Norwegian School of Economics
Bergen, Autumn 2018

A comparative analysis of listed and unlisted real estate investments

A Norwegian perspective

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Master Thesis in Financial Economics

Master of Science in Economics and Business Administration

NORWEGIAN SCHOOL OF ECONOMICS

Preface

With this thesis, we conclude our respective Master of Science in Economics & Business Administration degree at the Norwegian School of Economics (NHH).

Our supervisor, Kyeong Hun Lee, has greatly contributed to this thesis, and has provided invaluable consultation. We are deeply grateful for your input, which has been essential for the completion of the thesis.

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Abstract

This master thesis examines the performance of listed and unlisted real estate investments in Norway over the past eleven years, and tests whether real estate stocks in Norway are predominantly driven by the progress of the underlying real estate market or by the general stock market. Deviating from the conventional procedure of only focusing on unlisted real estate, real estate stocks and the general stock market, we take into account the macroeconomic environment in Norway as well. Following this approach allow us to consider if listed and unlisted real estate respond differently to macroeconomic factors and whether this can explain the disparity in returns.

Evaluations using Sharpe ratio and CAGR suggests that unlisted real estate investments outperform listed on a risk-adjusted basis, but when considering the arithmetic mean of expected return listed investments outperforms. Furthermore, our results imply that listed real estate investments tends to follow the general stock market, both short- and long-term, based on correlation analysis and the CAPM. Here we also find that investments in unlisted real estate yields the highest abnormal return. Lastly, with the use of the multifactor-model we find that the Indirect Index and OSEAX share the same significant macroeconomic factors, whereas IPD appears sheltered from them.

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1. Introduction

Understanding the link in performance between listed and unlisted real estate has taken on a new importance in recent years. Investments in the global property market of commercial real estate has seen a significant rise of 18% annually, to a new record high of $1.8tn in 2018 (Cushman & Wakefield, 2018). This growing acceptance of real estate as an asset class has resulted in an expansion of its securitization, thus becoming an integral part of the investment landscape, making it more accessible for both institutional and individual investors.

In theory, an asset owned by either a listed or unlisted real estate company should be indistinguishable in terms of performance. In practice, however, the two tend to differ extensively. Thus, comparative analysis of the performance characteristics of listed and unlisted real estate investments continues to attract attention. However, there are few recent studies on the topic, as most of them covers the time period before the global financial crisis. Furthermore, empirical research conducted on the topic has focused on markets outside of Norway. Therefore, this thesis aims to contribute to and expand on existing research, introducing a Norwegian perspective and controlling for macroeconomic variables.

Previous research on the topic show inconsistent results, with regards to differences in returns, and whether these returns are driven by the progress of the underlying real estate market or the general stock market. According to Liow (2001), direct investments yield a higher excess return compared to real estate stocks. Contrary, others conclude that listed real estate provide the highest return, with greater liquidity and lower transactions costs (Myer and Webb, 1993; Newell et al., 2007; Ang et al., 2013).

Further, there are inconsistent results of the relative performance progress. Some believe that listed real estate returns can be explained by the general stock market. The rationale for this proposition is as the stock price is subject to supply and demand, it will therefore be exposed to irrational market behavior and overall market risk (Myer and Webb, 1993; Ling and Naranjo, 1999; Hoesli and Serrano, 2007). At the same time, others are of the opinion that listed and unlisted real estate returns have a significant relationship simply because the value of the real estate stocks is essentially the value of the underlying properties (Quan and Titman, 1999; Morawski et al, 2008).

Moreover, some even suggest that the disparity in the performance characteristics of listed and unlisted real estate investments can be explained by additional factors such as macroeconomic drivers, besides the development of the underlying properties and stock markets (McCue and Kling, 1994; Sing, 2004; Sebastian and Schätz, 2009). Despite the inconsistencies, there seems to be a consensus where most studies detect that in the long-term, listed real estate correlates with the underlying real estate market, whereas in the short-term listed real estate shows significant co-movement with the stock market.

The first part of this thesis compares the performance of listed and unlisted commercial real estate investments from an investor`s perspective. Second, it examines whether real estate stocks in Norway are predominantly driven by the progress of the underlying real estate market or by the general stock market. In the extension of this, it also controls for different macroeconomic factors, to see if they can explain the differences in the returns.

Our results show that listed real estate, represented by the value-weighted Indirect Index, yields the highest arithmetic average return, prior to risk-adjustments. In terms of risk-adjusted returns, unlisted real estate represented by the Investment Property Databank Index (IPD) outperform listed real estate to a great extent, based on both the Sharpe ratio and compound annual growth rate (CAGR). According to Capital Asset Pricing Model (CAPM) regressions, both listed and unlisted real estate investments contain less systematic risk than the overall market portfolio. Yet, unlisted real estate is still superior, as the IPD Index yields the highest abnormal return with an alpha of 0.74% against the Indirect Index`s alpha of 0.48%.

Considering the second question of interest, based on our correlation and regression analysis it appears as listed real estate tends to follow the general stock market more than the underlying real estate market. Furthermore, the real estate stocks are most correlated with their net asset value when taking the lead of 3 quarters, with one exemption. This implies that information is first reflected in the stock prices, then gradually in the valuation of the underlying properties. In addition, our results show that listed real estate is more correlated with the stock market both short-and long-term. Lastly, our findings states that listed real estate stocks are driven by the same macroeconomic factors as the general stock market, in particular the Norwegian Interbank Offered Rate (NIBOR) and unemployment rate, whereas unlisted real estate seems sheltered from them.

The remainder of this thesis is structured as follows: First, in Chapter 2, we provide insight in existing research in the literature review. Next, we go through the relevant theory of real estate as an asset class, valuation methods of real estate and other considerations relevant. Chapter 3 provides a data description for the selection of listed companies, indexes and macroeconomic factors. Further, Chapter 4 outlines choice of method regarding performance measurements, correlation and regression analysis. In Chapter 5 we present our empirical analysis. Lastly, in Chapter 6, we conclude on the results presented throughout the thesis.

2. Theory and literature review

2.1 Literature review

A substantial amount of empirical research has been conducted to understand the dynamics of real estate as an investment vehicle, especially after the introduction of indirect investment opportunities such as REITs, real estate stocks and real estate funds. Prior to conducting our analysis of the dynamics of listed and unlisted real estate investments, relevant literature has been examined. The following chapter addresses the most critical aspects of the literature.

Relative performance of listed and unlisted real estate

The risk-return performance of direct and indirect[1] real estate investments has been a popular object of study. In 1993, Myer and Webb (1993) used a vector autoregressive model (VECM) to study the performance of REIT returns compared to direct investments in real estate. Their study showed that REITs appeared to be more similar to the general stock market than direct real estate investments in a time series sense, but when considering an intertemporal relationship REIT returns were stronger correlated to the direct investments.

Liow (2001) provides a long-term examination of the risk adjusted performance characteristics of direct real estate investments to real estate stocks in Singapore's emerging economy from 1975 to 1995. To measure the risk-adjusted performance, he includes the coefficient of return, Sharpe ratio and traditional Jensen abnormal return index. His results show that the performance of direct investments outperforms real estate stocks on a risk-adjusted basis. Also, analysis using time-varying JI reveals that the excess return of real estate stocks is significantly different from direct, and that the real estate stocks lead the underlying real estate performance. Further, the study also supports the proposition that real estate stocks are closely linked to the direct property market in the long-term.

Newell and Hsu (2007) analyze the performance of direct and indirect retail property in Australia over the period of 1995-2005. They employ risk-adjusted performance analysis to assess the added value of retail property in a mixed-asset portfolio and the portfolio diversification benefits of including such assets. Their results show that direct and indirect retail

[1] Direct and indirect investments is defined in chapter 2.3 Investment opportunities

property achieved sound risk adjusted-performance and diversification benefits. Further, direct and indirect investments provide different performance characteristics, as indirect investments deliver higher returns, while direct performs better on a risk-adjusted basis.

Quan and Titman (1999) uses regression analysis including data from 17 countries over 14 years, and identify a significant relationship between changes in listed real estate returns and the underlying real estate values. Consistent with other country-specific studies, their results show that the contemporaneous relation between listed real estate and the stock market is insignificant, with exception of Japan. Ling and Naranjo (1999), on the other hand, studies whether the commercial real estate markets, both listed and unlisted, are integrated with the equity markets. Using multifactor asset pricing models (MAP), their research detect integration between the risk premium of listed real estate and the stock market, contradicting the findings of Quan and Titman. Interestingly, the study also shows that the integration has increased considerably during the 1990s. However, the integration hypothesis does not apply to real estate portfolios which are based on appraisal-based returns.

Hoesli and Serrano (2007) examine the integration between listed real estate, stocks, bonds and unlisted real estate in 16 economies. They find time-varying correlations and that financial assets contribute greatly to the variance of listed real estate, while the impact of direct real estate is limited. Further, they detect a decrease in the impact financial assets have on listed real estate over the 1990-2004 period. However, a more recent study by Morawski et al. (2008) disclose that listed real estate stocks behave more like their underlying values than the stock market in the long run. Further, real estate stocks substantially lead the direct underlying market. The study was conducted in the UK and US, using correlation and cointegration analysis.

Ang et al. (2013), by the use of a factor model, find that REIT and unlisted real estate investments have different, idiosyncratic components, implying that there may be a short-and medium-term diversification benefit to hold both assets in a portfolio. However, in the long-term, the listed and unlisted vehicles exhibit similar characteristics. The short-term differences in return are supported by related studies (Gyourko and Keim, 1992; Myer and Webb, 1993), providing evidence that due to greater liquidity and informational efficiency, indirect real estate tends to lead the underlying real estate market, even after controlling for leverage and appraisal smoothing. As such, direct real estate returns may be more predictable compared to indirect, at least in the short-term.

As discussed, previous studies on the integration characteristics of listed real estate shows inconsistent results. Some researchers conclude that the real estate stocks` behavior is dominated by the stock market and others conclude that it is driven by the underlying property market. This inconsistency is largely due to differences in research method, market and sample.

Real estate and Macroeconomics

Until recently, research linking real estate with the macroeconomic environment has primarily focused on its feature as an inflation-hedge. In this context, Gyourko and Linneman (1988) studies the effect inflation has on both direct investing in commercial property and REIT investments. They find that commercial property investments are mostly positive correlated with inflation. Contrary, REITs are negatively correlated with inflation, much similar to bonds. Quan and Titman (1999) find that real estate is positively driven by inflation, as well as GDP. At the same time, using regression analysis their study also finds attractive features of real estate investments besides its ability to hedge against inflation.

Further, empirical studies have been conducted to identify the most important macroeconomic determinants for the real estate market. Accordingly, McCue and Kling (1994) studies the relationship between REIT returns and macroeconomic factors such as CPI, nominal short-term rate, industrial production and investment level. They control for covariation with the general stock market and find that approximately 60 percent of the variation in real estate series could be explained by the factors mentioned above, where the nominal short-term rate explains the majority of variation.

Sing (2004) examines the effect of systematic market risk and common risk factors, by using MAP to explain the variation in excess returns of direct and indirect real estate investments. Two estimation methodologies were used to test the market integration; the seemingly unrelated regression estimation (SUR), and Fama and MacBeth (1973) two-pass regression technique, which relaxes time-invariant constraints. The study reveals that macroeconomic risk factors are priced differently in indirect and direct real estate markets.

Sebastian and Schätz (2009) studies whether real estate stocks in the UK and US are predominantly driven by the underlying property market or the general stock market. Based on a VECM and variance decomposition, they detect a significantly stronger linkage between the real estate stocks and the underlying market in the long-term. Deviating from the conventional

approach, they also study the linkage to the macroeconomic environment. Their results show that the US real estate market is stronger linked to the macroeconomic environment than in the UK. Further, GDP and interest rates are the principal macroeconomic variables which drives the real estate market in the US.

2.2 Investing in real estate

The investment universe consists of a wide spectrum of asset classes. Real estate as an asset class is a considerable investment vehicle for commercial, institutional and private investors. Due to its nature as a real asset, real estate investments have different characteristics than traditional assets like stocks and bonds, with its long-term investment horizons, low volatility and distinctive risk/return structure (Sebastian and Schätz, 2009).

Historically, stocks and bonds have been the most popular assets among investors. Real estate has through the twentieth and twenty-first centuries been seen as a good, yet illiquid and capital-intensive, diversifier in investment portfolios. However, real estate has since the 1970s become more liquid and available for the common investor through different forms of securitized real estate, such as real estate syndicates, stocks, funds and REITs (Baum and Hartzell, 2012).

In Norway, many invest in real estate for private use. In fact, 77% of the population lived in their own homes in 2018 (SSB, 2018). In addition to primary housing, many also invest in secondary homes, where the homes are rented to others. Here, investors often have expectations of gains through rental income and value increase on the property. Such speculation has proved to be very favorable in Norway, especially in the post-banking crisis in the late 1990s.

Types of real estate

Residential real estate includes both new and resale homes. The two major categories are single-family houses and apartments, but also includes multi-family houses, townhouses and vacation homes. As an investment, residential rental property is purchased by an investor and then inhabited by tenants on either a rental agreement or a lease. The tenant will typically be a person or family. The business idea is to earn a steady cash flow from rental income and increase the return on the investment by a long-term appreciation on the property.

Commercial real estate includes mostly hotels, offices, shopping centers and educational buildings. As with residential real estate investments, the investor receives a cash flow from the tenants, being a corporate entity. In general, the investment costs of commercial property and costs associated with customizations for tenants are higher than residential real estate investments. Nonetheless, the overall return is also higher for commercial real estate, and the tenants tend to be less risky.

Industrial real estate includes manufacturing buildings & properties, and warehouses. The fourth category is land which includes vacant land, working farms and ranches. As this master thesis focuses on commercial real estate, we will not go further in depth on the remaining categories, and from now on refer to commercial real estate as real estate if not else stated.

2.3 Investment opportunities

When investing in commercial real estate, one dimension is whether to invest directly or indirectly. Direct investment means an investor who invests in and manages real estate without an intermediary, and as such direct investments will always be unlisted. Indirect investment, on the other hand, is when the investor buys a share of an underlying (portfolio of) real estate through an intermediary. Indirect investments can be both listed and unlisted, however, it is common to relate to indirect real estate as listed. For that reason, we use the two terms interchangeably throughout the thesis, referring to listed as indirect and unlisted as direct.

As this thesis focuses mainly on the difference between listed and unlisted investments, we will go through the different options within the two. Although both have exposure to the same real estate market, research has shown that listed real estate has a greater correlation with the equity market, at least in the short-term. Over longer time horizons, however, it is shown that the correlation between listed and unlisted real estate converges.

2.3.1 Listed real estate

In general, the fact that an instrument is listed means it can be traded on an exchange. The most common listed real estate options are stocks, funds and REITs.

Real estate stocks

Investing in real estate stocks means buying shares in companies that manage portfolios of real estate, through rental, buying, selling and overall maintenance of the properties. This has the same characteristics as investing in the general stock market, but with a more concentrated exposure to the real estate market. Stock markets provide a relatively high degree of liquidity as well as low transaction costs, where transaction prices are reported on a frequent basis. As a consequence, share prices can adjust instantly to news regarding their value. This also increases the volatility compared to a direct real estate investment. The return is determined by the price development of the shares and the potential dividend payments.

