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Is the Sell-Off of Oil and Gas Companies in the Government Pension Fund Global an Effective Way of Reducing Norway's Exposure to Oil Price?

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MASTER THESIS

Department of Industrial Economics

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A.H.

Summary and Conclusions

This thesis examines the decision to pull the Norwegian Government Pension Fund Global out of oil and gas companies. The risk and returns of a portfolio with and without oil and gas companies has been studied together with the different sectors and portfolios correlation with oil price. The main conclusion of this work is that a sell-off will reduce Norway's exposure towards changes in oil price, but the impact will be limited.The impact will be limited mainly because of the limited size of the holdings in oil and gas companies compared to Norway's economy and the overall pension fund. Secondly, the oil and gas companies stock prices follow the general market closer than they follow the oil price. Norway's economy as a whole will still be very dependent on the oil and gas industry even after a sell-off. It was found that oil companies have similar historical returns as the rest of the equity portfolio and no significant change in expected return can be expected when selling off oil and gas companies. However, the risk adjusted return for the portfolio will be reduced as the portfolio will become less diversified and riskier as a consequence of reducing oil and gas companies and increasing the share of the remaining industry sectors.

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Chapter 1

Introduction

1.1 Background

The motivation for this thesis comes from the decision made by Norges Bank Investment Bank (1) in 2017 to recommend to the Norwegian Ministry of Finance to reduce the ownership in oil related companies in the Norwegian Government Pension Fund Global, also known as "Oljefondet" in popular Norwegian. The recommendation was made in order to reduce Norway's overall exposure to fall in oil price as Norway's economy is already heavily exposed to changes in oil price. The oil industry is a significant part of the Norwegian economy either as direct income from the oil and gas industry, through oil and gas companies and through ownership in the partly state-owned oil company Equinor, previously known as Statoil. Some of the fundamental questions in such a decision is whether or not the risk and return of the portfolio changes with a sell-off of oil and gas companies, how closely linked are the oil and gas stocks to the oil price and are there alternative ways that is more effective than selling off oil and gas stocks. This thesis will look examine some of these questions and look at the impacts a sell-off of oil and gas companies will have on the portfolio of the Government Pension Fund Global.

1.2 Norwegian Economy and Oil Industry

Since the beginning of the oil era in Norway with the discovery of the Ekofisk field in 1969 and subsequent development starting in 1971, the economy of Norway has been closely linked with

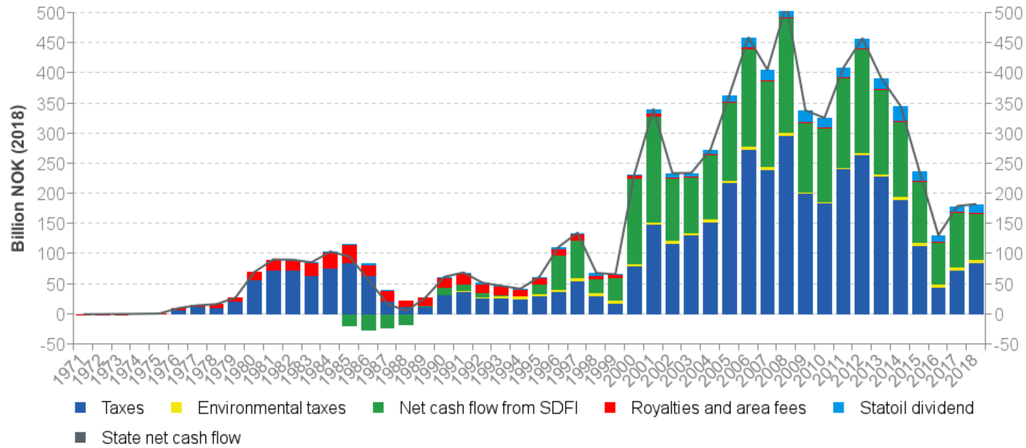


Figure 1.1: Cash flow from the petroleum industry deflated using the Norwegian consumer index split into the different sources of direct income to the government of Norway from the petroleum industry. Figure taken from (2)

the oil industry. After the end of the second world war, Norway transformed from a country primarily based on farming and fishing into a modern welfare society. A lot of that transformation is attributed to the discovery of the oil and gas resources in the North Sea. The oil production as seen in figure 1.2 increased steadily throughout the 70s, 80s and 90s and peaked around year 2000. The gas production kept on increasing with additional offtake of gas from existing fields and development of new gas fields. Especially the large Troll gas field made Norway an important gas producer as well as an oil producer. Because of the relatively low population in Norway, the majority of the oil and gas production are sold for export making Norway one of the worlds largest oil exporting countries. Figure 1.1 displays the cash flow from the oil and gas industry to the Norwegian government. The oil and gas revenues has been increasing together with the oil and gas production and increasing oil prices. While the oil and gas production has been fairly stable (figure 1.2), the cash flow from the oil industry has fluctuated alongside the fluctuations in oil price (figure 1.4). Because of the large impact the oil price variations has on the net cash flow it is difficult to plan and predict accurate net cash flow from the industry and for Norway as a whole. The importance of the oil and gas industry in the Norway's economy is clear when we compare it to the rest of the economy. The petroleum industry has for the last 15 years averaged about 20% of the total GDP and as much as 50% of the total exports (figure 1.3).

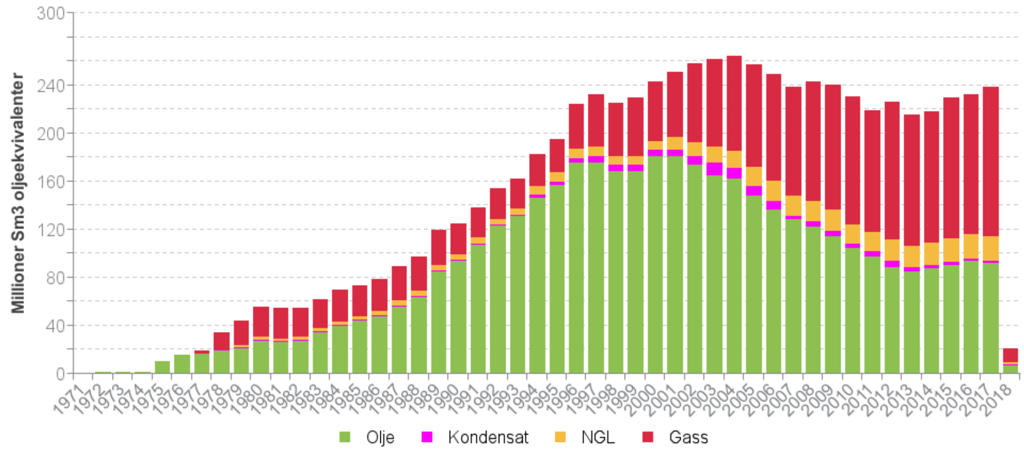


Figure 1.2: Norways annual oil and gas production. Figure taken from (2)

Making it without a question the largest industry sector in Norway. Being so dependent on one single commodity also makes the country vulnerable to changes in price. Any volatility on the oil price will cause impacts on the Norwegian economy as a whole. This was last seen with the oil price collapse in 2014, significantly reducing Norway's income from the petroleum industry while at the same time increasing unemployment and a general cool down of the economy. To counteract the volatility and create a more stable economy the Norwegian government has made prudent measures. The most important being the start-up of the Norwegian Government Pension Fund Global which sets asides income from the petroleum sector to be used by future generations once the oil resources are extracted and depleted. In addition, the government has an outspoken policy to follow the Keynesian principles by being conscious about government spending in periods with high output from the petroleum industry to avoid high inflation while allowing to spend more in periods where the economy or petroleum industry is struggling as seen under the financial crisis in 2008 and the latest oil downturn in 2014.

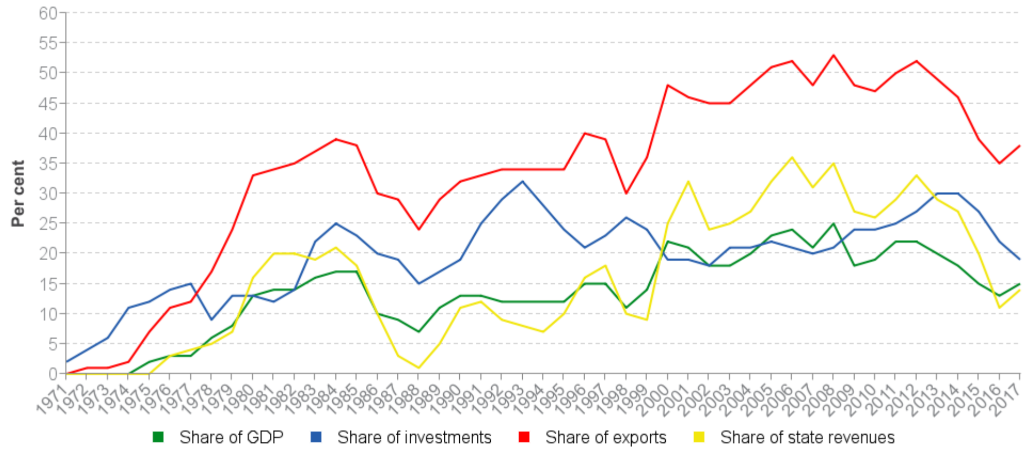


Figure 1.3: Importance of the oil industry in Norway in terms of share of GDP, share of investments, share of exports and share of state revenues. Figure taken from (2)

1.3 Oil Market and Oil Price Movements

Historical Oil Price Movements

Historically, the oil market has been impacted by several demand shocks and also supply shocks. Demand and supply shocks create large fluctuations in oil price and has a large impact on the overall world economy. Oil has been the primary energy source and large changes in oil price will lead to large impacts both for oil exporting countries such as Norway and oil importing countries. A low oil price may trigger larger global economic growth while high oil price may slow down the economic growth. Many authors, like Arzeki et al (3) and Hamilton (4) have tried to construct models that explains the oil price behaviour. In general, explaining the oil price mathematically is difficult. The demand elasticity, which is how easily the demand side reacts to price changes is difficult to measure but is found to be low. Hamilton (4) estimates the short term price demand elasticity of gasoline to be around -0.25 and the elasticity for crude oil to be about half of that. Long term price elasticity are thought to be 2 or 3 times as large. The supply side of the equation has similar low price elasticity. Primarily because of the historical long lag time between the exploration phase of new field to the production phase. From a discovery is made to a full development of an oil field the timeline may be several years. On the supply side,

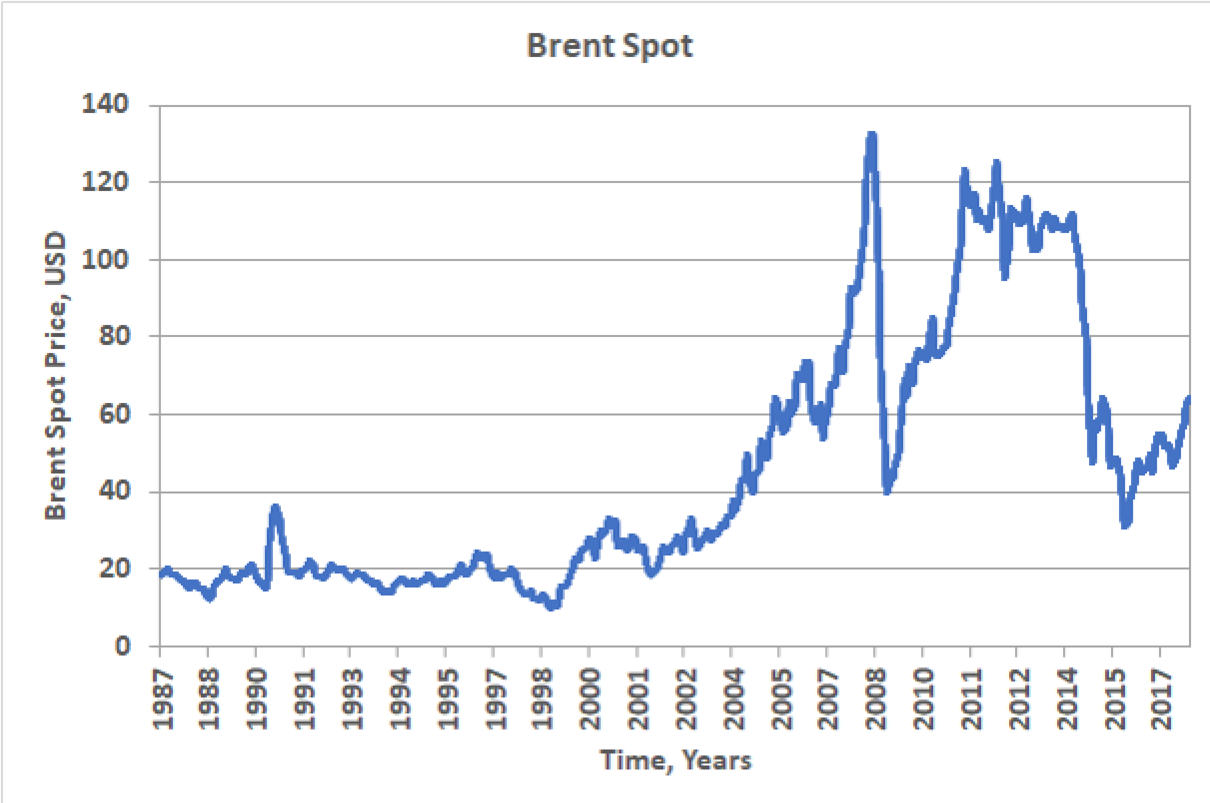


Figure 1.4: Historical oil price in nominal USD, source: EIA (5)

the role of OPEC must also be understood. As the role of OPEC is to control prices through cartel organization, the market is not perfectly competitive. The decisions OPEC make to increase or decrease their production quota impacts supply and oil price instantaneously. This can be seen by event 8, 12 and 13 in the chart in figure 1.5. Political unrest and chaos together with varying emotions of crude oil speculators may also influence the oil price more than traditional supply and demand theory. Especially turmoil and chaos in the middle east has large repercussions to the oil market. The Middle East Gulf is the primary exporting area of crude oil in the world and political events that may influence the Arabian oil production directly influences the oil price. In the past, political events such as the Iranian revolution, the Iran-Iraq war, Arabian oil embargo and 9-11 attack has all had a significant impact on the oil price. Both the low supply and demand elasticity combined with the political sensitive landscape creates the background for a volatile oil price behaviour.

