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Equity Duration as a Risk Factor in the Norwegian Stock Market

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Abstract

This paper investigates the link between firms' book equity duration, changes in investment environment and financial performance in the Norwegian stock market. Low-duration firms are more exposed to reinvestment risk than high-duration firms in times of financial distress, and investors require excess return for exposure. We apply a portfolio strategy and Fama-MacBeth regression to estimate risk premium. We find no significant return in a long-short strategy, which holds in various robustness checks. Neither do we find any significant relationship between equity duration and macroeconomic changes, nor equity duration as a priced risk factor in the Norwegian stock market.

Preface

This master thesis is the final part of the Master of Science in Business program at Nord University in Bodø. This is an independent project within the specialization finance and investment, and amounts to 30 credits. The thesis is written in article form with a corresponding theoretical framework (cape). The reason for this is to provide the reader a quicker and better understanding of the main features of the content. Furthermore, English is used as a language for the sake of our supervisor and the simplicity of using words and expressions in finance. First, we would like to honor Oleg Nenadic for being an excellent supervisor. His competence and technical support has been very valuable for shaping our thesis. We also want to honor Irena Kustec for the expertise and key discussions throughout the semester.

The thesis follows the guidelines of The Review of Asset Pricing Studies [1]

Nord University, June 2, 2020

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[1] http://sfsraps.org/guidelines-for-submissions/

Sammendrag

Dette studiet ser på sammenhengen mellom selskapers durasjon på egenkapital, samt underliggende risiko og avkastning i det norske aksjemarkedet mellom 2003 og 2018. Vi ønsker å bidra med bevis for eller i mot empiriske funn som sier at det eksisterer en risikopremie hos selskaper med lav durasjon på egenkapital. Videre ønsker vi å støtte opp under litteraturen som forsker på systematiske risikopremier. Beregningen av durasjon har som formål å reflektere forskjell i risiko mot makroøkonomiske trender. Vi anvender en porteføljestrategi ved bruk av Carhart (1997) og Fama-MacBeth (1973) regresjoner. Ut ifra dette finner ingen signifikant meravkastning hos porteføljer som inneholder selskaper med lav durasjon på egenkapital mot selskaper med høy durasion. Analysen viser ingen signifikant sammenheng mellom lav-durasjonsselskaper og makroøkonomisk utvikling, og vi finner heller ikke at forskjeller i selskapers durasjon på egenkapital er en priset faktor i det norske markedet.

Contents

List of Tables

List of Figures

Cape

1 Theoretical frameworks

The following chapter describes the theoretical frameworks used as the foundation for the paper.

1.1 Portfolio management

The purpose of portfolio management is adjusting assets in a portfolio to minimize risk while simultaneously maximizing expected return. This adjustment is usually based on several factors such as portfolio size, risk tolerance, investment goals and time horizon. A portfolio should be constructed on the basis of the investor's specific goals, needs and risk profile (Snopek, 2012).

The idea of portfolio management is to distribute assets in different categories, so they do not react equally to the market. Doing so reduces the portfolio risk. Ideally one wants a combination of companies that are low and/or negative correlated, depending on the desired level of risk. This is called diversification. Even the most diversified portfolios are not able to fully eliminate risk, measured as standard deviation (or variance). A portfolio's standard deviation reduces when more companies are included. Risk that can be eliminated by diversification is called unsystematic risk. The remaining risk after diversification is called market risk or systematic risk (Beja, 1972). Total risk is the sum of systematic and unsystematic risk.

1.1.1 Modern portfolio theory

Modern portfolio theory examines how to optimize the expected return in a portfolio given the degree of risk involved. Markowitz (1952) introduces the framework in his article *Portfolio Selection*. By constructing a portfolio of assets, investors can maximize the expected return given the preferred risk. Hence, *diversifying* a portfolio with low or negative correlation, a risk averse investor can eliminate much of the risk exposed from market. Markovitz argues that one should consider the risk of the portfolio rather than the risk of a single asset.

By calculating the variance of several assets as a measure of portfolio risk made it possible to quantify the impact of removing the unsystematic risk from the market through diversification (Bodie, Kane, & Marcus, 2018). Portfolio return is given by:

$$E(R_p) = \sum_{i=1} w_i \cdot E(R_i) \tag{1.1}$$

Where $E(R_p)$ is the expected return of a portfolio, w_i is the share of assets in the portfolio and $E(R_i)$ is the expected return for a given asset. Portfolio risk is given by the portfolio variance:

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j Cov(r_i r_j) \tag{1.2}$$

Where σ_p^2 represents variance of expected return in a given period and $Cov(r_i r_j)$ is the covariance between the assets. Since portfolio risk is given by its variance, the model can measure the optimal expected return for any given level of risk. Constructing portfolios this way is called efficient portfolios, and can be visualized graphically in Figure 1:

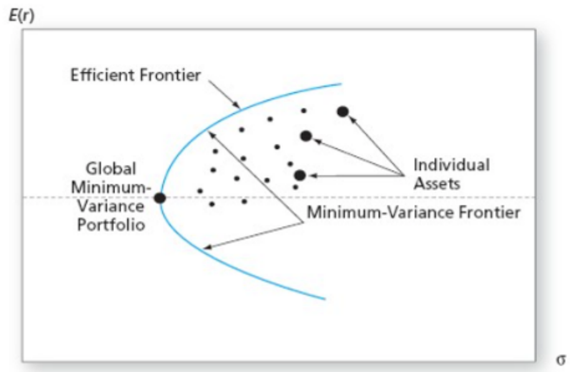

Figure 1: The minimum-variance frontier of risky assets

Figure 1 illustrates the trade-off between risk and return. Every unit of additional return $E(r)$ will involve a change in risk σ. Calculating the two relations together gives the expected return per unit of risk, called risk-adjusted return. The frontier that lies above the global minimum variance portfolio is called the efficient frontier of risky assets (Bodie, Kane, & Marcus, 2018). For any portfolio on the lower portion of the minimum-variance frontier there is a portfolio with the same risk and a greater expected return. Hence, the bottom part of the minimum variance frontier is inefficient.

1.2 Factor models

The Modern Portfolio Theory is the foundation of factor models. The theory is based on the mean-variance portfolio model, adapting the same ideas of risk and return.

1.2.1 The Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) explains how market risk in a portfolio affects expected return. The model is developed by Treynor (1962), Sharpe (1964), Lintner (1965) and Mossin (1966), and is explained by the following equation:

$$E(R_p) = r_f + \beta_i * [E(r_m) - r_f] \tag{1.3}$$

$E(R_p)$ is the expected return of the portfolio. Risk-free rate is represented by r_f, and reflects the achievable return without any risk involved. Expected excess market return is given by $[E(r_m) - r_f]$, called market risk premium. β_i is the sensitivity of expected return of an asset relative to the expected market return. A greater sensitivity with respect to the market factor, represented by higher beta, is associated with higher expected return. The portfolio is composed of a combination of risky assets and a risk-free asset, and the only way to achieve higher return in the model is to take on more risk. Hence, CAPM explains the amount of risk premium $(r_m - r_f)$ required to invest in an asset with additional risk.

Main assumptions of the CAPM:

i) No transaction costs, taxes, or problems with indivisibilities of assets.

ii) Investors evaluate investments according to expected return and risk.

iii) The capital market is always in equilibrium.

iv) All investors share the same expectations.

v) Every investor has the opportunity to borrow at a risk-free interest rate.

The CAPM considers a situation where a risk-averse investor borrows at a risk-free rate (r_f) in order to secure a given return on the portfolio. Investments need to generate higher return than the risk-free rate in order to be considered as a reasonable alternative. The risk level is reflected in the beta, where a higher number represents higher return at the expense of more risk relative to the market. The model is demonstrated graphically in Figure 2 below:

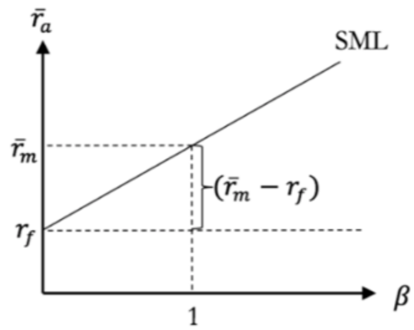

Figure 2: Capital Asset Pricing Model

The Security Market Line (SML) graphically illustrates the CAPM and demonstrates the relationship between a given a risk level (β) and the expected return (r). The model assumes expected return on two assets to be linearly tied to their covariance of market return with the portfolio return. A beta equal to 1 means that expected return of the portfolio equals the expected market return.

Even though the CAPM is highly influential in the financial literature, the model is still subject to criticism. Along with the assumptions mentioned above, it also considers beta to be stable over time, equal lending and borrowing rate and existing risk-free investments in the market (Rossi, 2016). Studies points out that the risk in different assets varies over time and make historical beta unstable as estimate for future risk. The model does not assume default of treasury bond rates that is usually categorized as risk-free, and it does not adjust for inflation which makes the actual return inaccurate.

1.2.2 Intertemporal Capital Asset Pricing Model (ICAPM)

ICAPM is an extension to the CAPM, introduced by Merton (1973). *Intertemporal* refers to investment opportunities over time. It considers investors to participate in markets for multiple years, unlike the *static* CAPM explained in chapter 1.2.1. Since investment opportunities change over time with the change in risk, situations occur where the risk-averse investor may consider hedging its portfolio. The ICAPM is therefore useful in the sense that it can forecast future market conditions.

The intuition is as follows (Cooper & Mayo, 2016): If asset i forecasts a decline in expected market returns, it pays well when the future market return is lower than average, because it is positively correlated with investment opportunities which in turn is negatively correlated with the future aggregate return. Hence, asset i provides a hedge against adverse changes in future market returns for a risk-averse investor and should thus earn a negative risk premium. The opposite relation occurs when future investment opportunities are measured by the second moment of aggregate returns.

If asset i forecasts a decline in future stock volatility (risk), it delivers high returns when the future aggregate volatility is also low. Assuming a multi-period risk-averse investor, such asset does not provide a hedge for changes in future investment opportunities and should therefore require a positive risk premium. Merton interpret the ICAPM by the following equilibrium relation between risk and return (Cooper & Maio, 2016):

$$E(R_{i,t+1} - R_{f,t+1}) = \gamma Cov(R_{i,t+1}, RM_{t+1}) + \gamma_z Cov(R_{i,t+1}, \tilde{z}_{t+1}) \tag{1.4}$$

Where $R_{f,t}$ is the risk-free rate, $E(R_{i,t+1})$ is the n x 1 vector conditional mean of stock returns R_{t+1} at time t+1, RM_{t+1} is the market return, and z_{t+1} is a vector of k state variables that shift the investment opportunity set. $Cov(R_{i,t+1}, RM_{t+1})$ + γ_z is the expected covariance between R_{t+1} and RM_{t+1}, meaning the covariances are conditional on information available at the time the assets are evaluated.

Where $\tilde{z}$ denotes the innovation in the state variable z, and γ_z denotes the corresponding risk price, given by Equation (1.5):

$$\gamma_z \equiv -\frac{Jw_z(W,z,t)}{Jw(W,z,t)} \tag{1.5}$$

Where Jw is the marginal wealth and Jw_z represents the change in marginal value of wealth with respect to the state variable. γ_z can be interpreted as a measure of aversion to intertemporal risk. Since Jw is always positive, it follows that the sign of Jw_z determines the sign of the "hedging" risk price. If the state variable z forecasts an improvement in future investment opportunities, the marginal value of wealth declines. The reason is that an improvement in future investment opportunities represents good times, and thus a lower marginal utility for wealth (Cooper & Maio, 2016). Based on this analogy, Merton argues that investors can charge a risk premium for stocks that show a strong positive correlation with the investment environment.

1.2.3 Arbitrage Pricing Theory (APT)

Ross (1976) establishes the APT as an alternative to CAPM. He finds it unreasonable that systematic risk is only found by the beta against a broad market index. The idea is that investors have subjective portfolio risk and thus several betas are necessary to consider. By deriving into n factors one can study these assumptions as predictors for expected return. The model is assumed linear and can be interpreted as Equation (1.6) shows:

$$r_a = r_f + \beta_1 f_1 + \beta_2 f_2 + ... + \beta_n f_n \tag{1.6}$$

Where the asset return (r_a) depends on the risk-free rate (r_f), the sensitivity of asset n's return to factor (β_n), and the risk premium to factor f_n. This captures the idea that variables affect the return on an asset in two steps. First, each factor is determined (e.g. inflation or GDP). Secondly, beta coefficients for each factor, β_n are determined.

By assuming a sufficient amount of assets, it is possible to diversify and thus remove unsystematic risk. The model assumes a functional market with no lasting arbitrage opportunities. As opposed to the CAPM, the APT model captures a broader array of factors and are more flexible and usable in its assumptions.

1.2.4 Smart beta investment portfolios

A trend within portfolio management is called *smart beta portfolios*, a collective term of different investment strategies that aims to improve risk-adjusted return. Its reasoned by scientific studies of factors that have historically given a risk premium. Smart beta investment portfolios offer the benefits of both passive and active strategies, hence placing it in the intersection of the efficient markets hypothesis and factor investing.

