WISEflow
Europe/Oslo(CEST)
30 Jun 2022

Handelshøyskolen BI

GRA 19703 Master Thesis

Thesis Master of Science 100% - W

Predefinert informasjon

Startdato:	16-01-2022 09:00	**Termin:**	202210
Sluttdato:	01-07-2022 12:00	**Vurderingsform:**	Norsk 6-trinns skala (A-F)
Eksamensform:	T		
Flowkode:	202210||10936||IN00||W||T		
Intern sensor:	(Anonymisert)		

Deltaker

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Informasjon fra deltaker

Tittel *:	Asset pricing models in the Nordic Stock Market
Navn på veileder *:	Kjell Jørgensen

Inneholder besvarelsen konfidensielt materiale?:	Nei	**Kan besvarelsen offentliggjøres?:**	Ja

Gruppe

Gruppenavn:	(Anonymisert)
Gruppenummer:	274
Andre medlemmer i gruppen:	

BI Norwegian Business School
Oslo, Spring 2022

Asset pricing models in the Nordic Stock Market

Test of Fama and French asset pricing models on all common and green stocks in the Nordic stock market

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Master of Science in Business

Major in Finance

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Acknowledgements

This thesis marks the culmination of our Master of Science degree in Business with Major in Finance at BI Norwegian Business School. First and foremost, we would gratefully like to express our sincere gratitude to our supervisor, Kjell Jørgensen, for his encouragement and constructive feedback throughout this process. We want to thank BI Norwegian Business School and the Department of Finance for a motivational and inspiring program which has been decisive for our future career paths. Finally, we would also like to thank our families for their support, and our fellow students for making our time at BI memorable.

Abstract

This thesis investigates the Fama and French asset pricing models on a sample of all firms, green firms, and half-green firms in the Nordic stock market. We find that when fitted to the full sample, the factor models of Fama and French provide a good explanation of the cross-sectional variance of return and outperform the CAPM. The sample of green firms contains extensive sample errors negating our ability to distinguish the tested model. The factor models explain less of the variance in excess return of half-green firms than all firms. We find evidence that the investment factor is more important when describing the excess return of half-green firms than all firms in the Nordic stock market.

Keywords – Asset pricing model, Fama and French, The Nordic stock market, Green stocks

Contents

List of Abbreviations

A	Aggressive
B	Big
B/M	Book to market
BE	Book equity
BH	Big high
BL	Big low
BN	Big neutral
BPS	Basis points
C	Conservative
CAPM	Capital Asset Pricing Model
CAP	Capitalization
CMA	Conservative minus aggressive
Corr	Correlation
Cov	Covariance
EXP	Expenses
FF	Fama and French
GRS	Gibbons Ross and Shanken
H	High
HML	High minus low
i.e.	in explanation
INV	Investment
L	Low
LHS	Left-hand-side
MC	Market capitalisation
ME	Market equity
Mkt	Market factor
MTP	Modern portfolio theory
N	Neutral
OBX	Oslo Stock Exchange index

OLS	Ordinary least square
OMXH25	OMX Helsinki 25 index
OMXS20	OMX Copenhagen 20 index
OMXS30	OMX Stockholm 30 index
OP	Operating profitability
R	Robust
Rev	Revenue
RF	Risk-free rate
RHS	Right-hand-side
RM	Market return
RMW	Robust minus weak
S	Small
SH	Small high
SL	Small low
SMB	Small minus big
SN	Small neutral
STAT	Statistics
TOT	Total
U.S.	United States
USD	United States Dollar
Var	Variance
VW	Value weighted
W	Weak

List of Symbols

A	Average
α_i	Regression intercept
$\hat{\alpha}$	$N \times 1$ vector of estimated α
β_i	Regression coefficient of $(R_M - R_f)$
c_i	Regression coefficient of CMA
ε_i	Error term
$\forall$	For all
H_0	Null hypothesis
H_1	Alternative hypothesis 1
h_i	Regression coefficient of HML
i	Parameter for asset or group of assets
L	Number of variables in the factor model
$\bar{\mu}$	$N \times 1$ vector of factor portfolio sample mean
N	Number of LHS portfolios
Ω	Estimator of factor portfolios' covariance matrix
R^2	R-squared
R^2_{adj}	R-squared adjusted
R_α	Excess return
R_f	Risk-free rate of return
R_i	Return asset i
r_i	Regression coefficient of RMW
$\bar{r}_i$	Difference between VW return of LHS portfolio and VW market return
R_M	Market return
$\widehat{\Sigma}$	Estimator of the residual covariance matrix
s	Standard deviation
s_i	Regression coefficient of SMB
T	Number of time periods
t	t- statistic
τ	parameter for time

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1 Introduction and motivation

The goal of any rational investor is to maximise return. There have been hundreds if not thousands of proposed methods to predict an asset's behaviour in order to "beat the market". A common understanding among investors is that the only source of excess return is the systematic risk of an asset. The question then becomes, what are the underlying risk factors affecting an asset or asset class. Eugene Fama and Kenneth French introduced one of the most famous empirical approaches to understanding and quantifying risk factors, the three-factor asset pricing model, in their 1993 paper "Common risk factors in the returns on stocks and bonds" Fama and French (1993).

The original three-factor model expanded the former Capital Asset Pricing Model (CAPM) Sharpe (1964), Lintner (1965) and Mossin (1966) by introducing two new factors, firm size, and firm value, to the existing excess market return. The three-factor model was shown to better capture the cross-sectional variance of excess return in diversified portfolios compared to the CAPM. One of the latest developments in the hunt for a perfect asset pricing model is Fama and French's extension of the three-factor model, the five-factor model, Fama and French (2015). The five-factor model expands the original three-factor by introducing the two new factors, profitability, and investment. The five-factor model provided an even better explanation of variation in excess return than the three-factor model. However, these findings might be sample-specific to the U.S. stock market and thus call for further global research.

With the integration of global financial markets, a reasonable assumption is that the same underlying risk factors would be applicable to markets beyond the borders of the United States. Fama and French tested this assumption and expanded on their research by applying the five-factor model to an international sample of firms, Fama and French (2016). Fama and French applied their asset pricing models to one global market and the North American, European, Japanese, and Asian Pacific markets. They found that the model performed well when fitted to each sample separately and failed to capture excess return of the different regions when fitted to a global market.

In this spirit, we want to expand on the research performed by Fama and French by applying their models to the Nordic stock market. We would like to better understand the underlying risk factor in our home market and specifically how these risk factors apply to green firms in the same market.

Green firms are vital in the fight against climate change and its consequences. These firms are the ones who actively help our society transform into a sustainable future. These firms might be engaged in renewable energy, recycling, or reducing our use of fossil fuels in other ways. While other firms may seek to reduce their climate impact, the green firms directly improve the environment. The nature of these firms' business model is that investors are willing to pay for a green premium when investing in these firms. The green premium is the reduction in return one is willing to accept for the betterment of the climate. Pástor et al. (2020) laid out the theoretical framework underlying the green premium and how it is affected by an investor or group of investors deriving utility from the externalities produced by green firms.

The willingness to pay for a green premium and other green firm-specific traits may expose these firms to different underlying risk factors or react to the same risk factors differently from non-green firms. This is what we want to investigate in this thesis. By applying the different asset pricing models of Fama-French to a sample of Nordic firms and a sample of green firms, we ought to understand how the different risk factors affect asset pricing of regular firms and of the firms that bring us into a sustainable future.

We have selected to limit our analysis to the Nordic region. There are several reasons for this. Even though the Nordic region is small in a geographic and demographic sense, it mimics traits of the global economy. It can be regarded as a microcosm of the global financial market. The Nordic region has a well-diversified economy. Norway specialises in energy production and offshore capabilities. Sweden produces commodities for the global market and has a robust financial sector. The health sector is predominant in Denmark, while the material sector is strong in Finland.

All the Nordic countries focus heavily on green technologies and have a large and well-funded green sector. They all have a well regulated financial sector and a high degree of transparency. For these reasons, we believe that our research will be possible to conduct, and our findings might be of interest to investors and researchers within and beyond the borders of the Nordic countries.

2 Literature review

For as long as the financial market has existed, investors have tried to develop strategies to predict future returns to make good investments. It is impossible to make these good investments without an understanding of the underlying dynamics that affect the market.

One of the most well know and still widely used models used to understand the market is the Capital Asset Pricing Model (CAPM) of Sharpe (1964), Lintner (1965), and Mossin (1966). The model was one of the first that used the relationship between an asset and the market to determine the fair value of an asset. The CAPM has been criticised for making too strict assumptions. Researchers have created alternative models to relax the reliance on the assumptions made by the CAPM. Black (1972) introduced the zero-beta CAPM, which substitutes the assumption of unlimited lending and borrowing at the risk-free rate for an assumption of unlimited short sales of risky assets. Black et al. (1972) found that the security market line is flatter than predicted by the standard CAPM.

Some of the most important elaborations on the CAPM has been performed by Fama and French in the 1990s. In their 1992 paper, Fama and French (1992), Fama and French reject the market beta associated with the CAPM and instead find that the stock size and book-to-market ratio better capture the cross-sectional variation in average stock returns. Fama and French later reincorporated the market factor into their model in Fama and French (1993). Their model replaced price-to-earnings with book-to-market, as book-to-market showed to be a better explanatory factor, making price-to-earning redundant.

Fama and French extended their own three-factor model, Fama and French (2015), by adding two additional factors, profitability, and investment. The new five-factor model performed better than the three-factor model by capturing the size, value, profitability, and investment patterns in average stock return. The paper focuses on a U.S. sample with all stocks listed on the NYSE, AMEC, and NASDAQ from the period between July 1963 and December 2013. They find that the value factor becomes redundant in explaining returns after the inclusion of profitability and investment. The model's performance is robust to the way its factors are defined. The five-factor model has trouble capturing average returns on portfolios with large exposure to profitability and investment, i.e., "stocks whose returns behave like those of firms that invest a lot despite low profitability".

The international tests of a Five-Factor asset pricing model conducted by Fama and French (2016) test their previously published five-factor model on samples of international markets. The paper conducted tests on four regions: North America, Europe, Japan, and Asia Pacific, and uses monthly returns for the period from July 1990 to October 2015. In line with the paper from 2015, Fama and French construct their market factors from value-weight portfolios of the regional market, with a one-month U.S. Treasury bill as a risk-free rate.

The international test uses a similar methodology as Fama and French (2015) when comparing model performance. The GRS statistic of Gibbons et al. (1989), tests with power the combined predictive capabilities of a model tested on several portfolios. Fama and French use the GRS in combination with other metrics to best understand their model's performance. Using these tests, they find that the five-factor model is a suitable pricing model for the North American, European and Asia Pacific markets. The Japanese market contains too little variation in excess return for the model to be useful. They find that the five-factor model outperform the three-factor model, however, by including profitability and investment, the value factor is rendered redundant and the four-factor model omitting value perform just as well as the full five-factor model.

Fama and French were not the first researchers to find that profitability and investment could be used to explain variation in excess return, and their finding has been replicated in other markets. Novy-Marx (2013) finds that firms with high profitability generate significantly higher returns than unprofitable firms. Aharoni et al. (2013) find a statistically significant relationship between an investment proxy and average returns. Næs et al. (2009) analysed return patterns and determinants at the Oslo Stock Exchange in the period 1980 to 2006, with the Fama and French three-factor model and different macroeconomic variables. The paper finds that a risk factor related to the market, company size, and liquidity factor provides a reasonable fit for the variance of the Norwegian stock market.

The theoretical framework of the green premium has been laid for worth by Pástor et al. (2020). According to their model, the existence of investors with environmental, social, and governance (ESG) concerns reduced the return of assets with these characteristics. This is due to the ESG concerned investors finding utility in the ESG characteristics, reducing their need for financial gains. However, they also point out that ESG firms provide a hedge against climate change and even ESG-neutral investors will derive utility from including ESG firms in their portfolios. The researchers also showed how increases in investor concerns about ESG will bring on an influx of new investors willing to pay for a green premium, driving up the price and yielding an excess return for existing shareholders.

3 Testable hypothesis

This thesis investigates Fama and French asset pricing models on different samples of firms in the Nordic stock market. To carry out this research, we address the following research questions (RQ):

> RQ 1: "*Can the Fama-French asset pricing models explain the cross-sectional variance in excess return of a sample of all common stocks and/or a sample of green stocks – alternatively, half-green stocks – in the Nordic stock market?*"

> RQ 2: "*Do we observe a significant difference between the optimal factor model fitted to the sample of all firms and the sample green firms – alternatively, half-green firms – in the Nordic stock market?*"

The first question clarifies the viability of explaining excess return in the Nordics using a three-, four-, or five-factor model. The second inquiries about the differences these models produce. The existence of a green premium inclines us to believe there is a difference between the optimal pricing model of green and non-green firms. We will investigate if there exists empirical evidence to support this belief. We acknowledge in the framing of the question that there is a possibility we will encounter issues in the pricing of green firms. This would likely be due to combining a small sample with short time horizons. We are still interested in analysing firms with a positive environmental impact. If this is to be the case, we will use the alternative sample of half-green firms. This sample should still give us some insight into the behaviour of green companies while also producing results with enough rigour to draw a conclusion.