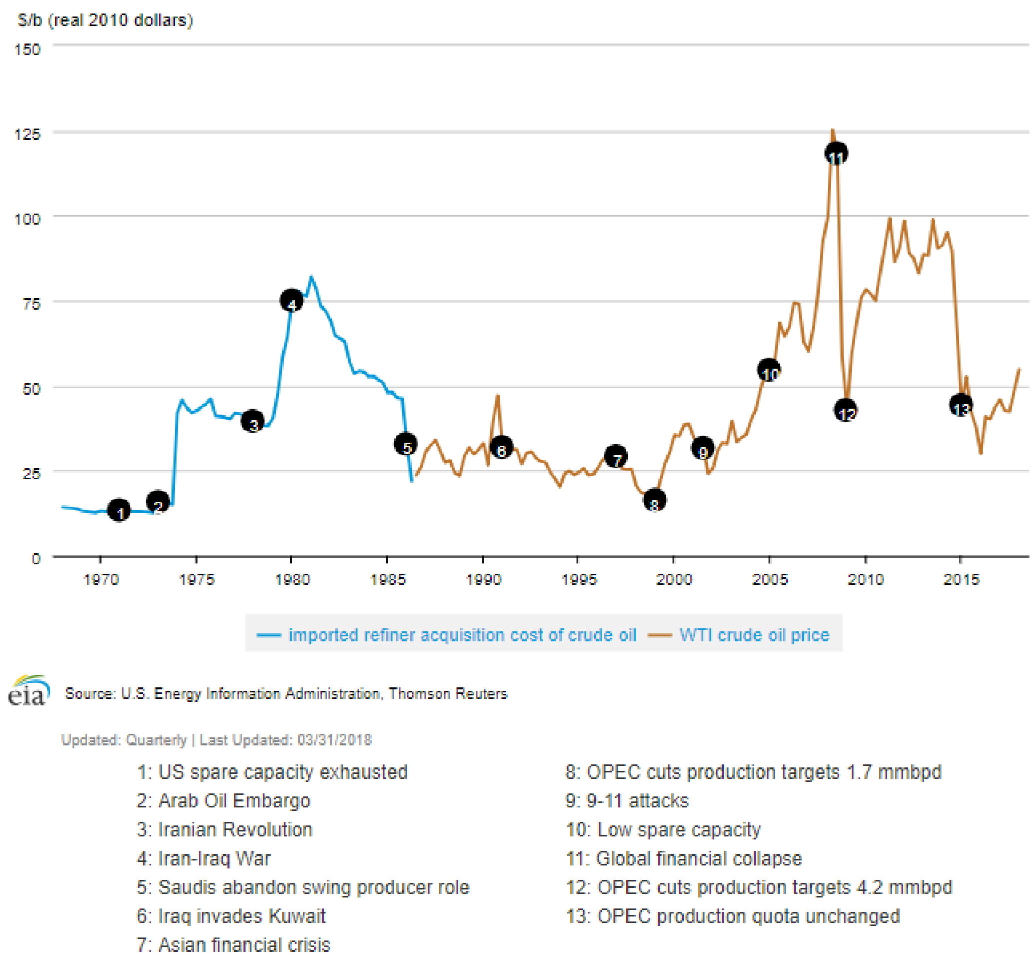


Figure 1.5: Historical oil price and key geopolitical and economic events. Figure taken from (6)

Current Oil Price Environment

The current oil price market has seen a surplus of supply for the past few years after OPEC decided to protect market share rather than to keep the oil price stable (7). The original intention behind the creation of OPEC was for the oil exporting countries to coordinate their production and maintain a sustained high oil price by price cooperation. Therefore, the OPEC has acted as a swing-producer in many cases, cutting production in periods where the market was overbalanced with supply and increasing production when the market was undersupplied. By the price manipulation, they made sure the oil prices remained stable which made their own government revenues predictable and higher. The introduction of production from unconventional sources starting around 2008-2009 timeframe, especially liquid rich shale plays, caused a new supply shock into the oil market. As new technology, primarily drilling of long horizontal wells combined with hydraulic fracturing of the rock, opened up a new source of oil to the market. Shale had previously been considered only as a source rock from which the oil and gas could migrate from into a reservoir where it could be trapped and accumulate into oil fields. Even though the oil companies knew that there were significant volumes of oil trapped in shale and other tight formations, the production from shale wells had been too low to be able to produce at economical rates. The new technology changed this and made the shale oil and gas able to compete with conventional sources. Continuous improvement in technology and attractive oil price environment combined with already well established infrastructure for the oil and gas production led to a boom in oil production in the US. OPEC realized, that if it were to cut production to maintain prices the US shale production would only increase further. So instead of cutting production OPEC decided to keep their production stable (8) in order to force some of the more expensive shale oil production out of the market and re-balance the oil price. As can be seen in figure 1.6, the oil market have started to re-balance again and prices are increasing. The recovery however may have been slower and the oil price drop deeper than most had anticipated.

Future Oil Price Scenaroies

Prediciting future oil price is extremely difficult. What appears to be the consensus among experts are that the future oil price will be volatile. With the growth of non-OPEC supply, primarily

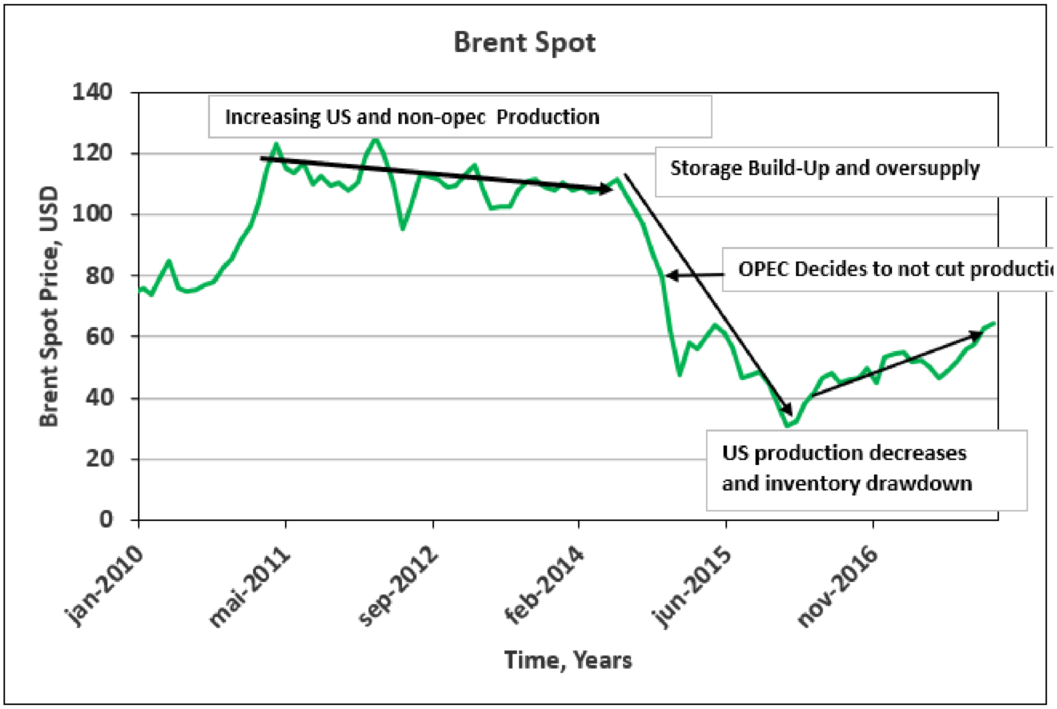


Figure 1.6: Oil price development from January 2010 to January 2018 and some of the key events and impact on oil price during that period. Source of data: EIA (5)

US shale production, OPEC will have a difficult time trying to control prices in the future. One can consider several different scenarios that may happen and as illustrated by the figure from ConocoPhillips (figure 1.7), there are several scenarios related to both supply and demand that may significantly impact the oil price on the mid to long term time horizons. ConocoPhillips (9) considers the following 4 scenarios for oil demand and supply and potential price scenarios they involve for the medium to long term time horizon.

- Supply/Resource Restriction. Significant reduction in supply either by legislative restricitons on for example US shale production or political unrest in oil exporting countries effectively reducing supply.
- Unrelenting unconventionals. Continued growth and innovations in the unconventional industry drives increasing supply.
- Demand destruction. A new global financial recession or more aggressive focus on renewable energy sources causing a decrease in demand.
- Great growth. Continued global economic growth fuels increasing demand for oil and gas.

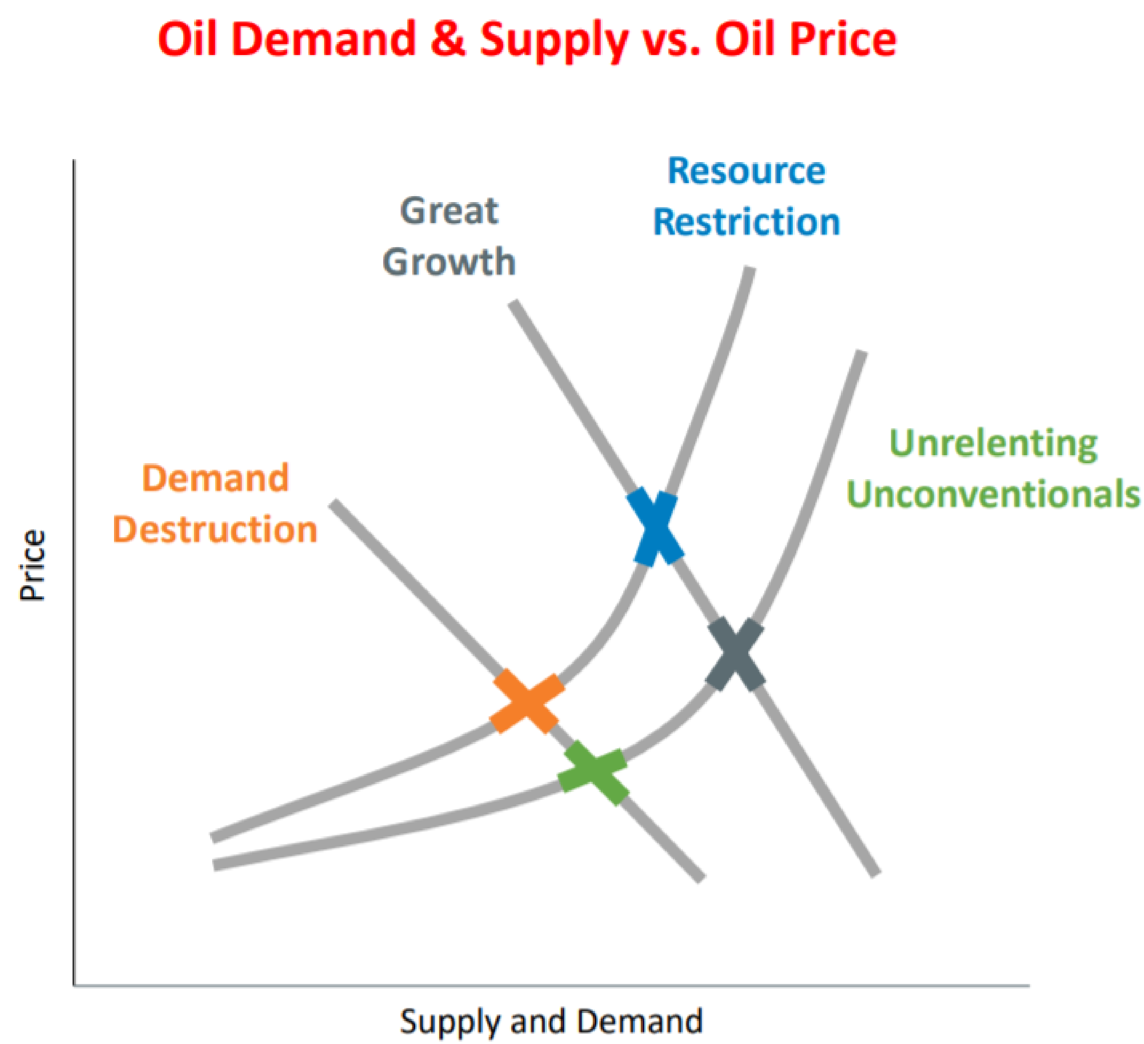


Figure 1.7: Oil price supply and demand illustration. Illustration taken from ConocoPhillips (9).

While these are some of the scenarios that may drive the long term oil price forecasts, the short-term market will most likely be a lot more volatile and chaotic causing short term large price fluctuations. The price for a scenario with demand destruction and unrelenting unconventionals (green cross in figure 1.7) is significantly different from the price scenario of resource restriction and great growth (blue cross in figure 1.7). One will have to prepare for a more volatile oil price going forward and that the relatively stable high oil price from 2010 to 2014 belongs to the past and the future seems to be more uncertain. In addition, with the introduction of shale oil as the swing producer the role of OPEC to control prices may be difficult going forward. If the shale oil becomes the primary swing producer, the prices will be determined more by the price elastisties and fundemendal supply-demand relationships which are slower to react than OPEC cutting production. Therefore, periods with undersupply in the market may cause significant oil price increase and periods with oversupply may cause a long lasting downturn in the market, similar to the downturn in 2014.

Chapter 2

Norwegian Government Pension Fund Global

2.1 History

The Norwegian Government Pension Fund Global was established by parliamentary resolutions in Stortinget in 1990 (10). The idea behind the fund was to create a buffer for the government while managing the petroleum revenues for future generations. In good times with high oil price, the profit from the State would be put aside in a specific fund such that in times with low oil price any deficit on the state budget could be covered by the fund. The fund was also intended to provide a mean to pay for the anticipated growing pension obligations and decreasing oil and gas revenues in the future. The investment was therefore primarily long term, but the fund could also be used short term if there was a need to provide additional funding to the government. The first deposit into the fund was made in 1996 by finance minister Sigbjørn Johnsen (11). From the beginning, 100% of the funds value was invested in foreign government bonds. In 1997 Stortinget changed the investment profile and allowed the fund to invest 40% in stocks in developed countries. From 2004 a set of ethical guidelines and rules were established for the fund in order to help the fund invest in ethical acceptable companies. In 2008 Stortinget once again increases the share of stocks from 40% to 60% in order to increase the expected return of the fund. Small cap companies were included in the funds reference index and portfolio from the same year. The financial crisis that shook the worlds financial markets in 2008 significantly reduced the value of the fund. The fund did not panic and continued to invest in the stock market and the value that was lost during the financial crisis was recovered the following years. In 2011 the fund also started to invest in real estate properties, primarily office buildings and retail buildings in large financial centres around the world such as London, Paris and New York. The maximum allocation to the real estate portfolio was set to 7%. In 2017 the share of stocks in the fund was again increased to a maximum of 70%. The increase in the share of investment in the stock market has primarily been triggered by the general higher return in stock market after the financial crisis significantly reduced the interest rates worldwide. In order to maintain high returns more of the portfolio was shifted towards the stock market.

2.2 Investment Strategies

The funds strategy is to have a well diversified and global portfolio that seeks to have the highest possible return on the investment by taking moderate risk. This is achieved by having a combined portfolio of bonds and fixed income investments, investment in the stock market and investment in the real estate market. As of December 2017, the fund had the following allocation: 66.6% in the stock market, 30.8% in fixed income and 2.6% in real estate properties. The fund is managed by Norwegian Bank Investment Management which manages most of the fund while the rest is managed by external managers with special competency in certain countries, sector or areas of investment. The funds performance and risk is measured against a benchmark index representing the broad investment the fund is undertaking. One of the most important measures to manage the risk is the relative risk compared to the benchmark index. The fund is allowed to deviate from the benchmark index, but not by more than 125 basic points.

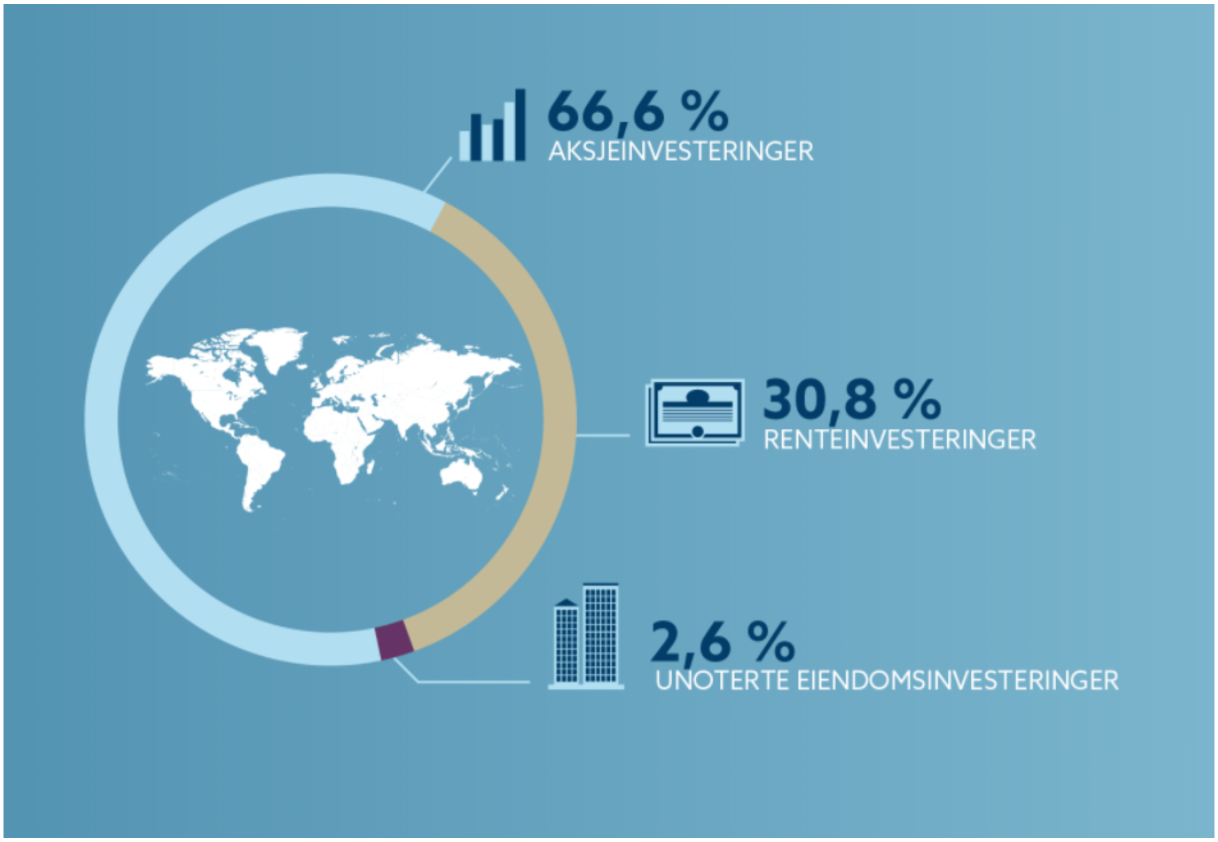


Figure 2.1: Norwegian Government Pension Fund Global investments. Figure taken from NBIM (12)

2.3 Equity Portfolio

This thesis will focus primarily on the equity portfolio of the Norwegian Government Pension Fund Global. The Norwegian Government Pension Fund Global have a diversified equity portfolio distributed globally and in all sectors.The pension fund is invested in all sectors, with the financial, industrial and consumer goods sector being the largest sectors in the portfolio (figure 2.2). The fund is invested in around 9000 companies worldwide. The largest single investment as of 31 March 2018 is Apple, Microsoft, Nestle, Alphabet and Royal Dutch Shell (12). With Apple being the largest holding with a total holding of 61 Billion Nok.

