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Returns across Asset Classes:
a Nordic Perspective

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Preface

This thesis was conducted to satisfy the research requirements of our master's degree in business administration at Oslo Metropolitan University. The primary goal of this research project was to examine the investment environments and financial performance of assets in Nordic countries. In terms of personal interests, we both find investing in various assets to be interesting, and this topic is particularly relevant due to the difficulty in identifying profitable investments in the twenty-first century's dynamic investment environment.

This semester, writing a master's thesis has been both difficult and educational, particularly at the beginning of the semester when restrictions were placed due to the pandemic. Our normal lives were affected when most of the society was compelled to go into lockdown. It was difficult for us to maintain our motivation because we were constantly being presented with new demands and constraints from the government. As a result, both mentoring and writing, as well as part-time jobs, were conducted via Zoom; this happily began to loosen up near the summer, allowing us to feel a little more liberated in our daily lives. Nonetheless, this has been a learning experience, and we are pleased that we have been able to motivate each other to complete this thesis.

We would like to express our gratitude to Danielle Zhang, our supervisor, for her assistance and constructive input during this semester. Friends and family have also been supportive during this process.

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Abstract

This paper examines the performance of five asset classes using global and Nordic data from the period of 1960–2021. To investigate the return performance of these assets, we have calculated the return on assets using various metrics of return before and after risk adjustment. In addition, we have executed a time-series regression with Capital Asset Pricing Model (CAPM) and a macroeconomic factor model. In the end, we have combined the assets and construct minimum variance portfolios. Our results imply equities were the best performing asset class in all the Nordic countries, followed by real estate and government bonds. Equities had the highest risk, followed by real estate and government bonds. Out of 12 Nordic assets, Finnish equities are the only Nordic asset that have delivered negative returns for the last 21 years. Our study suggests the Swedish minimum variance portfolio offers the best option regarding risk and return.

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Introduction

In this thesis, we examine the performance across different asset classes from Nordic investors' perspectives from 1960 until 2021 with the intention of answering the following research questions:

> *How does risk and return on assets differ among the Nordic countries? Which Nordic country offers the most ideal option for the minimum variance portfolio?*

The research questions above captures essential aspects of the Nordic investment universe. In a time where investors have witnessed large price fluctuations in investment markets for all asset classes and financial insecurity in the global economy, it can be confusing to find assets one might define as profitable. Further, extreme price fluctuations have been found in the past and the present as this paper was being written. It is essential for an investor to have a solid understanding of investment universe and what extent they should be exposed to different asset classes. Depending on the risk aversion of an investor, an optimal risk portfolio will either have the lowest risk for any given expected return or the highest possible expected return for any given risk (Meyer, 2014). Markowitz (1952) concluded that a combination of several assets will reduce risk and should improve the overall quality of the portfolio.

The Norwegian Oil Fund has the following portfolio weights: 72% invested in equities, 25.4% invested in bonds (fixed income), 2.5% in real estate, and 0.1% in renewable energy infrastructure (NBIM, 2022). The paper "Historical Returns on the Market Portfolio" reported that the average portfolio weights for stocks are 50.4% and 43.7% for bonds in the global market (Doeswijk, Lam, & Swinkels, 2020). Fogler (1984 as cited in NBIM, 2015) has recommended a minimum portfolio investment of 20% in real estate, which is a significant contrast to Norges Bank Investment Management (NBIM) in practice. Oosterlinck and Szafarz (2015) as well as Weinmayer (2015) have concluded that cryptocurrency should be included in an investor's portfolio since it improves the risk-reward tradeoff. Since there are significant discrepancies between research and actual practice on the topic, we hope our paper can contribute to existing literature with useful insight for investors exposed to the Nordic investment universe.

We employed a variety of approaches to examine the dynamics and performance of various asset investments in the Nordic area. We calculated the arithmetic average return, geometric average return, and Sharpe ratio to provide a balanced perspective of the risk-adjusted return for all assets. We found evidence that Norwegian bonds and real estate perform better than the other Nordic countries. During economic events, bonds performed well, demonstrating strong resistance to losses during periods of economic uncertainty; conversely, equities exhibited high volatility and faced significant reductions in value during these periods.

Furthermore, we used the CAPM and a multi-factor model to determine excess return and macroeconomic risk variables in Nordic countries. We found that equities and bonds provided the highest abnormal returns when compared to the overall market. The macroeconomic variables of inflation rates and interest rates affected the return on Nordic assets negatively across all Nordic countries. We implemented a correlation analysis for the return on each asset. From this analysis, we found that, in Finland, the correlation pattern between return on bonds and equities is different from all the other Nordic countries. Next, we constructed the minimum variance portfolio combined with all assets. Furthermore, we examined portfolios with assets from each Nordic country. We found that the weights in our minimum variance portfolios were different from portfolios in the real world and the literature.

Our thesis contributes to the literature in several ways. First, it examines asset classes from a Nordic point of view. Second, it examines how different assets perform and shed a light on risk factors each asset class is exposed to over time. Third, the construction of Nordic minimum variance portfolios offers useful insight regarding risk and return for investors exposed to Nordic assets.

The rest of the thesis proceeds as follows: in Section 2, we conduct a literature review of the relevant literature for our thesis. Section 3 presents the methodologies we used. Section 4 describes the data collection. Section 5 provides the results of our analyzes and a discussion related to previous research. In Section 6, we conclude and present our limitations and proposals for further research.

2. Literature review

In this section, we first review the papers that study the performance of various asset classes. Then, we move on to summarize the studies on risk factors. Finally, we will summarize the main findings of importance from the previous literature.

2.1 Performance of different assets

2.1.1 Returns on equites

2.1.1.1 Publicly listed equities

There has been significant effort put into finding the optimal portfolio with optimal weights of assets. In the well-known book *Stocks for The Long Run*, Siegel investigated several asset classes from an American point of view (Siegel J. J., 2014). Siegel's conclusion was that the compound annual real return on a diversified portfolio of common stock has been between 6% to 7%, and between 3% to 4% for long- and short-term US treasury bonds. When compared to other assets in the study, stocks displayed a remarkable constancy during the 210-year period Siegel investigated. Next, Soni (2017) stated that exclusively investing in equity markets is not ideal since risks exceed returns; however, the study found evidence of the highest returns in equities. Doeswijk, Lam, and Swinkels (2020) indicated that the global multi-asset market portfolio for 1960–2017 regarding weights consisted of 50.8% of equities on average. The remaining market portfolio consisted of real estate, non-government bonds, government bonds, and commodities. Jordà, Knoll, Kuvshinov, Schularick, and Taylor (2019) documented higher returns and lower standard deviations for real estate as an asset when compared to equites during their full sample period from 1870 to 2015; however, equities performed better than real estate with a higher standard deviation in their sample period from 1950 to 2015.

2.1.1.2 Private equities

Private equity is an alternative investment class and consists of capital that is not listed on a public exchange. We found numerous studies regarding this investment class in finance literature. For instance, Allen, Qian, Shan, and Zhu (2021) discovered China's domestic (A share) stock market was one of the worst performing markets in terms of buy- and-hold returns during 2000–2018. Furthermore, the operating performance of A share listed firms, as measured by net cash flows, was also inferior to matched unlisted Chinese firms. However, Moskowitz and Vissing-Jørgensen (2002) documented other results in their research study: they found that the returns to private equity were no higher than the returns for public equity in the US. Kaplan and Schoar (2005) discovered that, during 1980-1997 in the

US, venture funds weighted by committed capital outperformed the S&P 500, while buyout funds did not. Their estimates also suggest that, gross of fees, both types of private equity partnerships earned returns exceeding the S&P 500. Furthermore, Kaplan and Sensoy (2015) found results similar to previous authors; they found that funds that outperformed the S&P 500 (net of fees) by approximately 20% over the life of the fund. Venture capital funds raised in the 1990s outperformed the S&P 500, whereas venture capital funds raised in the 2000s underperformed.

2.1.2 Returns on fixed-income securities

2.1.2.1 Government bonds

Government bonds guaranteeing to repay borrowed money at a fixed rate of interest by a specified time are typically issued by a country's government. These bonds are seen as some of the safest assets in the investment universe. Ibbotson and Sinquefield (1976) documented in their study that US long-term government bond returns were positive 37 out of the 49 years of their study sample, and the annual returns for US long-term government bonds ranged from 16.8% to -9.2%. Next, Firer and McLeod (1999) deployed a similar study as previous authors in South Africa during 1925 to 1998. The study offered evidence that in 16 of the 74-year study sample period, equities produced a negative annual return, while bonds did so 15 times. Furthermore, Firer and McLeod reported the annual return (geometric mean) for equity as 13.65% with a standard deviation of 22.94%, and 6.69% for bonds, with a standard deviation of 6.47%. Siegel (2014) reported a compound annual real return between 3–4% for long- and short-term US treasury bonds during his study, and he also stressed the importance of understanding that stocks were far more reliable than any other asset in his study. The study completed by both Siegel and Firer and McLeod agree that stocks have far higher returns than treasury bills. Lastly, Dimson, Marsh, and Staunton (2000) documented annual returns for equities, long-term government bonds, and treasury bills in 16 countries for a 101-year period (1900–2000). They found empirical evidence that equites have been one of the best performing asset classes in 12 countries, and bonds have proved to be a disappointing investment over the 20th century. The authors stressed the importance of understanding that equities had the highest risk during the study.

2.1.2.2 Non-government bonds

Non-government bonds are typically fixed-income investments that represents a loan made by a financial institution or an investor to a borrower. The literature covers many studies regarding returns from corporate bonds. For instance, Ibbotson and Sinquefield (1976) reported that long-term corporate bonds returned 3.6% per year when compounded annually over the period 1926-1974, where long-term corporate bonds had positive returns in 39 of the 49 years and returns ranged from 18.4% to -8.1%. Moreover, Doeswijk, Lam, and Swinkels (2020) reported compounded average nominal return on 7.51% during their study about non-government bonds.

2.1.3 Returns on real estates

Real estate return studies have been conducted for a long period of time with various studies producing diverse outcomes. In addition to the fact that the studies use a range of data sets with varying periods, the return is estimated in a variety of ways. Shiller (2000) based his calculation of return on appreciation (Shiller, 1993), while the authors of "The Rate of Return on Everything, 1870–2015" included rental income (Jordà et al., 2019). Rental revenue is removed from certain research due to a lack of data and the difficulty of quantifying actual returns.[1]

Several studies have suggested that real estate investments outperform debt and other fixed-income assets, while others demonstrate that equities historically outperform real estate investments. Most of the existing literature reveals that real estate investments yield a higher return per unit of risk than conventional equities or bonds when risk is factored into the equation (Cohn, Robichek, & Pringle, 1972; Siegel & Ibbotson, 1984; McMahan, 1981; Brachman, 1981, as cited in Norman, Sirmans, & Benjamin, 1995).

Numerous other studies (Cohn, Robichek, & Pringle, 1972; Siegel & Ibbotson, 1984) have demonstrated that, while it has a lower average return than equites, residential real estate outperforms equities, bonds, and other investments on a risk-adjusted basis. Ibbotson and Siegel (1984) examined real estate returns using the Consumer Price Index data (for residential property), USDA data (for farmland), Building Cost Index data (for commercial real estate from 1960 to 1974), and CREF data (for commercial real estate from 1975 to 1982). Between 1960 and 1982, they discovered an annual nominal return of 9.21%. Two additional studies (McMahan, 1981; Brachman, 1981, as cited in Norman, Sirmans, & Benjamin, 1995) have revealed that real estate outperforms other investments in terms of absolute average return and risk-adjusted return. In contrast, Fogler (1984 as cited in Norman, Sirmans, & Benjamin, 1995)

[1] Generalizing a rental income for a country where the majority own a property may be misleading. Consequently, rental homes are frequently located in central districts with high rental revenue. This implies that rental indices are typically weighted in favor of the highest rental revenue in core regions, and, when all residences are adjusted appropriately, the overall return can be overstated. In addition, maintenance and repair expenditures are usually eliminated from the calculation, as those vary across homes and are difficult to ascertain. Similarly, few studies incorporate tax benefits into their overall return calculation

illustrated that common stocks generated higher returns than real estate between 1915 and 1978 in absolute and risk-adjusted terms. Additionally, Fogler noted that treasury bonds outperform real estate on a risk-adjusted basis. Furthermore, newly constructed residential real estate has been shown to generate higher returns than other investments (Coyne, 1993, as cited in Norman, Sirmans, & Benjamin, 1995).

According to a 2015 analysis by NBIM, the historical return on real estate investments varies significantly among countries. Between 2000 and 2013, the average annual return was generally between 7% and 9% in nominal terms, and 5% to 7% in real terms. In addition, analyses have indicated that the return has been diminishing in recent years. Furthermore, according to NBIM, although real estate tends to be closer to government bonds, average real estate returns and volatility can be placed between government bonds and stocks (NBIM, 2015).

Numerous studies have examined real estate's diversification effect and concluded that integrating real estate in an ideal mixed-asset portfolio may be prudent. Hartzell, Hekman, and Miles (1986) discovered that while integrating real estate has diversification effects, there is debate about whether the effect is justified when other expenses such as upkeep and effort are considered (Hartzell, Hekman, & Miles, 1987). Several other studies have indicated that including real estate reduces portfolio risk, but the percentage of the portfolio that should be real estate is disputed. According to Webb, Curico, and Rubens (1988), real estate should account for around two-thirds of the portfolio (Webb , Miles, & Guilkey , 1992). On the other hand, Irwin and Landa (1987) determined that approximately 20% of the portfolio should comprise real estate (Irwin & Landa, 1987). Fogler (1984 as cited in NBIM, 2015) made a similar statement, recommending a minimum portfolio investment of 20% in real estate, while Ennis and Burik (1991) concluded that real estate should account for between 10% and 15% of the portfolio (Ennis & Burik, 1991).

2.1.4 Returns on commodities

Levine, Ooi, Richardson, and Sasseville (2018) found that a portfolio with several asset classes could benefit from diversification when adding commodities from an asset-allocation perspective. The main reason why the authors claimed commodities add value to a portfolio is because of the behavior of the assets in relation to each other. Commodities, stocks, and bonds have responded differently to economic shocks over the 139-year period that was investigated. For instance, whereas commodity returns are stronger during up inflation periods, bond and stock returns are lower during those periods, according to the study. (Doeswijk, Lam, & Swinkels, Historical Returns of the Market Portfolio, 2020) reports compounded average nominal return on 6.03% for a set of combined commodities during their study, while (Siegel J. J., 2021) reported a 0.7% annualized real return for gold commodities during his study.

2.1.5 Returns on cryptocurrencies

Bitcoin and other cryptocurrencies have surged in popularity over the last few years by becoming increasingly popular among individuals and institutions. Global attention has been drawn to the average person when they nearly became a multimillionaire in a matter of years or a matter of weeks. Cryptocurrencies, including the world's largest cryptocurrency, bitcoin, were created in response to other currencies, but whether cryptocurrency is a currency itself is debatable. According to the European Central Bank, cryptocurrency cannot be called a currency (European Central Bank, 2021)**.** Nonetheless, there are businesses that allow clients to pay for their purchases with cryptocurrency. For example, Tesla accepted bitcoin as a payment option for a brief period before removing it (Shead, 2021), which illustrates the fact that bitcoin as a currency faces a variety of difficulties. However, whether it is a currency, the financial world views cryptocurrency as a speculative investment, and as such, bitcoin can be regarded an asset class (European Central Bank, 2021). Professional investors as well as the public have shown a tremendous interest in cryptocurrency assets, resulting in a strong demand for these assets. About 17% of Europeans are invested in cryptocurrencies (Hurst, 2022).

Nigro & Botte (2021) reported an annual return of approximately 110% from 2013 to 2021. Since cryptocurrency and bitcoin have not existed for as long as other asset classes, it is not as thoroughly documented whether they should be included in a diversified portfolio. Briére, Oosterlinck, and Szafarz (2015) discovered that integrating bitcoin into one's portfolio improves the risk-reward tradeoff. This is due to the high average return and volatility of the asset, as well as the asset's extraordinarily low correlation with other assets. Eisl, Gasser, and Weinmayer (2015) found comparable conclusions to Briére in their study "*Caveat Emptor: Does Bitcoin Improve Portfolio Diversification?,*" but they did not employ the Markowitz mean-variance framework as Briére did. Instead, they employed conditional value-at-risk (CVaR) because they believed it is more appropriate for returns that are not normally distributed (Eisl, Gasser, & Weinmayer, 2015). Oosterlinck and Szafarz (2015) and Weinmayer (2015) have also concluded that cryptocurrency should be included in an investor's portfolio since it improves the risk-reward tradeoff.

2.2 Risk factors

Every investment is accompanied by a distinct set of risks and returns. According to Holton (2004), risk is defined as an unexpected shift in returns or an unpredictability of returns. This risk is generally impacted by elements beyond a company's or asset's control (Kaplan and Mikes, 2012). The core principle behind risk and return is that an investor is ready to tolerate a greater degree of risk in exchange for a greater expected level of return (Pigou, 2009).

This risk may be split into two distinct categories: systematic and unsystematic. The systematic risk is the type of risk that companies and investors are most concerned about since it is impossible to avoid or diversify away from this form of risk; rather, it must be strategized and managed in the appropriate manner. Systematic risks are risks that have the potential to influence an entire economic market or a significant portion of the market. The term "market risk" is frequently used to refer to the systematic risk, and it is commonly known as undiversifiable risk (Markowitz, 1952).

Systematic risk refers to variables such as political risk and macroeconomic risk; both of which have an impact on the overall performance of the market. Other forms of systematic risk include country risk, interest rate risk, inflation risk, currency risk, liquidity risk, and geopolitical risk (Chen J. , 2022). The extent to which systematic risk factors affect specific companies or asset classes is largely determined by their reliance on the economic environment as well as their reliance on individual factors.

Unsystematic risk is a risk that is specific to a single firm or sector and, therefore, cannot be accounted for using traditional risk management methods. Since unsystematic risk only applies to one company or type of business, it is often called specific risk. Unsystematic risk can be mitigated within the framework of an investment portfolio by diversifying one's holdings in several asset classes or securities. Business risks, financial risks, strategic risks, and legal and regulatory risks are all examples of unsystematic risks.

There are a variety of risk metrics, and each of which provides a distinct method for assessing the risk associated with potential investments. Lintner (1965) and Sharpe (1964) calculated the risk of an asset based on its covariance with the return of the stock market. This correlation is referred to as the market's beta (Mangram, 2013; Markowitz H. M., 1959). The value of an individual security's anticipated return is calculated by adding the risk-free rate to the value of the market beta multiplied by the risk premium. This simple equation determines the expected return of the individual security and measures systematic risk. Accurate beta forecasts can help the investor to minimize unsystematic risks (Lawrence & Jules, June 1985).

Standard deviation, which measures the whole risk of an investment, is another metric for monitoring investment risk levels (Marshall, 2022). The standard deviation quantifies a dataset's dispersion compared to its mean. Doeswijk et al. (2020) examined the worldwide multi-asset market from 1960 to 2017. The authors found that the standard deviation for commodities is the highest at 24.9%, followed by real estate at 19.3%, stocks at 17.3%, non-government bonds at 8.4%, and government bonds at 7.3%. In this case, the value of real estate is based on residential and commercial real estate, but commercial real estate is in overweight. Jordà et al. (2019), on the other hand, examined housing solely and found a standard deviation of 10.6%, which is almost half of the standard deviation of real estate observed in the research by Doeswijk et al. (2020). According to Humphery-Jenner (2021), bitcoin has a standard deviation of 56%, which is much greater than the standard deviations found for any of the other asset classes examined in the research.

Another metric is the Sharpe ratio, which is a measure of the relative risk-return tradeoff (Fernando, 2022).[2] Doeswijk et al. (2020) found that the Sharpe ratio is highest for stocks and real estate, which are both at 0.37. The Sharpe ratio for non-government bonds, government bonds, and commodities is 0.36, 0.28, and 0.13, respectively.

We see from the literature that the different asset classes have different risks. In the following paragraphs, we introduce several studies of different asset classes and the risks that are pertinent to each of those asset classes.

2.2.1 Equities

Hughes et al. (1975) evaluated 46 multinational corporations and up to 50 national corporations throughout 1970–1973 and concluded that those who operate beyond national borders are exposed to less systematic risk. It has been determined that multinational corporations have a reduced level of systemic risk because the market views such corporations as being geographically diversified. A corporation becomes less reliant on the macroeconomic conditions that are prevalent in the company's home country. Given that a corporation is not completely dependent on the development of its own market, this may appear to be a realistic

[2] Sharpe ratio is calculated by dividing the mean returns by the standard deviation of those returns.

assumption. Michel and Shaked (1986) verified the results and concluded that systematic risk is less prevalent in multinational corporations.

Conversely, Reeb et al. (1998) presented findings that are contradictory: the authors found that the relationship between multinational companies and systematic risk is opposite (i.e., an increased degree of internationalization leads to a higher systematic risk) in a study conducted between 1987 and 1996. The authors argued that the costs and hazards involved with conducting business on a global scale are disproportionately high in comparison to the potential advantages of increasing international diversification. By extension, Kwok and Reeb (2000) demonstrated in a survey of 32 nations between 1992 and 1996 that there is a positive association between internationalization and systematic risk in American firms, but this relationship became inverse if the original firm was based in developing markets. It is plausible that corporations operating in developed markets incur more systemic risk when entering uncertain areas and vice versa. Madura (2008) had a study similar to Kwok and Reeb. Madura concludes that international activities lead to several additional factors that one must address, which leads to greater complexity and unpredictability. Reeb et al. (1998) found that the systematic risk of international operation is higher due to the increased standard deviation in the cash flows of the companies.

Johanson and Valhne (2009) found that companies have a better chance of experiencing lower levels of systematic risk if a firm has more expertise and has been operating in the same environment for a longer period. This makes sense, as entering new markets demands a large understanding and quantity of data. Simultaneously, it is legitimate for an investor to have greater trust in a firm that has demonstrated its performance through time.

Several studies have found that there can be an inverse relationship between the size of the firm and the level of systematic risk (Beaver, Kettler, and Scholes, 1970; Kwok and Reeb, 2000). Olibe et al. (2008) found that a larger organization produces more information and has reduced transaction costs and estimation risks. In addition, there are benefits associated with a company's scale, including the fact that it makes the company more stable, less reliant on outside factors, and less susceptible to payment delays (Harris and Raviv, 1991). Large organizations frequently have easier access to finance, which may lead to an increase in debt, which can lead to an increase in risk. In the long term, this can influence the risk that the company faces. Modigliani and Miller (1958) found that financial structure and debt levels are frequently related with a greater degree of systemic risk.[3] Despite this, there is research that provides contradictory results. Lee and Kwok (1988) demonstrated that a high level of long-term debt is not only related with a higher risk of illiquidity and insolvency but also that it can have a positive effect by reflecting a stock's long-term financial strategy. Moreover, a large amount of long-term debt lent from banks is frequently correlated with greater confidence from credit institutions. Between the years 1966 and 1999, Stambaugh and Pástor (2003) discovered that equities with a high sensitivity to liquidity generated an average return that was higher than the return on stocks with low sensitivity to liquidity.

Chan and Wei (1996) determined that political news enhances the volatility of both blue-chip and red-chip stocks in Hong Kong. A change in administration, legislative bodies, foreign officials, or military power may be the source of instability that has a detrimental impact on investment returns. Mbah and Wasum (2022) found that the Russia–Ukraine crisis has led to negative effects on household consumption, stock fluctuations, supply chain, investments, and economic growth.

Regardless of the scale of their operations, and whether they are local, national, or global, most businesses are impacted by shifts in the macroeconomic environment. Chen, Ross, and Roll (1986) discovered that macroeconomic factors account for most of the variance in stock returns. Other research examined specific economic factors and discovered that the federal funds rates and default spread can be utilized to forecast short- and long-term returns (Patelis, 2012). Hess (2003), on the other hand, discovered in a Swiss study that gross domestic product (GDP) can explain share prices, particularly in cyclical sectors. Sing, Mehta, and Varsha (2011) discovered that, while unemployment is insignificant in explaining the stock returns, GDP may explain some of the stock returns. Boyd, Jagannathan, and Hu (2005) concluded that, while the announcement of the unemployment rate had an influence on stock prices, the announcement of the GDP lacked significance.

Lynge and Zumwalt (1980) argued that changes in interest rates can explain the performance of commercial banks. Park and Choi (2011) corroborated Lynge's findings, revealing that interest rates may also account for the success of insurance stocks. Further, Adrangi, Chatrath, and Raffiee (1999) discovered that, in industrialized economies like Korea and Mexico, inflation has a negative relationship with stock returns. Interestingly, Kolluri and Wahab (2008)

[3] Short-term debt is seen as riskier than long-term debt and must thus be accounted for differently.

found that inflation and equity returns have a negative relationship during periods of low inflation, but a positive relationship during periods of high inflation.

