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DIVERSIFICATION BENEFITS OF REAL ESTATE IN A MIXED-ASSET PORTFOLIO

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TABLE OF CONTENTS

ABSTRACT

This thesis studies the performance and development of direct real estate investments compared with the stock market. More specifically, buy-to-rent investment of 1 room apartments in the five major cities in Finland with the OMX Helsinki 25 index. The results are based on data within a 10 year timeframe from 2010 - 2019. Both asset classes are examined individually and as a part of a mixed-asset portolfio. The main objective for this thesis is to find if real estate is an effective diversification method for a mixed-asset portfolio consisting of real estate and equity. The study is conducted by calculating and analysing the return, risk, correlation, portfolio choice and risk-adjusted return.

The results found in this thesis show that there are major differences between real estate and stock market investments. Real estate investments are noticeably less volatile, whereas higher return can be found from stock market investments. The correlation between real estate investment were very low, and negative for Helsinki, Turku and Jyväskylä, indicating for beneficia diversification. Five portfolios consisting of OMXH25 and real estate from each city were compiled to find the optimal portfolio allocation and risk-adjusted return. With equal portfolio allocation average return and standard deviation is at a level of approximately 10 percent. The best performing city according to efficient frontiers was Jyväskylä with a return of 11,2 percent and standard deviation of 12,1 percent. The risk adjusted return was computed by the Sharpe ratio, and the results indicates Jyväskylä as the most effective diversification instrument with Sharpe ratio of 0,86.

Keywords: Real estate, diversification, mixed-asset portfolio, stock market, OMXH25

INTRODUCTION

Private persons in today's society in Finland have a broad selection of opportunities to gain passive income through investments. They are provided with investment funds and bonds with different risk classes via their own banks, and such an investment method is the most common among Finnish private persons to gain stable passive income (Suomen Pankki 2020). Despite the fact that transaction accounts are still a popular way to save excess cash on, investments are having a larger part of Finnish households' investments (Suomen Pankki 2020). Investing in different asset classes, such as real estate investment has been growing, and therefore more investors consider real estate investments as a source for stable passive income and a portfolio diversifier. According to a survey made by Taloussanomat in 2019 consisting of a sample of almost 6500 Finnish private investors, real estate investments were the third most popular investment vehicle. Funds were the most popular, and stocks the second most popular (Olkkonen, Taloussanomat 2019).

The main aim for this thesis is to investigate the diversification benefits and risk-adjusted return of real estate investments in a mixed-asset portfolio consisting of stocks and real estate. By effective diversification benefits, a mixed-asset portfolio will contain of assets with a covariance as small as possible to decrease the risk without compromising the expected return. The aim is therefore to investigate whether it is possible to get noticeable diversification benefits by investing in real estate.

The research problem is based on one main problem, from which two sub problems have been presented to get an extensive view on the subject.

Research problem:

- Does real estate investments in Finland provide diversification benefits in a mixed-asset portfolio consisting of real estate and equity?
    - Which city performs best as a portfolio diversifier and provides best risk-adjusted return?
    - Is there significant correlation found between real estate investments and OMXH25 index?

This thesis will investigate investments from a Finnish private person's point of view. Real estate investments in this thesis are existing 1 room apartments, and all other forms of real estate are excluded, since they are not adequate for this research. The research area is distributed to the five biggest cities in Finland; Helsinki, Tampere, Turku, Oulu and Jyväskylä. This will get an extensive overview of the Finnish real estate market. For the intangible asset, the OMX Helsinki 25 index will be investigated. OMX Helsinki 25 is the Helsinki Stock Exchange leading share index. The index consists of the 25 most actively traded stocks on the Helsinki Stock Exchange. The OMX25 index will give an overview of a well distributed stock portfolio in the Finnish market.

This thesis is compiled based on quantitative data collection within a 10-year timeframe from 2010 to 2019. The limitation for this thesis can be stated as the relatively short timeframe and individual risk concerning real estate investments. It is due to limitation of data for the Finnish real estate market needed for compiling rental data end return. It will still give a credible overview of the topic.

This thesis consists of three different chapters. The first chapter will present an overview of creating a portfolio of real estate and equity. Both asset classes and measurement methods are presented, which then is followed by a literature overview of previous research. The second topic will present the characteristics of the research data for real estate investments and OMXH25. It presents also the methodology used for compiling an analysis on return, risk, correlation, portfolio efficiency and risk-adjusted return. The data has been used for evaluating the development of both asset classes individually. The third chapter consists of a in depth analysis of the empirical results gathered by using methods presented in previous chapters.

The studies presented in this thesis provides useful infromation especially for Finnish private investors interested in real estate investment. In addition, the studies seek advantages and possibilities of real estate investment compared with other investment instruments. Therefore, the general interest in real estate investment may grow and new ideas concerning portfolio allocation may be found.

1. CREATING A PORTFOLIO OF REAL ESTATE AND EQUITIES

This chapter will cover the theoretical background for both real estate investment in Finland and Helsinki Stock Exchange's OMXH25 index. The theoretical background of both asset classes is followed by an overview of measuring risk and return in a portfolio. This chaper will be conluded by a literature review of previous empirical findings.

1.1. Real estate investment in Finland

Owning a property in Finland in juridical terms means owning the land and the buildings on it (KTI 2019). This is the main form of direct property ownership. Another possible form of ownership is to own the building and have a long-terms lease agreement of the land with the landowner, typically the municipality (KTI 2019). Property ownership is organised trough a limited company founded for owning the property. The legal owner of the real estate is the company, which then has one or several shareholders connected to a specific apartment or amount of space in the property. This type of ownership is conducted through mutual real estate companies (MREC) and is commonly used for residential and commercial properties.
In properties designed for residential use the ownership is conducted through shares of the real estate company owning the real estate. One share or a combination of shares is typically equivalent for one apartment. This thesis will focus on the housing sector and apartment buildings designed for residential use.

Real estate investment is typically executed by purchasing an apartment, in other words becoming a shareholder in a housing company and renting the apartment as a long-term investment and gain passive income through rental cash flow. The rental agreement is made between the owner (later referred as landlord) and tenant, and the rent goes directly to the landlord. Real estate investment can also be conducted by only seeking for capital appreciation of an apartment. This method is executed by purchasing an apartment, usually for own use with a price lower than the expected market value, and later selling it with profit when the market value has increased. This form of investment will not be taken into concern in this thesis, since buying for rental purposes is the most common method and will generate predictable and steady long-term cash flow, and the market value of the apartments purchased for rental use will follow the current situation and in the ideal situation be a more valuable asset by time (Orava & Turunen, 2016; 17). Real estate investment is a form of investment that requires more starting capital than other forms of investment and is not as liquid as other investments. Therefore, it is considered as an expensive form of investment, but in reality, apartments purchased for rental purposes can be used as collateral for bank loans. Banks are much more generous to grant a mortgage for investment apartments because of the low risk level, predictable cash flow and value of the apartment (Orava & Turunen, 2016; 44). The chairman of the board of the Finnish Landlord Association stated that if one is able to save money for a car, then one is able to save for an investment apartment as well (Orava & Turunen, 2016; 21). Apartment prices in existing properties in major cities have been increasing steadily due to increase in population and centralization of employment. This phenomenon is expected to continue and increase in the future (PTT 2020). Therefore, real estate investment in such cities have become attractive for private persons because the asset will hold its value and people are demanding compact apartments near necessary services.

1.3 Risks in real estate investments

Real estate investment includes risks, as every other form of investment. There are risks which are more dependant on the decisions made by the investor and then there are unexpected risks, which cannot be minimized . The most recognized risk affecting return and operations within real estate investment according to Orava & Turunen are:

- Price risk – the general price level of housing decreases
- Interest risk – Significant increase in interest rates
- Empty months – Investor is unable to find a tenant to the apartment
- Bad tenant – A bad tenant who does not pay the rent or destroy the apartment
- Rent price level – A decrease in the rent price level
- Maintenance fee – The housing company’s costs increse
- Renavation – The housing company is affected by a long and expensive renovation

- Political risk – an increse in taxation, changes in financial aid, geopolitical decisions regarding educational institutions
- Natural phenomenon – Damage caused by a storm or flood

The majority of the risk mentioned above can be taken into consideration and minimized by choosing the investment object with great judgement and research. By focusing on investments in major cities and and to apartments with no major renovations scheduled for the future is a solid method to avoid unexpected decrease in return. Unexpected risks, such as political and natural are difficult to predict. Political decisions being made and coming into effect in 10 years might effect real estate investors negatively, but it is impossible to predict (Orava & Turunen 2016; 259). Natural disasters can destory property by fallen trees or floods, but since they are very rare and unpredictable there is no noticeable effect on returns in real estate investment in Finland (Orava & Turunen 2016; 259).

