.8670	337.8***
		(0.2236)	(0.000>)	(0.000>)	(0.000>)		(0.000>)
	P3	0.0024	0.9153***	0.5248***	0.0715	0.8481	289.4***
		(0.1083)	(0.000>)	(0.000>)	(0.2344)		(0.000>)
	P4	0.0035***	0.8904***	0.4377***	-0.0074	0.8869	403.0***
		(0.0057)	(0.000>)	(0.000>)	(0.8639)		(0.000>)
R6	P1	0.0025	0.9091***	0.4679***	0.2472***	0.8381	268.4***
		(0.1561)	(0.000>)	(0.000>)	(0.0003)		(0.000>)
	P2	0.0013	0.9673***	0.6633***	0.1772***	0.8728	355.5***
		(0.3622)	(0.000>)	(0.000>)	(0.000>)		(0.000>)
	P3	0.0031**	0.9029***	0.4836***	0.0764	0.8518	298.0***
		(0.0030)	(0.000>)	(0.000>)	(0.2226)		(0.000>)
	P4	0.0033**	0.8812***	0.4522***	0.0073	0.8842	395.6***
		(0.0101)	(0.000>)	(0.000>)	(0.8693)		(0.000>)

4.1.2 Industry portfolio regressions

The Fama-French three-factor regression results of the industry specific portfolios are presented in Table 8. The results are presented for each of the utilized PEG-ratio calculation methods. The F-statistics for all portfolios are statistically significant at 0.01 % level, which illustrates that the utilized regression model fits the analysed data well. The adjusted R-squared statistic values are in between 0.6537 – 0.8926 for all PEG specific regressions, with the lowest value for IP5 (Wang et al.) and the highest for IP1 (R6). Except for the lowest adjusted R-squared value of IP5 (Wang et al.), all the other portfolios' adjusted R-squared values are over 0.7040 which indicates that the models explain over 70 % of the variance of all observations. Hence, it can be considered that the regression model reflects the observations relatively well.

The Wang et al. -method results argues that IP2 is the only portfolio with negative intercept coefficient value. All other portfolios achieved positive intercept coefficients. However, IP3 (0.0029, p=0.0914) is the only one with statistically significant results, but only at 10 % significance level. The MKT coefficient is statistically significant for all portfolios at 0.01 % level, and the coefficient value varies between values of 0.8020 – 1.0470, with the lowest being for IP5 and the highest for IP1. Also, IP1 is the only portfolio of the group that has the MKT coefficient value over 1, which indicates that the returns are more volatile, and hence more risky, compared to the average returns of the market portfolio.

The SMB coefficient value is positive for all portfolios, and the values vary between 0.1587 - 0.5594 with IP5 having the lowest and IP4 the highest value of the group. The results are statistically significant at 0.01 % level for portfolios IP1-IP4. For IP5 the coefficient is statistically insignificant. The HML factor is positive for all portfolios excluding IP5. However, the results are statistically significant for only portfolios IP1-IP3. The coefficient value for IP1 (0.1338, p=0.0101) is significant at 5 % level, and for IP2 (0.2472, p<0.000) and IP3 (0.2266, p<0.000) the corresponding coefficients are significant at 0.01 % level. The results illustrate that IP4 has the highest SMB factor coefficient value of the group, and IP2 has the highest HML coefficient value, which might be consequence of different industrial characteristics.

The results of the R12-method indicate that all portfolios excluding IP2 obtained positive intercept coefficients. However, IP3 (0.0034, p=0.0457) is the only portfolio that gained statistically significant excess returns at 5 % significance level. All the other portfolios' results are statistically insignificant. The MKT coefficient values are in between 0.8347 – 1.0330, with IP3 value being the lowest and IP1 value the highest. All the MKT factor coefficients are significant at 0.01 % level. Again, as the coefficient value of IP1 is above 1, it can be interpreted that the returns of IP1 are on average more volatile than the market portfolio's returns.

The SMB coefficient values for IP1-IP5 are all positive. The coefficient of IP3 (0.2943, p=0.0118) is also the lowest value of the group, and it is significant at 5 % level. All other portfolios are significant at 1 % level, and IP4 (0.7561, p<0.000) has the highest SMB coefficient value of the group, which is similar to the previous method's results. The HML factor coefficients are positive for portfolios IP1-IP4, and for IP5 the coefficient value is negative. The coefficient values varies between -0.0905 – 0.1918. For IP1 (0.1136, p=0.0341) and IP4 (0.1331, p=0.0393) the results are statistically significant at 5 % level, and for IP2 (0.1915, p=0.0005) and IP3 (0.1918, p=0.0037) the result are significant at 1 % significance level. IP5 (-0.0905, p=0.20004) is the only portfolio having statistically insignificant coefficient. As with the Wang et al. -method, IP2 and IP3 seems to have the highest HML coefficient values of all portfolios.

As in the previous results, also the R9-method results argue that that all portfolios excluding the portfolio IP2 obtained positive values for the intercept coefficients. Hence, as the coefficients of IP1 (0.0027, p=0.0482) and P3 (0.0034, p=0.0457) are statistically significant at 5 % level, it can be concluded that these two portfolios gained significant excess returns on the market. Also, portfolios IP4 (0.0038, p=0.0681) and IP5 (0.0040, p=0.0700) achieved statistically significant excess returns at 10 % significance level. IP2 is the only portfolio with statistically insignificant coefficient. The MKT coefficient values are in between 0.8152 – 1.0332, with IP3 being the lowest and IP1 the highest value of the group. All the MKT factor coefficients are significant at 0.01 % level. The coefficient of IP1 is over 1, which indicates that on average the returns of IP1 are more volatile than the returns of the market portfolio.