Fama and French (1993) introduce the Fama-French three-factor model to solve the anomalies surrounding the CAPM, especially because it does not consider other factors than the market beta. A paper published in 1992 studies stocks at the New York Stock Exchange and NASDAQ in the time period 1962-1989 and finds company size and value give a more significant correlation as opposed to the market beta. On the basis of these findings they develop a three-factor model as an extension to CAPM, where expected return in any risky asset can linearly explain three independent variables; return on market portfolio (CAPM), excess return of small capitalization companies over large capitalization companies (SMB) and the excess return on value stocks over growth stocks (HML). Fama and French (1993) later demonstrate that when adding the size and value factors, the model's explanatory power rises substantially and thus give a more accurate model measure of excess returns. The model is given by:

$$R_{it} = \alpha_i + \beta_{iM} R_{Mt} + \beta_{iSMB} SMB_t + \beta_{iHML} HML_t + e_{it} \tag{1.7}$$

Where $R_{i,t}$ is the portfolio excess return at time t and α_i is the abnormal risk-adjusted return. SMB is the average return on a portfolio with small stocks minus the average return on a portfolio with large stocks. HML is the average return on a portfolio of stocks with high book-to-market value minus average return on a portfolio of stocks with low book-to-market value.

The SMB factor captures the excess return from small companies against large companies because small companies tend to generate higher return than large companies. The factor risk emerges as small firms are more exposed to financial trouble, which in turn helps the model to capture the sensitivity of macroeconomic risk. The intuition behind HML is that companies with a high price relative to their book value has larger risk. Fama and French (1993) argue that these two factors may explain or be explained by other unknown variables (Bodie, et al., 2014).

Carthart (1997) creates the four-factor model and introduces the momentum factor. Jegadeesh and Titman (1993) demonstrate that stocks performing good (bad) in a period will continue performing good (bad) the next period. Momentum in a stock can thus be described as the tendency for the stock price to continue rising if it is going up and to continue declining if it is going down. Using this factor in favor of buying historical *winners* one can achieve excess return. The factor is calculated by subtracting the average lowest performing firms from the average highest performing firms, lagged one month.

Another addition to the three-factor model is the liquidity factor, introduced by Pastor and Stambaugh (2003). Liquidity is the ability to quickly sell large quantities of securities without being affected by the price and large selling fees. It is usually categorized in four dimensions; volume, time, cost and flexibility. They find that stocks that are more sensitive to aggregate liquidity have substantially higher risk-adjusted return. Thus, the investor needs compensation for investing in less liquid stocks.

1.2.5 Marcoeconomic state variables

Petkova (2006) argues that the Fama-French three-factor (FF3) model does not satisfy a suitable proxy when forecasting future investment opportunities. By a vector autoregressive model (VAR, which will be explained later in the chapter), Campbell (1996) uses innovations in the Treasury bill rate, a term spread, a default spread and Treasury bill yield to better explain the cross-section of average returns. Findings show that when these variables are included in the forecasting model, SMB and HML lose their explanatory power in the cross section of stock returns. From a similar methodology, Petkova (2006) reaches the following conclusions:

i) a model using these innovations performs better than the FF3 model in explaining cross- sectional differences in asset returns;

ii) a model using the innovations in the SMB and HML factors and in predictive variables performs better than the FF3 model, and the innovations in SMB and HML are not statistically significant;

iii) the innovations in predictive variables are priced and the risk premiums are sizeable and significant.

Previous findings do not give a clear consensus that changes in macroeconomic variables significantly affects the return in the stock market (Skjeltorp et.al, 2008). It might be due to the difficulty in capturing variations in fundamental economic conditions in a precise manner. Stock markets can be the driving force for the macroeconomy and not the other way around. Furthermore, stock markets are based on expectations, and news will reflect the stock market before they are captured by macroeconomic variables.

Examples of state variables from the literature are cyclical variables such as dividend yield, credit spread (yield difference between bonds with similar maturity but different credit quality) and term spread (yield difference between bonds with different maturities)(Chen, Roll and Ross, 1986; Fama, 1990). Changes in spreads can affect companies' cash flow and cause changes in investment opportunities. Other state variables related to expected cash flows are industry production, unemployment rate, consumption, import and export and inflation. Changes in inflation expectation may affect future investment opportunities because of its effect on the interest rate. Moreover, money supply affects the liquidity in the financial markets because increased liquidity can affect the discount factor through a reduced pressure on the interest rate. The choice of state variables may vary depending on economic drivers that are distinctive for a given stock exchange. The Norwegian stock market may be uniquely more sensitive to the oil price than others.

1.3 The Efficient Markets Hypothesis

Kendall (1953) finds random changes in short term prices to be so large that any systematic effect will be overwhelmed, meaning that one cannot identify any predictable patterns in stock prices. In the following decade, economists like Fama (1965) find that stock prices follow a *Random Walk*, meaning that prices develop randomly and cannot be predicted. This lays the way for the Efficient Market Hypothesis (EMH) which Fama (1970) develops further.

EMH is the idea that stock prices reflect all current information available in the market. The implication of this is that stocks always trade at fair value, making it impossible to purchase undervalued stocks or sell at a premium. Investors can therefore not outperform the overall market by adjusting portfolio weights or make transactions at what would be considered at a preferable timing. The only way to beat the overall market would be to purchase riskier assets. The hypothesis points out that the only thing that can affect the future asset price in any meaningful way is the emergence of new information. EMH follows the assumptions of a perfect market, with rational investors, no transaction costs and information free of charge.

Fama (1970) describes three forms of market efficiency; weak, semi-strong and strong. Weak form of market efficiency appears when asset price reflects the information available from general market data, like historical prices and trading volume. The semi-strong form builds upon the weak form of market efficiency, assuming that asset prices reflect all information that is publicly available and used in computing the price of an asset. Investors can therefore no longer gain an advantage in their trading strategy by analyzing fundamental economic factors. Due to these assumptions, advocates of semi-strong market efficiency believe that only those with insider information can achieve excess yields. The strong form is concerned with whether individual or groups of investors have monopolistic access to information. Here, all information, both public and private, is considered to be accounted for in the price of an asset. Therefore, there is no way for the investor to gain any advantage in the market. This form of market efficiency is not expected to be a good fit in the real world and shall therefore be viewed as a benchmark which can be used to judge deviations from market efficiency (Fama, 1970).

The Efficient Markets Hypothesis receives criticism on multiple points. Behavioral economists study why investors make irrational errors when the underlying theory states that the investor should act rationally. Lim and Brooks (2011) state that the rationality of real investors is bounded by biases, heuristics, and other cognitive limitations, resulting in them being generally too loss averse or over-confident in their skills and over-optimistic about future returns. These statements contradict the assumption of perfect markets.

The January Effect is a hypothesis which suggests there is a seasonal anomaly in the financial market, where the stock prices increase more in the month of January than the rest of the year. Keim (1983) and Konak and Çelik (2016) find this to be true in the US and Middle Eastern markets. This implies an inefficient market, which is a direct contradiction to the Efficient Market Hypothesis.

1.4 Active versus passive portfolio management

A portfolio can be managed actively or passively. Actively managed portfolios attempt to create excess returns in the market or a given benchmark index. Investment decisions are usually based on market research, forecasting and the manager's own expertise. Passively managed portfolios will attempt to track or copy a specific benchmark portfolio to get similar returns. Specifically, a manager creates a portfolio consisting of similar weights on the same stocks and securities as the benchmark portfolio. These two approaches to portfolio management have different views on the hypothesis of efficient markets.

In active portfolio management there is an underlying assumption that the market is not efficient, because the investor is actively attempting to beat the benchmark. Using analyses of fundamental factors, investors attempt to find opportunities of arbitrage and mispricing of assets in the market to gain excess returns. Beating the benchmark is both an expensive and difficult process after costs are taken into consideration.

Passive portfolio management is based on the hypothesis that markets are efficient. Since the EMH states that prices are instantly reflected by the current information available in the market, stock prices will always be traded at fair value. Assuming this to be the case, a trading strategy for the investor can simply be to invest in a diversified portfolio with minimal investment costs. A passive investment strategy can give higher returns than the active investment strategy because the costs of passive management is low in comparison to active portfolio management, as there is no need to pay for analyses and forecasts.

The core-satellite investment strategy is a combination of active and passive portfolio management. The goal is to minimize costs and risk while still providing an opportunity to outperform the market. The *core* of the portfolio consists of passive investments and is the highest weighted part of the portfolio. *Satellite* investments are the actively managed investments with low correlation to the core, reducing the risk of the investments. Portfolio managers use satellite investments to create higher returns than the core investments, while the core investments provide stability through consistent performance, making it easier to focus on the satellite investments. Depending on the investment objectives, the weights of passive and active investments may be adjusted.

1.5 Index

An index is a composition of securities that represents a market, industry, sector or similar. The aim is to quantify the movements in the given index in order to represent the true risk-reward profile on underlying securities. Categorizing assets into indexes is a practical approach, because it is easier to compare investment alternatives (Sutcliffe, 2006). It also plays a prominent role in portfolio management where performances on active portfolios are measured and judged against its benchmark.

1.5.1 Weighting

Traditionally, weighting companies in an index is based on market capitalization but this varies across indexes depending on its influence. Ordering by higher weighting on securities with the larger market capitalizations may give the best representation as these have greater influence in the economy.

Liquidity-based market capitalization is another weighting measure among indexes. It works similar by ordering into market capitalization, except excluding those securities that is not available for selling and buying. The Norwegian indexes OSEBX and OBX are both liquidity-based. Norges Bank (2014) argues that having tradeable companies in the index gives a better representation of the market. Seifried and Zuft (2012) argue that such adjustment causes a significant lag that gives a wrong picture of the relative market value to companies in the index.

By multiplying the market price of the share with the number of shares outstanding, one gets the market value of the company. The market value is then divided by all the companies in the index, which gives the weighting of the company:

$$W_i = \frac{q_i \cdot p_i}{q_1 \cdot p_1 + q_2 \cdot p_2 + ... + q_n \cdot p_n} \qquad W_i = \frac{MCAP_i}{\sum_{j=1}^{n} MCAP_j} \tag{1.8}$$

Where $MCAP_i$ is the market capitalization of company i, $\sum_{j=1}^{n}$ is the sum of market capitalization of all companies, q_i is the amount shares for company i, p_i is the price per share for company i. Hsu (2014) has four main reasons behind market capitalization:

i) Weighting based on market capitalization does not require active management and thus has none or low costs.

ii) Portfolios are balanced automatically as prices are changing.

iii) The highest weights are assigned the largest companies, and since market capitalization is highly correlated with liquidity the portfolio will consist of liquid shares and reduces transaction costs.

iv) A market capitalized portfolio will be mean-variance optimal, given the interpretation of the Capital Asset Pricing Model (CAPM).

Recent research addresses weaknesses around the assumption that market capitalization is the most effective index allocation (Arnott et al., 2005), and it is an ongoing discussion whether one can have a

more optimal allocation. Price-based weighting categorize into price per share, where those with the highest price gets a higher weighting. Such weighting gives many of the same issues as with market capitalization, where companies can become overpriced in the market.
Equal weighting is another method, where every company gets identical weighting and influence on the index. This is for instance used to avoid concentrations of a very few companies. A downside is that it does not capture the benefits with the traditional market capitalization. Another issue is that small and medium companies are more volatile and less liquid, which increase the uncertainty.

1.5 Factor investing

There are generally three types of return; exposure to market risk, exposure to known factors and alpha (ability to create excess return). Blitz (2015) finds little evidence that active portfolio management gives excess return against market return, a possible reason why investors prefer low cost market indexes. The literature implies however, that the investor is compensated from stocks with higher risk. Similar to the CAPM, investors are rewarded a *risk premium* for the total market risk exposure. In recent years, several other factors have also proven to give a risk premium.

This has given a lot of interest around factor investing, which can be defined as an attempt to capture systematic risk premiums. Factors are usually studied using datasets that sometimes span very long time periods. Hsu et al. (2015) recommend applying factors that lasts over time and are significant in several countries. Baltussen et al. (2019) find high level of persistence among several factor premiums, with convincing evidence of most factor premiums studied across almost every decade. This undermines the idea that a diversified multi-factor portfolio can deliver stable returns over time.

Factor investing can thus be categorized in the intersection between active and passive management. Its neither a pure passive nor active strategy, but rather an active selection of factors that one believes drives the economy. The investor can systematically select companies with high exposure against the given systematic factors. Such strategy can be implemented and adjusted in the preferred mix between active and passive management, and the economic grounded factors are the basis for the investments rather than subjective analysis of stocks. By adding such risk factors into the existing market risk, the goal is to generate higher long-term return. In the following section we will explain the most influential factors from the literature.

1.5.1 Size

Banz (1981) finds a strong relationship between stock performance and the size of companies. After analyzing stock market data from New York Stock Exhchange (NYSE), he finds small stocks to generate higher risk-adjusted return than large stocks.

Klein and Bawa (1977) make a possible explanation of the firm size effect by stating that investors do not want to hold small stocks because of limited information among these companies. Risk-averse investors prefer to invest in those securities with the most information. In line with the Efficient Market Hypothesis, the market is therefore more likely to capture the true value of large stocks. The demand for small stocks is lower, which means that there are less bids for these in the market. Once the market recognizes the true value of a stock, the price adjusts. Size as a risk premium is thus reasonable, given the fact that the investor needs compensation for owning an illiquid stock.

1.5.2 Momentum

Momentum in a stock is the tendency for the stock price to continue its previous development in the market. A momentum strategy involves predicting future development based on historical information, assuming the trend to continue.

Momentum strategies generate substantial return on paper and constitute an apparent violation of the Efficient Market Hypothesis in its weak form (Fama, 1970). Behavioral theories explain momentum according to investors over- or underreactions. Hong and Stein (1999) argue that information on a stocks fundamental value diffuses only gradually into the market. Jegadesh and Titman (1993) find that the American stocks performing best (worst) over a 3-12 months period tend to continue to perform best (worst) over the coming period. These findings undermine the strategy of buying winners and selling losers in the financial markets (long-short strategy).