The risks mentioned above are possible risks affecting on return on investments. Due to the nature of the risks they are difficult to take into consiseration by calaculations when comparing with equity. Financial buffers are commonly used within real estate investors. A financial buffer can be defined as a insurance for unexpected costs, such as empty months and renovations. Financial buffers usually cover the rent for 2-3 months and is held on savings accounts or in low risk funds. Real esatate is a much less liquid asset than stocks, due to the fact that selling an apartment can be a long process. In real estate investment selling of an apartent comes into part usually when the investor is in financial trouble or the apartment does not generate steady cash flow due to location or bad condition. For a long-term investor the latter reason is more common, since the rental income will not decrese depending on the market value of the apartment (Orava & Turunen 2016; 247).

1.3 Equity investments into Helsinki stock exchange

Investments made for long-term purposes is a very common method for ensuring one’s wealth in the future. Therefore, investments in stocks and more specifically in equity funds are profitable to gain passive income with a controlled risk. Equity fund is a mutual fund that invest principally in stocks. It can be actively or passively managed (Chen 2019). Passively managed funds are also known as index funds. Index fund is a mutual fund with a portfolio constructed to match or track the components of a financial market index (Chen 2020). Since an index is a hypothetical portfolio they cannot be invested in directly. Therefore, there are plenty of investment vehicles providing funds tracking a certain index by holding the same securities at the same weight (FTSE Russell 2020). Helsinki Stock Exchange has been chosen for the second asset class in this thesis, because the profitability comparison is based completely on the Finnish market.

A stock market index is an indicator of statistical measure on the stock market representing a particular segment of it. A stock market index is a hypothetical portfolio of a combination of stocks to create one aggregate value that is used to help investors and economists to monitor market performance, movements and trends (Chen 2020).
This thesis will take into concern Helsinki Stock Exchanges leading share index, OMX Helsinki 25, later referred as OMXH25. The index consists of the 25 most actively traded shares on the Helsinki Stock Exchange. The limited number of components guarantees that all stocks in the index obtain excellent liquidity and is therefore suitable as underlying for derivatives products. OMXH25 is used as benchmark index for management diversified Finnish stock portfolios (Nasdaq, OMXH25). OMXH25 is a capitalization weighted stock price index. The maximum weight of one company is limited to 10 percent, and the composition of the index balance is revised semi-annually. A capitalization weighted stock index uses the total market value of a company's outstanding shares and is calculated by multiplying the outstanding shares by the current price of one share.

1.4 Measuring risk and return in a portfolio

1.3.1 Return on investment

Real estate can be classified as an investment asset, such as a share. Therefore, the rental return can be calculated and used in further studies. According to Orava & Turunen the annual rental return on real estate investment can be calculated with the following formula:

$$\frac{(Rent - Maintenance\ fee) * 12}{Free\ of\ debt\ price + Renovation\ expenses + Transfer\ tax} \tag{1.1}$$

This thesis does not take renovation expenses into concern, because each apartment and apartment house company have individual renovation needs and schemes. Therefore, the rental return might be overvalued, but in case of no renovation needs it is accurate. Transfer tax is 2 percent.

Return on investment concerning OMXH25 is calculated with the following formula:

$$Return = \frac{Ending\ value - Starting\ value}{Starting\ value} x\ 100 \tag{1.2}$$

Ending value is the value of OMXH25 at the current year and starting value is the value from the same date past year.

1.3.2 Measuring risk trough volatility

The risk of an investment can be measured via its standard deviation, in other words its volatility. The standard deviation is a statistical measure in finance that, when applied to the annual rate of return of an investment, gives insight on the historical volatility of an investment. The greater the standard deviation, the greater the variance between price and the mean, which shows a larger price range (Hargrave 2020). Higher volatility indicates for a riskier investment, that is, uncertainty of investment due to fluctuation of return. The standard deviation can be calculated with the following formula:

$$STD = \sqrt{\frac{\sum_{t=1}^{n}(R_t - \bar{R})^{\wedge}2}{n-1}} \tag{1.3}$$

Where: R_t = the return for period *t*, $\bar{R}$ = mean value of return for the whole period and n = number of periods.

1.3.3 Covariance and correlation of return

Covariance is a statistical measure of the directional relationship between the returns of two assets. Covariance is used in portfolio theory to determine what assets to include in the portfolio. A positive covariance indicates that the asset returns are moving in the same direction, whereas a negative covariance indicates of returns moving in opposite direction (Chen 2020). Investors are seeking for a negative covariance, or as low as possible to reduce the overall risk and find the optimal diversification for a positive return.
Covariance is calculated with the following formula:

$$Cov(R_a, R_b) = \frac{\sum_i^n (R_a - \bar{R}_a) * (R_b - \bar{R}_b)}{n-1} \tag{1.4}$$

The correlation coefficient is a statistical measure of strength of the relationship between the relative movements of two variables. The value range is between -1.0 and 1.0. A correlation of -1.0 shows perfect negative correlation and the returns are moving in opposite direction. A correlation of 1.0 shows perfect positive correlation, and the returns are moving the same direction. Correlation of 0.0 shows no correlation between two variables (Ganti 2020). As previous studies have showed (Markowitz 1952, Sivitandes 1997, Mueller & Mueller 2003, Falkenbach 2008) that investors should find assets correlating as low as possible to find the optimal diversification benefits. The correlation coefficient is calculated with the following formula:

$$Corr(R_a,\ R_b) = \rho_{ab} = \frac{Cov(R_a,\ R_b)}{\sigma_a\ \sigma_b} \tag{1.5}$$

Where: $\sigma_a\ \sigma_b$ = standard deviation of assets, ρ_{ab} = correlation coefficient and $Cov(R_a,\ R_b)$ = covariance for portfolio.

1.3.4 Modern portfolio theory

Markowitz (1952) introduced the Modern Portfolio Theory, which is a mathematical model to optimize the diversification of an investment portfolio. Markowitz has suggested that the process of portfolio selection be approached by making probabilistic estimates of the future performances of securities, analysing those estimates to determine an efficient set of portfolios and selecting that set the portfolios best suited to the investor's preferences (Sharpe, 1963; 277). The portfolio with maximum return is not necessarily the one with minimum variance. There is a rate at which the investor can gain return by taking on variance, or reduce variance by giving up return (Markowitz, 1952; 79). In Markowitz's model, an investor selects a portfolio at time *t*-1 that produces a hypothetical return at *t*. The model assumes investors are risk averse and, when choosing among portfolios, they care only about the mean and variance of their one-period investment return (Fama & French, 2004; 26). Markowitz noted that by diversifying securities across industries with different economic characteristics the covariances are lower than within the same industry. As other studies have analysed, diversification can be executed with different asset classes as well. In other words, an investor should combine securities which correlation is low in order to achieve the same return with a lower risk. When the return of securities fluctuates in different directions, the loss of one security will compensate with the return of one security. In this case the return of the portfolio will not decrease in a scenario of one security underperforming. If the two securities returns are negatively correlated, diversification will be an effective method to decrease risk, but otherwise the diversification reduces risk the less the return on different securities correlate.

1.3.5 Capital Asset Pricing Model (CAPM)

The Capital Asset Pricing Model of William Sharpe (1964) and John Lintner (1965) are considered as the founders of asset pricing theory. The fundamentals of CAPM is that it offers legitimate predictions on how to measure risk and the relation between expected return and risk. The CAPM builds on the model of portfolio choice by Harry Markowitz (1952). According to the CAPM an investor will view the outcome of any investment in probabilistic terms, thinking of the possible results in terms of some probability distribution. In assessing the desirability of a particular investment, an investor is willing to act on the basis of only two parameters of distribution, its expected value and standard deviation (Sharpe, 1964; 427-428). The CAPM describes the relationship between systematic risk and expected return for assets (Kenton 2019). According to the CAPM the expected return of an investment is in linear and positive relation with the systematic risk of an investment, which is measured by the beta factor. An investments beta factor measures its sensitivity, according to which the return on an individual investment fluctuates relative to the return on the market as a whole (Kuosmanen, 2002; 52). The CAPM formula can be presented in the form:

$$E(r_i) = r_f + \beta_i * (E(r_m) - r_f) \quad (1.6)$$

Where: $E(r_i)$= expected return of investment, r_f = risk-free rate, β_i = systematic risk or beta of the investment, $E(r_m)$ = expected market return and r_f = risk free rate.

The empirical equivalent of the CAPM is obtained by replacing the expected values with historical values. The historical return replaces expected values, and an error term has been added to the model (Kuosmanen, 2002; 52).

Systematic risk is an essential part of the CAPM formula. The systematic risk is presented by the beta coefficient (β). Beta coefficient is used for measuring the volatility of an individual security or asset in comparison to the entire market (Kenton 2020).

The beta coefficient can be calculated with the following formula:

$$\beta = \frac{Cov(R_{i,}R_m)}{Var(R_m)} \quad (1.7)$$

Where: $Cov(R_{i,}R_m)$ = the covariance between the security and market portfolio, $Var(R_m)$ = variance of the market portfolio. The formula gives the outcome of how much the return of the security fluctuates in relation with the market portfolio, which in this thesis is OMXH25.