The SMB coefficient values for IP1-IP5 are all positive. The coefficient value of IP5 (0.3258, p=0.0233) is the lowest and statistically significant at 5 % level. Portfolios IP1-IP4 are all significant at 1 % level, with P4 (0.8285, p<0.000) being the highest valued observation of all concerning regressions, also being in line with the previous method's results. The HML coefficients values are positive for portfolios IP1-IP4, but again for IP5 the coefficient is negative. The values are in between -0.0299 – 0.2003. For IP1 (0.1275, p=0.0135) the coefficient is significant at 5 % level, and for IP2 (0.1649, p=0.0005) and IP3 (0.2003, p=0.0023) the coefficients are significant at 1 % level. Both IP4 and IP5 have statistically insignificant coefficient. Similar to previous regression results, IP2 and IP3 seems to have the highest HML coefficient values of the observed portfolios.

The regression results of the R6-method are relatively similar to the results of the R9-method. It is observable that IP2 (-0.0009, p=0.5952) is the only portfolio that has negative intercept coefficient, also being highly insignificant. IP1 (0.0027, p=0.0442) achieved significant excess returns at 1 % level, IP3 (0.0043, p=0.0173) at 5 % level, and IP4 (0.0038, p=0.0648) at 10 % significance level. However, IP5 (0.0044, p=0.1111) has statistically insignificant coefficient value. The MKT factor values varies between 0.8121 – 1.0329, again with IP3 being the lowest and IP1 the highest value of the group. All the MKT factor coefficients are significant at 0.01 % level. Similar to previous results, IP1 appears to consist of more risky companies in comparison to the market portfolio.

All portfolios' SMB values are positive and statistically significant at 5 % level. The coefficient of IP5 (0.3564, p=0.012) is the lowest value of the group, also being the least significant. Portfolios IP1-IP4 are statistically significant at 1 % level, and as the highest value is presented by IP4 (0.8180, p<0.000), the results are in line with the previous results. For the portfolios IP1-IP3 the HML coefficients are positive and statistically significant at 5 % level. The coefficient of IP4 (0.0550, p=0.3832) is also positive, but statistically insignificant. As for IP5 (-0.0268, p=0.7781) the coefficient is negative and highly insignificant. All the coefficient values are in between -0.0268 – 0.2048, the lowest being IP5 and the highest IP4. Consistent to the previous results, IP2 and IP3 seems to have the highest HML coefficient of the constructed portfolios.

Table 8. Industry portfolios' regression results

*Note: p-values are presented in the parenthesis, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Statistic		Intercept	MKT	SMB	HML	Adjusted R^2	F-statistic
Wang et al.	IP1	0.0014	1.0470***	0.5341***	0.1338**	0.8926	430.3***
		(0.3299)	(0.000>)	(0.000>)	(0.0101)		(0.000>)
	IP2	-0.0014	0.9089***	0.5100***	0.2472***	0.8096	220.7***
		(0.4060)	(0.000>)	(0.000>)	(0.000>)		(0.000>)
	IP3	0.0029*	0.8270***	0.3241***	0.2266***	0.7841	188.6***
		(0.0914)	(0.000>)	(0.0032)	(0.0007)		(0.000>)
	IP4	0.0032	0.8580***	0.5594***	0.0612	0.7048	124.3***
		(0.1406)	(0.000>)	(0.000>)	(0.4068)		(0.000>)
	IP5	0.0026	0.8020***	0.1587	-0.0241	0.6537	98.54***
		(0.2044)	(0.000>)	(0.3612)	(0.7811)		(0.000>)
R12	IP1	0.0017	1.0330***	0.5430***	0.1136**	0.8896	417.3***
		(0.2234)	(0.000>)	(0.000>)	(0.0341)		(0.000>)
	IP2	-0.0015	0.8811***	0.4701***	0.1915***	0.8056	215.1***
		(0.3527)	(0.000>)	(0.0002)	(0.0005)		(0.000>)
	IP3	0.0034**	0.8347***	0.2943**	0.1918***	0.7775	181.5***
		(0.0457)	(0.000>)	(0.0118)	(0.0037)		(0.000>)
	IP4	0.0010	0.8961***	0.7561***	0.1331**	0.7536	159.0***
		(0.6330)	(0.000>)	(0.000>)	(0.0393)		(0.000>)
	IP5	0.0022	0.8665***	0.3817***	-0.0905	0.7234	136.1***
		(0.2888)	(0.000>)	(0.0016)	(0.2004)		(0.000>)
R9	IP1	0.0027**	1.0332***	0.5516***	0.1275**	0.8925	430.0***
		(0.0482)	(0.000>)	(0.000>)	(0.0135)		(0.000>)
	IP2	-0.0008	0.8605***	0.5209***	0.1649***	0.7952	201.7***
		(0.6520)	(0.000>)	(0.000>)	(0.0005)		(0.000>)
	IP3	0.0041**	0.8152***	0.4078***	0.2003***	0.7487	154.9***
		(0.0249)	(0.000>)	(0.0011)	(0.0023)		(0.000>)
	IP4	0.0038*	0.9163***	0.8285***	0.0537	0.7323	142.4***
		(0.0681)	(0.000>)	(0.000>)	(0.3856)		(0.000>)
	IP5	0.0040*	0.8842***	0.3258**	-0.0299	0.7040	123.9***
		(0.0700)	(0.000>)	(0.0233)	(0.7641)		(0.000>)
R6	IP1	0.0027**	1.0329***	0.5490***	0.1232**	0.8937	435.2***
		(0.0442)	(0.000>)	(0.000>)	(0.0143)		(0.000>)
	IP2	-0.0009	0.8535***	0.5343***	0.1669***	0.8021	210.4***
		(0.5952)	(0.000>)	(0.000>)	(0.0004)		(0.000>)
	IP3	0.0043**	0.8121***	0.3982***	0.2048***	0.7474	153.9***
		(0.0173)	(0.000>)	(0.0014)	(0.0022)		(0.000>)
	IP4	0.0038*	0.9268***	0.8180***	0.0550	0.7410	148.8***
		(0.0648)	(0.000>)	(0.000>)	(0.3832)		(0.000>)
	IP5	0.0034	0.8816***	0.3564**	-0.0268	0.7126	129.1***
		(0.1111)	(0.000>)	(0.0122)	(0.7781)		(0.000>)

4.1.3 Combined regressions

The combination of the PEG and the industry-based portfolios are referred as the combined portfolios in this occasion, to evaluate whether the anomalistic low PEG investment performance occurs on certain industry groups or not. Thus, the Fama-French three-factor regression alpha statistics of the combined portfolios are presented in Table 9. Furthermore, the combined portfolios' average PEG-ratios are observable in Appendix 3.