In Norway there are three companies listed on the Oslo stock exchange who holds and manages portfolios of real estate; Norwegian Property (NPRO), Entra (ENTRA) and Olav Thon Eiendomsselskap (OLT). For our research purpose these will be the companies we will investigate further.

Real estate funds

A real estate fund invests primarily in a range of real estate assets, either directly or through real estate companies' stocks. They also keep a post invested in liquid assets such as money market instruments and bonds, to ensure payout to participants of the fund.

REIT

A REIT is an investment company that owns and operates income-producing real estate. To qualify as a REIT, there are certain requirements that must be fulfilled. In particular, at least 75% of total assets must be invested in real estate, and the same share of gross income must come from real property rent. Moreover, at least 90% of taxable income must be paid as dividends to shareholders (SEC, 2012).

To invest in REITs one can either purchase their shares directly on an open exchange or invest in a mutual fund specializing in public real estate. Some REITs focus on a specific sector, such as healthcare or shopping malls, while other holds a broad variety of sector properties. As opposed to a direct investment in a single property, REITs hold a portfolio of multiple properties with different tenants, duration and geographical location, hence decreasing the risk. In other words, REITs can be a liquid and diversified way to obtain exposure to real estate.

However, as with real estate stocks, REITs tend to perform more similarly as the broad stock market in the short-term.

2.3.2 Unlisted real estate

Unlisted investments involve buying an interest in one or more real estate properties, where the investor receive cash flow payments from the lease as well as participating in the capital appreciation of the property. The investor can either purchase the entire property directly or participate through a syndicate. Due to the high capital intensity, the matching process of seller and buyer can be time-consuming and also involve high transaction costs. Therefore, these investments will generally be less liquid than the listed options, and hence trade less frequently. As such, asset values in private markets tend not to incorporate news as quickly as the pricing of listed assets in public markets (Hoesli and Lekanger, 2006).

Direct purchase

Direct investment means an investor who invests in real estate without an intermediary. Thus, the investor is responsible for buying, operating, maintaining, and finally selling the property. The level of risk and return is determined by the characteristics of the specific property bought. Direct investment in real estate has previously been problematic for most people because of the low liquidity, major capital required and necessity of active management. Smaller investors have therefore been forced to invest indirectly. This has contributed to the occurrence of various forms of ownership in order to make property easier to trade, such as syndicates (Binkley, 2013).

Syndicate

In a real estate syndicate, investors pool their capital to invest in larger properties that may otherwise be too expensive for them individually, and all administrative work is left to a professional manager. The manager normally charges an acquisition fee (.05-5%), in addition to receiving a small management fee (1-3%). The profits to investors come from both rental income and property appreciation, as properties tend to increase in value over time. The rental income is divided into a preferred return to investors, typically 8 – 12%, and a cash flow participation split between investors and manager paid after the preferred return is satisfied (Thomson, 2014). This way the sponsor only makes good money when the investor makes money, and their performance incentives are more closely aligned.

Syndicates can invest in a single property or a group of properties. Although investing in a single property syndicate entail more risk in its lack of diversification, it still provides stable cash flows, tax benefits and a potential asset appreciation. A syndicate tends to be closed-ended, meaning a restricted number of investors and set capital amount, and the life range is typically five to ten years from establishment. The advantage of syndicates is that the capital requirement is less than for direct investments, while at the same time you achieve great exposure to the real estate market.

Norwegian real estate syndicates have way outperformed Norwegian real estate stocks the past 15 years, and has given investors, primarily wealthy individuals, high profits at medium risk. During 2000-2015, the syndicates` average return and volatility has been 10.7% and 13.6% respectively, whereas the stocks only provided a 5% return at 26.8% volatility (Norne Securities, 2015).

2.4 Valuation of real estate

When valuing real estate, one seeks to find the correct market value of the property. A common issue when valuing unlisted investments is the lack of data availability and transparency, as well as historical returns, making the return based on a subjective perception of the actual market value.

With listed real estate, on the other hand, prices are continuously adapting to new information based on turnover and market value, providing the data needed to compute a more accurate return. The price investors are willing to pay is a result of the supply and demand in the market, indicating the fair market value of the combined real estates. However, as mentioned earlier, these prices could also be impacted by the general stock market conditions, market sentiment and irrational investor behavior in the short-term, not necessarily reflecting the actual value of the properties in the underlying portfolio (Sebastian and Schatz, 2009).

This means it would be expedient to value the underlying portfolio of properties on an individual stand-alone basis. There are several ways to value an individual property, where comparable transactions, the net capitalization method and the discounted cash flow (DCF) are among the most prevalent methods for both listed and unlisted. When valuing a portfolio of properties, one could value each property separately and then adjust for net debt to obtain the

net asset value (NAV), which tends to deviate from the market value of equity (stock price * number of shares).

2.4.1 Comparable transactions

This method is based on the assumption that the value of the property can be estimated by analyzing similar properties that have recently been sold. There are several ways to compare property values. This can be based on the sales value of the comparable property, which is further adjusted for factors that differ between the two, such as size, assumptions, leases, etc. A multiple can be made given the relationship between gross or net rental income, and the value of the property.

2.4.2 Discounted Cash Flow

Using a cash flow model, the cash flows that the properties generate over a given period is taken into account. These cash flows include rental income and estimated residual value less owner's cost and other current expenses. The cash flows are then discounted to a present value, indicating an estimate of what the investment (property) is worth today. At the beginning of the period, the actual circumstances concerning the property are used, based on knowledge of leases and current costs. Further on, the rental income and other costs are estimated as values converging at a given market level, such as an assumption that both revenues and expenses will grow given inflation expectations of, for example, 2%.

The formula is as follows:

$$Real\ estate\ value = \sum_{t=1}^{n} \frac{(L - O - T - C)_t}{(1+k)^t} + \frac{R_t}{(1+k)^t}$$

L = Gross Lease Income
O = Operating costs
T = Tax
C = Capital costs
R = Residual value
t = Time
k = Required rate of return
n = Number of periods

2.4.3 Net capitalization method

Using the net capitalization method, one uses the relationship between return, net rental income and property value. The value of the property is estimated as follows:

$$Real\ Estate\ Value = \frac{Net\ Lease\ Income}{Yield}$$

Net rental income is defined as gross rental income less owner costs. Ownership costs include, but are not limited to: insurance, maintenance, technical installations and joint costs in non-rented areas. Some of the players also include administration costs, audit fees and other fees. This is considered as conservative in the valuation of the properties, as an increase in owner costs will in isolation reduce the reported property value.

Yield is defined as the real, risk-adjusted return requirement for investors, and consist of:

Inflation
+ Risk-free rate
+ Swap spread
+ Interest rate
+ Location risk
+ Property specific risk
+ Other
= Yield

The lower the yield, the higher the value estimate of the property, given other conditions held constant. Although there is a clear relationship between area / segment and yield, each property will be subject to individual assessments of location, duration and quality of leases. Prime yield is the yield you achieve on the best properties, typically being in the central business districts.

2.4.4 Net asset value

The net asset value appears as the difference between the properties` market value and the company's net debt, thus reflecting the underlying values of the company. By dividing this value on the number of shares, you get a NAV per share, which allows you to compare the underlying value of the real estate portfolio against the share price the market pays. To

understand the relationship between listed and unlisted real estate markets, it is useful to look at listed real estate companies stock price and their NAV per share. A widely used target ratio for comparing stock prices and underlying values is the Price / NAV ratio. A rate of 1 means that the NAV is equal to the share price. If P / NAV is less than 1, the stock price is lower than underlying values, which may indicate a company trading at a discount, but it can also be proof that the assets are underpriced or that the company is run poorly. If P / NAV is greater than 1, the stock is trading at a premium.

2.5 Other considerations

2.5.1 Tax regime in Norway

An important consideration from an investor's perspective is the differences between investments regarding tax policies.

In general, Norwegian companies are taxed with 23% corporate tax on profits. In addition, the share dividend is taxed at 30.59%, totaling a marginal tax rate of 46.6% on rental income distributed as dividends in a listed real estate company. The marginal tax rate is more or less the same when distributed as salary, depending on the individual tax payer`s remaining income. This is most likely the main reason why investors choose private real estate investments over public, at least until the portfolio grows so that the establishment of a company is required for further investments.

Gains on the sale of properties from direct investments are taxed at 23%, unless you have lived there the last 12 months. The tax rate is the same for property sales from corporations, but in addition, the investor still taxes the additional 30.59% on dividends if he is to collect this gain. An individual investor holding shares in a listed real estate company also pay 23% tax on gains from potential share appreciation the day he sells his shares. If the holder of shares is a company itself, on the other hand, this gain is tax-exempt according to the exemption method (Norwegian Tax Administration, 2018). When a holding company own their properties through separate companies, and then sell the properties they also tax 23% on the gain. However, if the holding company sells the shares in the company instead, the gain will be tax free. The buyer receives the company with all its related assets, liabilities and tax positions. Since the legal owner of the

property remains, it will not be necessary to recall new legal basis, thus avoiding the 2.5% document fee as well.

Another tax directly affecting individual investors and their asset allocation is the wealth tax. Previously, direct investments in real estate have been tax-beneficial due to a low tax-equivalent value compared to the market value of the property, which, combined with a high loan-to-value ratio, offered wealthy people a negative tax asset. The commercial property tax policy has been tightened in recent years, where the tax-equivalent value has increased by more than 150% since 2011. Commercial real estate is currently brought to a tax-equivalent value of 80%, which is the same as for shares and other working capital after an adjustment from 90% to 80% in line with the tax settlement for 2018. Today it is also difficult to leverage oneself *out of* a wealth-tax position, as the banks will normally not lend more than 60% of the market value. (DNB, 2018)

In other words, considering the tax obligations from an investor's perspective, the two investments, listed vs unlisted real estate, will generally be more or less equivalent. Therefore, for the purpose of this thesis we will not go further into this.

2.5.2 Financing

Leverage is the ratio of total debt financing to the current market value of a property. There is no clear answer when it comes to the optimal leverage ratio. Leverage is often used to increase the potential return on an investment, because the cost of debt tends to be less than the unleveraged return generated by the property. At the same time, a high level of debt can be very costly and even fatal during bad times, especially for real estate, as a recession can heavily decrease the market value of the property. Based on the lessons from the recent crisis, the use of leverage has become more moderate, and the industry as a whole has become subject to stricter regulation. Bottom line is, there is a trade-off between risk and return when settling for optimal leverage (Berk and DeMarzo, 2017).

Finding the optimal ratio essentially depends on an individual evaluation, but academic research related to the real estate industry has shown that the use of leverage up to 40% supports an efficient risk-return profile with above levels disproportionately increasing the risk (INREV, 2013). Steiner and Riddiough explores the leverage ratios for international listed real estate

firms, after categorizing them into strong and weak firms, based on their Tobin`s Q where strong firms have a high degree of assets in relation to market value. They find the strongest firms to have an average leverage ratio of only 35%, whereas the weakest have a significantly higher ratio of 59% (Steiner and Riddiough, 2014).

Representing the indirect listed options, the three firms NPRO, OLT and Entra have an average leverage ratio of 66%, 48% and 46% respectively for the time period considered. For NPRO and OLT we also observe that this ratio was higher prior to the crisis than after. As for unlisted real estate, the typical leverage for syndicates in Norway is between 65%-80%, according to Norne Securities. The real estate investment policy for The Norwegian Government Pension Fund Global states that the total portfolio leverage shall on average not exceed 55% (Norway Ministry of Finance, 2009).

In addition to the debt taken by the firm/syndicate, investors can use debt as a part of their financing of an investment thereby further increasing the leverage ratio. For direct real estate investing, it depends on the default risk of the investor, which determines his ability to take on debt, as well as his personal risk preferences.

In the end, the amount of leverage is a crucial topic relating to an investment’s risk and return, but as investors are able to differentiate/adjust this to match their own preferences and capabilities, this will not be a topic of further discussion.

3. Data description

In this chapter, we will provide a descriptive presentation of the data, to give a better understanding of the figures used in our calculations. Further, we present the method we have used to reach the results as discussed in our analysis (Chapter 5).

3.1 Selection of listed Companies

As of 2018, there are six listed real estate companies on Oslo Stock Exchange, divided into development and management & development of real estate. For our scope of research, comparing listed and unlisted real estate investments and their returns, we only include the companies which hold and manage portfolios of real estate, namely Norwegian Property (NPRO), Entra (ENTRA) and Olav Thon Eiendomsselskap (OLT). Even though this is a small ground for generalizing listed real estate investments in Norway, these are the only listed companies there is, excluding pure developers.

Entra, established in 2000 and listed in 2014, is one of the leading real estate companies in Norway. They develop, let and manage their portfolio of buildings as well as exercising active portfolio management by purchasing new and sale of existing properties. As of 2018, Entra´s portfolio consist of 88 buildings, located in Oslo, Bergen, Stavanger and Trondheim. Their market portfolio is worth 44 billion NOK. Entra focuses on environmentally friendly solutions, and safe and long-term contracts. Thus, 64% of their tenants are of public sector.

Norwegian Property is a corporate real estate company, founded in 2006 and listed the same year on Oslo Stock Exchange. They acquire, develop, manage and sell commercial real estate properties in Norway. As of June 2018, the group holds a portfolio of 32 office and commercial properties located in Oslo, Bærum, Gardermoen and Stavanger. The market value of the portfolio is at 15,4 billion NOK. The portfolio consists of offices with associated warehouses and parking, and retail and restaurants.

Olav Thon Eiendomsselskap is a Norwegian real estate company, founded in 1982 and listed on Oslo Stock Exchange the following year. The company’s main focus is shopping center properties. They are the largest shopping center actor in Norway but also have a significant

share of the Swedish market. The portfolio has of 2018 a market value of approximately 52 billion NOK and consist of 134 properties.

3.2 Share prices and NAV

The data for each given company is gathered from their official financial reports on a quarterly basis in the time period Q4 2006 to Q2 2018, totaling 47 observations on each company and attached variables. Note, however, that Entra was listed in Q4 2014, and therefore only has 15 observations. Here we have extracted the companies´ interest bearing debt, amount of cash, number of shares and property portfolio value, in order to compute the NAV per share. The property portfolio is valued each quarter by two external appraisers, namely Akershus Eiendom and Cushman & Wakefield. In Bloomberg we found the dividend per share and stock price at the official quarter end-date as well as the actual date of report release. For each observation missing date, we have used the first stock price available following the date. Then we computed the holding period return for each quarter.

Below you can see the relationship between the share price and the NAV per share for the given companies, and the ratio between them (P/NAV).