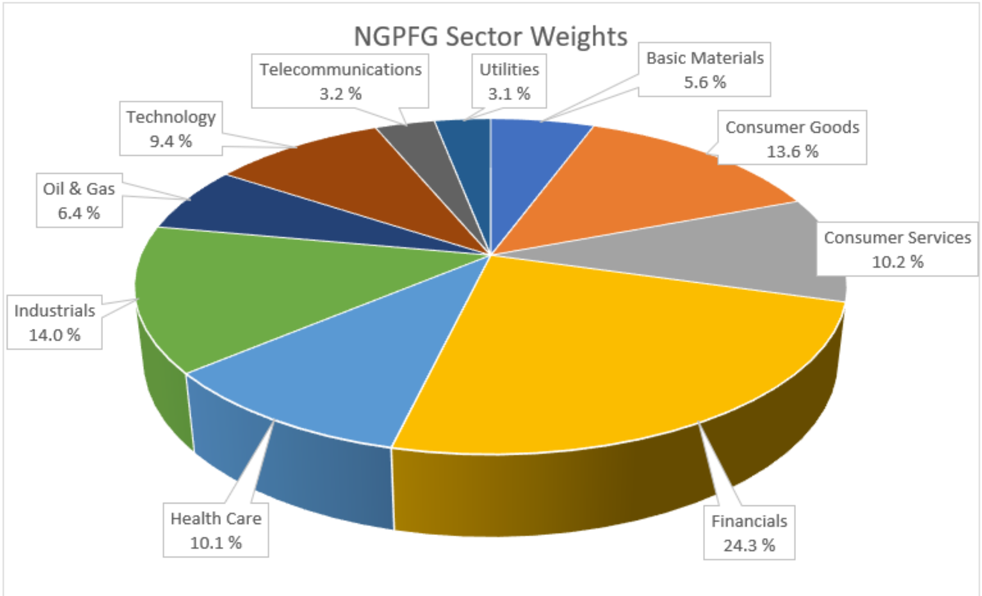


Figure 2.2: Norwegian Government Pension Fund Global (NGPFG) investments distributed into sectors. Source: (12)

Oil and Gas Companies

The fund also holds a significant amount of stocks in oil and gas companies. As of December 2017, 6.4% of the equity portfolio was invested in companies classified as oil and gas companies. Among those companies are traditional integrated Exploration&Production (E&P) companies such as Royal Dutch Shell and ExxonMobil, but also companies prodiving oil field services to the oil and gas industry. Notable service companies in the portfolio are Schlumberger and Halliburtion. In addition the fund is also invested in downstream oil and gas companies, such as Phillips66 and Valero Energy Corp which are not directly influenced by the crude oil price.

2.4 Historical Development of the Fund

The growth of the NGPFG from the start has been significant. From having a market value of 172 billion NOK in 1998 the fund has grown to more than 8 000 billion NOK in 2018 (figure 2.3). The fund has increased by more than 40 times over the last 20 years which is probably more than anyone could have imagined. The growth of the fund comes primarily from two sources, continued inflow of petroleum revenues from the government and return on the investments

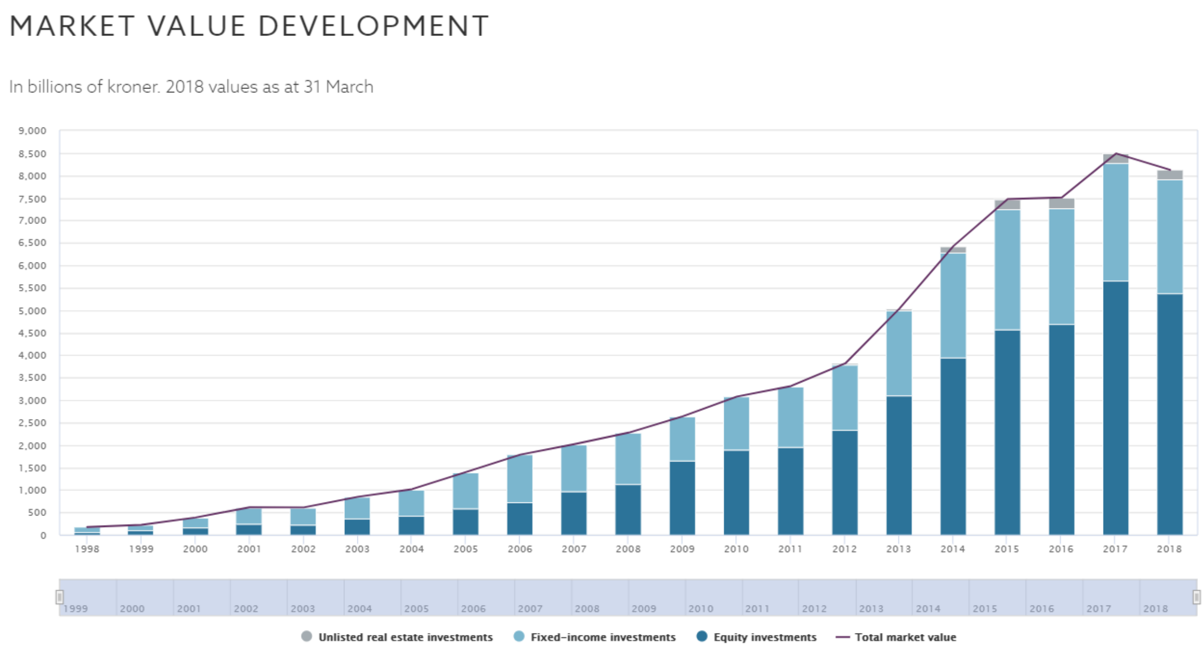


Figure 2.3: Historical market value development from 1998 to 208 for the Norwegian Government Pension Fund Global. Figure taken from (13)

made by the fund. In addition, changes in foreign exchange rate also impacts the funds value measured in Norwegian Kroner. Until 2007, the growth of the fund came primarily by inflow to the fund from the government while especially from 2012 and onwards, the growth in market value of the fund in that period can primarily be attributed to the return on the investments. As the size of the fund increases the relative size of the inflow decreases and continued growth of the fund is more reliant on return on investments. The fund has had a net positive change in market value every year from the beginning, except for the first 3 months of 2018 which has seen a correction in the stock markets and a currency effect. There are still 9 months left of 2018 and 2018 may end positive at year end aswell. The average annualized return of the investments as of March 2018 is 5.92% (13). The performance is quite remarkable and the size of the fund has grown such that the fund actual owns as much as 1.4% of listed companies worldwide and 2.4% of the listed companies in Europe (13). The equity portfolio has historically been providing the highest returns while the fixed income investments has provided more stable income with less volatility year over year (figure 2.4)

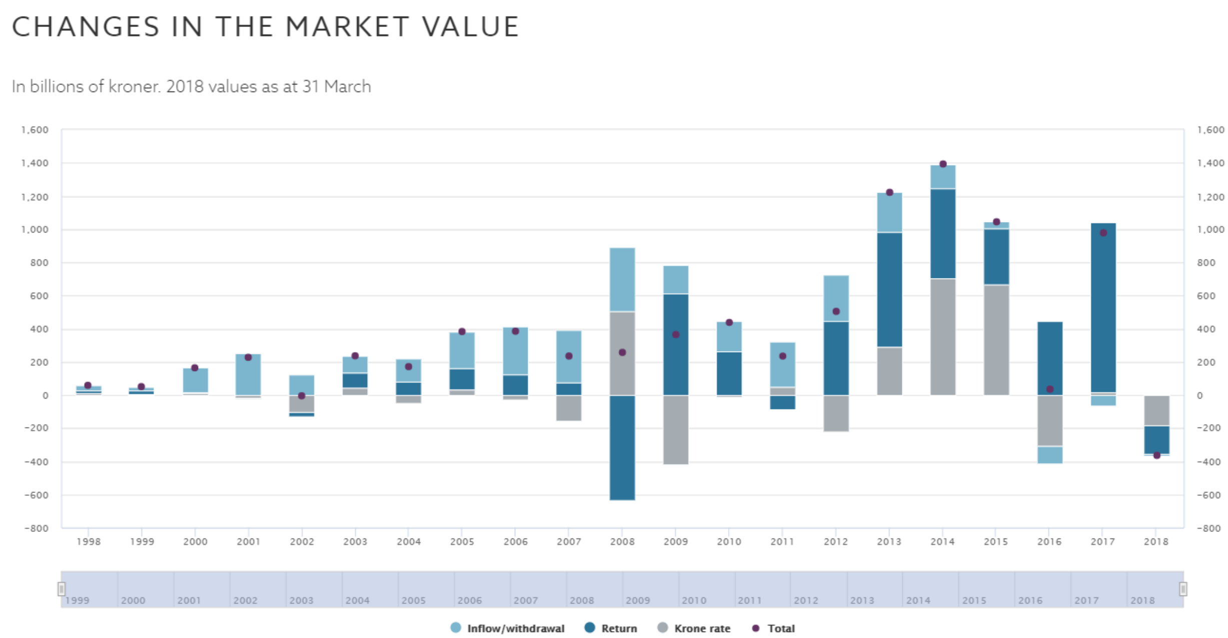


Figure 2.4: Yearly change in market value of NGPFG. Figure taken from (13)

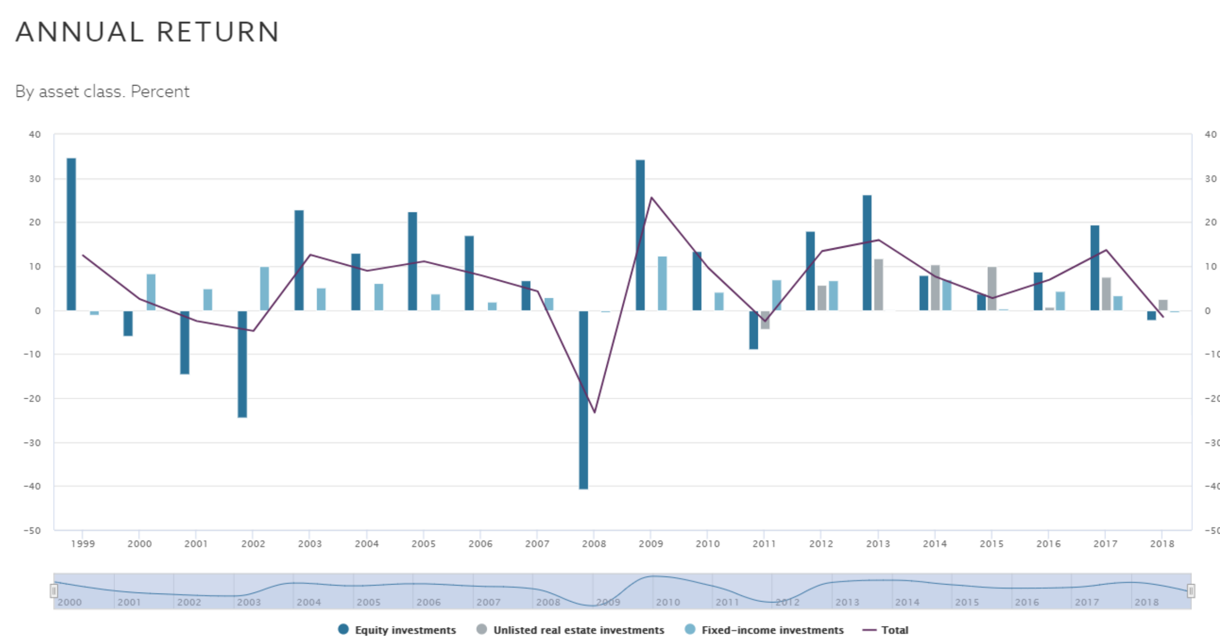


Figure 2.5: Yearly change in market value of NGPFG. Figure taken from (13)

Chapter 3

Theory

3.1 Basic Economical Principles

Return

The monthly return that is used throughout this thesis is defined as the closing price of an asset (index, stock or similar) of one month divided by the closing price of the previous month minus 1 as shown in equation 3.1

$$R(t) = \frac{P(t)}{P(t-1)} - 1 \tag{3.1}$$

Where P(t) denotes the price at the end of the current month and P(t-1) denotes the price at the end of the last month. The expected return of an asset is calculated as the mean of the returns.

$$\overline{R} = \mu = \frac{1}{N}\sum_{i=1}^{N} X_i \tag{3.2}$$

Nominal or Real Values

A nominal price is the price at any given time. In order to properly compare timeseries of prices, for example the oil price, a real value is typical used instead of nominal values to account for the inflation rate. The inflation rate reflects the general rise in prices. For example a consumer would be able to buy more goods for 1 USD in 1950 than today. Deflation is the opposite of inflation and is a measure of the decline in prices. Inflation and deflation is related to the total amount of money available which can be controlled by the central banks by interest rates and printing of money. To account for the inflation in prices, the price is corrected using for example a consumer price index to correct for the inflation. Stocks and stock indices on the other hand is often not deflated using an inflation rate. Stock indices often covers a wide range of different industries and markets and is therefore very difficult to correct for inflation as the inflation varies across the industries. Some markets are more sensitive to changes in consumer goods prices, while others are more sensitive to changes in commodity prices. For consistency, this thesis will use nominal values for both stock prices and oil prices throughout.

Risk and Volatility

While the historical return of an asset is straight forward the risk of an asset may be more ambiguous. One way to look at the riskyness of an asset is to evaluate how much the asset vary from month to month also known as volatility. The more volatile an asset is the more risky the asset is. Volatility can be defined as either the standard deviation of returns or the standard deviation of the log return, where the standard deviation for a population of $X_1, X_2....X_N$ return values is defined as:

$$\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(X_i - \mu)^2} \tag{3.3}$$

Where μ is the mean of the returns. The relationship between variance and standard deviation is

$$Var = \sigma^2 = \frac{1}{N}\sum_{i=1}^{N}(R_i - \mu)^2 \tag{3.4}$$

3.2 Portfolio Theory

The first attempts of modern portfolio theory started with the work by Harry Markowitz in the 1950s. His paper, Portfolio Selection (14), where he describes how to set up a portfolio of securities that can either maximize return, minimizes variability of return (volatility) or a combination of the two which gives the most return for a given level of risk. The theory follows the concept of higher return implies higher risk, but by diversifying the portfolio and choosing securities in the portfolio that is not well correlated with each other it is possible to maximize return for a given level of risk or minimizing risk for a given level of returns. Even though diversification is powerful, securities are too correlated with each other to be able to achieve a portfolio with zero risk.