Certain asset classes have been included as a macroeconomic variable in some recent studies. Buyuksalvarci (2010) examined gold prices as a macroeconomic variable and discovered that they did not account for a significant portion of stock returns in Turkey (Buyuksalvarci, 2010); however, the author discovered that the price of oil could account for some of the observed performance. Similar to Buyuksalvarci, Fedorova and Pankratov (2010) attempted to explain Russian stock returns by using the Brent oil price as a macroeconomic component and discovered that the price of Brent oil is the macroeconomic factor with the largest impact on stock returns in Russia (Fedorova & Pankratov, 2010). These studies illustrate some of the risk associated with commodities.

"Commodity price risk" refers to the possibility that a change in the pricing of commodities would have a detrimental effect on a particular industry or business. Carter, Rogers, Simkins, and Treanorc (2017) concluded that commodity price risk can impact stock returns. Firms that sell commodities benefit from rising commodity prices, but decreasing commodity prices are damaging to these businesses. The opposite impact can be seen by companies that use commodities as inputs in their production processes. Despite this, companies that are not directly involved with commodities are subject to the risks connected with commodities since there are typically ripple effects. According to Mbah and Wasum (2022), the rapid rise in the price of oil, natural gas, and food during the Russia–Ukraine crisis is contributing to an overall increase in inflation. Liadze, Macchiarelli, Mortimer-Lee, and Juanino (2022) estimated that the conflict added 3% to global inflation in 2022. Inflationary risk is the probability that an investment's returns may be negatively affected by a decline in purchasing power caused by inflation. Given that rising interest rates is conventionally combat inflation, a company's borrowing costs might potentially rise, increasing the financial risk further.

When purchasing or selling products and services, exchange rates can have a significant impact on major exporting or importing businesses. Dumas and Solnik (1995) investigated the world's four main markets for equities and found the presence of exchange risk premia. This risk, called exchange rate risk, is inherent to all foreign financial transactions, as changes in the relative values of the currencies involved can cause the value of an investment to decline.

2.2.2 Fixed-income securities

Hull, Predescu, and White (2012) learned that if interest rates increase (decrease), the present value of a bond's cash flows decreases (increases), and a negative (positive) return is achieved. If the interest rate increases, the bond's price will decrease proportionally. If an investor sell the bond on the secondary market, it will trade at a discount to reflect the reduced rate of return the buyer will receive; therefore, interest rates and bond prices are considered to have an inverse relationship, and the interest rate is viewed as a risk for bonds.

According to Kang and Pflueger (2015), the rates on corporate bonds reflect concerns of debt deflation. The authors did research on a panel of credit spread indexes from six developed countries, and they found that if inflation volatility or the connection between inflation and stocks increases by one standard deviation, credit spreads increase by 14 basis points. Fixed bonds, which have a predetermined interest rate, are the most susceptible to inflation risk.

Hsu, Saa-Requejo, and Santa-Clara (2004) discovered that the default risk may be used to price corporate bonds.[4] In the event that the bond issuer defaults, in addition to any accrued but unpaid interest, the investor runs the risk of losing some or all the principal amount invested. Bonds are given a rating that is reflective of the likelihood of them going into default: the lower the rating, the greater the probability of the issuer defaulting on their obligations.[5] This entails not only a greater risk but also a higher return on investment.

2.2.3 Real estate

When compared to traditional assets such as stocks and bonds, real estate investments stand apart due to their long-term investment horizons, lower levels of volatility, and distinctive risk and return structures (Sebastian and Schatz, 2009).

Numerous studies have being conducted to determine the relationship between the macroeconomic environment and real estate, and most of these studies concluded that real estate acts as a hedge against inflation. Within this framework, Gyourko and Linneman (1988) investigated the impact that inflation has on real estate investment trusts (REITs)[6] as well as direct investments in commercial real estate. They concluded that commercial property investments have a predominantly positive correlation with inflation, while, similar to bonds, REITs have an inverse relationship with inflation. According to Quan and Titman (1999), real

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[4] Default risk is the likelihood that a bond's issuer may declare bankruptcy and be unable to fulfill its obligations.
[5] Bonds with a low credit rating are frequently referred to as “junk bonds.”
[6] A real estate investment trust (REIT) is a type of organization that owns, manages, or funds real estate that generates income for investors.

estate is favorably influenced by both inflation and GDP. Similarly, Chen and Tzang (2020) found that both interest rates and expected inflation can explain the performance of real estate.

Sing (2004) investigated the impact of systematic market risk and common risk variables by employing multi-factor asset pricing models (MAP) to explain the heterogeneity in excess returns from direct and indirect real estate investments.[7] The research demonstrates that macroeconomic risk indicators are valued differently in indirect and direct real estate markets.

According to the findings of Sebastian and Schatz (2009), the real estate market in the US is more strongly tied to the macroeconomic environment than the real estate market in the UK. Additionally, the US real estate market is mostly driven by the country's GDP and interest rates. Brooks and Tsolacos (1999) argued that the unemployment rate can explain returns in the UK, particularly in sectors such as real estate.

2.2.4 Commodities

Investing in commodities is not without risk. Political, seasonal, technological, and financial circumstances of the market are all potential factors that can impact the value of commodities. The commodities market is volatile because of the nature of supply and demand, which is influenced by several unknown variables. For many commodities, storage is either not possible at all or excessively expensive. If storage is possible, producers determine that it is more cost effective to leave the item in the ground rather than store it above ground. Carpantier and Dufays (2012) discovered that volatility in commodity prices is higher when inventories are low. In contrast, the availability of storage and high inventories may function as a dampener on price volatility since it presents an extra lever with which to balance supply and demand.

Li (2018) found that leverage and speculation have a role in exacerbating the already volatile character of commodities. Commodities are often traded using futures contracts, where traders frequently utilize large leverage ratios. This, in turn, encourages traders to become nervous and respond accordingly when there is news that prices may significantly increase or decrease because of certain events.

Fugazza (2020) noticed that the pandemic affected the global supply chain of commodities, supply and demand, and labor forces. Liadze et al. (2022) concluded that the conflict in Russia–Ukraine has affected the prices for commodities, as it leads to supply chain issues. Rumors and

[7] A direct investment is when an investor who invests in and administers real estate without the use of an intermediary. As a result, direct investments are typically unlisted. If an investor purchases a share of the underlying real estate through an intermediary, this is referred to as an indirect investment.

speculation about a potential lack of oil and gas intensified the volatility in commodities prices further.

Prices may fluctuate dramatically daily depending on events and large suppliers. Loutia, Mellios, and Andriosopoulos (2016) discovered that Organization of the Petroleum Exporting Countries (OPEC), which may have the ability to restrict the supply of oil, is influencing the price. The policies of various governments present another risk. In 2018, President Trump placed taxes on imports. The purpose of the tariffs was to raise the price of aluminum and steel in the US relative to the prices of other nations. Amiti, Redding, and Weinstein (2019) discovered that the results of the tariffs were a shift in the supply chain of commodities and changes in demand and supply, which were ultimately reflected in the pricing of commodities.

Tsiakas and Zhang (2021) found that there is a correlation between exchange risk and commodities returns, where the value of the buyer's currency may drop relative to the value of the seller's currency, resulting in higher pricing for the buyer. Similarly, whenever the dollar depreciates relative to key currencies, an oil price rise is inevitable.

The pricing of commodities is strongly influenced by technological developments. It is possible for advancements in technology to result in a decline in the price of a commodity. Aluminum, for instance, was considered a precious metal until the development of new techniques that could be used to isolate it. Consequently, aluminum’s value as well as its market price declined (Ashkenazi, 2019). Jabeur, Khalfaoui, and Arfi (2021) found that increased Environmental, Social and Governance (ESG) awareness could lead to lower crude oil prices.

Gold has historically been a commodity viewed as a store of value, as it tends to climb or maintain its value when financial markets are experiencing difficulties. Dyhrberg (2016) examined whether bitcoin, which is known as "digital gold," can be a potential competitor to gold. The author found that bitcoin shares some of gold's hedging capabilities. Kyriazis (2020) thought that bitcoin is a useful hedge against oil and stock market indexes, but did not view bitcoin as a risk to gold since it correlates more with stock market indexes than gold does.

2.2.5 Cryptocurrencies

According to Grant and Hogan (2015), the greatest dangers associated with investing in bitcoin are the high price volatility. In addition, future laws and regulation of bitcoin pose a substantial threat. Furthermore, there have been instances of theft and loss of bitcoin as a result of hacks against cryptocurrency exchanges. Because of this, third party services become a potential risk.

2.3 Summary from the literature review

From the literature presented in this chapter, we find empirical evidence that listed equites have performed better than other asset classes over time; however, there are some existing literatures that claims real estate is a better asset class regarding return and risk when compared to stocks. Government bonds document stable returns with low standard deviations. Commodities seem to add value to portfolios because they tend to behave differently during economic shocks. Unlisted equities have been performing better than listed equities in some studies, but, in other studies, listed equities seem to be a better option. Regarding risk, the literature suggests commodities have the highest risk, followed by stocks, real estate, non-government bonds, and government bonds, respectively. When adjusted for risk, stocks, real estate, and non-government bonds have delivered better on a risk-adjusted basis, followed by government bonds and commodities. According to the research that has been done, the risks for most asset classes is largely affected by the macroeconomic environment.

The presented literature has given us useful insight into the performance of several assets and how the assets can be combined in a portfolio. We use the results from the literature to answer following research questions:

> *How does risk and return on assets differ among the Nordic countries? Which Nordic country offers the most ideal option for the minimum variance portfolio?*

Our purpose is to investigate whether the findings from the literature may be applied to the markets in the Nordic countries. Our contribution to existing literature will be focusing on a Nordic point of view rather than an international point of view.

3. Methodology

The paper employs a variety of approaches to examine the dynamics and performance of various asset investments in the Nordic area as well as their relationship with the selected macroeconomics variables. Following Ruppert and Matteson (2015), performance was first determined by computing the log returns with a few exceptions.[8] These values were then used in a mean return analysis calculating the arithmetic average return, geometric average return, and Sharpe ratio to provide a balanced perspective of the risk-adjusted return.[9]

Moreover, we used a correlation analysis and the CAPM to determine how asset classes move in relation to the market and other asset classes. As a result, hedging and diversification strategies may be implemented effectively. The multi-factor approach was also used to determine whether the different asset classes were driven by or would be explained by the macroeconomic environment. Finally, we analyze several portfolio combinations based on the information we have gathered. Detailed explanations of each approach are provided in the following subsections.

3.1 Risk and return

3.1.1 Nominal return

Nominal return refers to the achieved return measured in current prices, that is, without adjustment for inflation or other costs such as tax, brokerage, or other costs associated with the investment (CFI, 2022).[10] As a result, the nominal return, in most cases, is higher than the real return, except during periods of deflation. The method omits essential external factors, presenting an inaccurate view of the actual return and, in most cases, overestimates the performance. The advantage is investors can easily compare the portfolio's return over time, thus seeing how well they manage their portfolio.

The formula for the nominal rate of return is provided below:

$$R_n = \frac{P_c - P_o}{P_o} \qquad (3.1.1)^{11}$$

We used nominal return, as we worked with long time series data and several asset classes (Ruppert & Matteson, 2015). We wanted to look at historical performance; therefore, the

[8] Log return represents our nominal return. A more detailed explanation of the return computation may be found in Chapter 4.2.6.
[9] Calculated in both nominal and real return.
[10] Following Damodaran's (2022) method.
[11] Where R_n = *Nominal rate of return,* P_c = *Current market value,* P_o = *Original investment value*

nominal return provides us with a foundation for comparing different asset classes where inflation has varied throughout history.

3.1.2 Real return

Real return is the nominal return adjusted for inflation (Hargrave, 2022).[12] The real return expresses how much of the nominal return is a real return, which provides a more accurate representation of a change in purchasing power. Although the real return provides a more accurate representation of the investment performance than the nominal return, it excludes other expenditures, such as taxes and investing fees, which are not entirely accurate.

The formula for the real rate of return is given below:

$$Real\ rate\ of\ return = \left(\frac{1+r_n}{1+r_i}\right) - 1 \qquad (3.1.2)$$[13]

We analyzed the real and nominal returns, and by adjusting for inflation, we derived a more accurate representation of investment success.

3.1.3 Arithmetic average

The arithmetic average is the sum of the numbers divided by matching periods (Chen J. , 2021).[14] The arithmetic average is primarily used to exclude that previous numbers affect the next. It may be appropriate to use this technique to see how different assets perform in certain periods. Conversely, it can present a deceptive representation of the actual return over time, as it does not consider the compounding effect. In periods of extreme volatility, the method is particularly inappropriate if an investor wants to gain a more comprehensive representation of the actual return achieved.

The formula for arithmetic average is as follows:

$$Arithmetic\ average = \sum_{t=1}^{n} \frac{r_t}{n} \qquad (3.1.3)$$[15]

3.1.4 Geometric average

In the geometric average, the selected data values are first multiplied, then the product is taken at the root of the number of periods to determine the average value that expresses the central tendency of the dataset (Gallant, 2022).[16] The advantages of employing geometric average are

[12] Following Damodaran’s (2022) method.
[13] Where r_n = *Nominal rate*, r_i = *Inflation rate*
[14] Following Damodaran’s (2022) method.
[15] *Where* r_t = *return at time t, n = number of periods*
[16] Following Damodaran’s (2022) method.

many: for instance, the geometric average considers the return's order and the compounding effect. In finance, the term "compounding" refers to the process by which an asset's earnings, whether in the form of capital gains or interest, are reinvested to generate additional earnings. This implies that the approach provides a more accurate representation of the actual return over time than the arithmetic return method.

The formula for the geometric average is as follows:

$$Geometric\ average = \left(\prod_{t=1}^{n} r_t \right)^{\frac{1}{n}} \qquad (3.1.4)^{17}$$

3.1.5 Sharpe ratio

The Sharpe ratio was invented by Nobel Laureate William Sharpe and is used to risk adjust performance (Sharpe, 1966).[18] The method quantifies the size of the return on an asset or portfolio in relation to the risk in the same period. In the financial world, risk is synonymous with the term volatility, which refers to the price fluctuations of an asset or portfolio. Consequently, the Sharpe ratio can help determine if a portfolio's excess returns are the consequence of prudent investing selections or excessive risk. While a portfolio or fund may earn a greater rate of return than others, it is only a successful investment if the higher rate of return is not accompanied by an excessive amount of additional risk. The Sharpe ratio is estimated by calculating the return on a particular asset or portfolio from the risk-free rate and dividing it by the portfolio's standard deviation.

A high Sharpe value is desirable, as a higher value indicates superior risk-adjusted performance. A Sharpe ratio between 0 and 1 implies that the rate of return is higher than the risk-free rate and that the risk is, in principle, greater than the excess return. If the value is greater than one, the rate of return is greater than the risk-free rate and risk of excess risk. A Sharpe ratio on its own does not offer much information; one should compare a portfolio's Sharpe ratio to other portfolios to attain a better understanding of the risk-adjusted performance.

The formula for the Sharpe ratio is as follows:

$$Sharpe\ ratio = \frac{r_p - r_f}{\sigma_p} \qquad (3.1.5)^{19}$$

The advantages of Sharpe ratio are that it is simple to compute and allows investors to compare various types of investments. The disadvantages include its dependency on a normal

[17] Where r_t = *return at time t, n = number of periods*

[18] Following Jordà et al.'s (2019) method

[19] *Where* r_p *= return portfolio,* r_f *= risk-free rate,* σ_p *= standard deviation of portfolio*

distribution of standard deviations, and when the distribution is skewed, the Sharpe ratio can be misleading. The formula itself establishes the groundwork for more flaws. A negative excess return with a high degree of volatility reduces the Sharpe ratio's negative value (larger denominator). This demonstrates that performance has exceeded expectations. Similarly, small negative excess returns may be penalized if the volatility is regarded as high, increasing the negative value further. Given different degrees of risk, we used the Sharpe ratio to compare the performance of the different asset classes.

3.2 Correlation analysis

Correlation coefficients between variables can be used as a statistical tool for several purposes.[20] Correlation coefficients are useful for understanding the linear relationship between two different variables (*X* and *Y*). The estimation of the correlations is given through the following formula (Stock & Watson, 2015):

$$Correlation = corr\ (X, Y) = \frac{cov\ (X,Y)}{\sqrt{var\ (X)\ var\ (Y)}} = \frac{\sigma_{XY}}{\sigma_X \sigma_Y} \qquad (3.2)^{21}$$

The correlation is typically between -1 and 1 (Stock & Watson, 2015), where -1.0 indicates no correlation and 1.0 indicates a strong correlation between the variables. For our research purpose, it was of interest to see how the different asset classes behave in relation to each other in general and during special economic events. The correlation analysis was also of interest when applying the multi-factor model for the Nordic countries to investigate the differences in the Nordic asset classes (stocks, bonds, and real estate) within the countries. Further, this was of interest when constructing the minimum variance portfolio because such a portfolio would benefit if the assets in the portfolio tend to fluctuate differently in relation to each other.

3.3 Regression analysis

3.3.1 Capital asset pricing model (CAPM)

In 1964, William Sharpe created the CAPM, which addresses the relationship between expected return and systematic risk (Sharpe, 1964).[23] The CAPM is commonly used to determine the risk and expected return on investments, and its fundamental premise is that investors should be compensated for higher risk. The CAPM demonstrates that the expected return on any asset is equal to the risk-free rate plus the beta of the asset multiplied by the market risk premium.

[20] Following Doeswijk et al.'s (2020) method.
[21] *Where σ_{XY} = Covariance between X and Y, σ_X = Standard deviation of X, σ_Y = Standard deviation of Y*
[23] Following Ibbotson's (1976) method.

The formula for the CAPM is as follows:

$$E(r_i) = r_f + \beta_i[E(r_m) - r_f] \qquad (3.3.1a)^{24}$$

The standard approach for measuring asset beta (β) is through regression of changes in the price of an asset against changes in a specific benchmark, or, more precisely, the relationship between the covariance of the market *(m)* and the asset *(i)* and the market volatility (Damodaran, 2012).

The formula for beta is as follows:

$$\beta = \frac{COV_{m,i}}{Var_m} \qquad (3.3.1b)$$

A beta of one indicates complete correlation and movement in lockstep with the market. On the other hand, a beta of -1 indicates that it is negatively correlated with the market, implying that it moves in the opposite direction of the market. Above one implies greater volatility than the market, which represents increased risk as well as the potential for higher returns (Bodie et al., 2014.)

The market portfolio (m) consists of the effective portfolio of all available risky assets in the investment universe. In the market portfolio, the weight of each asset is set equal to the market value in relation to the total market value of all assets (Bodie et al., 2014). The market risk premium is found by subtracting the risk-free rate from the market return $[E(r_m) - r_f]$.

We utilized CAPM to calculate alpha (α) and beta (*β)*, which are two important measurements for evaluating an asset's or portfolio's performance. Alpha provides us with a perspective on how much the assets have returned in relation to the market index. [25] Beta presents us an indication of its relative risk.

3.2.2 Multi-factor model

When comparing multi-factor models to the CAPM, we saw that multi-factor models can include a greater number of explanatory factors than the CAPM to measure expected returns.[26] The three-factor model by Fama and French is an example of a similar model (Brealy, Myers, & Allen, 2020). A more suitable multi-factor model for our practical purposes is the arbitrage pricing model created by Stephen Ross. The model assumes that the return on each asset

[24] Where: *$E(r_i)$ = Expected return asset, r_f = Risk free rate, β_i = Asset beta, $E(r_m)$ = Expected return on marked*

[25] Alpha (α), which is a measure of excess return, uses the CAPM formula: *Excess return = RF+ β(MR-RF) -TR.* Seeing excess returns as the difference in return over a risk-free interest rate is another measure of excess return (Chen, 2021).

[26] Following Benaković and Posedel’s (2010) method.

depends partly on pervasive macroeconomic influences or "factors" and partly on "noise" (Brealy, Myers, & Allen, 2020).

The return on each asset is assumed to obey the following simple relationship:

$$Return = \alpha + b_1(r_{factor\ 1}) + b_2(r_{factor\ 2}) + b_3(r_{factor\ 3}) + \cdots + noise \quad (3.2.2a)$$

This means that, in a multi-factor model, we have the opportunity to add macroeconomic variables such as GDP, unemployment rate, or interest rate to measure the sensitivity of the return on the assets being investigated. In addition, we can measure how sensitive different assets are in relation to the macroeconomic variables included in a model. Our purpose for introducing this model was to analyze how the excess return (α) and the assets relation (*β)* change in macroeconomic factors and how these affect return on stocks, bonds, and real estate in the Nordic countries. Further, we wanted to investigate in which direction the return on the different assets fluctuates if macroeconomic variables change. The econometric model was given by this econometric equation (Stock & Watson, 2015):

$$Y_{i,t} = \beta_0 + \beta_{i,1}X_{1,t} + \beta_{i,2}X_{2,t} + \cdots \beta_{i,k}X_{k,t} + u_i \quad (3.2.2b)$$[27]

3.4 Portfolio construction

3.4.1 Portfolio return

A portfolio contains two or several assets; therefore, the performance of the portfolio regarding return, variance, and standard deviation depend on the weights each asset has in the portfolio. The idea behind a portfolio with several assets is to achieve diversification (Elton, Gruber, Brown, & Goetzmann, 2014). By diversification one can possibly eliminate *specific risk* (Brealy, Myers, & Allen, 2020). The specific risk is related to the specific characteristics of the asset. There is also some risk that one cannot avoid, and that is the *market risk*. This was relevant when we investigated several assets over time and constructed the efficient frontier and the minimum variance portfolio. It was also important to be familiar with the portfolio concept to understand how a portfolio with two or more assets works. The greatest payoff one could achieve when constructing a portfolio with several assets is to hold assets that are negatively correlated in the portfolio without sacrificing return (Makowitz, 1952).

[27] Where *$Y_{i,t}$= return on asset i, β_0 = expected value of Y when all the Xs equal to 0 (intercept), u_i = the error term, β_i =beta coefficient of asset, X_n= macroeconomic factor*

The expected return of a two-asset portfolio was provided by this formula (Brealy, Myers, & Allen, 2020):

$$Ep(r) = \left(X_1 \times e(r_i)\right) + \left(X_2 \times e(r_i)\right) \qquad (3.4.1a)^{28}$$

The relationship between two assets is called covariance. Covariance is a measure of the degree to which the two stocks covary (Brealy, Myers, & Allen, 2020). This is expressed as the product of the correlation coefficient, ρ_{12}, and the two standard deviations:

$$Covariance\ between\ asset\ 1\ and\ 2 = \sigma_{12} = \rho_{12}\,\sigma_1\sigma_2 \qquad (3.4.1b)$$

The portfolio variance was provided by this formula (Brealy, Myers, & Allen, 2020):

$$Portfolio\ variance = x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2(x_1x_2\,\rho_{12}\,\sigma_1\,\sigma_2) \qquad (3.4.1c)^{29}$$

The standard deviation of a portfolio is the square root of the portfolio variance. The standard deviation was provided by this formula:

$$Standard\ deviation\ of\ potfolio = \sqrt{x_1^2\sigma_1^2 + x_2^2\sigma_2^2 + 2(x_1x_2\,\rho_{12}\,\sigma_1\,\sigma_2)} \qquad (3.4.1d)$$

Therefore, the variance and standard deviation of a portfolio can be seen as the measure of the risk in a portfolio consisting of several assets with different behavior patterns. Standard deviation and variance are of interest not only when measuring the risk in each asset but also when constructing the optimal portfolio with a given level of risk or lowest possible risk.

3.4.2 Efficient portfolios

Portfolios that provide the largest possible expected return for given levels of risk are called *efficient portfolios* (Makowitz, 1952). When constructing the efficient portfolio, it is necessary to make some assumptions about how investors behave. We assume the same as Harry Markowitz in his paper "Portfolio Selection" (Makowitz, 1952):

1. The only two parameters that affect an investor's decision are the expected return and the variance.
2. Investors are risk averse.
3. All investors seek to achieve the highest expected return at a given level of risk.

[28] $Where\ X_1 = proportion\ invested\ in\ asset\ 1,\ X_2 = proportion\ invested\ in\ asset\ 2, e(r_i) = return\ on\ weighted\ asset_i$

[29] $Where\, x_1, x_2 = porpotions\ invested\ in\ each\ asset,\ \sigma_1^2\sigma_2^2 = variance\ of\ the\ asset\ returns,\ \rho_{12}\,\sigma_1\sigma_2 = covariance\ of\ return\ on\ asset,\ \rho_{12} = correlation\ between\ returns\ on\ asset\ 1\ and\ 2$

4. All investors have the same expectations regarding the expected return, variance, and covariances for all risky assets.
5. All investors have a common one-period investment horizon.