NPRO

Figure 1 Share price and NAV per share, NPRO

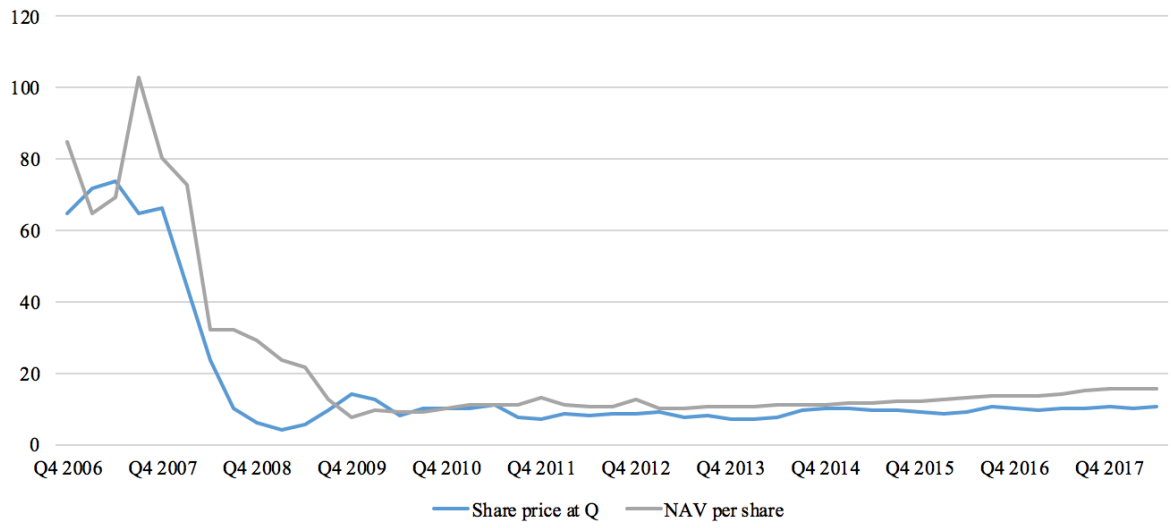
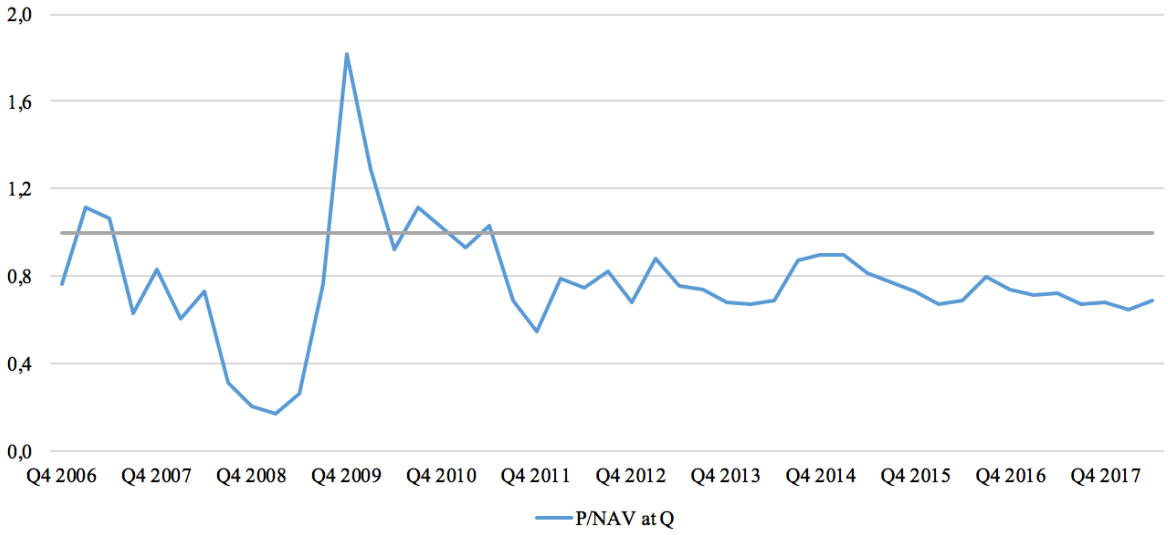


Figure 2 Share price / NAV per share –ratio, NPRO



In Figure 1, the development in NPRO´s share price and NAV per share is presented. As seen, NPRO´s share price was quite drastically reduced in 2008 after a share issue to raise NOK 2.5 billion in new capital. The NAV per share accordingly followed as the number of shares increased. From 2008 to this date, NPRO has reduced their holding portfolio from 124 to 32 properties. Consequently, its share price dropped from 70 to around 9 – 11 NOK per share.

From the P/NAV graph in Figure 2, we can see that this relation is very volatile and tends not to follow any stable pattern. The difference in the price and underlying value of properties was the widest during the financial crisis, in both directions. The P/NAV goes from close to 0.2 and then suddenly increase to about 1.8, before it stabilizes around 0.8. A reasonable explanation for this, is that NPRO experienced a substantial increase in the turnover of its shares in 2009 and as a result, was included in Oslo Stock Exchange`s OBX index.

OLT

Figure 3 Share price and NAV per share, OLT

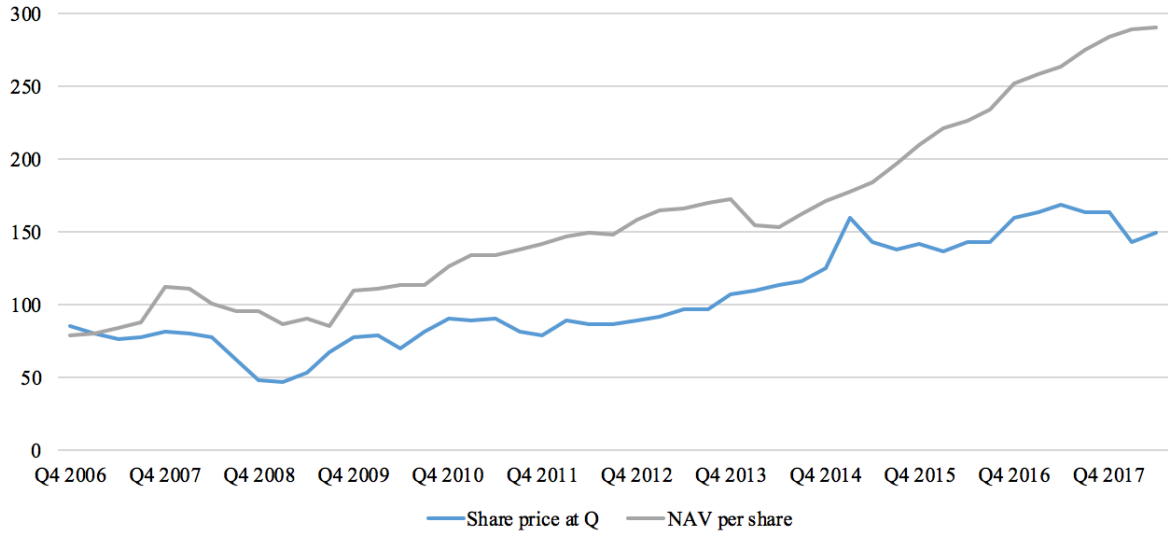


Figure 4 Share price / NAV per share –ratio, OLT

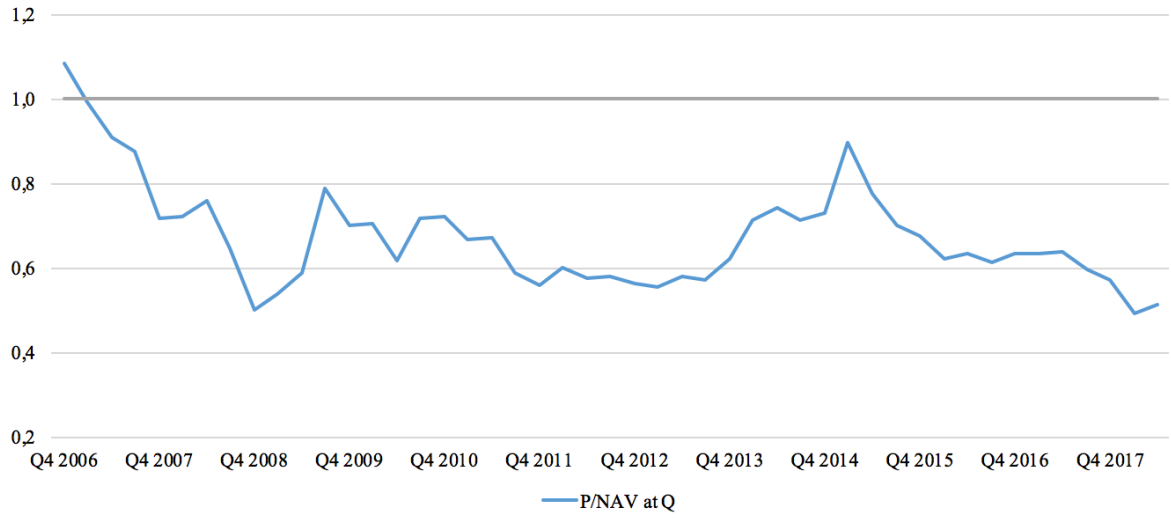


Figure 3 shows that OLT has had a stable growth in both its share price and underlying real estate portfolio. However, in Figure 4, we see that the gap between the share price and NAV per share has grown bigger, especially in recent years, where P/NAV is currently as low as 0.5. The P/NAV ratio for OLT is mostly in the interval 0.6 to 0.8, as illustrated in Figure 4, which is a considerable discount given its asset values.

The P/NAV discount has several explanations. First, the yield requirement in the shopping center sector has seen a small increase based on the understanding that appraisers have increased the property risk in their yield requirement. The higher risk expectations are probably

due to the fact that E-commerce[2] poses as a long-term threat to OLT´s most important tenants, brick-and-mortar stores. As of 2018, shopping centers constitute 81% of OLT`s property portfolio. These on-going structural changes in the sector will possibly accelerate in the next few years, consequently reducing property values. Further, other key risk are higher long-term interest rates and the high age of Olav Thon himself, resulting in a pessimistic outlook for OLT. As such, the discount suggests that the stock market has factored in these risk aspects.

ENTRA

Figure 5 Share price and NAV per share, ENTRA

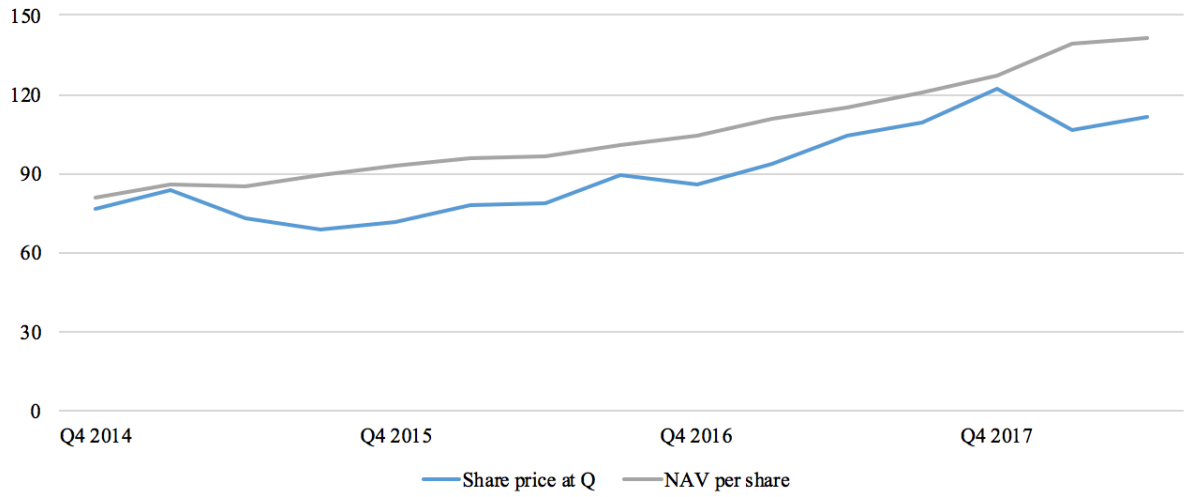
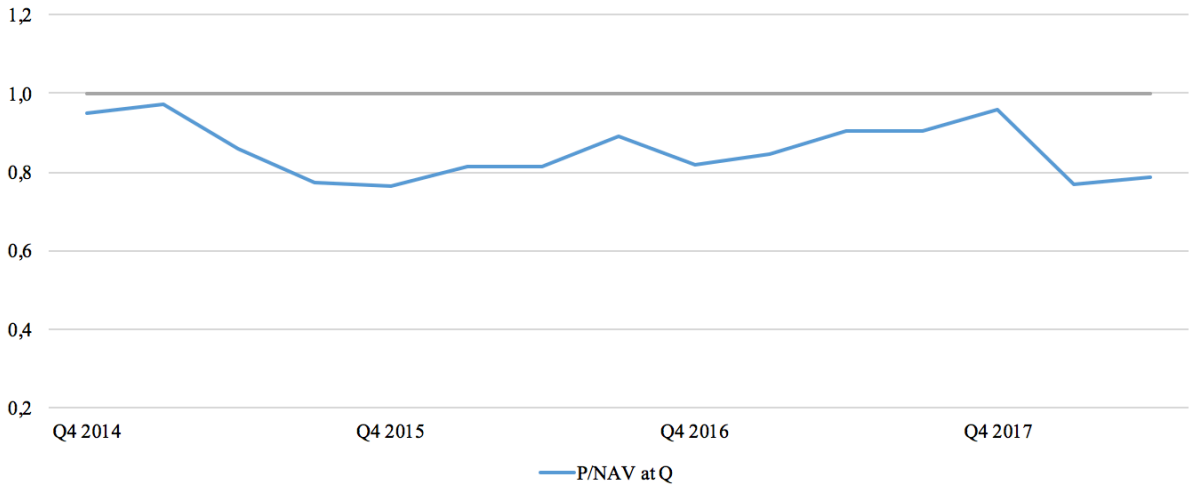


Figure 6 Share price / NAV per share –ratio, ENTRA



In Figure 5, it can be viewed that Entra has delivered solid results and has a positive market sentiment, which is represented in an increasing share price and NAV per share. Also, it is

[2] E-commerce: Buying and selling goods or services using the internet.

natural that Entra`s P/NAV ratio, illustrated in Figure 6, is more stable as the time period available is a lot shorter. The ratio is close to 1 several times, following a period of a wider spread. Compared to NPRO and OLT, the ratio indicates that the investors believe that the valuation of Entra`s properties is in fact the true values.

A plausible reason for the fact that the P/NAV ratio is close to 1 for Entra, is because the stock market emphases Entra´s opportunities rather than its risks, compared to NPRO and OLT. Currently, Entra has four projects in its project portfolio which will add approximately NOK 158 million to its rental income over the upcoming quarters. Further, with a high share of modern quality premises, Entra should be able to capitalize on a strong rental market. However, the reason for why the ratio is not over 1 could be because the stock market factors in that the rental market Entra operates in is among the most volatile in the Nordic. Also, the project portfolio contains some projects with significant amounts of square meters which have not yet been rented out.

In general

Although the stock prices and NAV seem to follow each other on a general level, the figures displaying P/NAV shows a more volatile image of how the ratio actually develops. As one can see, the P/NAV is generally below 1 for all three cases, meaning the stock is trading at a discount relative to the underlying asset value represented by the NAV. This can partly be explained by a skepticism among investors that the valuation of the properties might not represent the real market price, or at least the low ratio could reflect the risk associated with this uncertainty. In addition, listed real estate is known for providing a stable cash flow, but limited growth prospects as most cash is paid as dividends. This is especially the case for REITs, with their 90% dividend-policy, and might not be the case for *normal* stocks, but it could potentially be a bias.

That being said, there are also solid arguments stating the ratio should be close to or above 1. Many institutional investors are obligated to invest in certain types of securities / sectors. If they seek to diversify with real estate exposure, the options in Norway are quite limited. In terms of equities, this should imply that the stock is more expensive than the fundamental value since the major investors push up the price. Furthermore, as shares are more liquid than direct real estate investing, they normally contain a liquidity premium, although both NPRO and OLT are said to be trading at a liquidity discount due to a highly concentrated ownership. Not least,

assuming that the properties laying ground for NAV are valued correctly, if the company were to liquidate all properties, one would make a profit on the gap.