1.3.6 Sharpe ratio

Performance measures are used to compare a portfolios performance in some time period relative to another period to compare different portfolios in the same period (Jobson & Korkie, 1981;890). The idea of performance measures is to analyse the ratio between return and risk, that is, how much risk has been taken to achieve the return. The larger the ratio, the better the performance (Sharpe, 1966;123). The most common measures for risk-adjusted return are the Sharpe ratio and Treynor ratio. The Sharpe ratio behaves better with small sample sizes compared to the Treynor ratio, and also the Treynor ratio cannot capture the portion of variability that is due to lack of diversification. For this reason, it is an inferior measure of past performance. But for this reason,

it might be superior for future performance (Sharpe, 1966;128). Due to these reasons and data from a 10-year timeframe between 2010 - 2019 the Sharpe ratio has been chosen to measure risk-adjusted return in this thesis.
The Sharpe ratio can be calculated with the following formula:

$$S = \frac{(r_i - r_{f)}}{\sigma_i} \quad (1.8)$$

Where: r_i = return, r_f = risk-free rate and σ_i = standard deviation. For calculating the Sharpe ratio, the risk-free rate is according to the 12-month benchmark government debt yield.

1.5 Previous empirical findings

Real estate investment has not been researched in Finland as much as it has been researched globally. Real estate investments as a part of an investment portfolio has been studied both nationally and internationally, but much less nationally. The studies regarding portfolio allocation and real estate as a portfolio diversifier are for the most part international studies.

The first book regarding real estate investment in Finland "Osta, vuokraa, vaurastu" was published in 2013 by Orava & Turunen. The authors examine all necessary aspects a real estate investor should take into concern before making the investment decision, and how a successful investment is executed. Orava & Turunen explain all theories and models with real life examples to clarify and give more insight of methods to the reader. "Osta, vuokraa, vaurastu" focuses on the investment method of buying-to-rent and receiving long-term cash flow. The theory of the book is used in thesis for gathering rental returns and cash flow.

Kuosmanen (2002) examined the risk and returns on the housing markets in his dissertation "Riski ja tuotto asuntomarkkinoilla". The dissertation examines housing as an investment for long-term returns. Kuosmanen used Markowitz full covariance model, efficient frontier method and Capital Asset Price Model in his analysis. The results show that normal distribution is correct when using annual and quarterly returns, and that the risk-return relationship is valid with regard to the housing market. Further results showed that the optimal apartment portfolio consists of one-room flats and flats with three or more rooms with apartments mainly is Eastern and Northern Finland. Surprisingly investments should not concentrate on expanding cities of Southern Finland and Helsinki metropolitan area. This research also showed that real estate substantially improved the return-risk trade-offs of diversified stock portfolios (Kuosmanen, 2002).

Sivitandes (1997) found in his research "Why invest in real estate: An asset allocation perspective" that within 5, 10- and 18-year holding periods an investor should hold real estate in an investment portfolio. Research found that both short-term and long-term investors who accept moderate return should have included real estate in their portfolios 85 percent of the time. The results regarding the 18-year holding period showed that the most efficient portfolio with the highest efficiency ratio of 0,68 (Sharpe ratio) contained allocations of 33,9 percent in stocks, 22,4 percent in bonds and 43,7 percent in real estate.

Mueller and Mueller (2003) analysed in their article "Public and Private Real Estate in a Mixed-Asset Portfolio" the inclusion of both public (REITs) and private (NCREIF index) real estate in a mixed-asset portfolio within 5, 10, 15, 20- and 25-years' annual timeframes. Their research showed that within a 25-year timeframe a portfolio of public real estate generated a return of 14,45 percent, whereas private real estate generated 9,39 percent. For comparison the S&P500 index generated a return of 14,24 percent. Correlation between public real estate and S&P500 was mainly positive, while the correlation between public and private real estate was mainly negative. The inclusion of private real estate (NCREIF) provides major decreases in volatility of a Markowitz efficient portfolio for the lower half of the risk/return efficient frontier. The inclusion of public real estate (REITs) provides improvement for the entire efficiency frontier but has most substantial benefit at the upper half (Mueller & Mueller, 2013). Greater distribution benefit can be accomplished by adding private real estate to the portfolio.

Falkenbach (2008) analysed in her article "Diversification Benefits in The Finnish Commercial Property Market" if the Finnish property market provided diversification benefits in its early years of internalisation in the beginning of the 21st century as a part of a Finnish mixed-asset portfolio and an international real estate portfolio. Average return on real estate was between stocks and bonds with a return of 6,95 percent. The volatility of asset return was measured by the ratio of average return and standard deviation, which gave the lowest outcome of 0,28 for real estate. These results show that real estate is a more secure asset to invest in due the low volatility. She found that the correlation between stocks and direct real estate, as well as stocks and real estate stocks was positive, suggesting limited diversification benefits (Falkenbach 2008; 28). The correlation between real estate and stocks was the lowest with a result of 0,53, which according to the study has larger diversification benefits. Falkenbach's study show that when finding efficient portfolio allocation both direct and indirect real estate had a large allocation in efficient portfolios.

Etebari (2016) examined in his study "Real estate as a portfolio diversifier" the performance of real estate relative to bonds and common stocks in the U.S between 1978 and 2012. He found that common stocks earned the highest average return of any asset class during the timeframe. Stocks earned 12,63 percent, versus 10,05 percent for bonds and 9,40 percent for real estate. Presumably, stocks had the highest risk (standard deviation) of any asset class, 16,70 percent versus 12,78% for bonds and 8,01 percent for real estate. Real estate outperformed both stock and bonds on risk-adjusted basis, indicating for an effective diversification asset for investment portfolios. Etebari conducted an optimal portfolio within the Markowitz (1952) framework with an outcome of a major share of real estate in the optimal portfolio.

Oikarinen (2007) examined in his study "Studies on housing price dynamics" the housing portfolio diversification potentials in the Helsinki metropolitan area. This part of his study focuses on geographical diversification in Finland. Oikarinen based his study on the Modern Portfolio Theory, to achieve a portfolio where one asset can achieve same expeted return with lower risk level or higher return at a given risk level. Any significant diversification benefits found trought correlation analysis and efficient frontier was not found due to the long-term nature of real estate investments. Oikarinen also studied the linkages between housing markets and financial asset markets. He found that, if an long-term inevstor does not already have well diversified portfolio, he will reduce the unsystematic risk by inevesting in both stocks and real estate. His results also show that the price movements and volatility in real estate are highly predictable compared to the stock market, making long-term investors feel more secure.

2. DATA AND METHODOLOGY

This chapter will present the characteristics and development of Finnsih real estate investement and the Helsinki Stock Exchange OMXH25 index. The development of both asset classes during a 10-year timeframe are presented by graphs. This is followed by an overview of methodology used for conducting the analysis itself.

2.1. Real estate data

The data concerning real estate investment have been gathered from Statistics Finland and Kiinteistömaailma Oy, one of the largest real estate brokerage companies in Finland. All necessary data needed for calculating rental return are showed on annual basis within a 10-year timeframe from 2010 – 2019. The data include average rental fees, maintenance costs and average apartment prices. The average size of a 1 room apartment in Finland is 34 square meters according to Statistics Finland's overview in 2018, and therefore all calculations are based on this information. To get an extensive view of real estate investment in Finland, data from the five largest cities in Finland have been taken into concern. The five largest cities by population are Helsinki, Turku, Tampere, Oulu and Jyväskylä, all of which are university cities as well. This thesis will only investigate the return of 1 room apartments, since they are more profitable than 2 or 3 room apartments, because of lower maintenance costs and higher demand (Orava & Turunen, 2016).

The rental fees are based on non-subsidized rental apartments. Non-subsidized rental apartments are built without government subsidies and does not include any governmental restrictions regarding income and wealth. Non-subsidized apartments are usually owned by private persons and are rented out to private persons. The rental agreement is a contract made between the landlord and tenant by the obligations of the rental law (Ovikoodi, 2020).

Figure 1 presents the development of 1 room apartment average prices from 2010 – 2019 for all five sample cities. For this 10-year holding period acquisition price (2010) and ending price (2019) is relevant due to possible liquidation of an asset. Therefore, annual appreciation has not been taken into concern. It is noticeable that Helsinki stands out with an approximately two times higher price than the other cities. Oulu and Jyväskylä comes with lowest prices, but it is reasonable due to the demand of apartments and number of inhabitants in these cities. Turku holds the highest capital appreciation of 56 percent within the timeframe, and Jyväskylä have had the lowest capital appreciation of 29,2 percent. Helsinki, Tampere and Oulu have had a capital appreciation of approximately 45 percent.