The results of the Wang et al. method indicate that only 5 out of 20 portfolios achieved statistically significant intercept values at 10 % significance level, with the industry group IP1 being the sole one to not achieve statistical significance on any of the PEG portfolios constructed. The lowest PEG portfolio P1 of the industry group IP2 achieved the lowest average monthly returns (-0.0049, p=0.0861) of all constructed portfolios, with the result also being statistically significant. However, with the industry group IP3 the lowest PEG portfolio P1 (0.0038, p=0.0999), with the industry group IP4 the second lowest PEG portfolio P2 (0.0060, p=0.0802), and with the industry group IP5 the two lowest PEG portfolios P1 (0.0062, p=0.0572) and P2 (0.0073, p=0.0862) achieved statistically significant excess returns on the market. The results argue that the low PEG investment strategy is not beneficial for the investors on the consumer staples and discretionary industries. Vice versa with the financials and real estate, as well as with the health care and utilities industries, the low PEG securities seems overperform in relation to the high PEG securities. However, it is noteworthy, that the P2 portfolios of the industry groups IP4 and IP5 gained the highest returns of their industry groups. This indicates that in the concerning industries the lowest PEG portfolios are not the best performers, but in fact the portfolios with the medium PEG ratios, which is in line with empirical evidence by Sun (2001) and Fafatas and Shane (2011).

The R12-, R9-, and R6-methods' results are not exactly continuous with the Wang et al. -method's results. All the concerning methods' results indicate that the portfolio P3 of the industry group IP1 achieved statistically significant and positive returns at 5 % significance level, which indicates that the medium PEG securities outperformed all other portfolios in the industrial and basic material industries. Also, most of the industry group IP2 portfolios' average monthly returns were negative, but with only P1 (R12) being statistically significant at 10 % significance level. This is in line with the results of the

Wang et al. method, providing further evidence of the underperformance of the low PEG securities in the concerning industries. The lowest PEG portfolio P1 of the industry group IP3 gained statistically significant abnormal returns on the market with all concerning methods. Also, portfolios P2 (R12), P3 (R12), P3 (R9), P4 (R9), and P4 (R6) gained positive and significant excess returns, which indicates that the financials and real estate industries have performed overall well. This is also in line with the previous industry specific regression results of this research. However, the PEG characteristics or preferences of them are ambiguous as the results were not completely robust between the different methods, and the phenomena would require further research.

Remarkably, the industry group IP4 portfolios' alpha statistics were positive and statistically significant at 1 % level for only P4 (R9) and P4 (R6), which is in contradiction to the Wang et al. method's results. The P4 (R9) also achieved the highest average monthly returns (0.0102, p=0.0035), and P4 (R6) achieved the second highest average monthly returns (0.0098, p=0.0027) of all analysed portfolios, indicating that with the concerning methods the higher PEG securities of the telecommunications and technology industries overperforms all other securities. However, this may be due to the biases of individual companies' performance, as the total amount of observations with the industry groups P4 and P5 are relatively small in comparison to the other industry groups, and thus further analysis is necessary. With the industry group IP5 the portfolios P3 (R9) and P3 (R6) were the sole ones to achieve positive and statistically significant returns at 5 % significance level. Again, the results are robust between the R9- and R6-methods, but not with the Wang et al. method. Thus, it would be beneficial to research the possible differences of the growth rate estimation methods' characteristics, as the PEG-ratio based results are in most cases contrary, such as with the Wang et al. and R6-methods.

Table 9. Combined portfolios' alpha statistics

*Note: p-values are presented in the parenthesis, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Alpha statistics		**Industry portfolios (IP1-IP5)**				
		IP1	**IP2**	**IP3**	**IP4**	**IP5**
Wang et al.	P1	0.0007	-0.0049*	0.0038*	0.0028	0.0062*
		(0.7125)	(0.0861)	(0.0999)	(0.4090)	(0.0572)
	P2	0.0016	0.0012	0.0032	0.0060*	0.0073*
		(0.3990)	(0.6174)	(0.1767)	(0.0802)	(0.0862)
	P3	0.0015	-0.0007	0.0025	0.0021	0.0014
		(0.4278)	(0.7887)	(0.1899)	(0.6267)	(0.7150)
	P4	0.0015	-0.0013	0.0021	0.0019	-0.0046
		(0.4345)	(0.6267)	(0.3619)	(0.6886)	(0.1738)
R12	P1	-0.0005	-0.0045*	0.0046*	0.0025	0.0039
		(0.8227)	(0.0924)	(0.0630)	(0.4825)	(0.2575)
	P2	0.0022	-0.0001	0.0047*	-0.0013	0.0034
		(0.2268)	(0.9818)	(0.0517)	(0.6860)	(0.2296)
	P3	0.0058***	-0.0001	0.0037*	0.0027	0.0045
		(0.0028)	(0.9967)	(0.0839)	(0.4235)	(0.1878)
	P4	-0.0019	-0.0015	0.0019	0.0014	-0.0035
		(0.2802)	(0.5475)	(0.2857)	(0.7394)	(0.3441)
R9	P1	0.0021	-0.0003	0.0044*	0.0005	0.0047
		(0.3163)	(0.9417)	(0.0735)	(0.9103)	(0.2588)
	P2	0.0029	-0.0025	0.0023	-0.0001	0.0027
		(0.1437)	(0.2758)	(0.4117)	(0.9684)	(0.4627)
	P3	0.0044**	-0.0012	0.0047*	0.0058	0.0071**
		(0.0314)	(0.7074)	(0.0532)	(0.1461)	(0.0185)
	P4	0.0017	0.0009	0.0049**	0.0102***	0.0023
		(0.3398)	(0.7407)	(0.0321)	(0.0035)	(0.4769)
R6	P1	0.0017	-0.0014	0.0049**	-0.0006	0.0014
		(0.3525)	(0.6545)	(0.0453)	(0.8767)	(0.6890)
	P2	0.0022	-0.0028	0.0038	0.0009	0.0051
		(0.2281)	(0.2248)	(0.1594)	(0.7854)	(0.1750)
	P3	0.0051**	-0.0003	0.0032	0.0056	0.0057**
		(0.0123)	(0.9200)	(0.2163)	(0.1395)	(0.0459)
	P4	0.0019	0.0013	0.0056**	0.0098***	0.0011
		(0.2653)	(0.6010)	(0.0130	(0.0027)	(0.7146)