A *feasible portfolio* is any portfolio an investor can create given the assets that are available in the investment universe. The return, standard deviation, and variance fluctuate when the portfolio weights are changed. In contrast, the *efficient portfolio* is one that provides the highest expected return on all feasible portfolios with the same risk. An efficient portfolio is also a mean-variance efficient portfolio (Makowitz, 1952).

This framework was useful when we constructed the efficient frontier with all the assets we have investigated. Further, we used this framework to create the minimum variance portfolio under the assumption that investors are risk averse. In addition, we constructed portfolios with restrictions where we tried to achieve the same return as other portfolios from the practical world (we set a reference index based on the return from a real portfolio).

4. Data

Our study was created by quarterly observations for each asset. We used quarterly observations in our sample for several reasons. We used quarterly data because it is more detailed than annual data. Quarterly data documents seasonal effects and trends better than annual data. Furthermore, during economic events quarterly data is more suitable when tracking return across several assets. The time horizon for each asset was significantly different. For instance, in Sweden, we had a stock market index from the first quarter of 1960, whereas we also had gold prices from the third quarter of 1968; however, every asset class has an end observation in the fourth quarter of 2021. For additional information on the assets, see the accompanying subchapters.

4.1 Sample

Based on previous literature, equities, real estate, and bonds compose most of the investment universe. Commodities are included since they comprise a large market, and cryptocurrency has been included due to its popularity in recent years. In addition, we included two European bond assets to see how they correlate and perform compared with the Nordic bonds. We wanted to emphasize that the focus of this study is on equities, real estate, and bonds in the Nordic region.

4.2 Asset classes

4.2.1 Equities

The Federal Reserve Bank of St. Louis (FRED) maintains statistics on equities for all Nordic nations in the form of an index, which was initially created by the Organization for Economic Cooperation and Development (OECD). The length of the time series, combined with the ability for comparability, caused us to choose this set of data.

The *total share price index* is calculated using common shares of companies that are traded on the country's domestic or foreign stock exchange, with the daily closing prices functioning as the basis for calculation. The index adjusts for changes in market capitalization by weighting different shares. This provides a fair representation of the stock markets in the countries we have chosen to analyze. The index excludes dividends, implying that an investor would have earned a higher rate of return if they reinvested their dividends. The database was extracted monthly but has been converted to quarterly for comparability purposes. We collected data on equities dating back to 1960 for Finland and Sweden, 1983 for Denmark, and 1986 for Norway.

4.2.2 Real estate

Commercial real estate, in principle, is an asset class that should be included in our study of various asset classes, as it accounts for a sizable share of investments in the Nordic region (Mordor Intelligence, 2021). When investing in commercial real estate, one factor to consider is whether to make a direct or indirect investment. In real estate, a direct investment is defined as an investor who invests in and administers real estate without the use of an intermediary. As a result, direct investments are typically unlisted. If the investor purchases a share of the underlying real estate (or a portfolio of real estate) through an intermediary, this is referred to as indirect investment. In our situation, finding sufficient data, both indirect and direct, on commercial real estate proved to be a challenge.

Global Property Research (GRP) compiles information on publicly traded real estate companies in several nations. According to GRP’s statistics, there were significant disparities in the number of publicly traded companies that were engaged in real estate in different nations, with Norway having a disproportionately small number compared to that of the other countries (Global property reseach, 2022). As a result, the outcomes would be influenced by the performance of a few companies rather than the sector's underlying performance. Consequently, we decided not to include GRP's figures on commercial real estate in our analysis.

Conversely, there are many private- and institutional investors who are exposed to direct investments in commercial real estate in the Nordic countries (Newsec, 2020). We found that the data on direct real estate investments is scarce. Morgan Stanley Capital International (MSCI) has an unlisted real estate database, but we were unable to access it. As a result, commercial real estate was excluded from our database on real estate, which can be regarded as a weakness. However, the real estate market was not fully excluded, as we were able to gather sufficient information on another segment: residential real estate.

Residential real estate can be a useful component of an investor's portfolio. In addition, most habitants in the Nordic region own their homes mainly for living purposes (Trading Economics, 2022). In this context, we discovered an index from the FRED, which acquired it originally from the Bank of International Settlements, that represented the residential real estate market for our selected countries.

The index reflects both new and existing residential real estate prices in each country. Rental income is not included since the data on this field is limited; hence, generalizing a certain rate to the entire sample becomes problematic and misleading when the minority of people lease, and the data is not seasonally adjusted and extracted as quarterly numbers. By obtaining all data from the same source, we can be certain that the indices in each country were calculated identically, making the data more comparable. The Nordic countries' housing price indices extend back to the 1970s. “Residential real estate” shall henceforth be referred to as “real estate.”

4.2.3 Bonds

We utilized 10-year government bonds for Norway, Sweden, Denmark, and Finland. Apart from Norway, all respective countries have data dated back to 1987. For Norway, the data collected is from 1985. This data was sourced from the FRED, which originally obtained the data from the OECD. The data for 10-year government bonds are in percentages and reflect the prices at which they are traded on financial markets, not the interest rates at which they were issued.

The EU bond data was derived from the FRED, which was derived originally from the OECD, and symbolizes a weighted long-term government bond issued by the EU's 19 member nations. We have data on the EU bond dating back to 1970. The data for the High Yield Index (or high yield) comes from the FRED, which received it initially from The Intercontinental Exchange (ICE) data indexes. The High Yield Index is a weighted average of the ICE BofA Euro High Yield Index, which measures the performance of public corporate debt bonds in the European market. To be included, the public corporation's debt bond must have a particular level of investment grade. This index has 144 distinct bonds. We collected statistics on high yield bonds dating back to 1998.

4.2.4 Commodities

The data for gold, silver, platinum, and palladium was obtained from the London Bullion Market (LBMA). The LBMA's metal prices are well-known globally and often used as a benchmark. The prices are determined by daily auctions. We collected statistics on gold and silver (dating back to 1968) as well as platinum and palladium (dating back to 1990).

For oil, we retrieved data from the FRED, which initially acquired it from the US Energy Information Administration. The data was not seasonally adjusted and reflected spot prices of USD per barrel. The oil price was provided on a daily basis; however, in order to convert the data to monthly format, an unweighted average of the daily closing spot prices was calculated for the selected time period. We obtained data on oil prices starting from 1987. For gas, we obtained data from the FRED, which initially acquired data from the International Monetary Fund (IMF). The IMF publishes benchmark prices from the worldwide market for gas, expressed in dollars per million metric British thermal units, where prices monthly represent an unweighted average for the period. We collected gas price data starting from 1990.

4.2.5 Cryptocurrency

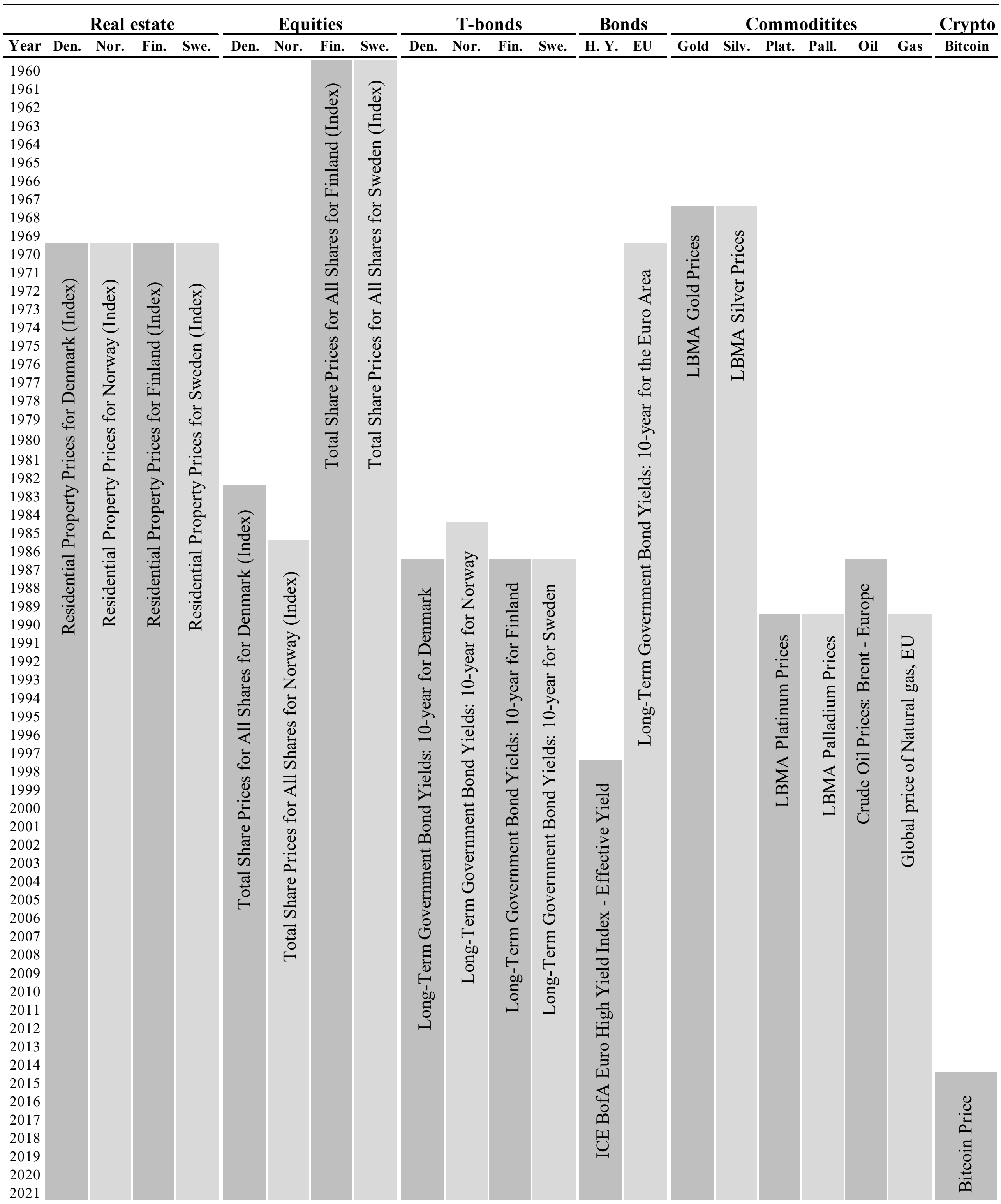
For cryptocurrency, we chose to use bitcoin, as it has accounted for most of the value of the cryptocurrency market over the last few years, and other cryptocurrencies are highly correlated with bitcoin (Yue, 2022). As a result, bitcoin can accurately represent the performance of the cryptocurrency market. Prices for bitcoin were collected from the FRED, which was originally derived from Coinbase, and this data begins from 2015.

4.2.6 Schematic overview of the return data by asset class

A diagrammatic summary with the five asset classes and their respective 21 individual assets are presented in the following Figure 1. The time horizon varies, but all asset data ends in 2021Q4. The data collected for all assets was either indices, prices, or rates.[30]

[30] Units of measurement: equities and real estate = indices, bonds = rate/yield, commodities and cryptocurrencies = prices in USD.

***Figure 1**: Schematic overview of the return data by asset class*



Note: Den, Denmark; Nor, Norway; Fin, Finland; Swe, Sweden; H.Y, High yield; EU, European government bonds; Silv, Silver; Plat, Platinum; Pall, Palladium.

For financial analysis, returns are often used to remove the scale of the indices, prices, and rates that can differ from asset to asset. Furthermore, when each asset is programmed as a quarterly return, it is much easier to compare the performance of the assets with each other.

We assumed that the data collected for all assets without return on bonds are independent, identically distributed, and log-normally distributed. The approach of using log returns provided more statistical freedom. The same approach is referred to as the simplicity of multi-period returns by Ruppert and Matteson (Ruppert & Matteson, 2015). The data collected can be transformed into log returns through the following formula:

$$r_t = \ln(P_t) - \ln(P_{t-1}) = \ln\left(\frac{P_t}{P_{t-1}}\right) \qquad (5.1.1.2a)^{31}$$

Log return is hereby referred to as nominal return throughout this paper. Please note that the natural logarithm approach does not suit all assets described in this paper. Treasury bonds for each country and EU bonds are calculated by Aswath Damodaran calculation procedure (Damodaran, 2022). The procedure was executed by using the promised coupon yield at the end of the prior period, followed by controlling for interest rate changes.

$$Bond\ Return = Yield_{t-1} + \left(\left(Yield_{t-1} * \left(\frac{1-(1+Yield_t)^{-n}}{1}\right) + \frac{1}{(1+Yield_t)^n}\right) - 1\right) \qquad (5.1.1.2b)$$

Further, the asset high yield is given in the effective yield; therefore, the effective yield was used as the return for each quarter for this asset.

4.3 Macroeconomic factors

For explaining the difference in return between the assets in the Nordic countries, this paper aims to control for macroeconomic variables. Our assumption is that the pattern in each country should be identical. Stocks, real estate, and treasury bonds should be impacted positively or negatively by the same control variables. We know most of the studies have been conducted for outside the Nordic countries; however, we find the same factors to be applicable in the Nordic countries. The macroeconomic factors of interest are GDP, policy rate, unemployment rate, and inflation rate. Following Fedorova and Pankratov (2010), we included oil prices in

[31] $Where,\ in\left(\frac{P_t}{P_{t-1}}\right),\ the\ natural\ logarithm\ of\ the\ ratio\ price\ P_t, at\ time\ t\ and\ price\ P_{t-1}\ at\ time\ t-1.$

Norway as a control variable because we assumed that the Norwegian economy has been affected by the oil industry since 1980.

4.3.1 Gross domestic product (GDP)

GDP is the monetary value of all finished goods and services made within a country during a specific period. GDP tends to have a positive relationship with the stock market and real estate market. When a country experiences economic growth, it has a positive impact on corporate activity, investment rates, and future cash flows of companies; therefore, GDP is expected to have a positive impact for return on stocks and real estate in the Nordic countries. The time series data was downloaded from the World Bank (The World Bank, 2022).

4.3.2 Policy rate

The value of an asset depends on the value of the future cash flows discounted by an appropriate rate; however, the value of the cash flow changes when the level of interest rates changes. High interest rates decrease the present value of future cash flows, and low interest rates increase the present value of future cash flows. According to economic theory, an increase in interest rate decreases the value of an asset, and a decrease in interest rate increases the value of an asset. We expect the same relationship for all assets (real estate, stocks, and treasury bonds) in the Nordic countries. The policy rate for the respective countries was downloaded from the database for the national bank for each country (Danmarks Nationalbank, 2022; Bank of Finland, 2022; Sveriges Riskbank, 2022; Norges bank, 2022).

4.3.3 Unemployment rate

OECD defines unemployment rate as "*The unemployed are people of working age who are without work, are available for work, and have taken specific steps to find work*" (OECD, 2022). When this definition is applied consistently across nations, it produces more comparable estimates of unemployment rates than that of the estimates based on national definitions of unemployment. Given that we compared multiple countries, it seemed appropriate to use the same source for data. This macroeconomic variable has the tendency to have a negative impact on economic growth and is a significant indicator of the overall health of an economy. It is expected that the return on real estate will have a negative relationship with this control variable. The data for unemployment rate was retrieved from OECD (OECD, 2022).

4.3.4 Inflation rate

Inflation gradually reduces the real value of money and, therefore, lowers the value of future expected cash flows; however, if future cash flows are adjusted for inflation (rental contracts), the value does not change. This may be the case for real estate if the asset is a rental. For bonds and stocks, the cash flows are expected to be reduced if inflation is high. Real estate assets that are rented out with a CPI-adjusted contract can work as an inflation hedge when compared to stocks and bonds. The data for inflation was retrieved from FRED (Federal Reserve Economic Data, 2022).

5. Results and discussion

In this chapter, we present our results. We aim to answer our two research questions through the empirical evidence we found when employing our methods mentioned in Chapter 3 with the data collected described in Chapter 4.

5.1 Returns

In this subchapter, we present the findings that we obtained using the various returns measurements. First, we examine the nominal and excess return findings.[32] Next, we analyze the distribution and correlation of returns.

5.1.1 Nominal return

In Table 1 below, we present descriptive statistics. The statistics are based on the nominal return for each asset. [33]

Table 1: *Descriptive statistics (nominal returns)*

Variables	Obs	Mean	Std. Dev.	Min	Max	p1	p99	Skew.	Kurt.
Equities Denmark	155	0.025	0.080	-0.394	0.216	-0.171	0.195	-1.200	7.018
Equities Finland	247	0.021	0.101	-0.348	0.416	-0.275	0.294	-0.141	4.974
Equities Norway	143	0.024	0.105	-0.510	0.293	-0.242	0.231	-1.251	7.242
Equities Sweden	247	0.024	0.085	-0.290	0.330	-0.256	0.209	-0.361	4.838
Real estate Denmark	205	0.015	0.028	-0.082	0.119	-0.066	0.082	0.006	4.433
Real estate Finland	205	0.014	0.027	-0.073	0.117	-0.056	0.095	0.359	5.505
Real estate Norway	206	0.018	0.032	-0.073	0.124	-0.041	0.100	0.309	3.276
Real estate Sweden	206	0.016	0.021	-0.069	0.066	-0.047	0.060	-0.551	4.515
T-bonds Denmark	139	0.014	0.013	-0.011	0.056	-0.009	0.047	0.425	3.067
T-bonds Finland	135	0.014	0.014	-0.026	0.058	-0.012	0.057	0.800	3.067
T-bonds Norway	147	0.016	0.014	-0.021	0.062	-0.011	0.056	0.371	3.407
T-bonds Sweden	140	0.015	0.015	-0.022	0.061	-0.022	0.051	0.379	3.005
Gas	127	0.022	0.173	-0.597	0.643	-0.486	0.631	0.320	6.428
Oil	138	00.01	0.162	-0.739	0.500	-0.542	0.381	-0.917	6.780
Gold	215	0.018	0.082	-0.189	0.419	-0.147	0.334	1.358	7.635
Silver	215	0.011	0.136	-0.830	0.582	-0.320	0.482	-0.273	11.718
Palladium	126	0.022	0.145	-0.548	0.369	-0.364	0.315	-0.725	4.563
Platinum	126	0.006	0.096	-0.577	0.260	-0.273	0.210	-1.810	12.970
Bitcoin	28	0.185	0.358	-0.316	0.996	-0.316	0.996	0.624	2.896
EU Bond	207	0.018	0.013	-0.009	0.050	-0.008	0.048	0.246	2.715
High Yield	97	0.080	0.048	0.000	0.230	0.000	0.230	1.014	3.672

Note: The observations are based on quarterly data. Mean, St.dev, Min, Max, p1, p99 must be multiplied with 100 to achieve numbers in percent.

[32] Since all asset classes have been adjusted with the same inflation derived from an average inflation rate from Europe, the real return will not be shown as a distinct subchapter in this report. Inflation will have the same effect on all different asset types. On the other side, inflation will impact geometric returns and will be presented in Chapter 5.1.2.
[33] All assets are tested for unit root, see Appendix, Table 12.

As highlighted in the table above, the Nordic asset classes that have the highest mean are equities, followed by real estate and government bonds. When we looked at the extreme values, bitcoin had the highest, and oil had the lowest. Among the Nordic asset classes, equities had, on average, the highest standard deviation, followed by real estate and government bonds. Bitcoin was the most volatile out of all the investments, whereas Danish government bonds were the least volatile.

For our practical purposes, large kurtosis can be associated with risk in the asset because it indicates high probabilities of significantly large and significantly small returns. There is also evidence of many assets that are left skewed. [34] Equities in the Nordic countries are left skewed, which is normal for equity data collected for long horizons (Singleton & Wingender, 2009).

5.1.2 Excess return

In Table 2, we see an overview of different measures of excess return. The first column (*mean*) expresses the nominal return minus the risk-free interest rate. Alpha (α) from the CAPM expresses how much more return the asset generates in relation to the market. Alpha (α) from *macrofactor* is an expression of how much return one asset generates, relative to other assets.

[34] Skewness is a measure of the asymmetry of a distribution. Kurtosis is a measure of mass in tails, also referred to as the probability of large values in the distribution (Stock & Watson, 2015). When skewness is equal to 0, the distribution is symmetric. When kurtosis is equal to 3, we have a normal distribution (Stock & Watson, 2015).

Table 2*: Overview of all assets measured with different measures of excess return.*

Variables	Mean	CAPM (α)	Macrofactor (α)
Equties Denmark	0.022	0.013**	2.218
Equties Finland	0.018	0.012*	3.957**
Equties Norway	0.022	0.012	1.164***
Equties Sweden	0.020	0.013**	1.865
Real estate Denmark	0.011	0.010***	1.098
Real estate Finland	0.010	0.011***	1.892***
Real estate Norway	0.014	0.063***	0.566*
Real estate Sweden	0.013	0.012***	0.726
T-bonds Denmark	0.011	0.011***	0.065
T-bonds Finland	0.012	0.012***	0.061
T-bonds Norway	0.014	0.014***	0.057***
T-bonds Sweden	0.012	0.013***	0.045
High yield	0.08	0.020***	
Eu bond	0.018	0.013***	
Gold	0.014	0.015**	
Silver	0.008	0.005	
Palladium	0.020	0.015	
Platinum	0.004	-0.003	
Gas	0.018	0.019	
Oil	0.008	0.006	
Bitcoin	0.185	0.173**	

Note: *** $p<0.01$, **$p<0.05$, *$p<0.1$

By examining the mean, we observed that bitcoin has the highest return by a significant margin, with a value of 0.201. Further, we observed that equities have the highest excess return (between 0.018 and 0.022). Denmark and Norway have the most abnormal return on equities, followed by Sweden and Finland. High yield, palladium, and gas have roughly identical excess returns to stocks at 0.020, 0.020, and 0.180, respectively. In addition, the returns on government bonds and real estate returns are considerably smaller, but they provide a comparable amount of excess return. Norway has the highest when it comes to treasury bonds (or t-bonds) and real estate. Oil, silver, and platinum offer the lowest returns on average among commodities. This distribution is in line with Jordà et al. (2019).

The CAPM reveals a relatively equal distribution of assets with the largest excess return; however, there are variations. Bitcoin continues to be the most valuable asset, followed by real estate Norway, high yield and gold. Equities had significant declines on average, and their performance was more in line with that of t-bonds, which lie within the range of 0.011 to 0.014. Both Norway and Finland saw significant declines in their real estate markets, and our results highlight that Finland's alpha is negative. Among commodities, we saw that gold and gas rose compared to the *mean* and silver's alpha has become negative.

The results of the macro factor model are displayed in the third column. Several assets were omitted in this case, as national macroeconomic considerations in the Nordic nations cannot explain global assets like commodities and bitcoin. Here, the assets inside the country are compared to one another. In Denmark, the biggest excess returns were generated by stocks, followed by real estate, then bonds. Apparently, this distribution applied to all nations except for Norway. In Norway, the returns on government bonds were somewhat greater than the returns on real estate. Even though the distribution appears to be identical across all nations, the relationship between them is vastly distinct. In Finland, the bond return on stocks were significantly larger than the return for t-bonds at 3.957 and 0.061, respectively. This proportion is 1.164 to 0.570 in Norway.

5.1.2 Distribution and correlations of quarterly returns

5.1.2.1 Statistical properties

The table below provides an overview of statistical properties. The results presented in Table 3 are discussed in further detail in the following subchapters.

