

NHH



Government Pension Fund Global's investments in petroleum equities

A response to White Paper nr. 19

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Abstract

As Norway possesses a large petroleum wealth, there has been calls for a change regarding the Government Pension Fund Global's (GPFG's) investments in petroleum equities based on diversification considerations. This subject has been debated by the Ministry of Finance in White Paper nr. 19, where the conclusion was not to alter the GPFG's investment strategy as no long-term relationship between the oil price and oil and gas stocks was discovered. Evaluating the investment strategy based on oil price exclusively, and ignoring other factors that impact the inflow of petroleum revenues, has been criticized.

The main objective of our thesis has been to uncover if there is a long-term relationship between the development in oil and gas stocks and the Norwegian state's petroleum related income. If a long-term relationship exists, it could suggest a divestment in GPFG's oil and gas investments to reduce Norway's exposure to petroleum related shocks.

In our thesis we present relevant research and theory, and illustrate the importance of the petroleum industry for the Norwegian economy. We have applied the Engle and Granger two-step error correction model to determine whether there exists a long-term relationship between oil and gas indexes and the petroleum related state income.

Our results show a statistically significant long-term relationship between petroleum related state income and two global oil and gas indexes. When testing for the relationship between individual components of petroleum related state income and oil and gas indexes, our results vary. Our findings suggest that the stock price development of global integrated oil companies share the strongest long-term relationship with petroleum related state income. On this basis, and with regard to wider national wealth considerations, we conclude that the GPFG should consider a sale of its holdings in global integrated oil companies.

Preface

This master thesis is the result of extensive research and hard work over the past months, and marks the end of a fruitful and educative time at the Norwegian School of Economics. We consider ourselves privileged to have had the opportunity to acquire valuable knowledge throughout our studies and to apply this in our own research.

Our thesis aims to uncover whether there is a long-term relationship between the development in the oil and gas stocks and the petroleum related state income, as such a relationship could suggest an alteration of the GPFG's current investment strategy. Even though our findings are not exhaustive in explaining this relationship, we believe our work can provide useful information related to the fund's investment strategy.

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1 Introduction

Since the discovery of oil on the Norwegian continental shelf in 1969, Norway has become a resource rich nation with a large oil and gas industry. The development of the oil and gas industry has led to Norway holding large petroleum wealth both in relation to its resources below the ground and its financial capital in the Government Pension Fund Global (GPFG). The purpose of the Government Pension Fund Global (GPFG) is to manage government savings in order to finance the expected increase in future public pension costs and support long-term considerations in the spending of government petroleum revenues (Norges Bank Investment Management, 2011). Sound long-term managing of the GPFG is crucial to ensure that the petroleum wealth also will benefit future generations.

The GPFG investment strategy is currently based on diversification considerations exclusively related to the assets it holds in its portfolio (Ministry of Finance, 2014a). This means that the Norwegian economy's exposure to petroleum related risk is not explicitly a part of the GPFG's risk evaluations. Norway holds a large amount of subsoil petroleum wealth and factors like oil price fluctuations, cost and productivity development will have large effects on the value of this wealth due to both changed potential earnings and an altered volume of profitable reserves. This will in turn affect the inflow of revenues to the GPFG. These facts have triggered a debate related to the fund's investment strategy and how Norway should think about petroleum wealth management. In our thesis we will shed light on this ongoing discussion by presenting reports from governmental departments and other research on the area.

The main objective in our thesis is to uncover whether there exists a long-term relationship between the petroleum related state income and the stock price development of oil and gas companies. A significant relationship between these two variables could suggest reducing or abandoning oil and gas equities from the GPFG's investment portfolio based on diversification considerations.

In our econometric analysis we will use the Engle and Granger two-step error correction model. The model allows us to uncover both long term relationships and both short and long term dynamics between the variables. As the GPFG is an investor with a very long

investment horizon, finding a long-term relationship will be crucial for considering a potential change in the investment strategy.

Our thesis is organized in the following manner.

Chapter two presents the theoretical basis and literary overview. The section will give insight into academic research, portfolio and diversification theory and empirical studies related to the petroleum industry and resource wealth management.

Chapter three presents the evolution of Norway's petroleum wealth and the way it is managed. This section covers the development of the petroleum industry in Norway and its economic impact on the country. It also presents the development of the GPF, its current investment strategy and the implications of the fiscal policy rule. Furthermore, it contains information about the different elements that together constitute the State's cash flow from the petroleum sector and the various indexes we intend to use as a proxy for the development of oil and gas companies stock prices.

Chapter four describes the statistical material, justify the choice of method and explains the methodology used in this empirical analysis. We first introduce the conditions that must be satisfied in order to perform an error correction model. Then we demonstrate how to apply various tests to confirm whether these conditions are fulfilled. The chapter ends with a detailed description and interpretation of the Engle and Granger error correction model.

In chapter five we present our findings when regressing petroleum related state income, as well as its individual components, on a range of oil and gas indexes. The first section describes the outcome of the Dickey-Fuller tests performed on the various variables used in the analysis, defining the level of integration. Furthermore, the long-term equilibrium relationship is defined when testing for co-integration between variables. Finally, the Engle and Granger error correction model is applied to identify the dynamics and convergence towards a long term equilibrium.

In chapter 6 we provide a thorough discussion of our findings in relation to our main objective in the thesis. This includes a comprehensive interpretation related to our empirical results and how the results coincide with previous research.

In chapter 7 we conclude. Here we present a summary of our findings, discuss their implications and provide suggestions for further studies.

2 Theory and literary overview

2.1 Previous research

2.1.1 White paper nr. 19

The petroleum sector is responsible for around one third of the State's income and over half of Norway's exports, and is thus a vital part of the Norwegian economy (Ministry of Finance, 2014a). This dependence on petroleum revenues has led to concerns about the GPFG's investment strategy of solely considering its portfolio diversification on a stand alone basis.

The issue has most recently been discussed by the Ministry of Finance (2014a) in White Paper nr. 19. The paper takes a closer look at the short and long term relationship between the oil price and the return on oil and gas stocks. It argues that a strong relationship could propose a different portfolio allocation of the GPFG to reduce the State's exposure to oil price risk. The analysis does not make any predictions of future price development for oil, but looks at historical returns to enlighten the different relationships for both short and long term horizons.

The main findings presented in White Paper nr. 19 were that observed correlation between the oil price and the oil and gas sector primarily is a short-term phenomenon. The ministry's analysis did not find a clear relationship between returns on oil stocks and the development of the oil price in the long run. In a long run perspective, they found that the return characteristics of the oil and gas sector to a larger degree resemble that of the broad stock market than the oil price.

According to the department's assessment the lack of robust relationships makes it difficult to change the GPFG's composition in order to reduce oil price risk. They point out that since the relationships between oil prices and stock markets change over time, adjustments have to be made frequently. Such adjustments may involve large transaction costs, especially if stock prices are affected by purchases and sales. Also, an exclusion of an entire industry from the portfolio might lead to higher total risk due to decreased diversification. The conclusion of the Ministry of Finance is that the relationship between the oil price and the stock price development of petroleum companies do not justify changing the current benchmark index.

2.1.2 Criticism of the white paper analysis

The department's analysis has been subject to criticism on several counts. Hoel & Holden (2014) claim that the analysis is done on the wrong premise. They argue that a more relevant basis for decision-making would be to investigate the relationship between the oil and gas sector returns and the State's income from the petroleum sector, rather than the oil price in general. Obviously the oil price is an important factor for both the return on oil and gas stocks and oil-related state income, but other factors like the cost development in the industry in general, and in Norway specifically, are also important. They argue that increased costs in the petroleum sector normally leads to lower returns on oil and gas stocks and reduced income for the state. At the same time the oil price can rise and thus reduce the correlation between the oil price and return on oil and gas stocks, without this being a sign of a reduced relationship between oil and gas stocks and the State's petroleum income.

Furthermore, Hoel & Holden (2014) argues that if the return characteristics of oil and gas stocks are more dependent on the development in the broad stock market than the oil price, the rationale of holding oil and gas stocks are less apparent. They claim that the extra exposure to oil through the ownership of oil and gas stocks is a bad way of spreading the risk in the GPFG's portfolio.

2.1.3 Investment strategies for sovereign wealth funds

The GPFG's stand-alone investment strategy has also led to criticism of its design. Bremer, Ploeg & Wills (2014) argue that oil exporters usually do not consider below-ground assets when allocating their sovereign wealth fund portfolios. They contend that total wealth includes both petroleum wealth and financial assets and that consequently subsoil oil and gas reserves should alter the GPFG's portfolio through additional leverage and hedging. Their analysis suggests that the GPFG should hold more of all risky assets, funded by leverage, to take into account the petroleum wealth. At the same time, the GPFG should offset their exposure to development of the petroleum industry by investing relatively more in assets that are negatively correlated with the oil price and investing less in assets that are positively correlated, such as oil and gas stocks. Their empirical simulations using the correlation of oil prices with financial assets, indicate that Norway's exposure to aggregate oil price volatility could be halved if oil wealth is hedged in the GPFG and is invested less aggressively in risky assets as it ages. Bremer et al. (2014) argue that if their strategy is implemented the result

would be an improvement by as much as a 15% permanent increase in the GPFG's dividend. However, this strategy does not take into account that the GPFG must adhere to short-sale restriction, and consider transaction costs and time-varying asset price correlations.