1.5.3 Low volatility

Empirical support for the outperformance of low-volatility portfolios is robust across time and countries (Chow, Hsu, Kou, & Li, 2014). Since much of the financial theory argue for the compensation for taking risk, the fact that less volatile has given better risk-adjusted return has challenged Markowitz's theory explained in chapter 1.1.1. Haugen and Heins (1972) show that stocks with low volatility returns subsequently outperform stocks with high volatility returns.

1.5.4 Liquidity

Liquidity is the ability to trade large quantities quickly at low cost with little price impact. This includes four liquidity dimensions – trading quantity, trading speed, trading cost and price impact. Researchers examine the importance of liquidity over the past decade, but only recently on liquidity risk. Recent studies try to examine the role liquidity plays in order to explain asset prices. According to Lustig (2001), the average investor wants higher return on stocks to compensate for liquidity risk because of low stock returns in recessions. Pastor and Stambaugh (2003) construct their measures based on the concept of price impact to capture the price reaction to trading volume.

1.5.5 Value

In general, investing in value stocks means buying at a market value which is lower than the associated fundamental value of the company. Value investing is thus closely related to fundamental analysis and is based on the idea that every investment has an intrinsic value (Petrusheva & Jordaniski, 2016). One of the main principles of value investing is that, in the short-term, stock price and intrinsic value of a company will not be in equilibrium but will be equalized in the longer run and rise/lower the market value.

Basu (1977) and Rosenberg et al. (1998) demonstrate that stocks with low price-to-earnings (P/E)-

ratio have excess return over a long time period in the stock market. Sharpe (1993) and Lakonishok (1991) find strong a relationship between the ratio called book-to-market and stock return. Merton (1973) and Fama (1992) state that such excess return happens as a compensation for risk. According to Lakonishok et al. (1994), the value premium arises because the market undervalues value stocks and overvalues growth stocks. Over time, these errors are corrected, resulting in a lower expected return for growth stocks and higher expected return for value stocks.

1.5.6 Equity duration

Basu (1977) finds a possible anomaly to the value premium because it does not give a compensation for the shares systematic risk exposure as implied by the CAPM (Sharpe, 1964; Lintner, 1965). Lakonishok et al. (1994) find little evidence that high book-to-market and high cash flow-to-price stocks are riskier when considering the original approach to systematic risk.

Recent studies introduce a new risk factor linking a firm's equity duration as a risk premium and suggest that cross-sectional differences in companies' cash flow pattern play an important role in explaining the value premium (Campbell and Voulteenaho, 2004; Letteau and Wachter, 2007). Companies that pay out a large fraction of their cash flows in the near future not only tend to exhibit high book-to-market ratios, but they are also more exposed to aggregate cash flow shocks. Thus, the value premium is rather a cash flow risk premium. In the following section we will address the theoretical consideration of equity duration.

Equity duration closely follow the theory of bond duration (Macaulay, 1938) and is estimated as a shares price sensitivity to changes in the discount rate. Duration in equity is the length of time required for cash flows from an asset to fully repay the initial investment. It is more formally described as a measure of an assets time horizon based on the present value-weighted average time to receipt of income or principal (Leibowitz, Sorensen, Arnott, & Hanson, 1989). Equity duration can be demonstrated by the following elasticity (Mohrschladt & Nolte, 2018):

$$D_t^k \equiv -\frac{\partial P_t^k / P_t^k}{\partial d_t^k / d_t^k} \tag{1.9}$$

Where D_t^k is the discount factor of asset k at time t, which is assumed to be the same for all maturities. P_t^k is the price of stock k at time t, which equals the expected cash flows CF_i^k:

$$P_t^k = \sum_{i=t+1}^{\infty} E_t(CF_i^k)/d(d_t^k)^{i-t} \tag{1.10}$$

Plugging in the equations for duration and stock price yields:

$$\frac{\Delta P_t^k}{P_t^k} - \frac{\partial P_t^k}{\partial t} \cdot \frac{\Delta t}{P_t^k} = \beta_{MCF}^k \cdot MCF_t + FCF_t^k - D_t^k \cdot \frac{\Delta d_t^k}{d_t^k} \tag{1.11}$$

The left side of the equation reflects the difference between stock return and expected stock return. The difference appears because of market-wide (MCF) and firm-specific (FCF) changes in cash flow expectations. β_{MCF}^k measures the cash flow dependence of firm k on the MCF-factor. Increasing MCF discount rates have a negative effect on the price. The extent of this effect increases the stocks equity duration.

Changes in discount rates can be connected to changes in the investment opportunities. For firms, improved investment opportunities rise the demand for capital, which in turn rises the capital costs and discount rates. For the investor, improved investment opportunities result in higher opportunity costs, which is compensated with higher expected returns. Thus, low expected returns results in a weaker investment opportunity set. In line with Merton's (1973) ICAPM framework, investors charge a risk premium on stocks that are positively correlated with investment opportunities. Hence, stocks with a strong positive correlation on $\frac{\Delta d_t^k}{d_t^k}$ should have a higher expected return. In accordance with Equation 1.9, stocks with high equity duration should have a lower expected return because they hedge against negative investment opportunities.

More studies point out that low-duration stocks on average yield higher returns than high-duration stocks (Weber, 2018; Mohrschladt & Nolte, 2018). At the same time, low-duration firms generate mainly short-run cash-flows and thus face a larger reinvestment risk making these more positively dependent on the investment opportunity set. This positive loading on the investment environment implies comparably higher expected return.

The theoretical consideration in this paper considers the timing of future cash flows to estimate the Macaulay equity duration. Transforming Equation 1.10 with respect to discount rate gives:

$$\frac{\partial P_t^k}{\partial d_t^k} = \sum_{i=t+1}^{\infty} E_t(CF_t^k) \cdot (d_t^k)^{t-i-1} \cdot (t-i) \cdot \frac{\partial E_t(CF_i^k)}{\partial d_t^k} \cdot (d_t^k)^{t-i} \tag{1.12}$$

Applying the definition of duration in Equation (1.9) leads to:

$$D_t^k = \sum_{i=t+1}^{\infty} \frac{E_t(CF_i^k) \cdot (d_t^k)^{t-i} \cdot (i-t)}{P_t^k} - \sum_{i=t+1}^{\infty} \frac{\partial E_t(CFi^k)}{\partial d_t^k} \cdot \frac{(d_t^k)^{t-i+1}}{P_t^k} \tag{1.13}$$

The first sum of Equation (1.13) reflects the timing of the following cash flow. The second sum reflects the sensitivity of cash flows with respect to discount rate changes. Including both estimates make it possible to interpret the model according to ICAPM, which is explained earlier in the chapter. Dechow et al. (2004) and Weber (2018) do not consider cash flow sensitivity to discount rate changes, which may avoid some key explanatory variables.

Mohrschladt and Nolte (2018) introduce a new balance sheet-based methodology for measuring equity duration, which intends to explain a firm's exposure to changes in discount rates and macroeconomic state variables. Their findings suggest that low-duration firms face stronger reinvestment risk, while high-duration firms experience increasing present value as discount rates decrease from a worse investment environment. The methodology consider the duration of assets and liabilities at time t. The the intersection between duration of assets and labilities can be explained by (Skinner, 2004): when a firm's duration on assets become larger relative to duration on liabilities, assets lose more value than liabilities when interest rates rise. This results in a reduced value of the firm's equity. If the interest rates fall, the value of firm equity rises as assets gain more value than liabilities. On the contrary, as a firm's duration on assets become smaller relative to duration on liabilities and interest rates rise, liabilities lose more value than assets. This will in turn increase the value of the firm's equity. If interest rates decline, liabilities gain more value than assets and decreases the value of the firm's equity.

Measures of duration based on forecasted future cash flow cannot be used as hedges against changes in the investment environment. Timing of future cash flows overstates the true duration value in firms with high duration on cash flows because they are considered more dependent on changes in the investment opportunity. Mohschladt and Nolte (2018) therefore consider the duration of a firm's assets and liabilities at time t, which in turn reflects the dependency on the investment environment set.

Some challenges are addressed regarding the use of duration as a measure for equity. Changes in macroeconomic fundamentals such as interest rates may have a little impact on equity prices compared with other factors. Cornell (1999) argues that equity discount rates included unobservable expected inflation, real rates and risk premiums that can affect equity growth rates differently. Other challenges are that equities have include variable cash flows, no maturity date, embedded options, and discount rates that are difficult to model (Broughton & Lobo, 2014).

1.6 Performance measures

1.6.1 Jensen's alpha

Jensen's Alpha, from Michael J. Jensen (1967), is a risk-adjusted portfolio performance that estimates how much a manager's forecasting ability contributes to the funds return. The measure is based on the Capital Asset Pricing Model, where the alpha reflects the abnormal return relative to CAPM. The model is illustrated as following:

$$r_{i,t} - r_f = \alpha_i + \beta_i(r_{m,t} - r_{f,t})\varepsilon_{i,t} \tag{1.14}$$

Where $r_{i,t} - r_{f,t}$ is the abnormal portfolio return relative to the theoretical expected return (CAPM). β_i

is the portfolio beta. $r_{m,t}$ is the market return, and $r_{f,t}$ is the risk-free rate. Deviations in the expected return from CAPM is considered abnormal, reflected by the alpha symbol (Jensen,1969). The measure is therefore commonly used when measuring the true performance of a portfolio.

1.6.2 Treynor ratio

The Treynor ratio is a risk-adjusted indicator that combines return and risk in one single value. The model is named after Jack L. Treynor (1965). The ratio gives the excess return per unit of systematic risk (beta):

$$T_p = \frac{r_p - r_f}{\beta_p} \tag{1.15}$$

Where r_p is the return on portfolio, r_f is the risk-free rate and β_p is the portfolio beta. Excess return is the difference between portfolio return and the risk-free return. It is useful to evaluate the quality rather than the quantity of the returns of a fund, and its often used as a measure of performance relative to other portfolios.

1.6.3 Sharpe ratio

The Sharpe ratio compare the portfolio return in excess of a risk-free rate with the volatility of the portfolio return. Sharpe (1966) demonstrates a performance measure on how well a portfolio return compensates the risk. The ratio gives excess portfolio return per unit of total risk (standard deviation), given the following formula:

$$S_p = \frac{r_p - r_f}{\sigma_p} \tag{1.16}$$

Where S_p is the Sharpe ratio of the portfolio, r_p is the portfolio return, r_f is the risk-free rate and σ_p is the standard deviation of the portfolio. Similar to the Treynor ratio, the Sharpe ratio is based on historical data.

1.6.4 Information ratio

The Information ratio measures the ability to give return above the benchmark portfolio, usually an index. It compares the *active return* from a portfolio relative to a given benchmark portfolio with the volatility of the active return, called *active risk*. The ratio therefore keeps track of how good the portfolio performs relative to the return and risk. The information ratio is given by:

$$IR = \frac{r_p - r_m}{\sigma_{p-m}} \rightarrow \frac{\alpha_p}{\sigma_{p-m}} \tag{1.17}$$

Where $r_p - r_m$ is the difference between portfolio return and index return (excess return) and σ_{p-m} is the standard deviation of excess return. It can either be a measure of historical or a realized active return and risk. In more formal distinction between active portfolio return and alpha, active risk has a more exact beta-adjusted counterpart, which Grinold and Kahn (1999) call *residual risk*.

Sharpe ratio, Treynor ratio and Information ratio are usually measured annually.

1.6 Time series analysis

Time series analysis can answer quantitative questions where cross-sectional data is inadequate (Stock & Watson, 2015). An example is how a change in a variable X has a causal effect on variable Y over time, i.e. the dynamic causal effect on Y based on changes in X. Using time series data, one can also make forecasts of the future value of a given variable. Simple regression models can be used for forecasting, but do not necessarily need to have a causal interpretation: If you see someone carrying an umbrella, you might forecast rain, even though carrying an umbrella does not cause rain (Stock & Watson, 2015).

The assumption that the future characteristics (i.e. the variance) of the data will be like the past is an important consideration in time series analysis. This concern is called stationarity. Economic time series often consider non-stationary data, meaning that the characteristics of the development in the time series change over time. One reason for why non-stationarity occur is economic trends. Generally, one prefers stationary data due to its stability, making it easier to work with.

1.6.1 Fama-MacBeth two-step regression

Fama and MacBeth (1973) introduce the Fama-MacBeth model in the paper *Risk, Return, and Equilibrium: Empirical Tests*. The model is a way of testing how portfolio or asset returns are impacted by various risk factors, such as the well-known factors in the Fama-French three-factor model. The model aims to identify whether, and how much, we are exposed to a premium to the chosen factors.

In the first step of the process, factor exposure β to the risk factors $F_{j,t}$ are determined by regressing each asset or portfolio against m risk factors n times:

$$\begin{aligned}
R_{1,t} &= \alpha_1 + \beta_{1,F1}F_{1,t} + \beta_{1,F2}F_{2,t} + \cdots + \beta_{1,Fm}F_{m,t} + \varepsilon_{1,t} \\
R_{2,t} &= \alpha_2 + \beta_{2,F1}F_{1,t} + \beta_{2,F2}F_{2,t} + \cdots + \beta_{2,Fm}F_{m,t} + \varepsilon_{2,t} \\
&\vdots \\
R_{n,t} &= \alpha_n + \beta_{n,F1}F_{n,t} + \beta_{n,Fn}F_{n,t} + \cdots + \beta_{n,Fm}F_{m,t} + \varepsilon_{n,t}
\end{aligned} \tag{1.18}$$

Where $R_{i,t}$ is the return of asset or portfolio i at time t. n is the total amount of assets or portfolios. The βs describe how the returns are exposed to j of m total factors $F_{j,t}$ at time t.