These research questions will guide our inquiry and inspire our research. To implement the research, we form two testable hypotheses. This thesis utilises two null hypotheses that we seek to reject in our analysis.

Hypothesis 1:

> H_0 1: "*The Fama-French asset pricing models provide no better*

explanation of the cross-sectional variance in excess return than the CAPM on a sample of all common stocks and/or a sample of green stocks – alternatively, half-green stocks – in the Nordic stock market."

H_1 1: "*The Fama-French asset pricing models provide a better explanation of the cross-sectional variance in excess return than the CAPM on a sample of all common stocks and/or a sample of green stocks – alternatively, half-green stocks – in the Nordic stock market.*"

Hypothesis 2:

H_0 2: "*There is no difference between the optimal asset pricing model fitted to a sample of all common stocks and a sample of green stocks – alternatively, half-green stocks – in the Nordic stock market."*

H_1 2: "*There is a difference between the optimal asset pricing model fitted to a sample of all common stocks and a sample of green stocks – alternatively, half-green stocks – in the Nordic stock market.*"

The first hypothesis tackles the viability of an asset pricing model on the Nordic stock market. The second hypothesis will be used to evaluate the difference between the models. The factor models might differ in three ways: type of model, factor values and factor loading, including the intercept. We are especially interested in which factors will be the most important to understanding the excess return of these firms. What are the differences in factor value and the efficiency of the models on different left-hand-side test portfolios?

Before starting our analysis, we are presuming some results. First, the five-factor model will perform better than the three-factor model and CAPM. Secondly, for green firms' profitability will be less important. Thirdly, for green firms' investment will be more important. Lastly, growth firms will be valued higher than value firms, the assumption is that green firms might be priced based on future earnings.

4 Theoretical Framework

4.1 Asset pricing

The basis of this thesis is the Fama and French asset pricing models. This model uses five risk factors to determine a fair asset value in a diversified portfolio. The five-factor model is based on decades of financial and economic research. The main idea behind the factor models is the modern portfolio theory proposed by Markowitz (1952) in his paper portfolio selection. Markowitz proposes the existence of an efficient frontier of asset mixes, and the only way to increase portfolio return is to increase systematic risk. This was incorporated into the efficient market hypothesis. Fama (1970) stated no information could be used to predict future returns because it is already incorporated into the asset's current price. It is therefore impossible to beat the market using price discovery.

The modern portfolio theory was later developed into the Capital Asset Pricing Model (CAPM) by Sharpe (1964), Lintner (1965), and Mossin (1966) independently. The CAPM proposes that the fair value of an asset is equal to the value it brings to a diversified portfolio. The CAPM was further expanded from a one-factor model into the three-factor model proposed by Fama and French (1993). This model presents two additional risk factors that explain abnormal returns. Later, Fama and French (2015) expanded the three-factor model into the five-factor model.

4.2 The modern portfolio theory

The modern portfolio theory (MPT) proposed by Markowitz (1952) is the first scientific and mathematical approach to constructing a portfolio. Before the adaption of the MPT, investors relied on sentiments such as "Don't put all your eggs in one basket". Markowitz showed how an investor could combine risky and less risky assets in a portfolio with a higher return per unit of risk. This can be achieved by utilising the covariance of different assets. If two assets have a negative correlation, their volatility will cancel out, and the overall volatility and risk of the portfolio will be reduced. A portfolio with two assets with a correlation of minus one would have zero risk, and the return would be the weighted average return of the two assets. Markowitz proposes the existence of an efficient frontier, a line of portfolios maximizing return per unit of risk. Any portfolio not located on the efficient frontier leaves a return “on the table”. A different combination of assets will exist that offers the same return at a lower level of risk. Any rational investor would want their portfolio to be located on the efficient frontier.

The existence of the efficient frontier implies that the only way to increase return is to increase risk. For this reason, the only risk is the only factor that higher returns should reward. The market portfolio is the optimal portfolio that maximises return per unit of risk. This can be located on the efficient frontier by constructing the capital market line. This is a line starting at the risk-free rate on the intercept and runs tangent to the efficient frontier. According to the MPT, creating a portfolio with a greater return per unit of risk than the market portfolio is impossible. Investors who believe in the MPT should invest their money in a cheap market index rather than more expensive active funds.

4.3 Capital asset pricing model

The MPT was later distilled into the capital asset pricing model (CAPM) by Sharpe (1964), Lintner (1965), and Mossin (1966) independently. They proposed that an asset should be valued based on its value in a diversified portfolio. The CAPM model values assets based on how they covary with the market portfolio. The model:

$$R_i = R_f + \beta \left(R_M - R_f \right)$$

Proposes that the expected return of an asset i will be equal to the risk-free rate R_f. Plus the market premium $(R_M - R_f)$ Times the assets beta β.

$$\beta = \frac{\text{Cov}\left(R_i, R_M\right)}{\text{Var}\left(R_M\right)}$$

The market risk premium is the return the market generates in excess of the risk-free rate. This is the premium investor's demand, bearing the risk of the market. The beta is the correlation of the asset with the market return. Suppose a stock has a beta of 1, the stock and the market move in sync with the same return. If the market increases by 8%, the stock also has a return of 8%. If the beta is 0.5, the stock return would be 4%, and with a negative beta of -0.5, the stock would return -4%. The CAPM can show the value a single asset would bring to a diversified market portfolio, this value should dictate the fair price of the asset.

4.4 Efficient market hypothesis

A core assumption in both the MTP and the CAPM is the efficient market hypothesis (EMH) Fama (1970). It states that all information relevant to an asset price is already reflected in the current price. This implies that no information, private or public, can be used to predict future stock returns. The only present information that can predict future returns is the riskiness of an asset in a portfolio. Price discovery is therefore pointless.

To test the efficient market hypothesis, an asset pricing model is needed. The most common model to use when assessing the EMH is the CAPM or a multi-factor model. Because the EMH is tested by using an asset pricing model, the resulting test is a joint test of the EMH and the asset pricing model. Accordingly, the dismissal could be tied to either the EMH or the asset pricing model if the test is rejected.

4.5 Fama and French three and five-factor model

Following the rejection of the CAPM, Fama and French (1993) proposed that a three-factor asset pricing model would be a better model for explaining asset return. Their model is an extension of the CAPM introducing two new factors: Size and value. Fama and French showed that this extended model produced a better explanation of an asset's excess return compared to the CAPM. The size factor is based on the market capitalisation of the firm, and the value factor is based on the book-to-market ratio. Firms with low book-to-market ratios are growth stocks, while high book-to-market are value firms. Fama-French three-factor model results in the following regression:

$$R_{i\tau} - R_{f\tau} = \alpha_i + \beta_i \left(R_{M\tau} - R_{f\tau}\right) + s_i SMB_\tau + h_i HML_\tau + \varepsilon_i$$

The $R_{i\tau}$ is the stock return, the SMB_τ is the size factor, the HML_τ is the value factor, and the s_i and h_i are their respective regression coefficients.

Later the three-factor model was expanded into the five-factor model, Fama and French (2015). In this paper, Fama and French expand on their model by including a factor for profitability and investment. This results in the following model:

$$R_{i\tau} - R_{f\tau} = \alpha_i + \beta_i \left(R_{M\tau} - R_{f\tau}\right) + s_i SMB_\tau + h_i HML_\tau + r_i RMW_\tau + c_i CMA_\tau + \varepsilon_i$$

Where RMW_τ represents profitability, and CMA_τ s investments. The expansion of the three-factor model can explain as much as 95% of the variation in excess return in the U.S. capital market Fama and French (2015).

5 Methodology

To test and possibly reject our null hypothesis, we develop a test methodology. First, we sort the Nordic firms into their respective samples. Second, calculate the model factors. Third, develop the test portfolios that the model will be fitted towards. Lastly, lay out the method of fitting and evaluating the asset pricing models.

5.1 Sample selection

The three samples of firms under investigation in this thesis are the full, green, and half-green firms. The full sample consists of listed firms in the Nordic region. The firms in our sample are listed on the following exchanges: Oslo Stock Exchange, Euronext Growth Oslo, Nasdaq Stockholm, Nasdaq Copenhagen, Nasdaq Helsinki, and Nasdaq First North Growth Market. All firms in all other samples are also included in the full sample.

The green firms will be distinguished from other non-green firms by their effect on the environment. The definition of a green firm are firms with strictly positive externalities on the environment. The green firms incorporate principles of sustainability and supply environmentally friendly products and services.

The half-green firms will have a less strict definition: Firms that have strictly positive externalities on the environment or utilize green firms and enable their operation while having neutral externalise on the environment themselves. All green firms fall into the half-green definition, not the other way around. The sample of half-green firms will be used when there is not enough data to evaluate the green firms. That is why the definition is broader and includes the green firms.

The firms will be sorted based on information provided by Refinitiv Eikon. The two samples will be subject to an annual rebalancing every calendar year.

5.2 RHS Factors

The explanatory variables on the right-hand-side (RHS) of our different factor models are created based on the one market-specific factor, market, and up to four firms' specific factors: size, value, profitability, and investment. We use the same method of factor construction as described by Fama and French (2015).

5.2.1 Variable definition

To calculate the five factors, four values must be calculated for each firm in each period in addition to the excess market return of the sample.

The size factor uses the firm's market capitalisation to sort them based on size. The market capitalisation (cap) is defined as the share price multiplied by the number of outstanding shares.

$$\text{Market Cap}_\tau = \text{ share price}_{\tau-1} \times \text{shares outstanding}_{\tau-1}$$

Market cap, and all other accounting data, are denominated in USD to enable cross-border comparisons. The market value is calculated yearly, using the closing share price on the last day of trading that year.

The value factor is the firm's Book-to-Market (B/M) ratio. The B/M ratio is calculated by dividing the Book-Equity (BE) by the firm's Market Cap at the end of the finical year. The BE is calculated by subtracting Total Liabilities from Total Assets.

$$B/M_\tau = \frac{\text{Book Equity}_{\tau-1}}{\text{Market Cap}_{\tau-1}}$$

$$\text{Book Equity}_\tau = \text{ Total Assets}_{\tau-1} - \text{ Total Liabilities}_{\tau-1}$$

The operating profitability (OP) of a firm is defined as the Operating Income divided by Book Equity at the end of the fiscal year. Operating Income is calculated by subtracting Total operating expenses and Interest Expenses from

Total Revenue.

$$OP_\tau = \frac{\text{Operating Income}_{\tau-1}}{\text{Book Equity}_{\tau-1}}$$

$$\text{Operating Income}_{\tau-1} = \text{Total Revenue}_{\tau-1} - \text{Total Operating Expenses}_{\tau-1} - \text{Interest Expences}_{\tau-1}$$

The investment (INV) of a firm is defined as the growth of the Total Assets.

$$\text{Investment}_\tau = \frac{\text{Total Assets}_{\tau-1} - \text{Total Assets}_{\tau-2}}{\text{Total Assets}_{\tau-2}}$$

The excess return of the firm is defined as the total return minus the risk-free rate. The total return is the rate of return of holding an asset, in this case a stock.

$$R_{e\tau} = R_{t\tau} - R_{f\tau}$$

Excess return is denoted in local currencies and calculated for each month.

The market excess return is the sum of the market-cap-weighted excess return of each firm in the market sample.

$$R_{Me\tau} = \frac{\sum_i (R_{e\tau,i} \times \text{Market Cap}_\tau)}{\sum_i \text{Market Cap}_{\tau,i}}$$

5.2.2 Factor sorting and calculation

Following calculating the necessary values for each firm, the next step is to sort them into groups based on these values. To isolate the factors from one another, the factors are sorted independently. We use the same method of factor sorting for both the three-, four-, and five-factor models, the 2×3 sorts. The 2×3 sorting method sorts all firms into two sizes bins and three value, profitability, and investment bins. The size bin is separated by the median market cap of the firms in each sample. The other values are sorted into the three bins based on the 30^{th} and 70^{th} percentile. This results in the firms ending up in one of two size groups, small (S) or big (B). One of three value groups, low (L), neutral

(N) and high (H). One of three profitability groups, robust (R), neutral and weak (W). And one of three investment groups, conservative (C), neutral and aggressive (A).

To calculate the factors using the 2×3 sorting method, the factors are combined using a double-sort method along two dimensions in three different ways: size-value, size-profitability, and size-investment. The value factor is calculated by combining the value sort and the size sort. This results in the formation of six portfolios, SH, SN, SL, BH, BN, and BL. These portfolios represent the small-high, small-neutral, small-low, big-high, big-neutral, and big-low firms. The value weighed excess return of each of these portfolios is then calculated and the average excess return of the high-value and low-value portfolios is further calculated. The difference between the return of the high and the low portfolios results in the formation of the high minus low (HML) factor. The same method is used when calculating the conservative minus aggressive (CMA) and robust minus weak (RMW) factors as well. For a full description, see Table 1. The last factor is calculated by averaging the excess return of all the small portfolios and subtracting the average excess return of all the big portfolios. This results in the small minus big (SMB) factor. All the factors are subject to a yearly rebalancing and recalculation.