At some point the P/NAV for NPRO and OLT is as low as 0.2 and 0.5 respectively. This was in the midst of the financial crisis in 2008, and both companies' share prices fell dramatically (40-60%) – just as the OSEAX and stock markets in general. At the same time, the IPD return was only negative by 4.7% in 2008, in other words not so dramatic for investors with exposure to unlisted real estate. This could be explained by a change in investors` preferences, so called money shifting, to more hard assets i.e. direct real estate preferred over stocks. A further study of the relationship between share price and NAV is presented in the correlation analysis.

3.3 Indexes

3.3.1 The IPD Index

The Investment Property Databank Index (IPD) is an annual property performance index that tracks retail, office and industrial properties in Norway. As of December 2017, the index consisted of 453 property investments and had a total capital value of NOK 140.1 billion. The appraisal-based index measures unlevered total returns of directly held standing property investments (MSCI, 2018). The returns are measured from one valuation to the next. Thus, the index provides insight into the financial and operating performance of the unlisted real estate market in Norway.

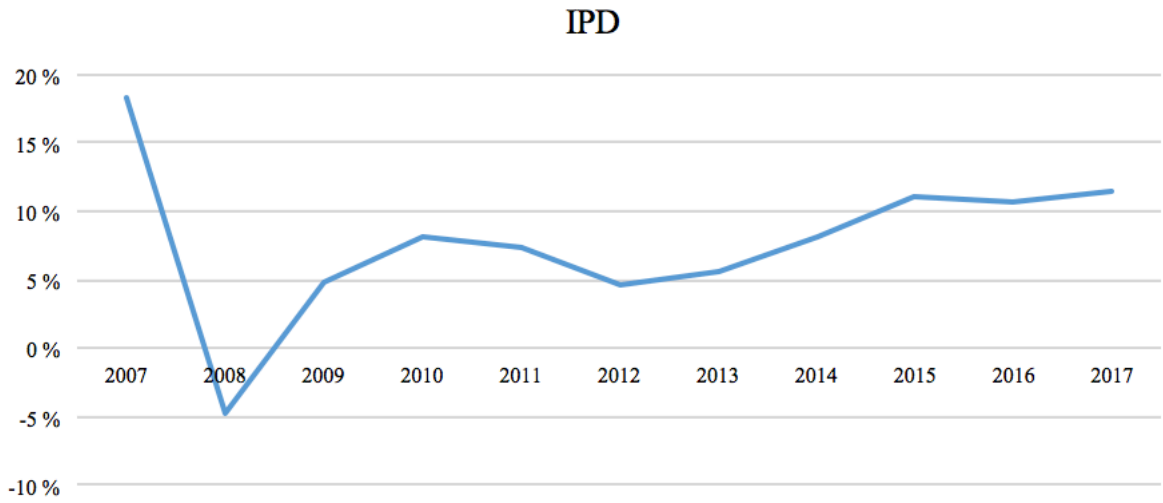
The IPD Index, with its 453 properties, is an appropriate measure of the general performance of the commercial real estate market in Norway. Furthermore, Norges Bank Real Estate Management use the IPD Global Property Index as a benchmark for their real estate investments. Argumentatively, the IPD Norway Annual Property Index can be viewed as a benchmark for unlisted Norwegian real estate investments.

Like other indices, IPD has a number of shortcomings. First of all, it is not possible to invest in the index. Hence, the diversification benefits and risk profile that comes with it is not realistically achievable when investing directly in a single property. Furthermore, appraisal-based indexes are in general reported to be smoothed, caused by the infrequent and time-delayed valuations. The consequence of this smoothing effect is that the volatility of the index appears lower than it really is, as well as autocorrelation in the error terms as valuations are

based on past period valuations. This autocorrelation is corrected for the analysis purposes (see appendix). Lastly, direct real estate investments are in most cases leveraged. Yet, indices like IPD assume wholly equity financing and does not account for leverage. Thus, comparing IPD and the other indices is not strictly equivalent to comparing “apples-to-apples”. Despite these characteristics, IPD is the best alternative available for replicating a portfolio with investments in direct commercial real estate.

The IPD return is gathered from an extensive search in related news articles and other research reports, as these reports are costly and otherwise classified from the public. This number is only released on a yearly basis, so to make it match our quarterly data we have used the accumulated rate going from years to quarters.

Figure 7 IPD development, 2007-2017



3.3.2 The Capitalization-weighted index

A capitalization-weighted index, also called market value-weighted index, consists of a set of securities where the weights are proportional to the total market value of their outstanding shares. The index is dynamic as the market value of each security changes frequently. The total return of the index is calculated of the returns on each security multiplied by their weights in the index. The formula for the total return is:

$$R_{i,t} = r_{i,t} * w_{i,t} + r_{k,t} * w_{k,t} + r_{j,t} * w_{j,t}$$

Where:

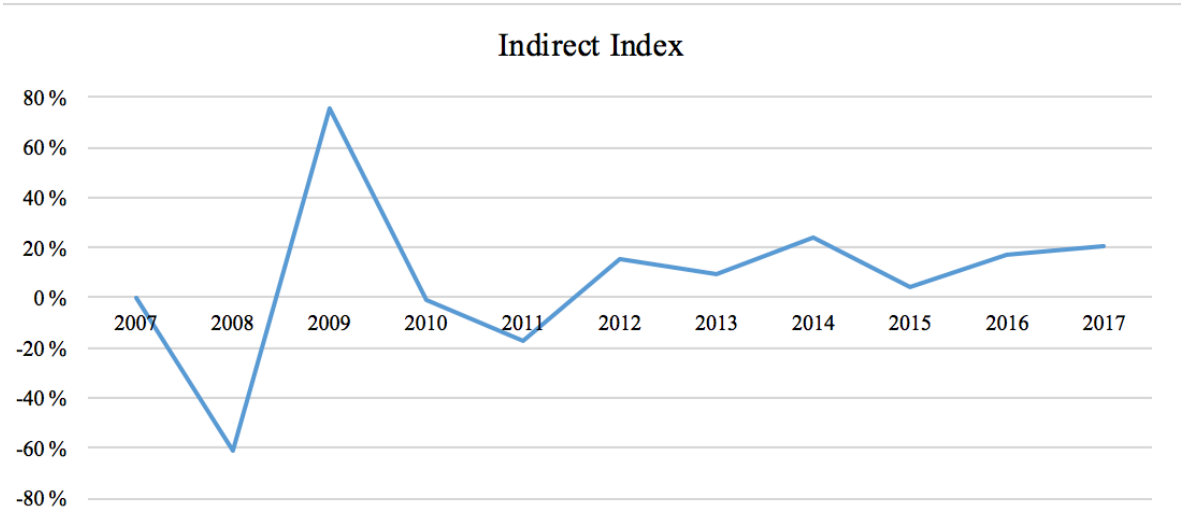
$R_{i,t} = Return\ capitalization - weighted\ index\ at\ time\ t$

$r_t = Return\ for\ stock\ i,j,k\ respectively\ at\ time\ t$

$w_t = Weight\ for\ stock\ i,j,k\ respectively\ at\ time\ t$

The Capitalization-weighted index represents the listed Indirect Index, and consists of NPRO, OLT and ENTRA according to their market cap. The proportion of each individual company's equity value to the combined total market value gives the weight of the company in the index. Consequently, the total return of the index is found by multiplying each security's weight with their respective return. Since the weights are a result of the market value of equity, the weights are dynamic and therefore change every quarter. In the period of Q3 2006 to Q3 2014, the index only consists of Norwegian Property and Olav Thon Eiendomsselskap, while the subsequent periods also include Entra.

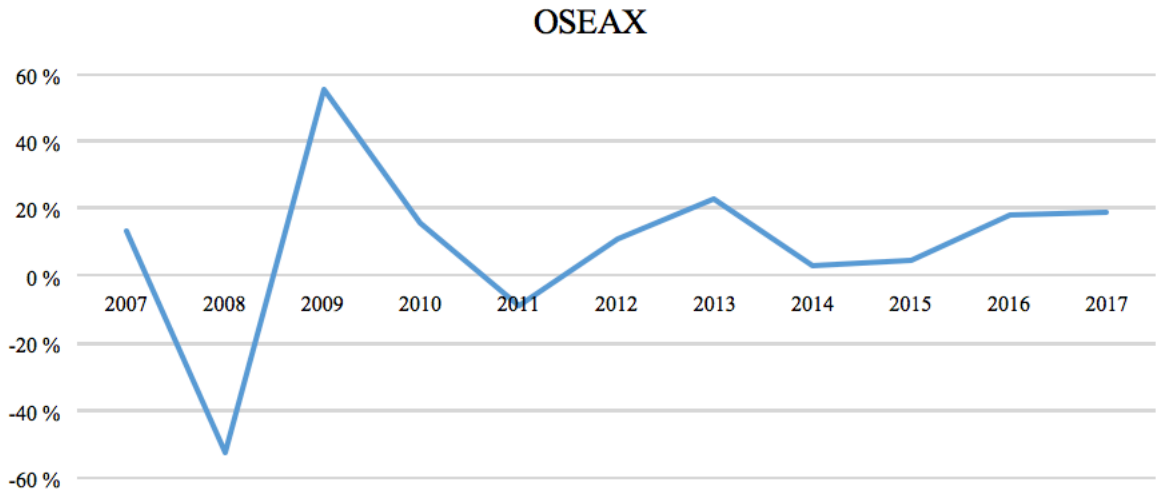
Figure 8 Indirect Index development, 2007-2017



3.3.3 OSEAX

OSEAX consists of all shares listed on Oslo Stock Exchange. The index is adjusted for corporate actions daily and the current outstanding number of shares is applied in the index (Oslo Børs, 2018). The index is measured as the quarterly return calculated as the percentage change in index value, adjusted for dividend payments.

Figure 9 OSEAX development, 2007-2017



3.4 Macroeconomic factors

For the purpose of explaining the disparity in performance of listed and unlisted real estate investments, this thesis aims to control for macroeconomic variables. We postulate that the variation in returns is partially a result of how listed and unlisted real estate reacts to changes in the undermentioned macroeconomic factors, as both the real estate market and the stock market is linked to the macroeconomic environment.

The selection of the macroeconomic factors is based on theoretical assumptions and related literature used in this thesis. Although most of the studies have been conducted outside of Norway, we find the same factors to be applicable in the Norwegian market as well. These macroeconomic factors are interest rates, inflation, GDP and unemployment rate. In addition, we have chosen to include new build. The following part addresses definitions of each macroeconomic factor and why they are included.

3.4.1 Interest Rates

The sensitivity of an asset's return to changes in the level of interest rates often depends on whether the value of future cash flows is fixed or not. If not, high interest rates decrease the present value of future cash flows, thus reducing the attractiveness of an investment. In accordance with economic theory, an increase in interest rates will result in a decrease in the value of the asset. Conversely, when interest rates fall, values increase.
In terms of real estate, when interest rates rise, the cost of debt increases, thus lowering investors` purchasing power and prices for real estate. Secondly, interest rates impact investors` discount rate, consequently affecting the valuation of investments. High dividend-paying stocks and interest rates are said to have an inverse relation, i.e. the value of the stock is expected to decrease when interest rates increase.

The interest rate used is the 3-month NIBOR based on monthly averages of quoted daily selling rates for five big banks. NIBOR is a major indicator on credit markets and the aggregate investment climate of an economy. Thus, this is preferable to long-term interest or mortgage rates.

3.4.2 Inflation

Inflation reduces the real value of money over time and therefore lowers the value of expected cash flows. Investors who own assets are exposed to changes in inflation, since their cash flows are dependent on the level of inflation during the holding period. As such, stocks and inflation are said to have a negative relationship. Direct real estate investments, however, are said to be an inflation-hedge.

The main reason for this is that most of the rental agreements are adjusted to the consumer price index (CPI), which allows for so-called step-ups in rent over the term of the lease. Therefore, the net operating income is often adjusted for inflation. Direct real estate investments should have a positive relationship with inflation, contrary to indirect.

Inflation is measured as the annual change in the Norwegian consumer price index (CPI), downloaded from SSB. The data is not seasonally adjusted and includes effects from energy prices and tax changes.

3.4.3 Gross Domestic Product (GDP)

GDP, which is the final value of the goods and services produced in a country for a specific period, has a well-documented, positive relationship with the real estate market and the stock market. GDP affects REITs, stocks, property stocks and the value of real estate in a similar manner. When the growth of the economy is increasing it has a positive effect on business activity, investment rates and future corporate cash flows. Therefore, GDP is expected to have a positive relationship with return for listed and unlisted real estate investments. The time series is downloaded from DataStream.

3.4.4 Unemployment rate

The unemployment rate is the percentage of the workforce that is unemployed at all times, adjusted for seasonality. This macroeconomic factor gauges the economy's growth rate and is therefore an important indicator to determine the overall health of the economy. Consequently, both listed and unlisted real estate is expected to have a negative relationship with unemployment rate. The time series is downloaded from DataStream.

3.4.5 New build

Deviating from the conventional sample of macroeconomic variables, we have included new build as a potential explanatory variable for returns of direct and indirect real estate investments. In accordance with economic theory, an increase in supply, all else being equal, will result in a decrease in value. Therefore, as the rate of new build rise so will the vacancy rate, consequently lowering prices of real estate. As such, new build is expected to have a negative relationship with both listed and unlisted real estate. The time series is downloaded from SSB. For analysis purposes we take the natural logarithm of the new build m2 area.

4. Method

In order to analyze the dynamics and performance of listed and unlisted real estate investments in Norway, as well as their relationship with the chosen macroeconomic variables, this thesis applies several methods. To determine the performance, we compute the holding period returns and apply these numbers in mean return analysis calculating the arithmetic average return, as well as the Sharpe ratio and CAGR to get a balanced view of the risk-adjusted-return. Further, when examining whether listed real estate investments are predominantly driven by the underlying real estate market or the general stock market, we conduct correlation analysis and the CAPM. Finally, to take into account the macroeconomic variables and their impact on the given indices, we apply correlation analysis and the multifactor model. In the following chapter we will present each method separately.

4.1 Risk and return

The return on a listed investment is easily calculated through the holding period return at any point in time due to the continuous pricing on the exchange, whereas the unlisted investment represented by the IPD is calculated as a syndicate return.

4.1.1 Holding period return

The return on an indirect investment in real estate is calculated in the same way as for a common stock using the holding period return (HPR):

$$HPR = \frac{P_1 - P_0 + D_1}{P_0}$$

Where:

P_0 = Beginning price
P_1 = Ending price
D_1 = Cash Dividend

The HPR consists of two components; dividends and the stock price development. Dividends are a distribution of the firm's earnings, related to the net rental income from the properties. The stock price development is expected to follow the underlying assets´ intrinsic value, which

depends on both the rent and appreciation of the properties. As discussed, the stock price tends to follow the general stock market as well, which could affect the stock price development.