Table 3*: Statistical properties of all- time data for each asset.*

	Housing market				Equties				T-Bonds				Bonds		Commoditites						Crypto
	Den.	**Nor.**	**Fin.**	**Swe.**	**Den.**	**Nor.**	**Fin.**	**Swe.**	**Den.**	**Nor.**	**Fin.**	**Swe.**	**H.Y.**	**EU**	**Gold**	**Silv.**	**Plat.**	**Pall.**	**Oil**	**Gas**	**Bitcoin**
Comp.avg. nominal return (%)	1.40	1.70	1.34	1.57	1.99	1.87	1.61	2.01	1.32	1.57	1.37	1.44	2.10	1.76	1.46	-0.06	0.02	1.10	-0.59	0.52	15.39
Comp. avg. real return (%)	1.38	1.68	1.31	1.55	1.97	1.85	1.59	1.98	1.30	1.55	1.35	1.42	2.09	1.73	1.44	0.00	0.02	1.08	-0.38	0.53	15.37
Arith. avg. nominal return (%)	1.45	1.76	1.39	1.61	2.45	2.43	2.11	2.36	1.35	1.60	1.40	1.47	2.13	1.78	1.77	1.13	0.57	2.20	1.04	2.20	20.12
Arith. avg. real return (%)	1.43	1.73	1.36	1.59	2.42	2.40	2.08	2.33	1.33	1.58	1.38	1.44	2.12	1.74	1.74	1.11	0.56	2.17	1.01	2.19	20.04
Arith. avg. excess return (%)	1.09	1.40	1.02	1.25	2.18	2.18	1.75	2.01	1.11	1.34	1.16	1.23	1.97	1.41	1.40	0.76	0.37	2.00	0.80	1.99	20.05
Standard deviation (%)	2.75	3.24	2.68	2.11	7.98	10.45	10.05	8.51	1.27	1.35	1.43	1.49	0.72	1.25	8.25	13.56	9.62	14.52	16.23	17.30	35.38
Minimum quarterly return (%)	-8.15	-7.30	-7.32	-6.86	-39.43	-50.95	-34.81	-29.02	-1.14	-2.10	-2.55	-2.23	1.01	-0.91	-18.91	-82.97	-57.72	-54.83	-73.85	-59.74	-31.62
Maximum quarterly return (%)	11.85	12.35	11.67	6.63	21.63	29.26	41.59	32.99	5.58	6.23	5.84	6.07	4.98	5.04	41.90	58.15	25.99	36.94	49.97	64.31	99.61
Sharpe ratio	0.22	0.29	0.41	0.59	0.27	0.21	0.18	0.24	0.94	1.07	0.86	0.88	2.87	1.25	0.17	0.06	0.04	0.14	0.05	0.12	0.57
Skewness	-0.52	0.25	0.27	-0.60	-1.19	-1.25	-0.14	-0.37	0.41	0.38	0.83	0.30	1.74	0.25	1.27	-0.31	-1.78	-0.72	-0.91	0.33	0.60
Kurtosis	4.23	3.24	5.72	4.20	6.90	7.18	4.94	4.8	3.27	3.83	4.81	3.28	7.29	2.71	7.34	11.71	12.86	4.54	6.73	6.30	2.92

Note: Comp.avg, Compounded average; Arith.avg, Arithmetic average. Den, Denmark; Nor, Norway; Fin, Finland; Swe, Sweden; H.Y, High yield; EU, European government bonds; Silv, Silver; Plat, Platinum; Pall, Palladium.

5.1.2.1.1 Arithmetic average

If we omit bitcoin, we can observe from Table 3 that, on average, equities in all nations (except Finland) generate larger arithmetic returns than other asset classes. Denmark had one of the highest quarterly returns on equity at 2.46%, followed by Norway at 2.43%, Sweden at 2.3%, and Finland at 2.12%. Gas generated 2.21%, high yield generated 2.14%, and palladium generated 2.20%, making them superior to equities in Finland. Nordic t-bonds yielded an average of 1.36% to 1.60%, with Norway offering the highest rate. As expected, EU bonds yielded slightly more than t-bonds, and the high yield bond yielded even more at 2.12%. This was consistent with the risk-reward relationship. Real estate in the Nordic countries yielded, on average, more than t-bonds, with Norway yielding the highest at 1.77%. There were significant disparities in return between commodities, with platinum having the lowest at slightly about 0.57%. Bitcoin had limited observations and averaged a quarterly return of 20.12%.

If we take the average of the various asset classes and convert it to an annual rate, we can see that equities provide a return of 9.72% annually, whereas Doeswijk et al. (2020) reported a return of 11.2%. The same holds true for government bonds, which yielded 5.96%, compared to 6.89%. When looking at the return on investment for real estate, we found that Jordà et al. (2019) reported an annual return of 11%, whereas we found 6.39% for the Nordic market.

In summary, the arithmetic return suggested that bitcoin, equities, high yield, natural gas, and palladium provided the highest returns; however, as previously highlighted in the method chapter (3.1.4), the arithmetic return overlooked the compounding effect, which resulted in volatile securities being overvalued. If we included the compounding effect, the outcome changes.

5.1.2.1.2 Geometric average

When we incorporated the compound effect, we can see from Table 3 that several assets were penalized for their price fluctuations. After periods of decline, the housing market in Norway outperformed the stock market in Finland in terms of returns. Given the exclusion of rental income, real estate can generate even greater returns than those found in our study. Real estate and t-bonds were not punished as severely, which is to be expected given that they are less volatile during the periods under consideration in this research. In terms of arithmetic return, high yield was among one of the best; however, after adjusting for the compounding effect, it was second after bitcoin. Gas and palladium, which were previously among the best performers prior to the adjustment, were among the worst performers after the adjustment. This can be explained by the fact that both gas and palladium have experienced periods of significant negative returns during some of the study's periods (see Appendix, Table 1). Similarly, the returns on oil and silver have shifted from positive to negative. Bitcoin was penalized for its volatility, which decreased by 5%. Nevertheless, bitcoin continued to deliver the highest return out of all the assets analyzed.

Taking the average of all asset classes and converting it to an annual rate reveals that stocks generate a 7.70% annual return, whereas Doeswijk et al. (2020) reported 9.76%. Similar considerations apply to government bonds, which yield 5.83% against 6.66%. Jordà et al. (2019) reported a yearly return of 10.53 % on real estate, compared to our 6.19 %. Doeswijk et al. (2020) and Jordà et al. (2019) had a larger time series than we do, which may have a significant role in explaining why we had a lesser return.[35] Nevertheless, according to our findings, the largest return was generated by stocks, followed by returns generated by real estate and bonds.

5.1.3 Correlations of quarterly returns

In Chapter 3.2, we mentioned why the correlation of returns between the assets can be a helpful indicator when diversifying or constructing a portfolio with low variance (risk). In this chapter, we present correlations within the Nordic countries regarding t-bonds, stocks, and real estate. Thereafter, we examine the 21 asset classes in the study.

5.1.3.1 Nordic stocks and bonds

After investigating Table 4, we found evidence of high correlations between Nordic stock markets. Stocks in Sweden and Finland had the highest correlation (0.82) and return on stocks in Norway and Finland had the lowest value (0.61).

Table 4: *Correlations of quarterly nominal returns*

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) Real estate Denmark	1.000											
(2) Real estate Finland	0.376	1.000										
(3) Real estate Norway	0.491	0.288	1.000									
(4) Real estate Sweden	0.355	0.474	0.285	1.000								
(5) T-bonds Denmark	-0.065	-0.080	-0.246	-0.180	1.000							
(6) T-bonds Finland	-0.046	-0.230	-0.221	-0.291	0.890	1.000						
(7) T-bonds Norway	-0.190	-0.071	-0.390	-0.199	0.605	0.579	1.000					
(8) T-bonds Sweden	0.018	-0.097	-0.261	-0.197	0.921	0.879	0.586	1.000				
(9) Equities Denmark	0.493	0.468	0.313	0.443	-0.073	-0.037	-0.092	-0.048	1.000			
(10) Equities Finland	0.327	0.376	0.343	0.119	-0.026	0.041	-0.099	-0.033	0.625	1.000		
(11) Equities Norway	0.376	0.417	0.332	0.335	-0.097	-0.028	-0.117	-0.090	0.799	0.611	1.000	
(12) Equities Sweden	0.389	0.409	0.343	0.291	-0.002	0.045	-0.096	0.018	0.815	0.815	0.786	1.000

Note: 1988Q3-2021Q3 (obs=133).

[35] According to Jorda et al.'s (2019) findings, the returns on all assets were greater before 1950.

We found evidence of relatively high correlations between the Nordic bonds. We observed that the highest correlation regarding bonds was between Danish and Swedish t-bonds (0.92), and the lowest correlation was between Norwegian and Finnish t-bonds (0.58). Furthermore, we discovered evidence of negative correlations in return between bonds and stocks in almost every country. This was in line with the general theory about the value of future discounted cash flows and other studies in the same field (MacKinnon, 2018). If the interest rate increases, the future discounted cash flows of listed companies have less value (return on stocks may decrease). When the interest rate moves in the opposite direction, the future discounted cash flows are worth more (return on stocks may increase). However, bonds and stocks in Finland seem to have a different relationship. In Finland, there is a positive correlation between return on bonds and stocks (0.04). This finding was not in line with some of the other studies in the same field (MacKinnon, 2018).

5.1.3.2 Nordic real estate

Table 4 indicates return on real estate in Nordic countries is generally positively correlated; however, all the correlations are relatively low, yielding lower than 0.50. This evidence was noteworthy because the return on Nordic stocks correlates relatively high, and the same can be said about the correlation in return between Nordic bonds (not lower than 0.57 for any variable). Furthermore, we found evidence of real estate return in almost every country is negatively correlated with all types of Nordic t-bonds within the period. This finding was in line with existing literature (MacKinnon, 2018). Return on Norwegian t-bonds and return on Norwegian real estate had the most negative value (-0.39). The value indicated that return on real estate in Norway is more sensitive to the policy rate when compared to the other Nordic countries. This evidence may be a sign for when interest rates in Norway are increasing, it could be an attractive time to enter real estate in Norway due to the negative relationship (from an investment timing perspective). In other Nordic countries, the negative correlation was weaker. Furthermore, we observed weak correlations between return on real estate and return on equities within the countries, which was in line with NBIM's thoughts on this relationship (NBIM, 2015). It was also in line with the paper "*Transactions-Driven Commercial Real Estate Returns: The Panacea to Asset Allocation Models*" (R., Mike, & David, 1992).

5.1.3.3 Correlations of commodities

When investigating commodities in Table 5, the data displays positive correlations between gold, silver, and platinum (above 0.50). Furthermore, we observed that gas was negatively correlated with gold, silver, and palladium.

***Table 5:** Correlations of quarterly nominal returns*

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) Palladium	1.000					
(2) Platinum	0.645	1.000				
(3) Silver	0.343	0.542	1.000			
(4) Gold	0.278	0.540	0.599	1.000		
(5) Gas	-0.010	0.037	-0.094	-0.091	1.000	
(6) Oil	0.261	0.527	0.191	0.173	0.220	1.000

Note: 1990Q2-2021Q3 (obs=126)

5.1.3.4 Correlations of all 21 assets

We created two correlation tables in a similar way to the tables presented earlier in the paper. One table is with bitcoin (21 assets), and one table is without bitcoin (20 assets). Please see Appendix Table 5 and Table 6 to investigate the tables further. We found similar patterns as previous presented results in the tables with 20 assets; however, the most extreme negatively correlated value was between return on gold and return on high yield bonds (-0.54), and the strongest positive correlation across all assets was the return on Danish and Finnish t-bonds (0.96). We also observed that both EU bonds and high-yield returns are positively correlated with returns on Nordic bonds.

5.2 Risk

In this subchapter, we examine the risk of the various assets. First, we examine the Sharpe ratio, which employs risks (systematic and unsystematic) as assessed by standard deviation. Then, we examine the beta from the CAPM, which indicates the risk of the assets relative to the market. In the end, we investigate a macroeconomic factor model to observe how various assets react to shifts in macroeconomic variables.

5.2.1 Market risk

5.2.1.1 Sharpe ratio

For each individual asset, we examined the average annual return, standard deviation, and Sharpe ratio presented in the following Table 6 for three different periods.[36]

[36] To make the computation, we used the arithmetic average of quarterly nominal returns and risk-free interest rates corresponding to the US 10-year government bond.

***Table 6**: Sharpe ratio for assets classes under different periods*

	Full timeline			1980-2000			2000-2021		
	Average	**St.dev**	**Sharpe**	**Average**	**St.dev**	**Sharpe**	**Average**	**St.dev**	**Sharpe**
Real estate Denmark	0.024	0.112	0.215	0.021	0.119	0.173	0.007	0.119	0.058
Real estate Norway	0.027	0.096	0.285	0.027	0.102	0.265	0.020	0.100	0.203
Real estate Finland	0.010	0.024	0.413	0.008	0.025	0.301	0.013	0.019	0.691
Real estate Sweden	0.013	0.021	0.587	0.011	0.021	0.493	0.015	0.017	0.891
Equties Denmark	0.022	0.080	0.273	0.022	0.080	0.273	0.021	0.082	0.260
Equties Norway	0.022	0.106	0.209	0.022	0.106	0.209	0.023	0.098	0.232
Equties Finland	0.018	0.100	0.175	0.021	0.112	0.188	0.001	0.110	0.009
Equties Sweden	0.020	0.085	0.237	0.027	0.094	0.291	0.013	0.088	0.153
T-bonds Denmark	0.011	0.012	0.944	0.011	0.012	0.944	0.007	0.008	0.796
T-bonds Norway	0.013	0.013	1.075	0.014	0.013	1.075	0.008	0.009	0.952
T-bonds Finland	0.012	0.014	0.862	0.012	0.014	0.862	0.007	0.008	0.881
T-bonds Sweden	0.012	0.014	0.878	0.012	0.014	0.878	0.007	0.009	0.799
High yield	0.020	0.007	2.871	0.020	0.007	2.871	0.020	0.007	2.701
Eu bond	0.014	0.011	1.248	0.014	0.012	1.151	0.008	0.008	0.967
Gold	0.014	0.083	0.170	0.005	0.071	0.076	0.019	0.059	0.327
Silver	0.007	0.136	0.056	-0.002	0.136	-0.013	0.016	0.113	0.145
Platinum	0.004	0.096	0.039	0.004	0.096	0.039	0.008	0.110	0.075
Palladium	0.020	0.145	0.138	0.020	0.145	0.138	0.017	0.160	0.104
Oil	0.008	0.162	0.050	0.008	0.162	0.050	0.012	0.168	0.074
Gas	0.020	0.173	0.115	0.020	0.173	0.115	0.029	0.198	0.145
Bitcoin	0.200	0.354	0.567	0.201	0.354	0.567	0.201	0.354	0.567

Period: Full time

Table 6 reveals that high-yield bonds have the highest Sharpe ratio, followed by t-bonds. When compared to its neighboring countries, real estate in Finland and Sweden exhibits a greater Sharpe ratio and, on average, outperforms equities. Our findings contradict the findings of Doeswijk et al. (2020), who discovered that the Sharpe ratio is highest for stocks. In comparison to real estate, equities not only have a higher average rate of return but also higher standard deviations. Of the asset groups, commodities have the lowest average Sharpe ratio, while gold, palladium, and natural gas performed slightly better than the other asset classes on a per-class basis. Bitcoin generated returns that outperformed all other investments, but it was penalized for its excessive volatility. As a result, it had a lower Sharpe ratio than all bonds, as well as real estate in Sweden.

Period: 1980–2000

Table 6 illustrates that high yield and bonds continue to provide the highest Sharpe ratios for the 1980–2000 period. The distribution appeared to be the same as it was previously, but, on average, the Sharpe ratio of real estate had slightly decreased, and the Sharpe ratio of equities had slightly climbed. Sweden had the greatest Sharpe ratio in both equities and real estate. Gold's Sharpe ratio decreased substantially, while silver's Sharpe ratio shifted from positive to negative.

Period: 2000–2021

According to Table 6, real estate, particularly in Finland and Sweden, had a significantly higher Sharpe ratio in the period of 2000–2021q4 when compared to prior periods. This can be explained by the fact that returns increased and the standard deviation decreased. Compared to previous years, the Sharpe ratio for real estate in Norway and Denmark decreased, which, given a relatively constant standard deviation, can be explained by reduced returns. Finnish equities faced a significant decline, yielding only a marginal advantage over the market with a Sharpe ratio of 0.1. High yield, followed by bonds, continued to produce the highest Sharpe ratio, albeit at a lower level than in previous periods. When compared to other commodities, gold received a substantially greater Sharpe ratio. In conclusion, we discovered that various assets are penalized for one's risk and that the assets that provided the highest return were outclassed when the risk was accounted. Additionally, we saw that the asset's performance and volatility fluctuate with time. As a result, when developing an investment strategy, one must be careful and critical, as it is not typically the case that the past foretells the future.

5.2.1.2 CAPM

In this subsection, we analyze the estimated beta coefficients as a measure of systematic risk for individual assets. The market return was derived from Fama and French (French, 2021). The abnormal return is represented by the alpha (intercept) in the following tables. In the CAPM, the combination of the highest possible abnormal return and the lowest possible risk (beta) is advantageous.

CAPM: Equities

Table 7 below displays that all equities were positively correlated with the market. This was as expected, as Fama and French's global portfolio primarily consisted of equities. Norway had the highest beta of 1.28, followed by Denmark, Sweden, and Finland. This means that a percentage increase in market excess return may lead to an increase in Norwegian shares of 1.28%. This also implied that shares in Norway, Denmark, and Sweden have greater systematic risk than the market. Finland, on the other hand, has slightly less. The R-squared value for all the Nordic equities was below 0.1764, which indicated that the market return explains a small proportion of its variance. Finally, all values were significant apart from the alpha for Norway.

Table 7: *CAPM for equities*

Variable	α	t-stat(α)	β	t-stat(β)	R squared
Equtites Denmark	0.0127**	(2.1176)	1.2016***	(5.7241)	0.1763
Equities Norway	0.0124	(1.4618)	1.2840***	(4.3745)	0.1195
Equities Finland	0.0119*	(1.8957)	0.9461***	(4.3684)	0.0722
Equitites Sweden	0.0130**	(2.5754)	1.1756***	(6.7235)	0.1557

Note: *** p<0.01, **p<0.05, *p<0.1

CAPM: Real estate

As demonstrated in Table 8, the beta for Finland was negative, which did not match our initial assumptions about the housing market and overall market. The correlation matrix, on the other hand, provided data in support of this. According to the correlation matrix in Table 5 in the Appendix, the relationship between stocks and housing in Finland seems to be the weakest among the Nordic countries; however, the beta coefficients for Finland, Norway, and Sweden are not statistically significant. Denmark had a positive beta of 0.19, which is statistically significant at a 1% level.

Table 8: *CAPM for real estate*

Variable	α	t-stat(α)	β	t-stat(β)	R squared
Real estate Denmark	0.0097***	(5.0263)	0.1900***	(2.9613)	0.0414
Real estate Norway	0.0625***	(5.9497)	0.0621	(0.8208)	0.0033
Real estate Finland	0.0105***	(5.6111)	-0.0322	(-0.5196)	0.0014
Real estate Sweden	0.0123***	(8.0950)	0.0357	(0.7065)	0.0024

Note: *** p<0.01, **p<0.05, *p<0.1

CAPM: Bonds

As expected, we discovered that most of the bonds have a negative relationship with the stock market. Given that most correlations between bonds and equities in this sample were negative, this finding was predicted by the correlation matrix in Table 5 in the Appendix. Once again, we had the market from Fama and French (mostly generated from equities), which implied that this CAPM model was essentially a regression against the stock market in nature. Only high yield was statistically significant among the betas.

Table 9: *CAPM for bonds*

Variable	α	t-stat(α)	β	t-stat(β)	R squared
T-bonds Denmark	0.0113***	(12.7124)	-0.0209	(-0.5698)	0.0022
T-bonds Norway	0.0136***	(12.7124)	-0.0209	(-0.5698)	0.0022
T-bonds Finland	0.0118***	(9.7185)	-0.0168	(-0.3910)	0.0011
T-bonds Sweden	0.0126***	(10.3217)	-0.0452	(-1.0770)	0.0083
High yield	0.0203***	(29.8673)	-0.0703***	(-3.1709)	0.0930
EU bond	0.0139***	(17.2977)	0.0408	(1.5258)	0.0112

Note: *** p<0.01, **p<0.05, *p<0.1

CAPM: Commodities and bitcoin

Bitcoin had a beta of 2.086, which indicated a significantly higher degree of systematic risk, while gold appeared to have a negative relationship with the stock market.[37] We found signs of this relationship from the correlation analysis. According to the correlation matrix in Table 5 in the Appendix, gold was negatively correlated with stocks in Denmark, and the correlation was virtually zero, but it was still positively correlated with equities in the remaining Nordic countries. All other commodities had positive correlations with the market, with oil and natural gas being the least correlated after gold. Among the assets, only the beta of platinum and the alpha of gold and bitcoin were significant.

Table 10: *CAPM for commodities and bitcoin*

Variable	α	t-stat(α)	β	t-stat(β)	R squared
Gold	0.0146**	(2.5353)	-0.0946	(-0.4859)	0.0011
Silver	0.0051	(0.5450)	0.4196	(1.3206)	0.0081
Platinum	-0.0003	(-0.0368)	0.5322*	(1.7476)	0.0240
Palladium	0.0144	(1.0849)	0.7259	(1.5764)	0.0196
Oil	0.0059	(0.4187)	0.2901	(0.5861)	0.0025
Gas	0.0197	(1.2339)	0.0319	(0.0577)	0.00002
Bitcoin	0.1753**	(2.3455)	2.0860	(0.8452)	0.0277

Note: *** p<0.01, **p<0.05, *p<0.1

CAPM: Summary

Equities had the strongest correlation with the market and delivered the most significant values. With a few exceptions, real estate and commodities had a lower correlation on average with the market. Gold and bonds had a negative relationship with the market, which opens the possibility of hedging. Except for stocks, the R-squared was significantly low or near zero; thus, the model had limited explanatory power. It is possible that the low R-squared among some of the assets

[37] This is consistent with the studies of sample returns during crises in Chapter 5.4. In Table 24, the figure demonstrates that stocks drop while gold rises.

was because the market is derived from Fama and French's global portfolio, where equities constitute most of the portfolio weight. Simply said, we performed regressions on an equity index, which may appear unreasonable.

We selected Fama and French's global market portfolio since there were few or no alternative internationally representative indices. Furthermore, a simplification was necessary owing to a shortage of time. To test if we could generate more significant values and explanatory power, we also tried utilizing Fama and French's three-factor model. We obtained less significant values, which can be viewed in Table 7 in the Appendix. This appeared logical because the addition of size risk and value risk components cannot, in principle, be tied to real estate, commodities, and bonds in the same way as equities.

5.2.2 Multi-factor model

In this chapter, we present the results of our multi-factor model for the Nordic countries. We present Denmark, Finland, Norway, and Sweden. The macroeconomic variables that are used in the model are GDP, inflation rate, policy rate, and unemployment rate in the respective countries. In Norway, we had an additional explanatory variable that was the oil price. We used this because a listed company named Equinor comprises almost 25% of the whole Oslo Stock Exchange in terms of value. Equinors' business area is mainly oil and gas (Revfem, 2022). The idea behind setting oil as a macroeconomic variable was based on the paper referred to in Chapter 2.2.1 written by Fedorova and Pankratov in 2010. Furthermore, we wanted to test how the explanatory variables affects return on equities, t-bonds, and real estate in Nordic countries.

5.2.2.1 Denmark

The return on Danish t-bonds was negatively affected by an increase in inflation; however, an increase in policy rate affected the return on Danish t-bonds in a positive way. An increase in inflation and policy rate affected Danish real estate negatively, and the same can be said about the return on Danish stocks. The results were significant at a 95% level for return on bonds and equities. For return on real estate, we had a 99% significance level.

Table 11: *Multi-factor model for assets in Denmark*

Variable	**GDP**		**Inflation**		**Policy rate**		**Unemployment rate**		
	β	t-stat	β	t-stat	β	t-stat	β	t-stat	R-square
Equities Denmark	-0.380	(-1.16)	-0.102**	(-2.23)	-0.742**	(-2.48)	0.263	(0.89)	0.153
Real estate Denmark	-0.109	(-0.48)	-0.126***	(-4.22)	-0.685***	(-3.64)	-0.097	(-0.49)	0.179
T-bonds Denmark	-0.005	(-0.39)	-0.009***	(-4.91)	0.030***	(2.86)	0.005	(0.43)	0.740

Note: Time series regression is executed on quarterly nominal returns. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

5.2.2.1 Finland

In Finland, we observed the same pattern for the return on bonds. An increase in inflation affects the return negatively, and an increase in policy rate affects the return positively. Furthermore, we observed that an increase in GDP, inflation rate, and policy rate affects the return on real estate negatively. However, the GDP coefficient had significance level at 94.6%, and the other two coefficients and significance levels at 95% and 99% (policy rate and inflation rate, respectively). For return on stocks, we did not find any statistically significant macroeconomic coefficients, but the constant was statistically significant at the 95% level for Finland in the model.

***Table 12:** Multi-factor model for assets in Finland*

Variable	GDP		Inflation		Policy rate		Unemployment rate		
	β	t-stat	β	t-stat	β	t-stat	β	t-stat	R-square
Equities Finland	-0.747	(-1.63)	-0.105)	(-0.83)	-0.889	(-1.10)	-0.333	(-0.42)	0.117
Real estate Finland	-0.27*	(-1.96)	-0.136***	(-3.56)	-0.459*	(-2.01)	-0.234	(-1.43)	0.326
T-bonds Finland	-0.005	(-0.49)	-0.008**	(-2.54)	0.045***	(2.97)	0.003	(0.86)	0.659

Note: Time series regression is executed on quarterly nominal returns. *** p<0.01, **p<0.05, *p<0.1

5.2.2.3 Norway

In Norway, we found evidence that a change in oil price affected the return on Norwegian t-bonds positively (marginally), and an increase in policy rate affected the return in the same way (also marginally). An increase in inflation is negative for the return on bonds. All coefficients were significant at the 99% level. Norwegian real estate yielded positive returns when oil price changed; however, an increase in inflation, policy rate, and unemployment rate affected return on real estate negatively.