To determine the risk premium for each factor, we perform a cross-sectional regression on all returns for a fixed period of time T against the betas that were estimated to the risk factors:

$$\begin{aligned}
R_{i,1} &= \gamma_{1,0} + \gamma_{1,1}\hat{\beta}_{i,F1} + \gamma_{1,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{1,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,1} \\
R_{i,2} &= \gamma_{2,0} + \gamma_{2,1}\hat{\beta}_{i,F1} + \gamma_{2,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{2,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,2} \\
&\vdots \\
R_{i,T} &= \gamma_{T,0} + \gamma_{n,1}\hat{\beta}_{i,F1} + \gamma_{n,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{n,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,n}
\end{aligned} \tag{1.19}$$

Where $R_{i,T}$ are the same returns as previously. γ are regression coefficients, which are used to compute the risk premium for each factor.

The final estimate of the exposure to factor risk premium is simply the average of the individual factor risk premia that were just computed. Similarly, the estimated error is the average of the errors in the individual time periods.

$$\hat{\lambda} = \frac{1}{T}\sum_{t=1} T\hat{\lambda}_t \qquad \hat{\varepsilon}_i = \frac{1}{T}\sum_{t=1}^{T} \hat{\varepsilon}_{i,t} \tag{1.20}$$

1.6.2 Autoregressive models

Autoregressive models are regression models that relates a time series variable, Y_t, to its past values, Y_{t-p} (Stock & Watson, 2015). We call the value of Y in previous periods for lags. The first lag of a time series Y_t is Y_{t-1}, and its p^{th} lag is Y_{t-p}. There are different orders of autoregression, depending on how many lags are used in the regression. First-order autoregression, abbreviated as AR(1), is a regression of a time series onto its own lag, Y_{t-1}, with only one lag being used. Using AR(1), we can make a linear model of Y_t with the following formula (1.21):

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + u_t \tag{1.21}$$

Where the β's are parameters, and u_t is an error term.

While AR(1) only takes the first lag into consideration, we may find it useful to base our analysis on information from the more distant past. One way to include this information is to use additional lags in the autoregression, which gives us the p^{th}-order autoregressive model. The number of lags, p, included in an AR(p) model is called the order of the autoregression, e.g. AR(2) would have two lags (Stock & Watson, 2015). Similar to the AR(1) model, we can make a linear estimate of Y_t with AR(p):

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \cdots + \beta_p Y_{t-p} + u_t \tag{1.22}$$

1.6.3 Autoregressive-moving average models (ARMA)

The autoregressive (AR) models can be extended with a *moving average* (MA) part, which attempts to capture shock effects (i.e. unexpected events) observed in the error terms. This is done by modeling the error term u_t as serially correlated, specifically as being a distributed lag of another unobserved error term (Stock & Watson, 2015). While the AR-model makes predictions based on previous values of Y, the MA-model makes predictions based on previous errors and the mean. The combination of the two models yields the autoregressive-moving average (ARMA) model. Where p is the order of the AR-part and q is the order of the MA-part, the ARMA(p, q) model can be written as:

$$Y_t = \beta_0 + \beta_1 Y_{t-1} + \cdots + \beta_p Y_{t-p} + u_t + \theta_1 u_{t-1} \cdots + \theta_q u_{t-q} \tag{1.23}$$

Here, the βs are autoregressive parameters, and the θs are the moving average parameters.

ARMA models has received criticism for being unstable and difficult to estimate. Due to its sensitivity, slight changes in parameter values or data sample size may have a great effect on the final estimates.

1.6.4 Autoregressive integrated moving average models (ARIMA)

The autoregressive integrated moving average (ARIMA) model is an expansion of the ARMA model and is influenced by George Box and Gwilym Jenkins in their 1970 book *Time Series Analysis: Forecasting and Control*. With the purpose of correcting the data set for stationarity, the ARMA model is expanded by including a differencing component. The expanded model is presented in the form of ARIMA (p, d, q), where the d represents the number of differencing transformations needed to reach stationarity. Differencing is a method of removing patterns in a dataset by looking at differences between values. The concept can be adapted using lag, which find how far apart two values are.

Since the only difference between ARMA and ARIMA is the differencing component, the two models will be equal for a stationary time series.

1.6.5 Vector autoregressive models

Popularized by Sims (1980), the use of vector autoregressions has become important tools for economic modeling and forecasting. A vector autoregression (VAR) is a set of k time series regressions, in which the regressors are lagged values of all k series (Stock & Watson, 2015). Rather than having a univariate autoregression, it is extended to a list, or vector, of time series variables. Sims (1980) argues that all explanatory variables can have an impact on the independent variables in a system. If we consider a case of supply and demand, then rather than only taking the demand of an item into consideration of pricing, the supply should also be included. If there is an expectation of limited supply in the future, then the demand should increase as people will want to prepare for an increase in price due to limited supply. This method of forecasting multiple variables in one model is useful because it can make the forecasts mutually consistent.

We get a system of equations called VAR(p) when the number of lags in each equation is the same and equal to p. If we consider a case of two variables, Y_t and X_t, the VAR(p) consists of the equations:

$$\begin{aligned} Y_t &= \beta_{10} + \beta_{11} Y_{t-1} + \cdots + \beta_{1p} Y_{t-p} + \gamma_{11} X_{t-1} + \cdots + \gamma_{1p} X_{t-p} + u_{ut} \\ X_t &= \beta_{20} + \beta_{21} Y_{t-1} + \cdots + \beta_{2p} Y_{t-p} + \gamma_{21} X_{t-1} + \cdots + \gamma_{2p} X_{t-p} + u_{2t} \end{aligned} \tag{1.24}$$

Where the βs and γs are unknown coefficients, and u_{1t} and u_{2t} are the error terms. VAR assumes that the conditional expectation of u_{1t} and u_{2t} are zero, given the past values of Y and X [that is, $E(u_t \mid Y_{t-1}, Y_{t-2}, ..., X_{1t-1}, X_{1t-2}, ..., X_{kt-1}, X_{kt-2}, ...) = 0$]. The random variables Y and X have a stationary distribution, and $(Y_t, X_{1t}, ..., X_{kt})$ and $(Y_{t-j}, X_{1t-j}, ..., X_{kt-j}$) become independent as j time between observations gets large. Additionally, it is assumed that large outliers are unlikely because X_{1t} through X_{kt} and Y_i have nonzero, finite fourth moments. Lastly, it is assumed to be no perfect multicollinearity (Stock & Watson, 2015). The coefficients of each equation in the VAR can be estimated using ordinary least squares.

1.6.6 Intersection between ICAPM, VAR and Fama-MacBeth

Petkova (2006) finds that the factors SMB and HML are correlated with innovations and variables that drives the investor investment opportunity set. She considers the Fama-French three-factor model as an ICAPM equilibrium model where HML represents duration risk and SMB represents distress risk. The empirical analysis of Petkova relies on Merton's (1973) ICAPM. Innovations in TERM spread, dividend yield, default, risk free rate, as well as HML and SMB are assumed to follow an first-order autoregressive AR(1) process. Fama and French (1989) find that positive shocks to the term spread signals bad innovations to the business cycle, which implies that value stocks are riskier than growth stocks in bad times. This means that value stocks experience higher expected returns in times of rising term spreads which causes HML strategies to lose money in recessions, when investors marginal utility is high.

The study by Petkova (2006) can thus be used as an example for understanding the Fama-MacBeth method for estimating the market prices of risk, following the same methodology as in chapter 1.6.1. The ICAPM suggests that the innovations mentioned above are risk factors which in addition to the market risk premiums affect firms return on equity. A t-statistic will tell if these factors are statistically different from zero.

While Fama and MacBeth (1973) suggest comparing the results to betas determined by a five-year rolling regression, Petkova (2006) find that estimating betas in a full sample provide the same results. The error-in-variables problem is addressed as an issue in the second step of the Fama-MacBeth regression. Shankens (1992) correction of standard errors is a method to adjust for overstated t-statistics. Campbell (1996) emphasizes that it is hard to interpret estimation results for a vector autoregressive model (VAR) unless the factors are orthologonalized and scaled. Petkova (2006) supports the suggestion and argue that this issue is solved by *triangualizing* the VAR system using the Gram-Schmidt orthogonalization.

2 Data

We study companies listed at Oslo Stock Exchange (OSE). Since the unit of analysis is the Norwegian stock market, we consider Oslo Stock Exchange Benchmark Index (OSEBX) as our proxy. The OSEBX contains a selection of stocks that are representative for all publicly listed companies at Oslo Stock Exchange. The data in our study includes all stocks that participate in the OSEBX during the period to ensure no survivorship bias. Our study take place in the time period between July 2003 and June 2018. Annual accouting data is linked to monthly stock returns from july$_t$ to june$_{t+1}$ to make sure that the information and reports are published before the return measurement. Monthly returns and balance sheet data are obtained from TITLON, a financial database offering data for stocks listed at OSEBX. We filter out abnormal returns; monthly return observations that increase more than 300% or decrease more than 50% are excluded from the dataset. Stocks that are traded below 5 Norwegian kroner (NOK) are treated as missing, due to large volatility driven by firms with low stock prices. We remove companies in sectors where the balance sheet does not allow for an appropriate measurement of duration. Similar to Fama & French (1992) we exclude firms in the financial sector, which includes banks, ETFs and other financials. In general, excluding financial firms is due to their high leverage, which is very different from other companies. Normal returns are chosen instead of logarithmic as it captures the "true" return change from the previous observation, and due to the fact that logarithmic return assumes continuous return. This is done by observing the percentage change between the last trading days in each month.

We use the Carhart (1997) four-factor model to analyze the excess return, which includes the variables excess market return (MKT), book-to-market ratio (HML), size (SMB) and momentum (MOM). We apply these factors in a regression to estimate the excess return, assuming it's possible to divide beta values into several factors to illuminate the risk. This makes it easier to draw conclutions on the exposure against the risk factors and the level of significance. The variables are drawn from Bernt Arne Odegaard's website[2]. These are constructed in the Norwegian market. According to Fama and French

[2] http://finance.bi.no/~bernt/financial_data/ose_asset_pricing_data/index.html

(2012), regional asset-pricing models perform better than global models.

In the end section we apply the Fama-MacBeth (1973) model to test whether our equity duration factor carries a significant return premium beyond the standard risk factors in the Norwegian stock market. We also construct a model where we investigate the relationship between equity duration and innovations in state variables, to support evidence for or against the idea that differences in firm equity duration reflects changes in the investment environment. We collect 10 year and 12 months Norwegian government bonds from Norges Bank[3]. Monthly oil prices are gathered from Quandl[4]. Lastly, we test whether equity duration as a risk factor is able to explain differences in average portfolio returns.

3 Methodology

3.1 Measurement of Equity duration

In order to examine the relationship between stock return and equity duration in the Norwegian stock market, we measure firm equity duration based on balance sheet data. Our approach and reasoning are largely inspired by Mohrschladt & Nolte (2018), Guedes & Opler (1996) and Stohs & Mauer (1996). In addition, we follow approaches by Thomas R. Robinson et al. (2015) and Sæther and Larsen (1999). We consider the duration of an asset portfolio as the weighted average lifetime of the individual assets. Unavailable data is replaced by the median value of the respective sector. For example, missing duration estimates from the company Equinor is replaced by the median of the Energy sector.

By subtracting total liabilities from total assets, we get the firm's book equity. Book equity duration is measured as the weighted average duration of assets and liabilities:

$$D(BE) = D(A) \cdot \frac{A}{BE} - D(L) \cdot \frac{L}{BE} \tag{1.25}$$

Where D(A) is the duration of total assets (A), calculated by cash (CS), current assets (CA), and tangible

[3]https://www.norges-bank.no/tema/Statistikk/Rentestatistikk/
[4]https://www.quandl.com/data/FRED/DCOILBRENTEU-Crude-Oil-Prices-Brent-Europe

and intangible assets (FA):

$$D(A) = D(CS) \cdot \frac{CS}{A} + D(CA) \cdot \frac{CA}{A} + D(FA) \cdot \frac{FA}{A} \tag{1.26}$$

The duration of cash D(CS) is set to zero. Cash is what firms have available instantly, which implies constant reinvestment risk and no hedge against changes in the investment environment. It's not always optimal for firms to keep large amounts of cash because cash can rather be invested and generate returns above the risk-free rate. The reason firm keeps cash is due to liquidity needs.

Duration of current assets D(CA) can be interpreted as the average remaining time until current assets are converted into cash. We measure D(CA) as short-term assets divided by operating expenses, because short-term assets are used to fund daily operations. D(CA) thus reflects how long it takes for current assets to be used up in the operating cycle.

Mohrschladt and Nolte (2018) measure the duration of tangible D(TA) and intangible D(IA) assets separately. D(TA) is measured as property, plant and equipment (PPE) divided by annual depreciation, and D(IA) as net intangible assets divided by annual amortization. Balance sheet data from TITLON reports depreciation and amortization together. Since it is not possible to extract the values from each other we consider TA and IA together as fixed assets (FA), which is the sum of PPE and intangible assets with a finite useful lifetime. The lifetime measure of FA is then given by:

$$D(FA) = \frac{FA}{Depreciation\ and\ Amortization} \cdot \frac{Net\ PPE}{Gross\ PPE} \tag{1.27}$$

Merging TA and IA do not seem to give any logical defaults and will neither cause any difference in the measurement of book equity duration, which is the source of our study. If data is not available for a measure of D(FA) it is set to the median as a whole, since TA and IA are assumed to be the same across time and entities. Net PPE over gross PPE represents the remaining lifetime of tangible and intangible assets. If this ratio is unavailable, it is set to 0.5. On average, the cash flows in both intangible and tangible assets arise halfway of the remaining lifetime (Mohrschladt & Nolte, 2018). Furthermore, calculating the lifetime of assets for each firm leads to inaccurate results because of inconsistencies in depreciation and amortizations in firms' operations. Another reason is due to the fact that financial reporting does not close the gap between actual economic lifetime and assumed lifetime of these assets. We use a discount factor of 1 on all firms, and therefore no sensitivity on cash flows. The reason is that we consider cash flows from existing assets, which intend to be independent of changes in the investment environment.