4.2 Robustness checks

The portfolios’ regression results are tested to conclude whether the results are still robust, and thus reliable, if the underlying parameters of the analyses are to change. Already, the different growth rate estimation methods for calculating the PEG-ratios provide some robustness evaluation for the acquired results. However, further evaluation is provided by adding a risk factor to the utilized asset-pricing method. As argued previously, the Fama-French three-factor model utilized in the prior analyses, is being supplemented with the momentum factor, as the Fama-French three-factor model does not explain the systematic differences of the returns' momentum characteristics (Schwert 2003, 951). Thus, the model utilized for the additional robustness checks is the Carhart four-factor model. The new acquired robustness results are being compared to the initial regression results to evaluate whether the results are consistent after changing the utilized parameters or not.

4.2.1 PEG portfolios

Table 10 describes the robustness results of the PEG portfolios. Adding the momentum factor to the asset-pricing model enhanced the adjusted R-squared values with most portfolios, which indicates that Carhart four-factor model explains the variance of the observations slightly better in comparison to the Fama-French three-factor model. Also, it is noteworthy, that the momentum factor is negative for all portfolios, with the value being statistically significant for 8 of the 16 portfolios considered. This indicates that the momentum effect does not occur with the concerning PEG portfolios, meaning that the past winner companies are in fact losers in the analysed time frame. In addition, the statistical significance of the HML factor seems to have diminished with almost all of the concerning portfolios after adding the MOM factor to the regression model.

The results indicate that the intercept values of the Wang et al. and the R12-methods can be considered robust and reliable, as the P2 (Wang et al.), P2 (R12), and P3 (R12) are still statistically significant with positive alphas, such as with the initial regression results. In fact, the significance of the concerning portfolios' results increased with the MOM factor included. Also, with the R9- and R6-methods the significance of the intercepts increased with the MOM factor included, leading to robust results of the P1 (R9), P4 (R9), P3 (R6), and P4 (R6), achieving positive and statistically significant alphas with both the initial regressions and the robustness checks. What is remarkable is that the robustness results indicate, that all four of the R9-method portfolios achieved positive and statistically significant excess returns on the market when including the MOM factor to the regression model. In addition, the R6-method portfolios achieved similar results for three portfolios, with the P2 (R6) being the sole one that is not statistically significant at 10% level. This indicates, that the R9- and R6-methods could in fact provide excess returns for the investors by functioning as a stock screening tool regardless of the level of the PEG-ratio. This phenomenon, however, would require further testing and research.

Table 10. PEG portfolios' robustness results

*Note: p-values are presented in the parenthesis, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Statistic		Intercept	MKT	SMB	HML	MOM	Adjusted R^2	F-statistic
Wang et al.	P1	0.0028	0.8765***	0.3513***	0.1522*	-0.1208**	0.8269	186.1***
		(0.1365)	(0.000>)	(0.000>)	(0.0606)	(0.0313)		(0.000>)
	P2	0.0034**	0.9150***	0.3992***	0.1226*	-0.0667	0.8704	261.3***
		(0.0336)	(0.000>)	(0.000>)	(0.0721)	(0.2868)		(0.000>)
	P3	0.0022	0.9363***	0.4440***	0.0627	-0.1089**	0.8805	286.5***
		(0.1182)	(0.000>)	(0.000>)	(0.2521)	(0.0484)		(0.000>)
	P4	0.0003	0.8993***	0.6055***	0.1282*	-0.0508	0.8651	249.6***
		(0.8572)	(0.000>)	(0.000>)	(0.0678)	(0.3913)		(0.000>)
R12	P1	0.0026	0.9093***	0.4339***	0.1410*	-0.1249**	0.8473	216.0***
		(0.1328)	(0.000>)	(0.000>)	(0.0615)	(0.0288)		(0.000>)
	P2	0.0030**	0.9061***	0.5473***	0.1269**	-0.0476	0.8731	267.6***
		(0.0453)	(0.000>)	(0.000>)	(0.0475)	(0.3924)		(0.000>)
	P3	0.0029*	0.9043***	0.3886***	0.0921	-0.0346	0.8563	232.0***
		(0.0642)	(0.000>)	(0.000>)	(0.1775)	(0.5206)		(0.000>)
	P4	0.0007	0.9295***	0.4959***	-0.0338	-0.1329**	0.8936	326.4**
		(0.6095)	(0.000>)	(0.000>)	(0.4729)	(0.0100)		(0.000>)
R9	P1	0.0035**	0.9022***	0.5038***	0.1955***	-0.0849	0.8359	198.4***
		(0.0402)	(0.000>)	(0.000>)	(0.0026)	(0.1482)		(0.000>)
	P2	0.0027*	0.9284***	0.6111***	0.1433**	-0.0997*	0.8692	258.4***
		(0.0925)	(0.000>)	(0.000>)	(0.0242)	(0.0742)		(0.000>)
	P3	0.0036**	0.8956***	0.4275***	0.0003	-0.1265**	0.8524	224.7***
		(0.0292)	(0.000>)	(0.000>)	(0.9964)	(0.0469)		(0.000>)
	P4	0.0041***	0.8807***	0.4361***	-0.0426	-0.0624	0.8876	306.9***
		(0.0042)	(0.000>)	(0.000>)	(0.4415)	(0.1091)		(0.000>)
R6	P1	0.0034*	0.8942***	0.4700***	0.1933**	-0.0958	0.8400	204.4***
		(0.0945)	(0.000>)	(0.000>)	(0.0145)	(0.1057)		(0.000>)
	P2	0.0023	0.9496***	0.6657***	0.1131**	-0.1139**	0.8758	274.1***
		(0.1351)	(0.000>)	(0.000>)	(0.0430)	(0.0460)		(0.000>)
	P3	0.0042***	0.8847***	0.4861***	0.0105	-0.1171*	0.8555	230.5***
		(0.0089)	(0.000>)	(0.000>)	(0.8910)	(0.0572)		(0.000>)
	P4	0.0038***	0.8731***	0.4533***	-0.0221	-0.0522	0.8845	297.7***
		(0.0079)	(0.000>)	(0.000>)	(0.6965)	(0.2118)		(0.000>)