***Table 13**: Multi-factor model for assets in Norway*

Variable	GDP		Inflation		Policy rate		Unemployment rate		Oil		
	β	t-stat	β	t-stat	β	t-stat	β	t-stat	β	t-stat	R-square
Equities Norway	-0.005	(-1.65)	-0.133***	(-4.21)	-1.095***	(-4.27)	-0.164	(-0.41)	0.002***	(4.05)	0.185
Real estate Norway	-0.001	(-0.34)	-0.093***	(-3.83)	-0.663***	(-3.83)	-0.634**	(-2.36)	0.001***	(2.66)	0.127
T-bonds Norway	0.000	(-1.66)	-0.008***	(-6.14)	0.280***	(3.66)	0.022	(1.39)	0.0001***	(-4.85)	0.690

Note: Time series regression is executed on quarterly nominal returns. *** p<0.01, **p<0.05, *p<0.1

5.2.2.4 Sweden

In Sweden, we observed many of the same patterns as Denmark and Finland. The inflation and policy rate affected the returns on stocks and real estate negatively. Furthermore, the return on bonds was positively affected by an increase in policy rate and negatively affected by an increase in inflation. The described explanatory variables were statistically significant at 95% and 99% levels.

***Table 14**: Multi-factor model for assets in Sweden*

Variable	GDP		Inflation		Policy rate		Unemployment rate		
	β	t-stat	β	t-stat	β	t-stat	β	t-stat	R-square
Equities Sweden	-0.240	(-0.83)	-0.162**	(-2.08)	-0.647**	(-2.16)	0.657	(0.65)	0.217
Real estate Sweden	0.010	(0.08)	-0.164***	(-4.73)	-0.677***	(-4.63)	0.106	(0.70)	0.231
T-bonds Sweden	-0-014	(-0.83)	-0.006**	(-2.07)	0.071***	(4.64)	0.026	(0.44)	0.722

Note: Time series regression is executed on quarterly nominal returns. *** p<0.01, **p<0.05, *p<0.1

5.2.2.5 Brief summary

The multi-factor model aided us with finding evidence in which macroeconomic variables that can be useful as tools for investors when investing in the Nordic region regarding risk. We found some clear patterns: both the inflation rate and policy rate were strong explanatory variables when explaining how they affected the return on t-bonds, real estate, and stocks. In addition, we found that Norwegian real estate was more sensitive to the unemployment rate when compared to the other three countries, which means the risk is higher in Norwegian real estate when unemployment rate increases, which can be explained by the high rate of house ownership in Norway (80.8% of Norwegian households owned their home in 2021). In comparison to Sweden, this number was 64.5%, 59.3% in Denmark, and 70.7% in Finland (Trading Economics, 2022). Furthermore, we saw that changes in oil price can be a useful indicator for Norwegian asset classes because the significance levels were strong in the regression models for Norway. This evidence could also be a finding that indicates the performance of Norwegian asset classes could be oil dependent; however, the oil coefficient was small in all cases, but statistically significant at a 99% level. Furthermore, we observed a deviation in Finland, where the return on real estate was negatively affected by an increase in GDP levels; however, the significance level was under 95%.

5.3 The minimum variance portfolio and efficient frontier

We investigated the levels of risk and return associated with a total of 21 assets, including international and Nordic assets. In addition, asset correlations have been investigated. In this chapter, we construct the minimum variance portfolio with different combinations. The purpose of constructing several minimum variance portfolios is to measure risk and performance over time when combining several assets. Furthermore, the portfolios assist us with answering our research question two (*Which Nordic country offers the most ideal option for the minimum variance portfolio?*).

5.3.1 The global minimum variance portfolio

When constructing the minimum variance portfolio for the whole period of the data presented in the paper, the result was the following portfolio with the illustrated weights in Table 15.

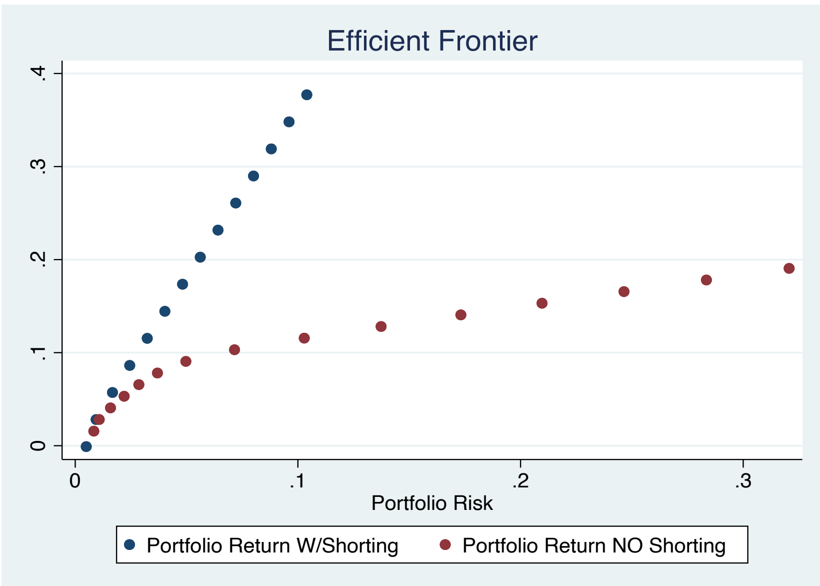
Table 15: *Global minimum variance portfolio*

Asset	T.b. Fin	T.b. Nor	R.e. Swe	R.e. Nor	R.e. Fin	R.e. Den	EU Bond	Silver	Gas	H.y.	Oil
Weights	33.32	26.51	18.65	7.73	5.49	5.10	1.64	0.61	0.60	0.27	0.06

Note: T.b. Fin, T-bonds Finland; T.b. Nor, T-bonds Norway; R.e. Swe, Real estate Sweden; R.e.Nor, Real estate Norway, R.e. Fin, Real estate Finland; R.e. Den, Real estate Denmark; H.y, High yield. Numbers are given in percent.

This portfolio yielded a 1.57% quarterly return (6.07% annual return) with a variance of 0.0007 and a standard deviation equal to 0.83% (3.36% annually). In comparison, the Norwegian Oil Fund delivered a return of 6.62% from January 1998 to the end of 2021. The standard deviation yielded 7.98% in the same period (NBIM, 2022). In addition, the well-known paper *"Historical Returns on the Market Portfolio"* reported a compounded nominal return of 8.6% annually with a standard deviation of 11.2% in the period from 1960 to 2017 (Doeswijk, Lam T, & Swinkels, 2019). We utilized the same approach to construct the minimum variance portfolio; however, we were interested in the period of 2000-2020 and 2010-2020. For our practical purpose, we focused on the "no-short" portfolio because it is not possible to short real estate in the same way as stocks or commodities.

Figure 2: *Efficient frontier*



Note: The figure above illustrates 15 different combinations of assets listed in Table 15. Y-axis represent the return, whereas X-axis represent the portfolio risk. The no-short portfolio is the portfolio with red dots. Please note that the portfolio with the shorting option has the best highest possible return potential and low-risk potential.

Our constructed minimum variance portfolio deviated from the real world in terms of its asset weights. When compared to the Norwegian Oil Fund managed by NBIM, there are different weights for the assets. The fund had 72% invested in equities, 25.4% invested in bonds (fixed income), 2.5% in real estate, and 0.1% in renewable energy infrastructure (NBIM, 2022). In addition, the famous paper "*Historical Returns of the Market Portfolio*" reported average weights for stocks as 50.4% and 43.7% for bonds during the study (Doeswijk, Lam, & Swinkels, 2020). Therefore, we construct more portfolios during this chapter where the goal is to observe whether our portfolios change weights in line with portfolios from the real world or other literature regarding portfolio selection.

5.3.1.2 Sample 2000Q1–2020Q1

In this sample, we compared the minimum variance portfolio with Nordic equities for the sample period (2000Q1–2020Q1). From the literature presented in the paper, we already know that equities generate the highest return. We wanted to investigate if the minimum variance portfolio can achieve higher returns with lower risk than equities in the Nordic countries. The minimum variance portfolio provided us with the following weights**.**

Table 16: *Minimum variance portfolio 2000Q1–2020Q1*

Asset	T.b. Nor	EU Bond	T.b. Den	R.e. Swe	R.e. Fin	T.b. Fin	Eq. Fin	Pall.	R.e. Nor
Weigths	33.67	31.70	14.88	7.94	7.05	3.29	0.86	0.59	0.01

Note: T.b. Nor, T-bonds Norway; T.b. Den, T-bonds Denmark; R.e. Swe, Real estate Sweden; R.e. Fin, Real estate Finland; T.b. Fin, T-bonds Finland; Eq.Fin, Equities Finland; Pall., Palladium; R.e. Nor, Real estate Norway. Numbers are given in percent.

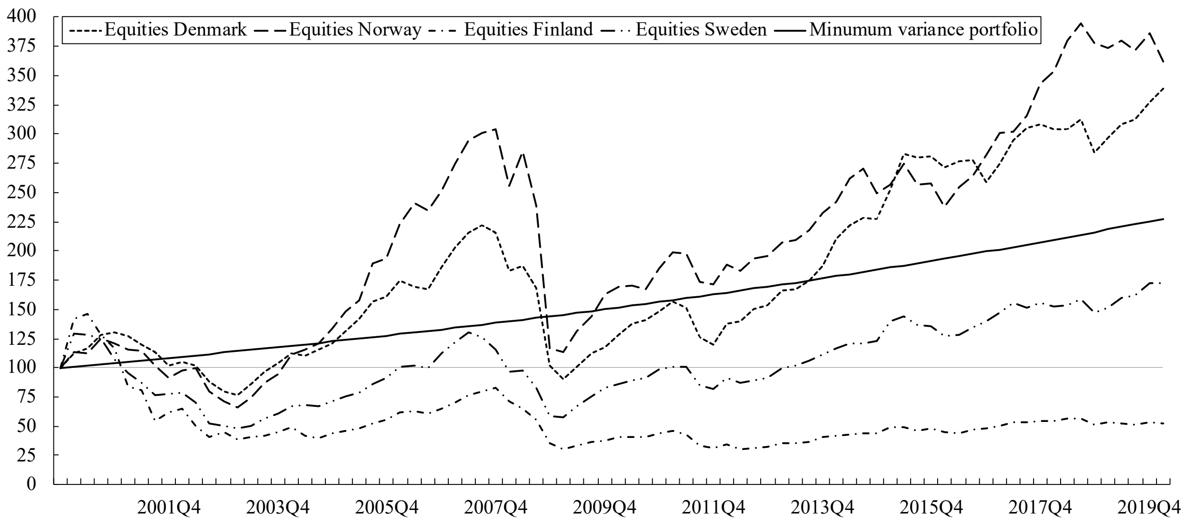
When compared to Nordic equities, we observed the true benefits of the minimum variance portfolio in the real world as well as the practical disadvantages of such portfolio. The performance of Nordic equities and the minimum variance portfolio are illustrated in Figure 3. The illustration should be seen together with Table 17.

Table 17: *Performance of equities in Denmark, Norway, Finland, and Sweden against the minimum variance portfolio between 2000Q1-2020Q1*

	Eq. Den	Eq. Nor	Eq. Fin	Eq. Swe	Min.var portfolio
Total return	239.10	261.97	-47.15	72.07	127.33
Cumulative quarterley return	1.51	1.60	-0.78	0.67	1.01
Cumulative annual return	6.21	6.55	-3.10	2.71	4.13
Standard deviation quarterly	2.54	2.66	1.28	1.72	0.84
Standard deviation annual	10.55	11.05	5.20	7.06	3.39

Note: Eq. Den, Equities Denmark; Eq.Nor, Equities Norway; Eq. Fin, Equities Finland; Eq. Swe, Equities Sweden.Cumulative return is calculated from total return. Numbers are given in percent.

Figure 3: *Equities and minimum variance portfolio performance between 2000Q1-2020Q1*



Note: Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

The minimum variance portfolio displayed two advantages: first, we observed low quarterly risk during the period when compared to the other assets. Second, we observed a decent amount cumulative quarterly return over time. Furthermore, when compared to the other assets in the figure, the portfolio outperformed a 100% invested portfolio in the Finnish and Swedish stock markets during the timeframe. We observed that if an investor invested funds in the Finnish stock market from 2000Q1 until 2020Q1, the funds would yield negative returns; however, Norwegian and Danish equities outperformed the minimum variance portfolio during the period with far greater cumulative return, but those stock markets also yielded higher risk. One should also note that the global minimum variance portfolio held 0.84% quarterly (3.39% annually). Finnish equities due to the low variance of this asset. When analyzing the return figure, one specific theory becomes relevant: the theory behind efficient portfolios presented in Chapter 3.4 (Makowitz, 1952). The minimum variance portfolio, equities Denmark, and equities

Norway yield the highest return. These three portfolios offer the highest expected return at a given level of risk (standard deviation); however, the minimum variance portfolio and equities in Denmark offer a higher return than equities in Finland and Sweden. If the given level of risk is a maximum standard deviation of 2.54% quarterly (10.55% annually), then both equities Denmark and minimum variance portfolio would be efficient portfolios when compared to equities Norway, Finland, and Sweden. One should also note that equities in Norway have a higher standard deviation than equities in Finland and Denmark, but Norwegian equities also yield a higher return during the period. Finland displayed negative returns during the sample period with lower standard deviation that any other Nordic country. In Chapter 3.4 we learned that investors don't prefer lower standard deviations if returns are scarified (Makowitz, 1952).

5.3.1.3 Minimum variance portfolio: 2010Q1–2021Q4

When we changed the horizon for performance from 2000–2020 to 2010–2021, we observed dramatic changes in cumulative return for the minimum variance portfolio. The 2010–2021 portfolio presented us with the following weights with eight different assets, seven of which are Nordic.

Table 18: *Minimum variance portfolio: 2010Q1–-2021Q4*

Asset	**R.e. Fin**	**T.b. Nor**	**T.b Fin**	**EU Bond**	**R.e. Swe**	**T.b Swe**	**Eq. Nor**	**T.b. Den**
Weights	23.60	22.22	19.52	11.12	10.93	10.39	1.99	0.21

Note: R.e. Fin, Real estate Finland; T.b. Nor, T-bonds Norway; T.b. Fin, T-bonds Finland; R.e Swe, Real estate Sweden, T.b Swe, T-bonds Sweden; Eq. Nor, Equities Norway; T.b. Den, T-bonds Denmark. Numbers are given in percent.

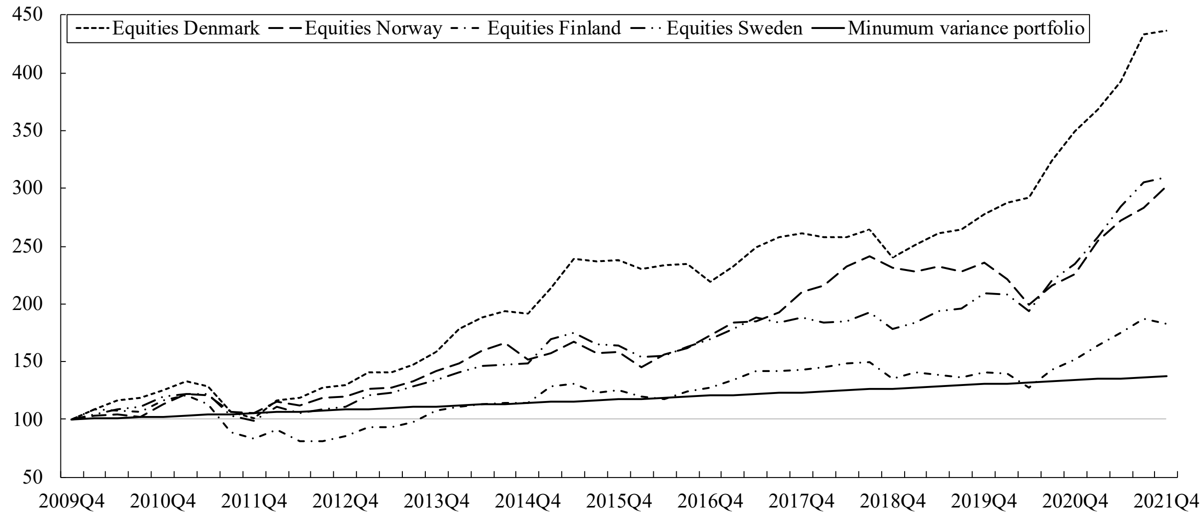
The performance of the minimum variance portfolio compared to Nordic equities is illustrated in Table 19.

Table 19: *Asset performance equities and minimum variance portfolio: 2010Q1-2021Q4*

	Eq. Den	**Eq. Nor**	**Eq.Fin**	**Eq. Swe**	**Min.var. Portfolio**
Total return	337.13	201.62	82.62	209.44	37.55
Cumulative quarterley return	2.99	2.23	1.21	2.28	0.64
Cumulative annual return	12.52	9.23	4.94	9.46	2.58
Standard deviation quarterly	5.85	5.59	6.45	5.61	0.46
Standard deviation annual	25.54	24.30	28.41	24.39	1.87

Note: Eq. Den, Equities Denmark; Eq.Nor, Equities Norway; Eq. Fin, Equities Finland; Eq. Swe, Equities Sweden.Cumulative return is calculated from total return. Numbers are given in percent.

Figure 4: *Equities and minimum variance portfolio performance between 2010Q1-2021Q4*



Note: Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

We observed a substantial change in the minimum variance portfolio if we constructed it for the given period. The portfolio performed less than all the Nordic equity portfolios regarding returns; however, regarding standard deviation and variance, it was still the portfolio with the lowest risk. An noteworthy observation became relevant when we observed the four selected Nordic countries. Stocks in Denmark, Norway, and Sweden all yielded significantly higher returns than stocks in Finland during the period. Furthermore, the standard deviation in all three countries was lower than 6.45%, which corresponds to the standard deviation in Finland for this period. The observation indicated that if an investor were 100% invested either in Denmark, Norway, or Sweden, the investor would have earned a higher return in these three countries when compared to Finland. In addition, the investor would have achieved a lower standard deviation in each of the three countries when compared to the Finnish equity portfolio during this period.

5.3.2 Nordic investments: t-bonds, real estate, and stocks

In this section, we are interested in the minimum variance portfolio within each country with their respective assets. We constructed a sample that reflects the "all-time portfolio" starting from the date each observation starts. The second portfolio is for the period between 2000Q1 and 2020Q1. Lastly, we reconstructed the portfolio again with a restriction of a specific rate of required return. The required rate of return was based on what we saw as a benchmark of returns. The required annual return was 6.62%, equivalent to 1.62% quarterly. The return rate was based on the annual return from the Norwegian Oil Fund, which was 6.62% from January

1998 until the end of 2021. The standard deviation yielded 7.98% in the same period (NBIM, 2022). In comparison, the well-known paper *"Historical Returns on the Market Portfolio"* reported a compounded annual real return of 4.45% with a standard deviation of 11.2% from 1960 to 2017 (Doeswijk et al., 2019). The purpose of this section is the observation of changes in weights between the asset classes and how this affects the risk and return.

5.3.2.1 Denmark

The results for Denmark are presented in Table 20. We observed that the minimum variance portfolio mainly consisted of t-bonds and real estate; however, the weights were changed during the 2000Q1–2020Q1 period. In addition, 2.03% of stocks were introduced during this period, and we also observed a decrease in return and standard deviation for the shorter period.

Table 20: *Portfolios with Danish assets*

	Weights		
Asset	**All time**	**2000Q1-2020Q1**	**Restricted portfolio**
Real estate Denmark	19.16	9.34	1.56
T-bonds Denmark	80.83	88.63	75.88
Equities Denmark	0.00	2.03	22.56
Standard deviation	1.13	0.73	1.99
Return	1.38	0.92	1.62

Note: Returns and standard deviation is reported quarterly. The required annual return for restricted portfolio is 6.62% annually, equivalent to 1.62% quarterly.

The requirement was based on the same annual return as the Norwegian Oil Fund (NBIM, 2022). We observed a change in the weights of the assets when we had a required rate of return equal to the Norwegian Oil Fund. The portion of equities increased significantly, t-bonds were reduced, and real estate was reduced.

5.3.2.2 Finland

The results for Finland are presented in Table 21. In Finland, the minimum variance portfolio was the same for both samples; however, stocks were introduced during 2000Q1–2020Q1. In addition, the portfolio yielded a lower return and risk when compared to the all-time portfolio. The restricted portfolio with a required rate of return moved in a similar pattern as the previous country. Real estate was removed from the portfolio, t-bonds were reduced, and equities increased a great amount.

Table 21: *Portfolios with Finnish assets*

	Weights		
Asset	**All time**	**2000Q1-2020Q1**	**Restricted portfolio**
Real estate Finland	26.44	23.14	0.00
T-bonds Finland	73.56	75.99	71.27
Equities Finland	0.00	0.87	28.73
Standard deviation	1.14	0.64	3.11
Return	1.41	0.84	1.62

Note: Returns and standard deviation is reported quarterly. The required annual return for restricted portfolio is 6.62% annually, equivalent to 1.62% quarterly.

5.3.2.3 Norway

The results for Norway are presented in Table 22. In Norway, we observed two almost identical portfolios regarding weights; however, real estate reduced in the 2000Q1–2020Q1 period, and t-bonds increased. The exposure to stocks also slightly increased. We noticed the same pattern regarding return and standard deviation as the previous two countries. The return and standard deviation was lower for the shorter period sample. In Norway, it is not possible to achieve a return lower than 1.66% quarterly if an investor is invested in Norwegian real estate, t-bonds, and equities (combined); therefore, we could not construct a portfolio with a required return of 1.62% quarterly.

Table 22: *Portfolios with Norwegian assets*

	Weights	
Asset	**All-Time**	**2000Q1-2020Q1**
Real estate Norway	18.17	9.33
T-bonds Norway	80.76	89.20
Equities Norway	1.08	1.47
Standard deviation	1.146	0.77
Return	1.66	1.11

Note: Returns and standard deviation is reported quarterly.

5.3.2.4 Sweden

The results for Sweden are presented in Table 23. The Swedish all-time minimum variance portfolio relied heavily on bonds and real estate with a small portion of stocks; however, the weights changed if we developed the same portfolio during 2000Q1-2020Q1. The weight of stocks and bonds increased, and real estate decreased. Furthermore, the return and standard deviation was lower. When constructing the restriction portfolio in Sweden, the portfolio was weighted significantly toward real estate and t-bonds. In addition, a small portion is invested in equities.

***Table 23**: Portfolios with Swedish assets*

	Weights		
Asset	**All time**	**2000Q1-2020Q1**	**Restricted portfolio**
Real estate Sweden	35.05	16.55	43.08
T-bonds Sweden	64.26	80.97	48.85
Equities Sweden	0.69	2.47	8.07
Standard deviation	1.12	0.71	1.33
Return	1.54	1.02	1.62

Note: Returns and standard deviation is reported quarterly. The required annual return for restricted portfolio is 6.62% annually, equivalent to 1.62% quarterly.

5.3.2.5 Brief summary

In all Nordic countries, the minimum variance portfolio mainly consisted of t-bonds and real estate with an eventual change in weights. The Norwegian all-time portfolio not only yielded the highest return with 1.66% each quarter but also the highest standard deviation of 1.15%; however, its risk was only marginally higher than the other countries. The Swedish all-time portfolio delivered 1.54% quarterly return, which was higher than the Danish and Finnish all-time portfolios. In addition, the risk was lower in the Swedish portfolio during this period (1.12% standard deviation).

When investigating the restriction portfolio, the Finnish portfolio had the highest risk measured with a standard deviation of 3.11% (each quarter). In comparison, Sweden had the lowest risk with a standard deviation of 1.33%. In this case, the Swedish restriction portfolio was the efficient portfolio when compared to the Finnish and Danish restriction portfolio (Makowitz, 1952). We also discovered that it was not possible to construct the restriction portfolio in Norway because it was not possible to achieve a quarterly return lower than 1.66% (the restriction portfolio required a return of 1.62%). When setting a benchmark equal to the Norwegian Oil Fund, we observed changes in the weights in all Nordic portfolios in a direction toward the Norwegian Oil Fund (NBIM, 2022). The weight of equities in the portfolios increased dramatically in Finland and Denmark in the direction of the fund; however, this was not the case for Sweden. Furthermore, the annual standard deviation in each restriction portfolio was higher than the Norwegian Oil Fund.