The duration of total liabilities (L) is calculated as the weighted average of current liabilities (CL) and long-term liabilities (LL):

$$D(L) = D(CL) \cdot \frac{CL}{L} + D(LL) \cdot \frac{LL}{L} \tag{1.28}$$

We measure the duration of current liabilities D(CL) as short-term debt divided by operating expences. Both short-term debt and operating expenses are incurred in a short time period. Since short-term debt is used to fund daily operating expenses, the ratio reflects the average time until the current liabilities are repaid.

We consider a constant duration for long-term debt (LL) among the firms. Similar to Sæther and Larsen (1999), we assume an average time of 5 years down payment. TITLON does not specify maturities in long-term debt for Norwegian firms. LL divided by Earnings Before Interest and Taxes (EBIT) reflects the average time until long term obligations are repaid, given the current earnings of the firm. This ratio gives a median lifetime of 5.74 years, which seems to be a good proxy against the suggested 5 by Sæther and Larsen (1999). But due to the fluctuations caused by negative and little earnings, the outliers cause inaccurate and improbable measures. Mohrschladt and Nolte (2018) find long-term debt duration based on available maturity data from American firms in the time period 1969-2015 with an average duration of 5.11 years and a standard deviation of 0.81, which indicate a very little deviation from the mean. This supports our decision of considering an average down payment of 5 year among all firms, with little impact on the further analysis. This method leads to less firms with negative D(BE), as D(L) becomes considerably lower compared to measuring LL over EBIT. Measuring LL over EBIT will result in more firms with negative book equity duration, and therefore more firms that co-vary with changes in the investment environment.

To ensure consistency, the accounting data has to meet the following requirements: the values for total assets, current assets, cash and current liabilities must be positive. Additionally, current assets (liabilities) must not exceed total assets (liabilities), and the difference between total assets and total liabilities must be positive.

3.2 Performance evaluation of equity duration

We create portfolios based on the average equity duration of firms in order to investigate its relationship with financial performance. A portfolio approach is used because returns on individual stocks are more volatile, and thus make it harder to discard the hypothesis of equality of average return. Through a portfolio analysis we sort stocks with similar characteristics related to duration, which enables us to capture differences in average returns. This methodology makes it possible to do valid studies on asset pricing models.

To evaluate the performance equity duration, we apply the four-factor model by Carhart (1997). A multi-factor model includes several control variables to reduce the likelihood that that the results are driven by other factors. We account for size, momentum and value versus growth stocks. Including these factors make it possible to estimate the degree to which each factor contributes to the historical return. We consider equally weighted portfolios in our analysis. The abnormal risk-adjusted return of the portfolios is therefore calculated by:

$$R_{i,T} = \alpha_i + \beta_i MKT_{i,t} + s_i SMB_{i,t} + h_i HML_{i,t} + m_i MOM_{i,t} + \varepsilon_{i,t} \qquad (1.29)$$

Where R$_{i,t}$ is the portfolio excess return at time t, α is the abnormal risk-adjusted return, MKT$_{i,t}$, SMB, HML and MOM are the returns on the market, size, value and momentum factors at time t. ε is the error term. Excess returns are calculated by subtracting the risk-free rates from the monthly returns.

We do a long-short strategy, where we take a long position in the low equity duration portfolio and a short position in the high equity duration portfolio, as we investigate if low-duration firms outperformes high-duration firms. A t-test on this strategy will test whether the return is significantly different from zero.

We construct the equity duration risk factor LDMHD (Low-duration minus high-duration) by creating portfolios with the average return of stocks with the bottom half duration minus the average return from stocks of the top half durations. This enables us to interpret the exposure that low-duration firms have on innovations in state variables and the market. We investigate the relationship between equity duration and innovations in state variables by deriving the following equation:

$$R_{i,T} = \alpha_i + \beta_i \widehat{TERM}_{i,t} + s_i \widehat{RF}_{i,t} + h_i \widehat{OIL}_{i,t} + \varepsilon_{i,t} \tag{1.30}$$

Where $R_{i,t}$ is the excess return of LDMHD at time t, α is the abnormal risk-adjusted return, TERM, RF and OIL are the innovations in term spread, risk-free rate and logharitmic changes in the oil price at time t. ε is the error term. Excess returns are calculated by subtracting the risk-free rates from the monthly returns.

The reason to include macroeconomic state variables is to see if LDMHD is significantly exposed to changes in the investment enrironment. Our analysis relates to Petkova (2006) and Merton's ICAPM (1973). We consider the state variables risk-free rate (RF) as the 1-year norwegian treasury yield and the term spread (TERM) as is the difference between 10-year and 1-year yield in Norwegian government bonds. As we find the Norwegian stock market to be correlated with the price of oil, we will also be introducing log changes in the Brent Crude oil price as an additional state variable. Since oil is traded in US dollars, we use the log changes in the price of oil to isolate oil price variations from currency variations. Innovations in these factors will also be tested against LDMHD. Following Petkova (2006) and Mohrschladt & Nolte (2018), we assume the state variable innovations to follow a first-order vector autoregressive (VAR) process. The innovations will be estimated by the resulting VAR residuals. The VAR model will be tested to ensure that there exists no multicollinearity between the state variable innovations and the stock returns. As suggested by Campbell (1996), we triangualize the VAR process by orthogonalization in order for the factors to be orthogonalized and scaled.

3.2 Risk premium

In this chapter, we perform a cross-sectional asset pricing test to investigate if equity duration as a risk factor carries a significant risk premium. That is, whether an investor can expect to gain excess return over risk-free investments by considering firm equity duration in an investment strategy. We apply the Fama-MacBeth (1973) model to analyze the duration's direct effect on the return, by testing if these returns are not captured by other known determinants of cross-sectional return differences. The aim is to find if there is a premium for exposure against equity duration as a risk factor.

We do a rolling regression in a time series with the average monthly return in LDMHD, where the portfolios are rebalanced each year according to changes in durations. In the first step of the process, factor exposure to the risk factors are determined by regressing the portfolios against the chosen risk factors n times:

$$R_{i,T} = \alpha_i + \beta_i MKT_{i,t} + s_i SMB_{i,t} + h_i HML_{i,t} + m_i MOM_{i,t} + l_i LDMHD_{i,t} + \varepsilon_{i,t} \quad (1.31)$$

Where β_i, s_i, h_i, m_i, l_i are the exposures against market, size, value, momentum and equity duration. For the second step we perform a cross-sectional regression on all returns for a fixed period of time T gainst the betas that were estimated to the risk factors to determine the risk premium for each factor:

$$
\begin{aligned}
R_{i,1} &= \gamma_{1,0} + \gamma_{1,1}\hat{\beta}_{i,F1} + \gamma_{1,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{1,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,1} \\
R_{i,2} &= \gamma_{2,0} + \gamma_{2,1}\hat{\beta}_{i,F1} + \gamma_{2,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{2,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,2} \\
&\vdots \\
R_{i,T} &= \gamma_{T,0} + \gamma_{n,1}\hat{\beta}_{i,F1} + \gamma_{n,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{n,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,n}
\end{aligned}
\tag{1.32}
$$

Where $R_{i,T}$ is the portfolio return i over risk-free rate. β is the estimated beta-values from the first step, γ are regression coefficients which are used to compute the risk premium for each factor and ε is the standard error. Risk premium, standard error, standard deviation (SD) and t-statistics are calculated by the following equations:

$$
\hat{\lambda} = \frac{1}{T}\sum_{t=1} T\hat{\lambda}_t \qquad \hat{\varepsilon}_i = \frac{1}{T}\sum_{t=1}^{T}\hat{\varepsilon}_{i,t} \qquad \hat{\sigma}_j = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{\lambda}_{,t} - \hat{\lambda}_j)^2} \qquad t_{\lambda_j} = \sqrt{T}\frac{\hat{\lambda}_j}{\hat{\sigma_j}} \tag{1.33}
$$

The risk premium can be explained as the premium for undertaking the risk (beta) involved. Since factor exposure is based on historical numbers, estimated future return will not always be correct. The relationship between return, risk exposure and risk premium will most likely change in the future (Chincarini & Kim, 2016).

3.4 Methodological criticism

3.4.1 Duration measure

The sources behind our data collection is reliable. Any critiques therefore need to be related to the methodology. Available balance sheet data from Norwegian companies force us to apply a few alternative measures. Using operating expenses are likely to slightly underestimate the duration of current assets and liabilities, since it includes expenses beyond the cost of goods sold. A growing problem is that book value, which intends to represent value strategies, is becoming less representative of a company's production and recourses (Robinson et al, 2015). Measuring a company's duration on intangible assets is difficult to quantify. Our framework consider a fixed long-term debt on all companies. Maturity structure on long-term is not specified among firms, even though there is a disclosure requirement attatched to the Norwegian law that imposes companies to publish this information.

Furthermore, we replace missing values with the sector median. This leads to bias in our model, as we are not able to measure the true duration measures of all individual firms. These imputed duration values may lead to further inconsistencies in the analysis when we are comparing the returns to other variables, such as the macroeconomic state variables. As an example, we may not be able to capture the true relationship between company return and changes in interest rate.

3.4.2 Transaction costs

Costs related to transactions and tax payments are not considered, and the portfolio returns are not illuminating its true return.

3.4.3 Fama MacBeth

The two-step Fama MacBeth in our paper does not account for individual stocks, and hence does not rely on any robustness check for the risk premium. Ang et al. (2006) argue that a portfolio approach may lead to larger standard errors of cross sectional risk premium estimates.

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Scientific article

EQUITY DURATION AS A RISK FACTOR IN THE NORWEGIAN STOCK MARKET

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Abstract

We investigate the link between firms' book equity duration, changes in the investment environment and financial performance in the Norwegian stock market. Low-duration firms are more exposed to reinvestment risk than high-duration firms in times of financial distress, and investors require excess return for exposure. We apply a portfolio strategy and Fama-MacBeth regression to estimate the risk premium. We find no significant return in a long-short strategy, which holds in various robustness checks. Neither do we find any significant relationship between equity duration and macroeconomic changes, nor equity duration as a priced risk factor in the Norwegian stock market.

Keywords: Asset pricing, Duration, Multifactor models, Risk management, State variable innovations

JEL classification: G11, G12, G32, M41

1 Introduction

We investigate the difference in return and risk exposure between companies with high and low equity duration in the Norwegian stock market from 2003 to 2018. Fama and French's (1992) *value premium* for investing in firms with high book-to-market fundamentals recieves criticism as the underlying risk

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is not clear. Studies suggest that differences in companies' duration on equity may examine the risk exposure of value premiums, as they find firms with low equity duration to perform poorly in times of financial distress (Campbell and Voulteenaho, 2004; Letteau and Wachter, 2007). Duration in equity is the length of time for cash flows from an asset to fully repay the initial investment, and can also be a measure of sensitivity against changes in the investment environment. We therefore invesigate if differences in the book equity duration of firms can explain differences in risk and return in the stock market.

Our research relates to the literature with a different measurement methodology than the majority of other researchers. Lettau and Watcher (2007) use expected cash flows as a measure of duration, similar to Dechow et al. (2004), van Binsbergen et al. (2012) and Weber (2018). None of the these studies construct firm's duration as a risk factor. Mohrschladt and Nolte (2018) argue against measuring equity duration according to the timing of expected cash flows. They claim it can only be appropriately measured when cash flows are generated with the realized assets and liabilities of firms. We therefore base our methodology on the duration of assets and liabilities at time t, as a new approach within the scope of asset pricing modelling. Firms book equity duration is therefore the weighted duration of assets minus liabilities at time t, which is supposed to measure the sensitivity on market value of equity against changes in investment opportunities. Firms with lower duration are more likely to have a positive relationship with the investment environment. A positive investment environment reflects higher interest rates, while a negative investment environment reflects lower interest rates. The second practicality is that low-duration firms generate shorter cash flows and therefore face larger reinvestment risk. The reason is that there is always risk involved in new projects, as they do not guarantee the same level of cash flows as previous ones. High-duration firms have longer cash flows and their present value on assets increase when the investment environment deteriorates. Firms with higher weighted duration on assets relative to liabilities serves as hedges in times of economic recessions since their present value rise from decreasing discount rates.

In the analysis, our hypothesis is therefore that the investor require more reward for the additional risk involved in holding low-duration stocks. To verify the relationship, we rank companies according to their equity duration and test them against priced risk factors and macroeconomic variables. We test the connection between firm's equity duration and changes in macroeconomic state variables, given the hypothesis that equity duration as a risk factor reflects changes in the investment environment. Mohrschladt and Nolte (2018) find low-duration firms that are measured on assets and liabilities at time t to be significantly related to macroeconomic changes. Following the analogy of Merton's ICAPM (1973), investors charge risk premiums for stocks that are positively related to the investment environment. We test the link between the firm's equity duration, financial performance and macroeconomic changes by several regression procedures.