Scherer (2009) also criticized the GPFG's investment strategy. In his article "Portfolio Choice for Oil-Based Sovereign Wealth Funds" he examines how risk stemming from non-financial assets can be hedged through financial assets. He too claims that that the key is exploiting correlations between financial and non-financial assets to reduce the total risk of the portfolio, not only considering the correlation of the financial assets. He proposes a two-fund separation, the first fund being an optimal growth fund entirely driven by its Sharpe ratio with the second fund being an oil price risk-hedging portfolio. The composition of this portfolio would not only depend on the Sharpe ratio, but also on its ability to hedge out unanticipated shocks to petroleum wealth.

2.1.4 Uncertainty related to the size of petroleum wealth

According to calculations in Norway's national budget for 2015, the present value of future cash flow from the petroleum sector is estimated to be around 4 400 billion NOK (Ministry of Finance, 2014b). The value of Norway's petroleum reserves are of course subject to a large degree of uncertainty. The estimate is based on strict assumptions of future production, costs and prices. The Ministry of Finance (2014b) assumes an average oil price of 650 NOK in 2015 and an average oil price of about 550 (2015-NOK) from 2016 and beyond. They also conduct a sensitivity analysis with respect to the oil price, holding the cost and production level constant. They find that an oil price 100 NOK higher than expected and an increase in the gas price by the same percentage, leads to an estimated subsoil petroleum wealth of 6 200 billion NOK. On the other hand, the analysis shows that with an oil price 100 NOK lower than expected, and a corresponding percentage decrease in the gas price, the estimated subsoil petroleum wealth is 2 650 billion NOK. These calculations are founded on fairly farfetched assumptions as there normally will be fluctuations in costs and production volume as well, but they do give interesting insight into the level of uncertainty related to the size of petroleum wealth.

2.1.5 National wealth and human capital

The focus of this thesis is to determine whether there is a long-term relationship between the State's cash flow from the subsoil petroleum assets and the return on oil and gas stocks, that can serve to recommend divestment or downscaling of the GPFG's oil and gas stocks. However, the wider national wealth perspective is of interest when interpreting the importance of this relationship.

National wealth is the sum of net wealth of all economic units in a country, including both private citizens and companies, and public institutions (Stoltz, 2009). Statistics Norway (2014) has categorized national wealth into four main components, which include human capital, real capital, financial capital and natural resource capital.

Human capital relates to the portion of value creation connected to labour and especially the knowledge labourers possess, while real capital refers to material wealth such as machines, buildings etc. (Statistics Norway, 2011). The natural resource capital includes both renewable natural resources such as agricultural land, woods and fish, and non-renewable natural resources like petroleum wealth. Finally, the financial capital relates to the country's purely financial assets such as the Government Pension Fund Global and the debt Norway owes abroad. Even though the development of national wealth as a whole is important, it is useful to break down the different wealth components to understand their respective impact on the national economy.

According to the Ministry of Finance (2014b) the estimated present value of the petroleum wealth accounts for only three percent of national wealth, while the financial capital accounts for five percent. This portion of national wealth is relatively small in share of the total wealth, but has a major impact on public finance as it represents a source of great funding for social welfare. However, the decidedly greatest component is human capital, which is estimated to represent 82 percent of national wealth as shown in figure 1. This illustrates that the most important driver for value creation and economic growth in the long run is increased labour productivity.

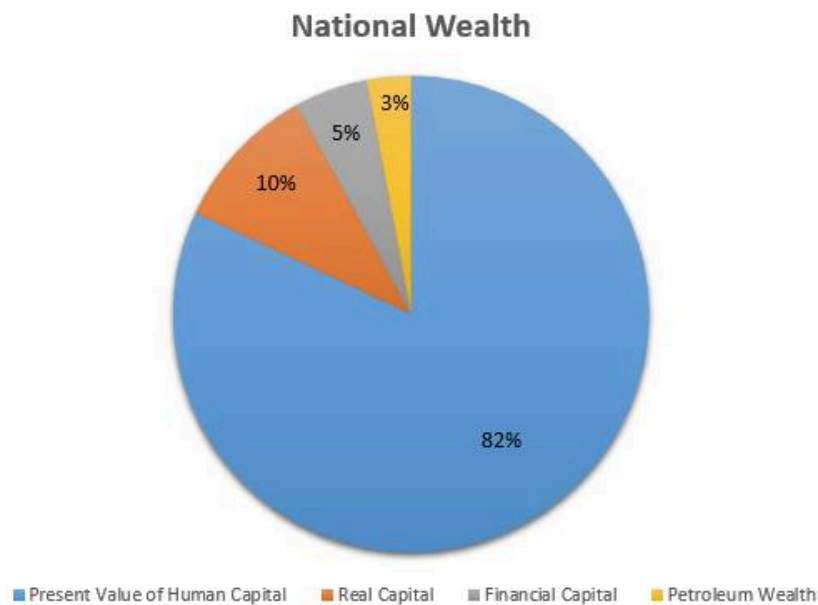


Figure 1. National Wealth – Ministry of Finance (2014b)

The International Research Institute of Stavanger (2015) has assessed the level of employment related to the Norwegian petroleum sector. They find that about 330 000 Norwegian citizens are employed in petroleum related occupations, representing about 13 percent of total employment. These calculations include both employees directly related to the petroleum industry such as operators and suppliers, and those indirectly associated like suppliers of general goods and services of transport, finance etc. Oil price uncertainty is thus not only a factor that concerns the relationship between subsoil petroleum wealth and the financial capital, but that also has implications for human capital and the Norwegian economy in general. These considerations are obviously important when evaluating the investment strategy of the GPFG.

2.2 Theory

In order to evaluate and interpret the GPFG's choice of asset allocation, we should present the basics of well known financial theories regarding portfolio optimization as well as its shortcomings.

2.2.1 Modern Portfolio Theory

The Modern Portfolio Theory (MPT) states that when creating a portfolio consisting of different assets, you should not look at each asset individually, but take into account the

correlation between them (Bodie, Kane, & Marcus, 2011). This means examining how different asset returns develop relative to each other.

An investor will be able to reduce the portfolio risk by adding securities to the portfolio. How much one can gain by combining risky assets depends on the covariance between them (Bodie et al, 2011). This phenomenon is called diversification. To calculate portfolio risk with two risky assets, i and j , we look at equation 1:

$$\sigma_p^2 = w_i\sigma_i^2 + w_j\sigma_j^2 + 2w_iw_jCov(r_i, r_j) \quad \text{Equation 1}$$

As stated in the formula, reduced covariance between the assets, will reduce portfolio risk, illustrating the effect of diversification by mixing risky assets.

The Modern Portfolio Theory explains how one can maximize a portfolio's return for a given amount of risk (Markowitz, 1952). By interpreting the portfolio combinations this way Harry Markowitz, considered as the founder of Modern Portfolio Theory, came up with the efficient frontier. This frontier describes the portfolios achieving the highest expected return for different degrees of volatility (risk). The efficient frontier shows that you can gain a higher return by taking on an extra amount of risk, or you can reduce the risk of your portfolio by giving up expected return, as illustrated in figure 2.

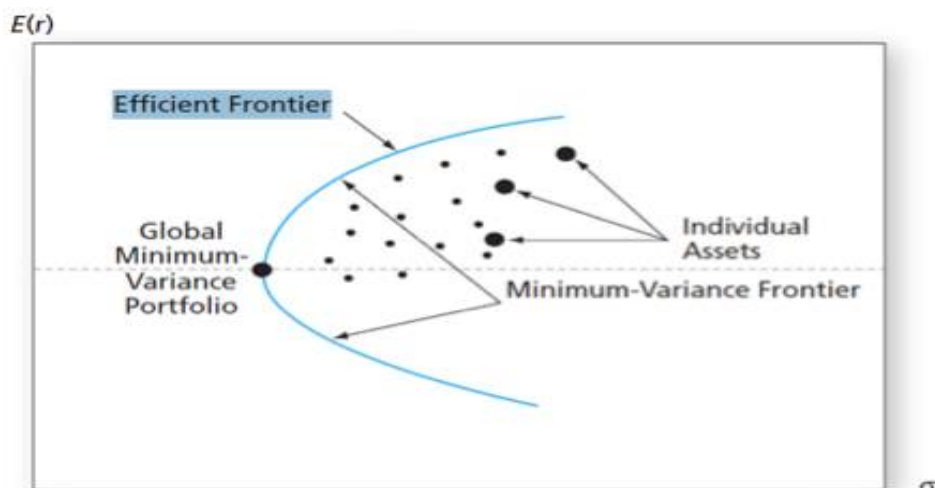


Figure 2. Minimum-Variance Frontier – Bodie et al (2011)

This efficient frontier includes the fact that there is a co-movement, also known as correlation, between the different assets in the portfolio (Bodie et al, 2011). By doing so the portfolios described by the efficient frontier represent combinations of assets that yield the best risk-return combinations.

By combining a risk-free asset with a portfolio on the efficient frontier one can construct a portfolio whose Sharpe Ratio¹ is superior to other portfolios on the efficient frontier (Bodie et al, 2011). All portfolios represented on the Capital Allocation Line (CAL) as shown in figure 3, will have the same Sharpe ratio and the exact allocation of the optimal portfolio will depend on the investors' risk aversion.