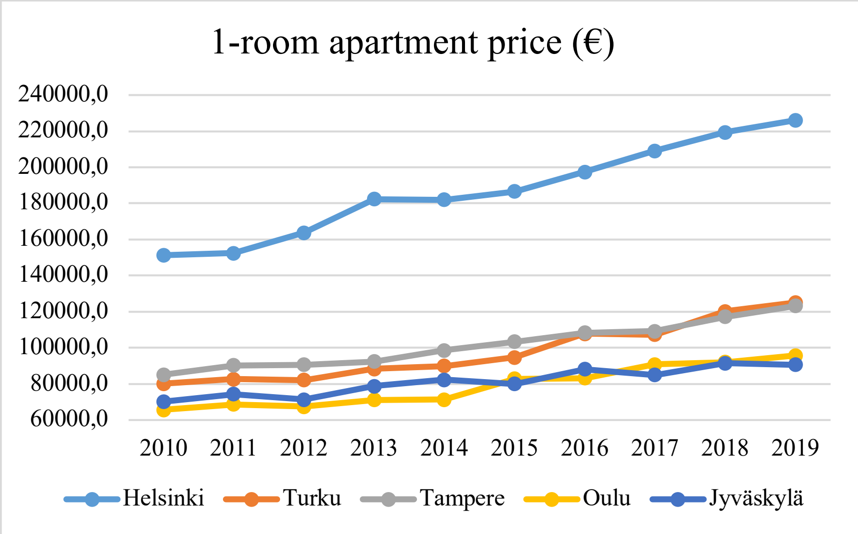

Figure 1. Average acquisition price - 1 room apartments 2010-2019.
Source: Kiinteistömaailma https://www.kiinteistomaailma.fi/asuntojen-hinnat (2020). Compiled by authors calculations.

Figure 2 represents the development of rental prices in the five sample cities. Helsinki is noticeably more expensive than the other cities, but it correlates directly to apartment prices and demand. The growth within the 10-year holding period was highest in Helsinki, which had a growth of 38,9 percent. Turku and Tampere were relatively close to each other with a growth of 32,3 percent and 34,6 percent. Oulu and Jyväskylä were also close to each other with growth rates of 25,5 percent and 26,3 percent. All five cities have had a positive growth rate, which is predictable due to increase in demand and inhabitants. Due to lack of exact data concerning rental prices from 2019, rental prices for 2019 have been calculated by the growth percentage index given by Statistics Finland for non-subsidised apartments in Finland. Growth rates for 2019 were as follows: Helsinki: 1,9 percent, Turku: 1,6 percent, Tampere: 1,8 percent, Oulu: 1,7 percent and Jyväskylä: 0,6 percent. Also, data concerning maintenace fees for 2019 have not been provided by Statistics Finalnd. Therefore data from 2018 will be used for 2019 as well.

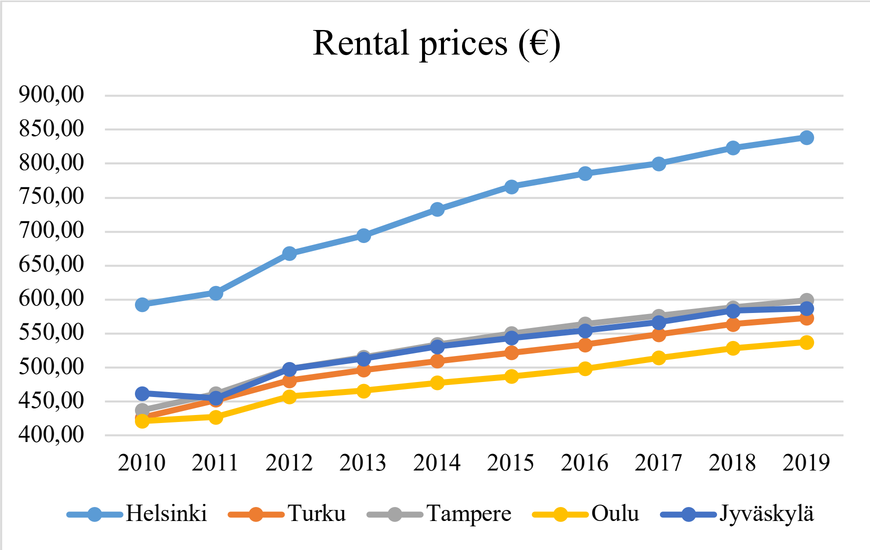

Figure 2. Average rental price - 1 room apartments 2010 – 2019. Source: Statistics Finland https://www.stat.fi/til/asvu/tau.html (2020). Compiled by authors calculations.

2.2. Equity data

The data concerning the stock market is gathered from Nasdaq Global Indexes and Kauppalehti. The primary objective of the index is to reflect the development of the shares included in the portfolio (Nasdaq). OMXH25 is diversified into ten industries which are: Basic Materials, Consumer Goods, Consumer Services, Financials, Health Care, Industrials, Oil & Gas, Technology, Telecommunications and Utilities.

Figure 3 represents the development of OMXH25 during a 10-year timeframe of 2010 – 2019. The value of the index is taken annually on the first trading day in March each year. The development has been increasing since 2010, after the financial crisis in 2007 – 2010. The growth from 2010 to 2019 has been 88 percent, and the highest value of 4117,3 was achieved in March 2019.

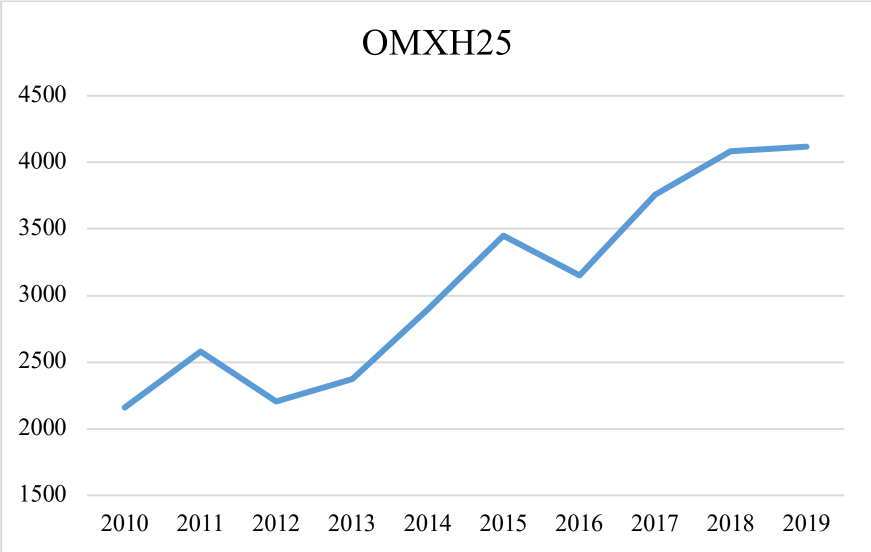

Figure 2. OMX Helsinki 25 2010-2020. Source: Nasdaq OMX. Source: https://indexes.nasdaqomx.com/Index/Overview/OMXH25 (2020) . Compiled by author.

For the usage of the Capital Asset Pricing Model (CAPM) and Sharpe ratio, the risk-free rate will be following the yield on 10-year Government Debt of Finland. Figure 4 represents the development and yields of the 10-year government benchmark bond. During the 10-year timeframe it has decreased noticeably from 3,13 percent in 2010 to -0,19 percent in 2019. This is due to the uncertainty on the markets, and ECB's (European Central Bank) decision to decrease the rates. Central banks have compensated obstacles by decreasing interest rates, and according to Nordea Finland's head analyst Jan von Gerich, it is invadable for the markets to survive (Karkkola, Talouselämä, 2020).

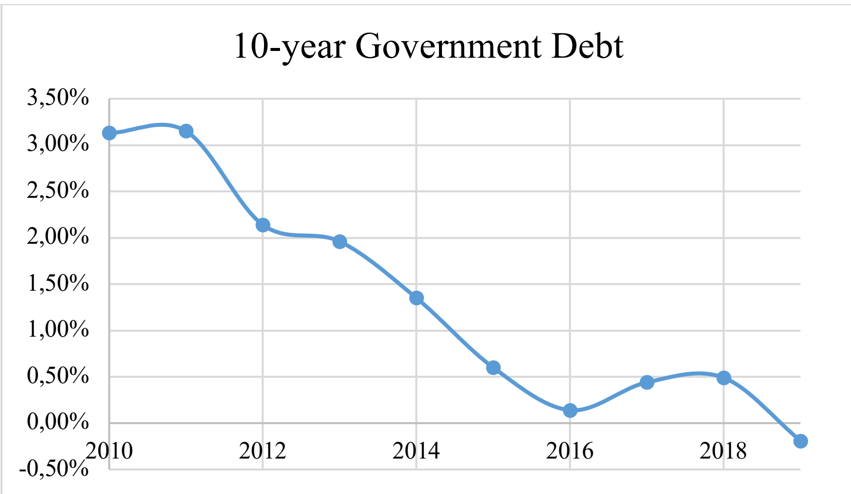

Figure 3. Yield on 10-year benchmark Government bond. Source: https://www.suomenpankki.fi/fi/Tilastot/korot/taulukot2/korot_taulukot/viitelainojen_korot_fi/ (2020) Compiled by author.