The market (Mkt) factor is the value-weighted monthly excess return of the sample.

Table 1: Factor Construction

We use independent sorts to assign stocks to two Size groups, and two or three B/M, operating profitability (OP), and investment (Inv) groups. The VW portfolios defined by the intersections of the groups are the building blocks for the factors. The first always describes the Size group, small (S) or big (B). In the 2 x 3 sorts, the second describes the B/M group, high (H), neutral (N), or low (L), the OP group, robust (R), neutral (N), or weak (W), or the Inv group, conservative (C), neutral (N), or aggressive (A). The second character is B/M group, the third is OP group, and the fourth is Inv group. The factors are SMB (small minus big), HML (high minus low B/M), RMW (robust minus weak OP), and CMA (conservative minus aggressive Inv), Fama and French (2015)

Sort	Breakpoints	Factors and their components
2×3 sorts on Size and B/M, or Size and OP, or Size and Inv	*Size*: Sample median	$SMB_{B/M} = (SH + SN + SL)/3 - (BH + BN + BL)/3$ $SMB_{OP} = (SR + SN + SW)/3 - (BR + BN + BW)/3$ $SMB_{Inv} = (SC + SN + SA)/3 - (BC + BN + BA)/3$ $SMB = \left(SMB_{B/M} + SMB_{OP} + SMB_{Inv}\right)/3$
	B/M: 30th and 70th Sample percentiles	$HML = (SH + BH)/2 - (SL + BL)/2 = [(SH - SL) + (BH - BL)]/2$
	OP : 30 th and 70th Sample percentiles	$RMW = (SR + BR)/2 - (SW + BW)/2 = [(SR - SW) + (BR - BW)]/2$
	Inv: 30th and 70th Sample percentiles	$CMA = (SC + BC)/2 - (SA + BA)/2 = [(SC - SA) + (BC - BA)]/2$

5.3 LHS portfolios

The factors of chapter 5.2 will be fitted on a set of left-hand-side (LHS) test portfolios. These portfolios are diversified on size and value, profitability, or investment using a 4×4 sorting method. This sorting method results in three sets of 16 portfolios diversified along size-value (size-B/M), size-profitability (size-OP), and size-investment (size-INV). The 4×4 sorting method separates the firms into four groups based on the respective dimensions' 25^{th} , 50^{th} , and 75^{th} percentiles. The LHS portfolios are rebalanced yearly.

The monthly excess value-weighted return of each portfolio is calculated and is the bases for the LHS of the final regression that the RHS factors will be fitted to.

5.4 Regression model

The asset pricing models are computed with a time-series regression using ordinary least squares to fit the set of RHS factors to the LHS portfolio returns.

5.4.1 RHS pricing models

The RHS will evaluate six different asset pricing models, CAPM, one three-factor model, three four-factor models, and one five-factor model. The CAPM consist of a constant term and the market factor.

$$R_{i\tau} - R_{F\tau} = \alpha_i + \beta_i Mkt_\tau + \varepsilon_i \tag{5.1}$$

The three-factor model consists of the constant term and the market, size, and value factors.

$$R_{i\tau} - R_{F\tau} = \alpha_i + \beta_i Mkt_\tau + s_i SMB_\tau + h_i HML_\tau + \varepsilon_i \tag{5.2}$$

The three four-factor models all consist of the constant term, market, and size factors, with a combination of two of the three, value, profitability, or investment factors.

$$R_{i\tau} - R_{F\tau} = \alpha_i + \beta_i Mkt_\tau + s_i SMB_\tau + h_i HML_\tau + r_i RMW_\tau + \varepsilon_i \tag{5.3}$$

$$R_{i\tau} - R_{F\tau} = \alpha_i + \beta_i Mkt_\tau + s_i SMB_\tau + h_i HML_\tau + c_i CMA_\tau + \varepsilon_i \tag{5.4}$$

$$R_{i\tau} - R_{F\tau} = \alpha_i + \beta_i Mkt_\tau + s_i SMB_\tau + r_i RMW_\tau + c_i CMA_\tau + \varepsilon_i \tag{5.5}$$

The final model is the full five-factor model incorporating the constant term and all the five factors.

$$R_{i\tau} - R_{f\tau} = \alpha_i + \beta_i \left(R_{M\tau} - R_{f\tau}\right) + s_i SMB_\tau + h_i HML_\tau + r_i RMW_\tau + c_i CMA_\tau + \varepsilon_i \tag{5.6}$$

5.4.2 LHS test portfolios

The LHS of the time series regression is the value weighted excess return of each of the three sets of 16 portfolios, 48 in total. Each factor model will be fitted to each set of LHS portfolios, and the results will be analysed separately.

5.5 Regression results

A pricing model that explains the variation in return has an interception (a_i) of zero. We use the GRS statistic of Gibbons et al. (1989) in combination with other summary metrics to evaluate whether the true value of the intercepts is indistinguishable from zero or not. These metrics will evaluate each factor model's absolute and relative performance on each of the three sets of LHS portfolios.

5.5.1 The GRS-test

The GRS-test tests the mean-variance efficiency between LHS portfolios and the RHS factor model. The GRS determines whether the intercept values from individual model regressions are jointly different from zero. The GRS-test is defined as:

$$fGRS = \frac{T}{N} \times \frac{T-N-L}{T-L-1} \times \frac{\widehat{\alpha}' \times \widehat{\Sigma}^{-1} \times \widehat{\alpha}}{1 + \bar{\mu}' \times \hat{\Omega}^{-1} \times \bar{\mu}} \sim F(N, T-N-L)$$

Where N is the number of simultaneous regressions or test portfolios, T is the number of time periods, L is the number of explanatory variables and factors in the model, $\widehat{\alpha}$ is $N \times 1$ vector of estimated intercepts, $\hat{\Sigma}$ is an unbiased estimate of the residual covariance matrix, $\bar{\mu}$ is a $L \times 1$ vector of the factor portfolios' sample means. $\hat{\Omega}$ is an unbiased estimate of the factor portfolios' covariance matrix.

The null hypothesis of the GRS-test is:

$$H_0 : \alpha_i = 0, \quad \forall i$$

If the null hypothesis holds, the GRS statistic will be close to zero. The greater the regression intercepts in absolute value, the greater the GRS statistic. The critical value of the GRS-test is determined by the degrees of freedom. The p-value of the F-statistic determines whether the results are statistically robust or not. The GRS-test, tests with power whether the regression model produced intercepts indistinguishable from zero.

In addition to testing the null hypothesis, the GRS can be used as a tool to rank the models based on how close their combined alphas are to zero. The models with lower f-statistics will in general have more explanatory power than alternative models with higher f-statistics. However, this ranking does not tell the whole story, and the other tests are needed to truly rank the models against each other. This is also true even if the model passes the GRS test with power, there might be anomalies in the data that the GRS does not account for.

5.5.2 Summary metrics

In addition to the GRS, we use a set of four summary metrics. These tests provide insights into the regression results that the GRS does not. The four tests are: the average absolute intercept $A\left|\alpha_i\right|$, the ratio of unexplained dispersions of the test portfolios to the total dispersion of the same portfolios $A\alpha_i^2/A\bar{r}_i^2$, the proportion of unexpected dispersion in average return attributed to sampling error $As^2\left(\alpha_i\right)/A\alpha^2$, and the mean of adjusted R-squared AR_{adj}^2.

The average absolute interception is defined as the mean of the intercept in regression i, $A\left|\alpha_i\right|$. A low $A\left|\alpha_i\right|$ indicates a good factor model that produces intercepts close to zero.

The ratio of unexplained dispersion to total dispersion is calculated by dividing the average of the squared alpha i, $A\alpha_i^2$ by the average of the squared difference between the average return of the market portfolio i and the average return of the value-weighted market return, $A\bar{r}^2$. A low value of $A\alpha_i^2/A\bar{r}_i^2$ indicates a low interception dispersion relative to the dispersion of the left-hand side. This suggests that the factor model is a good model.

The proportion of unexpected dispersion in average return attributed to sampling error is measured by dividing the average of the squared sample standard error of the $\alpha_i, As^2\left(\alpha_i\right)$, by the average of the squared alpha, $A\alpha_i^2$. A low value of $As^2\left(\alpha_i\right)/A\alpha^2$ indicates that the dispersion of intersections is due to sampling error rather than the dispersion of the true intercept, this suggests a bad factor model. A very large value is also bad, it may indicate that all variation in intercept is caused by sample error and not any underlying risk factors.

Lastly, the mean of the adjusted R-squared is simply the average of the coefficient of determination of regression i adjusted for the number of explanatory variables, AR_{adj}^2. A high value indicates that the factors can pick up the variation in the average return of the LHS portfolios.

6 Data

In this section, we present the data used in our analysis throughout the paper and our method of data manipulation. First, we elaborate on the sources of our data and the structure and size of the samples. Second, we present the filtering process of the raw data, and how we selected the green stocks. Finally, we elaborate on our factor concerns and limitations. All data analysis is conducted using Phyton and R.

6.1 The sample

Accurate and well-defined data is crucial to our investigation and to answer our two research questions. Since our focus is the Nordic stock market, we sample data from all available active and delisted stocks in the Norwegian, Swedish, Danish, and Finnish stock markets. Creating and testing portfolios requires monthly security data and yearly accounting data. We extracted all relevant data from Refinitiv Eikon for the period spanning January 2015 to December 2021, 84 months to be exact. We extract two data files for the companies listed in the Nordic Stock Market. The first data file contains all available monthly security data needed, Eikon (2022b), and the second data file contains all available yearly accounting data needed, Eikon (2022c). This raw data consists of 1836 stocks and must be filtered to ensure accurate and usable data.

6.2 Filtering the sample

The raw data sample contains several stocks with missing data and data errors that ought to be removed. This thesis's filtering process was conducted to make the sample valid for analysis. Companies with negative book equity were removed in the first stage of the filtering sample. In the second step, stocks with missing values are dropped from the sorts for the year or month in question. In the final step, we remove stocks without data for at least one year of the sample period. This is nevertheless unfavourable in our green stock selection, considering our already small sample size. This filtering process removed approximately 400 companies in the total sample.

Table 2: The number of stocks in the filtering process

Step 0, raw data. In Step 1, remove firms with negative book equity. In Step 2, remove stocks with missing data points. In Step 3, remove stocks without data for at least one year of the sample period.

	Step 0	Step 1	Step 2	Step 3
Number of firms	1836	1637	1592	1460

6.3 Green stock selection

This subjection details how we separate green stocks from non-green stocks. Definitions of green can be ex-ante arguments or based on specific indicators. We define green firms as companies that generate positive externalities to the environment. These are companies that produce renewable energy or seek investment opportunities that benefit the natural environment. The selected companies derive most of their revenues and profits from green business activities. The green firms incorporate principles of sustainability and supply environmentally friendly products or services. When sorting the firms, we manually reviewed every single firm in our sample. The firms were sorted into different samples based on their core business activity and revenue structure, Eikon (2022a). A full list of green and half-green stocks can be found in the appendix, Table 15. Examples of green stocks included are Tomra Systems, a global leader in automation of waste sorting, their sorting system optimize resource recovery and minimize waste in the food, recycling, and mining industries, Tomra (2021). Another firm is Scatec, a leading renewable energy solutions provider. Their mission is to deliver competitive and sustainable renewable energy, and to protect our environment through innovative integration of reliable technology, Scatec (2021).

The second stock selection is called half-green. These are the firms that do not impose negative externalities on the environment. These companies have an overall net favourable impact on the environment. The companies are somehow involved in protecting the environment but do not necessarily generate the majority of their revenues and profits from green business activities. The green activities may not be associated with a particular product or service but a green technology or process. For instance, Kahoot, a global eLearning platform, and the company operate sustainably and responsibly, leveraging platforms, apps and learning resources to impact wider society tangibly and positively, Kahoot (2021). Another example of a half-green company is Nordic Semiconductor, the fabless company plays a key role in the realization of the wireless future. The company develops ultra-low power products, enabling energy efficient end products for their consumers, and targeting to increase the share of renewable energy and reduce greenhouse gas emissions, Nordic Semiconductor (2021).

Our three samples of all firms, green and half green firms contained an average of 1060, 30, and 83 firms per period respectively, Table 3.

Table 3: The firm per count per year sample

Number of firms per sample per year, and average per year.

Year	**All**	**Green**	**Half-Green**
2015	773	19	53
2016	907	23	65
2017	977	27	75
2018	1095	29	83
2019	1178	34	96
2020	1212	36	97
2021	1275	40	113
Mean	**1060**	**30**	**83**

Table 4 provides information on the firm samples per cent of market capitalisation. The samples of green and half-green are nearly indistinguishable. This is due to a few large firms with large firms dominating the green sample. With a few very large firms the green and half-green samples might yield large variations in outcome from very small changes in portfolio composition. Historically the market size of the green and half-green firms has been very small, it is only in the last couple of years these firms make up a sizable portion of the overall market, increasing from 0.03 in 2015 to 0.10 in 2021. This might indicate our analysis is premature, and a later study would yield better results.