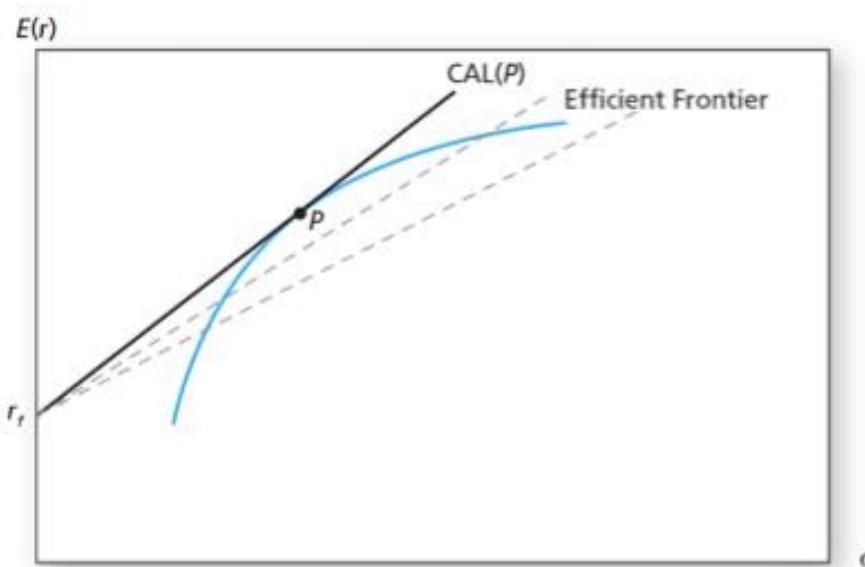


Figure 3. Efficient frontier with an optimal CAL – Bodie et al (2011)

The MPT has experienced criticism for its assumption related to financial markets and behavioural economics (Curtis, 2004). Especially in the case of GPF, the assumptions of no transaction costs and the investors' absence of influence on the financial markets do not hold. In 2014 the GPF held an average of securities equivalent to approximately 1,3% of the world stock market (Norges Bank Investment Management, 2015). This means that actions done by the GPF could generate large transaction costs and fluctuations in market

¹ Risk-adjusted return

prices of certain assets. Even though these assumptions seem to make our analysis to some extent deficient, we would like to proceed with the MPT as it is considered to be the prime theory in portfolio optimization, and used by several investment institutions.

2.2.2 Shortcomings related to Modern Portfolio Theory

In search of the optimal portfolio one have to be familiar with the composition of the market portfolio. In reality this portfolio should also include non-tradable assets like human capital (Schumlerich & Leporcher, 2015). Non-tradable assets, meaning assets that are not traded among investors, may be hard to value and therefore contributes to uncertainty related to the construction of the optimal portfolio. The non-tradable asset's market capitalization has to be known in order to construct a reliable market portfolio. This leads to complications when looking at the Norwegian economy and the use of MPT when constructing an optimal portfolio for the GPFG. This is because the Norwegian economy in particular consists of two large portions of non-tradable assets, human capital and the remaining petroleum reserves.

As mentioned by the Ministry of Finance (2014a), the Norwegian economy also has a large portion of a non-tradable asset represented by the remaining petroleum reserves that represents a future income to the GPFG. However, the GPFG follows a strategy similar to modern portfolio theory by aiming to achieve a highly diversified equity portfolio, and choose the share of equity investment matching their risk preferences.

The complication by following this strategy is the fact that the GPFG to a minor degree take into consideration, when diversifying their equity portfolio, the remaining reservoir of oil and gas still lying beneath the ground in the North Sea (Bremer, Ploeg, & Wills, 2014). The Ministry of Finance (2014a) states that by steadily transferring wealth from beneath the ground to the GPFG, they will gradually diversify their portfolio in the long term. However, as the current value of below-ground petroleum wealth still represents a large share compared to the current value of the GPFG and the fact that the remaining oil and gas represents a substantial and volatile part of the fund's cash inflow, the Ministry of Finance has experienced criticism regarding petroleum wealth diversification.

2.2.3 Interpreting Outside income in Portfolio Theory

According to Cochrane (2013) investors with an outside income, meaning income from assets that cannot be sold in a market, should hedge non-marketed risk. He provides examples of such hedging would be to buy bonds and sell stocks when you get closer to the retirement age. This because labour income could be seen as a bond, and therefore increasing the weights of bonds will serve as a hedge when having less future labour income.

As mentioned, inclusion of outside income streams poses challenges when applying modern portfolio theory to find the optimal asset allocation. The complication arises, as it is difficult to observe the value of outside incomes (Cochrane, 2013). To use the portfolio theory one need to be able to quantify the future outside income streams.

Cochrane (2013) argues that outside-income hedging in practise is being ignored to a big extent. His example relates to the steel workers pension funds that do not short the steel industry portfolio, meaning that in case of a negative demand shock towards the steel industry both their human capital and financial wealth would be at risk. The article claims that academic research only has focused on mean variance investors who have no outside income.

2.2.4 The relationship between the stock price and free cash flow

It is important to understand the dynamics affecting the stock price and the elements influencing the value of a company's equity

One way to calculate a company's stock price is by discounting the firm's future free cash flows with the weighted average cost of capital. A company's free cash flow is defined to be the after tax cash flow that's achieved from the company's operations, net of investments in capital and net working capital, and includes cash flow available to both debt and equity holders (Bodie et al, 2011). This can be described the following way:

$$FCF = EBIT \times (1 - T_c) + Depreciation - Capital Expenditures - Increase in Net working Capital \quad \text{Equation 2}$$

In equation 2, T_c represents the corporate tax rate that the firms have to pay to the government. It's worth noticing that a rise in a firm's EBIT, everything else kept constant, will increase both the tax amount generated to the government and the firm's free cash flow.

According to Bodie et al (2011), one could further calculate the value of the firm by discounting future free cash flows and adding an estimate for the terminal value, V_t^2 , as presented in equation 3.

$$Firm\ value = \sum_{t=1}^T \frac{FCF_t}{(1 + WACC)^t} + \frac{V_t}{(1 + WACC)^t} \quad Equation\ 3$$

At this stage the equity value is calculated by subtracting the market value of debt from the total firm value generated by the cash flow. The share price is then derived as the equity value divided by the shares outstanding.

2.3 Empirical studies

2.3.1 Relationship between stock markets and oil prices

Henriksen & Kværner (2015) perform a quantitative exercise where they study the effects of oil-price changes on equity returns. They argue that changing the industry composition of the equity portfolio might substantially reduce the variance of total wealth for investors also holding non-tradable commodity wealth. They examine the potential reduction in total variance for an investor with 80% of total wealth in financial assets and 20% in oil reserves. The financial portfolio is originally made up of 10%, 25% and 65%, in commodity, consumer goods and the rest of the market equity, respectively.

By changing the composition of the financial portfolio Henriksen & Kværner (2015) investigate the change in total variance compared to the market portfolio. By investing all financial assets in the portfolio with the highest negative correlation with the non-tradable asset, consumer goods, they find that this portfolio yields the lowest total variance in the

² V_t represents the terminal value and is calculated through a constant growth model used on estimates of future cash flows.

short term, but ends up with the highest total variance in the long run. They find that a financial portfolio that consists of 50% consumer goods and 50% invested in the market portfolio that excludes commodities and consumer goods, yields the lowest total variance for long term holding periods. They conclude that for an oil-rich investor commodity stocks become less risky over time, while consumer goods stocks represent a robust hedge against oil price volatility.

Kilian & Park (2009) states that even though the oil market is of great importance to the world economy, there is no general consensus as to the relationship between the oil price and stock prices. One important reason for this is that the effects of oil price changes on the economy and stock prices seem to depend on the underlying cause of the price change. They examined these relationships and found that shocks to the global production of oil have a weaker effect on stock markets than shocks to the global aggregate demand for industrial commodities or shocks to the precautionary demand for oil that reflect uncertainty about future oil supply shortfalls.

Ready (2014) also examines the relationship between oil and stock prices. In his article “Oil Prices and the Stock Market”, he performs a simple regression of monthly aggregate U.S. stock returns on contemporaneous changes in oil prices from 1986 to 2011 which suggests essentially zero relation between the two variables. However, with a more thorough analysis where supply and demand shocks are examined separately he finds that the apparent lack of relationship is a result of the conflicting effects of the two types of shocks. Ready uncovers that both demand and supply shocks are strongly correlated with aggregate stock returns over the sample period. Supply shocks have a strongly significant negative correlation with stock returns, while demand shocks have a strong positive relation. His results show that the negative relation of supply shocks is strongest for producers of consumer goods, while demand shocks are most strongly correlated with manufacturing firms. These discoveries could justify the fact that the correlation between oil prices and global stock markets has varied substantially over time.

The ministry of Finance (2014a) observed the development in the 10 year rolling annual average returns on a portfolio consisting of five large integrated oil companies, an index of the US stock market, and the oil price over the last three decades. According to their observations they concluded that there is not a particularly strong correlation between the oil

price and oil and gas equities, or with the stock market in general in the long run. However, the general stock market is composed of various sectors that could be affected differently from changes in oil prices and this paper will find it more interesting to study these isolated effects on each sector.

2.3.2 Short and long-term links between oil prices and stock markets in Europe

The White Paper presented by the Ministry of Finance (2014a) refers to research done by El Hedi & Fredj when they discuss the diversification risks related to oil and gas investments. El Hedi & Fredj (2010) completes a thorough analysis of the short and long term links between the oil price and stock price developments in various sectors.