Covariance, Correlation and Diversification

The concepts of covariance is known from statistics and is a measure of how two variables vary together. Covariance is defined mathematically as (15)

$$\text{cov}(X, Y) = \frac{1}{N} \sum_{i=1}^{N} (x_i - \mu_x)(y_i - \mu_y). \tag{3.5}$$

The Pearson Correlation Coefficient is variable to measure the linear correlation between two variables. It is normalized from +1 (perfect positive correlation) to -1 (perfect negative correlation). A value of 0 means that there are no correlation between the two variables. The correlation is defined as the covariance between X and Y variables divided by the product of the standard deviation of the two variables.

$$\rho_{X,Y} = \frac{Cov(X, Y)}{\sigma_x \sigma_y} \tag{3.6}$$

Risk and Return of a Portfolio of Assets

For a portfolio with one asset the expected return of portfolio equals the expected return of the asset and the expected risk of the portfolio is defined as the standard deviation of the returns. For a portfolio of more than one asset the expected return of the portfolio is given as the weighted sum of the individual assets. We have therefore for a portfolio with $i = 1, 2...N$ assets with expected returns $\overline{R}$ and weights X the following equation to calculate expected return for a portfolio (16).

$$\overline{R}_p = \sum_{i=1}^{N} (X_i \overline{R}_i) \tag{3.7}$$

The risk of the portfolio of more than one asset is not only defined on how the assets in the portfolio vary, but also how they vary together. The expected risk of the portfolio can therefore be seen as containing both an individual risk term for each asset and a covariance term. The variance of the portfolio, σ_p^2, can mathematically be written as (16)

$$\sigma_p^2 = \sum_{j=1}^{N}(X_j^2\sigma_j^2) + \sum_{j=1}^{N}\sum_{\substack{k=1 \\ k\neq j}}^{N}(X_j X_k \sigma_{jk}) \tag{3.8}$$

Where σ_{jk} denotes the covariance between asset j and k. Note from equation 3.8 that for a two asset portfolio and covariance equal to 0 (i.e. no correlation) the covariance terms will be eliminated. A cornerstone in modern portfolio analysis is to look at assets not on an individual basis, but how they fit in with the overall portfolio. An asset may be seen as risky on its own and a poor investment descision, but it may reduce the overall portfolio riskyness due to a poor correlation with the other assets. Therefore, including the asset in the portfolio is a sound investment descision.

Efficient Frontier

The concept of efficient frontier was first introduced by Markowitz in his paper Portfolio Selection (14). The efficient frontier is the optimal portfolio in terms of risk and return. Either as the highest return for the same risk or lowest risk for the same return. Portfolios that either give lower return for the same amount of risk or higher risk for the same amount of return are defined as sup-optimal. Typically a more diversed portfolio will be more optimal than an undiversed as different type of securities may reduce the overall risk of the portfolio.

Capital Asset Pricing Model

The capital asset pricing model was independently developed by William F. Sharpe, John Lintner and Jan Mossin building on the work by Harry Markowitz. The capital asset pricing model prices a security based on the risk associated with the security.

$$\overline{R}_e = R_F + \frac{\overline{R}_m - R_f}{\sigma_m}\sigma_e \tag{3.9}$$

Where $\overline{R}_e$ denotes the expected return of the security, R_F the risk free return, σ_m the risk of the market and σ_e the expected risk of the secuirity. In a plot of expected return versus risk, the capital asset pricing model plots as a straight line, with intersection equal to R_F and slope equal to $(\frac{\overline{R}_m - R_f}{\sigma_m})$. Hence the term, $\frac{\overline{R}_m - R_f}{\sigma_m}$ is often seen as the market price of risk for all efficient portfolios. It is the extra return that can be expected to be gained by increasing the level of risk on an efficient portfolio by one unit (16).

Sharpe Ratio

The Sharpe ratio, first introduces by William Sharpe in 1966 (17) is a financial metric to evaluate the return of an asset considering the risk it has taken on. The Sharpe ratio is defined mathematical as:

$$Se = \frac{\overline{R}_e - R_f}{\sigma_e} \tag{3.10}$$

Where Se is the Sharpe ratio, $\overline{R}_e$ expected return, R_f risk free return and σ the standard deviation of the returns. The Sharpe ratio is useful in evaluating different types of securities that has different return and volatility. One of the key assumptions in the relationship as discussed before is that volatility implies risk. This is not always the case, but this thesis will also use the assumption that volatility is a good measure of risk.

3.3 Portfolio Management

Utility Function

An important concept in portfolio management is the concept known as a utility function. The utility function, U, describes the relationship between risk and return. All utility functions has a constant know has the coefficient of risk aversion (16), which specifies the tradeoff between risk and return. The preference for risk will vary from portfolio to portfolio and from investor to investor. The risk profile is also a function of wealth and can be written as $U(W)$. The investor may have a different willingness of risk depending on the wealth it has. If the investor is willing to take the same risk if he owns $10,000 or $100,000, the investor is risk neutral. If the investor is more willing to take risk if the wealth is low, the investor is risk averse and if the investor increases the risk if the wealth is higher, the risk is said to be risk seeking.

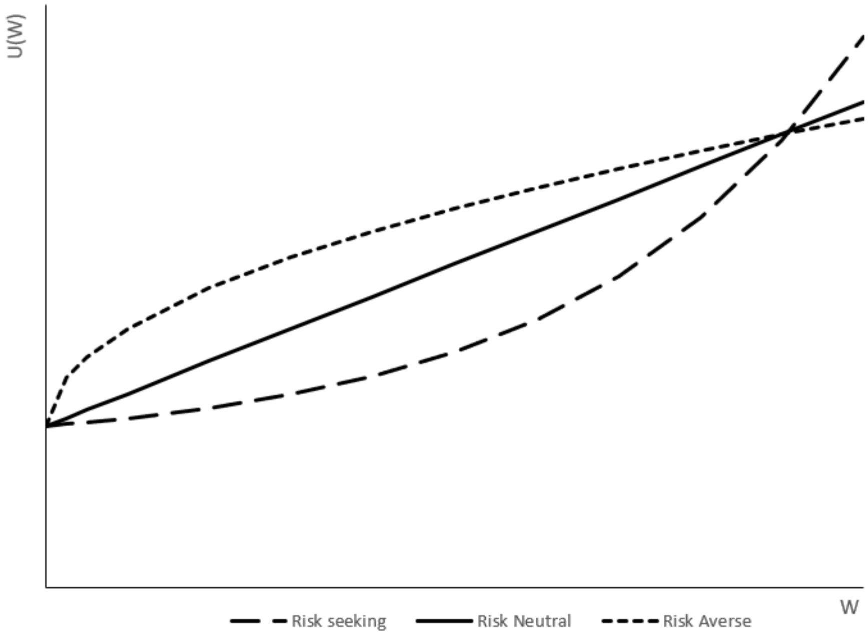


Figure 3.1: Utility function charecteristicks for risk seeking investor, risk neutral investor and risk averse investor.

Portfolio Management and Diversification

Portfolio management revolves around the policy and decision making around the portfolio. The key component of portfolio management is the investment mix in the portfolio. What should be the risk and return of the portfolio? Should the portfolio be invested globally or locally? What kind of sectors? Key to modern portfolio management is diversification. By having a diversified portfolio the portfolios exposure to risk is reduced. The concept of diversification is only valid if the securities in the portfolio are not perfectly correlated. Goetzman and Kuma (18) analyzed 60,000 individual investors equity portfolio from 1991-1996. They found evidence for a risk reduction if the investor holds more than one security. They also found that the number of securities has increased from 1991 to 1996 for the average investor, indicating that investors become more conscious about diversification and seeks to have a diversified portfolio. How an investor wants to diversify it's portfolio also dependent on the utility and the level of risk the investor is seeking for his portfolio. The NGPFG strategy is also to have a diversified portfolio to reduce risk and maximize return within the guidelines set by Ministry of Finance (12) which fits well with the financial theory.

3.4 Regression Modelling

In order to find relationship between different stock indices, commodity prices, exchange rates and so forth regression analysis will be used in this thesis together with simpler mathematical tools such as correlations. Particular in order to find out a combined response in a variable given several underlying predictor variables. Regression analysis is a tool to establish how a change in one variable effects another variable. A linear regression model uses a simple linear equation fit between the dependent variable and the independent variable.

$$Y = \alpha + \beta x \tag{3.11}$$

Where Y is the dependent variable, dependent on the variable X and α and β is unknown constants the regression analysis seek to find out by minimizing the error between the model and the data. The model can also be expanded by including several independent regression variables and it can take a more generalized form with up to n indepdent variables as shown in equation 3.12. This generalized form with more than one variable is known as multiple linear regression.

$$Y = \alpha + \beta_1 x_1 + ...\beta_i x_i ... + \beta_n x_n \tag{3.12}$$

A measure of how good the model is at reproducing the actual data can be calculated by using the coefficient of determination, R^2. For a data set containing $y_1,...,y_n$ data points and corresponding modeled data $f_1,...,f_n$, the R^2 is defined as (15)

$$R^2 = 1 - \frac{SS_{res}}{SS_{tot}} \tag{3.13}$$

Where SS_{res} is the sum of squared residuals between the actual data and modeled data defined as

$$SS_{res} = \sum_i (y_i - f_i)^2 \tag{3.14}$$

and SS_{tot} is the total sum of squares defined as

$$SS_{tot} = \sum_i (y_i - \overline{y})^2 \tag{3.15}$$

Where $\overline{y}$ is the mean of the data as in equation 3.2.

3.5 Time Series Analysis

Time series is a dataset containing data as a function of time. Time series are common in the field of economics, for example stock prices and stock indices are classical examples of time series. One of the phenomena that is special for time series of data is that two datapoints that are next to each other in time often is closely linked to each other (19) . For example the stock price in February is related to what the stock price was in January the same year. The fact that data sampled close to each other are related is logical and intuitively, but it causes problems in the field of statistics where methods only are valid if the samples are independent of each other. In order to avoid the dependency in the time series data, an option is to consider the change from one time to another rather than the actual value. This can be done by using the return of stock prices rather than the stock value. Whether or not a stock increases in value in February is less dependent on whether or not the stock increased or decreased in January. The problem with two adjacent data points being naturally correlated with each other is known as autocorrelation and there are several important checks that can be done in order to look for how valid a regression model is. An important feature is the characteristics of the residual data set in order to check for autocorrelation. Plotting the histogram of residuals for a regression analysis, the residuals should have an approximate normal distribution centered around 0. In addition looking at a residuals versus fitted plot for pattern is useful for pattern recognition of autocorrelation. If there is no correlation between lagged data the values should be randomly distributed. If there are recognizable patterns in the plot, there is a large chance that the residuals are correlated and hence the regression analysis is not statistical valid.

Chapter 4

Analysis

4.1 Stock Indices

In order to evaluate the oil and gas industry stocks performance versus other industry sectors and the impact the oil market has on share price the MSCI USA IMI Indexes (20) has been chosen as the data for the analysis. The MSCI USA IMI Indexes covers all the industry sectors in the US stock market. The MSCI USA IMI Index covers approximately 99% of the total free float-adjusted market capitalization in the US. All though the Norwegian Government Pension Fund Global is globally diverse, the MSCI USA IMI indices covers only the US market, the relative behaviour between the different industry sectors are assumed to behave similar in the US as for the global economy. Similarly, the impact the oil price has on the share price of US companies are also assumed to be representative for a globally diverse portfolio. These are two important assumptions in the thesis, but there are no global industry sector indices that are available for easy data handling and therefore the MSCI USA IMI sector indices has been chosen. The MSCI USA IMI Index is divided into the following 11 sectors as shown in figure 4.1 according to Global Industry Classification Standard (GICS). Information technology covers technology and computer science companies such as Apple, Microsoft and Facebook. This is also the largest sector in the index. The financial sector covers banking, insurance and other financial institutions such as J.P. Morgan Chase, Bank of America and Warren Buffet's investment company Berkshire Hathaway. The health care sector includes pharmaceutical, biotechnology and other health related companies such as Johnson and Johnson, Pfizer and United Health. The consumer discretionary sector

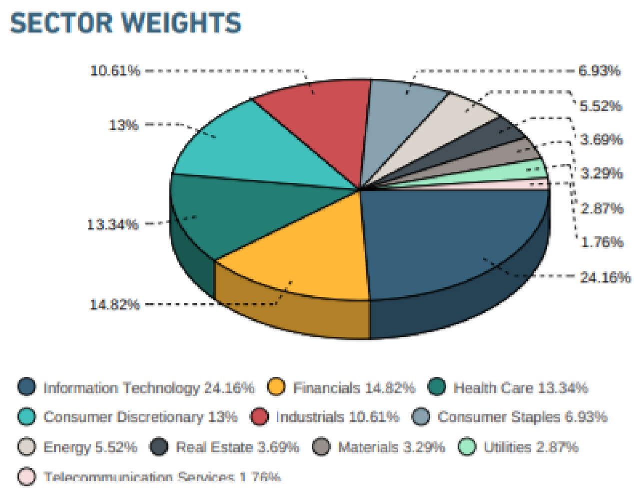


Figure 4.1: MSCI USA IMI sector weights as of December 2017. Energy sector constitutes 5.52% of the total MSCI USA IMI Index. Figure taken from (20)

consists of companies that sell non-essential consumer goods such as internet retail, home entertainment, luxury goods and automobiles. Key companies in this sector includes Amazon, Home Depot and Disney. Industrial sector contains everything from heavy construction, industrial conglomerates and aerospace and defence companies. The largest companies in this sector are Boeing, 3M and General Electrics. Consumer staples are basic consumer needs such as food, beverages and household items. Key companies include Proctor & Gamble, Coca Cola Co. and Walmart. The energy sector, which is the key for this thesis, is divided into 7 sub-industries. The integrated oil and gas companies such as Chevron and ExxonMobil together with the pure-play Exploration and Production companies such as ConocoPhillips and EOG Resources makes up roughly 70 % of the sector. In addition, service companies and drilling companies which supply goods and services to the oil and gas companies make up another 15 % of the sector. The rest of the sector consists of mid- and downstream oil and gas companies, such as Phillips 66 and other energy companies. 85% of the energy sector is directly exposed to the changes in oil price and the sector is therefore a representative measure of the performance of oil and gas stocks. Real estate sector covers companies that primarily deal with renting out real estate property or buying and selling of real estate properties. The real estate sector was introduced as a separate sector in June 2006. Materials covers companies that deal with various metals, minerals, chemicals, glass, fertilizers and other materials. The final sector that the MSCI USA IMI Index is

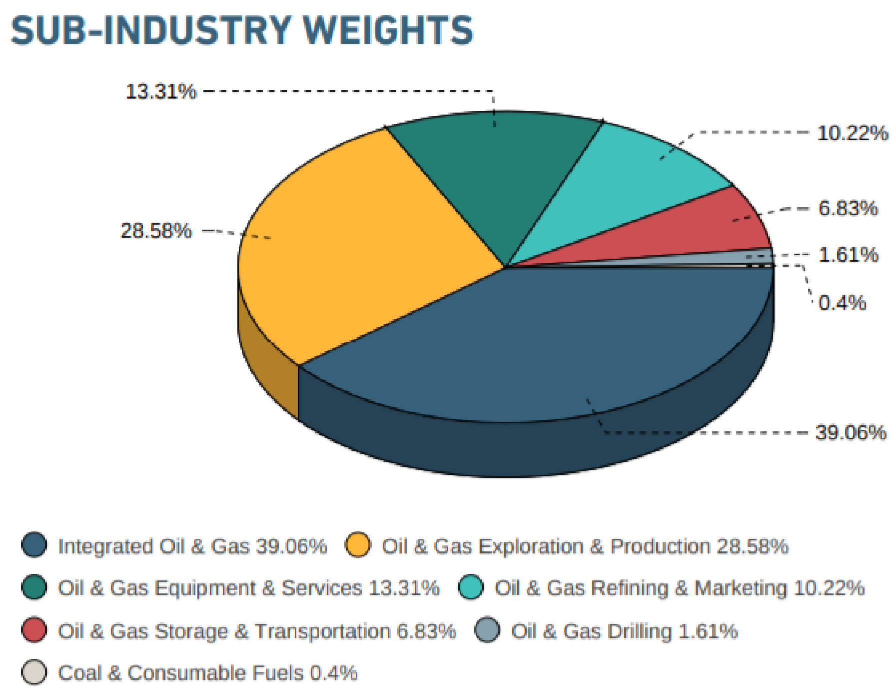


Figure 4.2: MSCI USA IMI Energy sub-sector weights as of December 2017.Figure taken from (20)

divided into is telecommunication which covers companies that deal with providing telecommunication services. This sector was introduced as a separate sector in January 1999.