4.1.2 Syndicate return

The syndicate return also consists of two components; net rent providing a positive cash flow and the value appreciation of underlying properties.

$$Net\ Lease\ Return = \frac{Net\ Lease\ Cash\ Flow}{Property\ Value} \qquad Value\ Appreciation = \frac{V_t - V_{t-1}}{V_{t-1}}$$

The two formulas give:

$$Total\ Return = \sum_{t=1}^{n} \frac{Return_{a,t} \times V_{a,t}}{\sum_{i=1} V_{i,t}}$$

The return from net rent in period t is calculated as a percentage of the capital bound up in the syndicate. The reason that the denominator used is the property value in period t, is that the alternative option to receive the return is to sell the property at market price.

4.1.3 Arithmetic mean return

The arithmetic mean of the return is simply the sum of returns for given sub-periods, divided by the number of periods. This is often used for the purpose of computing expected returns, however, it ignores the compounding effect and can be misleading of actual returns, especially in the presence of high volatility. Arithmetic mean is given by the formula:

$$\bar{r} = \sum_{t=1}^{n} \frac{r_t}{n}$$

Where:

$\bar{r} = Arithmetic\ mean\ return$

$r_t = Return\ at\ time\ t$

$n = Number\ of\ periods$

4.1.4 Sharpe ratio

The Sharpe ratio is a measure of risk adjusted return and compares an investment's excess return over the risk-free rate to its volatility. In general, the higher the Sharpe ratio, the more attractive the investment. The modified Sharpe ratio is based on the arithmetic mean of excess returns divided by the standard deviation of those returns. When taking the geometric average, which will be lower the higher the volatility in the returns, and dividing by standard deviation, you essentially account for volatility twice.

The formula is as follows:

$$Sharpe\ ratio = \frac{\bar{r_i} - r_f}{\sigma_i}$$

Where:

$\bar{r_i}$ = Mean return on asset *i*

r_f = Risk-free rate

σ_i = Standard deviation of asset *i*

We have used the Sharpe ratio to compare the profitability, simply to get a standardized measure of what provides the best return given relevant risk.

4.1.5 CAGR

The compound annual growth rate (CAGR), also referred to as the geometric mean, is the annual growth rate of an investment over a specified period of time. Due to market volatility, the growth of an investment may be inconsistent and difficult to interpret. Hence the CAGR is expedient by calculating the actual growth based on the initial and final value of an investment. This makes it superior to arithmetic mean returns because it considers the fact that an investment is compounded over time, and that negative returns have greater impact than reflected by just taking the sum and dividing it by the number of observations.

$$CAGR = \left(\frac{End\ value}{Beginning\ value}\right)^{\frac{1}{years}} - 1$$

The geometric mean will always be equal to or less than the arithmetic. For an asset with high volatility, the arithmetic mean tends to exaggerate the actual average return to a large extent, and the difference between the two becomes more significant. One limitation is that it presents a smoothed return over the time period measured, when an investment in reality experiences short-term ups and downs. In addition, CAGR is subject to manipulation as the variable for the time period is determined subjectively.

4.2 Correlation analysis

Correlation analysis is a statistical method measuring the degree of linear correlation between two variables. The correlation indicates to what extent two time series develop in relation to each other, given by the formula:

$$Correlation = \frac{Cov(x, y)}{\sigma_x * \sigma_y}$$

Where:

$Cov(x, y) = Covarince\ between\ x\ and\ y$

$\sigma_x = Standard\ deviation\ of\ x$

$\sigma_y = Standard\ deviation\ of\ y$

The coefficient has a value between -1 and +1, where values close to 1 indicate strong correlation, and values close to zero indicate little or no relation. Although changes in one variable reliably predicts changes in another, this does not necessarily mean that the change is caused by that variable, as correlation does not imply causation. There might be an unknown factor impacting both variables similarly. For our research purpose, it is of interest to see whether the real estate stocks` return is mostly correlated with the stock market (OSEAX) or the unlisted real estate market (IPD), both separately and through our market cap-weighted index (Indirect Index). Furthermore, it is interesting to see to what degree the share price follows its underlying value represented by NAV per share. Lastly, we look at the correlation with a set of macroeconomic factors which are said to be the main drivers of the real estate market.

4.3 Regression analysis

Regression analysis is used to examine the relationship between a dependent variable and one or more explanatory variables. In general, the dependent variable is regressed on the independent variables, where the magnitude and significance are determined by the beta-coefficient and its related t-statistic. The intercept is the expected mean value of Y when all beta-coefficients equal zero. The error term represents the variation in the dependent variable that the independent variable cannot predict.

4.3.1 Capital Asset Pricing Model

The Capital Asset Pricing Model (CAPM) by William Sharpe (1964), John Lintner (1965) and Jan Mossin (1966) serves as a model to calculate the expected return of a security in relation to a single factor - the market. The model describes a linear relationship between systematic risk and expected return, and is based on the premise that investors require compensation for taking on additional risk in form of a risk premium. The expected return of an asset equals the relationship between the asset's beta and the expected risk premium of the market. Beta reflects an asset´s co-movement with the market and level of systematic risk. A beta of 1 indicates that the asset is fully correlated with the market. If an asset has a beta above 1, it means that it is more volatile than the market. Contrary, a beta of -1 means that the asset is inversely correlated with the market. Portfolios holding assets with betas above 1, will increase the portfolio's risk, but also increase the expected return.

Alpha, along with beta, is one of two key coefficients in CAPM and is the intercept of the security characteristic line (SCL). It reflects the return of an investment that is not a result of the general market and can either be positive or negative. In efficient markets, the expected value of the alpha-coefficient is zero. Therefore, alpha is also referred to as the abnormal rate of return and is a measure of performance after accounting for the risk involved (Bodie et al. 2013).

As for all models, CAPM is a simplification of reality, and relies on assumptions such as competitive and efficient markets, no transactions costs, unlimited borrowing and lending at the risk-free rate and homogenous expectations. When applying CAPM for empirical testing, the model is conducted ex-post.

The formula for CAPM is as follows:

$$E(R_i) = \alpha_i + R_f + \beta_{i,}[E(R_m) - R_f] + \epsilon_i$$

Where:

$(R_i) = Expected\ return\ on\ asset\ i$
$\alpha_i = Intercept$
$\beta_i = Beta\ coefficient\ of\ asset$
$R_f = Risk - free\ rate$
$E(R_m) = Expected\ Return\ market$
$\epsilon_i = Error\ term$

4.3.2 Multifactor Model

Unlike CAPM, which estimates the systematic risk by a single-factor, multifactor models include a number of factors in its calculations to explain asset returns. Factor models are based on the Arbitrage Pricing Theory (APT) by Ross (1976), which states that the expected return of an asset can be modeled as a linear function of multiple factors. Within factor models, the macroeconomic factor model observes the sensitivity of an asset return as a function of observable economic time series such as GDP, inflation and interest rates. The macroeconomic factor model deviates from the fundamental factor model by using the systematic risk as factors, which arises from changes in the macroeconomic environment. The purpose of implementing this model is to analyze the relation between the change in macroeconomic factors and returns for direct and indirect real estate investments, as well as the direction and magnitude of the relation.

The econometric model is given by the following equation:

$$R_{i,t} = \alpha_i + \beta_{i,1}F_{1,t} + \beta_{i,2}F_{2,t} + \cdots + \beta_{i,k}F_{k,t} + \epsilon_i$$

Where:

$R_{i,t} = Return\ on\ asset\ i$
$\alpha_i = Intercept$
$\epsilon_i = Error\ term$
$\beta_i = Beta\ coefficient\ of\ asset$
$F_n = Macroeconomic\ factor$

5. Analysis

5.1 Risk and return

This chapter aims to provide answers to whether listed or unlisted real estate outperforms one another, both in terms of average return and risk-adjusted return. The comparative analysis is based on the mean return, Sharpe ratio and CAGR.

5.1.1 Mean return

Table 1 compares the arithmetic average returns for listed and unlisted real estate investments and the general stock market. Note that these are quarterly returns converted to annual returns.

Table 1 Comparison of the development in mean returns, 2007-2017

Year	IPD	Indirect Index	OSEAX	NPRO	OLT	ENTRA
2007	18.30%	0.35%	13.45%	6.15%	-3.76%	
2008	-4.70%	-60.99%	- 52.59%	-87.10%	-39.75%	
2009	4.80%	75.91%	55.47%	133.55%	62.08%	
2010	8.20%	- 1.01%	15.80%	-27.11%	19.48%	
2011	7.40%	-17.12%	- 9.05%	-26.24%	-12.31%	
2012	4.70%	15.61%	10.86%	18.21%	14.47%	
2013	5.60%	9.84%	22.89%	- 14.47%	21.80%	
2014	8.20%	24.01%	2.81%	38.93%	18.79%	
2015	11.00%	4.37%	4.71%	-10.00%	14.58%	0.33%
2016	10.60%	17.09%	17.83%	11.22%	14.08%	22.81%
2017	11.50%	20.84%	18.61%	6.81%	3.25%	44.72%
Average return[3]	**7.65%**	**9.85%**	**10.54%**	**0.82%**	**10.35%**	**17.27%**

As can be seen in Table 1, unlisted investments represented by the IPD deliver quite stable returns. At the same time, listed real estate, represented by our value-weighted Indirect Index, outperform unlisted with an average return of 9.85%, whereas IPD yields 7.65%. To compare, OSEAX is superior to both, with its 10.54%. From the stocks in the Indirect Index, Entra has the highest average return of 17.27%, whereas NPRO only provides 0.82%.

[3] Also includes Q4 2016 and Q1-2 2018

Thus, listed investments in real estate appears to be a better investment vehicle than unlisted, in terms of arithmetic mean returns. However, as pointed out in the method section above, the arithmetic mean fails to account for negative returns, so the returns of volatile assets tend to be overstated.

5.1.2 Sharpe ratio

In Table 2 below, we have listed the HPR, standard deviation and Sharpe ratio based on quarterly data for the given companies, as well as the Indirect Index, OSEAX and IPD. To compute the Sharpe ratio, we have taken the arithmetic average of quarterly HPR and converted it to an annual return for the time period Q4 2006 (Entra starting Q4 2014) to Q2 2018. The standard deviation is also corrected to match the annual return, by multiplying it by the square root of 4. As for the risk-free rate, we have used the 5-year Norwegian government bond.

Table 2 Comparison of Sharpe ratios, Q4 2006 – Q2 2018

	Return	**Risk free**	**Std.dev**	**Sharpe ratio**
Indirect Index	9,85 %	1,07 %	26,27 %	0,334
NPRO	0,82 %	1,07 %	45,77 %	-0,006
OLT	10,35 %	1,07 %	20,35 %	0,456
ENTRA	17,27 %	1,07 %	16,98 %	0,954
OSEAX	10,54 %	1,07 %	24,05 %	0,394
IPD	7,65 %	1,07 %	2,60 %	2,524
IPD*	7,78 %	1,07 %	5,68 %	1,182

Here we see that the stocks yield quite different returns, where Entra has the best performance among the three stocks and NPRO the worst. All in all, the indirect investment option represented by our Indirect Index yields the highest average return when compared to IPD. However, the IPD way outperform the other investments when the risk is taken into account, with a Sharpe ratio of 2.52 compared to the Indirect Index of 0.33 and OSEAX of 0.39.

Even so, because the IPD is only measured annually, its quarterly standard deviation might yield an underestimated risk. To account for this we also include the Sharpe ratio based on the annual values directly (IPD*), where we see the standard deviation increase resulting in a Sharpe ratio of *only* 1.18. This is based on less observations, but at least the returns change between each period. For the quarterly measure, the return is equal in the four quarters within each individual year, hence the variation is very stable.

At the same time, one could argue that the IPD is less volatile simply because of its investment characteristics; a stable rental cash flow on long-term contracts for a well-diversified portfolio of commercial real estate that on average appreciates in value year by year, shielded from all the noise and potential biases occurring in the stock markets. In a way, the benefit of the IPD being unlisted is also its major drawback, as one can simply not invest in the IPD. For the average investor it is challenging (or even unachievable) enough to invest directly in a single property/syndicate. The risk related to specific characteristics for a given property and contract will be much higher on an individual basis. There can be great discrepancies in the economic conditions over time affecting geographic location and contract duration (i.e. in the middle of a downturn) quite differently. Other risk factors deviating can be the quality of the building and the tenant`s default risk. In other words, the reduced risk that will come from a pool of diversified properties measured by the IPD is not actually realistic, and the risk related to a direct investment must be seen in light of the given real estate under evaluation.

5.1.3 CAGR

When comparing the CAGR as shown in Table 3, the IPD also outperforms the Indirect Index, and slightly the OSEAX as well. This is because the CAGR takes the volatility directly into account due to the compounding effect. As the IPD has a low volatility and no periods with significantly negative returns, the investment grows at a steady rate of 7.6%, close to its arithmetic mean of holding period return. The Indirect Index, on the other hand, has high volatility and multiple periods with great losses along with great gains, meaning the CAGR of 6.3% is below the arithmetic mean.

Further, we observe a great disparity in the CAGR for the three stocks, where ENTRA is about the double of all three indexes with 15.64%, whereas NPRO is negative with 9.96%. As the Indirect Index has a high share of NPRO throughout the period of study, this obviously has a great impact on the performance, and is effectively the reason why listed real estate is underperforming in relation to unlisted.

Table 3 Comparison of CAGR, Q4 2006 – Q2 2018

	Indirect Index	**IPD**	**OSEAX**	**NPRO**	**OLT**	**ENTRA**
CAGR	6.28%	7.61%	6.98%	- 9.96%	8.21%	15.64%

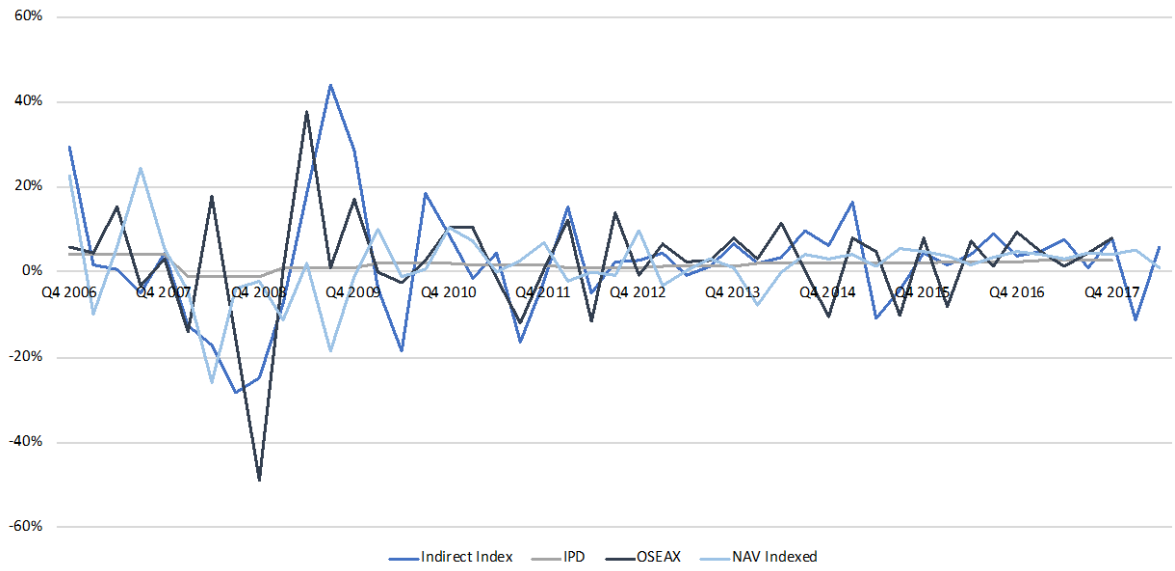
5.2 Correlation analysis

As mentioned before, previous studies on whether listed real estate investments are dominated by the underlying values or the stock market show inconsistent results. The consensus seems to be that in the short-term, real estate stocks are more correlated with the stock market. Contrary, in the long-term real estate stocks seem to be driven by the underlying values, i.e. the NAV. Others further discuss whether the NAV affects the stock price, or if the stock price is a proxy of upcoming NAV. The following chapter presents and discusses the results from the correlation analysis.