El Hedi & Fredj (2010) point out the fact that there only are a few studies focusing on the isolated effect on different industrial sectors when it comes to the influence of oil price changes. However, they argue that this is of relevance as each sector may be influenced in different ways and with different magnitude. The easy and logical explanation for this is the fact that the different industries vary between having oil as an output or input. But there are also other factors like the degree of competition and concentration in the industry, and the ability for the sector to transfer oil price shocks towards the consumers and by doing so maintain their degree of profitability.

To complete their analysis El Hedi & Fredj (2010) used weekly stock market indices for twelve European sectors over a 15-year period. We find these European sectors highly relevant for the GPFG as the European market amounts for 39,8% of their total investments (Norges Bank Investment Management, 2015a). However, it would have been interesting to include American markets as well, to get a more global impression of oil shocks. They also used the weekly Brent crude oil price in their analysis.

El Hedi & Fredj (2010) descriptive statistics of the short term relationship shows there is a low correlation between the oil price and the returns in different European Sectors. The oil and gas sector has the highest average correlation with the oil price (33%) over the representative time period. The statistics also show that the sector returns from *Food &*

Beverages seems to have the highest negative correlation with changes in the oil price (-10%)

El Hedi & Fredj (2010) also completes empirical analysis examining the long-term interaction between the oil price and the sector stock prices. They do so by testing for co-integration between the series and study the convergence toward a long-term target. Their results conclude that only the Food and Beverage sector seems to be co-integrated with the oil price. This implies that there is only a significant long-term relationship between the Food and Beverage sector and the oil price. The beta coefficient from the regression has a value of -0.201 implying a negative long-term relationship between these two variables.

2.3.3 Oil price relationship with and financial indicators in the oil sector

To understand the influence of oil price fluctuations on oil and gas companies it is interesting to study how it affects different parts of the value chain in this industry.

Gold (2013) completed tests to provide information regarding the correlation between Brent Crude Oil spot prices and general performance indicators for oil companies. These tests examined how oil price changes affected different parts of the value chain. He did so by dividing the oil companies into three categories: Exploration and Production (E&P) Companies, Refining and Marketing (R&M) companies and Integrated Oil Companies (IOC's). The analysis aimed to reveal how oil price fluctuations could explain changes in the companies' earnings per share (EPS), revenues per share and stock price. The sample period extends from 2003 to 2013.

When testing for the oil price effect on E&P company's³ stock prices Gold (2013) found a correlation equal to 0.89. However, the co-movement of oil price fluctuations with E&P companies' earnings and revenue was not significant.

³ The sample consists of the four largest E&P companies listed in North America

For the R&M companies⁴, the results showed that the correlation between oil price and stock price were 0.45, while the correlation between oil price and revenues and earnings was 0.94 and 0,25 respectively. This could indicate that oil prices are the main revenue driver for R&M companies, but have only a minor impact on the companies' earnings. This might be due to the developments of costs and productivity of the companies selected for the regression.

When testing the oil price correlation with regards to the stock price of integrated oil companies, Gold (2013) finds a correlation of 0,5. As for IOC's revenues and earnings the results show a correlation equal to 0.9 and 0.94, respectively. The sample used to represent the integrated oil and gas companies are the companies defined as the global "Big Oil" firms⁵, and described as the super majors of the oil industry. It's also worth noticing that the GPFG has a share of 1,5 – 2% ownership in most of these companies (Norges Bank Investment Management, 2015a).

The conclusion of these tests is the fact that integrated oil and gas companies represents the part of the value chain where the earnings and revenues have the strongest relationship with the oil price. On the other side the stocks prices issued by E&P companies are the ones most affected by fluctuations in the oil price.

2.3.4 Petroleum equities' relationship with the oil price

The Ministry of Finance (2014a) completed a regression analysis to test whether there is a significant correlation between oil price fluctuations and the return on oil and gas companies. This analysis tries to explain historical returns in different sections of the stock market, through a Fama-French model. The Fama-French approach uses two firm characteristics that seem on empirical ground to proxy for exposure to systematic risk (Bodie et al, 2011). The first characteristic represented by HML accounts for the difference in returns between growth and value stocks. The second characteristic, SMB, includes the difference in return between small and big companies. The Ministry of Finance added the oil price as an extra explanatory variable in the model. The analysis is based on the American stock market as it

⁴ The sample consists of companies classified as R&M companies under the Global Industry Classification Standard

⁵ The sample of "Big Oil" firms consists of BP, Chevron, Exxon Mobile, Royal Dutch Shell, Total, Eni and Conoco Phillips

gives the best data, and the sample represents monthly returns from the period December 1993 until August 2013.

The output of the analysis shows how much of the variation in returns that can be explained by the development in the different variables. This is shown through the model's explanatory power, R^2 . The result shows that the oil and gas business is by far the most sensitive industry in the short term when it comes to fluctuations in the oil price.

The study performed by the Ministry of Finance (2014a) also shows that the oil and gas industry is the only industry for where the model's explanatory power, R^2 , increases in value when the oil price is added as an explanatory variable. This underpins the fact that the oil and gas business is more vulnerable to fluctuations in the oil price, compared to other industries. However, the analysis also indicates that there exist other factors besides oil price fluctuations that explain a higher share of changes in returns for oil and gas companies. This can be inferred as the Fama–French model without the oil price as explanatory variable explains 41.8% of the oil and gas companies return, while adding the oil price variable only leads to an explanatory power of 58%.

3 Background

The goal of this thesis is to expose the relationship between the stock price development of oil and gas companies, and petroleum related state income. If a robust relationship exists, exclusion of oil and gas equities from GPFG's portfolio should be considered to reduce its risk exposure to developments in the oil and gas industry. The purpose of this chapter is to give insight into the development of the Norwegian petroleum industry, clarify its impact on the Norwegian economy and explain how the government, directly and through taxes, obtain income from these resources. In addition, the section will explain the purpose and structure of the GPFG and describe its investment strategy.

3.1 Presentation

3.1.1 Activity and production on the Norwegian shelf

The activity on the Norwegian continental shelf increased dramatically during the latter part of the 20th century (Norwegian Petroleum, 2015b). As more oil companies started to operate in Norwegian waters the production of oil and gas rose substantially in this period. During the 21st century the total production of petroleum has stagnated. While the production of oil historically has represented the largest share of total production, the share of gas production has recently been greater than that of oil. The evolution of production of petroleum on the Norwegian continental shelf is shown in the figure below.

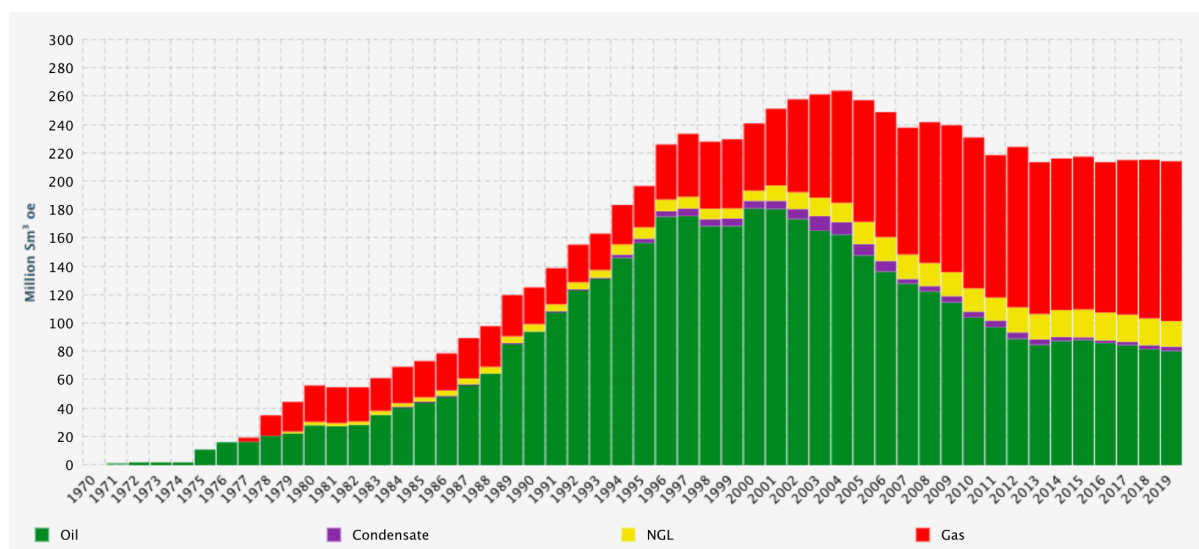


Figure 4. Petroleum production – Norwegian Petroleum (2015b)

The volume of production does not by itself explain the magnitude of petroleum related state income, but is in combination with other factors such as oil price, productivity and cost development, an important variable explaining the inflow of cash to the GPFG.

3.1.2 Employment in the oil and gas industry

In line with increased activity in the oil fields, demand grew for services and equipment related to the oil industry (SNL, 2014). Norway's position as a shipping nation and its expertise within local maritime affairs created a blossoming supply industry on the Norwegian mainland. The development of the Norwegian petroleum industry has led to large changes in the labor market. From being a virtually nonexistent sector 60 years ago, the petroleum sector now constitutes about 13% of total employment, including both directly and indirectly petroleum related occupations (International Research Institute of Stavanger, 2015). This industry is obviously very dependent on the activity level on the Norwegian shelf and decreased production might have a negative influence both on the cash flow to the GPFG as well as on Norway's human capital. As both the State's cash flow and parts of Norway's human capital will be affected by the development on the Norwegian shelf, one can argue that the GPFG should concentrate their investments on assets with no relations to the oil and gas sector.