4.2.2 Industry portfolios

The industry portfolios' robustness results are presented in Table 11. As with the PEG portfolios, including the momentum factor to the regression model enhanced the adjusted R-squared values with 15 out of 20 portfolios, indicating that Carhart four-factor model also explains the variance of the industry portfolios somewhat better in comparison to the Fama-French three-factor model. In addition, the momentum factor is negative for all industry portfolios, with statistically significant results for 8 of the 20 portfolios considered. As with the PEG portfolios, the results argue that the momentum effect is not observable with the concerning industry portfolios, and the HML factors' significances similarly diminished for most of the portfolios. The initial regression result indicated that the IP1, IP2, and IP3 portfolios had positive and statistically significant value effects observable, but the robustness results only show similar results with all the IP3 portfolios, and solely for the IP2 (Wang et al.) portfolio. Thus, it is arguable whether the value effect occurs within the concerning IP1 and IP2 industry portfolios or not, and further research is needed.

The robustness results argue that IP3 (Wang et al.) and IP3 (R12) both acquired positive and statistically significant alphas, which indicates that the results are continuous with the initial regression results, thus increasing the reliability of the acquired results. Divergent to the initial results, the robustness results also argue that IP5 (Wang et al.) achieved positive and statistically significant excess returns. Furthermore, with the R9- and R6-methods the robustness results are in line with the initial regressions, except for IP5 (R6) also achieving statistically significant abnormal returns, which is different to the initial regression results. To conclude, with the R9- and R6-methods, all industry portfolios, except for the IP2 portfolios, achieved statistically significant excess returns on the market. The results with both of the methods are continuous almost without exception in terms of the different risk factors. It is noticeable that the R9- and R9-methods are relatively different compared to the Wang et al. and R12-methods through this whole paper, and thus it would be beneficial to compare the Wang et al. and R12-methods' results to each other and the R9- and R6-methods' results to each other. This is due to the fact, that the results between the different methods, especially with the Wang et al. and the R6-methods, differ quite drastically, and for the group of Wang et al. and R12-methods the results seem relatively robust, which also applies for the group of R9- and R6-methods.

Table 11. Industry portfolios' robustness results

*Note: p-values are presented in the parenthesis, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Statistic		Intercept	MKT	SMB	HML	MOM	Adjusted R^2	F-statistic
Wang et al.	IP1	0.0020	1.0363***	0.5356***	0.0952	-0.0687	0.8931	324.8***
		(0.2078)	(0.000>)	(0.000>)	(0.1225)	(0.2078)		(0.000>)
	IP2	0.0002	0.8829***	0.5136***	0.1533**	-0.1670**	0.8170	174.0***
		(0.9227)	(0.000>)	(0.000>)	(0.0414)	(0.0146)		(0.000>)
	IP3	0.0033*	0.8201***	0.3251***	0.2016***	-0.0444	0.7834	141.1***
		(0.0575)	(0.000>)	(0.0033)	(0.0069)	(0.3762)		(0.000>)
	IP4	0.0040	0.8449***	0.5612***	0.0140	-0.0838	0.7050	93.59***
		(0.1093)	(0.000>)	(0.000>)	(0.8752)	(0.3687)		(0.000>)
	IP5	0.0040*	0.7780***	0.1620	-0.1108	-0.1542*	0.6600	76.22***
		(0.0796)	(0.000>)	(0.1978)	(0.2016)	(0.0529)		(0.000>)
R12	IP1	0.0023	1.0235***	0.5443***	0.0788	-0.0618	0.8899	314.2***
		(0.1499)	(0.000>)	(0.000>)	(0.2032)	(0.3465)		(0.000>)
	IP2	0.0001	0.8545***	0.4738***	0.0951	-0.1713**	0.8141	170.7***
		(0.9494)	(0.000>)	(0.000>)	(0.1935)	(0.0157)		(0.000>)
	IP3	0.0038**	0.8281***	0.2952**	0.1680**	-0.0424	0.7767	135.8***
		(0.0291)	(0.000>)	(0.0119)	(0.0229)	(0.4181)		(0.000>)
	IP4	0.0025	0.8708***	0.7596***	0.0418	-0.1622**	0.7595	123.4***
		(0.2582)	(0.000>)	(0.000>)	(0.6100)	(0.0319)		(0.000>)
	IP5	0.0030	0.8527***	0.3836***	-0.1405	-0.0889	0.7241	102.7***
		(0.1739)	(0.000>)	(0.0044)	(0.1502)	(0.2885)		(0.000>)
R9	IP1	0.0037**	1.0172***	0.5538***	0.0692	-0.1036*	0.8947	330.4***
		(0.0157)	(0.000>)	(0.000>)	(0.2505)	(0.0874)		(0.000>)
	IP2	0.0004	0.8415***	0.5235***	0.0962	-0.1221	0.7990	155.0***
		(0.8499)	(0.000>)	(0.000>)	(0.1898)	(0.1097)		(0.000>)
	IP3	0.0050***	0.7989***	0.4101***	0.1415*	-0.1044*	0.7510	117.9***
		(0.0062)	(0.000>)	(0.0011)	(0.0554)	(0.0951)		(0.000>)
	IP4	0.0042*	0.9093***	0.8294***	0.0285	-0.0448	0.7311	106.3***
		(0.0553)	(0.000>)	(0.000>)	(0.7123)	(0.5370)		(0.000>)
	IP5	0.0047**	0.8724***	0.3275**	-0.0725	-0.0758	0.7038	93.1***
		(0.0372)	(0.000>)	(0.0238)	(0.5236)	(0.3748)		(0.000>)
R6	IP1	0.0037**	1.0169***	0.5512***	0.0651	-0.1034*	0.8959	334.4***
		(0.0145)	(0.000>)	(0.000>)	(0.2697)	(0.0861)		(0.000>)
	IP2	0.0003	0.8332***	0.5371***	0.0935	-0.1304*	0.8067	162.7***
		(0.8516)	(0.000>)	(0.000>)	(0.1912)	(0.0772)		(0.000>)
	IP3	0.0052***	0.7962***	0.4004***	0.1470**	-0.1026	0.7496	117.0***
		(0.0044)	(0.000>)	(0.0014)	(0.0496)	(0.1022)		(0.000>)
	IP4	0.0043**	0.9186***	0.8192***	0.0253	-0.0527	0.7400	111.3***
		(0.0483)	(0.000>)	(0.000>)	(0.7464)	(0.4723)		(0.000>)
	IP5	0.0041*	0.8691***	0.3581**	-0.0720	-0.0804	0.7127	97.1***
		(0.0633)	(0.000>)	(0.0126)	(0.5010)	(0.3172)		(0.000>)