5.2.1 Drivers of listed real estate

The deviations between stock prices and NAV is typically explained by two separate, yet overlapping theories, namely the noise theory and the information theory. According to the noise theory, the deviation from NAV is caused by changes in investor sentiment. This means, when investors become irrationally pessimistic about real estate stocks, the share price is pushed below the true underlying value. Correspondingly, when investors are unreasonably optimistic about real estate stocks, share prices are pushed above NAV. On the other hand, the information theory is simply based on the concept of stock markets being more informationally efficient than unlisted real estate markets, hence share prices lead the real estate market, and flowingly NAVs.

Figure 10 Comparison of the development in returns, Q4 2006 – Q2 2018



In Figure 10 we have plotted the development in returns from the Indirect Index, IPD and OSEAX. Additionally, included the development in NAV, calculated as a percentage change based on the weights used for the Indirect Index. As can be seen, the IPD return is more or less a straight line appearing uncorrelated with neither the Indirect Index nor OSEAX. The Indirect Index and OSEAX seems the most correlated, and whether the NAV is lagging or leading is hard to tell from the eye. To control for this, we have run correlation analysis testing for both lags and leads of NAV and found the lead of 3 quarters to be most applicable. This is also consistent with our presumption that factors affecting the value of the underlying real estate will be immediately reflected in the stock price, whereas it may take some time to be reflected in the underlying real estate valuations. The results are presented in Table 4 below.

Table 4 Correlation between listed real estate and potential drivers, Q4 2006 – Q2 2018

	OSEAX	**IPD**	**NAV**	**NAV lead (2)**	**NAV lead (3)**
Indirect Index	0.514	0.373	0.101	0.230	0.400
NPRO	0.500	0.401	-0.053	0.233	0.430
OLT	0.513	0.258	0.239	0.090	-0.021
ENTRA	0.166	0.521	0.059	0.064	0.513

For both the Indirect Index, NPRO and OLT correlation with OSEAX is positive slightly above 0.5, and somewhat less for the IPD. Entra has a more positive correlation with IPD and less with the OSEAX, but the results could be affected by the short period of observations available. When considering the NAV, all observations are the most correlated when taking the lead of 3 quarters, except for OLT where the correlation is highest for the given quarter`s NAV.

Short-term dynamics

To examine whether the influence of the underlying property market and the general stock market on listed real estate varies across short-and long-term, the full period has been divided into two separate time-periods. The results are shown below in Table 5 and 6.

Table 5 Correlation between listed real estate and potential drivers, Q4 2006 - Q4 2011

	OSEAX	**IPD**	**NAV**	**NAV lead (2)**	**NAV lead (3)**
Indirect Index	0.536	0.397	0.111	0.255	0.388
NPRO	0.543	0.432	-0.048	0.238	0.451
OLT	0.570	0.339	0.290	0.134	-0.091

For the first period, namely Q4 2006 – Q4 2011, presented in Table 5 show that the correlation between the Indirect Index and both OSEAX and IPD is higher compared to the full period (Table 4). In line with our presumptions and related literature, listed real estate (Indirect Index) is more correlated with the general stock market (OSEAX) in the short-term than in the long-term. However, the short-term correlation coefficient of 0.536 is only slightly above the long-term coefficient of 0.514. Also, NPRO and OLT are more correlated with OSEAX than IPD.

Further, as share prices of listed real estate are affected by volatility in the stock market, and underlying values are subject to infrequent appraisals, the correlation between listed and unlisted real estate is expected to be low in short time horizons. As such, the increased correlation between the Indirect Index and IPD in the first period contradicts our hypothesis. Overall, the correlation coefficients for all assets are higher in the first period compared to the full period, with exception of the Indirect Index and NAV with a lead of 3.

Table 6 Correlation between listed real estate and potential drivers, Q1 2012 - Q2 2018

	OSEAX	**IPD**	**NAV**	**NAV lead (2)**	**NAV lead (3)**
Indirect Index	0.377	0.109	-0.043	-0.156	0.498
NPRO	0.217	0.061	-0.260	-0.213	0.399
OLT	0.349	-0.125	0.095	-0.035	0.199
ENTRA	0.166	0.521	0.059	0.064	0.513

The second period, Q1 2012 to Q2 2018, is presented in Table 6. As seen, all listed real estate assets and OSEAX have lower correlation coefficients in the given period compared to the full period (Table 4). These results contradict the findings from the first period and our hypothesis of increased correlation between listed real estate and the stock market in the short-term. Even so, listed real estate is more correlated to the stock market compared to the underlying real estate market, with exception of Entra[4].

The majority of the correlation coefficients are lower in the second period compared to the first period. Several studies conclude that during periods of high volatility and crisis, correlation among assets increase (Loretan and English, 2000; Chesnay and Jondeau., 2001; Xiu et al,

[4] Entra was listed on Oslo Stock Exchange Q4 2014. Therefore, the results in the second period is equal to the full period.

2016). Argumentatively, the increased correlation between the assets in the first period can be a result of the global financial crisis in 2008.

5.2.2 Macroeconomic factors

To further support our analysis, we investigate which macroeconomic variables are significant in explaining the development of our Indirect Index, and comparing this to how they affect the IPD and OSEAX. In this part we do a correlation analysis to see which variables are the most correlated with the listed real estate index, and whether we should lag or lead any of the variables. Next, based on the correlations we apply the most suited forms of the variables in our regression analysis.

Table 7 Correlation between indexes and macroeconomic drivers, Q4 2006 – Q2 2018

	GDP lead (1)	**NIBOR**	**Inflation**	**Unemp.**	**Newb. lag (1)**
Indirect Index	0.342	- 0.424	- 0.107	- 0.062	- 0.236
IPD	0.106	- 0.295	- 0.114	- 0.322	- 0.267
OSEAX	0.262	- 0.299	- 0.048	- 0.310	- 0.150

The results from the correlation analysis is presented in Table 5. The strongest positive correlation for change in GDP levels is with a lead of 1 quarter, which makes sense as a growth in GDP is a consequence of the good economic conditions which one would expect to be immediately reflected in share prices. For NIBOR, inflation and unemployment we see the highest correlation for the nominal values, these figures are initially measured in percent. These are of course negative correlations, in line with economic theory. For new build, measured in log change, the correlation is negative, and higher for a lag of 1. This is also in line with our expectations, as it can take time from offices are completed until they impact the rents and overall supply. A period of high levels of new buildings entering the market is expected to have a negative effect on market prices of the existing. The correlation is not very high, but at least it is stronger for IPD and the Indirect Index than OSEAX, as both rely on the supply of commercial real estate in the market.

5.3 Regression Analysis

In this part we have conducted several regressions, based on the variables from our correlation analysis. First, we test the CAPM against listed and unlisted real estate to see how much of the return can be explained by changes in the market portfolio - represented by OSEAX, and whether they yield a positive significant alpha or not, for a better basis for comparison of the two. We also test the CAPM on each stock, to obtain a deeper understanding of our results. Second, we employ a multifactor model to control for our macro factors to see if they can explain any of the difference in returns, and whether the same factors affecting the OSEAX are affecting listed and/or unlisted real estate investments, which we expect to be somewhat in line with the results from our CAPM regression.

5.3.1 CAPM - Indexes

Table 6 provides the estimated beta coefficient and abnormal return for IPD and the Indirect Index to the market risk premium by implementing CAPM in regression analysis. We have used quarterly returns over the whole period of study, i.e. Q4 2006 to Q2 2018 (IPD Q4 2017).

Table 8 CAPM on listed and unlisted indexes, Q4 2006 – Q2 2018

	α	**t-stat (α)**	**β**	**t-stat (β)**	**R-squared**
Indirect Index	0.0048	(0.29)	0.561	(4.01)	0.263
IPD	0.0074	(2.70)	0.032	(1.98)	0.092

Both beta coefficients are positive and significant. As expected, the Indirect Index has the highest beta in relation to the market with a value of 0.56, compared to IPD which has a beta of 0.03. This means that a one percentage point increase in the market excess return causes the Indirect Index excess return to increase by 0.56 percentage points, whereas for IPD the magnitude is irrelevant as it is close to zero. Accordingly, both listed and unlisted real estate investments contain less systematic risk than the overall market portfolio.

These results are also in line with what we found in the correlation analysis, although we assumed the beta of the Indirect Index to be somewhat higher. Further, the R-square value of 0.263 for the Indirect Index states that the market return explains only a small proportion of its variance. The R-square of IPD is not surprisingly also close to zero. A sensible explanation is

simply that the market index for stocks is not the appropriate benchmark for IPD, and using it for regression purposes does not practically make sense, hence the low explanatory power. This of course only emphasizes the differences between listed and unlisted real estate further.

The abnormal return is represented by the alpha (intercept). Both listed and unlisted shows a positive abnormal return over the market, where IPD yields the highest with an alpha of 0.74% against Indirect Index`s alpha of 0.48%. Note, however, alpha is only significant for IPD. From an investor's perspective, unlisted investing is the most attractive as it has the lowest risk, represented by beta, and yields the highest abnormal return.

5.3.2 CAPM - Real estate stocks

Table 7 provides the estimated beta coefficient and abnormal return for NPRO, OLT and ENTRA to the market risk premium. We have used quarterly returns over the whole period of study, with exception to Entra, which period starts from Q4 2014.

Table 9 CAPM on real estate stocks, Q4 2006 – Q2 2018

	α	**t-stat (α)**	**β**	**t-stat (β)**	**R-squared**
NPRO	-0.0226	(-0.76)	0.951	(3.87)	0.249
OLT	0.0078	(0.60)	0.434	(4.01)	0.263
ENTRA	0.0265	(1.11)	0.207	(0.61)	0.028

All beta coefficients are positive meaning the stocks follow the overall direction of the market, although with different magnitude. A one percentage point increase in OSEAX would lead to a 0.95 percentage point increase in NPRO, but only a 0.21 increase in Entra. The betas are significant for NPRO and OLT, but not for ENTRA. A possible explanation for this is Entra's short track-record. When comparing each firm's individual beta to the Indirect Index beta, they are all lower except for NPRO. This is due to the fact that by diversifying, one reduces the firm-specific risks and the correlation with the overall market performance becomes higher.

Further, the adjusted R-square value indicates that the stocks` movement only by a low degree can be explained by the movements of OSEAX. OLT has the highest degree of explanatory power, followed by NPRO and then ENTRA. These findings are also in line with our correlation analysis. Alpha is negative for NPRO by 2.26%, and contrary positive for Entra by 2.65%,

whereas OLT is in between with a positive alpha of 0.78%. However, none of them are significant.

5.3.3 Macroeconomic Multifactor Model

By the use of a multifactor model we have observed the sensitivity of returns for listed and unlisted real estate investments and the general stock market as a function of multiple macroeconomic factors. The reason for the inclusion of OSEAX is to examine whether listed real estate investments follow the characteristics of the underlying real estate market or the general stock market. The regression results are shown in Table 8 below.

Table 10 Multifactor regressions on indexes to macroeconomic factors, Q4 2006 – Q2 2018

	NIBOR		**Inflation**		**GDP**		**Unemployment rate**		**Newbuild**	
	β	t-stat	β	t-stat	β	t-stat	β	t-stat	β	t-stat
Indirect Index	-7.705	(-3.33)	1.705	(0.54)	3.538	(2.45)	-12.118	(-2.21)	-0.056	(-1.51)
IPD	-0.236	(-0.63)	-0.180	(-0.37)	0.015	(0.13)	0.047	(0.08)	-0.007	(-1.64)
OSEAX	-6.066	(-3.01)	2.534	(0.81)	2.664	(1.47)	-11.580	(-2.38)	-0.031	(-0.80)

As seen in Table 8, NIBOR has a negative coefficient for all indices. Negative regression coefficients imply that the growth in NIBOR reduces the return, which is in line with our model assumptions. Increased interest rates decrease the present value of future cash flows, thus reducing the attractiveness of the investment. As such, a one percentage point increase in NIBOR leads to a 7.507 percentage point decrease in the Indirect Index returns and 6.066 percentage point decrease in OSEAX. The factor is statistically significant for both, but not for IPD. Even though direct real estate is said to be highly driven by interest rates, this is mostly due to the fact that this is typically leveraged investments. As the IPD is based on unleveraged returns, this can explain the lack of significance and magnitude of the factor coefficient.

Inflation, given by the quarterly change in CPI, is statistically insignificant for all indices. Interestingly, the majority of research conducted on the dynamics between unlisted real estate and inflation shows a significant positive relationship among the two. A key feature of investments in unlisted real estate is its ability to hedge against inflation, however, the negative regression coefficient for IPD does not resemblance this. It implies that returns for unlisted real estate tend to decrease, when inflation increase. According to financial theory, inflation reduces

the real payoff on listed securities for investors during the holding period. As such, we see violations to our assumptions with positive coefficients for Indirect Index and OSEAX, which indicates that returns increase with inflation. But then again, as the coefficients are not significant, we will not emphasize this further.

GDP, a measure of economic activity, is represented as a lagged explanatory variable. This is based on the assumption that GDP growth becomes apparent after some period of time. Further, GDP is expected to have a positive and significant effect on all dependent variables. Yet, the macroeconomic factor is only statistically significant for the Indirect Index. All coefficients are positive, meaning that increased economic activity leads to increased return for all indices. This is in line with our model, where a one percentage point increase in GDP upcoming period reflects a 3.538 percentage point increase in the prior period`s Indirect Index return.

Unemployment rate, which is a measure of the percentage of the workforce that is unemployed at all times, is significantly different from zero for both Indirect Index and OSEAX. In line with economic theory, their coefficients are negative which implies increased returns when the unemployment rate decreases. Accordingly, a one percentage point increase in unemployment rate leads to a decrease of 12.12 percentage points in the Indirect Index and 11.58 in OSEAX. These high values seem reasonable as the unemployment rate has never increased more than 0.5 percentage points from one quarter to the next for the past 11 years.

The negative coefficients for new build imply that an increase in new build, all else equal, will result in a decrease in return. This is in accordance with basic supply and demand theory, but the new build factor coefficient is statistically insignificant at the 5% level for any of the indices. However, the coefficient is close to significant at the 10% level for both IPD and the Indirect Index, so at least it has a higher relevance for the real estate assets.

To sum up, the Indirect Index and OSEAX have the same significant macroeconomic factors, whereas IPD appears sheltered from them, at least short-term. The exception, not surprisingly, is for the new build factor. This is in line with the findings in our correlation and CAPM regression analysis, where listed real estate represented by the Indirect Index tends to follow the broad stock market.

Conclusion

This thesis aims to compare the performance of listed and unlisted commercial real estate investments from an investor`s perspective. Further, it examines whether real estate stocks in Norway are predominantly driven by the progress of the underlying real estate market or by the general stock market. In the extension of this, it also controls for different macroeconomic variables, to see if they can explain the differences in the returns.