3.1.3 The petroleum sector's influence on the economy

The petroleum sector plays a vital role in the Norwegian economy and is very important for the financing of the welfare state. Since production started in the early 1970's the petroleum activities on the Norwegian continental shelf have contributed more than NOK 11,000 billion in current NOK to Norway's GDP (Norwegian Petroleum, 2015a). Yet so far, only 45% of the estimated extractable resources on the Norwegian shelf has been produced and sold. In figure 5, one can see the importance of the oil and gas industry for the Norwegian economy, displayed by various macroeconomic indicators.

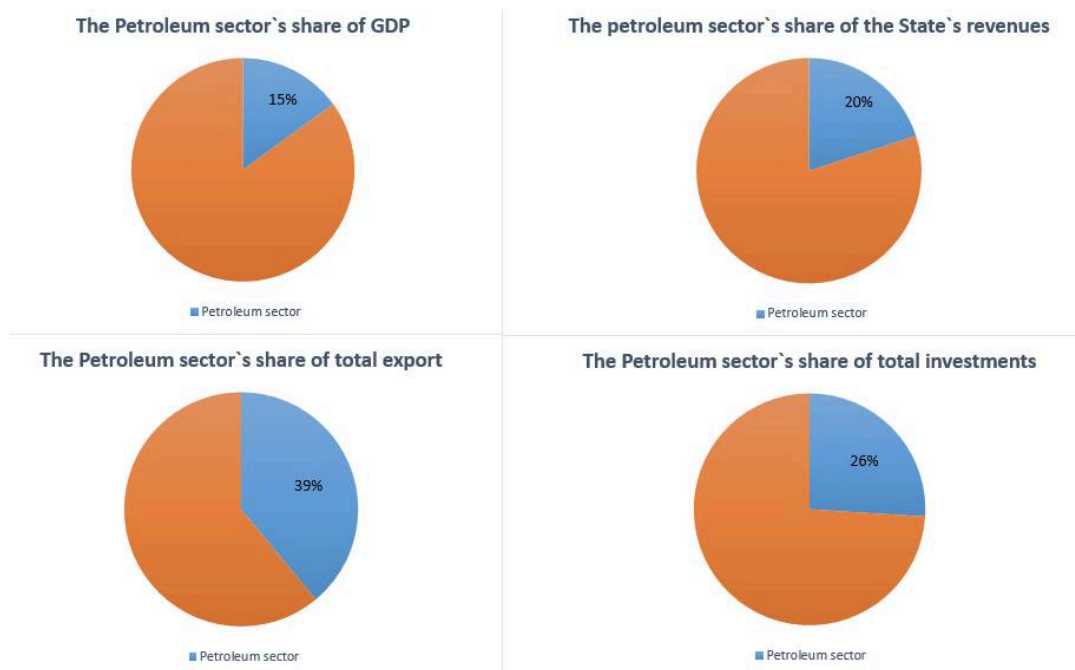


Figure 5. Macroeconomic indicators – Norwegian Petroleum (2015a)

As there still exists vast petroleum resources on the Norwegian shelf, there is little doubt that the petroleum industry will continue to play a major role for the Norwegian economy in the years to come. With continued inflow of substantial petroleum related income, it is important to manage the financial wealth in a way that reduces its risk exposure to the petroleum industry.

3.1.4 The foundation of the Government Pension Fund Global

With the speedy development of the petroleum industry and the inflow of petroleum revenues it soon became clear that the values involved might be larger than previously assumed (Ministry of Finance, 2014a). It was also acknowledged that the revenue from the petroleum sector was not revenue in the ordinary sense, as they were offset by the extraction of a non-renewable resource. Furthermore, it was understood that these revenues would fluctuate greatly with the oil price. It was therefore important to manage the state's spending of petroleum revenues to ensure balance in the economy. The Government Petroleum Fund was created in 1990 to underpin long-term considerations with regards to phasing in petroleum revenues in the Norwegian economy (Norges Bank Investment Management, 2015b). The fund was renamed the Government Pension Fund Global in 2006 to highlight the fund's role in saving government revenues to finance the expected increase in future public pension costs

In the beginning the GPFG did not accumulate any funds. The petroleum revenues were allocated to the fund, but the entire amount was returned to the fiscal budget to relieve the non-oil deficit (Ministry of Finance, 2014a). As the Norwegian economy started to recover from the bank crisis in the late 1980's and early 1990's, the first net allocation to the GPFG was made in 1996. Since then the GPFG has grown to a value of about 7000 billion NOK. In comparison to the mainland economy this constitutes about 240% of the GDP of mainland Norway as shown in figure 6.

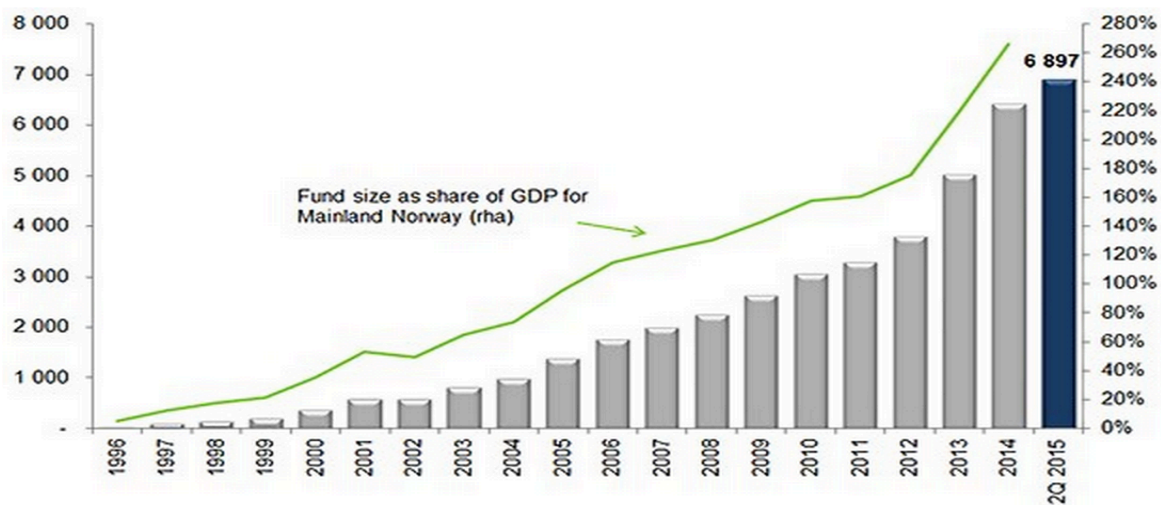


Figure 6. GPFG Development – Ministry of Finance (2014c)

3.1.5 The fiscal policy rule

An important view regarding the nation's petroleum wealth was that it should benefit future, as well as present, generations (IMF, 2013). It was therefore important to implement mechanisms that would prevent excessive use of petroleum wealth. Policy measures designed to smooth spending from the petroleum wealth were also necessary to insulate the economy from Dutch disease. Due to these considerations the fiscal policy rule was implemented in 2001, stipulating a gradual phase-in of petroleum revenues in the Norwegian economy equivalent of the expected real return on the GPFG, estimated at 4%. The fiscal policy rule is however not set in stone and permits spending more than the expected return in a cyclical downturn, while spending should lie below the expected return when the economy is booming. Figure 7 shows how the GPFG's expected real returns are integrated in the state budget through the financial policy rule.

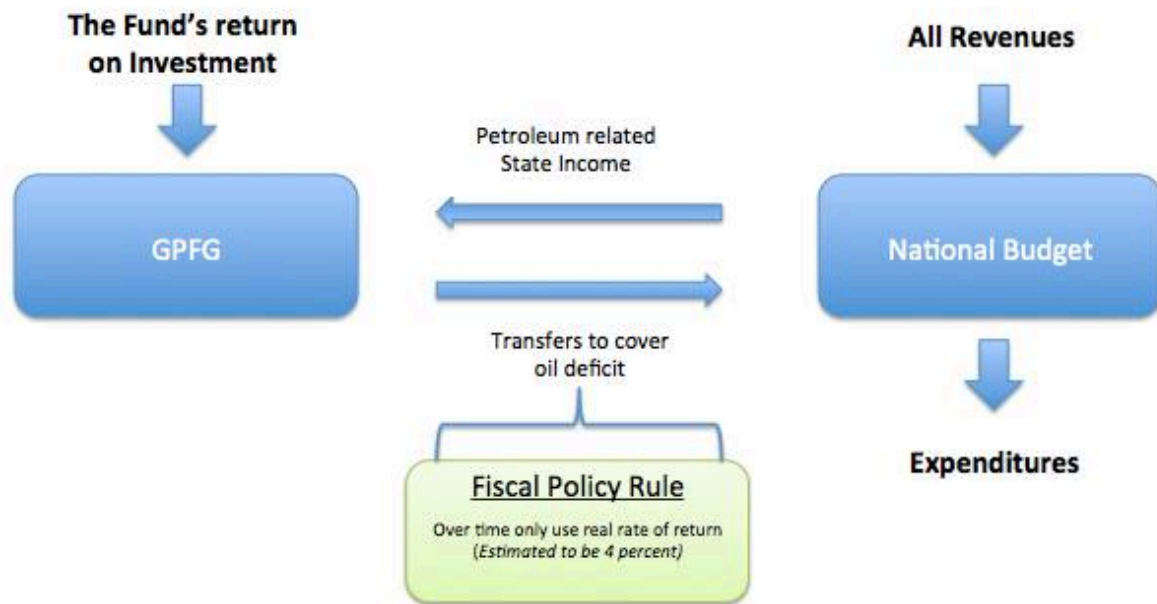


Figure 7. GPFG's integration in the fiscal policy – Gjedrem (2015)

As mentioned, the GPFG portfolio also consists of oil and gas equities. The objective of this thesis is to see if there is a long-term relationship between the petroleum related state income presented in the figure and the development of this part of the fund's investments. Such a relationship could increase variations in the basis for transfers to the national budget, *ceteris paribus*. The transfer of funds from the GPFG is important for the development of the Norwegian welfare state, as these revenues increase the State's ability to finance important public services such as health care, education, pension plans and other social security benefits (Gjedrem, 2015).