Table 4: Green and Half-Green market size

Market size of the green and half green sample as a percentage of the Nordic stock market, market capitalization.

Year	**Green**	**Half-Green**
2015	3%	3%
2016	3%	4%
2017	4%	5%
2018	4%	5%
2019	6%	7%
2020	7%	8%
2021	10%	12%

6.4 Data used in the regression analysis

In similar fashion as Fama and French (2016), we take the view of a U.S. investor. This is to prevent exchange rate anomalies that could accrue if taking the perspective of a local investor. Therefore, all data is collected in U.S. Dollars. In line with the assumption of a U.S. investor, the risk-free rate is one month U.S. Treasury Bill. All factors are in U.S. Dollars, and the return is in local currency to not be exposed to exchange rate risk. Further, we assume full liquidity, and portfolio rebalancing without transaction costs.

To test whether our data sample is representative of the Nordic markets we checked the correlation between the return of our sample data per country and the countries' respective benchmark indices. We used OBX, OMXC20, OMXH25, OMXS30, as the market benchmark indexes for the Norwegian, Danish, Finish and Swedish markets. From Table 5, we see that our sample accurately described the Nordic market in our sample period.

Table 5: Correlation between sample and benchmark indices

The correlation coefficient between the monthly value-weighted return of the data sample and the corresponding countries' benchmark indices. OMX, Oslo, OBXC20, Copenhagen, OMXH23, Helsinki, OMXS30, Stockholm, as the market benchmark indices.

	OBX	OMXC20	OMXH25	OMXS30
Correlation	0.982	0.972	0.974	0.954

6.5 Factor concerns

Certain adjustments to the data sample are needed to ensure that the factors have intended economic meaning.

6.5.1 Negative book value of equity

When the company's balance sheet's total debt exceeds total assets, the company has a negative book value of equity. If the company has negative operating profit and negative book equity (BE), the operating profitability (OP) measure will be positive. In line with Fama and French (2015), we do not include companies with a negative book value of equity when creating the profitability measure. Because the negative book value of equity switches the sign for the profitability factor, these values were removed, approximately 50 stocks.

6.5.2 Preferred vs. Common stocks

Our empirical analysis focus on companies listed in the Nordic stock market, both existing and new green firms. Companies listed in the Nordic may issue preferred and common stocks. Common stocks are ordinary shares that give the shareholder the right to share a company's profits and vote on the general assembly. The preferred stocks are generally regarded as a hybrid instrument between a stock and a bond. Preferred stocks are far less volatile than common stocks because guaranteed dividends are more popular for conservative investors and retirees seeking an income supplement. Disregarding class definition, both stocks represent identical fundamental characteristics of the firm. In our study, we exclude all preferred stocks from our empirical framework.

6.6 GRS critical values

In the GRS-test, we seek to keep the null hypothesis with power. To test this, we need a GRS f-statistic, lower than the F-value based on our degrees of freedom and confidence level. In our test, we use 16 LHS portfolios, 84 time periods, and between 1 and 5 RHS explanatory values. We will keep the null hypothesis at a 95% confidence level if:

$$fGRS_{CAPM} < F(16, 84 - 16 - 3) = 0.477$$

$$fGRS_{FF3} < F(16, 84 - 16 - 3) = 0.476$$

$$fGRS_{FF4} < F(16, 84 - 16 - 4) = 0.476$$

$$fGRS_{FF5} < F(16, 84 - 16 - 5) = 0.476$$

6.7 Limitations

There are certain limitations with the data set we want to highlight because these limitations may affect our findings and conclusions. First, the Nordic stock market is relatively small, with an average of 1060 listed stocks in our sample period. Further, our sample of green stocks is even smaller, and most of the green stocks are listed in 2020 and 2021. While we do not believe this leads to a biased sample, the small sample size might lead to less rigorous results. Ideally, a larger sample of green stocks would have allowed for even larger samples in the portfolios. The companies included in the study need to have available data for at least one year of the sample period, which reduces the number of stocks observed.

Another limitation in the Nordic stock market is that we have excluded Iceland from the analysis. The main reason for the exclusion is because of the low number of stocks listed on Nasdaq Iceland. There are also a few limitations to our delisted stocks. Companies at Euronext Growth and Nasdaq First North Growth Market are excluded due to a lack of required data. However, companies delisted in the growth market in favour of the main marketplace are included in the sample size.

By holding the assumptions of free liquidity and no transaction costs, we are able to achieve a higher portfolio return than a real-world investor. These returns can be used to evaluate the pricing models as it is predominantly relative performance that we are interested in. It is also not possible to know whether an abnormal returns, intercept, is due to an increase in undiscovered risk, or due to a high-performance portfolio. Nevertheless, the findings of this thesis should be viewed as an investigation into the performance of existing pricing models, not as an investigation into investment strategies.

7 Summary statistics

Before evaluating the results of our asset pricing models, we must first be familiar with both the LHS and RHS of the regression. This will reveal the potential efficiency of the models and give insights into how they apply to the different samples of firms. We will start by examining the behaviour of the LHS. Then assess the factor of the RHS for each of the samples, their values and how they interact with one another when combined into a full factor model.

7.1 LHS, test portfolio return

7.1.1 Firms per portfolio

The portfolios employ a 4×4 sorting method to diversify the 16 portfolios on size-BM, size-OP, and size-Inv. Table 6 shows the average number of firms per portfolio. The full sample has an average of 66.3 firms per portfolio per year. Except for the portfolio of large-cap – low profitability firms, all portfolios contain more than 29 firms. This indicates that the portfolios are well diversified and mostly pick up firms' systematic risk of each portfolio rather than the idiosyncratic risk of any specific firm. This is reflected in the low average standard deviation of return from Table 7 of between 5.09 and 5.38.

The green firms tell a different story, the average number of firms per portfolio is just 1.9 firms. Except for one portfolio, all have a minimum average of 1 firm per portfolio per year. This is not good news for the validity of our factor model tests, with an average standard deviation of 12.8 and 13.2, the volatility of return is very high compared to the full sample.

The sample of the half-green firm has some better robustness in their portfolio diversification. The average number of firms per portfolio is 5.1. With a couple of exceptions, the lowest number of average firm-count is 3. This is better than the average number of firms for the green sample and is reflected in the standard deviation of the returns of between 9.7 and 12.2. However, it is still not a significant number and might reduce the rigidity of the half-green sample as well.

Table 6: Number of firms per LHS portfolio

Average number of firms for the LHS portfolio formed on size-B/M, size-OP, size-Inv per sample for the sample period.

Sample	Size	B/M				OP				INV			
		Low	**2**	**3**	**High**	**Low**	**2**	**3**	**High**	**Low**	**2**	**3**	**High**
Full	**Small**	82.3	64.6	57.4	61.3	142.6	61.6	29.4	31.7	108.0	44.7	44.3	68.3
	2	79.1	59.6	58.0	68.9	81.3	81.0	55.0	48.3	76.9	56.6	58.1	73.6
	3	65.4	65.9	66.4	67.6	33.6	69.7	82.6	79.7	48.9	68.3	71.6	77.0
	Big	38.6	76.0	83.4	67.7	8.3	53.3	98.4	105.7	31.9	96.0	91.6	46.6
Green	**Small**	2.9	2.6	1.0	1.4	4.1	1.4	1.1	0.6	2.7	1.6	1.6	1.7
	2	2.3	2.3	1.4	1.7	1.3	3.1	2.1	1.6	2.0	1.6	1.9	2.4
	3	1.7	1.4	2.0	2.4	1.9	2.1	1.9	1.7	2.1	1.6	1.3	2.6
	Big	1.0	1.6	3.3	2.0	0.1	1.1	2.7	3.9	1.1	2.9	3.0	0.9
Half-Green	**Small**	8.0	4.1	4.4	3.9	11.1	4.3	2.3	3.1	9.4	3.0	3.4	4.7
	2	7.4	5.1	3.9	5.0	5.1	6.7	5.9	3.7	6.0	5.9	4.4	5.1
	3	2.4	6.3	3.4	6.7	2.6	4.1	6.3	5.6	2.3	5.0	6.3	5.0
	Big	3.0	3.7	8.7	5.1	1.1	5.7	5.7	8.1	3.0	5.7	6.4	5.6

Table 7: Average standard deviation of the LHS portfolios

Average standard deviation per set of LHS portfolios per sample

Sample	B/M	OP	INV
Full	5.25	5.38	5.09
Green	13.18	12.8	13.2
Half-Green	12.1	10.29	9.65

7.1.2 Average excess return per portfolio

The average excess return per LHS portfolio is presented in Table 8. The green and half-green samples have a higher average excess monthly return of 1.08% and 1.09%, compared to the full sample with an average excess monthly return of 0.5%. This is a very large difference in excess return. However, the high volatility of these samples indicates that these returns might be well adjusted for the level of risk. We hope to capture the risk associated with the green firms in our asset pricing model. Note that the average excess monthly returns per portfolio are not the same as the sample's average excess monthly return and are not to be confused with the RM – RF factor.

Table 8: Average excess return per LHS portfolio

Average excess monthly return for each of the LHS portfolios formed on size-B/M, size-OP, size-Inv per sample for the sample period.

Sample	Size	B/M				OP				Inv			
		Low	2	3	High	Low	2	3	High	Low	2	3	High
Full	**Small**	0.13	0.64	0.77	0.69	0.19	0.41	0.59	1.45	-0.05	0.62	1.06	68.3
	2	0.27	0.12	1.19	0.65	0.23	0.47	0.78	1.02	-0.04	0.5	0.99	73.6
	3	0.1	0.54	0.91	1.15	0.27	0.38	0.77	1.07	0.44	0.61	0.6	77.0
	Big	0.43	-0.01	0.23	0.31	-0.03	0.34	0.09	0.31	0.29	-0.01	0.43	46.6
Green	**Small**	4	2.13	-1.01	-1.23	0.38	6.16	-2.68	2.87	2.23	-4.05	0.65	1.7
	2	1.74	2.32	0.56	2.45	4.27	-0.38	1.44	3.22	0.23	0.38	2.07	2.4
	3	3.34	-0.91	-0.35	1.29	0.07	0.05	1.6	0.62	1.1	0.64	1.16	2.6
	Big	0.25	0.64	1.27	0.79	-0.33	0.95	-0.01	1.63	-0.54	0.7	1.74	0.9
Half-Green	**Small**	1.96	-1.15	0.71	-1.34	-0.68	2.14	0.57	0.54	-0.29	0.23	-1.03	4.7
	2	1.06	2.04	2.69	-1.08	1.31	-0.32	2.95	4.16	1.27	1.39	1.06	5.1
	3	3.66	2.05	2.35	0.8	2.94	1.08	1.74	1.84	0.98	1.08	3.01	5.0
	Big	0.54	1.58	1.18	0.32	0.48	0.67	0.65	1.53	-0.36	0.68	1.3	5.6

7.2 Summary statistics for factor returns

Table 9 shows that the equity premium for green stocks is significantly higher than the full sample of stocks (1% per month, t = 172.33 for green; and 0.25% per month, t=51.09 for the full sample). The sample of half-green stocks shows that the equity premium is the same as the green sample (1.00% per month, t = 182.19). The largest size premium is 0.94% per month for green stocks. The value premium HML for green stocks are negative, with a mean monthly return of -0.21% and a standard deviation of 12.60%. In comparison to Fama and French (2016), they found large value premiums in all sample markets. A negative value premium is expected in the sample of green stocks, meaning growth stocks outperform value stocks. Further, the profitability premium RMW for green and half-green stocks are substantial (0.72%, t=0.56 for green; 0.98%, t=0.70% for half-green). Investment premiums CMA are also noteworthy higher for green and half-green stocks (1.83%, t=1.89 for green; 1.57%, t=2.38% for half-green). The high average value of the investment factor is in line with our assumption that investment would be a more important factor for green and half-green firms than the general market. It will be interesting to see if this higher value of CMA will be reflected in the efficacy of the pricing models.

Table 9: Factor summary per sample

Mean factor value, average standard deviation, and average t-stat of the Mkt, SMB, HML, RMW, and CMA factor of the five-factor model eq. 5.6.

Sample		RM - RF	SMB	HML	RMW	CMA
	Mean	0,25	0,34	0,36	0,45	0,37
Full	**Std Dev**	3,99	2,35	2,92	3,07	2,07
	t-Mean	58,25	1,34	1,15	1,33	1,63
	Mean	1,00	0,94	-0,21	0,72	1,83
Green	**Std Dev**	5,29	8,47	12,60	11,65	8,89
	t-Mean	172,33	1,02	-0,15	0,56	1,89
	Mean	1,00	0,44	0,44	0,98	1,57
Half-Green	**Std Dev**	5,07	4,99	7,40	12,77	6,05
	t-Mean	181,63	0,81	0,55	0,70	2,38

7.3 Factor correlation between factors

The correlation between the factors of a sample indicates how similar the risk factors are to one another. Table 10 shows the correlation matrices between each set of factors. The size factor, value, and the investment factor are negatively correlated with the market and the profitability factor for the full sample of stocks. According to Fama and French (2015), small stocks tend to have higher market betas than big stocks. Therefore, it is surprising that the size factor negatively correlates with the excess market return, which is opposite to their findings. This implies that all stocks usually have lower market betas than big stocks.