4.2.3 Combined portfolios

The robustness results of the combined portfolios' alpha statistics are presented in Table 12. The results indicated that the industry group IP1, IP2 and IP4 (Wang et al.) portfolios were all statistically insignificant at 10 % significance level. However, the P1 portfolios of the industry groups IP3 (0.0047, p=0.0326) and IP5 (0.0094, p=0.0085) both acquired positive and statistically significant excess returns at 5 % significance level, with the results also being continuous with the initial regressions. It can be concluded based on the initial regressions and the robustness checks, that at least the lowest PEG securities seems to gain positive excess returns on the financials and real estate, and health care and utilities industries. Thus, the low PEG investment strategy can be considered to be visible on certain industries. However, the statistically significant overperformance of the P2 portfolios within the industry groups IP4 and IP5 is not observable with the Carhart four-factor model, as the results are not statistically significant. Hence, there is no clear and continuous evidence of the medium PEG portfolios' possible overperformance in the concerning industry groups, and further investigation of the matter is therefore necessary.

The R12-method results are continuous with the initial regression results, excluding the portfolio P1 (R12) of the industry group IP2, as in this case the alpha is negative but not statistically significant. The P3 (R12) of the industry group IP1 achieved positive and statistically significant excess returns (0.0059, p=0.0094) also being robust to the initial regressions, which indicates that the medium PEG securities outperformed all other portfolios in the industrial and basic material industries. Also, the P4 (R12) of the industry group IP3 is the only portfolio not achieving positive and significant results, which is in line with the initial regression results, also indicating that low and medium PEG securities outperform the high PEG securities within the financials and real estate industries.

The R9- and R6-method robustness results with industry groups IP2-IP5 were strongly continuous with the initial regression results. However, in contradiction to the Fama-French three-factor regression results, with both growth rate estimation methods the portfolios P2-P4 of the industry group IP1 achieved abnormal and statistically significant returns, with the exception being the lowest PEG portfolio P1. Again, the industry group IP4 portfolios' alpha statistics were positive and statistically significant at 1 % level for only the highest PEG portfolios P4 (R9) and P4 (R6), with the P4 (R9) achieving the highest average monthly excess returns of the whole group (0.0098, p=0.0083), which is contradict to the Wang et al. method's results. Based on the acquired results, the R9- and R6-methods seems to prefer and profit more from the higher PEG securities, and the concerning methods' characteristics should be investigated more accurately to acquire further evidence of the contrary phenomena in relation to the traditional literature.

Table 12. Combined portfolios' robustness results

*Note: p-values are presented in the parenthesis, *** p < 0.01, ** p < 0.05, * p < 0.1.*

Alpha statistics		**Industry portfolios (IP1-IP5)**				
		IP1	**IP2**	**IP3**	**IP4**	**IP5**
Wang et al.	P1	0.0019	-0.0037	0.0047**	0.0053	0.0094***
		(0.3811)	(0.2493)	(0.0326)	(0.1539)	(0.0085)
	P2	0.0023	0.0020	0.0038	0.0053	0.0067
		(0.2601)	(0.4677)	(0.1060)	(0.2003)	(0.1288)
	P3	0.0017	0.0032	0.0029	0.0025	0.0033
		(0.4230)	(0.2575)	(0.1502)	(0.6208)	(0.4072)
	P4	0.0020	-0.0012	0.0018	0.0030	-0.0055
		(0.3477)	(0.6758)	(0.4492)	(0.5355)	(0.3190)
R12	P1	0.0001	-0.0020	0.0054**	0.0040	0.0055
		(0.9761)	(0.4711)	(0.0306)	(0.3009)	(0.1339)
	P2	0.0025	0.0019	0.0050**	-0.0016	0.0049
		(0.2072)	(0.4858)	(0.0431)	(0.6422)	(0.1436)
	P3	0.0059***	0.0009	0.0039*	0.0042	0.0046
		(0.0094)	(0.7467)	(0.0875)	(0.2362)	(0.1985)
	P4	-0.0006	-0.0006	0.0023	0.0050	-0.0029
		(0.7255)	(0.8275)	(0.2536)	(0.2179)	(0.4609)
R9	P1	0.0025	0.0012	0.0058**	0.0023	0.0061
		(0.2617)	(0.7473)	(0.0320)	(0.6104)	(0.1193)
	P2	0.0040*	-0.0009	0.0034	-0.0005	0.0043
		(0.0526)	(0.7377)	(0.2201)	(0.8970)	(0.2942)
	P3	0.0050**	-0.0009	0.0053**	0.0066	0.0077**
		(0.0252)	(0.7818)	(0.0355)	(0.1031)	(0.0123)
	P4	0.0033*	0.0018	0.0057**	0.0096***	0.0014
		(0.0977)	(0.5038)	(0.0114)	(0.0083)	(0.6819)
R6	P1	0.0024	0.0006	0.0059**	0.0015	0.0027
		(0.2449)	(0.8605)	(0.0302)	(0.7286)	(0.4161)
	P2	0.0032*	-0.0014	0.0049*	0.0006	0.0075*
		(0.0903)	(0.5871)	(0.0675)	(0.8587)	(0.0936)
	P3	0.0059**	0.0006	0.0042	0.0063	0.0062**
		(0.0114)	(0.8573)	(0.1048)	(0.1017)	(0.0392)
	P4	0.0034*	0.0018	0.0062***	0.0091***	-0.0008
		(0.0826)	(0.4438)	(0.0061)	(0.0076)	(0.9784)