2.3 Methodology

The empirical analyses on both real estate investments and stock market investments are based on quantitative data gathered from different databases containing statistics and data. As previous research has found the menthods presented in this chapter effective for analysing portfolio diversification benefits and efficiency, this thesis will use similar methods for research of the Finnish market. This thesis will focus on return, risk, correlation and risk-adjusted return for evaluating individual assets and portfolios. Explanations of formulas used for calculating return, risk, correlation and risk-adjusted return by the Sharpe ratio for both individual asset classes and portfolios have been presented in the first chaper, and the outcome is presented below. By using these measures, a broad view of the effecitveness of real estate as portfolio diversifier can be provided.

3. RESULTS AND ANALYSIS

In this part of the thesis the author will examine and present the results of methods presented in the previous part. First, the returns of investment concerning real estate in the five sample cities and OMXH25 will be compared to show which cities perform the best compared to OMXH25 from an investor's perspective. After return on investment, the diversification benefits will be examined and presented by risk (standard deviation) and correlation. CAPM is used to measure the relation between risk and return for both asset classes. To get an overview of an optimal portfolio, an efficient frontier will be compiled to show at which weight a portfolio will perform at its best. Finally, the risk-adjusted return will be presented by the Sharpe ratio.

3.1 Return on investment

The return on investment for real estate concerning the five sample cities (Helsinki, Turku, Tampere, Oulu and Jyväskylä) compared with the Helsinki Stock Exchange (OMXH25 index) differ significantly. As table 1 presents, it is noticeable that the return on real estate is lower, but much less volatile than OMXH25. The Finnish real estate market has not been affected by heavy decreases typical for the stock market (Orava & Turunen, 2016; 33). It is typical for the stock market to have heavy increases as well, where increases can be over 10 percent (Orava & Turunen 2016; 33).

Table 1. Return on investments 2010 – 2019.

Year	OMXH25	Helsinki	Turku	Tampere	Oulu	Jyväskylä
2010	73,80 %	3,67 %	6,25 %	6,04 %	7,53 %	7,74 %
2011	19,45 %	3,73 %	6,43 %	6,01 %	7,31 %	7,19 %
2012	-14,54 %	3,86 %	6,88 %	6,45 %	7,98 %	8,22 %
2013	7,59 %	3,66 %	6,62 %	6,56 %	7,70 %	7,66 %
2014	22,08 %	3,86 %	6,66 %	6,37 %	7,88 %	7,58 %
2015	19,07 %	3,96 %	6,48 %	6,26 %	6,91 %	7,99 %
2016	-8,64 %	3,86 %	5,82 %	6,13 %	7,04 %	7,40 %
2017	19,21 %	3,74 %	6,01 %	6,20 %	6,66 %	7,84 %
2018	8,77 %	3,69 %	5,52 %	5,90 %	6,75 %	7,50 %
2019	0,81 %	3,66 %	5,39 %	5,72 %	6,60 %	7,62 %
Average	**14,76 %**	**3,77 %**	**6,21 %**	**6,16 %**	**7,24 %**	**7,67 %**

Source: Compiled by authors calculations

When comparing the return on investment on real estate only, there are noticeable differences on returns within the sample cities. Figure 5 presents the development of rental return for the timeframe of 2010-2019. The differences are due to apartment prices and rental prices on the different regions. These both components are affected by the demand and supply of 1-room apartments. Helsinki has the lowest rental return but has also significantly the highest prices on apartments (average 187,078,20 €) and rents (average 731,10 €/month), but not high enough in relation with the other cities to increase the rental return percentage. Jyväskylä having the highest rental return indicates of low apartment prices (average 81,226,00€) and relatively high rents (average 529,19€/month). Oulu has the second highest rental return, and the lowest apartment prices (average 78,903,80 €) and rents (average 481,26 €/month). There is not any noticeable volatility of rental returns on individual sample cities. The lowering curve at the more recent years is a sign of the rise in apartment prices which is not followed by an increase in rents. Also, smaller cities, such as Oulu and Jyväskylä are dependant of students, since people are moving to larger cities because of companies' centralisation of operations. As stated in the earlier chapters, real estate is a predictable investment method and therefore have the returns been stable and following the development of apartment prices and rents.

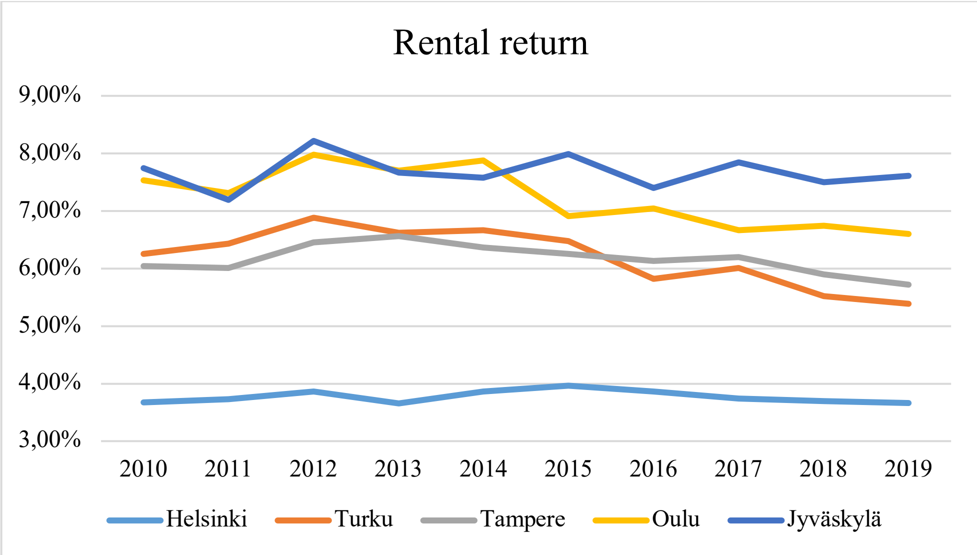

Figure 5. Rental return in real estate 2010-2019. Source: Compiled by authors calculations.

Return on investment of the Helsinki Stock Exchange index, OMXH25, has been volatile due to the much less predictable development of the stock market. Table 1 presents the individual development of OMXH25 during the timeframe of 2010 – 2019. The highest annual return has been 73,8 percent in 2010 and the lowest annual return has been -14,54 percent in 2012. The most recent return in 2019 has only been 0,81 percent. It is noticeable that the value of the index has almost been doubled in 10 years. This states the efficiency of stock market investment compared to real estate. But due to this volatility, it can be measured as risk, and therefore more predictable asset classes are choses for an investment vehicle.

Table 2. Return of OMXH25 2010 – 2019.

Year	P	Return (%)
2009	1242,55	
2010	2159,61	73,80 %
2011	2579,67	19,45 %
2012	2204,51	-14,54 %
2013	2371,87	7,59 %
2014	2895,68	22,08 %
2015	3447,96	19,07 %
2016	3150,02	-8,64 %
2017	3755,26	19,21 %

2018	4084,74	8,77 %
2019	4117,73	0,81 %
Average		14,76 %

Source: Compiled by authors calculations.

3.2 Risk on investment

Table 3 presents the standard deviation and coefficient of variation of returns for both asset classes. As it has been noted, stock market has significantly higher risk (standard deviation) compared to real estate in all five cities. During the timeframe of 2010 – 2019 plenty of fluctuation have occurred in the stock market causing annual differences of close to 50 percent at the highest. The standard deviation of real estate investments is low, as expected. Helsinki has the lowest standard deviation of only 0,11 percent, which is an outcome of the stable annual rental returns. Turku and Oulu have the highest standard deviation of 0,50 percent and 0,52 percent, because of the volatility in annual rental returns. Surprisingly, Jyväskylä with the highest average annual rental return has a relatively low standard deviation. It can be explained by the low apartment prices in relation with rent.

The coefficient of variation has been calculated by dividing the standard deviation with average return. It gives an insight on how much risk there is in comparison with the return. The lower the coefficient of variation, the better the risk-return trade-off (Hayes 2020). As expected, the coefficient of variation was much higher for stocks, than for real estate. The coefficient of variation goes for the most part in the same direction with the standard deviation with Helsinki having the lowest. The only exception was that Turku has the highest ratio of 0,081 whereas Oulu has 0,071.

Table 3. Risk measures in both asset classes.

	OMXH25	**Helsinki**	**Turku**	**Tampere**	**Oulu**	**Jyväskylä**
St. Dev	24,24 %	0,11 %	0,50 %	0,26 %	0,52 %	0,29 %
Coeff. of variation	1,642	0,029	0,081	0,042	0,071	0,038

Source: Compiled by authors calculations.