From our results, we see that listed and unlisted investments provide different performance characteristics, as listed investments deliver higher returns, while unlisted performs better on a risk-adjusted basis. This is in line with our presumptions and in accordance with Newell and Hsu`s (2007) results among others. Listed real estate, represented by our value-weighted Indirect Index, yields the highest arithmetic average return of 9.85%, prior to risk-adjustments, compared to unlisted yielding 7.65%. In terms of risk-adjusted returns, unlisted real estate represented by the IPD outperform listed real estate to a great extent, with a Sharpe ratio of 2.52 (1.18^5) compared to 0.33. Further, unlisted provides a CAGR rate of 7.61% compared to listed of 6.28%. This is because listed real estate experience high volatility and multiple periods with great losses, partly caused by trading noise and potential biases occurring in the stock market. Contrary, unlisted real estate has a low volatility and no periods with significantly negative returns, growing at a steady rate sheltered from short-time market movements.

According to the CAPM regression, both listed and unlisted real estate investments contain less systematic risk than the overall market portfolio. IPD yields the highest abnormal return with an alpha of 0.74% against the Indirect Index`s alpha of 0.48%. From an institutional investor's perspective, direct investing represented by IPD is the most attractive as it has the lowest market risk, represented by beta, and yields the highest risk-adjusted and abnormal return. For the average investor, equivalent IPD exposure is not possible, and thus listed real estate is not a bad alternative either, given its return, liquidity and low transaction costs.

Considering the second question of interest, based on our correlation and regression analysis it appears like listed real estate tends to follow the broad stock market more than the underlying real estate market, when compared to the IPD and the portfolios` net asset values. These

[5] Based on annual values of IPD directly

findings apply to both short-and long-term. P/NAV is generally below 1 for all three stocks, meaning the stock is trading at a discount relative to the underlying asset value represented by the NAV. The ratio is also very volatile stating that the stock price and underlying value does not follow each other. This confirms our belief that additional drivers besides the development of the underlying properties affect the performance and risk/return development of listed real estate. Furthermore, NPRO and ENTRA are the most correlated with NAV when taking the lead of 3 quarters. This implies that information is first reflected in the stock prices, then gradually in the valuation of the underlying properties.

Lastly, our findings states that listed real estate stocks are driven by the same macroeconomic factors as the general stock market. The Indirect Index and OSEAX has the same significant macroeconomic factors, in particular the NIBOR and unemployment rate, whereas unlisted real estate seems sheltered from them. The exception, not surprisingly, is for the new build factor, which has the highest significance for both listed and unlisted real estate, and no significance for OSEAX. This is in line with the findings in our correlation and CAPM regression analysis, where listed real estate represented by the Indirect Index tends to follow the broad stock market.

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Appendix

Table 1 Descriptive statistics - All variables

Variable	N	Mean	St.dev	Min	p5	p25	p50	p75	p95	max	skewness	kurtosis
IPD	45	0.018	0.013	-0.012	-0.012	0.012	0.019	0.025	0.043	0.043	-0.438	4.023
Indirect Index	47	0.023	0.133	-0.284	-0.186	-0.043	0.029	0.076	0.286	0.439	0.391	4.485
OSEAX	47	0.025	0.121	0.489	-0.141	-0.007	0.031	0.081	0.170	0.376	-1.224	9.162

Variable	N	Mean	St.dev	Min	p5	p25	p50	p75	p95	max	skewness	kurtosis
NPRO	47	0.002	0.231	-0.578	-0.392	-0.084	-0.003	0.076	0.425	0.710	0.246	4.412
OLT	47	0.024	0.103	-0.213	-0.126	-0.031	0.016	0.062	0.252	0.273	0.332	3.646
ENTRA	25	0.040	0.087	-0.128	-0.128	-0.022	0.062	0.095	0.140	0.140	-0.803	2.510

Variable	N	Mean	St.dev	Min	p5	p25	p50	p75	p95	max	skewness	kurtosis
GDP	47	0.003	0.009	-0.025	-0.012	-0.002	0.002	0.008	0.019	0.028	-0.098	3.620
NIBOR	47	0.025	0.016	0.008	0.009	0.012	0.019	0.030	0.059	0.066	1.248	3.534
Inflation	47	0.005	0.006	-0.011	-0.007	0.003	0.005	0.009	0.013	0.020	-0.504	3.994
Unemployment	47	0.035	0.007	0.024	0.024	0.030	0.034	0.040	0.047	0.048	0.270	2.224
New build	47	11.914	0.434	11.130	11.376	11.588	11.867	12.206	12.725	12.750	0.404	2.206

Table 2 Key figures - Entra

Period	Date	Net debt	Share price (Q)	Nb of shares	MV of equity (Q)	Property value	NAV	NAV per share	P/VEK at Q
Q4 2014	31.12.2014	13 890	76,50	183 732 461	14 056	28 720	14 830	80,72	0,95
Q1 2015	31.03.2015	12 271	83,75	183 732 461	15 388	28 087	15 816	86,08	0,97
Q2 2015	30.06.2015	12 901	73,00	183 732 461	13 412	28 526	15 625	85,04	0,86
Q3 2015	30.09.2015	12 843	68,75	183 732 461	12 632	29 226	16 383	89,17	0,77
Q4 2015	31.12.2015	14 640	71,25	183 732 461	13 091	31 777	17 137	93,27	0,76
Q1 2016	31.03.2016	14 515	78,00	183 732 461	14 331	32 127	17 612	95,86	0,81
Q2 2016	30.06.2016	15 039	78,50	183 732 461	14 423	32 740	17 701	96,34	0,81
Q3 2016	30.09.2016	17 516	89,50	183 732 461	16 444	35 979	18 463	100,49	0,89
Q4 2016	31.12.2016	17 454	85,75	183 732 461	15 755	36 681	19 227	104,65	0,82
Q1 2017	30.03.2017	17 631	93,75	183 732 461	17 225	38 008	20 377	110,91	0,85
Q2 2017	30.06.2017	17 478	104,00	183 732 461	19 108	38 622	21 144	115,08	0,90
Q3 2017	30.09.2017	17 378	109,00	183 732 461	20 027	39 551	22 173	120,68	0,90
Q4 2017	31.12.2017	17 852	122,00	183 732 461	22 415	41 199	23 347	127,07	0,96
Q1 2018	31.03.2018	17 207	106,80	183 732 461	19 623	42 765	25 558	139,10	0,77
Q2 2018	31.06.2018	17 734	111,20	183 732 461	20 431	43 671	25 937	141,17	0,79

Table 3 Key figures - NPRO

Period	Date	Total IBD	Cash	Net debt	Share price (Q)	Nb of shares	MV of equity (Q)	Property value	NAV	NAV per share	P/VEK at Q
Q4 2006	31.12.2006	10 978	1 253	9 725	65,00	98 512 929	6 403	18 074	8 349	84,75	0,77
Q1 2007	31.03.2007	12 751	1 345	11 406	72,00	105 481 570	7 595	18 237	6 831	64,76	1,11
Q2 2007	30.06.2007	12 861	1 100	11 760	73,75	105 481 570	7 779	19 088	7 328	69,47	1,06
Q3 2007	30.09.2007	21 455	924	20 531	65,00	105 481 570	6 856	31 406	10 875	103,10	0,63
Q4 2007	31.12.2007	23 268	635	22 633	66,50	105 481 570	7 015	31 114	8 481	80,41	0,83
Q1 2008	31.03.2008	23 171	513	22 659	44,00	105 481 570	4 641	30 316	7 658	72,60	0,61
Q2 2008	30.06.2008	21 972	324	21 648	23,70	201 635 416	4 779	28 167	6 518	32,33	0,73
Q3 2008	30.09.2008	21 325	69	21 257	10,00	201 635 416	2 016	27 743	6 487	32,17	0,31
Q4 2008	31.12.2008	21 879	174	21 705	6,08	201 635 416	1 226	27 575	5 870	29,11	0,21
Q1 2009	31.03.2009	20 345	231	20 114	4,00	201 635 416	807	24 873	4 759	23,60	0,17
Q2 2009	30.06.2009	20 323	231	20 092	5,70	201 635 416	1 149	24 443	4 351	21,58	0,26
Q3 2009	30.09.2009	18 667	191	18 477	9,75	453 270 832	4 419	24 290	5 813	12,83	0,76
Q4 2009	31.12.2009	11 454	180	11 274	14,20	453 270 832	6 436	14 810	3 536	7,80	1,82
Q1 2010	31.03.2010	11 138	629	10 509	12,50	453 270 832	5 666	14 892	4 383	9,67	1,29
Q2 2010	30.06.2010	11 108	568	10 540	8,28	498 596 832	4 128	15 018	4 478	8,98	0,92
Q3 2010	30.09.2010	10 629	150	10 479	10,20	498 596 832	5 086	15 046	4 567	9,16	1,11
Q4 2010	31.12.2010	10 295	248	10 047	10,25	498 596 832	5 111	15 062	5 015	10,06	1,02
Q1 2011	31.03.2011	10 212	242	9 970	10,15	498 596 832	5 061	15 425	5 455	10,94	0,93
Q2 2011	30.06.2011	10 241	89	10 152	11,30	498 596 832	5 634	15 635	5 483	11,00	1,03
Q3 2011	30.09.2011	10 240	121	10 119	7,88	498 596 832	3 929	15 803	5 684	11,40	0,69
Q4 2011	31.12.2011	10 165	1 173	8 992	7,36	498 596 832	3 670	15 655	6 663	13,36	0,55
Q1 2012	31.03.2012	9 869	934	8 935	8,88	498 596 832	4 428	14 523	5 588	11,21	0,79
Q2 2012	30.06.2012	9 860	682	9 179	8,13	498 575 596	4 053	14 588	5 409	10,85	0,75
Q3 2012	30.09.2012	9 432	234	9 198	8,75	498 575 596	4 363	14 523	5 325	10,68	0,82
Q4 2012	31.12.2012	9 172	1 156	8 016	8,50	548 446 832	4 662	14 853	6 837	12,47	0,68
Q1 2013	31.03.2013	8 550	335	8 215	9,17	548 446 832	5 029	13 911	5 696	10,39	0,88
Q2 2013	30.06.2013	8 644	36	8 609	7,70	548 446 832	4 223	14 207	5 598	10,21	0,75
Q3 2013	30.09.2013	8 632	86	8 546	7,95	548 446 832	4 360	14 444	5 898	10,75	0,74
Q4 2013	31.12.2013	8 947	63	8 885	7,27	548 425 596	3 987	14 763	5 878	10,72	0,68
Q1 2014	31.03.2014	9 284	27	9 258	7,25	548 425 596	3 976	15 174	5 916	10,79	0,67
Q2 2014	30.06.2014	9 750	14	9 736	7,55	548 425 596	4 141	15 780	6 045	11,02	0,69
Q3 2014	30.09.2014	9 209	11	9 199	9,61	548 425 596	5 270	15 231	6 032	11,00	0,87
Q4 2014	31.12.2014	9 635	22	9 614	10,10	548 425 596	5 539	15 797	6 183	11,27	0,90
Q1 2015	31.03.2015	9 839	42	9 797	10,40	548 425 596	5 704	16 179	6 382	11,64	0,89
Q2 2015	30.06.2015	9 952	8	9 944	9,70	548 425 596	5 320	16 455	6 512	11,87	0,82
Q3 2015	30.09.2015	9 359	11	9 348	9,44	548 425 596	5 177	16 038	6 691	12,20	0,77
Q4 2015	31.12.2015	9 520	56	9 464	9,09	548 425 596	4 985	16 256	6 792	12,39	0,73
Q1 2016	31.03.2016	9 391	25	9 366	8,62	548 425 596	4 727	16 375	7 009	12,78	0,67
Q2 2016	30.06.2016	9 406	16	9 390	9,14	548 425 596	5 013	16 680	7 291	13,29	0,69
Q3 2016	30.09.2016	7 414	316	7 098	10,85	548 425 596	5 950	14 530	7 432	13,55	0,80
Q4 2016	31.12.2016	6 767	46	6 721	9,99	548 425 596	5 479	14 112	7 391	13,48	0,74
Q1 2017	30.03.2017	6 974	211	6 763	9,86	548 425 596	5 407	14 341	7 578	13,82	0,71
Q2 2017	30.06.2017	6 933	117	6 816	10,30	548 425 596	5 649	14 644	7 828	14,27	0,72
Q3 2017	30.09.2017	7 055	259	6 796	10,10	548 425 596	5 539	15 036	8 241	15,03	0,67
Q4 2017	31.12.2017	6 950	89	6 861	10,60	548 425 596	5 813	15 361	8 499	15,50	0,68
Q1 2018	31.03.2018	6 950	147	6 804	10,12	548 425 596	5 550	15 410	8 607	15,69	0,64
Q2 2018	31.06.2018	6 951	111	6 841	10,80	548 446 832	5 923	15 435	8 594	15,67	0,69