3.1.6 Investment strategy of the GPFG

The investment strategy of the GPFG is governed by mandates laid down by the Ministry of Finance. The objective of the GPFG is to maximize the fund's return over time, given a risk level set by the composition of its benchmark portfolios (Ministry of Finance, 2014d). The investment strategy has been changed over time as new guidelines has been set by the Ministry of Finance. Currently, the long-term investment strategy stipulates a fixed equity portion of 60%, a fixed bond portion of no less than 35% and a real estate portion of no more than 5%. These investments are diversified across markets in many countries, and in each market investments are diversified across a number of individual companies and issuers.

Besides the GPFG's growth due to its return on investments, it is important to take into account that it also has an outside income represented by the petroleum related state income which might imply extra exposure to the oil and gas industry. However, the management mandate from the Ministry of Finance expresses a long-term strategy for the GPFG and is based on a strategic benchmark index excluding any specific considerations regarding oil and gas industries (Ministry of Finance, 2014d). This benchmark index is based on broad indices given by leading index providers that largely reflect the development in the global equity and fixed income markets. The GPFG tracks this index to a large degree and is subject to a maximum tracking error of 1%. Thus the possibility of active management is quite restricted and the return on the fund is predominately determined by the general market developments.

3.1.7 GPFG's investments in oil and gas stocks

As a consequence of its investment strategy of broad global diversification and allocations made on the basis of market weights, the GPFG naturally has investments in the oil and gas sector. At year-end 2014, around 7% of the fund's equity portfolio was invested in the oil and gas sector (Norges Bank Investment Management, 2015a). The GPFG has investments in most oil companies around the world and has ownership shares of around 1% in large oil companies such as ConocoPhillips and Exxon Mobil. One of the largest single investments done by the GPFG is in Royal Dutch Shell, where it owns 2 % of all shares. As Norway possesses large below-ground petroleum assets, there have been discussions about whether the fund should stop investing in the oil and gas industry based on a holistic diversification perspective.

3.1.8 Productivity and profitability on the Norwegian shelf

As our objective in this thesis is to look at the relationship between the Norwegian state's petroleum related income and the stock returns on oil and gas companies, one needs to examine the development in both costs and revenues among companies operating on the Norwegian shelf. This is important since their earnings will affect the level of petroleum state income.

Petoro is a Norwegian state-owned corporation responsible for managing the commercial aspects of the state's direct financial interest in petroleum activities on the Norwegian shelf

(Petoro, 2015). Petoro's perspective record expresses concern for the significant decline in earnings among oil and gas companies (Moen, 2014). This decline is due to the fact that the oil price from the period 2010 until 2014 has remained relatively constant, while the oil and gas companies' costs have increased significantly. In the case of Petoro, a study of their cost's development shows a 400% cost increase the last decade.

The consequence of decreased earnings in these oil and gas companies is further capital constraints, and rigorous prioritization of projects (Moen, 2014). According to Moen (2014) the level of production and activity at the Norwegian shelf relies on the oil and gas companies' capability to reduce their costs, so that they can get access to more capital and secure profitability in future projects.

Rystad Energy (2014) present a thorough analysis related to the development in costs and productivity at the Norwegian shelf. We consider these components as relevant when studying the profitability in this area, as they play an important role for the development of petroleum related state income.

One crucial factor for the petroleum related state cash flow, except for the oil price, is the cost and capital expenditure development in the different oil and gas companies. As long as the cost development exceeds the growth in oil price, the oil related state income would decrease even though you experience an increase in oil price. According to Rystad Energy (2014) the last four decades the costs in the Norwegian petroleum sector has grown on average with respectively 6%, 8%, 10% and 11% annually. In 2014 the total cost amount for companies operating in Norway was estimated to be 307 billion NOK. This includes capital expenditure of 225 billion NOK, operating costs of 67 billion, organization costs and seismic purchases outside license.

Rystad Energy (2014) also analyse the development of *total productivity*⁶ on the Norwegian shelf to study how the level of employees in both oil and supply companies have affected the amount produced. They find that the average annual development in total productivity has in the last five decades since 1970s been: -6%, -3%, 2% -6% and -8%. As stated the total

⁶ Rystad Energy defines total productivity to be the total production per employed in both oil and supply companies.

productivity at the Norwegian Shelf has been decreasing except for the period during the 1990's. This means that the relationship between the number of people employed and the amount produced haven't been proportional. The reason for the positive development in the 1990's was due to the increased focus on cost development in the oil and gas industry and the need for more effective procedures to stay competitive.

The purpose of this section was to illustrate the fact that the profitability of companies operating at the Norwegian shelf, which in turn will affect the petroleum related state income, also is influenced by other factors than just the oil price. As described, both developments in petroleum related costs and productivity would affect the final income and profit of the energy companies. In addition, costs related to investments on the Norwegian shelf, capital expenditures, will also impact the petroleum related income.

3.2 Data

3.2.1 The composition of the petroleum related state income

The State's cash flow from the petroleum sector is made up of three main elements. These are taxes and fees from the petroleum sector, operating profit from the SDFI and returns on the State's ownership of Statoil stocks (Statistics Norway, 2013).

The taxes and fees are mainly related to the taxation of profits of the companies that are involved in petroleum extraction. These companies have to pay the normal corporate tax of 27%, but are in addition obligated to pay an extraordinary tax of 51% (Statistics Norway, 2013). The companies who are active on the Norwegian continental shelf is thus subject to a marginal tax of 78%. The extraordinary tax is due to the especially great earnings potential for the companies, in other words the possibilities for resource rent. Resource rent is a term to describe the excess return stemming from the use of natural resources when these resources are in short supply. The purpose of the high tax is to secure the highest possible share of the excess return to the state from the petroleum sector, while still offering competitive returns to the companies operating on the Norwegian shelf. In addition to taxes on profits, companies pay area fees and CO₂ fees. Area fees are fees that are paid by the companies to maintain extraction concessions after the initial period of ten years are up. The CO₂ fee is a fee on CO₂ emissions from the petroleum companies operating on the Norwegian continental shelf.

The second bulk of the state's income from the petroleum sector refers to the operating profit of the SDFI. SDFI is the State's Direct Financial Interest in Norway's petroleum sector and the portfolio contains a third of the oil and gas reserves on the Norwegian continental shelf as well as platforms, pipelines and land-based plants (Petoro, 2015). Since 2001 Petoro has been responsible for the management of the SDFI, and negotiates the licensing agreements with petroleum companies active on the Norwegian shelf (Petoro, 2012). A central part of creating value for the State is to achieve an optimal extraction of the resources within each licensing agreement and to secure that the State receives its rightful share of that value (Petoro, 2015). Petoro does this through active participation in prioritized oil fields on the Norwegian shelf in all phases of the projects, from exploration to development and operation. As one of many owners, the Norwegian state covers its share of the investments and costs and receives a corresponding share of the income from the extraction licenses. These attributes indicate that the proportional EBIT of Petoro might coincide with other integrated oil companies on the various oil fields. As a state-owned firm, Petoro does not pay petroleum tax and differs in this regard to other oil companies on the Norwegian shelf.

Finally, the last income stream from the petroleum sector is the return on the State's shares of Statoil's stocks. The State owns 67% of the stocks in Statoil and receives dividends like all other shareholders (Statoil, 2015).

3.2.2. Magnitude of the income streams

The petroleum tax is a significant income stream for the Norwegian state. During the 1990's the petroleum tax represented on average above 4% of the public administration's total income (Oil-tax office, 2013). The 2000's were characterized by strong growth in the tax income both as a result of increased oil prices and due to the sale of SDFI-shares which led to a bigger part of the revenues being canalized through the tax system. During this period the petroleum tax revenues has been on average above 12% of total state income.

The SDFI's contribution to the State's cash flow has also been significant. During the first 15 years since its formation SDFI yielded results varying from negative returns in the late 1980's to returns averaging around 25 billion NOK in the 1990's. Since the establishment of Petoro in 2001 and with increased oil prices and continued activity on the Norwegian shelf,

the cash flow to the State has averaged well above 100 billion NOK (Norwegian Petroleum, 2015a). The petroleum tax and the SDFI profits are thus a substantial part of the State's income and has made possible the welfare policies Norway enjoys today. These two elements of the State's cash flow from the petroleum sector has been the largest contributors since the GPFG started accumulating funds in 1996, as shown in the figure 8.