Nevertheless, the negative correlations with the market may be explained because diversified investment strategies focusing on any factor with a positive mean return should be able to produce higher returns through additional variance in comparison to the market. Also, the half-green sample is the only sample with a positive correlation between profitability and investment, with 0.08. The correlation between the size and investment factors is 0.57, which is not surprising given that high B/M value firms tend to be low investment firms. The correlation is also expected to be lower for all green firms than all stocks. However, the correlation between size and investment for half-green is low as 0.08. The correlation between the value and profitability is negative for the green sample. For half-green stocks, we have a positive correlation.

Further examination of Table 10 shows a marginally negative correlation between profitability and investments for green stocks. The results are expected; profitability and investments are tied to the previous year's income result. At the same time, the remaining factors are based on the end of the previous fiscal year. Another explanation for the negative correlation is that an investment strategy solely focused on operating profitability is improved by controlling for investment.

Table 10: Factor correlation between factors

Factor-factor correlation matrices within each sample for the Mkt, size, value, profitability and investment factors of the five-factor model eq. 5.6

Sample		**RM - RF**	**SMB**	**HML**	**RMW**	**CMA**
	RM - RF	1,00	-0,08	-0,07	0,12	-0,06
	SMB	-0,08	1,00	0,15	-0,31	0,11
Full	**HML**	-0,07	0,15	1,00	-0,26	0,66
	RMW	0,12	-0,31	-0,26	1,00	-0,12
	CMA	-0,06	0,11	0,66	-0,12	1,00
	RM - RF	1,00	-0,05	-0,11	0,15	-0,18
	SMB	-0,05	1,00	0,04	-0,23	0,16
Green	**HML**	-0,11	0,04	1,00	-0,04	0,57
	RMW	0,15	-0,23	-0,04	1,00	-0,08
	CMA	-0,18	0,16	0,57	-0,08	1,00
	RM - RF	1,00	-0,21	0,05	0,01	-0,13
	SMB	-0,21	1,00	0,23	0,04	-0,05
Half-Green	**HML**	0,05	0,23	1,00	0,07	0,05
	RMW	0,01	0,04	0,07	1,00	0,08
	CMA	-0,13	-0,05	0,05	0,08	1,00

7.4 Factor correlation between samples

The market factor of the green and half-green samples are, as expected, highly correlated with a correlation of 0.99. Table 11 shows the factor correlation between samples. For the size factor, we observe lower correlations. Between green and half-green, the correlation is 0.33. We observe a higher correlation between the two samples, 0.48 for the value factor. Even higher for profitability and investment, respectively 0.56 and 0.50. We expect a higher correlation between the green and half-green samples. However, we find similarly low correlations when compared with the control sample.

The low correlation between the green and half-green samples might tell us that the half-green sample is a bad proxy for the green firms. On the other hand, they have a much higher correlation than the correlation between the green and the full sample. It is not possible to determine the suitability of the half-green sample as a proxy for the green sample purely by the factor correlation between the two samples.

Table 11: Factor correlation between samples

Rm-Rf, is the return on the value-weighted market portfolio minus the US one month Treasury bill rate. SMB (Small minus big) is the size factor, HML (high minus low B/M) is the value factor. RMW (Robust minus weak) is the profitability factor, and CMA (conservative minus aggressive Inv) is the investment factor.

Sample		**Full**	**Green**	**Half-Green**
	Full	1,00	0,68	0,74
RM - RF	**Green**	0,68	1,00	0,99
	Half-Green	0,74	0,99	1,00
	Full	1,00	0,40	0,45
SMB	**Green**	0,40	1,00	0,32
	Half-Green	0,45	0,32	1,00
	Full	1,00	0,34	0,29
HML	**Green**	0,34	1,00	0,48
	Half-Green	0,29	0,48	1,00
	Full	1,00	0,11	0,16
RMW	**Green**	0,11	1,00	0,57
	Half-Green	0,16	0,57	1,00
	Full	1,00	0,01	-0,01
CMA	**Green**	0,01	1,00	0,49
	Half-Green	-0,01	0,49	1,00

7.5 Factor spanning

The factor spanning regression test if an explanatory factor can be explained by combining other explanatory factors. To analyse the intercepts, spanning tests are performed by regressing returns of one factor to the returns of all other factors. The intercepts in the Mkt regression are positive for green (0.01% per month, t=1.83) and half-green stocks (0.01% per month, t=2.22). The intercept for HML for green stocks is negative (-1.53% per month, t= -1.26). For half-green stocks, the intercepts are closer to zero (-0.06% per month, t= -0.07). The factor spanning test suggests similarly to Fama and French (2016) that the profitability factor, RMW, is important to describing average returns for all samples. The investment factor for the green stocks (1.92% per month, t=2.35) with significant intercept and (1.74% per month, t=2.53) for half-green stocks. In comparison to size and profitability (0.67% per month, t=0.70) and (0.70% per month, t=0.53) respectively. However, both regressions to explain size and profitability show insignificant intercepts.

The factor spanning inferences can be sample-specific, and redundant factors for describing average returns in one period are important in another, Fama and French (2016). Evidence of redundancy from factor spanning is nevertheless definitive within a sample. If the factor's average return for a period is captured by its exposure to other factors, the factor does not describe average returns in the model for the specific period. However, evidence that a factor's average return is not captured by its exposures to other factors in the model does not imply it is a good proxy to describe average returns for all LHS assets with nontrivial loading's on the factor. Hence, some assets may violate the model's predictions about how factor loading's relate to expected returns.

Table 12: Factor spanning

Rm-Rf, is the return on the value-weighted market portfolio minus the US one month Treasury bill rate. SMB (Small minus big) is the size factor, HML (high minus low B/M) is the value factor. RMW (Robust minus weak) is the profitability factor, and CMA (conservative minus aggressive Inv) is the investment factor, with t-statistics and AR^2_{adj}.

Sample		**Intercepts**						**t-statistic**						
		Int	**RM - RF**	**SMB**	**HML**	**RMW**	**CMA**	**Int**	**RM - RF**	**SMB**	**HML**	**RMW**	**CMA**	AR^2_{adj}.
	RM - RF	0,00		0,00	0,00	0,00	0,00	0,53		-0,32	-0,11	0,82	-0,17	0,02
	SMB	0,41	-2,05		0,04	-0,22	0,06	1,60	-0,32		0,34	-2,54	0,34	0,10
Full	**HML**	0,11	-0,66	0,04		-0,18	0,88	0,44	-0,11	0,34		-2,21	7,58	0,47
	RMW	0,61	6,51	-0,35	-0,32		0,14	1,90	0,82	-2,54	-2,21		0,70	0,17
	CMA	0,17	-0,77	0,03	0,48	0,04		0,93	-0,17	0,34	7,58	0,70		0,44
	RM - RF	0,01		0,00	0,00	0,00	0,00	1,83		0,00	-0,29	1,23	-1,01	0,05
	SMB	0,67	-0,06		-0,07	-0,16	0,20	0,70	0,00		-0,84	-2,04	1,61	0,08
Green	**HML**	-1,53	-6,52	-0,12		-0,02	0,82	-1,26	-0,29	-0,84		-0,18	6,14	0,33
	RMW	0,70	29,74	-0,31	-0,02		0,00	0,53	1,23	-2,04	-0,18		0,01	0,07
	CMA	1,92	-15,53	0,16	0,39	0,00		2,35	-1,01	1,61	6,14	0,01		0,36
	RM - RF	0,01		0,00	0,00	0,00	0,00	2,22		-2,18	0,96	0,25	-1,30	0,07
	SMB	0,70	-23,04		0,16	0,02	-0,07	1,26	-2,18		2,26	0,36	-0,83	0,11
Half-Green	**HML**	-0,06	15,70	0,37		0,03	0,09	-0,07	0,96	2,26		0,50	0,69	0,07
	RMW	0,55	7,39	0,11	0,10		0,17	0,36	0,25	0,36	0,50		0,70	0,01
	CMA	1,74	-17,63	-0,12	0,06	0,04		2,53	-1,30	-0,83	0,69	0,70		0,03

8 Results and analysis

A perfect asset pricing model captures all cross-sectional variance of the excess return, the model intercept α will therefore be indistinguishable from zero. To evaluate the efficiency of our models we use a set of test statistics. Our primary test is the GRS-test. The GRS-test is an F-test with the null hypothesis that the true intercept α of all LHS portfolios are indistinguishable from zero. In addition to the GRS, we conduct two additional sets of tests, one statistical test consisting of four summary metrics and one qualitative analysis evaluating each of the portfolio intercepts. These tests are needed to check for anomalies in the data not uncovered by the GRS and to get a better understanding of the model's ability to capture excess return for different types of portfolios. The analysis of the intercepts is performed in Chapter 9.

The four statistical metrics comprise of the average absolute intercept $A\left|\alpha_i\right|$, it tests the average distance between the alphas and zero. The third and fourth tests measures the proportion of unexplained returns. The $A\alpha_i^2/A\bar{r}_i^2$ estimates the proportion of dispersion of intercepts resulting from dispersion in LHS returns. The $As^2\left(\alpha_i\right)/A\alpha_i^2$ estimates the proportion of dispersion of intercepts attributed to sampling error. Lastly, we evaluate the average coefficient of determination AR^2_{adj}. This evaluates how well the models capture the data in our sample. The AR^2_{adj}. will not determine the performance of an asset pricing model by itself but should be in line with the other results and will be used to make sure our findings make sense.

In our test, we evaluate six models the CAPM eq. 5.1, the three-factor model eq. 5.2, the three four-factor models eq. 5.3, eq. 5.4, eq. 5.5 and lastly, the five-factor model eq. 5.6. All factor models use a 2×3 sorting method. The models will be fitted to three sets of LHS portfolios, size-B/M, size-OP, and size-INV. All sets of LHS portfolios consist of 16 diversified portfolios using a 4×4 diversification method along their two dimensions.

8.1 GRS-test results

We find that the null hypothesis of the GRS test is rejected at a 95% confidence level for all the models fitted to all LHS portfolios, Table 13. This is expected, as passing the GRS test means that the asset pricing model is a perfect description of the variance of excess return. Although our models are imperfect descriptions of the real-world, they still capture a lot of the variance in return, and the f-statistic of the GRS can be used to rank the models against one another.

The results of the GRS-test show that models, for the most part, perform quite well when fitted to all three samples. The pricing models fitted to the full sample of Nordic firms picks up a lot of the variation in excess return when fitted to the LHS portfolios diversified along size-B/M and size-OP, with GRS f-values close to 1. The pricing models struggles to explain the return of the size-Inv LHS portfolios with GRS f-statistics ranging from 2.38 to 3.74. The models perform even better when fitted to the green and half-green firms, according to the GRS. In the green sample, all the GRS f-statistics are close to 1. The models perform best when fitted to the size-OP LHS portfolios and worst when fitted to the size-INV portfolios. For the half-green firms, the GRS f-statistic show that the models perform best when fitted to the size-OP portfolios, and struggles with the size-B/M portfolios. However, this might not tell the full story, there might be anomalies in the data that the GRS does not account for.

8.2 Summary metrics results

The GRS in combination with the other test statistic provides the best statistical analysis of the fit of the different pricing models. We start by examining the performance of the models fitted to the full sample.

8.2.1 Full sample

Initially, when fitted to the full sample, the CAPM seems to perform quite well as judged by the GRS. However, it is clear when looking at the other metrics that the CAPM is not able to capture variation in return for any of the three sets of LHS portfolios, Table 13.

Both the three-factor model and the four-factor model eq. 5.4 omitting profitability performs very well on the size-B/M LHS portfolios. The four-factor model performs the best and seems to be a decently accurate description of the real-world with the GRS f-statistic of 0.74, close to the critical value of 0.47. The average intercept of the model is just 0.2. The dispersion of the intercepts as a portion of the LHS variation and sampling error is also very good with ratios of 0.18 and 0.62. Lastly the AR^2_{adj} is very good, close to 1. The three-factor model performs only slightly worse with the main difference being a $As^2\left(\alpha_i\right)/A\alpha^2$ score of 0.54. The five-factor model also performs quite well in absolute terms. These are the best-performing models across all tested models and samples. We know from the factor correlation and factor spanning tests that HML and CMA are strongly related to each other, we have shown here that the inclusion of both factors provides the best explanation of variation in return.

When fitted to the size-OP LHS portfolios the three-factor model performs worse than the CAPM. The four-factor model eq. 5.5 omitting HML performs the best with the five-factor model just behind. Both models perform quite well but struggle with a very low proportion of the dispersion is caused by sampling error with $As^2\left(\alpha_i\right)/A\alpha^2$ values of 0.06 and 0.05. This means that there is possible a model capable of explaining an even higher amount of the variance of excess return for the size-OP portfolios.