5.4 Samples: Performance during economic events

In our analysis, we found that various asset classes went from being among the greatest investments (when compared to the arithmetic average) to being among the worst (when negative returns and volatility were considered). Several assets experienced huge negative movements in a short period of time, and the existence of economic events can help explain this phenomenon in part. The following establishes the groundwork for further investigation into how different assets performed during economic events. The analysis of samples allowed us to compile a large, comprehensive knowledge base that can be utilized to improve portfolio diversification and hedging of during periods of excessive volatility.

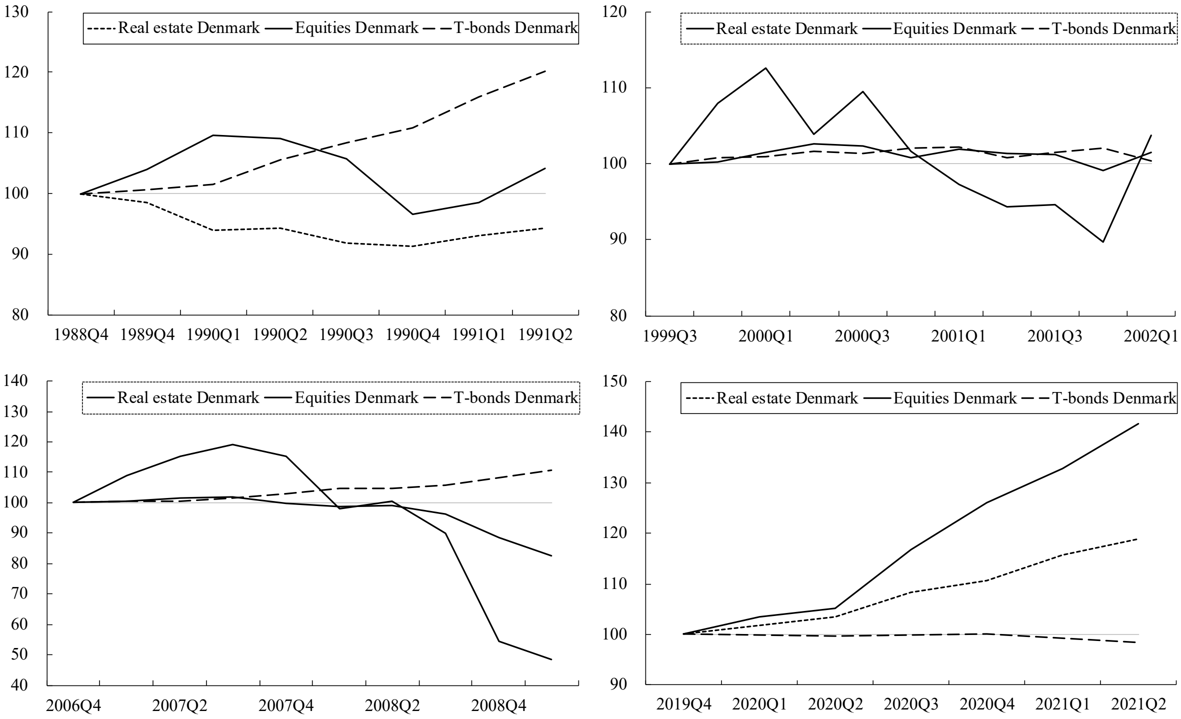
We decided to examine four separate economic events to determine how assets have performed over the course of the time and whether there are any patterns within asset classes and within specific Nordic countries. The first economic event was during 1989Q4–1991Q2. During this period, the Gulf War occurred and the slow-moving saving and loan crisis begun (Kenton, 2022). These major global events caused economic recession with major uncertainty in the investment universe across all asset classes. Second, we chose the dotcom bubble (Hayes, 2022) since, between 1995 and 2000, the Nasdaq index went from 1,000 points to more than 5,000 points. The bubble burst between 2001 and 2002 and major technology companies almost dropped 80% across the stock exchanges globally. We have defined this event during 1999Q4 to 2001Q4. Third, we have chosen the financial crisis of 2007–2009 (Singh, 2022). The crisis that fueled a housing bubble began years earlier with cheap credit and low lending standards. When the bubble burst, financial institutions were left holding trillions of dollars' worth of near-worthless investments in subprime mortgages. Finally, we chose the pandemic caused by the COVID-19 virus that caused lockdown and restrictions globally from early 2020 to late 2021 and defined this as the 2020Q1–2021Q2 economic event.

5.4.1 Denmark

As illustrated in Figure 5, the performance of Danish real estate, stocks, and government bonds during four different economic events may be observed. During the first event, which occurred in the 1990s, real estate was the sector most adversely affected. A considerable increase in the yields for government bonds was observed, although the yields on stocks fluctuated considerably. It is evident from the graph that Danish bonds and real estate provided rather constant returns during the IT boom of the early 2000s, and they appeared to be unscathed by the bubble bursting. The stock market had a couple down quarters before beginning to rebound. During the financial crisis of 2007-2009, the Danish market witnessed increased volatility.

While government bonds rose in value, the housing market dropped approximately 20% and stocks became the poorest performer, losing more than half of their value. In the final sample, we investigated the pandemic, and it appears that the real estate market and the stock market altered their old patterns and witnessed substantial gains. The government bond, on the other hand, was stable, albeit with a tiny inclination in the direction of a downward movement.

Figure 5: *Asset performance in Denmark under economic events*

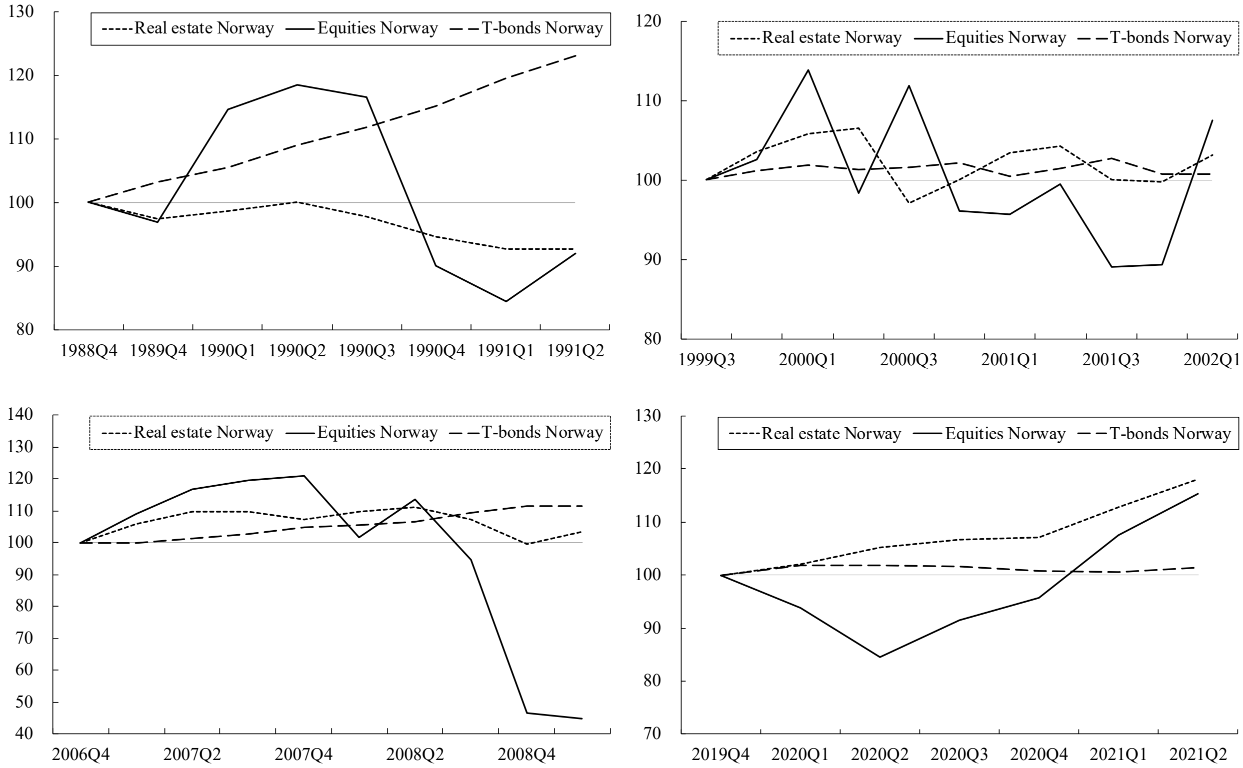


Note: Quarterly observations of each asset. Please note that the number of quarters for each event is not the same. Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

5.4.2 Norway

The performance of real estate, stocks, and government bonds in Norway during four economic events can be seen in Figure 6. Throughout all economic events, the Norwegian government bond preserved its value and exhibited low volatility. The government bond increased significantly during the first quarter of 1990 to the second quarter of 1991 as well as during the financial crisis from 2007 to the first quarter of 2009. Equities underwent significant volatility with a high return followed by a period of significant negative returns in the 1990s. In the next economic events, it appeared that equities endured corrections of 10–20% before recovering and rising in value, apart from the financial crisis in 2007–2009, whereby the equities more than halved in value. While the value of real estate fluctuates slightly, it had not experienced significant declines or gains throughout the first three events. During the pandemic, the value of real estate increased significantly.

***Figure 6:** Asset performance in Norway under economic events*

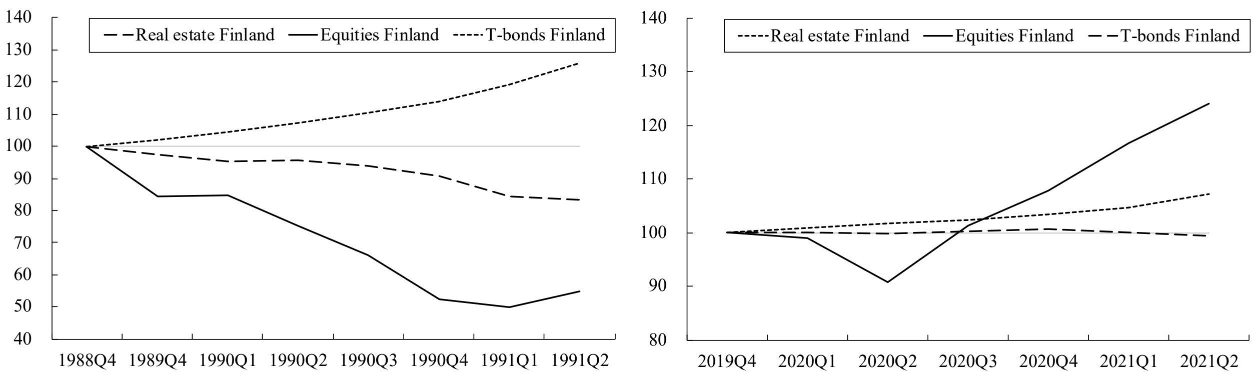


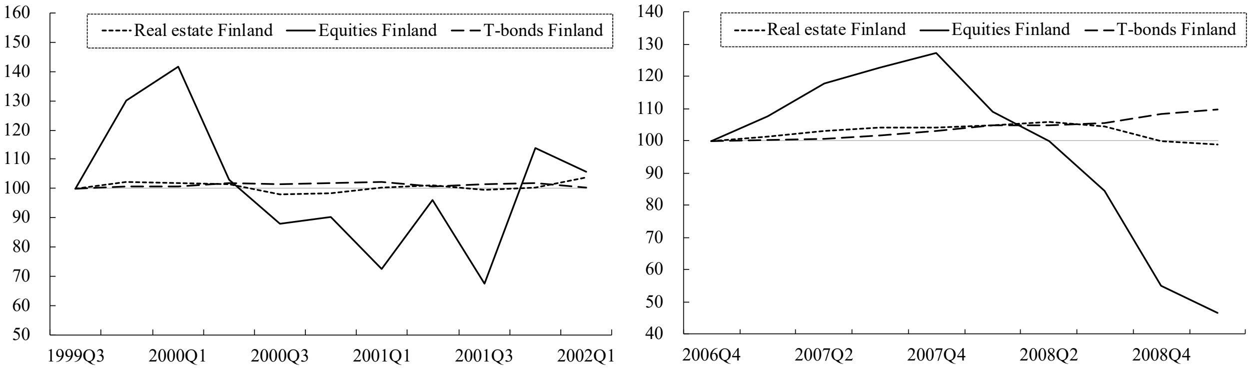
Note: Quarterly observations of each asset. Please note that the number of quarters for each event is not the same. Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

5.4.3 Finland

As highlighted in Figure 7, we observed that the Finnish government bonds had lower volatility during all events and maintained its value or provided a positive return on a general basis. During the first three events, stock prices were significantly volatile, and they lost a significant amount of value. Comparatively, stocks in Finland suffered bigger losses during these events than those in Norway, Sweden, and Denmark. The value of real estate dropped by nearly 20% during the first event, but it maintained or increased in successive events.

***Figure 7:** Asset performance in Finland under economic events*



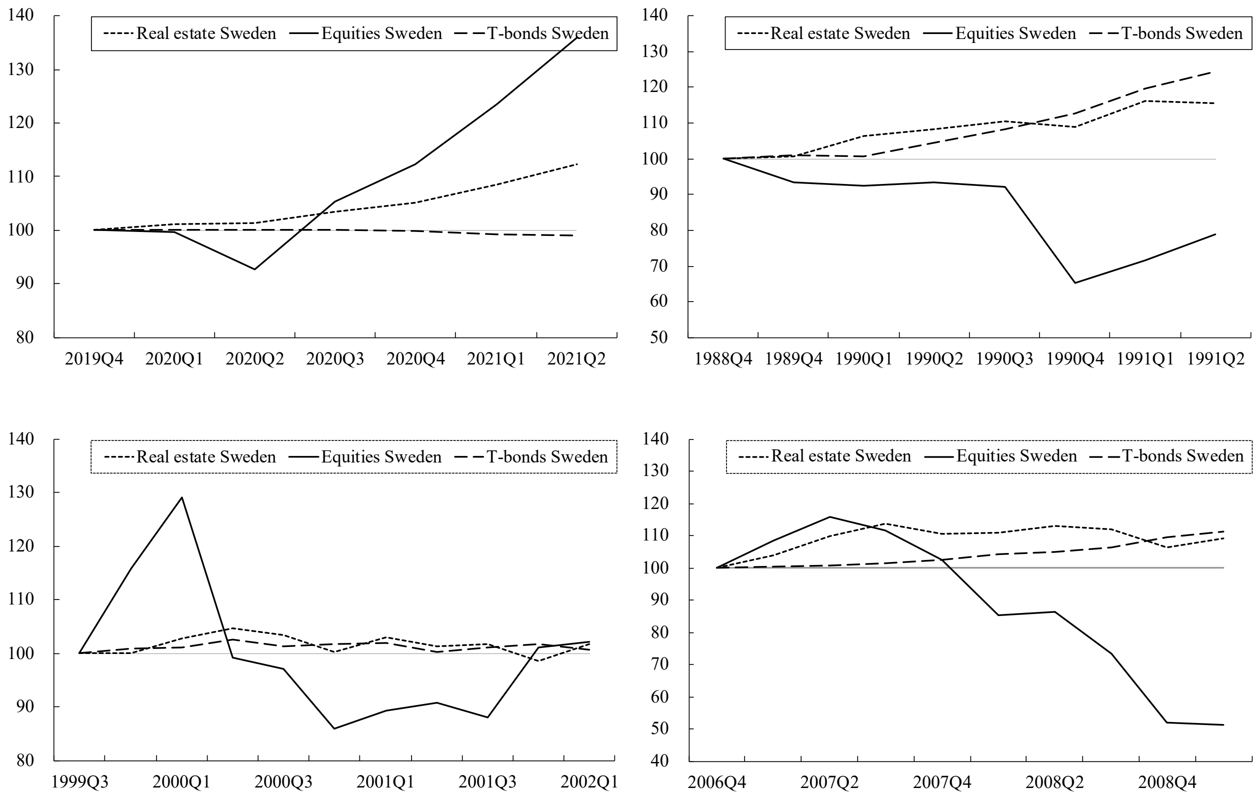


Note: Quarterly observations of each asset. Please note that the number of quarters for each event is not the same. Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

5.4.4 Sweden

Swedish government bonds displayed lower volatility and retained its value, and, in some cases, they produced a positive return during all events. Equities endured tremendous volatility in the initial instance, and their value halved during the financial crisis in 2008–2009. Equities had a minor dip during the pandemic, but they swiftly recovered and surged substantially higher. In all the economic events, the value of real estate either remained constant or increased.

Figure 8: *Asset performance in Sweden under economic events*

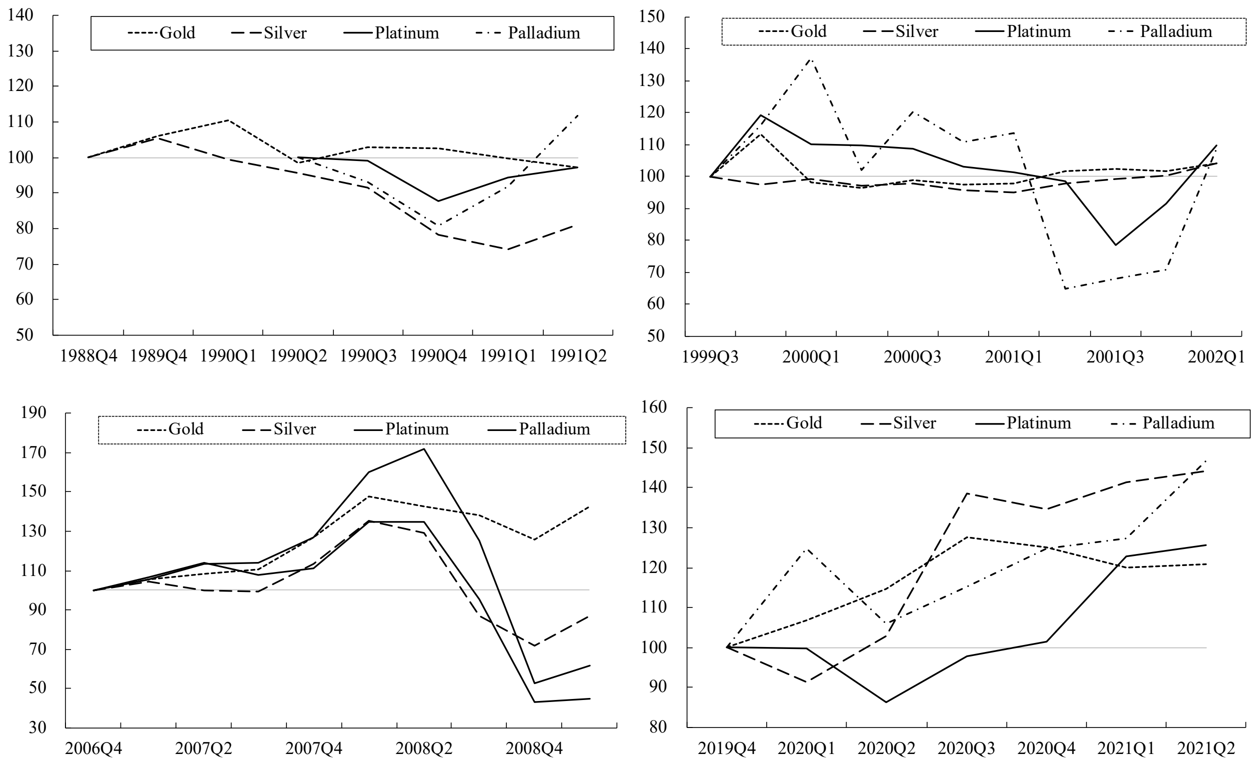


Note: Quarterly observations of each asset. Please note that the number of quarters for each event is not the same. Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

5.4.5 Commodities

Figure 9 depicts the performance of gold, silver, platinum, and palladium throughout the course of four economic events. It appeared that gold was less volatile and performed better than other assets during selected events. The other metals were slightly more volatile than gold and silver. Volatility was more pronounced in the first three economic events depicted in the figure than it was under the last event. Every asset experienced a decline in value, while gold experienced a rise during the financial crisis. In the Nordic region, the movement and performance of platinum, palladium, and silver appeared to have a similar pattern as stocks. This discovery was supported by the correlation matrix seen in Table 6 in the Appendix, which demonstrates that the correlation between gold and stocks was about 0, while the correlation between the other metals ranged from 0.2 to 0.538, depending on the country. As a result of these characteristics, gold appeared to be a superior choice for boosting the diversification effect of a portfolio during periods of high volatility, which is line with the findings from Kyriazis (2020).

Figure 9: *Performance of commodities under economic events*

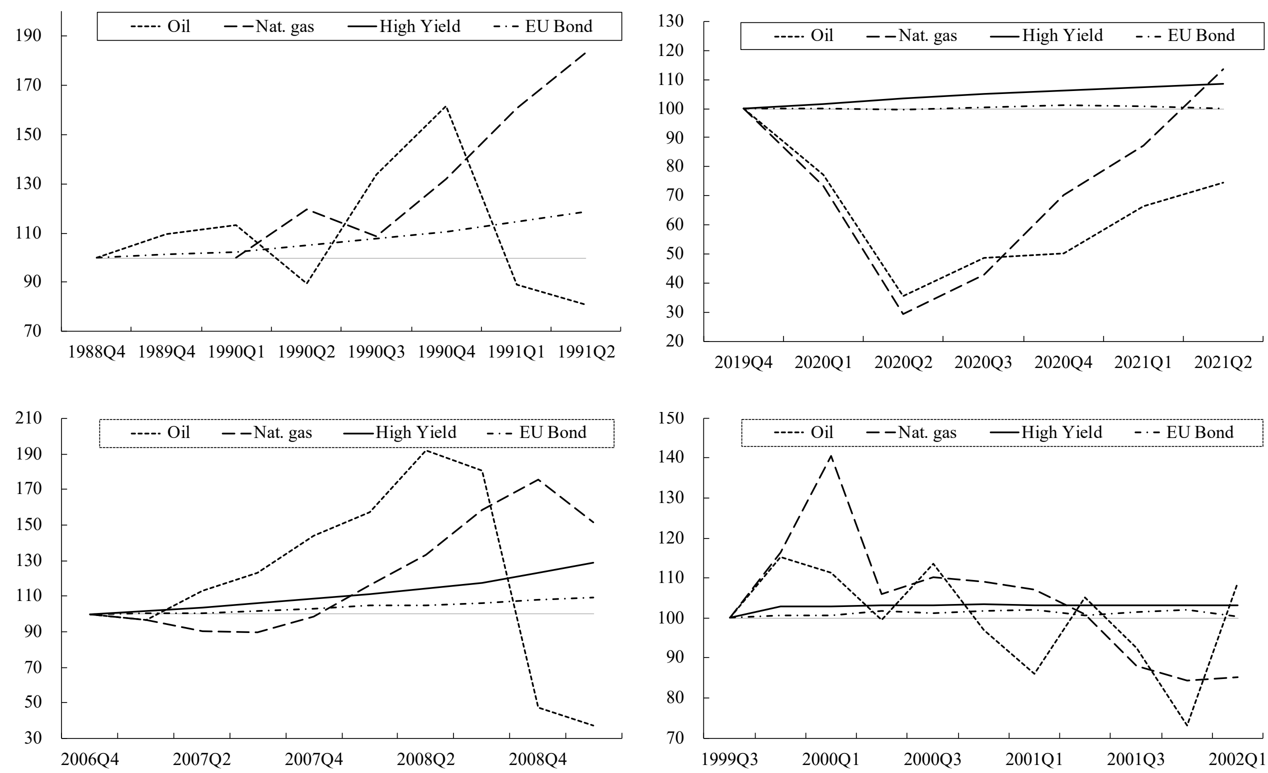


Note: Quarterly observations of each asset. Please note that the number of quarters for each event is not the same. Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

5.4.6 EU bond, high yield, oil and gas

Figure 10 depicts the performance of oil, natural gas, high yield, and EU bonds over four economic events. In line with our expectations, the EU bond and high yield were relatively stable and exhibited little volatility. Nonetheless, we observed that EU bonds in the chosen events provided returns ranging from 10–20 % in the first and third event. Oil and gas were volatile, and, at the beginning of each period, oil appeared to be in the lead before gas followed suit with similar movement and performance, which appeared rational for natural reasons. The correlation value between oil and gas, however, was only 0.29, which is not particularly high in principle and could indicate that there was less covariation outside of the sample periods.