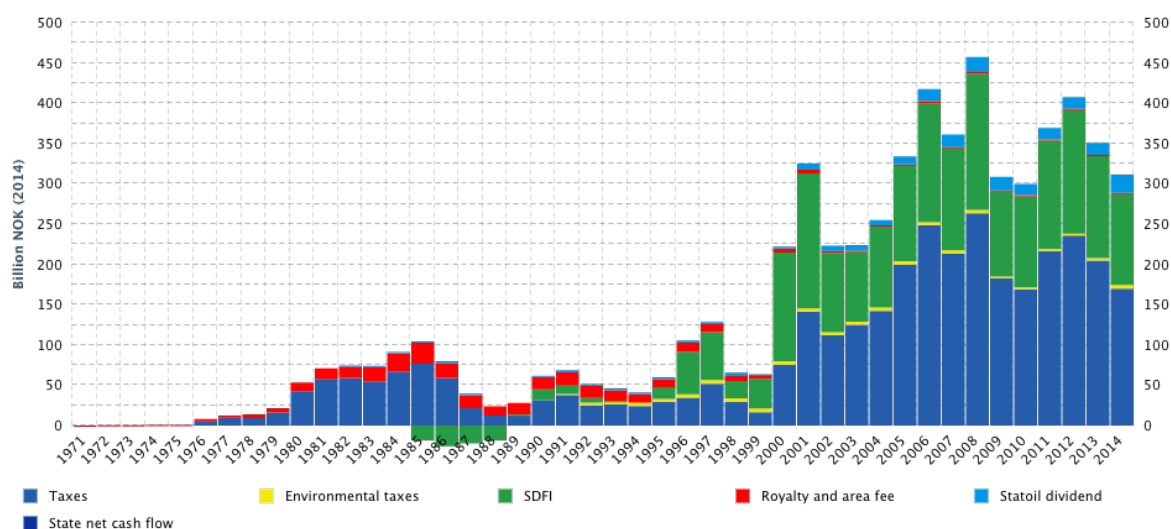


Figure 8. Petroleum related state income – Norwegian Petroleum (2015a)

3.2.3 Proxies for stock market returns of the oil and gas industry

The State's net cash flow from the petroleum sector is in its entirety transferred to the GPFG. Together with the return on its holdings this transfer constitutes the fund's revenues. As the cash flow from the petroleum sector is an integral part of the fund's inflow it is interesting to compare it to the return on oil and gas stocks.

As a proxy for the stock price development in the oil and gas industry we use different indexes gathered from Thomson Reuters Datastream that track the performance of the petroleum sector. The World-DS Integrated Oil and Gas index, hereafter referred to as WIO, is an index that is based on the performance of 77 of the largest integrated oil companies in the world. The GPFG has ownership shares in most of these companies and WIO is therefore an interesting index to include in our analysis. Another index we want to include is the FTSE World Oil and Gas Producer index. This index tracks the performance of a broad range of oil and gas producers all over the world and is thus a good measure of the general development in the oil and gas industry. Furthermore, we include both the FTSE W Europe Oil and Gas

Producer index and the FTSE USA Oil and Gas Producer index since these are similar to those proxies used in previous research referred to in this paper. These geographical markets are also of interest as they represent the largest share of the investments done by the GPFG. As figure 9 shows, there are differences in the development pattern of the various indexes. Since all indexes has various index levels, all have been reset to a value of 1 starting in 1996.

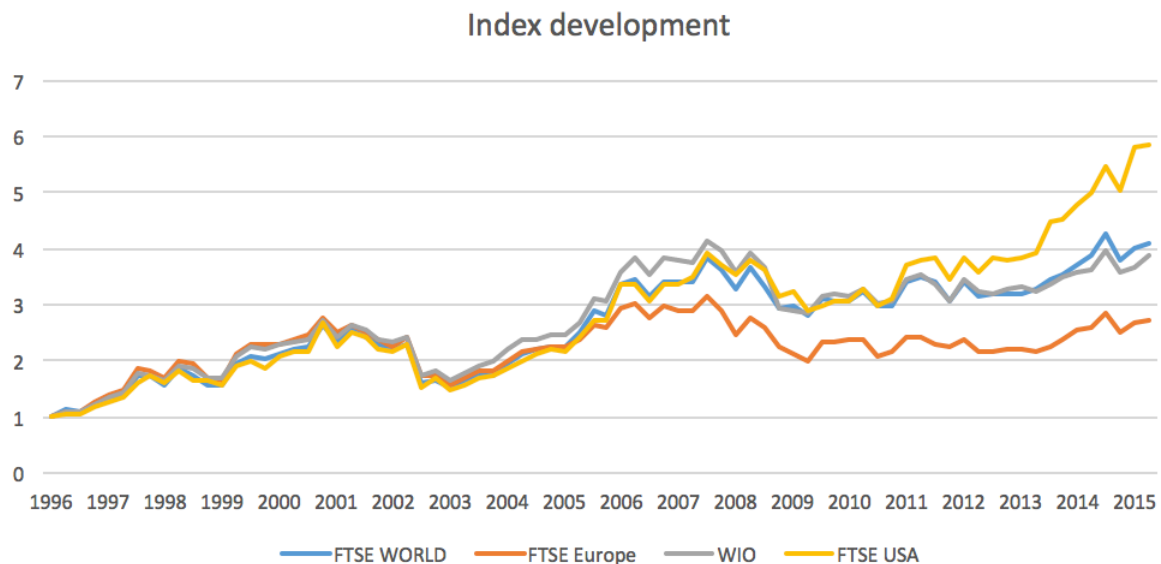


Figure 9. Index Development – Own calculation

In addition to the proxies representing the oil and gas industry, we have also included indexes representing four additional sectors. These indexes are FTSE World Consumer Services, FTSE World Finance, FTSE World Industrials and FTSE World Consumer Goods. These are included to test for the existence of a possible hedge for the petroleum related State income.

4 Empirical data analysis

4.1 Statistical material

4.1.1 Choice of data

In our econometric analysis we want to uncover if there is a relationship between petroleum related state income and the stock price development of oil and gas companies. Through this analysis we will also examine the dynamics between these variables. Regarding Norway's cash flow from the petroleum sector we only include the two major sources of income; taxes and fees, and the operating profit from the SDFI. Together, these two elements have historically constituted more than 95% of the State's petroleum related income. We have decided to use various indexes⁷ related to the oil and gas industry to discover potential differences in relationships and dynamics.

4.1.2 Collection of data

Our analysis is based on the time period between 1996 and 2014, beginning with the first quarter of 1996 and ending with the last quarter in 2014. We have chosen this time period because it covers the period the GPFG has had funds to allocate in the global markets. We apply quarterly data because of the poor availability of more frequent time series related to the State's cash flow from the petroleum sector. In total, the time series is based on 76 quarterly observations.

The quarterly data on the various indexes has been collected from Thomson Reuters Datastream. The data regarding taxes and fees from the petroleum sector has been gathered from Statistics Norway in their records of the government's account of income and expenses. Finally, the data concerning the operating profits from SDFI has been collected through correspondence with Petoro and Statoil and through the collection of Petoro's quarterly reports.

⁷ Presented in section 3.2.3

4.1.3 Data configuration of taxes and fees

In 2008 Norway's parliament implemented new rules regarding tax payments from the petroleum sector. Prior to 2008 the taxes from the petroleum sector were paid semi-annually, in the 1st of April and the 1st of October. In the following years the new rules imply tax payments six times a year on the 1st of February, April, June, August, October and December. As a result, we have defined quarterly tax income by estimating quarterly weights based on the seasonality patterns discovered in the period of frequent payments from 2008. The earlier semi-annual tax payments in April and October are divided into 1st and 4th quarter payments and 2nd and 3rd quarter payments, respectively. The distribution of the semi-annual tax payments between the quarters is based on the relative weights found in the post-2008 sample.

4.1.4 Analysis of the individual elements of the State's cash flow

Another dimension in our analysis is to uncover the individual relationships and dynamics between the subcategories taxes and fees and SDFI's operating profit, and the stock price development of oil and gas companies. This is interesting because the two income streams display different ways the petroleum income is canalized to the State. SDFI's operating profits are directly related to the operations of Petoro in prioritized oil fields while the taxes and fees are indirectly associated with the profitability of oil and gas companies on the Norwegian shelf. In addition to the general analysis related to the State's cash flow as a whole, we also want to investigate the effect on these elements separately.

4.2 Methodology

4.2.1 The purpose of the empirical method

In the following regression analysis, we will uncover if there are significant relationships between the State's cash flow from the petroleum sector and the development of oil and gas companies stock prices. Through our empirical analysis we want to expose both the long term equilibrium relationships and short term dynamics between these variables in order to support or reject arguments related to downscaling or revoking GPFG's current investments in the oil and gas industry. As mentioned, to get a more nuanced picture of these relationships we will use different oil and gas indexes to discover the various relationships with the State's cash flow. Furthermore, we also intend to discover the isolated relationships

related to the cash flow from taxes and fees and the SDFI. Finally, we would also like to see if there are significant long-term relationships between the State's petroleum cash flow and other non-oil and gas sectors.