All the models struggle to capture the excess return of the size-INV portfolios, this is evident by the very high GRS f-statistics of between 2.4 and 3.7. The best performing model is again the four-factor model eq. 5.4 that omits the profitability factor. This model performs quite well as judging by the remaining statistics, with and average intercept of 0.3 and a good proportion of dispersion explained by LHS variation and sampling error with $A\alpha^2/Ar^2$ of 0.30 and $As^2(\alpha_i)/A\alpha^2$ of 0.36. It is not possible to rank the rest of the models using these statistics due to the large discrepancies between the ranking of the models' using GRS and using the rest of the statistics. We observe that the four-factor model eq. 5.5 omitting HML perform very similar to the five-factor model, however, it is not obvious that these two models perform better than the three-factor model given the much larger GRS f-statistics.

8.2.2 Green sample

When fitting the models to the sample of green firms in the Nordic, we again observe that the CAPM struggles to pick up on variation in excess return, this is also true for the three-factor model fitted to the size-B/M and size-Inv LHS portfolios. The model performs quite well when fitted to the size-OP portfolios. Furthermore, we observe that the five-factor models perform very well across the board. All four-factor models perform quite well on the size-B/M portfolios, and the four-factor model that includes profitability performs well for the portfolios diversified on profitability and the same for the models including investments and the size-Inv portfolios.

However, good these models might perform, there is one big issue with the green sample, the standard error of the intercepts. With $As^2(\alpha_i)/A\alpha^2$ values between 10 and 31 for the three sets of LHS portfolios, most if not all variation in alpha and then some is due to sampling error. The model is not able to pick up on trends in the data to provide meaningful insight into the behaviour of green firms in diversified portfolios. Looking at the intercept value for each of the LHS portfolios revealed that there is no pattern in portfolio pricing and no discernible improvement between the models, despite improvements in test statistics. For these reasons, we will not include the green firms in the detailed discussion in the next chapter.

8.2.3 Half-Green sample

The performance of the factor models fitted to the sample of half-green firms is similar to the performance of the models fitted to the green sample with one major difference, the sampling error is significantly smaller for the half-green sample. The similarity between the two samples suggests that the half-green firms are a good proxy for the green firms, and they provide a more rigorous test.

The model fitted to the size-B/M portfolios with the best fit is the CAPM. The CAPM has the best GRS f-stat and performs very well across the other statistics relative to the other models. However, the CAPM does not perform well in absolute terms, with an average absolute intercept of 1.16, it is obvious that it is not a good description of the real-world returns of the half-green firms. The three- and five-factor models perform very similar and is hard to distinguish from one another.

For the size-Inv portfolios, the five-factor model performs best, with a GRS f-stat of 0.77 and an average absolute intercept of 0.63. There is, however, a large sampling error, but a low percentage of dispersion explained by LHS variation. The five-factor model fitted to the size-OP portfolios performs slightly worse with an average intercept of 0.73 and twice as much sampling error. Interestingly, the model with the highest explanatory power for the size-OP portfolios is the four-factor model of eq. 5.4. This model does not include profitability in exchange for value and investment. This is in line with our assumption that the investment factor would be more important for the green and half-green firms.

8.3 Other tests performed, not included in the analysis

Several other tests were conducted in addition to the ones presented. We performed the same test as mentioned above using three additional sorting methods, 2×2, 2×3×3, 2×2×2×2. All these models were fitted to two different sets of three LHS portfolios using a 3×3 and 5×5 diversification method, containing 9 and 25 portfolios. None of the alternative sorting methods produced any meaningful difference in asset pricing accuracy. The set of 25 portfolios resulted in too few firms in each of the portfolios for the green and half-green sample, and the set of 9 portfolios performed largely the same as the set of 16.

In addition to the alternations of the LHS and RHS, we fitted the factors constructed from the full sample on the LHS portfolios constructed from the green and half-green sample to compare the predictive power of a general factor model on a specific subsection of firms. As expected, these models performed significantly worse than the factor model constructed from the respective samples.

None of the alternative tests provided any better explanation of the variation in excess returns, performing similar or worse than the tests included in this thesis. These are interesting results, however, they do not improve our understanding of the pricing of firms in the Nordic market compared to the results already presented. We have therefore elected to not include the results to save space and improve readability.

Table 13: Factor correlation between samples

Summary tests of asset pricing models for the 44 LHS portfolios of each sample of firms. Results are shown for the CAPM eq. 5.1, the three-factor model eq. 5.2, the three four-factor models eq. 5.3, eq. 5.4, eq. 5.5, and the five-factor model eq. 5.6.The GRS statistic and its p-value, p(GRS), test whether the intercepts of the 16 portfolios are combined zero or not. Also presented arem the average absolute intercepts, $A\left|\alpha_i\right|$. The average squared intercept divided by the average squared value of r_i, $A\alpha^2 Ar^2$. The average of the estimates of the variances of the sampling errors of the estimated intercepts over $A\alpha^2$, $As^2\left(\alpha_i\right)/A\alpha^2$. And the average coefficient of determination, adjusted for the number of explanatory variables,AR^2_{adj}.

Panel A: Size – Book

Sample	Model	Size - BM					
		GRS	**GRSp**	$A\left\|\alpha_i\right\|$	$\frac{A\alpha^2}{Ar^2}$	$\frac{As^2(\alpha_i)}{A\alpha^2}$	AR^2_{adj}
Full	**CAPM**	1.29	0.23	0.34	0.48	0.53	0.64
	SMB, HML	1.21	0.28	0.20	0.19	0.54	0.80
	SMB, HML, RMW	1.29	0.23	0.24	0.26	0.43	0.81
	SMB, HML, CMA	1.12	0.35	0.20	0.18	0.62	0.80
	SMB, RMW, CMA	1.22	0.28	0.26	0.29	0.55	0.78
	SMB, HML, RMW, CMA	1.21	0.28	0.24	0.26	0.48	0.81
Green	**CAPM**	0.91	0.57	1.14	0.61	26.13	0.12
	SMB, HML	0.86	0.61	0.92	0.41	21.42	0.26
	SMB, HML, RMW	0.81	0.67	0.85	0.36	24.29	0.27
	SMB, HML, CMA	0.73	0.75	0.86	0.31	30.21	0.28
	SMB, RMW, CMA	0.78	0.70	0.96	0.43	28.57	0.24
	SMB, HML, RMW, CMA	0.69	0.79	0.81	0.28	33.51	0.29
Half Green	**CAPM**	1.19	0.30	1.16	0.72	1.43	0.22
	SMB, HML	1.84	0.04	1.17	0.82	1.03	0.32
	SMB, HML, RMW	2.02	0.03	1.28	0.92	0.94	0.34
	SMB, HML, CMA	1.91	0.04	1.07	0.72	1.33	0.32
	SMB, RMW, CMA	1.55	0.11	1.17	0.78	1.63	0.30
	SMB, HML, RMW, CMA	1.83	0.05	1.16	0.77	1.26	0.35

Panel B: Size – Profitability

Sample	Model	Size - OP					
		GRS	**GRSp**	$A\left\|\alpha_i\right\|$	$\frac{A\alpha^2}{Ar^2}$	$\frac{As^2(\alpha_i)}{A\alpha^2}$	AR^2_{adj}
Full	**CAPM**	1.15	0.33	0.34	0.51	0.07	0.63
	SMB, HML	1.49	0.13	0.36	0.51	0.02	0.76
	SMB, HML, RMW	1.18	0.31	0.26	0.34	0.04	0.78
	SMB, HML, CMA	1.35	0.20	0.34	0.46	0.03	0.76
	SMB, RMW, CMA	0.94	0.53	0.22	0.26	0.06	0.77
	SMB, HML, RMW, CMA	1.09	0.38	0.24	0.30	0.05	0.78
Green	**CAPM**	2.19	0.01	1.37	0.73	11.33	0.14
	SMB, HML	2.12	0.02	1.24	0.58	10.74	0.23
	SMB, HML, RMW	2.03	0.02	1.13	0.52	12.30	0.29
	SMB, HML, CMA	2.55	0.00	1.38	0.65	10.56	0.25
	SMB, RMW, CMA	2.34	0.01	1.32	0.67	11.98	0.28
	SMB, HML, RMW, CMA	2.49	0.01	1.30	0.60	11.79	0.30

Half Green	**CAPM**	1.48	0.13	1.02	0.54	5.22	0.22
	SMB, HML	1.36	0.19	0.88	0.37	6.57	0.32
	SMB, HML, RMW	1.37	0.18	0.94	0.46	5.35	0.38
	SMB, HML, CMA	1.18	0.31	0.70	0.26	8.90	0.33
	SMB, RMW, CMA	1.22	0.28	0.75	0.31	7.87	0.37
	SMB, HML, RMW, CMA	1.17	0.32	0.73	0.29	8.10	0.39

Panel C: Size – Investment

Sample	**Model**	**Size - INV**					
		GRS	**GRSp**	$A\|\alpha_i\|$	$\frac{A\alpha^2}{Ar^2}$	$\frac{As^2(\alpha_i)}{A\alpha^2}$	AR^2_{adj}
Full	**CAPM**	2.90	0.00	0.40	0.52	0.23	0.66
	SMB, HML	2.90	0.00	0.33	0.35	0.28	0.79
	SMB, HML, RMW	3.40	0.00	0.35	0.39	0.28	0.79
	SMB, HML, CMA	2.69	0.00	0.29	0.30	0.36	0.79
	SMB, RMW, CMA	3.20	0.00	0.31	0.32	0.37	0.79
	SMB, HML, RMW, CMA	3.36	0.00	0.32	0.33	0.35	0.79
Green	**CAPM**	1.03	0.43	1.20	0.79	9.92	0.13
	SMB, HML	1.01	0.46	1.11	0.67	10.26	0.20
	SMB, HML, RMW	1.08	0.39	1.10	0.69	10.71	0.22
	SMB, HML, CMA	0.79	0.69	0.92	0.47	16.19	0.24
	SMB, RMW, CMA	0.90	0.57	0.91	0.53	16.41	0.26
	SMB, HML, RMW, CMA	0.87	0.60	0.93	0.49	16.58	0.26
Half Green	**CAPM**	0.84	0.64	0.83	0.55	2.08	0.25
	SMB, HML	0.85	0.62	0.68	0.41	2.76	0.34
	SMB, HML, RMW	0.87	0.61	0.78	0.50	2.28	0.35
	SMB, HML, CMA	0.82	0.66	0.67	0.35	3.90	0.37
	SMB, RMW, CMA	0.72	0.77	0.64	0.34	4.27	0.37
	SMB, HML, RMW, CMA	0.77	0.71	0.63	0.34	4.05	0.39

9 Detailed analyses

A detailed analysis of each intercept from the regression model gives a deeper insight into the pricing behaviour of the models and adds to the understanding provided by the regression results in Table 13. We will compare the intercepts of the CAPM, three-factor model, and five-factor model fitted to the full and half-green samples. We have not included the four-factor models in this analysis to save space and we believe it would be redundant given that all factors are included in the five-factor model. The green sample has also been excluded due to its high sampling error, yielding no meaningful results. The intercepts of the green sample contain no pattern, it seems like the models randomly over- and underprice portfolios. The table of green intercepts has not been included to save space. The three sets of regression intercepts for the size-BM, size-OP, and size-Inv LHS portfolios are shown in Table 14.

9.1 Size-BM portfolios

9.1.1 Full sample

The CAPM model struggles to capture the return of both high and low-value firms in the full sample, with alphas as high as 0.92 and 0.84 for two of the portfolios in the highest and second-highest value firms. The CAPM undervalues high-value firms and overvalues low-value firms. The CAPM is best able to pick up the excess return of large firms and struggles more with the return of the smaller firms. This rules out the CAPM as a viable pricing model for the set of size-BM portfolios.

The three-factor model picks up more of the return and is better able to accurately model the behaviour of both small and large firms and low and high-value firms. The pattern of underpricing high-value firms and overpricing low-value firms, although less prominent than for the CAPM, persists. The portfolios with intercepts of 0.92 and 0.84 using the CAPM, now have intercepts of 0.55 and 0.54. The error is still large, however, it does not rule out the three-factor model.

The five-factor model does not improve on the intercepts from the three-factor model. Most of the intercepts stay largely the same and some drastically increase the difference from zero in both positive and negative directions. This reinforces the finding from Table 13 that the five-factor model does not provide a better explanation of the excess return of the 16 size-BM portfolios than the three-factor model when fitted to the full sample of firms.

9.1.2 Half-Green sample

All three models struggle to pick up on the excess return of the portfolios when fitted to the sample of half-green firms. Both the CAPM, three-factor and five-factor have several extreme values of alpha intercepts of more than 2. This by itself is enough to rule out all three models as viable pricing models for the size-BM portfolios of the half-green firms. Other than this we observe that the mispricing of value firms flips compared to the full sample. For the half-green firms, the high-value firms are severely overpriced and the low-value firms are highly underpriced. This is in opposition to our assumption that low-value green and half-green firms would be priced higher than high-value firms. All three models produce roughly the same intercepts for the portfolios, this confirms our finding from Table 13 that there is no proof that the three-factor or five-factor models perform any better than the CAPM.