3.3 Correlation between real estate and equity

The correlation between returns of OMXH25 and real estate have been calculated separately for all five cities to get an extensive overview of the correlation, and which city would perform best as a portfolio diversifier. As Markowitz (1952) stated in his Modern Portfolio Theory, the benefits of divesification reduces when the correlation between two assets is as low as possible. The correlation between OMXH25 and real estate investment in all five sample cities is negatively correlated, suggesting diversification as effective method to decrease risk. The lowest correlation when comparing OMXH25 and real estate can be found in Helsinki, with a figure of -0,286, and the highest in Oulu with a figure of 0,086. These figures indicates that the cities with a lower risk (standard deviation) are more effective as portfolio diversifiers, and the opposite with cities having higher risk, if only correlation is used as a measure. On the basis of these measures, Helsinki and Tampere would be the best alternatievs for an investor when planning portfolio diversification, and Oulu and Turku would provide the least benefits of diversification. The correlation between the cities have been calculated with each other, but they are not taken into consideration in portfolio diversification. It is still noticeable that the correlation between the cities is high. It is due to the similarity of real estate market and investments on different geographical areas in Finland. The most siginificant difference and lowest correlation is between Helsinki and the four other sample cities.

Table 4. Correlation matrix of annual returns.

	OMXH25	**Helsinki**	**Turku**	**Tampere**	**Oulu**	**Jyväskylä**
OMXH25	1					
Helsinki	-0,286	1				
Turku	0,083	0,433	1			
Tampere	-0,153	0,415	0,843	1		
Oulu	0,086	0,177	0,842	0,707	1	
Jyväskylä	-0,072	0,370	0,402	0,458	0,217	1

Source: Compiled by authors calculations.

3.4 Portfolio choice

The efficient frontier, presented by Markowitz (1952) in his Modern Portfolio theory as mean-variance model. This method is used for choosing optimal portofolio construction and asset

allocation and as a means for rationalizing the value of diversification. The optimization assumes that the investor prefers a portfolio of securities that offers maximum return for some given risk level (Michaud 1989; 31). Effcient frontier have been calculted for OMXH25 and all five sample cities with portfolio weight of 0 percent to 100 percent, with 10 percent intervals (Appendix 1). Helsinki and Tampere will be presented, as they have been identified as the most effective portfolio diversifiers by correlation measurements. Also Jyväskylä will be presented, because it holds the highest return of all five cities.The y-axis presents mean return of portfolio and the x-axis presents standard deviation of portfolio on different portfolio weights. The left side of the efficient frontier is 100 percent real estate investments, whereas the right side is 100 percent stock investments.
The efficient frontiers presented in this thesis are linear due to the fact that if a portfolio would be compiled according to minimun variance portfolio choice, it would consist of 99,9 percent real estate. The risk and return in the portfolio increases linearly as the amount of stocks increses in the portfolio. Therefore, the graphs presented are not concave as efficient frontiers usually are, and is similar to a capital market line. Figure 10 presents the efficeint frontier of a portfolio consisting of OMXH25 and real estate investments in Helsinki. It is noticeable that the more the portfolio consists of stocks, the higher the risk and return, and the opposite with a majority of real estate investments. Highest return of 14,76 percent can be achieved with 100 percent stocks, but with an equal allocation of 50 percent a return of 9,27 percent and standard deviation of 11,5 percent can be achieved.

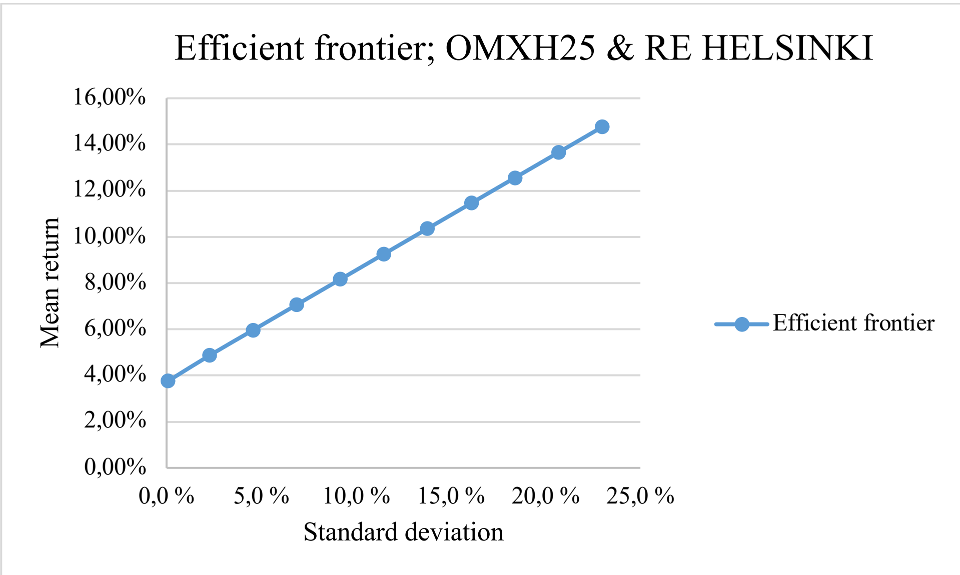

Figure 6. Efficient frontier OMXH25 & RE Helsinki. Source: Complied by authors calculations.

The second efficient frontier presented in figure 7 presents the portfolio consisting of OMXH25 and real estate investments in Tampere. The return acieved by real estate investments only is at 6,16 percent, wheras the return with stock market investments only stays at the same level as with Helsinki. With an equal allocation, a return of 10,46 percent and standard deviation of 11,5 percent can be achieved. When achieving for higher returns with a majority of stocks, the return increases by approximately 1 percent per 10 percent of addition into weight of stock, wheras the standrad deviation increase by more than 2 percent. This phenomonen is similar for all five cities.

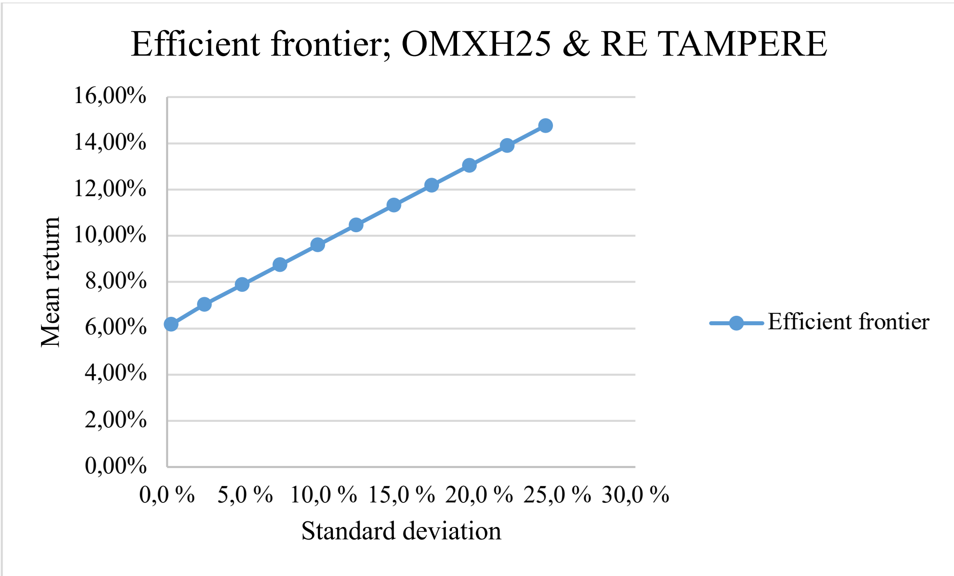

Figure 7. Efficient frontier of OMXH25 and RE Tampere. Compiled by author.

Jyväskylä as the highest performing city, when comparing returns is performing well when looking at the efficient frontier. This is presented in figure 8. Eventhough, the high correaltion with OMXH25, Jyväskylä has the same standard deviation with an equal portfolio allocation. The return is at 11,22 percent and the standard deviation is 11,5 percent. It is noticeable that Jyväslylä performs the best as a porfolio diversifier when using efficient frontier as measurement method. The results obtained from efficient frontier show how efficiently the real estate investments reduce risk in a mixed-asset. An investor seeking for the highest return with Finnish real estate, the investor should consider Jyväskylä as a diversification vehicle.