To evaluate the performance, we create portfolios according to the equity duration of firms and apply a long-short strategy, where we compare the return difference between the lowest and the highest duration portfolios. This helps to prove if low-duration stocks outperform high-duration stocks. The method is widely used in the literature, as it helps to provide evidence of the outperformance between different oppositions. Mohrschladt and Nolte (2018) constructed value weighted portfolios based on equity duration, and find that low duration portfolios outperform high-duration portfolios with a significant monthly average return of 0.47%. Gonçalves (2019) creates equally weighted portfolios and sort stocks according to the duration on cash flows, excluding small companies to make sure the results are not driven by these. He finds low-duration stocks to yield an annual premium of 9.2% relative to long-duration stocks. Weber (2018) finds the low-duration stocks to earn a significant excess return of 0.48% over high-duration stocks, which is robust against the Fama-French factors. We further investigate the relationship between the stock return pattern of equity duration portfolios and underlying macroeconomic state variables. In this way we test the hypothesis that the trade-off between low-duration firms and high-duration are due to changes in the investment environment. Mohrschladt and Nolte (2018) find macroeconomic state variables to be significantly and positively correlated with low-duration firms.

Different arguments are made on the relationship between low and high duration firms. While Cornell

(1999) claims that high-duration firms are exposed to more risk due to a higher covariance with the market, Campbell and Vuolteenaho (2004) argue that market declines will compensate these by higher expected returns. Lettau and Watcher (2007) develop a model where they consider the timing of cash flow. They find high-duration are highly dependent on changes in the market price of risk while low-duration stocks are more dependent on cash flow fluctuations. Weber (2018), van. Binsbergen et al. (2012) and Dechow et al. apply the same model and find low-duration stocks outperform high-duration stocks. Dechow et al. (2004) study cash-flow duration in the cross-section of US stock returns and find high-duration stocks to have lower returns and consider the Fama and French (1995) book-to-market factor to be a proxy for equity duration. These are measures of future cash flows, which intend to reflect the timing of cash flow. Our methodology intend to reflect stocks discount rate sensitivity. Most studies are tested in the American market, and we find no similar studies done in the Norwegian market.

In summary, our study seeks to a provide stronger evidence for or against the empirical findings that suggests there is an existing risk premium for low-duration stocks, whether return differences in firms equity duration are explained by macroeconomic changes and to support a better framework in the financial literature to better address price changes of stocks.

2 Data

We study companies listed at Oslo Stock Exchange (OSE). Since the unit of analysis is the Norwegian stock market, we consider Oslo Stock Exchange Benchmark Index (OSEBX) as our proxy. The OSEBX contains a selection of stocks that are representative for all publicly listed companies at Oslo Stock Exchange. The data in our study includes all stocks that participate in the OSEBX during the period to ensure no survivorship bias. Our study take place in the time period between July 2003 and June 2018. Annual accouting data is linked to monthly stock returns from july_t to june_{t+1} to make sure that the information and reports are published before the return measurement. Monthly returns and balance sheet data are obtained from TITLON, a financial database offering data for stocks listed at

OSEBX. We filter out abnormal returns; monthly return observations that increase more than 300% or decrease more than 50% are excluded from the dataset. Stocks that are traded below 5 Norwegian kroner (NOK) are treated as missing, due to large volatility driven by firms with low stock prices. We remove companies in sectors where the balance sheet does not allow for an appropriate measurement of duration. Similar to Fama & French (1992) we exclude firms in the financial sector, which includes banks, ETFs and other financials. In general, excluding financial firms is due to their high leverage, which is very different from other companies. Normal returns are chosen instead of logarithmic as it captures the "true" return change from the previous observation, and due to the fact that logarithmic return assumes continuous return. This is done by observing the percentage change between the last trading days in each month.

We use the Carhart (1997) four-factor model to analyze the excess return, which includes the variables excess market return (MKT), book-to-market ratio (HML), size (SMB) and momentum (MOM). We apply these factors in a regression to estimate the excess return, assuming it's possible to divide beta values into several factors to illuminate the risk. This makes it easier to draw conclutions on the exposure against the risk factors and the level of significance. The variables are drawn from Bernt Arne Odegaard's website[7]. These are constructed in the Norwegian market. According to Fama and French (2012), regional asset-pricing models perform better than global models.

In the end section we apply the Fama-MacBeth (1973) model to test whether our equity duration factor carries a significant return premium beyond the standard risk factors in the Norwegian stock market. We also construct a model where we investigate the relationship between equity duration and innovations in state variables, to support evidence for or against the idea that differences in firm equity duration reflects changes in the investment environment. We collect 10 year and 12 months Norwegian government bonds from Norges Bank[8]. Monthly oil prices are gathered from Quandl[9]. Lastly, we test whether equity duration as a risk factor is able to explain differences in average portfolio returns.

[7]http://finance.bi.no/~bernt/financial_data/ose_asset_pricing_data/index.html
[8]https://www.norges-bank.no/tema/Statistikk/Rentestatistikk/
[9]https://www.quandl.com/data/FRED/DCOILBRENTEU-Crude-Oil-Prices-Brent-Europe

3 Methodology

3.1 Measurement of Equity duration

In order to examine the relationship between stock return and equity duration in the Norwegian stock market, we measure firm equity duration based on balance sheet data. Our approach and reasoning are largely inspired by Mohrschladt & Nolte (2018), Guedes & Opler (1996) and Stohs & Mauer (1996). In addition, we follow approaches by Thomas R. Robinson et al. (2015) and Sæther and Larsen (1999). We consider the duration of an asset portfolio as the weighted average lifetime of the individual assets. Unavailable data is replaced by the median value of the respective sector. For example, missing duration estimates from the company Equinor is replaced by the median of the Energy sector.

By subtracting total liabilities from total assets, we get the firm's book equity. Book equity duration is measured as the weighted average duration of assets and liabilities:

$$D(BE) = D(A) \cdot \frac{A}{BE} - D(L) \cdot \frac{L}{BE} \tag{2.1}$$

Where D(A) is the duration of total assets (A), calculated by cash (CS), current assets (CA), and tangible and intangible assets (FA):

$$D(A) = D(CS) \cdot \frac{CS}{A} + D(CA) \cdot \frac{CA}{A} + D(FA) \cdot \frac{FA}{A} \tag{2.2}$$

The duration of cash D(CS) is set to zero. Cash is what firms have available instantly, which implies constant reinvestment risk and no hedge against changes in the investment environment. It's not always optimal for firms to keep large amounts of cash because cash can rather be invested and generate returns above the risk-free rate. The reason firm keeps cash is due to liquidity needs.

Duration of current assets D(CA) can be interpreted as the average remaining time until current assets are converted into cash. We measure D(CA) as short-term assets divided by operating expenses, because short-term assets are used to fund daily operations. D(CA) thus reflects how long it takes for current assets to be used up in the operating cycle.

Mohrschladt and Nolte (2018) measure the duration of tangible D(TA) and intangible D(IA) assets separately. D(TA) is measured as property, plant and equipment (PPE) divided by annual depreciation, and D(IA) as net intangible assets divided by annual amortization. Balance sheet data from TITLON reports depreciation and amortization together. Since it is not possible to extract the values from each other we consider TA and IA together as fixed assets (FA), which is the sum of PPE and intangible assets with a finite useful lifetime. The lifetime measure of FA is then given by:

$$D(FA) = \frac{FA}{Depreciation\ and\ Amortization} \cdot \frac{Net\ PPE}{Gross\ PPE} \tag{2.3}$$

Merging TA and IA do not seem to give any logical defaults and will neither cause any difference in the measurement of book equity duration, which is the source of our study. If data is not available for a measure of D(FA) it is set to the median as a whole, since TA and IA are assumed to be the same across time and entities. Net PPE over gross PPE represents the remaining lifetime of tangible and intangible assets. If this ratio is unavailable, it is set to 0.5. On average, the cash flows in both intangible and tangible assets arise halfway of the remaining lifetime (Mohrschladt & Nolte, 2018). Furthermore, calculating the lifetime of assets for each firm leads to inaccurate results because of inconsistencies in depreciation and amortizations in firms' operations. Another reason is due to the fact that financial reporting does not close the gap between actual economic lifetime and assumed lifetime of these assets. We use a discount factor of 1 on all firms, and therefore no sensitivity on cash flows. The reason is that we consider cash flows from existing assets, which intend to be independent of changes in the investment environment.

The duration of total liabilities (L) is calculated as the weighted average of current liabilities (CL) and long-term liabilities (LL):

$$D(L) = D(CL) \cdot \frac{CL}{L} + D(LL) \cdot \frac{LL}{L} \tag{2.4}$$

We measure the duration of current liabilities D(CL) as short-term debt divided by operating expences. Both short-term debt and operating expenses are incurred in a short time period. Since short-term debt is used to fund daily operating expenses, the ratio reflects the average time until the current liabilities are repaid.

We consider a constant duration for long-term debt (LL) among the firms. Similar to Sæther and Larsen (1999), we assume an average time of 5 years down payment. TITLON does not specify maturities in long-term debt for Norwegian firms. LL divided by Earnings Before Interest and Taxes (EBIT) reflects the average time until long term obligations are repaid, given the current earnings of the firm. This ratio gives a median lifetime of 5.74 years, which seems to be a good proxy against the suggested 5 by Sæther and Larsen (1999). But due to the fluctuations caused by negative and little earnings, the outliers cause inaccurate and improbable measures. Mohrschladt and Nolte (2018) find long-term debt duration based on available maturity data from American firms in the time period 1969-2015 with an average duration of 5.11 years and a standard deviation of 0.81, which indicate a very little deviation from the mean. This supports our decision of considering an average down payment of 5 year among all firms, with little impact on the further analysis. This method leads to less firms with negative D(BE), as D(L) becomes considerably lower compared to measuring LL over EBIT. Measuring LL over EBIT will result in more firms with negative book equity duration, and therefore more firms that co-vary with changes in the investment environment.

To ensure consistency, the accounting data has to meet the following requirements: the values for total assets, current assets, cash and current liabilities must be positive. Additionally, current assets (liabilities) must not exceed total assets (liabilities), and the difference between total assets and total liabilities must be positive.

3.2 Performance evaluation of equity duration

We create portfolios based on the average equity duration of firms in order to investigate its relationship with financial performance. A portfolio approach is used because returns on individual stocks are more volatile, and thus make it harder to discard the hypothesis of equality of average return. Through a portfolio analysis we sort stocks with similar characteristics related to duration, which enables us to capture differences in average returns. This methodology makes it possible to do valid studies on asset pricing models.

To evaluate the performance equity duration, we apply the four-factor model by Carhart (1997). A multi-factor model includes several control variables to reduce the likelihood that that the results are driven by other factors. We account for size, momentum and value versus growth stocks. Including these factors make it possible to estimate the degree to which each factor contributes to the historical return. We consider equally weighted portfolios in our analysis. The abnormal risk-adjusted return of the portfolios is therefore calculated by:

$$R_{i,T} = \alpha_i + \beta_i MKT_{i,t} + s_i SMB_{i,t} + h_i HML_{i,t} + m_i MOM_{i,t} + \varepsilon_{i,t} \tag{2.5}$$

Where $R_{i,t}$ is the portfolio excess return at time t, α is the abnormal risk-adjusted return, $MKT_{i,t}$, SMB, HML and MOM are the returns on the market, size, value and momentum factors at time t. ε is the error term. Excess returns are calculated by subtracting the risk-free rates from the monthly returns.

We do a long-short strategy, where we take a long position in the low equity duration portfolio and a short position in the high equity duration portfolio, as we investigate if low-duration firms outperformes high-duration firms. A t-test on this strategy will test whether the return is significantly different from zero.

We construct the equity duration risk factor LDMHD (Low-duration minus high-duration) by creating portfolios with the average return of stocks with the bottom half duration minus the average return from stocks of the top half durations. This enables us to interpret the exposure that low-duration firms have on innovations in state variables and the market. We investigate the relationship between equity duration and innovations in state variables by deriving the following equation:

$$R_{i,T} = \alpha_i + \beta_i \widehat{TERM}_{i,t} + s_i \widehat{RF}_{i,t} + h_i \widehat{OIL}_{i,t} + \varepsilon_{i,t} \tag{2.6}$$

Where $R_{i,t}$ is the excess return of LDMHD at time t, α is the abnormal risk-adjusted return, TERM, RF and OIL are the innovations in term spread, risk-free rate and logharitmic changes in the oil price at time t. ε is the error term. Excess returns are calculated by subtracting the risk-free rates from the monthly returns.

The reason to include macroeconomic state variables is to see if LDMHD is significantly exposed to changes in the investment enrironment. Our analysis relates to Petkova (2006) and Merton's ICAPM (1973). We consider the state variables risk-free rate (RF) as the 1-year norwegian treasury yield and the term spread (TERM) as is the difference between 10-year and 1-year yield in Norwegian government bonds. As we find the Norwegian stock market to be correlated with the price of oil, we will also be introducing log changes in the Brent Crude oil price as an additional state variable. Since oil is traded in US dollars, we use the log changes in the price of oil to isolate oil price variations from currency variations. Innovations in these factors will also be tested against LDMHD. Following Petkova (2006) and Mohrschladt & Nolte (2018), we assume the state variable innovations to follow a first-order vector autoregressive (VAR) process. The innovations will be estimated by the resulting VAR residuals. The VAR model will be tested to ensure that there exists no multicollinearity between the state variable innovations and the stock returns. As suggested by Campbell (1996), we triangualize the VAR process by orthogonalization in order for the factors to be orthogonalized and scaled.

3.2 Risk premium

In this chapter, we perform a cross-sectional asset pricing test to investigate if equity duration as a risk factor carries a significant risk premium. That is, whether an investor can expect to gain excess return over risk-free investments by considering firm equity duration in an investment strategy. We apply the Fama-MacBeth (1973) model to analyze the duration's direct effect on the return, by testing if these returns are not captured by other known determinants of cross-sectional return differences. The aim is to find if there is a premium for exposure against equity duration as a risk factor.