9.2 Size-OP portfolios

9.2.1 Full sample

Fitted to the full sample, the CAPM model struggles to predict the excess return of the LHS portfolios. It struggles most with the extreme portfolios, small firms with very large profits are the most overvalued and the big firms with very small profits are the most undervalued. The trend is that profitable firms are undervalued with large positive alphas, and less profitable firms are overvalued. This is expected, previous research, Fama and French (2015) has shown that firms with robust profits perform better than those with weak profitability.

Going from the CAPM to the three-factor model does not improve the pricing of the size-OP portfolios. The alphas of the three-factor model of the least profitable firms range from −0.44 to −0.57, compared to between −0.01 and −0.27 when fitted to the CAPM. The intercepts indicate that the CAPM outperform the three-factor model when fitted to size-OP portfolios.

The five-factor model performs much better than both the CAPM and three-factor model. The systematic overpricing of the weak profitability portfolios is eliminated, with alphas ranging from −0.23 to 0.21. The smallest firm with the largest profits is still an issue for the model, with an intercept of 1.06. However, this is not a killing blow for the five-factor model, due to the low t-value of 1.33. The five-factor model is suitable for pricing the size-OP portfolios using the full sample.

9.2.2 Half-Green sample

For the half-green sample, the CAPM is not able to pick up the excess return of the LHS portfolios diversified on Size-OP, this is in line with our previous results. There are several extreme alpha values higher than 2 with significant t-stats. We observe a slight trend of underpricing portfolios of profitable firms and overpricing less profitable portfolios. This trend is not as strong as we observe when fitting CAPM to the full sample.

When fitting the half-green sample using the three-factor model we get a decrease in extreme alpha values, and a more promoted pattern of over-, and underpricing of weak and robust profitable firms. This is the same pattern that occurs when fitting the CAPM and three-factor model to the full sample. Although the extreme values are reduced, the increase in systematic mispricing based on profitability means that the three-factor model is insufficient to price the LHS portfolio diversified on size and OP.

The five-factor model is able to pick up on the effect profitability has on excess return. The mispricing based on profitability was completely eradicated. The model still struggles with a couple of the portfolios with alphas of 2.13 and −1.95 with t-stats of 1.67 and −2.06. These are high, but not so high as to rule out the five-factor model as an adequate pricing model by itself.

9.3 Size-Inv portfolios

9.3.1 Full sample

The CAPM is not well equipped to capture the cross-sectional variance of the excess return of the LHS portfolios diversified on Size-Inv when fitted to the full sample. It underprices all but two portfolios within the 3 quantiles conservative investments. There is no single extreme value with alphas above 1, but several portfolios have alphas close to 1 and t-stats above two. The CAPM is not a suitable pricing model for the size-Inv diversified LHS portfolios.

The three-factor model performs much better than the CAPM. There is a persisting pattern of underpricing the top three quantiles of investment portfolios, however, most of these intercepts are now close to 0.2 instead of 0.6. This is a great improvement in prizing accuracy. However, two of the portfolios have alphas of −0.62 and 0.54 with t-stats of −3.01 and 2.72. These indicate that the model struggles to capture the excess return of all the portfolios.

The five-factor model struggles with the size-Inv portfolios as well. The intercepts are very similar to the three-factor model and the t-statistics are equally as high. The high t-statistics of the intercepts might explain the high GRS values of the pricing models fitted to the Size-Inv portfolios. We expect the model that includes one of the risk factors that the portfolios are diversified on to improve model accuracy, as we saw for the five-factor model fitted to the size-OP portfolios, this pattern does not repeat itself.

9.3.2 Half-Green sample

As with the full sample, the CAPM is not able to pick up on the pricing pattern of the size-Inv portfolios when fitted to the half-green sample. There is a consistent overpricing of firms with conservative investment and a strong mispricing of small firms.

The three-factor model does not improve the pricing of the size-Inv LHS portfolios. The intercepts are largely the same with identical pricing patterns along with size and investment. There is a slight general decrease in the t-stat of the intercepts. However, this is not enough to make the three-factor model a viable it a viable .

The five-factor model performs better than both the three-factor model and the CAPM. It captures more of the variation in excess return with intercepts closer to zero than the other models. There is still some pattern of mispricing small-cap firms, however, the intercepts have mostly been reduced.

9.4 A note on the analytical approach

The statistical analysis of Chapter 8 and the qualitative assortment of this chapter have shown to align very well. The high-performance models have performed well across both chapters and the more ambiguous models have yielded the same results. Models with a high level of sampling error have been shown to not improve on intercept performance despite strong test results. This implies that our tests are complementary and provide a good overall picture of the performance of the various asset pricing models.

Table 14: Regression intercept and t-statistic

Regressions intercept and intercept t-statistic for the CAPM eq. 5.1, three-factor eq. 5.2, and five-factor eq. 5.6 fitted on the 48 value-weighted, 4×4 sorted, Size-B/M, Size-OP and Size-INV portfolios for both the full sample and half-green sample of firms.

Panel A: Size-B/M

Model	**Sample**		**Intercept**				**t-statistic**			
			Low	**1**	**2**	**High**	**Low**	**1**	**2**	**High**
CAPM	**Full**	**Small**	-0.13	0.36	0.52	0.45	-0.23	0.79	1.00	0.80
		1	0.07	-0.13	0.92	0.41	0.26	-0.46	2.31	0.96
		2	-0.17	0.26	0.64	0.84	-0.46	0.97	2.68	2.21
		Big	0.14	-0.27	-0.01	0.07	0.48	-1.49	-0.08	0.38
	Half-Green	**Small**	1.06	-2.16	0.50	-1.92	0.80	-2.11	0.19	-1.70
		1	0.26	1.05	1.77	-1.66	0.31	1.21	1.28	-0.94
		2	3.73	1.41	1.22	-0.02	0.96	1.96	1.02	-0.03
		Big	-0.29	0.96	-0.01	-0.54	-0.45	1.93	-0.04	-0.77
Three-Factor	**Full**	**Small**	-0.19	0.07	0.20	-0.01	-0.42	0.19	0.46	-0.02
		1	0.03	-0.31	0.55	-0.09	0.20	-1.63	2.46	-0.37
		2	-0.08	0.14	0.48	0.54	-0.34	0.63	2.31	1.65
		Big	0.34	-0.14	-0.05	-0.01	1.58	-0.97	-0.47	-0.05
	Half-Green	**Small**	1.12	-2.43	0.09	-2.26	0.88	-2.42	0.03	-2.05
		1	-0.13	0.66	1.10	-2.77	-0.21	0.87	0.89	-2.01
		2	3.79	1.31	1.05	-0.20	0.96	1.86	0.87	-0.28
		Big	-0.23	1.01	-0.02	-0.57	-0.39	2.09	-0.07	-0.82
Five-Factor	**Full**	**Small**	-0.16	0.06	0.26	0.34	-0.34	0.17	0.59	0.72
		1	-0.03	-0.44	0.52	0.00	-0.19	-2.26	2.24	-0.02
		2	-0.08	0.13	0.42	0.74	-0.34	0.56	1.93	2.23
		Big	0.35	0.03	-0.07	-0.18	1.55	0.25	-0.59	-1.32
	Half-Green	**Small**	0.57	-2.74	-0.74	-2.64	0.43	-2.65	-0.28	-2.31
		1	-0.02	0.58	1.24	-2.14	-0.02	0.72	1.24	-1.49
		2	3.39	1.11	1.14	-0.22	0.82	1.50	0.92	-0.29
		Big	-0.02	1.05	-0.14	-0.86	-0.04	2.06	-0.39	-1.19

Panel B: Size-OP

Model	**Sample**		**Intercept**				**t-statistic**			
			Low	**1**	**2**	**Hig**	**Low**	**1**	**2**	**High**
CAPM	**Full**	**Small**	-0.08	0.20	0.39	1.15	-0.15	0.56	1.07	1.33
		1	-0.01	0.25	0.58	0.72	-0.03	0.93	2.50	1.86
		2	-0.06	0.11	0.51	0.76	-0.11	0.43	2.15	3.08
		Big	-0.27	0.06	-0.15	0.06	-0.48	0.35	-1.25	0.50
	Half-Green	**Small**	-1.30	1.57	0.44	-0.38	-1.25	0.90	0.53	-0.35
		1	0.43	-0.98	2.01	3.40	0.31	-1.68	2.63	2.25
		2	2.15	0.43	0.62	1.13	1.06	0.40	0.72	1.61
		Big	-0.66	-0.18	-0.17	0.39	-0.47	-0.26	-0.43	0.95

Three-Factor	**Full**	**Small**	-0.47	0.02	0.29	1.11	-1.11	0.08	0.95	1.48
		1	-0.57	0.07	0.50	0.50	-2.11	0.43	2.66	1.71
		2	-0.44	-0.03	0.43	0.66	-0.87	-0.13	2.12	3.02
		Big	-0.47	0.13	-0.12	0.04	-0.83	0.78	-1.04	0.39
	Half-Green	**Small**	-1.58	1.09	0.35	-0.47	-1.69	0.65	0.42	-0.44
		1	-0.69	-1.24	1.63	2.65	-0.73	-2.30	2.46	1.99
		2	1.18	0.21	0.47	1.11	0.64	0.20	0.55	1.56
		Big	-0.82	-0.14	-0.09	0.40	-0.59	-0.20	-0.22	0.99
Five-Factor	**Full**	**Small**	-0.19	-0.05	0.10	1.06	-0.47	-0.17	0.33	1.34
		1	-0.23	0.02	0.37	0.09	-1.13	0.09	1.93	0.38
		2	0.01	0.07	0.40	0.61	0.02	0.32	1.88	2.66
		Big	0.21	0.21	-0.11	-0.03	0.44	1.29	-0.91	-0.33
	Half-Green	**Small**	-1.95	-0.18	0.29	-0.41	-2.06	-0.11	0.33	-0.36
		1	0.64	-1.31	1.16	1.20	0.99	-2.29	1.67	1.22
		2	2.13	-0.25	0.33	1.27	1.67	-0.23	0.36	1.71
		Big	0.02	-0.06	-0.12	0.41	0.02	-0.08	-0.30	0.99

Panel C: Size-Inv

Model	**Sample**		**Intercept**				**t-statistic**			
			Low	**1**	**2**	**High**	**Low**	**1**	**2**	**High**
CAPM	**Full**	**Small**	-0.33	0.41	0.80	0.60	-0.69	0.85	1.70	1.08
		1	-0.28	0.27	0.74	0.63	-0.75	1.13	2.38	1.52
		2	0.13	0.35	0.30	0.83	0.44	1.62	1.26	2.51
		Big	0.05	-0.27	0.18	-0.19	0.21	-2.33	1.16	-0.75
	Half-Green	**Small**	-1.14	-0.18	-1.79	2.26	-1.19	-0.14	-1.45	1.14
		1	0.53	0.47	0.17	0.96	0.43	0.69	0.21	1.00
		2	0.61	0.33	1.97	0.64	0.71	0.51	2.23	0.40
		Big	-1.22	-0.27	0.20	0.56	-1.94	-0.73	0.46	0.80
Three-Factor	**Full**	**Small**	-0.56	0.21	0.69	0.18	-1.49	0.57	1.52	0.39
		1	-0.62	0.24	0.54	0.20	-3.02	1.26	2.72	0.83
		2	0.01	0.32	0.17	0.60	0.03	1.80	0.81	2.09
		Big	0.14	-0.23	0.18	-0.32	0.63	-2.10	1.21	-1.37
	Half-Green	**Small**	-1.35	-0.33	-1.64	1.70	-1.48	-0.25	-1.34	0.92
		1	-0.40	0.21	-0.16	0.23	-0.45	0.33	-0.22	0.32
		2	0.57	0.23	1.81	0.09	0.64	0.36	2.04	0.06
		Big	-1.19	-0.24	0.29	0.48	-1.93	-0.65	0.75	0.67
Five-Factor	**Full**	**Small**	-0.40	0.18	0.63	0.31	-1.02	0.46	1.35	0.65
		1	-0.57	0.13	0.46	0.20	-2.90	0.65	2.24	0.90
		2	0.16	0.32	0.11	0.71	0.61	1.73	0.49	2.37
		Big	0.33	-0.19	0.05	-0.37	1.57	-1.70	0.32	-1.66
	Half-Green	**Small**	-1.20	-0.48	-1.45	-0.19	-1.26	-0.35	-1.12	-0.11
		1	1.25	0.10	-0.37	-0.79	2.19	0.15	-0.47	-1.27
		2	0.76	0.06	1.82	0.39	0.81	0.09	1.95	0.31
		Big	-0.86	-0.16	0.08	0.15	-1.35	-0.41	0.18	0.21

10 Conclusion

The objective of this thesis is to investigate the performance of the Fama-French asset pricing models on green and non-green firms in the Nordic stock market. To evaluate the models, we compared the efficiency of the CAPM, three-, four-, and five-factor models on a sample of all firms, green firms, and half-green firms.