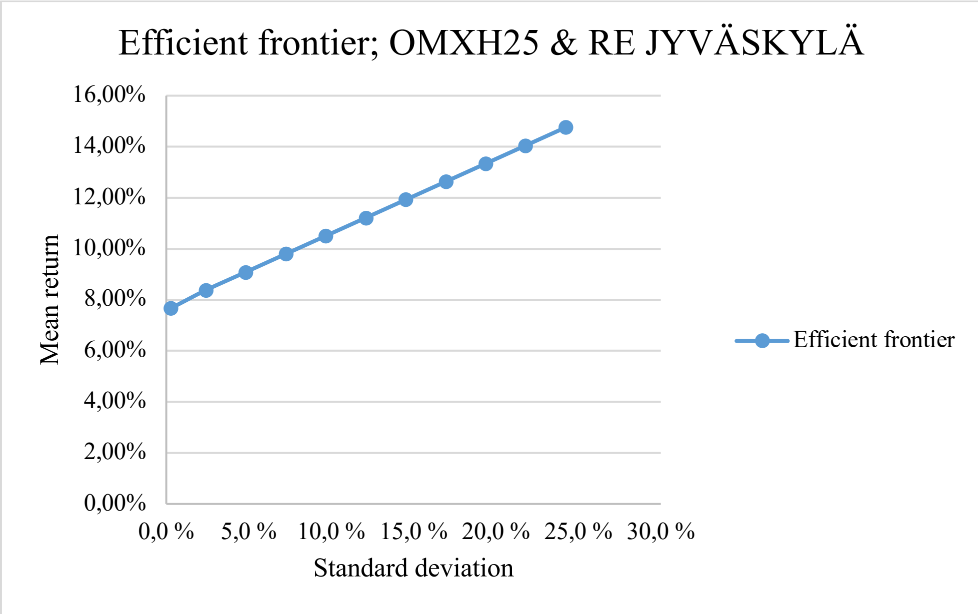

Figure 8. Efficient frontier; OMXH25 & Re Jyväskylä. Compiled by author.

Using the Capital Asset Pricing Method as measurement method when comparing diversification benefits in a mixed-asset portfolio will give an imvestor insight on the realtion on the risk and return. Table 5 presents the essential results from the CAP-model. The results have been obtained by a regression analysis for each city individually (Appendix 2). The beta factor explain the change occuring in real estate investment when OMXH25 increases by 1 percent. The beta factor for all cities indicates of relatively low sensitivity in relation with OMXH25, and that real estate is less volatile than the stock market, making the portfolio less risky. The lowest beta factor is held by real estate investment in Tampere, with -0,0016. This means that the real estate investment in Tampere fluctuates in the opposite direction with OMXH25. The highest beta factor is found from Oulu with 0,0017, but it is still very low, and makes the portfolio less risky as well. As and example, when the OMXH25 index increses by 1 percent, the real estate investments in Oulu increases by 0,17 percent. This phenomen is accurate for all cities, except that the cities with negative beta decreases when OMXH25 increases. R square is a measure of percentage of a securitys movement that can be explained by OMXH25 (Kenton 2020). The highest R2 is found from Helsinki, meaning that 8,2 percent of movement in real estate investing in Helsinki can be explained by movements of OMXH25. Least movent of real estate investing can be explained by the OMXH25 is in Jyväskylä with olnly 0,52 percent. The values from the F-test indicates that p-values from the regression analysis are significant (< 0,05), and the development of real estate investment in Finland can be explained by the development of OMXH25 index. The R(e) is the outcome of the CAPM formula, giving the required return. The required return results are quite low due to high volatililty in OMXH25 during the 10-year timeframe, making the average annual return 14,75 percent. The required return for all sample cities are beyond or close to the risk free rate 1,32 percent (average yield on 10-year government bond).

Table 5. CAPM results 2010 – 2019 (Rm = OMXH25)

	Helsinki	Turku	Tampere	Oulu	Jyväskylä
R square	0,082	0,0068	0,023	0,0074	0,0052
Beta	-0,0013	0,0017	-0,0016	0,0018	-0,00088
F	0,71	0,055	0,19	0,060	0,042
R(e)	1,30 %	1,34 %	1,30 %	1,34 %	1,31 %

Source: Compiled by authors calculations.

3.5 Risk-adjusted return of the portfolio

The risk-adjusted return for each asset has been calculated individually and as a part of a portfolio. The Sharpe ratio has been computed by reducing the risk free rate from the return, and dividing the outcome by standard deviation. Sharpe ratio for portfolios has been computed with equal allocation of stocks and real estate (Appendix 1). Table 6 presents the Sharpe ratios for each city and portfolio, as mentioned above. It is notiecable that when comparing the risk-adjusted return on an individual level, real estate has significally higher ratios than the stock market, which means real estate has performed better in relation to risk that has been taken. OMXH25 has indeed siginifically higher return and standard deviation, which affects directly to a lower Sharpe ratio. The high difference in standard deviaiton sets real estate's Sharpe ratio between a scale of 22,54 – 9,88, whereas OMXH25 has a ratio of 0,55. When exmining the Sharpe ratio of portfolios consisting of stock and real estate, the difference between the five cities decreases considerably. The best risk-adjusted return can be found from a equally allocated portfolio consisting of stocks and real estate in Jyväskylä, with a Sharpe ratio of 0,82. The lowest portfolio Sharpe ratio can be found from a portfolio consisting of stocks and real estate in Helsinki. When comparing Sharpe ratios at different weight allocation between stocks and real estate investents, any significant difference is not found when real estate holds 70 percent or less of the weight in the portfolio. If an investor is seeking for a return around 10 percent, with a standard deviation also around 10 percent, a portfolio with an equal allocation, or +-10 percent towards either asset is recommendable, depending on the tolerance of risk. With such a portfolio it is possible to achieve a Sharpe ratio close to 1,0. Altough any prefrences of portfolio risk and return mentioned above, Jyväslylä offers best risk adjusted return whereas Helsinki still the lowest.

Table 6. Sharpe ratio for individual asset and portfolio.

	OMXH25	Helsinki	Turku	Tampere	Oulu	Jyväskylä
r(i)	14,76 %	3,77 %	6,21 %	6,16 %	7,24 %	7,67 %
r(f)	1,32 %	1,32 %	1,32 %	1,32 %	1,32 %	1,32 %
St. Dev	24,24 %	0,11 %	0,50 %	0,26 %	0,52 %	0,29 %
Sharpe	0,55	22,54	9,68	18,72	11,48	21,58
Sharpe portfolio*		0,66	0,75	0,76	0,80	0,82
	*Equal portfolio allocation; Calculated with portfolio return and standard deviation (Appendix 1)					

Source: Complied by authors calculations.

CONCLUSION

This thesis examined two significally different asset classes, real estate and equity. More specifically real estate investments in the major cities in Finland and the OMX Helsinki 25 index. Real estate often receive less attention among investment instruments, while equity investments are a much more researched topic. This thesis was conducted from a average Finnish private investors point of view, since Finnish investors are quite risk-averse, the stock market can feel uncomfortable when reaching for steady long-term cash flow. Therefore, real estate investments in major Finnish cities can feel more comfortable due to steady long-term cash flow, eventhough the returns can be lower. Due to this, it was chosen to examine the differences and similarities of these two asset classes, and can they be combined to get as efficient returns as possible.

The aim for this thesis was to study the diversification benfits of real estate in a mixed-asset portfolio consisting of real estate and equity during a timeframe of 10 years, from 2010 - 2019. The study was based on quantitative data gathered form Statistics Finland, Kiinteistömaailma and Nasdaq. Real estate investments were reviewed in Helsinki, Turku, Tampere, Oulu and Jyväskylä, which represent the major cities and give a geographically spread sample. Both investment instruments were compared individually by annual return, growth, correlation, volatility and risk-adjsuted return. Since reale estate investments include risks which are impossible to calculate, the returns and volatilty might differ from a real life scenario, but not necessarily since every investment is unique. To get an answer to the reseach question; "Does real estate provide diversification benefits in a mixed-asset portfolio?" the following method was used. Diversification benefits was examined by compiling portfolios consisting of real estate in each city and stocks from OMXH25. An efficient frontier was complied to examine the portfolio choice with different weight allocations.

The results gathered from both asset classes in this differ noticeably with each other. Real estate investments own a much lower volatility, whereas stock market investments own a higher return. During the 10-year timeframe returns of real estate investments have differed annually by approximately one percent, whereas OMXH25 have had annual differentiation of as much as 50 percent. The results indicate that diversification benefits are achievable by including real estate in a portfolio consisting of stocks market investments. This can be proved by the correlation results between real estate and OMXH25. The correlation between OMXH25 and all five sample cities was low, and partly negative within a range of -0,286 – 0,086. Lowest correlation was found between OMXH25 and Helsinki.

Portfolio choice was calculated by efficient frontiers and Sharpe ratios. Since the volatility between the two asset classes differ significantly, the efficient frontier did not become concave as usually. Hence, the efficient frontier resembles a capital market line since the real estate investments own low risk during the period. The results indicate that if the weight allocations are equal the average annual return and standard deviation for all five portfolios is approximately 10 percent. By adding real estate to the portfolio, the investor can decrease the standard deviation, but with an outcome of decreased return. Also, if the investor is reaching for higher return, he shall increase the weight of stocks in his portfolio. The best performing portfolio according to efficient frontiers was OMXH25 and Jyväskylä with an average annual return of 11,22 percent and a standard deviation of 12,1 percent. As a comparison, OMXH25 and Helsinki's similar results were 9,27 percent and 12,1 percent. The portfolio's risk-adjusted return was computed by the Sharpe ratio of equally allocated portfolios. The results between the five portfolios were between a range of 0,66 – 0,82. An investor shall reach for a Sharpe ratio as high as possible, and therefore the portfolio with real estate in Jyväskylä turns out to be the most effective.