We do a rolling regression in a time series with the average monthly return in LDMHD, where the portfolios are rebalanced each year according to changes in durations. In the first step of the process, factor exposure to the risk factors are determined by regressing the portfolios against the chosen risk factors n times:

$$R_{i,T} = \alpha_i + \beta_i MKT_{i,t} + s_i SMB_{i,t} + h_i HML_{i,t} + m_i MOM_{i,t} + l_i LDMHD_{i,t} + \varepsilon_{i,t} \quad (2.7)$$

Where β_i, s_i, h_i, m_i, l_i are the exposures against market, size, value, momentum and equity duration. For the second step we perform a cross-sectional regression on all returns for a fixed period of time T gainst the betas that were estimated to the risk factors to determine the risk premium for each factor:

$$\begin{aligned} R_{i,1} &= \gamma_{1,0} + \gamma_{1,1}\hat{\beta}_{i,F1} + \gamma_{1,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{1,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,1} \\ R_{i,2} &= \gamma_{2,0} + \gamma_{2,1}\hat{\beta}_{i,F1} + \gamma_{2,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{2,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,2} \\ &\vdots \\ R_{i,T} &= \gamma_{T,0} + \gamma_{n,1}\hat{\beta}_{i,F1} + \gamma_{n,2}\hat{\beta}_{i,F2} + \cdots + \gamma_{n,m}\hat{\beta}_{i,Fm} + \varepsilon_{i,n} \end{aligned} \quad (2.8)$$

Where $R_{i,T}$ is the portfolio return i over risk-free rate. β is the estimated beta-values from the first step, γ are regression coefficients which are used to compute the risk premium for each factor and ε is the standard error. Risk premium, standard error, standard deviation (SD) and t-statistics are calculated by the following equations:

$$\hat{\lambda} = \frac{1}{T}\sum_{t=1} T\hat{\lambda}_t \qquad \hat{\varepsilon}_i = \frac{1}{T}\sum_{t=1}^{T}\hat{\varepsilon}_{i,t} \qquad \hat{\sigma}_j = \sqrt{\frac{1}{T}\sum_{t=1}^{T}(\hat{\lambda}_{,t} - \hat{\lambda}_j)^2} \qquad t_{\lambda_j} = \sqrt{T}\frac{\hat{\lambda}_j}{\hat{\sigma}_j} \tag{2.9}$$

The risk premium can be explained as the premium for undertaking the risk (beta) involved. Since factor exposure is based on historical numbers, estimated future return will not always be correct. The relationship between return, risk exposure and risk premium will most likely change in the future (Chincarini & Kim, 2016).

4 Empirical analysis

This section seeks to answer the three main objectives of our paper; if low-duration firms significantly outperform high-duration firms, if the LDMHD factor significantly relates to innovations in macroeconomic state variables and if LDMHD carries a significant positive risk premium. For the first objective we use the Carhart (1997) four-factor model (Equation 2.5) to account for control variables, as we analyze whether investors can expect a significant risk-adjusted return by investing in low-duration firms. The next objective attempts to find evidence of the relationship between LDMHD and changes in the investment environment (Equation 2.6). The last last objective (Equation 2.8) adresses if investors can expect a significant risk premium in a long-short strategy by holding a long position in low-duration firms and a short position on high-duration firms.

Table 1 presents the descriptive statistics for all components of our duration measures. Estimates are winsorized at 1% and 99% to remove extreme outliers. Similar durations of D(FA) is caused by the lack of depreciation and amortization listed in the books and the use of global median as opposed to sector median that goes along with the constraints explained in the methodology chapter. We also consider D(LL) to be constant[10]. The procedure described in the methodology chapter yields a respective median and mean book equity duration of 1.098 and 2.091. Mohrschladt and Nolte (2018) measure a median and mean book equity duration of 2.39 and 3.42, respectively. Leibowitz (1986) uses regression to

[10]A table containing the descriptive statistics for D(LL) based on long-term liabilities over EBIT can be found in Appendix 1. We note that this change causes large standard deviations for D(L) and D(BE).

estimate stock price sensitivity with respect to discount rates at the S&P 500 index, and finds a median stock market duration of 2.19. Our measure contributes to these findings with a similar book equity duration. Methods that consider a cash flow-based duration measurement yield substantially higher duration, as they rely more on the future investment environment. Weber (2018) and Dechow et al. (2004) find a respective mean duration of 18.77 and 15.13 years when they consider cash flows.

Table 1: Summary statistics for the duration estimates based on balace sheet data.

Variable	D(FA)	D(CA)	D(A)	D(CL)	D(LL)	D(L)	D(BE)
Mean	5.901	1.136	2.462	0.386	5.000	2.645	2.091
SD	1.153	3.161	2.304	0.191	0.000	1.685	6.564
q0.1	5.601	0.258	0.408	0.189	5.000	0.619	-2.434
q0.5	5.601	0.566	1.594	0.339	5.000	2.612	1.028
q0.9	5.601	2.136	4.944	0.658	5.000	4.347	7.138

In Table 2 we apply the portfolio approach to evaluate the impact on equity duration in the cross-section of stock returns. We create ten equally weighted portfolios based on firm equity duration. As the portfolios are rebalanced yearly, the model considers a 1 year holding period for the investor. Portfolio alpha (α) and Carhart (1997) factor exposures are also reported. D(BE) is the mean duration value for each portfolio. Annual accounting data are linked to monthly stock returns from july$_t$ to june$_{t+1}$, between 2003 and 2018. Average monthly returns R and alphas (α) are stated in %.

We find no clear correlation between book equity duration and portfolio returns in the stock market. As expected, the high-duration portfolios yield lower returns than the low-duration portfolios, as investors to demand compensation for the additional risk of investing in firms exposed to reinvestment risk. Note that three portfolios hold negative mean durations. The reason for this outcome is that the weighted duration of assets are less than the weighted duration of liabilities (see Equation 2.1), resulting in a negative duration gap. As interest rates rise, liabilities lose more value than assets. This will in turn increase the value of the firms equity. Reversely, if interest rates decline, liabilities gain more value than assets. This decreases the value of the firms equity. The three portfolios with the lowest durations in Table 2 are therefore expected to show a positive correlation with changes in interest rates.

The portfolios in the middle yield higher returns than the outliers. Since these porfolios provide significant alpha values that are robust against other factors, they lay out credible information about excess returns in the market. We therefore make an interpretation of the matter; as the duration of a firms equity and liabilities are more equal, their exposure to changes in the investment environment decrease. The large and consistent Sharpe ratios among the middle-portfolios can therefore be explained by the reduced volatility from having lower exposure against changes in interest rates. This may also be the reason why these portfolios provide high average returns, as they perform stable regardless of changes in the investment environment. Our findings therefore suggests that by having a portfolio of companies with a healthy balance between duration and weighting of assets and liabilities, one can better optimize the relationship between risk and return.

Moreover, we notice a considerably higher Sharpe ratio among the 30% firms with the lowest duration relative to the top 30%. Low-duration firms thus yield more return per unit of risk, similar to what Weber (2018) finds. Low-duration portfolios are therefore compensated for the additional risk compared with high-duration firms.

A long-short strategy in the lowest and highest duration portfolios are tested to see the if there is a significant return. The t-statistics in parentheses are based on standard errors following Newey and West (1987). We find no significant return in the long-short strategy t(1-10) and therefore no evidence that low-duration firms outperform high-duration firms when considering the extremes to make the difference. As a robustness check we calculate D(LL) as long-term liabilities over EBIT in Appendix 2. Using this methodology the result continues to lack significance.

To account for biases related to inadequate measurements of intangible assets in technology firms, we run a robustness check in Appendix 3. Intangible assets are difficult to quantify, as they are less representative of firms' production resources. These are assets that technology firms depend on considerably more than others. The technology sector represents 18.5% of the sector distribution in our sample. The results remain qualitatively the same. Our long-short strategy remains insignificant as we remove these firms from the sample. The majority of technology firms are placed in the low-duration portfolio, as shown in Appendix 4.

Table 2: Equity duration based portfolios

	$Return$	α	β_{MKT}	β_{SMB}	β_{HML}	β_{MOM}	$D(BE)$	$SharpeRatio$
Low	1.42	0.86	0.53	0.31	0.17	0.16	-3.77	0.18
2	1.30	0.67	0.48	0.23	0.11	-0.04	-0.93	0.21
3	2.07	1.17	0.62	0.32	0.14	0.04	-0.18	0.29
4	1.39	0.89	0.34	0.11	0.16	0.16	0.13	0.22
5	1.44	0.74	0.56	0.42	0.02	-0.12	0.34	0.20
6	2.06	1.80	0.39	0.18	0.13	-0.22	0.88	0.29
7	1.63	0.99	0.49	0.26	0.16	-0.03	1.38	0.23
8	1.37	0.62	0.65	0.19	0.30	-0.06	4.09	0.17
9	1.00	0.47	0.45	0.28	0.23	-0.07	5.34	0.13
High	0.63	-0.18	0.66	0.33	0.22	0.08	13.30	0.05
1-10	0.79	1.04	-0.13	-0.02	-0.04	-0.08	-17.06	0.08
t(1-10)	(1.32)	(1.57)	(-0.98)	(-0.83)	(-0.61)	(-0.07)	-	-

In Table 4, we test wether the constructed portfolios in Table 3 links to innovations in state variables. We create the LDMHD (low duration minus high duration) factor, containing the bottom-half duration portfolios (deciles 1-5) minus the top-half duration portfolios (deciles 6-10). LDMHD therefore reflects the monthly returns in a long-short strategy, with a long position in low-duration stocks and a short position in high-duration stocks. We use the Ordinary Least Squares (OLS) method to estimate the coefficients in Panel A and B. The time series satisfies the OLS requirements (Dougherty, 2016). The t-statistics are based on standard errors following Newey and West (1987).

Panel A tests if LDMHD is significantly driven by other factors. We regress the factor against the MKT, SMB, HML and MOM. Beyond the significance, we expect SMB and LDMHD to be positively related, and HML and LDMHD to be negatively related, as Panel A marginally suggests. Small firms are less likely to take on long-term investment projects, while expected high-duration cash flows with stocks containing low book-to-market fundamentals are dependent on the future investment environment (Mohrschladt and Nolte, 2018). However, the t-value of the intercept is less than the critical value, and we therefore find no significant evidence for LDMHD to provide independent information without being driven by other known factors.

Panel B addresses the link between LDMHD and innovations in state variables. Figure 4 and 5 in Appendix 5 plots the development of the Norwegian 12 months government bond and oil price in the time period that our study consider. Note that the interest rate has declined on average, which is in favor of high-duration firms as their value of equity increase when the discount rate declines. Low-duration firms face stronger reinvestment risk and are more likely to be positively related with changes in the investment environment. 3 out of 5 portfolios within the low-duration portfolio have negative D(BE), which means duration on liabilities are larger than duration of assets. This implies the value of equity decreases when interest rates decline. Following Petkova (2016), the state variables follow a first-order vector autoregressive (VAR) process. The state variables are regressed in time t on their lagged values and on the lagged values of MKT, SMB and HML. In addition, we triangualize the VAR system of the state variables using a Gram-Schmidt orthogonalization to account for multicollinearity. Campbell (1996) suggests that regression results are better interpreted if the VAR models are orthogonalized and scaled. Innovations in state variables are denoted with a hat.

The results show no significant relationship between LDMHD and innovations the state variables. Consequently, there is no evidence to support the hypothesis that the factor reflects changes in the investment environment. Finding $\widehat{RF}$ to be negatively correlated with LDMHD is counterintuitive, given that the factor intends to be positively correlated with improving investment environment. However, a very small coefficient of $\widehat{RF}$ imply that the low-duration firms are not as sensitive to changes in interest rate as first assumed. We notice a negative link between $\widehat{OIL}$ and LDMHD, implying that high-duration firms are more sensitive to changes in the oil price. This can be explained by the fact that most companies in the Norwegian energy sector is placed within the high-duration portfolios[11]. Although we find the Norwegian stock market to have a correlation ratio of 0.49 against changes in oil price, we find no significant relationship between changes in oil price and LDMHD. $\widehat{TERM}$ is also insignificant in the model.

In summary of Table 3, LDMHD does seem not carry a significant risk premium beyond the Carhart risk factors or the innovations in state variables. The model finds no significant relationship between LDMHD and exposure to risk factors and state variables. We find no evidence for the state variables in the model to be the underlying source of risk that low duration firms face[12].

Table 3: Regressing LDMHD on the Carhart (1997) four-factor model and state variable innovations

Panel A		Panel B	
	LDMHD		LDMHD
Intercept	0.001	Intercept	0.001
	(0.490)		(0.770)
MKT	-0.020	$\widehat{TERM}$	0.002
	(-0.340)		(0.080)
SMB	0.030	$\widehat{RF}$	-0.013
	(0.460)		(-0.470)
HML	-0.087	$\widehat{OIL}$	-0.020
	(-1.370)		(-0.640)
MOM	0.030		
	(0.650)		

[11] The sector distribution in the low-duration and high-duration portfolios are presented in Appendix 4.

[12] We find no significant relationship between LDMHD and state variables when considering LL over EBIT as a proxy for D(LL).