***Figure 10**: Asset performance under economic events*



Note: Quarterly observations of each asset. Please note that the number of quarters for each event is not the same. Due to a lack of data, high yield is removed from the first economic event. Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

5.4.7 Brief summary

From Table 24, we saw that among Nordic assets classes, bonds performed the best in terms of their average return during economic events, followed by real estate and equities. Sweden was the best performer in real estate, while Denmark was the greatest performer in stocks and Norway was the best performer in t-bonds. Regarding all assets, gold and natural gas were one of the best performers. We found evidence of real estate performing well or, at the least, not losing a significant amount of value throughout these economic downturns. This was consistent with the findings of Gao, Lin, and Na (2009) who discovered that, during economic upturns, house prices tended to respond with rapid house price increases; however, during economic downturns, house prices exhibited strong resistance to house price declines (Gao et al., 2009). Overall, bonds and gold performed well, demonstrating strong resistance to losses during periods of economic uncertainty. Equities and commodities (except for gold and silver), on the other hand, exhibited high volatility and faced significant reductions in value. Results from Table 24 indicated that gas yields high returns on average during economic events yielding a return of 4.55 for each quarter. However, the risk measured in standard deviation is high (21.21%).

***Table 24:** Summary of the performance for all assets during economic events.*

	1989Q4-1991Q2		1999Q4-2002Q1		2007Q1-2009Q1		2020Q1-2021Q2		Average	
Variable	**Return %**	**St.dev**	**Return %**	**St.dev**	**Return %**	**St.dev**	**Return %**	**St.dev**	**Return %**	**St.dev**
Real estate Denmark	-0.83	2.31	0.15	1.01	-2.08	3.29	2.94	1.37	0.04	2.00
Real estate Norway	-1.09	1.95	0.31	3.01	0.39	4.20	2.81	2.36	0.61	2.88
Real estate Finland	-2.60	2.22	0.37	1.72	-0.12	1.90	1.17	0.78	-0.29	1.65
Real estate Sweden	2.09	3.03	0.17	1.79	0.98	3.53	1.94	1.21	1.29	2.39
Equties Denmark	0.58	5.19	0.37	7.43	-7.73	14.89	5.97	3.92	-0.2	7.86
Equties Norway	-1.19	12.83	0.72	8.59	-8.49	19.58	2.39	7.01	-1.64	12.00
Equties Finland	-8.25	10.32	0.54	23.40	-8.16	14.55	3.67	6.99	-3.05	13.82
Equties Sweden	-3.34	13.15	0.22	13.55	-7.19	12.09	5.26	6.87	-1.27	11.42
T-bonds Denmark	2.65	1.52	0.03	0.64	1.14	0.86	-0.25	0.48	0.89	0.87
T-bonds Norway	2.99	0.47	0.08	0.69	1.23	0.92	0.22	0.52	1.13	0.65
T-bonds Finland	3.36	0.47	0.04	0.61	1.04	0.75	-0.09	0.43	1.09	0.78
T-bonds Sweden	3.15	1.31	0.06	0.66	1.20	0.93	-0.17	0.38	1.06	1.02
High yield			0.31	0.19	2.87	1.17	1.38	0.31	1.14	0.56
Eu bond	2.49	1.05	0.05	0.61	1.00	0.66	0.04	0.58	0.89	0.72
Gold	-0.42	5.80	0.42	5.00	4.01	8.82	3.22	5.51	1.81	6.28
Silver	-2.97	7.73	0.39	2.54	-1.53	17.68	6.28	14.91	0.54	10.72
Platinum	-0.69	5.03	0.92	11.48	-5.21	25.74	3.86	13.05	-0.28	13.83
Palladium	2.80	12.83	0.83	24.79	-8.56	22.93	6.60	14.63	0.42	18.79
Oil	-3.03	30.47	0.85	13.47	-10.32	29.73	4.79	29.91	-4.32	25.90
Gas	12.89	13.22	-1.58	16.85	4.75	11.70	2.15	43.08	4.55	21.21
Bitcoin							25.00	37.00	25.00	37.00

Note: The table summarizes performance of each asset during economic events as presented in previous subchapters. The table reports measurements in numbers for comparison purposes.Return is equal to cumulative nominal quarterly return in percent.

5.5 Sample: Nordic asset performance 2000Q1-2021Q4

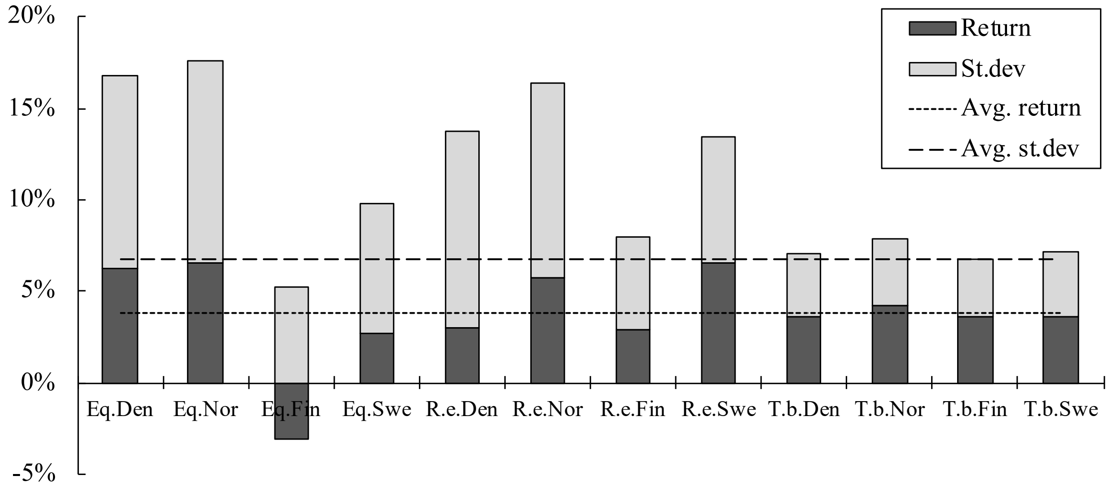
Table 25 below describes the risk and return for Nordic assets from 2000Q1 to 2021Q4. Figure 11 is a graphical illustration of Table 25.

Table 25: *Performance for Nordic assets from 2000Q1-2020Q1*

Variable	Total return (%)	Quarterly return (%)	Annual return (%)	St.dev quarterly (%)	St.dev annual (%)
Equities Denmark	239.10	1.51	6.21	2.54	10.55
Equities Norway	261.97	1.60	6.55	2.65	11.05
Equities Finland	-47.16	-0.78	-3.10	1.27	5.20
Equities Sweden	72.07	0.67	2.71	1.72	7.06
Real estate Denmark	82.26	0.74	3.00	2.57	10.71
Real estate Norway	208.99	1.40	5.72	2.56	10.64
Real estate Finland	79.62	0.72	2.93	1.23	5.02
Real estate Sweden	257.71	1.58	6.49	1.70	6.98
T-bonds Denmark	103.21	0.87	3.56	0.86	3.49
T-bonds Norway	132.33	1.04	4.25	0.89	3.61
T-bonds Finland	103.49	0.88	3.57	0.78	3.18
T-bonds Sweden	104.35	0.88	3.59	0.87	3.56
Average	133.16	0.92	3.79	1.64	6.75

Note: Quarterley return is calculated by total return. Quarterley return and annual return is equal to cumulative nominal return in percent.

Figure 11: *Annual Risk and return for Nordic assets from 2000Q1-2020Q1*

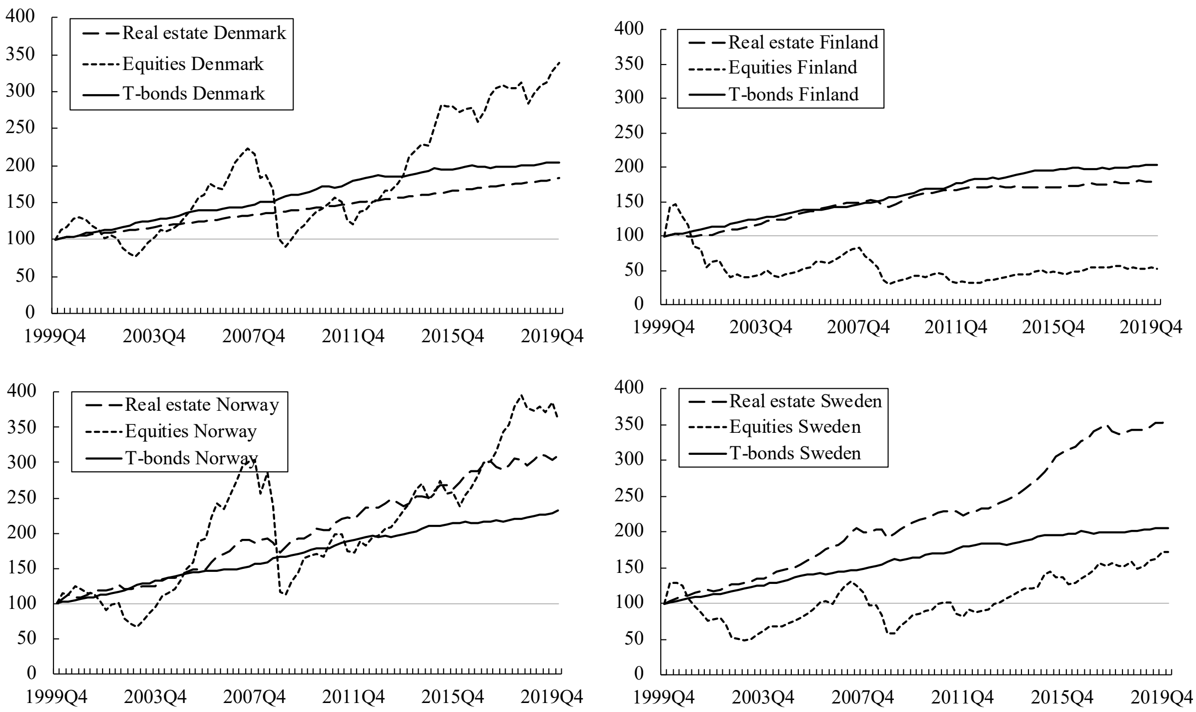


Note: Eq.Den, Equities Denmark; Eq.Nor, Equities Norway; Eq.Fin, Equities Finland; Eq.Swe, Equities Sweden; R.e.Den, Real estate Denmark; R.e.Nor, Real estate Norway; R.e.Fin, Real estate Finland; R.e.Swe, Real estate Sweden; T.b.Den, T-bonds Denmark; T.b.Nor; T-bonds Norway; T.b.Fin, T-bonds Finland, T.b.Swe, T-bonds Sweden

In terms of total return, equities in Norway yielded the highest returns. Finland was the only Nordic country that yielded negative returns for equities. Real estate in Sweden and Norway yielded far higher returns than Finland and Denmark and, therefore, may be the most ideal option for Nordic real estate investments during the period. Returns on government bonds are identical, except for returns from Norway. In Norway, the return on t-bonds was 30% higher in total when compared to other Nordic countries (see Table 25, total return for t-bonds); therefore, this may be the best option regarding bonds during the period. Regarding the risk measured in standard deviation during the period, we found evidence for bonds as the asset class with the lowest risk, followed by real estate, in some cases, then equities. The results implied that

Norwegian real estate and Danish real estate had almost the same standard deviations as their respective stock markets. In Finland, we discovered the lowest standard deviation regarding stocks, but the returns were negative for this period. The results implied that there were several Nordic assets that performed during this period. For instance, all Nordic bonds had higher returns and lower standard deviations than Finnish stocks. Furthermore, the same can be said about Finnish real estate when compared to Finnish stocks. Dimson, Marsh, and Staunton (2008) reported that stocks were the best performing asset in all countries during their study, and our findings regarding stocks for the 2000Q1 to 2021Q4 period were in line with the literature for three of the four investigated Nordic countries.

Figure 12: *Performance for Nordic assets from 2000Q1-2020Q1*



Note: Quarterly observations of each asset. Y-axis illustrates the value of an investment of 100, invested from the beginning and throughout the period illustrated in the X-axis

6. Conclusions and implications

This section includes a presentation of the study's conclusion, a discussion of the study's limitations, and a recommendation for further research.

6.1 Conclusion

This paper aims to investigate long-term investment returns of several assets, mainly focusing on the assets in Nordic region. Performance of the assets are investigated in general and through samples. In Chapter 2.3 we defined the following two research questions:

> *How does risk and return on assets differ among the Nordic countries? Which Nordic country offers the most ideal option for the minimum variance portfolio?*

The findings imply that equities are one of the best performing asset classes in all the Nordic countries, followed by real estate and government bonds. Equities have the highest risk, followed by real estate and government bonds. During four different economic events, we found the highest risk and the lowest return in Finnish equities, while the returns on Swedish real estate were the highest. One of the main findings was that Finnish equities are the only Nordic asset that delivers negative returns the last 21 years. The findings for the first research question are that risk and return differ among Nordic asset classes. Depending on the asset class investors are exposed to, risk and return will vary. In addition, risk and return vary among the countries.

Regarding research question two, the Swedish minimum variance portfolio offers one of the best options regarding risk and return when combining assets within the Nordic countries. In addition, the Norwegian all-time portfolio yields the highest return with the highest risk.

The study is a contribution to existing literature, especially from a Nordic point of view regarding investment returns. Furthermore, since previous research focuses on global or national studies, our study is a contribution to practical investment purposes for private investors, institutional investors, and real estate developers in the Nordic region.

6.2 Limitations and further research

We were aware that direct commercial real estate investments are a profitable investment object in the Nordic region, and, as a result, they should have been included in our selection of assets; although the data does exist, these assets were excluded from our analysis since we did not have access to it. Further research may include direct commercial real estate investments in the creation of a portfolio that is more reflective of the Nordic investment environment.

We employed both the CAPM and Fama and French's three-factor models, and we discovered that achieving statistically significant values for all assets was difficult. In this circumstance, we observed that the model itself may not be problematic, but rather the market we chose. Following up on what was said previously, this is the portfolio of Fama and French, which was distinguished by the predominance of stocks. Further study should, therefore, attempt to implement a global portfolio that is more reflective of all the asset classes available in the market, as this would most likely result in higher degrees of significance. Alternatively, one might design a Nordic portfolio based on market capitalization. This conforms with Doeswijk et al. (2020).

Considering macroeconomic conditions and their impact on returns, it is possible to further study how the economic conditions of other nations affect the Nordic region. Examples include how macroeconomic conditions in the United States can explain asset performance in the Nordic region.

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Appendix

***Table 1:** Annual nominal return (all time)*

	Real estate				Equities				T-Bonds				EU bonds		Commoditites						Crypto
Year	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**H.Y**	**EU**	**Gold**	**Silver**	**Plat.**	**Pall.**	**Oil**	**Gas**	**Bitcoin**
1960							2	4													
1961							-8	2													
1962							7	-11													
1963							1	24													
1964							2	13													
1965							-9	9													
1966							-8	-20													
1967							-7	3													
1968							36	24							0	-7					
1969							26	5							-6	-7					
1970	0	0	4	5			18	-26						5	-1	-9					
1971	18	5	5	5			7	20						9	14	-23					
1972	16	12	11	8			49	13						8	44	37					
1973	15	1	31	7			44	0						6	48	53					
1974	5	14	14	13			-21	0						6	60	42					
1975	16	3	5	17			-2	23						13	-20	-9					
1976	11	7	4	15			-17	-4						7	-12	1					
1977	16	17	1	16			-20	-16						12	25	10					
1978	11	14	4	12			8	17						11	32	23					
1979	8	4	8	9			24	-2						7	83	166					
1980	-3	19	13	-1			-4	15						9	37	-66					
1981	-6	27	15	-2			14	60						10	-35	-57					
1982	0	16	19	3			32	22						19	-1	6					
1983	26	5	20	1	64		71	73						15	-10	-12					
1984	14	6	8	4	-17		10	-9						17	-14	-29					
1985	19	12	3	3	37		-5	7		12				14	-3	-11					
1986	5	31	6	9	-18	0	69	66		14				14	23	-10					
1987	-9	14	17	14	-6	-1	35	-1	9	14		10		6	17	18			-5		
1988	4	-7	40	19	38	0	26	27	16	19	5	14		11	-13	-10			-25		
1989	-4	-14	6	16	35	56	-13	25	8	12	9	9		7	-6	-12			36		
1990	-7	-3	-7	8	-7	-7	-38	-30	10	12	12	12		9	-3	-26	-13	-25	47	32	
1991	4	-5	-17	6	8	-12	-22	5	14	13	17	19		13	-5	-2	-15	-11	-46	1	
1992	-5	-4	-20	-16	-29	-21	-11	-20	9	12	12	9		10	-6	-8	-1	16	-8	-8	
1993	8	8	3	-4	35	62	89	68	15	13	21	17		16	10	28	5	27	-22	7	
1994	6	10	2	4	-3	3	21	6	2	2	2	1		4	3	0	9	21	8	-5	
1995	12	8	-4	-1	5	16	-2	17	12	11	16	16		12	0	8	-1	-14	2	12	
1996	11	10	13	3	26	22	21	28	10	9	10	13		12	-3	-10	-8	-13	37	7	
1997	9	11	15	7	39	41	46	32	9	7	8	9	9	8	-19	14	3	66	-22	-17	
1998	9	6	9	11	-7	-37	29	0	9	6	9	10	10	9	-4	-13	-12	32	-44	-23	
1999	5	18	10	8	19	32	107	46	2	2	2	2	11	2	0	3	23	39	97	5	
2000	7	9	0	12	30	20	16	7	6	7	6	7	13	6	-9	-10	36	86	22	79	
2001	4	8	1	5	-22	-24	-47	-28	7	5	6	5	14	6	3	-7	-28	-65	-39	-20	
2002	4	3	9	9	-21	-22	-28	-35	5	9	6	6	13	6	16	7	32	-22	36	-15	
2003	4	4	7	6	30	34	1	21	5	8	5	5	10	5	20	21	28	-36	6	27	
2004	14	10	6	10	16	40	-2	18	6	5	5	7	8	6	10	20	10	1	47	19	
2005	25	8	9	11	33	45	25	27	5	4	5	6	8	5	11	20	12	12	26	56	
2006	14	16	5	10	16	30	18	24	3	2	2	3	8	3	25	48	16	30	3	23	
2007	0	7	4	10	15	21	27	2	3	5	3	3	8	3	27	14	27	11	44	-2	
2008	-11	-7	-4	-4	-53	-62	-57	-49	5	6	5	7	14	5	-1	-37	-58	-61	-67	79	
2009	-5	11	8	11	16	40	6	41	5	4	5	3	15	5	36	63	56	73	27	-69	
2010	3	6	5	6	26	13	17	19	5	4	5	4	9	4	23	51	20	81	15	33	
2011	-6	8	2	-1	-19	-7	-28	-17	5	7	4	6	8	3	22	7	-11	-10	24	37	
2012	1	7	3	4	28	14	2	12	4	2	4	2	7	9	2	-1	4	3	0	-4	
2013	3	1	0	7	22	19	25	21	0	1	1	0	6	0	-27	-41	-13	10	-2	-6	
2014	4	6	-1	10	21	7	7	11	4	6	4	5	6	7	-6	-19	-13	7	-34	-6	
2015	8	4	1	14	24	4	10	10	1	2	1	2	7	2	-8	-14	-27	-25	-50	-46	36
2016	4	10	1	6	-8	9	1	3	2	0	2	2	8	1	9	16	2	10	4	-26	98
2017	4	1	1	3	19	22	12	11	0	1	0	0	6	1	5	-1	-3	43	23	37	596
2018	3	2	1	1	-8	10	-5	-5	1	2	0	1	7	0	-4	-12	-12	14	8	22	-52
2019	2	2	1	3	15	2	4	17	2	3	2	2	6	4	20	16	10	50	-8	-59	14
2020	11	7	3	5	26	-4	8	12	0	1	1	0	6	1	25	35	2	25	-50	-30	90
2021	8	10	4	9	25	33	20	32	-2	0	-1	-1	4	-1	-4	-4	3	-22	70	305	136

Table 2: *Cumulative return for all time (starting from 100)*

	Real estate				Equties				T-Bonds				Bonds		Commoditites						Crypto
Year	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**H.Y**	**EU**	**Gold**	**Silver**	**Plat.**	**Pall.**	**Oil**	**Gas**	**Bitcoin**
1959							100	100													
1960							102	104													
1961							93	106													
1962							100	94													
1963							100	116													
1964							102	132													
1965							93	144													
1966							86	115													
1967							80	118							100	100					
1968							109	147							100	93					
1969	100	100	100	100			137	154						100	94	86					
1970	100	100	104	105			162	114						105	93	79					
1971	118	105	109	110			173	137						115	106	61					
1972	137	118	122	118			257	155						124	153	83					
1973	158	119	159	127			371	156						132	226	127					
1974	166	136	181	143			294	156						140	363	180					
1975	191	140	190	168			287	192						158	291	164					
1976	212	149	198	192			237	184						170	257	165					
1977	245	174	200	223			191	155						190	322	182					
1978	273	199	208	249			206	180						210	424	224					
1979	296	207	226	273			255	177						226	776	596					
1980	287	245	256	271			246	203						245	1065	201					
1981	268	312	296	265			280	324						269	690	86					
1982	268	363	354	274	100		369	396						319	681	90					
1983	338	381	426	278	164		631	687						368	611	80					
1984	384	404	458	289	136		693	622		100				431	523	57					
1985	456	451	471	298	186	100	656	668		112				492	505	51					
1986	478	592	499	324	153	100	1105	1107	100	127		100		560	624	46			100		
1987	437	675	583	369	143	99	1496	1100	109	146	100	110		596	727	54			95		
1988	453	630	814	438	198	98	1884	1395	126	174	105	125		661	635	49			71		
1989	434	544	863	507	268	153	1631	1739	136	194	115	137		709	594	43	100	100	96	100	
1990	403	529	803	549	249	143	1012	1215	149	217	129	153		772	575	32	87	75	141	132	
1991	417	501	664	580	269	126	789	1277	170	245	151	182		876	544	31	74	67	77	133	
1992	396	481	534	489	190	99	702	1018	186	275	169	198		963	509	29	73	78	70	122	
1993	429	518	551	470	257	160	1324	1713	213	312	204	232		1117	561	37	77	99	55	131	
1994	453	569	560	488	249	165	1602	1819	216	319	209	234		1158	577	36	84	120	59	124	
1995	505	612	536	483	260	192	1569	2136	242	354	242	271		1293	577	39	84	103	60	139	
1996	563	673	605	499	327	234	1900	2730	266	386	267	307		1448	563	35	77	89	82	149	
1997	612	746	695	535	453	329	2776	3608	288	414	289	335	109	1570	456	41	79	148	64	123	
1998	668	792	760	593	421	206	3572	3599	313	441	314	368	120	1707	437	35	69	196	36	95	
1999	703	937	839	643	503	271	7393	5239	321	451	320	375	134	1735	435	36	85	271	71	99	
2000	756	1025	836	719	654	326	8585	5612	341	483	338	401	151	1833	395	33	115	504	86	178	
2001	783	1102	847	752	509	247	4563	4050	364	509	360	422	172	1950	408	30	83	178	53	143	
2002	815	1131	920	820	403	192	3295	2646	384	555	381	446	195	2062	472	32	109	138	72	121	
2003	848	1176	987	870	523	257	3318	3190	403	598	400	468	214	2159	568	39	140	88	76	153	
2004	965	1297	1043	956	608	361	3261	3761	426	631	421	500	231	2280	626	47	154	89	112	182	
2005	1210	1399	1140	1058	808	524	4069	4774	448	657	442	527	249	2386	696	56	173	99	141	285	
2006	1382	1625	1202	1162	938	682	4806	5902	460	673	453	542	270	2451	867	83	202	128	145	351	
2007	1382	1744	1251	1284	1082	824	6109	6040	474	707	467	556	293	2527	1100	94	256	143	209	345	
2008	1224	1617	1200	1234	511	317	2652	3073	499	750	490	594	332	2651	1093	59	107	55	69	617	
2009	1162	1801	1294	1375	594	443	2801	4324	522	777	516	613	381	2783	1485	97	167	96	87	194	
2010	1192	1916	1358	1457	746	500	3279	5159	550	808	540	637	414	2899	1830	146	201	173	100	258	
2011	1123	2064	1389	1438	602	466	2348	4281	576	862	562	674	447	2988	2229	157	179	155	124	353	
2012	1138	2203	1429	1492	769	531	2401	4783	597	880	586	689	479	3243	2269	156	186	160	124	338	
2013	1177	2223	1433	1593	938	630	3013	5808	596	891	592	687	509	3255	1651	92	161	176	122	318	
2014	1227	2350	1426	1756	1139	674	3216	6442	618	946	618	723	539	3477	1555	75	140	189	81	300	
2015	1319	2453	1434	2000	1409	700	3523	7114	626	963	624	735	578	3559	1428	64	102	142	41	162	136
2016	1375	2696	1444	2128	1300	763	3563	7306	637	967	634	746	622	3601	1562	75	104	156	42	119	269
2017	1433	2712	1465	2185	1548	930	3995	8140	637	979	635	744	658	3653	1632	74	101	222	52	164	1876
2018	1479	2771	1483	2200	1429	1025	3804	7721	642	1002	637	753	701	3660	1565	65	89	254	56	200	905
2019	1516	2839	1494	2272	1646	1046	3947	9045	653	1030	651	766	745	3795	1873	75	98	380	52	82	1031
2020	1677	3039	1544	2391	2074	1001	4259	10159	653	1037	654	765	792	3836	2343	101	100	474	26	57	1964
2021	1803	3341	1602	2615	2594	1336	5115	13379	643	1038	646	760	826	3806	2240	97	103	372	45	233	4635