The results from this thesis comes with certain restraints. The timeframe of 10 years can be stated as rather short, not providing as extensive results from a longer period of time. Also, the risks concerning real estate investments are unique for every object and are therefore not taken into concern in this thesis when computing national averages. The results presented in this thesis can be beneficial for Finnish private investors interested in real estate investment as part of their portfolio. Therefore, the results from 2010 – 2019 provide results extensive enough for making conclusions about the development and profitability. An interesting continuation for this thesis could be to compare the performance and development of REIT's with direct real estate investments and other financial assets, such as stocks and bonds, both individually and as a part of a mixed-asset portfolio.

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APPENDICES

Appendix 1. Efficient frontier data sets including Sharpe ratio for portfolio

OMXH25	**RE HEL**				
Weight	Weight	Mean Ret	Variance	Std dev	Sharpe
0 %	100 %	3,77 %	0,00000119	0,1 %	22,44
10 %	90 %	4,87 %	0,00057614	2,4 %	1,48
20 %	80 %	5,97 %	0,00232908	4,8 %	0,96
30 %	70 %	7,07 %	0,00526002	7,3 %	0,79
40 %	60 %	8,17 %	0,00936896	9,7 %	0,71
50 %	50 %	9,27 %	0,01465589	12,1 %	0,66
60 %	40 %	10,37 %	0,02112083	14,5 %	0,62
70 %	30 %	11,46 %	0,02876376	17,0 %	0,60
80 %	20 %	12,56 %	0,03758469	19,4 %	0,58
90 %	10 %	13,66 %	0,04758362	21,8 %	0,57
100 %	0 %	14,76 %	0,05876055	24,2 %	0,55

OMXH25	**RE TKU**				
Weight	Weight	Mean ret	Variance	Std dev	Sharpe
0 %	100 %	6,21 %	0,0000254	0,5 %	9,70
10 %	90 %	7,06 %	0,0006244	2,5 %	2,30
20 %	80 %	7,92 %	0,0023954	4,9 %	1,35
30 %	70 %	8,77 %	0,0053382	7,3 %	1,02
40 %	60 %	9,63 %	0,0094530	9,7 %	0,85
50 %	50 %	10,48 %	0,0147396	12,1 %	0,75
60 %	40 %	11,34 %	0,0211982	14,6 %	0,69
70 %	30 %	12,19 %	0,0288286	17,0 %	0,64
80 %	20 %	13,05 %	0,0376310	19,4 %	0,60
90 %	10 %	13,90 %	0,0476052	21,8 %	0,58
100 %	0 %	14,76 %	0,0587513	24,2 %	0,55

OMXH25	**RE TAMPERE**				
Weight	Weight	Mean Ret	Variance	Std Dev	Sharpe
0 %	100 %	6,16 %	0,00000665	0,3 %	18,78
10 %	90 %	7,02 %	0,00057568	2,4 %	2,38
20 %	80 %	7,88 %	0,00232370	4,8 %	1,36
30 %	70 %	8,74 %	0,00525070	7,2 %	1,02
40 %	60 %	9,60 %	0,00935669	9,7 %	0,86
50 %	50 %	10,46 %	0,01464167	12,1 %	0,76
60 %	40 %	11,32 %	0,02110563	14,5 %	0,69
70 %	30 %	12,18 %	0,02874857	17,0 %	0,64
80 %	20 %	13,04 %	0,03757051	19,4 %	0,60
90 %	10 %	13,90 %	0,04757143	21,8 %	0,58
100 %	0 %	14,76 %	0,05875134	24,2 %	0,55

OMXH25	**RE OULU**				
Weight	Weight	Mean Ret	Variance	Std Dev	Sharpe
0 %	100 %	7,24 %	0,0000266	0,5 %	11,47
10 %	90 %	7,99 %	0,0006284	2,5 %	2,66
20 %	80 %	8,74 %	0,0024015	4,9 %	1,51
30 %	70 %	9,49 %	0,0053459	7,3 %	1,12
40 %	60 %	10,25 %	0,0094615	9,7 %	0,92
50 %	50 %	11,00 %	0,0147483	12,1 %	0,80
60 %	40 %	11,75 %	0,0212064	14,6 %	0,72
70 %	30 %	12,50 %	0,0288358	17,0 %	0,66
80 %	20 %	13,26 %	0,0376364	19,4 %	0,62
90 %	10 %	14,01 %	0,0476082	21,8 %	0,58
100 %	0 %	14,76 %	0,0587513	24,2 %	0,55

OMXH25	**RE JYVÄSKYLÄ**				
Weight	Weight	Mean Ret	Variance	Std Dev	Sharpe
0 %	100 %	7,67 %	0,00000868	0,3 %	21,56
10 %	90 %	8,38 %	0,00058524	2,4 %	2,92
20 %	80 %	9,09 %	0,00233907	4,8 %	1,61
30 %	70 %	9,80 %	0,00527017	7,3 %	1,17
40 %	60 %	10,51 %	0,00937853	9,7 %	0,95
50 %	50 %	11,22 %	0,01466417	12,1 %	0,82
60 %	40 %	11,93 %	0,02112706	14,5 %	0,73
70 %	30 %	12,63 %	0,02876723	17,0 %	0,67
80 %	20 %	13,34 %	0,03758467	19,4 %	0,62
90 %	10 %	14,05 %	0,04757937	21,8 %	0,58
100 %	0 %	14,76 %	0,05875134	24,2 %	0,55

Source: Complied by authors calculations (Vuorenoja 2020)

Appendix 2. Regression analysis

SUMMARY OUTPUT (OMXH25 & Helsinki)

Regression Statistics	
Multiple R	0,285901836
R Square	0,08173986
Adjusted R Square	-0,033042658
Standard Error	0,001089901
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	8,45926E-07	8,4593E-07	0,71212813	0,423252304
Residual	8	9,50307E-06	1,1879E-06		
Total	9	0,000010349			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,037876691	0,00040955	92,4837406	2,0856E-13	0,036932267	0,03882111	0,03693227	0,03882111
X Variable 1	-0,001264841	0,001498846	-0,8438768	0,4232523	-0,004721186	0,0021915	-0,0047212	0,0021915

SUMMARY OUTPUT (OMXH25 & TURKU)

Regression Statistics	
Multiple R	0,082722633
R Square	0,006843034
Adjusted R Square	-0,117301587
Standard Error	0,005323554
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1,56216E-06	1,5622E-06	0,05512147	0,820277451
Residual	8	0,000226722	2,834E-05		
Total	9	0,000228284			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,061806301	0,00200042	30,896657	1,3088E-09	0,057193324	0,06641928	0,05719332	0,06641928
X Variable 1	0,001718826	0,007321019	0,23477962	0,82027745	-0,015163475	0,01860113	-0,0151635	0,01860113

SUMMARY OUTPUT (OMXH25 & TAMPERE)

Regression Statistics	
Multiple R	0,153029453
R Square	0,023418014
Adjusted R Square	-0,098654735
Standard Error	0,002703287
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1,4019E-06	1,4019E-06	0,19183654	0,672977763
Residual	8	5,84621E-05	7,3078E-06		
Total	9	5,9864E-05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,061880333	0,001015808	60,9173279	5,8604E-12	0,059537875	0,06422279	0,05953788	0,06422279
X Variable 1	-0,001628275	0,003717595	-0,4379915	0,67297776	-0,010201065	0,00694451	-0,0102011	0,00694451

SUMMARY OUTPUT (OMXH25 & OULU)

Regression Statistics	
Multiple R	0,086188168
R Square	0,0074284
Adjusted R Square	-0,11664305
Standard Error	0,005448471
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	1,77735E-06	1,7773E-06	0,05987196	0,812857677
Residual	8	0,000237487	2,9686E-05		
Total	9	0,000239264			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,072089391	0,00204736	35,2109039	4,6317E-10	0,067368171	0,07681061	0,06736817	0,07681061
X Variable 1	0,001833396	0,007492806	0,24468746	0,81285768	-0,015445046	0,01911184	-0,015445	0,01911184

SUMMARY OUTPUT (OMXH25 & JYVÄSKYLÄ)

Regression Statistics	
Multiple R	0,072354974
R Square	0,005235242
Adjusted R Square	-0,119110352
Standard Error	0,003117188
Observations	10

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	4,09103E-07	4,091E-07	0,04210235	0,84254951
Residual	8	7,77349E-05	9,7169E-06		
Total	9	7,8144E-05			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95,0%*	*Upper 95,0%*
Intercept	0,076869829	0,001171339	65,6256054	3,2339E-12	0,074168717	0,07957094	0,07416872	0,07957094
X Variable 1	-0,000879602	0,004286797	-0,2051886	0,84254951	-0,010764973	0,00900577	-0,010765	0,00900577

Source: Compiled by author (Vuorenoja 2020)

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