5 CONCLUSIONS

5.1 Summarizing the findings

The main purpose of this research was to examine whether the low PEG investment strategy, or the PEGR effect, is observable on the Nordic stock market, and whether it is possible for investors to achieve abnormal stock returns by utilizing the concerning investment strategy in certain industries. Also, it was pursued to provide further evidence of the log-linear EPS growth rate estimation model presented by Wang et al. (2020), and to investigate whether the concerning method could be reliably exploited in calculating the company-specific PEG-ratios. Furthermore, three alternative estimation models were constructed and tested accordingly, pursuing to provide possible alternative and more adjusting methods for the EPS growth rate estimation, and to check for the robustness of the Wang et al. method's results.

Based on the results, the P2 (Wang et al.) with the average PEG of 1.41, was the only portfolio achieving statistically significant excess returns on the market. Thus, the results were in contradiction to most of the previous empirical evidence of the PEGR effect, as the lowest PEG portfolio did not overperform in relation the other higher PEG portfolios (Peters 1991; Schaztberg – Vora 2009; Wang et al. 2020). To conclude, the PEGR effect does not seem to appear on the whole Nordic stock market during years 2010-2022, and thus the first hypothesis of this research is rejected. However, as the medium PEG portfolio outperformed all other portfolios, the results provide further evidence and somewhat similar results as the research by Sun (2001) and Fafatas and Shane (2011), hence casting more suspicions on the traditional PEGR effect. As the PEG-ratio of the concerning well-performed portfolio is relatively different from the traditional PEG benchmark of 1, and should hence be overpriced and underperforming, the results provide similar evidence of the problematic and ambiguous characteristics of the PEG benchmarking as previously argued (Arak – Foster 2003; Trombley 2008; Schnabel 2009). Hence, the third hypothesis of this research is regarded as true.

The IP2 (Wang et al.) appeared to achieve negative average monthly returns in general, also with the lowest PEG portfolio P1 achieving statistically significant and negative results as the only portfolio of this paper. This indicates that the PEG ratio appears to not function well as a screening tool or in portfolio construction within the consumer staples and consumer discretionary industries. However, the P1 results were not exactly continuous with the robustness checks, as the statistical significance diminished when the MOM factor was included in the asset-pricing model, and hence further research of this matter is necessary. The IP3 (Wang et al.) was the only industry portfolio achieving statistically significant excess returns of all industry groups. Further analysis illustrated that, in fact, the lowest PEG portfolio P1 was the only portfolio of the concerning industry group achieving abnormal returns. It is important to acknowledge that the higher leverage structure of financial companies, as stated by Fama and French (1992), might also have some kind of impact on the results. Similar performance results were also observable with the P1 of the industry group IP5 (Wang et al.). Thus, the results remarkably indicate that with both IP3 (financials and real estate) and IP5 (health care and utilities) industry groups the lowest PEG portfolios outperformed all other portfolios. This also supports the fact that the PEGR effect does exist on certain industries during years 2010-2022, although the phenomenon is not observable on the whole Nordic stock market level in the same time period.

To conclude, it can be argued that the PEGR effect is observable on the industries mentioned above, and thus the second hypothesis of this research is also regarded as true. However, it is important to acknowledge, that the maintained financial theories and asset-pricing models might have some inadequacies, which could cause distortions on the acquired results. Also, as the transaction costs and taxations are not considered in the analyses, the obtained results might not completely reflect the real markets. Nevertheless, as the mentioned factors are generally not acknowledged in related research, the results of this research are in line and comparable with the previous empirical evidence.

The alternative EPS growth rate estimation methods provided, the R12-, R9-, and R6-methods, proved to be also usable in defining the PEG portfolios. The PEG portfolios' results argue that with the R12-method the medium PEG portfolios P2 (R12) and P3 (R12) achieved statistically significant excess returns, also providing further evidence of the overperformance of the medium PEG portfolios on the Nordic stock market, similar to the main finding of this research. However, with the R9-method all portfolios remarkably achieved positive and significant alphas, and with the R6-method 3 out of 4 portfolios achieved similar results. It could be argued that the R12-method's results were somewhat continuous with the Wang et al. method's results, but the R9- and R6-methods provided non-robust results in relation to the initial Wang et al. method's results. Thus, it is suggested to discuss these methods separately, by comparing the Wang et al. and R12-

methods jointly, and the R9- and R6-methods jointly as well, due to their apparent differing PEG characteristics.

Furthermore, the R12-method also provided the closest and partly continuous results with the Wang et al. method of the combined portfolios' performance, with the exception that P1 of the IP5 (R12) did not achieve statistically significant excess returns and P3 of IP1 (R12) did. Also, with all concerning alternative methods 3 out of 4 of the IP3 portfolios achieved statistically significant excess return, arguing that the IP3 (financials and real estate industries) overperformed relatively comprehensively regardless of the portfolios' PEG ratios. Similar results were also achieved for the P2-P4 of the IP1 with both R9- and R6-methods, indicating that all PEG portfolios except for the lowest PEG portfolio P1 remarkably achieved statistically significant excess returns. Thus, the results are in contradiction to the previous low PEG anomaly research, which may be due to the different characteristics of the R9- and R6-methods' EPS growth rate estimates in relation to the Wang et al. estimates and the previous analyst estimates. However, as the concerning methods controversially provided higher number of observations for the analyses, and ended up with various overperforming portfolios especially with the higher PEG portfolios, this matter should be investigated more as the methods could be highly beneficial for the investors in the future.