Table 4 Key figures - OLT

Period	Date	Total IBD	Cash	Net debt	Share price (Q)	Nb of shares	MV of equity (Q)	Property value	NAV	NAV per share	P/VEK at Q
Q4 2006	31.12.2006	9 333	408	8 925	85,00	106 445 320	9 048	17 266	8 341	78,36	1,08
Q1 2007	31.03.2007	9 392	359	9 033	79,80	106 445 320	8 494	17 596	8 563	80,45	0,99
Q2 2007	30.06.2007	10 704	441	10 263	76,50	106 445 320	8 143	19 235	8 972	84,29	0,91
Q3 2007	30.09.2007	11 230	383	10 847	77,00	106 445 320	8 196	20 216	9 369	88,02	0,87
Q4 2007	31.12.2007	11 377	506	10 871	81,00	106 445 320	8 622	22 879	12 008	112,81	0,72
Q1 2008	31.03.2008	11 590	313	11 277	80,00	106 445 320	8 516	23 061	11 784	110,70	0,72
Q2 2008	30.06.2008	12 340	562	11 778	77,00	106 445 320	8 196	22 550	10 772	101,20	0,76
Q3 2008	30.09.2008	12 663	587	12 076	62,00	106 445 320	6 600	22 313	10 237	96,17	0,64
Q4 2008	31.12.2008	12 713	223	12 490	48,00	106 445 320	5 109	22 684	10 194	95,77	0,50
Q1 2009	31.03.2009	13 293	256	13 037	46,60	106 445 320	4 960	22 229	9 192	86,35	0,54
Q2 2009	30.06.2009	13 231	449	12 782	53,00	106 445 320	5 642	22 360	9 578	89,98	0,59
Q3 2009	30.09.2009	13 543	520	13 023	67,50	106 445 320	7 185	22 119	9 096	85,45	0,79
Q4 2009	31.12.2009	13 253	566	12 687	77,00	106 445 320	8 196	24 389	11 702	109,93	0,70
Q1 2010	31.03.2010	13 745	564	13 181	78,30	106 445 320	8 335	24 991	11 810	110,95	0,71
Q2 2010	30.06.2010	14 077	564	13 513	70,30	106 445 320	7 483	25 594	12 081	113,50	0,62
Q3 2010	30.09.2010	14 685	563	14 122	81,60	106 445 320	8 686	26 196	12 074	113,43	0,72
Q4 2010	31.12.2010	14 200	597	13 603	91,00	106 445 320	9 687	27 003	13 400	125,89	0,72
Q1 2011	31.03.2011	13 792	811	12 981	89,60	106 445 320	9 538	27 289	14 308	134,42	0,67
Q2 2011	30.06.2011	13 983	476	13 507	90,00	106 445 320	9 580	27 806	14 299	134,33	0,67
Q3 2011	30.09.2011	13 945	509	13 436	81,00	106 445 320	8 622	28 100	14 664	137,76	0,59
Q4 2011	31.12.2011	14 024	746	13 278	78,80	106 445 320	8 388	28 304	15 026	141,16	0,56
Q1 2012	31.03.2012	14 112	1 080	13 032	88,80	106 445 320	9 452	28 722	15 690	147,40	0,60
Q2 2012	30.06.2012	13 798	533	13 265	86,00	106 445 320	9 154	29 172	15 907	149,44	0,58
Q3 2012	30.09.2012	13 945	532	13 413	86,20	106 445 320	9 176	29 241	15 828	148,70	0,58
Q4 2012	31.12.2012	14 298	635	13 663	89,00	106 445 320	9 474	30 490	16 827	158,08	0,56
Q1 2013	31.03.2013	14 051	562	13 489	91,50	106 445 320	9 740	30 998	17 509	164,49	0,56
Q2 2013	30.06.2013	15 370	652	14 718	96,40	106 445 320	10 261	32 419	17 701	166,29	0,58
Q3 2013	30.09.2013	15 341	786	14 555	97,00	106 445 320	10 325	32 613	18 058	169,65	0,57
Q4 2013	31.12.2013	15 178	456	14 722	107,00	106 445 320	11 390	33 025	18 303	171,95	0,62
Q1 2014	31.03.2014	13 536	310	13 226	110,00	106 445 320	11 709	29 633	16 407	154,14	0,71
Q2 2014	30.06.2014	15 026	1 438	13 588	113,50	106 445 320	12 082	29 878	16 290	153,04	0,74
Q3 2014	30.09.2014	16 604	354	16 250	116,00	106 445 320	12 348	33 529	17 279	162,33	0,71
Q4 2014	31.12.2014	16 650	282	16 368	125,50	106 445 320	13 359	34 655	18 287	171,80	0,73
Q1 2015	31.03.2015	16 431	264	16 167	159,50	106 445 320	16 978	35 097	18 930	177,84	0,90
Q2 2015	30.06.2015	16 802	191	16 611	142,50	106 445 320	15 168	36 172	19 561	183,77	0,78
Q3 2015	30.09.2015	16 702	283	16 419	137,50	106 445 320	14 636	37 357	20 938	196,70	0,70
Q4 2015	31.12.2015	18 008	158	17 850	142,00	106 445 320	15 115	40 177	22 327	209,75	0,68
Q1 2016	31.03.2016	19 630	185	19 445	137,00	106 445 320	14 583	42 943	23 498	220,75	0,62
Q2 2016	30.06.2016	19 923	187	19 736	143,50	106 345 320	15 261	43 796	24 060	226,24	0,63
Q3 2016	30.09.2016	19 704	236	19 468	143,50	106 345 320	15 261	44 403	24 935	234,47	0,61
Q4 2016	31.12.2016	21 252	325	20 927	160,00	106 345 320	17 015	47 680	26 753	251,57	0,64
Q1 2017	30.03.2017	21 249	279	20 970	164,00	106 345 320	17 441	48 473	27 503	258,62	0,63
Q2 2017	30.06.2017	21 678	193	21 485	168,00	105 745 320	17 765	49 388	27 903	263,87	0,64
Q3 2017	30.09.2017	21 557	256	21 301	163,50	105 745 320	17 289	50 358	29 057	274,78	0,60
Q4 2017	31.12.2017	21 713	366	21 347	163,00	105 745 320	17 236	51 435	30 088	284,53	0,57
Q1 2018	31.03.2018	21 295	275	21 020	142,40	105 745 320	15 058	51 552	30 532	288,73	0,49
Q2 2018	31.06.2018	21 500	256	21 244	149,40	105 745 320	15 798	51 948	30 704	290,36	0,51

Table 5 Key figures - Indirect Index (value-weighted index)

Period	wNPRO	wOLT	wENTRA	HPR NPRO	HPR OLT	HPR ENTRA	w*HPR NPRO	w*HPR OLT	w*HPR ENTRA	HPR Index
Q3 2006	0,32	0,68	-							
Q4 2006	0,41	0,59	-	35,4 %	25,3 %		14,68 %	14,79 %	0,00 %	29,47 %
Q1 2007	0,47	0,53	-	10,8 %	-6,1 %		5,08 %	-3,23 %	0,00 %	1,85 %
Q2 2007	0,49	0,51	-	5,9 %	-4,1 %		2,88 %	-2,11 %	0,00 %	0,77 %
Q3 2007	0,46	0,54	-	-11,9 %	0,7 %		-5,40 %	0,36 %	0,00 %	-5,05 %
Q4 2007	0,45	0,55	-	2,3 %	6,2 %		1,04 %	3,44 %	0,00 %	4,47 %
Q1 2008	0,35	0,65	-	-33,8 %	-1,2 %		-11,94 %	-0,80 %	0,00 %	-12,73 %
Q2 2008	0,37	0,63	-	-40,5 %	-3,8 %		-14,90 %	-2,37 %	0,00 %	-17,27 %
Q3 2008	0,23	0,77	-	-57,8 %	-19,5 %		-13,53 %	-14,92 %	0,00 %	-28,45 %
Q4 2008	0,19	0,81	-	-39,2 %	-21,3 %		-7,59 %	-17,17 %	0,00 %	-24,76 %
Q1 2009	0,14	0,86	-	-34,2 %	-2,9 %		-4,78 %	-2,51 %	0,00 %	-7,29 %
Q2 2009	0,17	0,83	-	42,5 %	13,7 %		7,19 %	11,41 %	0,00 %	18,60 %
Q3 2009	0,38	0,62	-	71,1 %	27,4 %		27,06 %	16,94 %	0,00 %	44,00 %
Q4 2009	0,44	0,56	-	45,6 %	15,3 %		20,08 %	8,55 %	0,00 %	28,62 %
Q1 2010	0,40	0,60	-	-12,0 %	1,7 %		-4,84 %	1,01 %	0,00 %	-3,84 %
Q2 2010	0,36	0,64	-	-33,8 %	-10,2 %		-12,00 %	-6,58 %	0,00 %	-18,59 %
Q3 2010	0,37	0,63	-	23,2 %	16,1 %		8,56 %	10,14 %	0,00 %	18,70 %
Q4 2010	0,35	0,65	-	1,5 %	12,7 %		0,51 %	8,34 %	0,00 %	8,85 %
Q1 2011	0,35	0,65	-	-1,0 %	-1,5 %		-0,34 %	-1,01 %	0,00 %	-1,34 %
Q2 2011	0,37	0,63	-	11,3 %	0,4 %		4,20 %	0,28 %	0,00 %	4,48 %
Q3 2011	0,31	0,69	-	-30,3 %	-10,0 %		-9,47 %	-6,87 %	0,00 %	-16,34 %
Q4 2011	0,30	0,70	-	-4,1 %	-1,5 %		-1,24 %	-1,03 %	0,00 %	-2,27 %
Q1 2012	0,32	0,68	-	20,7 %	12,7 %		6,59 %	8,64 %	0,00 %	15,23 %
Q2 2012	0,31	0,69	-	-8,4 %	-3,2 %		-2,59 %	-2,19 %	0,00 %	-4,78 %
Q3 2012	0,32	0,68	-	7,6 %	0,2 %		2,46 %	0,16 %	0,00 %	2,62 %
Q4 2012	0,33	0,67	-	-0,6 %	4,6 %		-0,19 %	3,11 %	0,00 %	2,92 %
Q1 2013	0,34	0,66	-	7,9 %	2,8 %		2,68 %	1,85 %	0,00 %	4,54 %
Q2 2013	0,29	0,71	-	-16,0 %	5,4 %		-4,67 %	3,79 %	0,00 %	-0,88 %
Q3 2013	0,30	0,70	-	3,2 %	0,6 %		0,96 %	0,44 %	0,00 %	1,40 %
Q4 2013	0,26	0,74	-	-8,6 %	11,8 %		-2,22 %	8,71 %	0,00 %	6,49 %
Q1 2014	0,25	0,75	-	-0,3 %	2,8 %		-0,07 %	2,09 %	0,00 %	2,02 %
Q2 2014	0,26	0,74	-	4,1 %	3,2 %		1,06 %	2,37 %	0,00 %	3,43 %
Q3 2014	0,30	0,70	-	27,3 %	2,2 %		8,16 %	1,54 %	0,00 %	9,71 %
Q4 2014	0,17	0,41	0,43	5,1 %	9,6 %	3,3 %	0,86 %	3,88 %	1,39 %	6,13 %
Q1 2015	0,15	0,45	0,40	3,0 %	27,1 %	9,5 %	0,45 %	12,08 %	3,83 %	16,36 %
Q2 2015	0,16	0,45	0,40	-6,7 %	-10,7 %	-12,8 %	-1,06 %	-4,77 %	-5,08 %	-10,90 %
Q3 2015	0,16	0,45	0,39	-2,7 %	-3,5 %	-5,8 %	-0,43 %	-1,58 %	-2,27 %	-4,28 %
Q4 2015	0,15	0,46	0,39	-3,7 %	4,6 %	8,0 %	-0,56 %	2,09 %	3,16 %	4,68 %
Q1 2016	0,14	0,43	0,43	-4,6 %	-3,5 %	9,5 %	-0,65 %	-1,53 %	4,04 %	1,86 %
Q2 2016	0,14	0,44	0,42	6,6 %	4,7 %	2,8 %	0,96 %	2,09 %	1,17 %	4,21 %
Q3 2016	0,16	0,41	0,44	18,7 %	0,0 %	14,0 %	2,96 %	0,00 %	6,12 %	9,08 %
Q4 2016	0,14	0,44	0,41	-6,8 %	12,9 %	-2,2 %	-0,98 %	5,74 %	-0,92 %	3,84 %
Q1 2017	0,13	0,44	0,43	-0,6 %	2,5 %	9,3 %	-0,08 %	1,09 %	4,01 %	5,02 %
Q2 2017	0,13	0,42	0,45	5,2 %	2,4 %	13,1 %	0,69 %	1,02 %	5,87 %	7,58 %
Q3 2017	0,13	0,40	0,47	-1,2 %	-2,7 %	4,8 %	-0,15 %	-1,08 %	2,25 %	1,02 %
Q4 2017	0,13	0,38	0,49	5,6 %	1,0 %	13,9 %	0,72 %	0,39 %	6,83 %	7,95 %
Q1 2018	0,14	0,37	0,49	-3,9 %	-12,6 %	-12,5 %	-0,53 %	-4,73 %	-6,08 %	-11,34 %
Q2 2018	0,14	0,37	0,48	7,4 %	4,9 %	6,2 %	1,04 %	1,84 %	3,00 %	5,88 %

Econometric Model

The following part tests and discusses the empirical framework for our econometric model.

Ordinary Least Squares (OLS) linear regression is a statistical method for estimating the linear relationship between a dependent variable and one or more explanatory variables. The method is based on the principle of least squares, i.e. minimizing the sum of the squares of the differences between the observed dependent variable and those predicted by the linear function. Further, OLS is the best linear unbiased estimator (BLUE) given that the Gauss-Markov assumptions 1-5 holds. The assumptions are as follows:

1. The population model is linear in parameters:

$$y = \beta_0 + \beta_1 x_1 + \epsilon$$

2. Data is a random sample of the population:

$$y = \beta_0 + \beta_1 x_1 + \ldots + \beta_i x_i + \epsilon$$

$$i = 1, 2, 3, \ldots, n$$

3. There is sample variation in the explanatory variable and no multi-collinearity.

4. Zero conditional mean: The error term ϵ has an expected value of zero given any values of the independent variables.

$$E(\epsilon|\mathrm{x}) = 0$$

5. Homoscedasticity: The variance of the error term is constant conditional on x. If this does not hold, the error term exhibits heteroscedasticity.

$$Var(\epsilon|\mathrm{x}) = \sigma^2$$

And no autocorrelation: The error terms over time are uncorrelated, i.e. they are independently distributed.

$$Cov(\epsilon_i \epsilon_j|\mathrm{x}) = \sigma^2$$

In the case of heteroscedasticity and autocorrelation, OLS is inefficient and therefore no longer BLUE. The estimated variances of the regression coefficients will be biased and inconsistent and will provide invalid testing.

To test for heteroscedasticity, we conduct the Breusch-Pagan test (hettest) and to test for autocorrelation, we apply the Breusch-Godfrey test.

In the presence of heteroscedasticity and autocorrelation, we apply the Newey-West estimator. This approach produces consistent standard errors for OLS regression coefficient estimates, without changing the regression model. The beta-coefficients remain unchanged, whereas the t-values are corrected to be used for statistical inference.

The method handles autocorrelation up to and including a lag of n. Thus, it assumes that any autocorrelation at lags greater than n can be ignored. According to Greene (2008), the optimal number of lags equal the integer closest to $n^{1/4}$. With 47 observations, we used a number of 2 lags.

In order to correct the unknown form of autocorrelation in the error terms, Newey and West (1987) suggested:

$$\operatorname{Var}\widehat{(\beta_1 \mid X)} = \frac{1}{\{\sum_{t=1}(X_t - \bar{X})^2\}^2} \times \left\{ \sum_{t=1}^{N} \hat{u}_t{}^2 \, (X_t - \bar{X})^2 + \sum_{I=1}^{L} \sum_{t=I+1}^{N} w_I \hat{u}_t \hat{u}_{t-\mathrm{I}} \, (X_t - \bar{X}) \, (X_{t-I} - \bar{X}) \right\}$$

where

$$w_I = 1 - \frac{I}{L+1}$$

The correlation between u_t and u_{t-I} is approximated with $\left(1 - \frac{I}{L+1}\right) \hat{u}_t \hat{u}_{t-1}$

The above standard error is also robust to arbitrary heteroscedasticity.

Test for autocorrelation

Sample: Q4 2006 - Q2 2018
Null hypothesis: No serial correlation

Table 7 Breusch-Godfrey test for autocorrelation CAPM

	Obs	chi2	Prob > chi2
IPD	45	21.320	0.0000
Indirect Index	45	1.397	0.2372
NPRO	45	0.000	0.9952
OLT	45	1.897	0.1684
ENTRA	13	2.039	0.1533

Table 8 Breusch-Godfrey test for autocorrelation Multifactor Model

	Obs	chi2	Prob > chi2
IPD	44	15.967	0.0001
Indirect Index	45	3.507	0.0611
OSEAX	45	0.569	0.4507

Test for heteroskedasticity

Sample: Q4 2006 - Q2 2018
Null hypothesis: Constant variance (homoskedasticity)

Table 9 Breusch-Pagan test for heteroskedasticity CAPM

	Obs	chi2	Prob > chi2
IPD	45	0.17	0.6819
Indirect Index	45	0.24	0.6211
NPRO	45	0.39	0.5331
OLT	45	0.09	0.7676
ENTRA	13	0.06	0.8111

Table 10 Breusch-Pagan test for heteroskedasticity Multifactor Model

	Obs	chi2	Prob > chi2
IPD	44	15.36	0.0001
Indirect Index	45	2.60	0.1066
OSEAX	45	17.43	0.0000