The previos regression results did not provide any significant relationship between firms equity duration, stock returns and exposure to innovations in state variables. This imply that equity duration is not priced in the market. To investigate further, we conduct the Fama-MacBeth (1973) procedure to test if LDMHD is able to explain differences in average portfolio returns and if there is a risk premium for exposure against LDMHD. The equally weighted test portfolios are collected from Bernt A. Odegaard and include 10 portfolios of Size (market capitalization), 10 portfolios of BM (book-to-market ratio) and 8 portfolios of industry characteristics. In addition, we run our 10 portfolios of equity duration fundamentals. Evaluating different characteristics increase the chance of having higher dispersion in the cross-sectional betas, which in turn lead to more information captured in the cross-section with a more accurate measure of risk premia (Ang et al., 2017).

Table 4 summarizes the average risk premiums and t-statistics in parenthesis. The average intercept is significant for the test portfolios based on all four models at 1% level. We note that these intercepts yield average monthly returns of 3.311%, 1.704%, 3.387% and 6.055%, which are considerably high in economic terms.

There is no significant risk premium for LDMHD in neither of the models where it is included, which continues to be the case as more explanatory variables are included in models (3) and (4). Although the premiums are positive, we find no evidence to support the hypothesis that LDMHD is a priced risk factor in the Norwegian stock market[13]. The explanatory power in each model is reflected by R^2. All models contain a relatively high explanatory power and increase as more explanatory variables are included.

We find the factors MKT, SMB, HML and MOM to be significantly priced in the market, which supports the findings from Treynor (1962), Carhart (1997) and Fama and French (1993).

The state variable innovations are included in model (4). There are reasons to believe that changes in macroeconomic state variables affect the cross section of stock return. However, it is important to notice that news reflect stock prices before they are captured in accessible macro variables. The

[13] LDMHD remains insignificant when we reconstruct the factor to contain decile 1-3 minus decile 7-10.

state variables in model (4) find $\widehat{TERM}$ and $\widehat{RF}$ to be significantly priced in the market at 5% and 1% significance level, respectively. The negative premium in $\widehat{RF}$ is likely a result of lower discount rates that contributes to higher valuations. As discount rates decrease, investors have less alternative investment opportunities that are viable which in turn shifts the proportion of investments over to more risky assets. The falling interest rates from 2007 (see Appendix 5) onwards have been paralell with an average annual increase in stock prices by 10.2% in our total sample.

The significant positive risk premium in $\widehat{TERM}$ from model (4) can be interpreted in the sense that the market expects increased inflation. Firms with a positive co-variation with the term spread creates high returns in an improving investment environment. This implies that investors demand risk compensation for holding companies that yield high returns when the marginal utility of consumption is low, and low returns when marginal utility is high. Moreover, although we find oil price to co-vary with the market, we do not find $\widehat{OIL}$ to have a systematic risk premium in the Norwegian market. A possible explanation is that some sectors may be unaffected by changes in oil price. The fact that our test-portfolios contain different sector and firm fundamentals supports this case. Although we find $\widehat{RF}$ and $\widehat{TERM}$ to carry significant risk premiums, it's worth mentioning that they are not as robust against changes in the portfolios they attempt to price in the model. The effects on the stock market from innovations in state variables may also be related to expected cash flows.

Table 4: Prices of risk

	(1)	(2)	(3)	(4)
Intercept	3.311	1.703	3.387	6.055
	(4.603)***	(5.733)***	(3.496)***	(3.496)***
MKT	1.737	2.287	1.948	0.106
	(2.081)**	(5.735)**	(4.311)***	(2.421)**
SMB		-0.554	-0.424	
		(-2.158)**	(-2.941)***	
HML		1.480	1.593	
		(2.147)**	(4.213)***	
MOM			-0.429	
			(3.428)***	
LDMHD	0.806		0.530	0.932
	(1.760)		(0.140)	(1.420)
$\widehat{TERM}$				6,639
				(2.027)**
$\widehat{RF}$				-4,270
				(-2.79)***
$\widehat{OIL}$				2.369
				(1.775)
R^2	0.273	0.377	0.580	0.652

5 Conclusion

The aim of this paper is to provide insights to the literature on equity duration, where we apply a measure of book equity duration based on the firm's balance sheet data. We construct the factor LDMHD (low duration minus high duration) which intends to co-vary with changes in the investment environment, since low duration stocks are more exposed to reinvestment risk. Our portfolios are tested in the time period between July 2003 and June 2018. To provide evidence from different perspectives, we apply a portfolio strategy by Carhart (1997), as well as a cross-sectional approach by Fama and MacBeth (1973).

Low-duration stocks show no significant return against high-duration stocks in a long-short strategy, after controlling for other risk factors. We note, however, that our constructed portfolios with low duration firms yield monthly excess returns that are higher than high-duration firms. The econometric models reveal no statistical evidence for the risk and return trade-off between low and high-duration firms, and thus suggest that the results are caused by chance. Since none of the state variables show a statistically significant exposure against LDMHD, we can't conclude if the relationship is valid. The Fama-MacBeth procedure yields no significant risk premium for exposure against LDMHD.

Our findings do not suggest any significant impact between equity prices and interest rates. This may imply that interest rates have less impact on low-duration firms than first expected. However, we find portfolios with the more balanced book equity duration to perform better in the market as well as in terms or risk. These portfolios provide significant alpha values that are robust against other risk factors. A portfolio of companies with a evenly balanced relatioship between duration on assets and liabilities can be more likely to yield higher returns with less risk in the market.

We hope our findings will be useful information to risk managers as well as insitutions such as banks, pension funds and investors who are exposed to reinvestment risk. We encourage further research to consider longer time-series, different holding periods and consideration of value weighted portfolios, as these may provide different results. Furthermore, we incentivize to test against other state variables, as suggested by Fama (1990) and Chen, Roll and Ross (1986).

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7 Appendix

7.1 Appendix 1

Table 5: Summary statistics for the duration estimates with D(LL) based on LL over EBIT

Variable	D(FA)	D(CA)	D(A)	D(CL)	D(LL)	D(L)	D(BE)
Mean	5.901	1.136	2.462	0.386	6.916	2.176	2.562
SD	1.153	3.161	2.304	0.191	5.866	15.596	39.340
q0.1	5.601	0.258	0.408	0.189	2.409	-1.769	-7.405
q0.5	5.601	0.566	1.594	0.339	5.742	0.949	1.3152
q0.9	5.601	2.136	4.944	0.658	11.650	9.093	9.973

7.2 Appendix 2

Table 6: Equity duration based portfolios - With D(LL) based on long-term liabilities over EBIT

	$Return$	α	β_{MKT}	β_{SMB}	β_{HML}	β_{MOM}	$D(BE)$	$SharpeRatio$
Low	1.14	0.10	0.51	0.20	0.21	-0.05	-15.65	0.15
2	1.41	0.28	0.44	0.17	0.08	0.05	-1.29	0.23
3	1.54	0.15	0.59	0.21	0.02	-0.04	-0.32	0.20
4	2.09	0.18	0.51	0.46	0.15	-0,18	1.09	0.26
5	1.50	0.10	0.43	0.20	0.08	-0.13	1.26	0.34
6	1.73	0.13	0.45	0.22	0.11	-0.07	2.56	0.25
7	1.57	0.11	0.50	0.26	0.10	-0.10	3.04	0.29
8	1.57	0.09	0.47	0.36	0.17	-0.05	3.68	0.16
9	0.73	0.01	0.58	0.36	0.26	-0.17	6.40	0.11
High	0.63	0.00	0.66	0.33	0.29	-0.05	26.51	0.12
1-10	0.62	0.80	-0.15	-0.14	-0.09	-0.01	42.16	0.07
t(1-10)	(1.47)	(1.35)	(-1.05)	(-0.86)	(-0.55)	(-0.05)	-	-

7.3 Appendix 3

Table 7: Equity duration based portfolios - Excluding the Information Technology sector

	$Return$	α	β_{MKT}	β_{SMB}	β_{HML}	β_{MOM}	$D(BE)$	$SharpeRatio$
Low	1.07	0.49	0.62	0.27	0.24	-0.20	-3.77	0.11
2	1.38	0.70	0.50	0.22	0.25	0,11	-0.93	0.19
3	1.80	1.21	0.45	0.22	0.06	-0.02	-0.18	0.29
4	1.50	1.17	0.41	0.18	0.22	-0.06	0.13	0.23
5	1.81	1.29	0.43	0.31	0.00	-0.11	0.34	0.24
6	1.72	1.25	0.47	0.18	0.16	-0.04	0.88	0.27
7	2.06	1.54	0.48	0.25	0.10	-0.08	1.38	0.29
8	1.75	0.23	0.54	0.29	0.21	-0.11	4.09	0.12
9	0.61	0.28	0.33	0.20	0.17	-0.02	5.34	0.08
High	0.54	-0.22	0.66	0.32	0.24	-0.02	13.30	0.05
1-10	0.53	0.71	-0.04	-0.06	0.00	-0.18	-17.06	0.07
t(1-10)	(1.26)	(1.32)	(-0.29)	(-0.35)	(-0.03)	(-1.27)	-	-

7.4 Appendix 4

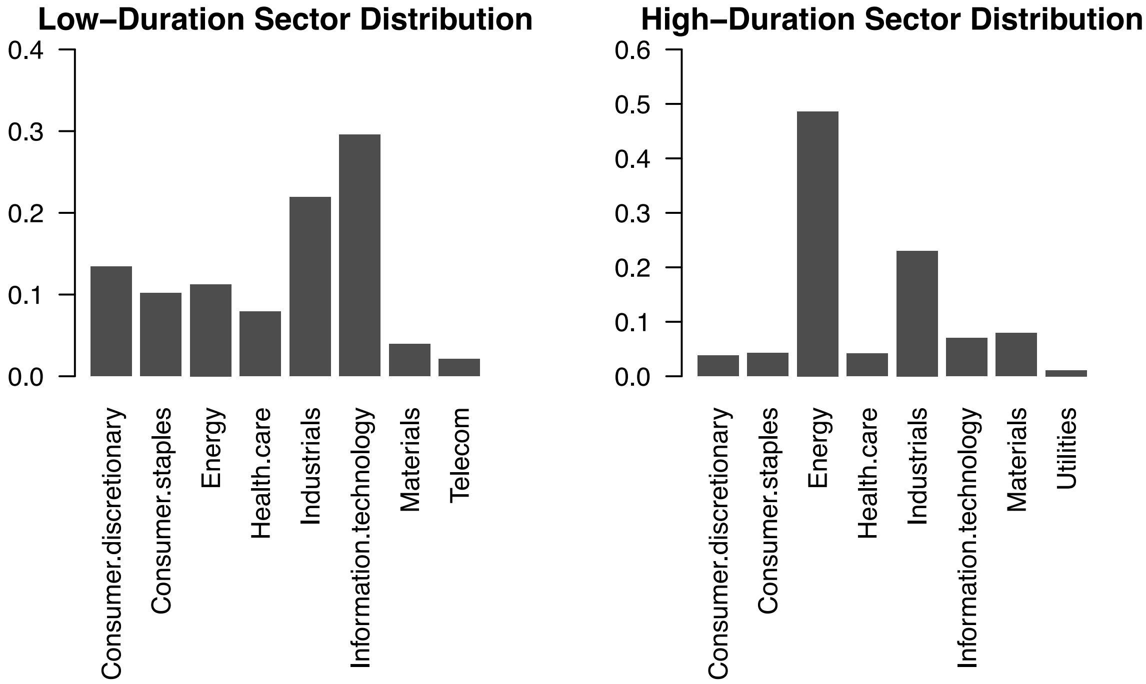

Figure 3: Sector distributions within the duration portfolios

7.5 Appendix 5

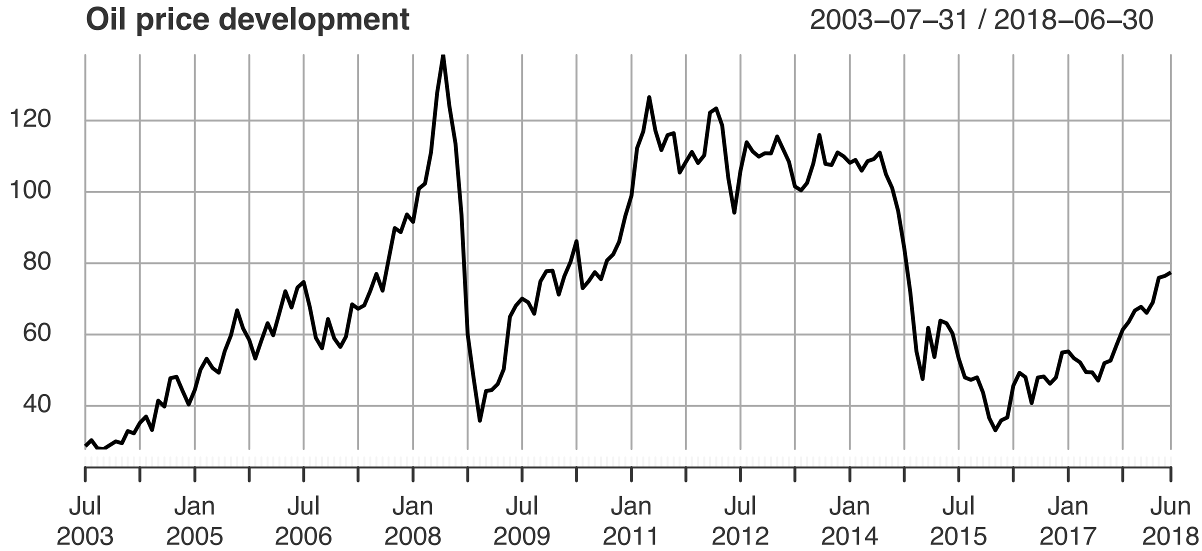

Figure 4: Time series: Oil price development

Figure 5: Time series: Risk-free rate development