Comparison with Norwegian Government Pension Fund Global

The sector weights of the NGPFG is shown in figure 2.2. The largest difference in the sector classification is that the NGPFG differentiates the consumer sectors into consumer goods and consumer services rather than consumer discretionary and consumer staples. Therefore the weights of these sectors in the MSCI USA IMI index are different than for the NGPFG. The total sum of consumer discretionary and staples in the MSCI USA IMI index are 20% while the total sum of consumer goods and consumer services for the NGPFG is 23.8%. In terms of sector weights the largest difference is for information technology which makes up about 24.1% of the MSCI USA IMI index while the technology sector only makes up 9.4% of the NGPFG. These differences can be explained by the fact that the NGPFG is globally diverse while the MSCI USA IMI Index consists only of US stocks where the technology sector is proportionally a larger share of the total stock market. The oil and gas companies makes up about the same share in both the MSCI USA IMI Index and NGPFG, 5.5% and 6.4% respectively.

Performance of Industrial Indices

The historical performance of all sectors are shown in figure 4.3. The stock indices are normalized to a value of 1000 in June 2006, equal to the entry of the most recent sector, the real estate sector. Generally the stock performance has been very good since 1994. The IT bubble and the following collapse is clearly visual in the late 90s and beginning of 2000. The energy sector in yellow outperformed all other sectors to the financial crisis in 2007/2008 while it has underperformed against all other sectors after the financial crisis and especially from the start of the crash in oil price in 2014. The key metrics average yearly return, standard deviation and Sharpe ratio for the different sectors are given in table 4.1. The Sharpe ratio is calculated using equation 3.10 with an assumed average yearly risk free interest rate of 3%. The risk free is approximately equal to the average yield on the 10 year U.S treasury bill for the recent years. As can be seen from the table, the Information Technology sector has been the most profitable with an average

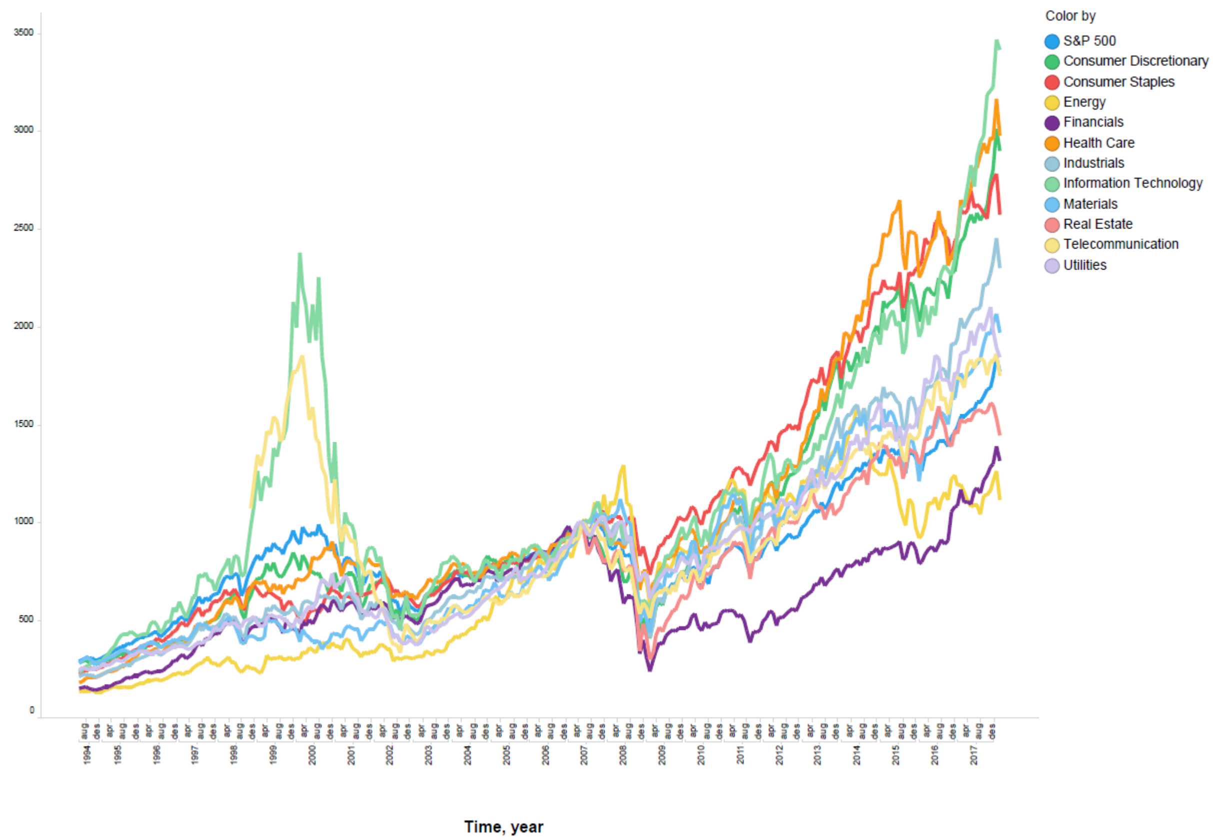


Figure 4.3: MSCI USA IMI Sector Indices performance from 1994 to 2018. Source MSCI (20)

Sector	Average Yearly Return	Std. Dev	Sharpe Ratio
Consumer Discretionary	0.122	0.055	1.67
Consumer Staples	0.116	0.037	2.33
Energy	**0.118**	**0.063**	**1.41**
Financials	0.121	0.063	1.45
Health Care	0.135	0.043	2.44
Industrials	0.124	0.054	1.74
Information Technology	0.157	0.077	1.64
Materials	0.109	0.062	1.28
Real Estate	0.080	0.083	0.60
Telecommunication	0.049	0.062	0.31
Utilities	0.100	0.043	1.60

Table 4.1: MSCI USA IMI Sector average yearly return, standard deviation and calculated Sharpe ratio using an risk-free interest rate of 3%. Energy sector is highlighted.

yearly return of 15.7%. However, it has also been one of the most volatile sectors with a high standard deviation and therefore only a medium Sharpe ratio. On the other end of the scale is the telecommunication sector which has had only 4.9% average yearly return, but it must be noted that the telecommunication yearly return is only calculated from calculated from when the sector was introduced in January 1999. The sector which has provided the most consistent return with low volatility and risk is the health care sector with an average return of 13.5% with a standard deviation of 0.043 and a calculated Sharpe ratio of 2.44. The energy sector comes out more or less in the middle of the pack with average yearly return of 11.8% and standard deviation of 0.063 with a Sharpe ratio of 1.41. Holding energy sector stocks has therefore not given any extra return over the last 24 years nor has it been underperforming to the rest of the sectors even though the collapse in oil price in 2014 has hit the industry hard.

Correlation Between Industries

To evaluate how closely the different industries are together, the correlation between the different industry indices are caluclated using equation 3.6 and plotted together in a matrix in figure 4.4. Highlighted in bold are how the energy sector correlate with the other industries. In general, all stock indices show a positive correlation with each other which shows that normally the market moves in the same direction. If the stock market goes up, normally all sector go up while

	Consumer Discretionary	Consumer Staples	Energy	Financials	Health Care	Industrials	Information Technology	Materials	Real Estate	Telecommunication	Utilities
Consumer Discretiona	1.00	0.58	**0.52**	0.80	0.63	0.88	0.72	0.79	0.82	0.70	0.34
Consumer Staples	0.58	1.00	**0.41**	0.65	0.67	0.62	0.30	0.54	0.70	0.37	0.49
Energy	0.52	0.41	**1.00**	0.54	0.44	0.66	0.40	0.70	0.53	0.41	0.50
Financials	0.80	0.65	**0.54**	1.00	0.67	0.83	0.47	0.72	0.83	0.51	0.42
Health Care	0.63	0.67	**0.44**	0.67	1.00	0.67	0.51	0.55	0.72	0.51	0.43
Industrials	0.88	0.62	**0.66**	0.83	0.67	1.00	0.65	0.87	0.78	0.60	0.43
Information Technolo	0.72	0.30	**0.40**	0.47	0.51	0.65	1.00	0.53	0.68	0.71	0.19
Materials	0.79	0.54	**0.70**	0.72	0.55	0.87	0.53	1.00	0.72	0.52	0.37
Real Estate	0.82	0.70	**0.53**	0.83	0.72	0.78	0.68	0.72	1.00	0.67	0.61
Telecommunication	0.70	0.37	**0.41**	0.51	0.51	0.60	0.71	0.52	0.67	1.00	0.33
Utilities	0.34	0.49	**0.50**	0.42	0.43	0.43	0.19	0.37	0.61	0.33	1.00

Figure 4.4: Correlation matrix with calculated correlation between the different sectors that make up MSCI IMI Index.

if the general stock market go down, most sectors also follow the same trend. The utility sector is the sector which has the lowest correlation with the other sectors, while the energy stocks relate fairly poor with the other sectors as the correlation ranges from 0.41-0.70. Other sectors, correlate strongly with each other, such as the consumer discretionary and industrial sector and real estate and financial sector.

Oil Price Influence on Stock Indices

In order to evaluate the oil price infulence on the various stock indices, a correlation value between the Brent spot monthly returns and the various stock indices monthly returns were calculated using equation 3.6. The results are shown in table 4.2. The start point of the calculation varies, most indices are calculated back to 1994 while Real Estate and Telecommunication were not introduced as separate indices before 2007 and 1998 respectively. As can be seen from the table, most industry indices share little to no correlation with the oil price. The industry that is mostly correlated with the oil price is the Energy sector which confirms the hypothesis that the oil price do influence the Energy stocks the strongest and that the Energy stocks are most exposed to a fall in the oil price. The Real Estate sector also show up with a relatively strong correlation to the oil price with 0.319, without there being any logical reasoning for why the real

Stock Indices Correlation with Oil Price	
Consumer Discretionary	0.166
Consumer Staples	-0.010
Energy	0.387
Financials	0.153
Health Care	0.108
Industrials	0.227
Information Technology	0.166
Materials	0.278
Real Estate	0.319
Telecommunication	0.182
Utilities	0.134

Table 4.2: Stock Indices correlation with oil price, source MSCI and EIA

estate industry should strongly correlate with the oil price. A possible explanation for the strong correlation between real estate sector and oil price can be that the time period for real estate index is shorter than the other indices and hence the population to calculate the correlation from is smaller and more likely to give abnormal correlation values.

4.2 Norwegian Kroner and Oil Price

As shown in chapter 1, the economy of Norway is heavily dependent on the oil industry. The oil industry has in periods constituted as much as 50 percent of the total export from Norway and 20 percent of the total GDP. Naturally, as the state revenues is so tightly linked to the oil price, the Norwegian krone is also linked to the oil price. As can be seen in figure 4.5, the USD to NOK exchange rate follows the development in the oil price. A decrease in oil price typically leads to a weakened krone, increasing the USD to NOK exchange rate. The oil price and USD to NOK exchange rate is negatively correlated. This is particular clear after the financial crisis in 2008 and with the collapse of the oil price in 2014 the exchange rate reacted almost immediately. The correlation is not perfect as other factors also influences the exchange rate such as interest rates in the two countries and general market economical factors. The correlation coefficient is calculated to be -0.45 for the time period from 2000 to 2018. Interesting to note is that the USD to NOK exchange rate is stronger negatively correlated with the oil price than the Energy stock indices is positively correlated with the oil price and one can argue that the exchange

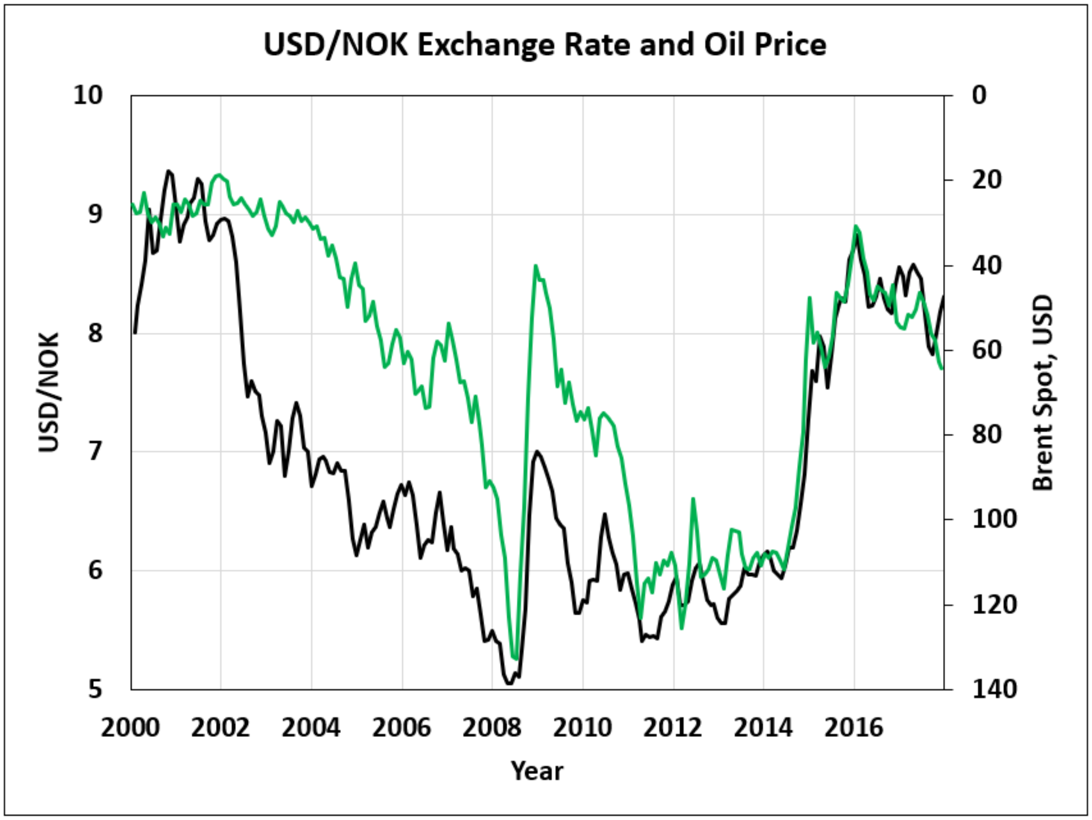


Figure 4.5: Left hand scale: USD to NOK exchange rate (black line). Right hand scale: Brent spot oil price (green line). Source: Norges Bank (21) and EIA (5).

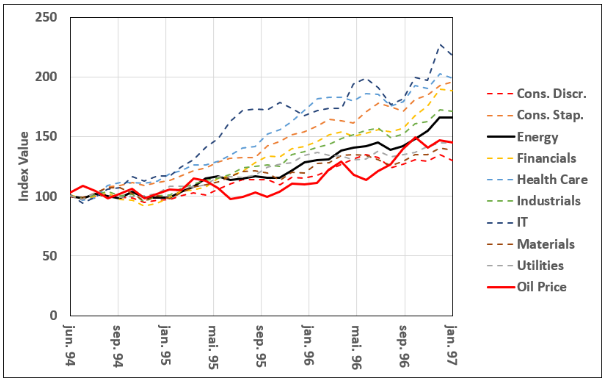
rate is even more exposed to the oil price than the stock value of the oil and gas companies. A natural consequence of the negative correlation between oil price and exchange rate is that the value of the Norwegian Government Pension Fund Global will increase measured in Norwegian kroner in times where the oil price is low and act as an insurance against falling oil prices. The decision to invest in asset es outside of Norway is therefore a natural hedge in itself against a drop in oil price. This is also seen in figure 2.4, where some of the best years in terms of return of the Norwegian Government Pension Fund Global was 2014, 2015 and 2016 where the value of the fund in NOK increased significantly following the collapse in oil price and subsequent weakening of the Norwegian Krone.