10.1 Conclusion

We find that the Fama-French factor model outperforms the CAPM when fitted to the full sample of firms. Although the models are not perfect, none of the tested models passed the GRS-test at a 95% confidence level, the factor models provide a good description of excess return in the Nordic stock market. We can therefore reject null hypothesis 1, that there is no difference between the performance of the factor models and the CAPM. The best performing model is either the five-factor model or the four-factor that includes the variable the portfolios are diversified on. For the portfolios diversified on size and value, the best performing model includes both value and investment, this is likely due to the high correlation between the two factors.

Due to a high degree of sample error, it is not possible to conclude on model efficiency using the green sample. The half-green sample must be used as a proxy to investigate the underlying risk factors affecting the asset price of green firms in the Nordic stock market. When fitting the models to the sample of half-green firms, we find that the Fama-French asset pricing models only outperform the CAPM when fitted to the portfolios diversified on size and profitability, and size and investment, not the portfolios diversified on size and value. Therefore, we only partially reject null hypothesis 1 for the half-green firms. The best performing factor models are the four-, and five-factor models that include investment as a factor. This is aligned with our expectations that the investment factor would be more important when describing variation in excess return for the green and half-green samples of firms.

We have shown that there is a difference in the optimal asset pricing model between the two samples. The factor model including the diversified variable is optimal for the full sample, and the factor model including investment is optimal for the half-green sample. However, this is only evident from the size-OP portfolios as investment is the diversified variable for the size-Inv portfolios and there is a high correlation between value and investment, making the results of the size-B/M portfolio ambiguous. We can therefore not reject null hypothesis 2, that there is no difference between the optimal asset pricing models between the two samples, with certainty. Further research is needed.

10.2 Proposals for future research

We encourage more research on asset pricing models for the Nordic stock market. There is limited research conducted in this market, particularly on green firms. Future research on similar asset pricing models may provide a better perspective by observing a larger sample size over a longer time period. This is particularly important for green firms, as they have limited historical data at the time of writing this thesis. Further research may expand to a larger sample size, by introducing developed markets such as the Eurozone and North America. It would be particularly interesting to investigate the effect investment has on green firms, and the possibility to expand the factor model to capture more of the underlying risk factors of green firms.

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Appendix

Table 15: List of green and half-green stocks

Green Stocks

Ticker	Company	Country
ABTA.OL	Aqua Bio Technology ASA	NO
AEGA.OL	Aega ASA	NO
AFK.OL	Arendals Fossekompani ASA	NO
AGLX.OL	Agilyx AS	NO
ALTA.OL	Alternus Energy Group PLC	NO
ANDF.OL	Andfjord Salmon AS	NO
ASA.OL	Atlantic Sapphire ASA	NO
AZELIO.ST	Azelio AB	SE
BCS.OL	Bergen Carbon Solutions AS	NO
BIOGAS.ST	Scandinavian Biogas Fuels International AB	SE
BONHR.OL	Bonheur ASA	NO
BWIDL.OL	Bw Ideol AS	NO
CADLR.OL	Cadeler A/S	DK
CAMBI.OL	Cambi ASA	NO
CARBN.OL	Carbon Transition ASA	NO
CLOUD.OL	Cloudberry Clean Energy ASA	NO
COEN.ST	Cortus Energy AB	SE
DSRT.OL	Desert Control AS	NO
EAM.OL	EAM Solar ASA	NO
ECOWVE.ST	Eco Wave Power Global AB (publ)	SE
EFUEL.OL	Everfuel A/S	DK
ELO.OL	Elopak ASA	NO
ELOSSb.ST	Elos Medtech AB	SE
FKRFT.OL	Fjordkraft Holding ASA	NO
FORTUM.HE	Fortum Oyj	FI
GNP.OL	Gnp Energy AS	NO

GREENH.CO	Green Hydrogen Systems A/S	DK
GREENM.CO	GreenMobility A/S	DK
HAVH.OL	Hav Group ASA	NO
HEX.OL	Hexagon Composites ASA	NO
HEXI.ST	Hexicon AB	SE
HPUR.OL	Hexagon Purus ASA	NO
HRGI.OL	Horisont Energi AS	NO
HYARD.OL	Havyard Group ASA	NO
HYN.OL	Hynion AS	NO
HYPRO.OL	Hydrogenpro AS	NO
KALK.OL	Kalera AS	NO
KYOTO.OL	Kyoto Group AS	NO
MGN.OL	Magnora ASA	NO
MIDSU.ST	Midsummer AB	SE
MINEST.ST	Minesto AB	SE
MVWM.OL	M Vest Water AS	NO
NEL.OL	Nel ASA	NO
NESTE.HE	Neste Oyj	FI
NILAR.ST	Nilar International AB	SE
NSOL.OL	Norsk Solar AS	NO
ORSTED.CO	Orsted A/S	DK
OSUN.OL	Ocean Sun AS	NO
OTOVO.OL	Otovo AS	NO
OX2SE.ST	OX2 AB (publ)	SE
PCELL.ST	Powercell Sweden AB (publ)	SE
PROXI.OL	Proximar Seafood AS	NO
PRYME.OL	Pryme BV	NL
QFUEL.OL	Quantafuel ASA	NO
RECSI.OL	REC Silicon ASA	NO
SAGAS.OL	Saga Pure ASA	NO
SAVOS.ST	Savosolar Oyj	FI

SCATC.OL	Scatec ASA	NO
SKAND.OL	Skandia Greenpower AS	NO
SOLT.ST	Soltech Energy Sweden AB	SE
STRLNG.ST	Swedish Stirling AB	SE
STWA.ST	SeaTwirl AB (publ)	SE
TOM.OL	Tomra Systems ASA	NO
VOLUE.OL	Volue ASA	NO
VOW.OL	Vow ASA	NO
VWS.CO	Vestas Wind Systems A/S	DK
ZAP.OL	Zaptec AS	NO

Half-Green Stocks

Ticker	Company	Country
ABTA.OL	Aqua Bio Technology ASA	NO
ADMCM.HE	Admicom Oyj	FI
ADVBOX.ST	Adventure Box Technology AB (publ)	SE
AEGA.OL	Aega ASA	NO
AFK.OL	Arendals Fossekompani ASA	NO
AGLX.OL	Agilyx AS	NO
ALTA.OL	Alternus Energy Group PLC	NO
ANDF.OL	Andfjord Salmon AS	NO
ANOT.ST	Anoto Group AB	SE
ASA.OL	Atlantic Sapphire ASA	NO
ATEA.OL	Atea ASA	NO
AZELIO.ST	Azelio AB	SE
B3.ST	B3 Consulting Group AB (publ)	SE
BALCO.ST	Balco Group AB	SE
BAS1V.HE	Basware Oyj	FI
BCS.OL	Bergen Carbon Solutions AS	NO
BETCO.ST	Better Collective A/S	DK
BILOT.HE	Bilot Oyj	FI

BIOGAS.ST	Scandinavian Biogas Fuels International AB	SE
BONHR.OL	Bonheur ASA	NO
BOUV.OL	Bouvet ASA	NO
BRIG.ST	Brighter AB (publ)	SE
BWIDL.OL	Bw Ideol AS	NO
CADLR.OL	Cadeler A/S	DK
CAMBI.OL	Cambi ASA	NO
CARBN.OL	Carbon Transition ASA	NO
CHEMM.CO	Chemometec A/S	DK
CLEMO.ST	Clean Motion AB	SE
CLOUD.OL	Cloudberry Clean Energy ASA	NO
COEN.ST	Cortus Energy AB	SE
CRAYN.OL	Crayon Group Holding ASA	NO
DETEC.HE	Detection Technology Oyj	FI
DIAH.ST	Diadrom Holding AB	SE
DSRT.OL	Desert Control AS	NO
EAM.OL	EAM Solar ASA	NO
ECOWVE.ST	Eco Wave Power Global AB (publ)	SE
EFUEL.OL	Everfuel A/S	DK
EKOBOT.ST	EKOBOT AB (publ)	SE
ELO.OL	Elopak ASA	NO
ELOP.OL	Elop AS	NO
ELOSSb.ST	Elos Medtech AB	SE
EMGS.OL	Electromagnetic Geoservices ASA	NO
ENALYZ.CO	Enalyzer A/S	DK
ENEDO.HE	Enedo Oyj	FI
ENENTO.HE	Enento Group Plc	FI
EWRK.ST	Ework Group AB	SE
EXL1V.HE	Exel Composites Oyj	FI
FKRFT.OL	Fjordkraft Holding ASA	NO
FORTUM.HE	Fortum Oyj	FI

FPIP.ST	FormPipe Software AB	SE
GARO.ST	Garo AB	SE
GNP.OL	Gnp Energy AS	NO
GOFORE.HE	Gofore Oyj	FI
GREENH.CO	Green Hydrogen Systems A/S	DK
GREENM.CO	GreenMobility A/S	DK
HANZA.ST	Hanza Holding AB	SE
HAVH.OL	Hav Group ASA	NO
HDLY.OL	Huddly AS	NO
HEX.OL	Hexagon Composites ASA	NO
HEXI.ST	Hexicon AB	SE
HONBS.HE	Honkarakenne Oyj	FI
HPUR.OL	Hexagon Purus ASA	NO
HRGI.OL	Horisont Energi AS	NO
HTRO.ST	Hexatronic Group AB	SE
HUDL.OL	Huddlestock Fintech AS	NO
HYARD.OL	Havyard Group ASA	NO
HYN.OL	Hynion AS	NO
HYPRO.OL	Hydrogenpro AS	NO
IMPERO.CO	Impero A/S	DK
INDCT.OL	Induct AS	NO
ITERA.OL	Itera ASA	NO
KAHOT.OL	Kahoot ASA	NO
KALK.OL	Kalera AS	NO
KIT.OL	Kitron ASA	NO
KNOW.ST	Knowit AB (publ)	SE
KYOTO.OL	Kyoto Group AS	NO
MGN.OL	Magnora ASA	NO
MIDSU.ST	Midsummer AB	SE
MINEST.ST	Minesto AB	SE
MVWM.OL	M Vest Water AS	NO

MYCR.ST	Mycronic AB (publ)	SE
NCOD.OL	Norcod AS	NO
NEL.OL	Nel ASA	NO
NESTE.HE	Neste Oyj	FI
NILAR.ST	Nilar International AB	SE
NOD.OL	Nordic Semiconductor ASA	NO
NSOL.OL	Norsk Solar AS	NO
NXTMH.HE	Nexstim Oyj	FI
ODICO.CO	Odico A/S	DK
ORSTED.CO	Orsted A/S	DK
OSUN.OL	Ocean Sun AS	NO
OTOVO.OL	Otovo AS	NO
OX2SE.ST	OX2 AB (publ)	SE
PCELL.ST	Powercell Sweden AB (publ)	SE
PEXIP.OL	Pexip Holding ASA	NO
PLT.OL	Polight ASA	NO
POLYG.ST	Polygiene AB	SE
PREC.ST	Precise Biometrics AB	SE
PROXI.OL	Proximar Seafood AS	NO
PRYME.OL	Pryme BV	NL
QAIR.ST	Qleanair AB	SE
QFR.OL	Q-Free ASA	NO
QFUEL.OL	Quantafuel ASA	NO
QLIRO.ST	Qliro AB	SE
QTCOM.HE	Qt Group Oyj	FI
RECSI.OL	REC Silicon ASA	NO
RENEW.ST	ReNewCell AB	SE
RIVER.OL	River Tech plc	MT
SAGAS.OL	Saga Pure ASA	NO
SAVOS.ST	Savosolar Oyj	FI
SCATC.OL	Scatec ASA	NO

SEMC.ST	Semcon AB	SE
SENS.ST	Sensys Gatso Group AB	SE
SEZI.ST	Senzime AB (publ)	SE
SHAPE.CO	Shape Robotics A/S	DK
SITOWS.HE	Sitowise Group Oyj	FI
SKAND.OL	Skandia Greenpower AS	NO
SLXIT.CO	Seluxit A/S	DK
SOLT.ST	Soltech Energy Sweden AB	SE
SOLTEQ.HE	Solteq Oyj	FI
STRLNG.ST	Swedish Stirling AB	SE
STRO.OL	Strongpoint ASA	NO
STWA.ST	SeaTwirl AB (publ)	SE
TECH.OL	Techstep ASA	NO
TIETO.HE	TietoEVRY Corp	FI
TLT1V.HE	Teleste Oyj	FI
TOBII.ST	Tobii AB	SE
TOM.OL	Tomra Systems ASA	NO
TRAD.ST	TradeDoubler AB	SE
UNIBAP.ST	Unibap AB	SE
UPSALE.ST	Upsales Technology AB	SE
VINCIT.HE	Vincit Oyj	FI
VOLUE.OL	Volue ASA	NO
VOW.OL	Vow ASA	NO
VWS.CO	Vestas Wind Systems A/S	DK
WPAY.ST	Westpay AB	SE
WSTEP.OL	Webstep ASA	NO
XMR.ST	XMReality AB (publ)	SE
YAYTRD.ST	Ytrade Group AB (publ)	SE
ZAP.OL	Zaptec AS	NO
ZAPLOX.ST	Zaplox AB	SE