Table 3: *Cumulative return from 2000 (starting from 100)*

	Real estate				Equities				T-Bonds				EU bonds		Commoditites						Crypto
Year	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**H.Y**	**EU**	**Gold**	**Silver**	**Plat.**	**Pall.**	**Oil**	**Gas**	**Bitcoin**
2000	101	106	102	103	113	114	142	129	101	102	101	101	103	101	98	99	110	137	111	140	
2001	109	113	100	115	127	115	84	96	108	108	108	109	117	108	89	86	137	211	105	192	
2002	113	121	105	119	105	98	65	79	114	114	113	113	133	113	98	87	107	71	81	122	
2003	116	123	112	128	77	67	39	48	122	126	122	122	150	121	118	87	144	44	118	136	
2004	124	134	121	138	113	111	49	67	128	133	127	128	163	126	136	129	185	38	116	145	
2005	143	144	127	150	132	148	46	76	135	142	134	136	176	133	142	131	184	29	170	212	
2006	184	158	137	170	175	223	62	101	140	146	139	141	190	138	181	192	220	43	216	314	
2007	197	184	145	187	203	274	70	122	144	149	142	145	206	142	211	239	249	50	198	343	
2008	194	190	150	200	183	256	71	96	150	157	148	151	224	148	294	310	379	64	321	411	
2009	163	180	142	197	90	113	30	58	159	166	155	161	260	154	284	199	146	21	77	537	
2010	166	198	159	217	128	169	41	86	164	175	163	165	291	161	344	256	218	43	125	227	
2011	168	215	164	229	157	199	46	101	170	182	168	169	315	166	425	505	249	74	169	273	
2012	160	228	168	226	138	189	35	92	181	193	178	180	340	176	514	452	220	62	188	364	
2013	164	242	172	236	166	207	36	100	184	197	184	183	364	186	494	375	222	66	178	333	
2014	170	243	171	255	211	242	42	117	187	200	186	185	386	190	386	258	193	67	170	316	
2015	181	260	170	284	252	257	49	140	196	210	196	196	410	203	363	206	159	70	74	272	
2016	191	271	171	315	272	237	45	127	196	215	197	197	442	207	350	193	120	45	43	125	159
2017	200	298	174	340	274	301	51	147	198	216	198	198	472	207	359	217	126	64	65	148	364
2018	209	295	176	337	304	354	55	152	198	218	198	199	499	210	391	201	126	85	79	189	2057
2019	215	303	177	342	296	373	53	152	201	224	201	202	533	213	381	185	105	114	74	142	619
2020	219	309	180	358	339	362	53	172	203	232	203	204	566	219	459	189	115	175	57	60	1070
2021	249	342	186	383	435	415	62	213	202	229	204	203	598	221	517	293	142	179	49	72	3908

Table 4: *Cumulative return under four different economic events (starting from 100)*

	Real estate				Equities				T-Bonds				EU bonds		Commoditites						Crypto
1989Q4-1991Q2	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**Den**	**Nor**	**Fin**	**Swe**	**H.Y**	**EU**	**Gold**	**Silver**	**Plat.**	**Pall.**	**Oil**	**Gas**	**Bitcoin**
1989q4	99	97	97	101	104	97	84	94	101	103	102	101		101	106	105			110		
1990q1	94	99	95	106	110	115	85	92	102	106	104	101		102	110	99			113		
1990q2	94	100	95	108	109	118	75	93	106	109	107	104		105	99	96			89	120	
1990q3	92	98	94	110	106	117	66	92	108	112	110	108		108	103	91	99	93	134	109	
1990q4	91	95	91	109	97	90	52	65	111	115	114	113		110	103	78	88	81	162	132	
1991q1	93	93	84	116	99	84	50	72	116	119	119	119		115	100	74	94	92	89	161	
1991q2	94	93	83	116	104	92	55	79	120	123	126	124		119	97	81	97	112	81	183	
Total return	-4 %	-5 %	-15 %	15 %	0 %	-5 %	-35 %	-16 %	19 %	19 %	24 %	23 %		17 %	-8 %	-23 %	-2 %	20 %	-27 %	53 %	
1999Q4-2002Q1																					
1999q4	100	104	102	100	108	103	130	116	101	101	101	101	103	101	113	97	119	116	115	116	
2000q1	101	106	102	103	113	114	142	129	101	102	101	101	103	101	98	99	110	137	111	140	
2000q2	103	106	101	105	104	98	103	99	102	101	102	103	103	102	96	97	110	102	99	106	
2000q3	102	97	98	103	110	112	88	97	101	102	101	101	103	101	99	98	109	120	114	110	
2000q4	101	100	99	100	102	96	90	86	102	102	102	102	103	102	97	96	103	111	97	109	
2001q1	102	103	100	103	97	96	73	89	102	100	102	102	103	102	98	95	101	114	86	107	
2001q2	101	104	101	101	94	99	96	91	101	101	101	100	103	101	102	98	99	65	105	101	
2001q3	101	100	100	102	95	89	67	88	102	103	102	101	103	101	102	99	79	68	93	88	
2001q4	99	100	100	99	90	89	114	101	102	101	102	102	103	102	102	100	92	71	73	84	
2002q1	101	103	104	102	104	107	106	102	100	101	100	101	103	100	104	104	110	109	109	85	
Total return	1 %	0 %	1 %	2 %	-4 %	5 %	-19 %	-12 %	0 %	0 %	0 %	0 %	0 %	0 %	-8 %	7 %	-8 %	-6 %	-6 %	-27 %	
2007Q1-2009Q1																					
2007q1	100	106	101	104	109	109	108	109	100	100	100	100	102	100	106	104	105	106	97	97	
2007q2	102	110	103	110	115	117	118	116	101	101	101	101	104	101	109	100	114	114	113	90	
2007q3	102	110	104	114	119	120	123	111	102	103	102	101	106	102	110	99	114	108	123	90	
2007q4	100	107	104	110	115	121	127	102	103	105	103	103	108	103	127	114	127	111	144	98	
2008q1	99	110	105	111	98	102	109	85	105	105	105	104	111	105	147	136	160	135	157	116	
2008q2	99	111	106	113	100	114	100	86	105	107	105	105	114	105	142	129	172	135	192	133	
2008q3	96	107	104	112	90	95	85	73	106	110	106	106	117	106	138	87	125	95	181	158	
2008q4	89	100	100	106	54	47	55	52	108	111	108	110	123	108	126	72	53	43	47	176	
2009q1	83	104	99	109	48	45	46	51	111	112	110	111	129	109	142	87	62	45	38	152	
Total return	-18 %	-6 %	-5 %	-4 %	-59 %	-62 %	-62 %	-54 %	9 %	8 %	8 %	10 %		8 %	29 %	-12 %	-64 %	-67 %	-70 %	31 %	
2020Q1-2021Q2																					
2020q1	102	102	101	101	104	94	99	100	100	102	100	100	102	100	107	91	100	125	77	73	104
2020q2	103	105	102	101	105	85	91	93	100	102	100	100	104	100	115	103	86	106	35	30	108
2020q3	108	107	102	104	117	91	101	105	100	102	100	100	105	100	128	139	98	115	49	43	130
2020q4	111	107	103	105	126	96	108	112	100	101	101	100	106	101	125	135	102	125	50	70	190
2021q1	116	113	105	108	133	108	117	123	99	101	100	99	107	101	120	141	123	127	66	87	379
2021q2	119	118	107	112	142	115	124	136	98	101	99	99	109	100	121	144	126	147	74	114	388
Total return	17 %	16 %	6 %	11 %	37 %	23 %	25 %	36 %	-2 %	-1 %	-1 %	-1 %	7 %	0 %	13 %	58 %	26 %	18 %	-3 %	55 %	274 %

***Table 6:** Correlation of all assets without (Bitcoin), 91 observations*

Matrix of correlations with (Bitcoin)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
(1) EU Bond	1.000																			
(2) High yield	0.423	1.000																		
(3) Equities Denmark	-0.198	-0.444	1.000																	
(4) Equities Finland	-0.183	-0.307	0.639	1.000																
(5) EquitiesNorway	-0.351	-0.399	0.827	0.593	1.000															
(6) Equities Sweden	-0.263	-0.372	0.816	0.846	0.787	1.000														
(7) Gas	-0.074	-0.130	0.020	0.116	0.113	0.092	1.000													
(8) Gold	0.101	0.040	-0.003	0.026	0.086	0.021	-0.077	1.000												
(9) Real estate Denmark	-0.121	-0.364	0.536	0.324	0.485	0.400	0.033	0.034	1.000											
(10) Real estate Finland	-0.097	0.012	0.457	0.423	0.445	0.467	-0.086	0.137	0.520	1.000										
(11) Real estate Norway	-0.192	-0.071	0.444	0.395	0.479	0.494	-0.106	0.135	0.492	0.604	1.000									
(12) Real estate Sweden	-0.103	-0.116	0.480	0.223	0.431	0.365	-0.086	-0.087	0.566	0.465	0.464	1.000								
(13) Oil	-0.277	-0.152	0.400	0.304	0.642	0.368	0.290	0.160	0.340	0.431	0.302	0.286	1.000							
(14) Palladium	-0.210	-0.297	0.486	0.479	0.509	0.538	0.093	0.315	0.256	0.308	0.337	0.291	0.374	1.000						
(15) Platinum	-0.087	-0.096	0.448	0.394	0.562	0.414	0.131	0.550	0.326	0.481	0.478	0.359	0.623	0.646	1.000					
(16) Silver	-0.001	-0.036	0.265	0.194	0.310	0.261	-0.045	0.653	0.141	0.217	0.247	0.094	0.257	0.346	0.557	1.000				
(17) T-bonds Denmark	0.849	0.545	-0.320	-0.231	-0.378	-0.322	0.014	0.115	-0.174	-0.075	-0.096	-0.132	-0.307	-0.225	-0.100	-0.025	1.000			
(18) T-bonds Finland	0.887	0.544	-0.295	-0.227	-0.398	-0.313	-0.041	0.102	-0.153	-0.034	-0.112	-0.111	-0.301	-0.216	-0.101	-0.045	0.956	1.000		
(19) T-bonds Norway	0.264	0.402	-0.234	-0.262	-0.310	-0.335	-0.011	0.067	-0.106	0.061	-0.202	-0.104	-0.013	-0.220	-0.086	-0.192	0.317	0.350	1.000	
(20) T-bonds Sweden	0.798	0.453	-0.348	-0.239	-0.431	-0.341	0.036	0.056	-0.119	-0.067	-0.082	-0.105	-0.358	-0.246	-0.183	-0.124	0.909	0.909	0.362	1.000

***Table 5:** Correlation of all assets with (Bitcoin), 23 observations*

Matrix of correlations with (Bitcoin)

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)
(1) Bitcoin	1.000																				
(2) EU Bond	0.232	1.000																			
(3) High Yield	-0.370	0.084	1.000																		
(4) Equities Denmark	0.215	0.126	-0.272	1.000																	
(5) Equities Finland	0.245	0.064	-0.505	0.632	1.000																
(6) Equities Norway	0.343	-0.164	-0.636	0.387	0.719	1.000															
(7) Equities Sweden	0.269	0.013	-0.532	0.673	0.890	0.743	1.000														
(8) Gas	0.201	-0.210	-0.519	0.247	0.656	0.655	0.591	1.000													
(9) Gold	-0.052	0.529	0.189	0.145	-0.052	-0.335	-0.082	-0.290	1.000												
(10) Real estate Denmark	0.173	0.069	-0.008	0.642	0.468	0.249	0.390	0.055	0.272	1.000											
(11) Real estate Finland	0.106	-0.187	-0.137	0.466	0.274	0.207	0.353	0.007	0.081	0.713	1.000										
(12) Real estate Norway	0.019	-0.215	0.089	0.313	0.214	0.166	0.241	-0.160	0.173	0.765	0.798	1.000									
(13) Real estate Sweden	0.016	-0.121	0.111	0.363	0.302	0.102	0.304	0.097	-0.182	0.470	0.352	0.342	1.000								
(14) Oil	0.301	-0.028	-0.544	0.367	0.650	0.920	0.721	0.618	-0.159	0.327	0.202	0.189	0.112	1.000							
(15) Palladium	-0.066	0.146	-0.472	0.138	0.366	0.240	0.368	0.299	0.320	-0.118	-0.013	-0.145	-0.205	0.281	1.000						
(16) Platinum	0.344	0.231	-0.331	0.319	0.463	0.422	0.483	0.401	0.424	0.465	0.246	0.327	0.117	0.586	0.470	1.000					
(17) Silver	0.055	0.301	0.207	0.235	0.125	0.049	0.173	0.053	0.726	0.401	0.097	0.262	0.062	0.224	0.058	0.550	1.000				
(18) T-bonds Denmark	-0.012	0.731	0.216	-0.217	-0.155	-0.129	-0.197	-0.193	0.419	-0.101	-0.286	-0.127	-0.272	-0.024	0.102	0.136	0.313	1.000			
(19) T-bonds Finland	0.053	0.880	0.227	-0.036	-0.050	-0.190	-0.060	-0.281	0.524	0.020	-0.148	-0.039	-0.231	-0.072	0.098	0.149	0.313	0.903	1.000		
(20) T-bonds Norway	-0.345	-0.139	0.154	-0.126	-0.373	-0.316	-0.283	-0.445	0.061	-0.050	0.186	0.097	-0.015	-0.189	0.116	-0.131	-0.211	-0.074	-0.151	1.000	
(21) T-bonds Sweden	-0.178	0.667	0.171	-0.057	-0.095	-0.243	-0.143	-0.436	0.398	0.144	0.021	0.099	-0.033	-0.148	0.012	0.002	0.114	0.649	0.764	-0.077	1.000

Table 7: *Fama and French three-factor model*

Variable	α	t-stat (a)	β	t.stat (β)	SMB	t.stat (SMB)	HML	t.stat (HML)	R squared
Real estate Denmark	0,018	1,258	0,093	1,371	0,166	1,023	0,060	0,649	0,189
Real estate Norway	0,059	5,354	0,091	1,709	0,033	0,262	0,006	0,081	0,157
Real estate Finland	0,015	1,007	0,010	0,141	-0,214	-1,245	-0,034	-0,344	0,075
Real estate Sweden	0,002	0,171	-0,019	-0,382	0,014	0,115	0,058	0,839	0,039
Equties Denmark	0,043	0,948	0,690	3,175	0,294	0,567	-0,015	-0,051	0,397
Equties Norway	0,033	0,692	0,784	3,405	0,405	0,738	0,250	0,799	0,446
Equties Finland	0,000	-0,002	0,160	0,584	-0,664	-1,014	-0,590	-1,582	0,130
Equties Sweden	-0,002	-0,058	0,030	0,203	-0,252	-0,724	-0,486	-2,448	0,225
T-bonds Denmark	0,038	0,668	-0,171	-0,631	0,577	0,895	0,657	1,786	0,149
T-bonds Norway	0,045	1,445	-0,056	-0,378	0,188	0,537	0,555	2,780	0,270
T-bonds Finland	-0,001	-0,014	0,167	0,610	-0,660	-1,013	-0,592	-1,593	0,132
T-bonds Sweden	-0,004	-0,126	0,038	0,252	-0,317	-0,884	-0,494	-2,418	0,225
High yield	0,090	1,650	-0,226	-0,868	0,736	1,187	0,671	1,898	0,180
Eu bond	0,045	1,473	-0,030	-0,207	0,212	0,618	0,545	2,780	0,270
Gold	-0,037	-0,636	0,293	1,059	-0,225	-0,342	-0,806	-2,146	0,213
Silver	-0,026	-0,554	0,456	2,022	0,581	1,081	-0,588	-1,919	0,379
Platinum	0,016	0,311	0,212	0,852	0,830	1,396	1,216	3,591	0,427
Palladium	0,130	1,667	0,435	1,167	-1,460	-1,646	0,133	0,263	0,137
Oil	-0,025	-0,237	0,265	0,531	-0,072	-0,060	-0,873	-1,289	0,087
Gas	0,054	0,294	-0,608	-0,689	0,366	0,174	0,567	0,473	0,032
Bitcoin	0,432	0,562	7,673	1,803	18,782	1,629	7,622	1,348	0,716

Econometric method

Ordinary least squares (OLS) are a statistical approach that is used to estimate the coefficients of a relationship between a dependent and an independent variable. Following a set of assumptions, the OLS regression is claimed to be one of the best linear objective estimator of parameters, according to the Gauss–Markov theorem, also known as the BLUE regression (Stock & Watson, 2015). The term "best" refers to estimators that have the lowest variance in comparison to other objective linear estimators. When we say that an estimator is unbiased, we are referring to the fact that the sample target distribution's average is equal to the real value of its estimated parameters. The assumptions are based on the regression's error term and serve as the foundation for actual random error terms.

BLUE Assumptions include:

1. For the OLS approach to work, the parameters that we are estimating must be linear in nature.
2. The data must have been collected through a random sampling of the population.
3. The regressors used to generate the coefficients are not fully correlated.
4. There is no correlation between the regressors and the error term.

5. The error of the variance remains constant regardless of the values of our regressors.

Mathematically speaking, linear regression represented by:

$$y_i = x_i{'}\beta + \varepsilon_i$$

will be BLUE if the following assumptions are met:

$$1. E\{\varepsilon_i\} = 0, i = 1, \dots, N \rightarrow expexted\ value\ of\ error\ term\ is\ zero$$

$$2. \{\varepsilon_1 \dots \varepsilon_n\}\ and\ \{x_1, \dots, x_n\}\ are\ independent \rightarrow collinearity$$

$$3. cov\{\varepsilon_i, \varepsilon_j\} = 0, i, j = 1, \dots, N\ I \neq J \rightarrow exogenity$$

$$4. Var\{\varepsilon_1 = \sigma^2, \}i = 1, \dots N \rightarrow homoscedasticity$$

When heteroscedasticity and autocorrelation are present, OLS becomes inefficient and thus no longer BLUE. The regression coefficients' estimated variances will be biased and inconsistent, resulting in inaccurate testing. [38]

In our analysis of CAPM and the multi-factor model, the Breusch-Pagan test was used to test for heteroskedasticity, and the Breusch-Godfrey test was used to test for autocorrelation.

[38] We have used Heteroskedasticity and autocorrelation consistent standard errors (HAC) to correct for autocorrelation and for heteroskedasticity. In Stata we use the command “robust”.

Test for autocorrelation

Table 9: *Breusch-Godfrey test for autocorrelation CAPM*

Asset	Obs	Chi2	Prob > chi2
Bitcoin	27	1.572	0.0000
EU bond	206	93.32	0.0000
High yield	96	65.06	0.0000
Equities Denmark	154	18.79	0.0000
Equities Finland	246	24.63	0.0000
Equities Norway	142	2.057	0.1515
Equities Sweden	246	14.43	0.0001
Real estate Denmark	204	44.69	0.0000
Real estate Finland	204	92.89	0.0000
Real estate Norway	205	19.62	0.0000
Real estate Sweden	205	39.38	0.0000
T-bonds Denmark	138	40.97	0.0000
T-bonds Finland	134	57.61	0.0000
T-bonds Norway	146	54.79	0.0000
T-bonds Sweden	139	51.563	0.0000
Gas	126	32.21	0.0000
Oil	137	1.504	0.2201
Palladium	125	10.08	0.0015
Plantinum	125	4.53	0.0333
Silver	214	3.70	0.0542
Gold	214	13.51	0.0002

Note: Samples: 1960Q2 – 2021Q4. Null hypothesis: No serial correlation

Table 8: *Breusch-Godfrey test for autocorrelation Multi-factor Model*

Asset	Obs	Chi2	Prob > chi2
Equities Denmark	154	1.62	0.2025
Equities Finland	246	4.79	0.0286
Equities Norway	142	1.90	0.1679
Equities Sweden	246	1.14	0.2849
Real estate Denmark	204	26.54	0.0000
Real estate Finland	204	5.35	0.0207
Real estate Norway	205	2.04	0.1524
Real estate Sweden	205	4.30	0.0380
T-bonds Denmark	138	13.11	0.0003
T-bonds Finland	134	0.91	0.3379
T-bonds Norway	146	12.96	0.0003
T-bonds Sweden	139	9.03	0.0027

Note: Samples: 1960Q2 – 2021Q4. Null hypothesis: No serial correlation

Test for heteroskedasticity

Table 10: *Breusch-Pagan test for heteroskedasticity CAPM*

Asset	Obs	Chi2	Prob > chi2
Bitcoin	27	0.95	0.3301
EU bond	206	2.59	0.1078
High yield	96	6.38	0.0115
Equities Denmark	154	11.77	0.0006
Equities Finland	246	8.90	0.0028
Equities Norway	142	2.38	0.1228
Equities Sweden	246	0.11	0.7389
Real estate Denmark	204	0.00	0.9896
Real estate Finland	204	1.60	0.2059
Real estate Norway	205	0.72	0.3965
Real estate Sweden	205	0.00	0.9820
T-bonds Denmark	138	0.95	0.3287
T-bonds Finland	134	0.20	0.6532
T-bonds Norway	146	0.68	0.4083
T-bonds Sweden	139	0.60	0.4401
Gas	126	23.13	0.0000
Oil	137	3.59	0.0583
Palladium	125	3.34	0.0676
Plantinum	125	50.15	0.000
Silver	214	0.43	0.5110
Gold	214	15.73	0.0001

Note: Samples: 1960Q2 – 2021Q4. Null hypothesis: Constant variance (homoskedasticity)

Table 11: *Breusch-Pagan test for heteroskedasticity Multi-factor Model*

Asset	Obs	Chi2	Prob > chi2
Equities Denmark	154	15.28	0.0001
Equities Finland	246	20.05	0.0000
Equities Norway	142	14.72	0.0001
Equities Sweden	246	7.63	0.0057
Real estate Denmark	204	4.94	0.0262
Real estate Finland	204	3.98	0.0462
Real estate Norway	205	0.22	0.6415
Real estate Sweden	205	9.31	0.0023
T-bonds Denmark	138	6.64	0.0100
T-bonds Finland	134	1.31	0.2532
T-bonds Norway	146	22.32	0.0000
T-bonds Sweden	139	45.20	0.0000

Note: Samples: 1960Q2 – 2021Q4. Null hypothesis: Constant variance (homoskedasticity)

Test for unit root

Samples: 1960Q2 – 2021Q4
Null hypothesis: The return variable has a unit root.

***Table 12**: Dickey Fuller test. Testing for unit root in each asset in the series*

Asset	Obs	Test Statistics	1% Critical Value	MacKinnon P-value	Unit root
Bitcoin	27	-3.536	-3.736	0.0071	Yes
EU bond	206	-5.394	-3.475	0.0000	No
High yield	96	-1.276	-3.516	0.6400	Yes
Equities Denmark	154	-7.835	-3.492	0.0000	No
Equities Finland	246	-5.271	-3.461	0.0000	No
Equities Norway	142	-9.351	-3.496	0.0000	No
Equities Sweden	246	-10.866	-3.496	0.0000	No
Real estate Denmark	204	-8.26	-3.475	0.0000	No
Real estate Finland	204	-6.059	-3.475	0.0000	No
Real estate Norway	205	-10.18	-3.475	0.0000	No
Real estate Sweden	205	-8.921	-3.475	0.0000	No
T-bonds Denmark	138	-5.700	-3.497	0.0000	No
T-bonds Finland	134	-4.856	-3.499	0.0000	No
T-bonds Norway	146	-5.250	-3.495	0.0000	No
T-bonds Sweden	139	-5.271	-3.497	0.0000	No
Gas	126	-6.023	-3.501	0.0000	No
Oil	137	-10.311	-3.498	0.0000	No
Palladium	125	-7.669	-3.502	0.0000	No
Plantinum	125	8.814	-3.502	0.0000	No
Silver	214	-12.613	-3.472	0.0000	No
Gold	214	-11.299	-3.472	0.0000	No

The Dickey–Fuller test is one of the most commonly used tests for stationarity. The null hypothesis is that the series has a unit root (Reyna, 2022). For our practical purpose, having a unit root in the return on one asset would mean there is more than one trend in the series of the return that is collected. If this is the case investors can follow the trend to achieve return.