4.3 Cyclical Behavior of Oil and Gas Stocks

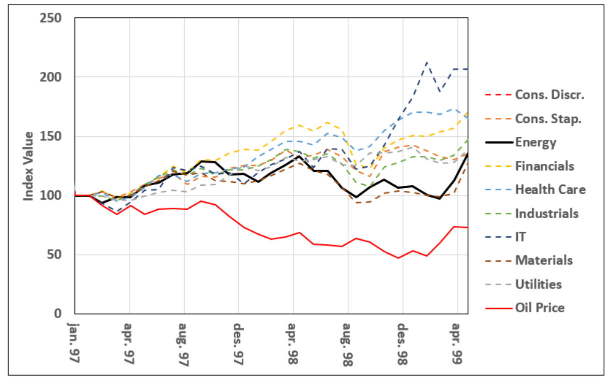
As described in the introduction, the nature of the oil price is cyclical with several large fluctuations in the oil price. How does the energy stocks react to those fluctuations? Do the oil and gas companies outperform the other sectors in periods with high oil price and in periods with low oil price significantly underperform? Dividing the history into specific periods the performance of the oil and gas companies can be analysed on both the up and downturns of the oil and gas industry. The following periods has been chosen:

- 1994-1997 - Stable oil price environment
- 1997-2000 - Oil price collapse following Asian financial crisis
- 2000-2007 - Steady oil price gain reaching peak before financial crisis
- 2008-2009 - Financial crisis
- 2009-2014 - Recovery after the financial crisis
- 2014-2017 - Oil price collapse following shale oil supply.

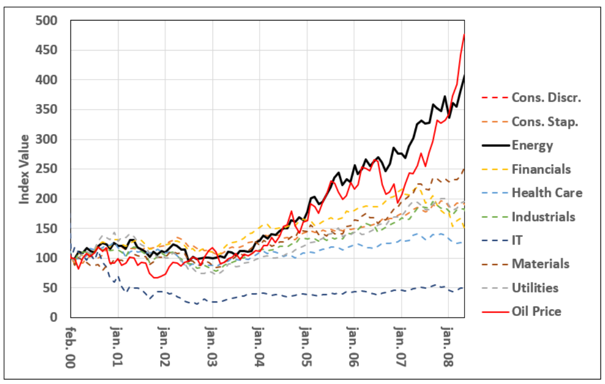
The first period is a period with financial stability and a fairly stable oil price environment. The energy stocks follows in general the market trends while the oil price is slightly increasing during the period. The second period covers the last major oil price collapse in 1998, where slowing demand growth triggered an oversupplied market and a collapse in the oil price. However, the oil and gas companies managed to keep their stock price fairly stable in this period even though the oil price dropped by as much as 50% from beginning of the period to the lowest point in the period. In this period, the energy stocks lagged behind the other sector, but not as much as one could expect given the drop in oil price. Following that period of oil price collapse, the oil price started to pick up again and steadily increased for the next 8 years. The oil and gas companies followed the oil price and significantly outperformed the other sectors stock performance for the period. In this period the oil and gas companies managed to increase their value by 4 times. Following the financial crisis, both the oil price and the energy stocks was also significantly impacted by the unrest in the financial market. The energy sector followed the general market trends and fell about 50% in value in less than a year. The financial markets recovered well the following years, including the oil price and energy companies. This was another period of very little volatility in the oil price and the margins for the oil companies remained high. The oil price collapse in 2014 caused by oversupply in the market and following collapse in oil price, with the oil price trading at as low as 30% of what it had been before the crash. The oil price collapse had a significant impact on the oil and gas companies. However, the stocks did not fall as much as the oil price. The overall energy index only fell by about 60%. Some of that can be attributed toward the oil and gas companies ability to transform and cut costs during the oil price collapse. In addition, the major integrated oil and gas companies also has a significant downstream business that increased their margin and hence made the oil and gas companies less vulnerable to the oil price shock. In terms of oil price and stock performance and the underlying causes the oil price collapse of 97-99 is not that different from the oil price collapse 2014-2017. Whether or not the following period with increasing oil price will repeat itself remains to be seen, but it is not unlikely that following the oil price collapse and subsequent investment cuts the supply situation in the worlds market might tighten up if the shale oil cannot deliver the necessary growth that is required. If that is to happen, a similar situation as the situation that was observed in the 2000s may happen and the energy companies may once again significantly outperform the rest of the market.



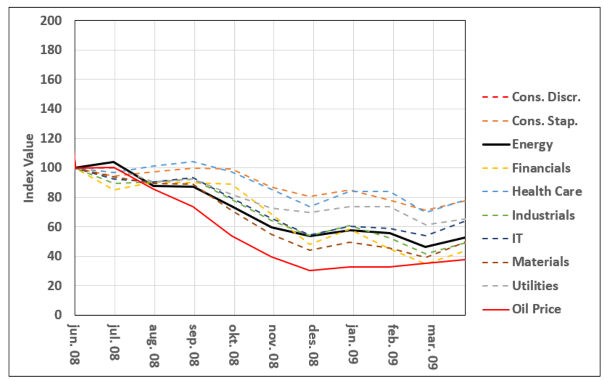
(a) MSCI Sector performance from June 1994 to January 1997 in a period with stable and slightly increasing oil price.



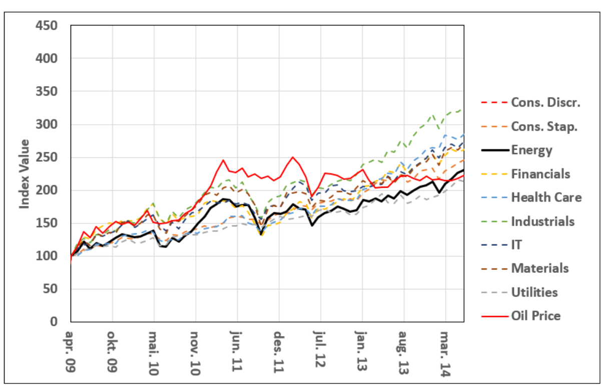
(b) MSCI Sector performance from February 1997 to February 2000 in a period with a drop in oil price.



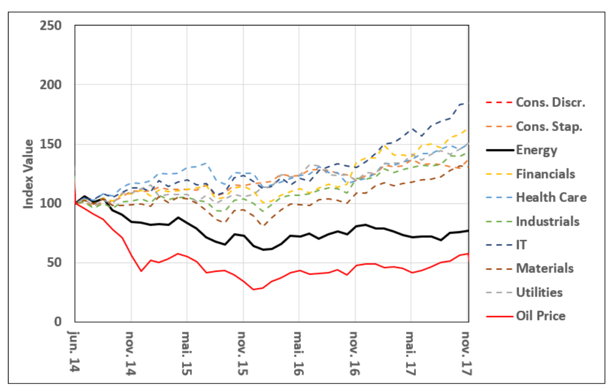
(c) MSCI Sector performance from February 2000 to June 2008 in a period with increasing oil prices and oil and gas companies stocks.



(d) MSCI Sector performance during the financial crisis.



(e) MSCI Sector performance during the recovery from the financial crisis.



(f) MSCI Sector performance from june 2014 to January 2017 with falling oil prices and problems in the oil and gas industry.

Figure 4.6: Sector stock performance during key periods.

Chapter 5

Regression Modeling

This chapter seeks to expand on the analysis performed in chapter 4 where it was found that the there exists a correlation between oil price and oil and gas stocks and the correlation between oil price and the energy sector were the strongest among all sectors. However, it was also clear that the oil price alone does not explain the return of the oil and gas sector companies. This chapter will therefore look at the results of the regression modeling analysis and examining the data for autocorrelations and confirm that the models are valid by analyzing the residuals between the regression model and the actual values. The three fundamental hypothesis to examine in this chapter is how does the oil and gas stocks behave as functions of the general market conditions as measured with the S&P 500 Index that is a broad index covering 500 of the largest companies in the US. Secondly is how the oil and gas stocks behave as a function of the oil price and thirdly is it possible to construct a combined model that predicts the performance of the oil and gas stocks better than the two variables alone.

5.1 Model based on Oil Price

In chapter 4 it was found that the energy sector is positively correlated with the oil price, but how good would a regression model be? A linear regression model was set up using the return of the Brent Spot oil price as a the predictor variable and return of the MSCI Energy index as the response variable. A regression model based on return rather than the actual index value is chosen to avoid autocorrelation between the two time series as a regression model based on two indexes will give an artificial good match between the two time series. The best fit line was found with an intercept of 0.0082 and a slope of 0.2285 indicating that for every 1 change in return of the oil price the energy companies changes by 0.2285. -The goodness of fit of the the regression model is found with an R^2 of 0.1476 and an adjusted R^2 of 0.1446. These values are closer to 0 than to 1 indicating a fairly poor regression model between the two variables. Only 14% of the variance in the return of the energy stocks can be explained by the return of the oil price.

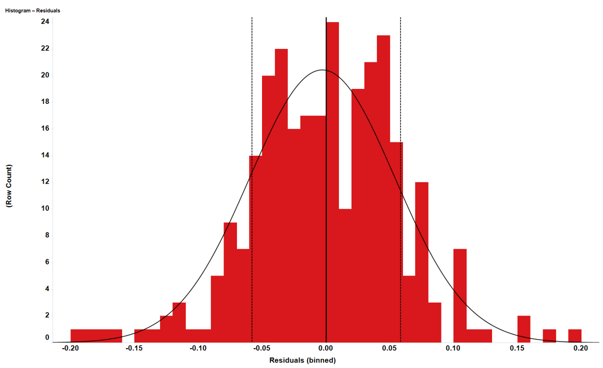
Table 5.1: Regression coefficients between energy stocks and Brent Spot oil price

Regression Coefficients		
	α	β
Brent Spot	0.0082	0.2285

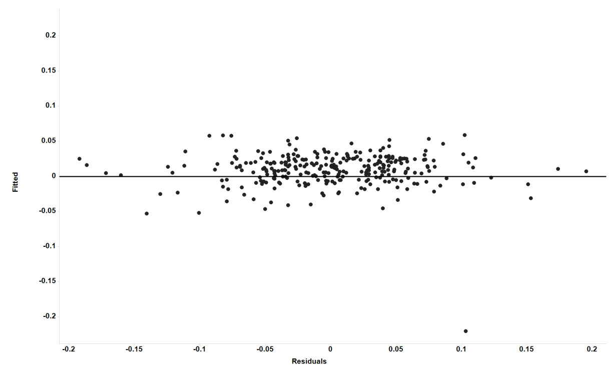
Table 5.2: Regression statistics for model with energy stocks and Brent Spot oil price

Regression Statistics	
R Squared	0.1476
Adj. R Squared	0.1446
Residual Standard Error	0.05818

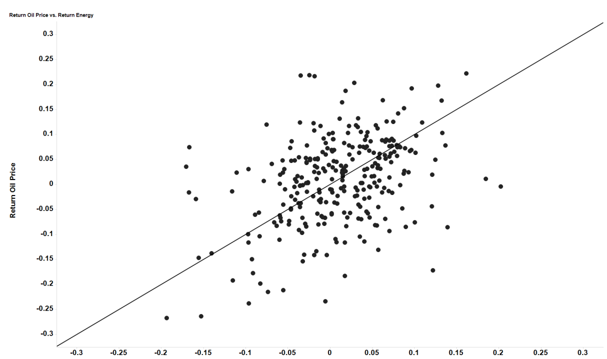
This is also evident by studying the crossplot (figure 5.1c). The crossplot contains a significant amount of scatter and there are no visual obvious relationship between the two variables. Compared to the regression line, there are many outliers confirming a poor R^2 of the regression analysis. The residuals of the regression analysis is normal distributed with a mean of 0 and standard error of 0.058. There are also no obvious pattern in the residuals indicating that the model is statistically consistent.



(a) Histogram of residuals



(b) Plot of residuals versus fitted values



(c) Crossplot of return oil price and return energy. Black line is $y = x$.

Figure 5.1: Key diagnostic plots and figures of the oil price and energy stock regression model

5.2 Model based on S&P 500

A regression model is constructed on the background of the historical returns of the energy stocks and the historical return of S&P500 Index. This is done to see how well the energy stocks follow the changes in the general market. The return as defined in chapter 3 is used in order to avoid autocorrelations between the two time series. The regression coefficients found from the regression analysis is found in table 5.3. A β value of 0.8601 implies that for a change in the returns of 1 for S&P500 the energy stocks changes by 0.8601.

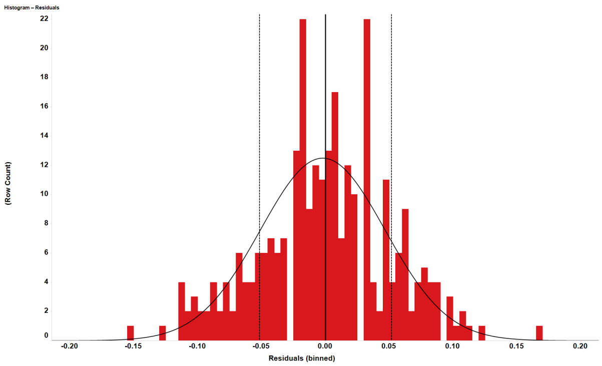
Table 5.3: Regression coefficients between energy stocks and S&P500

Regression Coefficients		
	α	β
S&P500	0.0032	0.8601

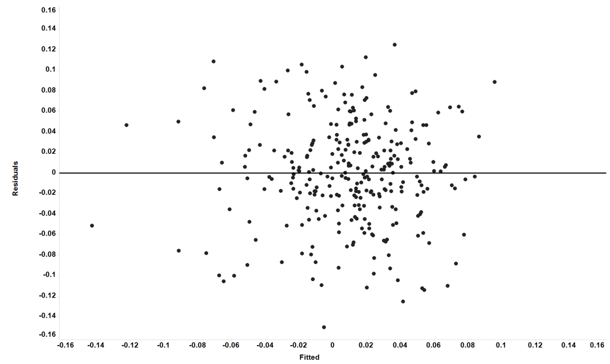
How good the regression model is can be determined by examining the R^2 values. The calculated R^2 for this regression model is found to be 0.3267 for the regression model between S&P500 and energy stocks. A perfect correlation model would had a R^2 value of closed to 1 so the model is not able to accurately predict all the changes in the return of energy stocks by general market trends. It does however provide a better R^2 value than the model based on the return of the oil price, but both models has clear limitations.

Table 5.4: Regression Statistics for model with energy stocks and S&P500

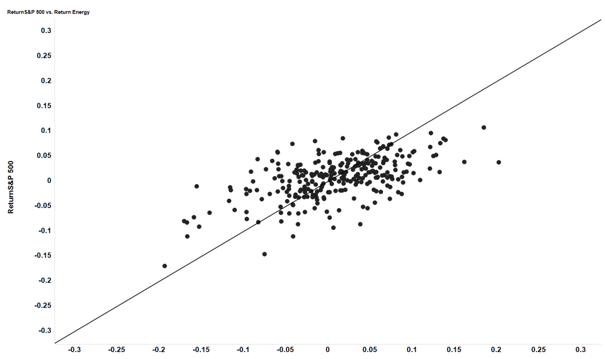
Regression Statistics	
R Squared	0.3267
Adj. R Squared	0.3243
Residual Standard Error	0.05171



(a) Histogram of residuals



(b) Plot of residuals versus fitted values



(c) Crossplot of return S&P500 and return energy. Black line is $y = x$.

Figure 5.2: Key diagnostic plots and figures of the S&P500 and energy stock regression model

Analysis of Residuals

In order to check that the model are statistically correct and that the two series are independent of each other, the residuals between the model and the actual values are examined. The residuals are approximately normally distributed with a mean of 0 and standard deviation of 0.05. The residuals are also randomly distributed plotted versus the fitted values, indicating that the residuals are noise in the model and there are no underlying trends in the residuals. Noise of this sort is know as white noise. Plotting the actual values (figure 5.2c) against each other one can also see that the two series do follow each and are correlated to some extent, but that there are significant scatter associated with the plot. The correlation trend by looking at the crossplot is better between S&P500 and energy stocks than between oil price and energy stocks confirming a closer relationship between the general market and the energy stocks than between oil price and energy stocks.