5.2 Contribution and further research possibilities

The anomalistic evidence of the PEGR effect has previously been researched mainly on the US market, and to the best knowledge only one related research has been conducted on the European stock market so far by Chahine and Choudhry (2004). Thus, the first main contribution of this research was to provide further empirical evidence of the concerning phenomenon on the Nordic stock market, and on the industry specific level. The second main contribution of this research was to provide further evidence of the log-linear EPS growth rate estimation model presented by Wang et al. (2020), and to test whether the PEG-ratios could be reliably calculated with the concerning method. The third main contribution of this research was to provide alternative, and possibly more adjustable and practical log-linear estimation methods for the EPS growth rate in addition to the Wang et al. method.

Based on the acquired results, the Wang et al. method proved to be a practical tool for evaluating the EPS growth rate estimates for the PEG-ratio, as the method conducted similar PEG characteristics and scale of the PEG values in relation to the previous related research mainly utilizing analyst estimates, such as the I/B/E/S estimates, in defining the companies' PEG-ratios. To conclude, the observed goodness of the Wang et al. method could be highly beneficial for the investors and analysts, as it seems to function as an alternative method for the traditional analyst estimates. Also, the alternative estimation methods, the R12-, R9-, and R6-methods, provided interesting results and profitable characteristics, but further research of the concerning methods is still needed.

The log-linear estimation methods provide equally available information for all market participants, which usually is not the case with analyst estimates, as they are generally available either for a certain group of investors or for a charge. Also, the concerning methods provide more adjustable models for the PEG-ratio based analysis in occasions that the analyst estimates are not available, such as with smaller companies or markets. Thus, it can be argued that the log-linear EPS growth rate estimation methods, and especially the method by Wang et al. (2020), benefit the investors with the availability of the information, and thus improve the efficiency of the markets, which is desirable in terms of the traditional financial theories and asset-pricing models (Markowitz 1952; Sharpe 1964; Fama 1970, 1993).

The further possible research of this matter could extend the analysis period, for example by covering a longer historical period of time, and investigating whether the PEGR effect has been observable over time, or in certain sub-periods. The possible research could also extend the analysed markets geographically to cover the whole European stock market to provide further evidence in addition to the previous research by Chahine and Choudhry (2004). Alternatively, the further research could focus on certain countries' stock markets to observe the country-specific PEG-ratio based investment strategy characteristics.

Even though the log-linear EPS growth rate estimation model presented by Wang et al. (2020) has so far proved to function well as an alternative method for the analyst estimates when defining the company-specific PEG-ratios, it would be highly beneficial to obtain further empirical evidence of the utilization of the concerning estimation method. The research could be executed on other markets around the globe, or alternatively within the markets or countries suggested above. In addition, the alternative estimation methods presented in this research, and their PEG-ratio characteristics could be further researched. As the obtained results and the PEG characteristics obtained with these three methods differed a bit from the more traditional and continuous findings, and the return characteristics and profits of the portfolios constructed were relatively favourable, it would be highly beneficial to investigate this matter more precisely.

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Appendices

Appendix 1. Example of the EPS growth rate estimation

Wärtsilä is being used as the example company in this occasion. The EPS data being collected from the years 1998-2009 to calculate the growth rate of EPS for the year 2010, by utilizing the log-linear estimation model by Wang et al. The EPS data from the years 1998-2009 are presented below:

Year (t)	EPS	Year (t)	EPS
1998	0.10	2004	0.09
1999	0.16	2005	0.29
2000	0.46	2006	0.56
2001	0.81	2007	0.42
2002	0.61	2008	0.58
2003	0.09	2009	0.70

Thus, the regression result over time (t) is as follows:

$$\ln EPS_t = -1.8111 + 0.09889 * t$$

where β_2 = 0.009889 is the slope coefficient. The growth rate is then calculated accordingly, $\text{EPS (g)} = e^{\beta_2} - 1 = e^{0.09889} - 1 = 0.1039$, or 10.39 %. Thus, the example calculation indicates that the estimated EPS growth rate is 10.39 % for Wärtsilä during years 1998-2009, with the result functioning as an estimate for the PEG-ratio calculations and portfolio construction for the year 2010. This procedure is repeated for all years and companies in the sample.

Appendix 2. Groupings of the industry portfolios (IP1-IP5)

Industry portfolio (IP)	Industries included
IP1	Industrials, Basic Materials
IP2	Consumer Discretionary, Consumer Staples
IP3	Financials, Real Estate
IP4	Technology, Telecommunications
IP5	Health Care, Utilities

Appendix 3. Average PEG-ratios of the combined portfolios

Average PEG-ratios		Industry portfolios (IP1-IP5)				
		IP1	IP2	IP3	IP4	IP5
Wang et al.	P1	0.97	0.78	0.40	0.97	0.62
	P2	1.73	1.49	0.95	1.69	1.71
	P3	2.75	2.58	1.87	2.90	2.71
	P4	5.62	5.64	4.77	5.86	5.24
R12	P1	0.64	0.53	0.29	0.72	0.48
	P2	1.31	1.09	0.69	1.41	1.46
	P3	2.15	2.08	1.44	2.79	2.47
	P4	5.01	5.11	3.88	5.91	4.91
R9	P1	0.31	0.23	0.12	0.40	0.22
	P2	0.80	0.67	0.37	0.99	0.93
	P3	1.53	1.52	0.91	2.03	1.89
	P4	4.19	4.45	2.93	4.44	4.40
R6	P1	0.33	0.23	0.12	0.42	0.25
	P2	0.91	0.73	0.39	1.12	1.04
	P3	1.54	1.52	1.01	1.93	1.89
	P4	4.10	4.30	2.87	4.33	4.32