Table 5.5: Regression coefficients for model with both Brent Spot oil price and S&P500

Regression Coefficients	
α	0.0028
$\beta_{\text{S\&P500}}$	0.7882
$\beta_{\text{Oil Price}}$	0.1791

Table 5.6: Regression statistics for model with both Brent Spot oil price and S&P500

Regression Statistics	
R Squared	0.4151
Adj. R Squared	0.4109
Residual Standard Error	0.04828

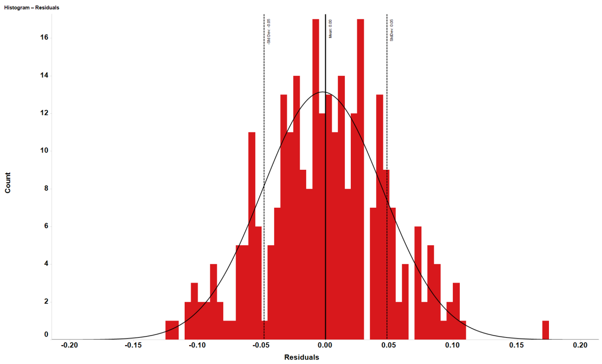
5.3 Combined Oil Price and S&P 500 Model

To further expand on the models for oil price and S&P500 model, a combined model with both oil price and S&P500 as the predictor variables was constructed. Again, the return of the 3 time series was used in the analysis. The point of making a combined model is to see if the energy stocks performance can better be explained by a simple combined model using both variables together. The model takes the following form

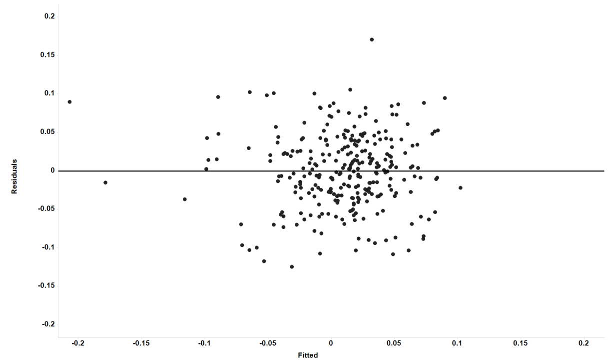
$$R_{energy} = \alpha + \beta_{S\&P500} R_{S\&P500} + \beta_{OilPrice} R_{OilPrice} \tag{5.1}$$

And the coefficients are found using multiple linear regression analysis. The regression coefficient for the S&P 500 is closer to 1 than the coefficient for the oil price, indicating that the return of energy stocks are more closely linked to the S&P500 than it is to the change in oil price. Hence, the S&P500 is the most important of the two variables confirming again a stronger relationship to the general market performance than the oil price performance.

The R^2 of 0.4151 is better than both of the R^2 for the individual models proving that a combined model using both oil price and the general market is a better model to explain the return of the energy company stocks. Intuitively, this also makes a lot of sense as both the general stock market as well as the oil price should influence stocks that are so dependent on one single commodity. Looking at the residuals, the residuals are approximately normal distributed with



(a) Histogram plot of residuals for regression models using both the return of S&P500 and return of Brent Spot oil price as the predictors.



(b) Plot of residuals versus fitted values

a mean of zero and a lower standard error (0.048) than for the two other models. The residuals are also randomly distributed and no autocorrelation exists in the dataset.

Chapter 6

Impact of a Sell-Off of Oil Stocks

This chapter will focus on the impact a sell-off of all oil stocks will have on the Norwegian Government Pension Fund Global. As shown in chapter 4, the energy stocks does not stand out in neither direction compared to the other sector when it comes to return or risk. Chapter 4 also shows that it has a relatively poor correlation with the other sectors, while it is the sector that has the most correlation with the oil price. As shown in chapter 2, the share of energy stocks in the NGPFG is fairly small, about 6%, hence the changes in terms of risk, return and exposure to oil price is expected to be relatively small. This chapter uses different constructed portfolio of stocks using the MSCI USA IMI indexes discussed in chapter to evaluate the changes a sell-off will have on an artificial portfolio. The share of energy stocks is varied between 0 and 0.3 as having a share of energy stocks in the portfolio of More than 30% is considered unrealistic.

Impact on overall return and risk of the portfolio?

One of the fundamental questions regarding an investment decision to not invest in the energy sector stocks is how does the decision impact the overall portfolio viewed in context with modern portfolio theory. The portfolio is assumed to have a sector weights equal to that of figure 2.2. Hence, different sets of portfolio can be constructed with varying portion of energy sector stocks in the portfolio. The risk and return can be evaluated and an efficient frontier can be constructed as a function of portion of energy stocks in the portfolio to find an optimum amount of energy stocks. The energy stocks weight is changed and the other sector stocks are adjusted according to the new portfolio mix and the return of the portfolio is calculated with the following equation

$$R_p = \sum \frac{X_i}{\sum X_i} R_i \tag{6.1}$$

Where R_p is the monthly return of the portfolio, X_i sector weight which is fixed for all other sectors than for the energy sector and R_i is the monthly return of the different sectors. A sell off of all oil and gas companies will lead to a slight increase in the expected return of the portfolio as a result of that the return of the energy stocks is less than the average of the portfolio. However, the overall risk of the portfolio increases with decreasing amount of energy stocks in the portfolio. This can be explained by a relatively poor correlation coefficient with the other stocks and including the energy stocks actually reduces the overall risk of the portfolio. An efficient frontier with varying degrees of energy stocks is constructed, and all though the changes are small when it comes to expected return and risk for a large portfolio such as the NGPFG. As can be seen in figure 6.1, the optimum portfolio when it comes to return has 0 energy stocks in it, while an optimum portfolio when it comes to risk has 15% energy stocks in the portfolio mix. Any share of energy stocks greater than 15% is supoptimal with lower returns and higher risk. The NGPFG portfolio with 6.4% balances fairy well the risk and return. Selling all oil and gas companies stocks will lead to an increased risk with a slight increase in expected return compared to the current portfolio.

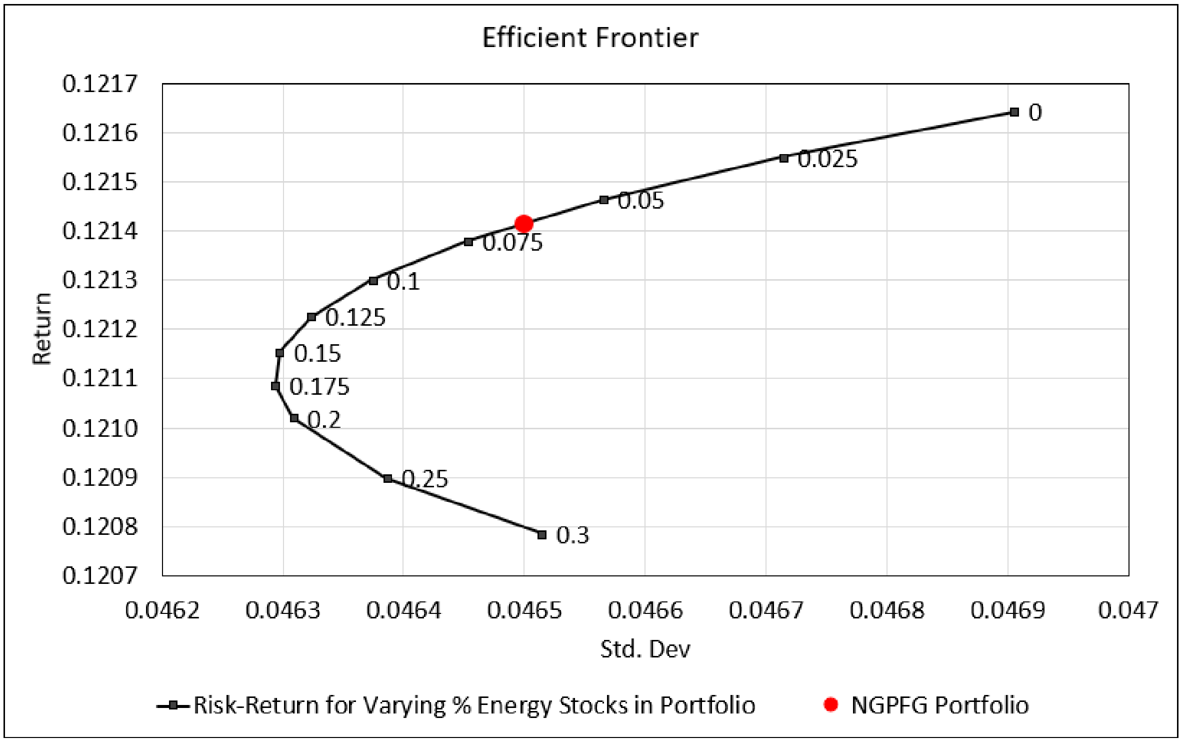


Figure 6.1: Efficient frontier for a portfolio with varying amount of energy stocks in the portfolio, with share of the portfolio shown next to the markers in the plot.

The risk adjusted return, here measured with the sharpe ratio (eq. 3.10) assuming a risk-free interest rate of 3% also changes with varying amount of energy stocks in the portfolio. As can be seen in figure 6.2, the best sharpe ratio is achieved with 10-15% energy stocks in the portfolio. The NGPFG portfolio lies close to the optimal amount of energy stocks in the portfolio, with a sharpe ratio of 1.966 whereas the maximum sharpe ratio that can be achieved by varying the portion of energy stocks is 1.97. A complete sell off of the oil and gas stocks will reduce the risk adjusted return, sharpe ratio, from 1.966 to 1.954. It is evident from figure 6.1 and figure 6.2 that a sell off of all oil and gas stocks will in fact reduce the expected risk adjusted returns and make the portfolio less optimal because of less diversification. It is clear that from a portfolio managament perspective, keeping a share of oil and gas companies in the portfolio is wise in order to optimize return and reduce volatility (risk).

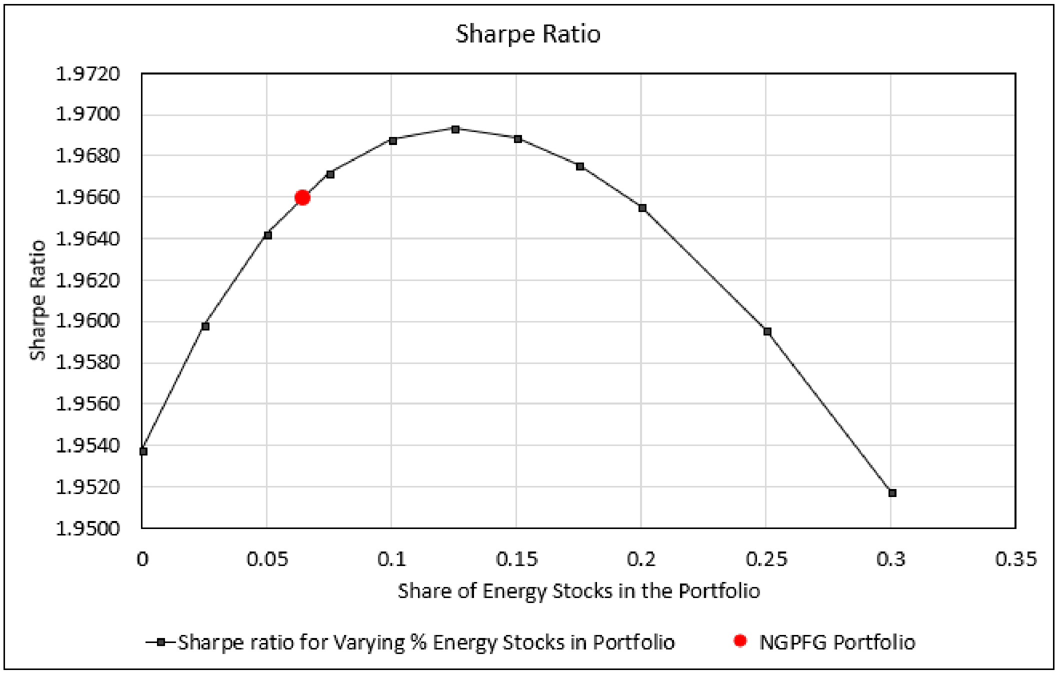


Figure 6.2: Sharpe ratio for the portfolio for varying amount of energy stocks in the portfolio.

Does exposure to oil price change?

The exposure to oil price, as measured with correlation as defined in chapter 3 will decrease with decreasing amount of energy stocks in the portfolio. The equivalent of the current NGPFG portfolio, measured in USD, has a limited positive correlation with the oil price with a correlation coefficient of 0.21. A complete sell of of energy stocks will reduce the correlation coefficient to 0.19. As can be seen in figure 6.3 the correlation coefficient is clearly increasing with increasing share of energy stocks in the portfolio as is expected. As shown in chapter 4, the energy stock has the strongest correlation with the oil price and hence an increasing share of energy stock should increase the overall portfolios correlation with changes in oil price. The portfolio however, still only has a limited correlation with the oil price. There is only a change in the correlation coefficient from 0.21 to 0.19 if the fund sell off all oil and gas stocks in their portfolio.

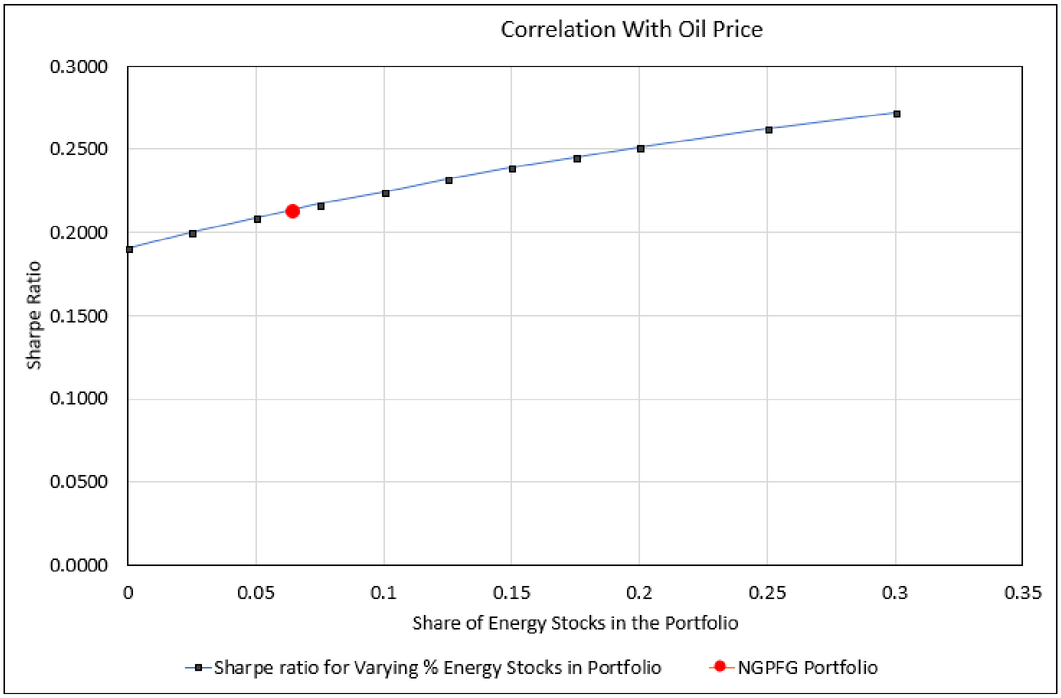


Figure 6.3: Correlation coefficient with Brent Spot for portfolios with amount of energy stocks in the portfolio.

No Oil and Gas Companies - Sensitivity

The aim of doing a sell-off of oil and gas companies is to reduce the negative effect of a potential oil price collapse on the portfolio in the future. To simulate the effect this can have on the NGPFG portfolio, a sensitivity study was performed on the period from January 2014 to January 2017. The period was chosen as a representative period of oil price collapse. The portfolio with sector weights equal to NGPFG was chosen as a reference portfolio including oil and gas companies while an alternative portfolio was constructed without any oil and gas companies in the portfolio. The NGPFG portfolio has 6.4% of energy stocks in the portfolio. The complete sector mix makeup of the two portfolios are given in table 6.1. The development of the two artificially created portfolios are similar and follow the same trend as the change in the portfolio is limited. The return of the equivalent NGPFG portfolio using the MSCI indeces, measured in USD, is 40.48% from 1.1.2014 to 1.1.2017. The portfolio with no energy stocks in the portfolio would had a return of 44.14% for the same time period. The incremental return for the portfolio would be 4.34% or 1.43% annualized. Even for a period with a very large difference of oil and gas com-

	NGPFG With Oil Stocks	NGPFG without oil stocks
Consumer Discretionary	13.6 %	14.5 %
Consumer Staples	10.2 %	10.9 %
Energy	**6.4 %**	**0.0 %**
Financials	24.3 %	26.0 %
Health Care	10.1 %	10.8 %
Industrials	14.0 %	15.0 %
Information Technology	9.4 %	10.1 %
Materials	5.6 %	6.0 %
Telecommunication	3.2 %	3.5 %
Utilities	3.1 %	3.3 %
Sum	100.0 %	100.0 %

Table 6.1: Sector mix for portfolios with and without oil and gas companies.

panies stock performance versus the rest of the market, the incremental gain by excluding oil and gas companies is small. The NGPFG had a total market value of 5038 Billion NOK with the placement in the stock market accounting for 3107 Billion NOK at the end of 2013 (12). These values are used to understand the monetary value of having no oil companies in the portfolio compared to the current portfolio of NGPFG while also considering the impacts of the exchange rate and the general return of the portfolio. From 2014 to 2017 the NGPFG portfolio had a calculated return of 938 Billion NOK excluding additional transfers and offtake from the government. Because of the weakened Norwegian Krone following the oil price collapse, the fund would also had a currency gain of 1517 Billion NOK during that period only considering USD and NOK and not the reference currency basket used officially by the NGPFG. If the NGPFG had sold all their energy stocks before the oil price collapsed and re-invested them into other sectors , the fund would have increased the return for that period by another 4%. In monetary terms, the equivalent fund portfolio would have increased by 132 Billion NOK. The sell-off of oil and gas companies would therefore only be less than 10% of the effect of the change in foreign exchange rate for example. It is therefore fairly clear that a sell-off of oil and gas companies would only have a limited impact on the overall fund performance and that the fundamental idea behind the NGPFG to invest in foreign stock markets would be the dominating effect giving high returns and in addition a strong currency effect in times when the oil price falls.

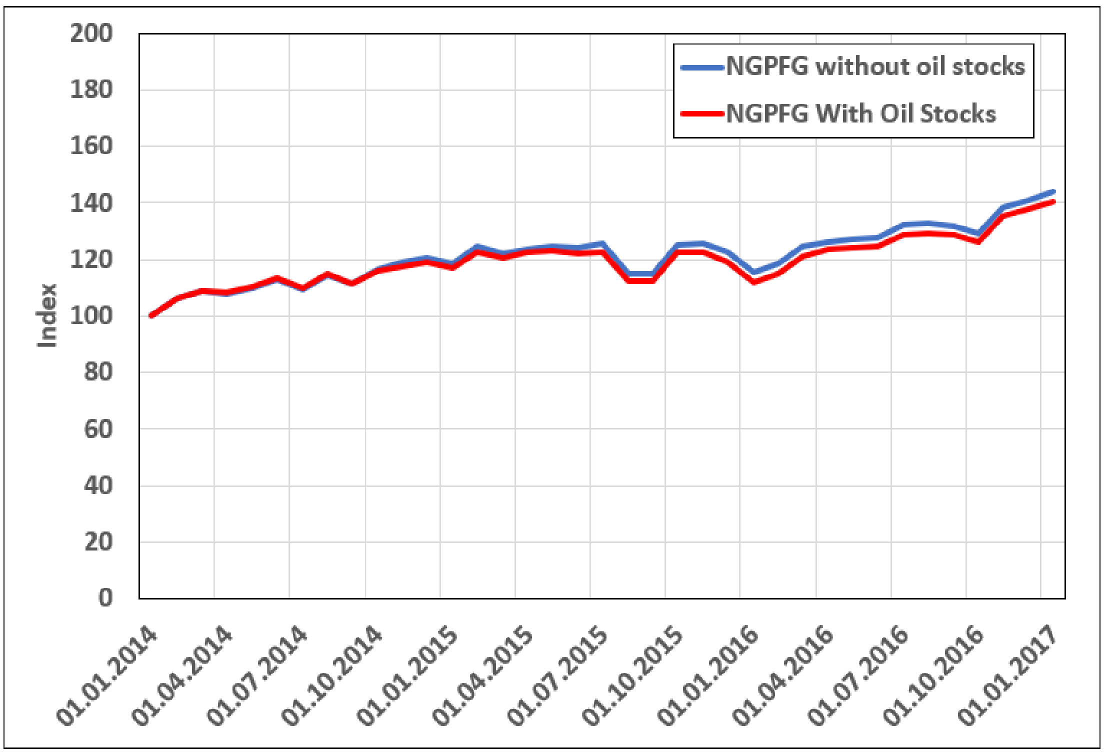


Figure 6.4: Development of a portfolio equivalent to the NGPFG portfolio compared to the same portfolio but without and oil and gas companies.

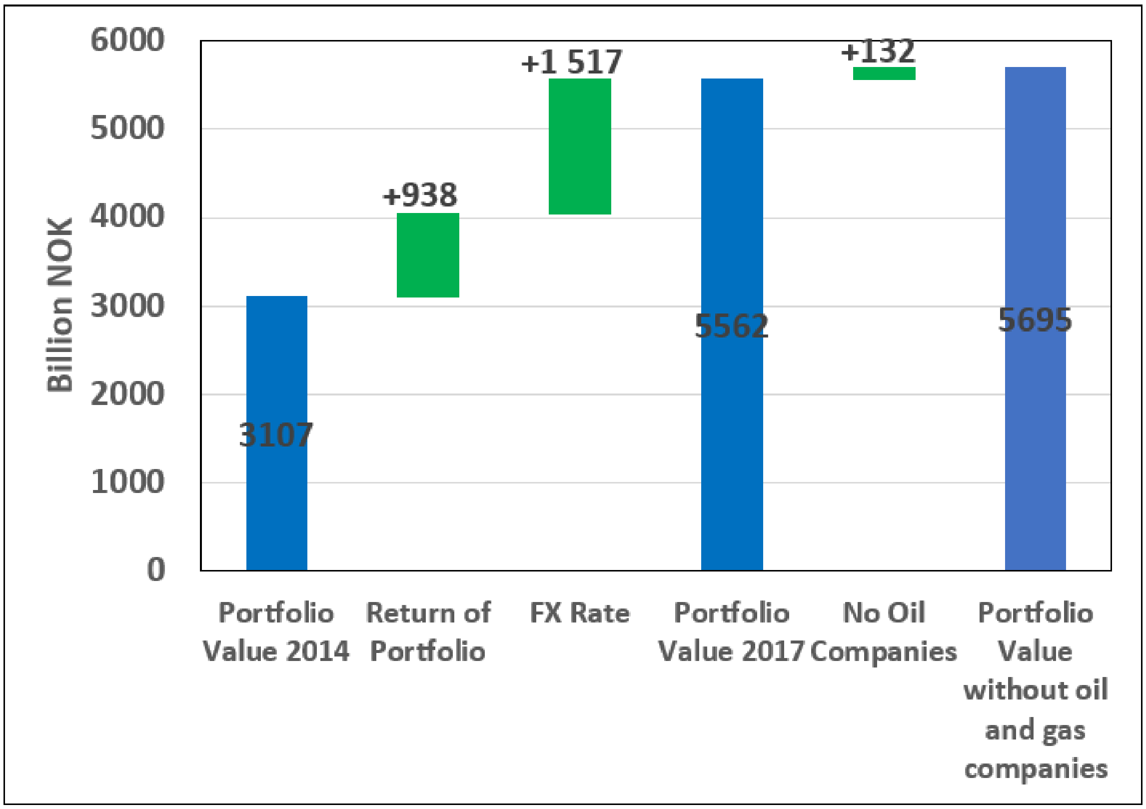


Figure 6.5: Impact of return, exchange rate and the incremental return of having no oil and gas companies in the portfolio for the period January 2014 to January 2017 during the last major oil crisis.

Chapter 7

Alternative Investments That Reduces Exposure to Oil Price

The previous chapter has showed that the oil and gas companies are positively correlated to the oil price, but the stock performance are more linked to how the general market behaves rather than the oil price. Therefore, the impact of selling down oil and gas companies only has a limited impact on the overall correlation with oil price for the NGPFG. And even less impact for the Norways economy as a whole. The goal to reduce the exposure to oil price can be divided into two subcategories, where the first category is the desire to reduce the impact of short to medium term fluctuations in oil price that causes volatility in the state revenue and export revenues of Norway given the large dependendency on the oil and gas industry. The second category is to reduce Norway's dependency on the oil and gas industry on the long term because of reducing carbon emissions will lead to a significant reduction in oil and gas demand and hence the value of the oil industry will decrease. For the first subcategory, to avoid the short term fluctuations and volatility, there are more effective ways to reduce exposure to the oil price than selling off oil and gas companies. For the second subcategory, the long term impacts of the world going away from carbon fuels, there are few alternatives other than a general transformation of Norways economy as a whole to reduce the importance of the oil and gas industry. Any form of hedging the oil price 10-15 years ahead in time in the financial markets would be very costly and undesirable. Hedging the oil price on a short time horizon of months to a few years is possible. Borenztein et al (22) published a paper on Macro-Hedging for Commodity Exporters, such as

Norway, to evaluate the possibility of hedging as an insurance to the uncertainty in commodity prices and to reduce the need for countries to hold significant amount of foreign currencies in funds, such as the Norwegian Government Pension Fund Global.

Hedging

Hedging is an investment that is designed to reduce the risk associated with another investment. This can be to insure against price increase or decrease and is commonly used by companies who are very dependent on the price of a single commodity. For example oil and gas companies may hedge the oil price in order to have a more predictable future income in case the oil price collapses. Similarly airline companies may also hedge the oil price in order to have predictable fuel costs going forward. There are several forms of hedging. Most form of hedging revolves around future contracts. A future contract is a contract that typically is bought and sold on stock exchanges with a predetermined price to buy or sell a commodity or financial instrument at a fixed date in the future (23). For example an investor may choose to buy a contract for crude oil 6 months ahead of time for a given price. In addition to future contracts, investor may also trade options. An option is a right to buy for example crude oil 6 months ahead in time, but not the obligation to do so. There are two types of options commonly used, a put and call option. A put option gives the owner the right to sell the underlying security at a strike price while a call option gives the owner the right to buy the underlying security at a strike price. A future contract can be made without any associated cost to it, while an option often has a premium associated with the contract. If the NGPFG had used a hedging strategy, the fund would have gotten a direct exposure to the oil price rather than an indirect exposure through sell-off of oil and gas company stocks. Borenztein et al (22) found that hedging the oil price would give oil exporting countries a more stable and predictable income. However, hedging would also tie-up a significant amount of capital into hedging positions if it were to make any significant impact for Norway's exposure to oil price in general. That capital must therefore be taken out of the fund where it is currently making a strong return on the investment. In addition, hedging would also reduce Norway's revenues in times where the oil price is increasing.

Increasing the NGPFG

As shown in chapter 7, the NGPFG in itself is a very good financial instrument against falling oil prices. One of the primary idead behind the creation of the fund was that it could be used in times when the oil price were low. The NGPFG then serves as a buffer against lower oil price. Setting aside majority of the petroleum revenues to invest in other stocks, fixed income instruments and real estate to be used in times of low price or by future generation is a very strong strategy against fall in oil price and oil revenues. The natural hedge of having a foreign pension fund is clear. Both the currency effect and the return of the investments are strong. One way to counteract a potential lower oil price for a longer period of time is to increase the size of the fund either by increasing the transfers from the government or reducing the withdrawals from the fund. However, it may result in reduced government spending in Norway and possible reduced welfare, but would increase the size of the fund and set Norway up to be able to be better equipped for the time when the oil revenues are reduced.

Chapter 8

Discussion and Conclusions

As shown in this thesis, the impact of a sell-off will have on the portfolio is complex and the conclusions may therefore depend on the point of view of the one who makes the conclusion. As the oil and gas companies only make up about 5% of the portfolio the impact will always be fairly small, but the value of the portfolio is large and any small change is significant in monetary value. One of the fundamental questions for the policy and decision-makers is whether or not the NGPFG should be managed isolated and be managed to maximize the risk adjusted return of the fund. For the fund isolated a sell-off is not a good thing as the portfolio will be less diverse and have a lower risk-adjusted return. As Norways exposure to oil price is already high, a sell-off for Norway as a whole is a good thing as it reduces the exposure slightly. The following conclusions and key take-aways from this thesis are:

8.1 Conclusion

- Oil and gas companies is as expected more sensitive to fluctuations in oil and gas prices than the other sectors and a sell-off of oil and gas companies will make the equity portfolio less correlated with oil price and reduce the funds exposure to the oil price.

- While oil and gas companies are positive correlated with oil price, the stocks of oil and gas companies is stronger correlated with the general market performance than to oil price.

- The impact of the decision to sell of oil and gas companies will be limited. Mainly because the size of the investment into oil and gas companies are small relative to the overall fund and Norway's economy and secondly because the oil and gas stocks follow the market more than it follows the oil price directly.

- From a strictly investment analysis and portfolio management standpoint, selling oil and gas stocks leads to a less diverse and less optimum portfolio. The portfolio will become more exposed to the remaining sectors and hence become more volatile. The expected risk-adjusted return of the portfolio will be reduced for a portfolio with no oil and gas companies compared to today's share of about 6.4%.

- The oil and gas industry is a cyclical industry, historically dominated by large changes in oil price causing impacts on the oil and gas companies share price. Historically, the return of the oil and gas sector has not been significantly less than the rest of the market. Demand for oil and gas will also continue to be strong for the next few years at least and a strong rebound of oil and gas stock prices may happen. Timing of the sell-off is therefore important, but difficult, to avoid selling at a low point in the cycle.

- There are other more effective financial instruments that can be used to hedge against fluctuations in oil price. For example traditional hedging with future contracts may be an option. The NGPFG is already naturally hedged to a large extent by having a diversified portfolio invested in foreign countries and currencies. As the oil price and exchange rate is negatively correlated a drop in oil price will lead to an increased value of the fund in NOK and also maintain the value in other currencies and provide a source of access to foreign currency if needed.

8.2 Discussion

Whether or not the decision to perform a sell-off of oil and gas companies in the portfolio will eventually boil down to the utility function of the fund owner. I.e how risk willing or risk adverse towards the oil price the fund owner wants to be. Whether or not a decision is "effective" is also subject to understanding the utility function of the fund owner. Effective is not an absolute measure, hence different people may have different opinions. The fund owner, in this case is the Norwegian people. While the conclusion from this study is that yes, the overall exposure to oil price will be reduced by selling off oil and gas companies, the impact will be fairly limited. On the contrary, the fund would also become less diversified and increase its exposure to the risk in the other sectors. The risk-adjusted return will be less for a portfolio without oil and gas companies than for a portfolio with oil and gas companies. So there is both pros and cons with performing a sell-off of oil and gas companies in the portfolio and the decisions makers will have to balance these two. If the utility of the fund owner is very risk adverse to volatility in the oil price, other more impactful measures may be taken. To avoid short term fluctuations in state revenues, hedging the oil price with future contract is one option. To insure against a lower oil price for a longer period of time is more difficult. One of the most effective ways to insure against falling oil prices is by having a fund invested in foreign markets, such as the NGPFG, to be used in times with low oil price or when the petroleum resources are extracted. Increasing the NGPFG or reducing the withdrawals by reducing "handlingsregelen" is one possible solution. Accelerating the transformation of Norways economy from petroleum industry to green energy forms is another. Perhaps interestingly, the proposal to sell-off oil and gas companies actually came from the manager of the NGPFG, NBIM who actually will have a less optimal portfolio without oil and gas companies in it. A thourough discussion around oil price risk in the Storting and the different options that could be used to reduce the exposure to the oil price would have been appropriate. It would also then more clearer express the risk willingness of the owner of the petroleum fund and whether the owner would prefer other options than selling off oil and gas companies in the equity portfolio of NGPFG. Investigating the alternative options is outside the scope of this thesis as well is the analysis of the political decisions leading up to the sell-off.

Appendix A

Acronyms

EIA Energy Information Agency

IMF International Monetary Fund

MSCI Morgan Stanley Capital International

MSCI IMI MSCI Investable Market Index

NBIM Norges Bank Investmant Management

NGPFG Norwegian Government Pension Fund Global

NOK Norweigan Kroner

USD US Dollar

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