To discover the the interaction between the long term equilibrium relationships and short term dynamics of our variables we will use the Engle and Granger two-step error correction model. An error correction model is defined as a dynamic model where the movement of a variable in any period is related to the previous period's deviation from the long-run equilibrium (Ssekuma, 2011). In order to perform an error correction model, the variables involved must be co-integrated, meaning that they share a long-term relationship (Engle & Granger, 1987). Engle and Granger's two step procedure entails that one first tests each variable to determine their order of integration. The order of integration defines the number of differences needed, to obtain a stationary process. If one finds that the variables are integrated of the same order, the second step is to test whether these variables are co-integrated. This is done by estimating the long-run equilibrium relationship and testing whether its residuals are stationary. If this is the case, one can perform the error correction model. A more detailed description of this process will follow.

The reason the error correction model is highly favored is because it allows for both interactions between short run dynamics and long run relationships, so it is a lot richer than just regressing first differences which is just short term relationships or just doing a regression on levels which just shows long run relationships. The error correction model combines both short run and long run characteristics, as the deviation of the current state from its long-run relationship is fed into its short-run dynamics. The model provides estimates of the speed of adjustment, which suggests how fast the dependent variable returns to equilibrium after a deviation has occurred (Lambert, 2013).

As mentioned, the goal of this analysis is primarily to test if there exist a long-run relationship between the Norwegian government income related to the petroleum industry, and the stock prices of oil and gas companies. If such a long-term dependency between these variables exists, the variables should be co-integrated. In the analysis we wish to specify econometric relationships, quantify short-term dynamics and long-run relations, and thus establish rigorous econometric tests for the relationships we wish to expose.

In our analysis we will use the time series in their original form when performing the E&G error correction model. The parameters in our analysis are estimated by the method of ordinary least squares (OLS) and are obtained using STATA.

4.2.2 Prerequisites for the Empirical Analysis

According to Engle and Granger (1987) the variables has to be integrated of the same order and be co-integrated in order to perform the error correction model. When discussing the time series' level of integration one interpret whether the time series have stochastic trends. The term unit root is used to describe whether the time series are stationary or not. If the time series do not have a unit root, one can conclude that the series are stationary and have a finite mean and variance that do not depend on time (Wooldridge, 2014).

However, if the time series have a unit root, and thus are non-stationary, one has a situation where the series appears follow a *random walk*. Such time series are not mean-reverting, and the effect of any shock is permanently incorporated into the series. In contrast to stationary time series, non-stationary series have an infinite variance and no mean (Wooldridge, 2014).

Awareness of non-stationary time series is important when studying the co-integration of two time-series because one need to be attentive to the risk of getting *spurious results*. One general rule is that such results might occur when regressing two time-series that are non-stationary, resulting in a significant relationship in the series even though there is none in reality. If the variables in the regression model are not stationary the standard assumptions for asymptotic analysis will not be valid. In other words, the usual t-ratios will not follow a t-distribution, so hypothesis tests about the regression parameters yields questionable results (Brooks, 2014). There is however one exception to this general rule regarding the case in which both series are non-stationary at level, but stationary in first difference, meaning they are integrated of the same order, order of one. In these exceptions one may trust the results of the regression if the residuals are stationary (Nilsen, 2014).

To sum up, a prerequisite for applying the error correction model is that both series are integrated of the same order and when regressed have a co-integrated relationship.

4.2.3 Dickey-Fuller unit root test

The Dickey-Fuller Test (DFT) makes it possible to define a time series' level of integration by testing the time series for random walk properties. To describe the test one can use the following equation:

$$\Delta Y_t = \alpha + \gamma Y_{t-1} + \varepsilon_t \quad \text{Equation 4}$$

This equation illustrates the fact that the change in Y can be explained by its past values, Y_{t-1} , whenever γ is different from zero. This is not the case for time series that follows a random walk. The conclusion is that whenever a time series represents a random walk, the value of γ equals zero, the time series have a unit root and is defined as not stationary (Wooldridge, 2014).

DFT has a null hypothesis stating that the Y variable follows a random walk, meaning that γ should be zero. If the test statistics implies that we can reject this null hypothesis, the time series are stationary. If we cannot reject the null hypothesis for Y, we assume the time series are not stationary at level, and one must proceed by completing a DFT on the first differences of Y (Best, 2008).

4.2.4 Co-integrating Regression

By completing a co-integrating regression one can study the long-term equilibrium relationship between the variables. As mentioned previously, in cases where the time series are not stationary, but integrated of order one, they need to be co-integrated with stationary residuals to prove the existence of a long-term relationship. The co-integrating regression implies the following long-term equilibrium equation:

$$Y_t = b + \beta X_t + v_t \quad \text{Equation 5}$$

In this equation the beta describes the long-term relationship between the X and Y variable, and it needs to be significant for the variables to be co-integrated (Best, 2008). We can see from equation 8 that the error term is a measure of deviation from the long-term equilibrium, expressed in the following equation:

$$v_t = Y_t - \beta X_t - b \quad \text{Equation 6}$$

The second precondition for co-integration implies that the error term v_t of the long-term equilibrium equation should be stationary. The predicted residuals, \hat{v}_t , are therefore tested for unit root. If the predicted residuals are stationary, meaning that they don't have a unit root, one can conclude that the two variables are co-integrated and have a long-term relationship. Once co-integration is confirmed it is possible to go on with the study and examine the convergence towards the long-term equilibrium by using an error correction model.

4.2.5 Engle and Granger Error Correction Model

As previously mentioned besides identifying a co-integrating relationship between petroleum related state income and development in oil and gas companies stock prices, we also want to examine the adjustment dynamics of the variables towards a long term equilibrium. For this matter we use the E&G error correction model as it allows for an easy interpretation of the effects related to the independent variable, both short and long term. In contrast to the co-integrated regression, the error correction model only consists of stationary variables and thus yields more reliable results.

The method requires stationary data, implying that for non-stationary variables at level, one need to convert to first differences (Engle & Granger, 1987). The Engle and Granger error correction model can be written the following way:

$$\Delta Y_t = \delta + \beta_1 * \Delta X_t + \beta_2 * \Delta Y_{t-1} + \beta_3 * \Delta X_{t-1} + \beta_4(\hat{v}_{t-1}) + u_t \quad \text{Equation 7}$$

In the equation above, β_1 is the estimated effect of a change in X on the change in Y, β_2 is the estimated effect of last period's change in Y on the change in Y and β_3 is the estimated effect of last period's change in X on the change in Y. These are all coefficients that estimates short term effects on changes in Y. The term stated in parentheses represents the error correction term, which we recall as the predicted deviation from the long-run equilibrium. This term equals zero when the variables are in equilibrium. However, if this error term is different from zero, we have a deviation from equilibrium that leads to a long-term adjustment in the dependent variable (Best, 2008). The speed of this adjustment is given by the β_4 coefficients and suggests how the correction of deviation will be spread over future time periods. One refers to β_4 as *the rate of error correction*. For the error correction

model to be the appropriate model, the output of the regression needs to provide a β_4 between -1 and 0. If any of the Beta-values in the E&G error correction model are found to be insignificant, one removes the variables one by one until one is left with a reduced model where all the estimated coefficients are significant (Lambert, 2015).

5 Results

5.1 Test for stationarity

A prerequisite for the application of the Engle and Granger error correction model is that our variables are integrated of the same order. To test for stationarity, we use the Dickey-Fuller test. In the tables in this chapter we show the value of the test statistics, beta-coefficients and their p-value in parenthesis.

In order to reject the null hypothesis of the variables being non-stationary, the absolute value of the test statistics have to exceed a critical value put forth by the regression. The test statistics are marked by one or two asterisks if they are significant at the 1% or 5% significance level, respectively.

Our results from the Dickey-Fuller test on our various dependent and independent variables are presented in the tables below. The first unit root test is performed on our variables at level form. To be clear, FTSE World, FTSE Europe, WIO and FTSE USA are abbreviations for the oil and gas indexes⁸.

Unit root test on level series	
	DFT - Levels
State Income	-1.695 (0.434)
Taxes and Fees	-1.824 (0.368)
SDFI	-2.424 (0.135)
FTSE World	-1.581 (0.493)
FTSE Europe	-2.894 (0.053)
WIO	-1.922 (0.322)
FTSE USA	-0.564 (0.879)

Table 1. Unit root test on level series

⁸ discussed in section 3.2.3

As shown in table 1, the results from the DFT illustrates that all the variables have a p-value above 5% indicating that we cannot reject the null hypothesis claiming that the variables are non-stationary. We see that FTSE Europe is close to the 5% significance level indicating that for this variable the null hypothesis of it having a unit root is nearly rejected. However, we choose to proceed with the conclusion that all our variables seem to be non-stationary at level.

As none of our time series are stationary at level, we perform the DFT on their first differences. If we find the dependent and independent variables to be integrated of the same order, meaning stationary at the same level of difference, we can proceed to test for co-integration.

We therefore perform a DFT on the first differences of our variables to test to if our variables are integrated at level one.

Unit root test on First differences	
	DFT - First Differences
State Income	-9.648* (0.000)
Taxes and Fees	-9.861* (0.000)
SDFI	-9.339* (0.000)
FTSE World	-10.404* (0.000)
FTSE Europe	-9.091* (0.000)
WIO	-9.663* (0.000)
FTSE USA	-10.783* (0.000)

Table 2. Unit root test on first differences

As shown in table 2, all the test statistics are significant and we may therefore reject the null-hypothesis of non-stationarity. We can therefore conclude that our variables seem to be stationary in first differences. As the first differences of both dependent and independent time series are stationary, all the variables used are integrated of the same order, and we can test for co-integration between our variables.

5.2 Testing for co-integration

The next step is to examine whether our various dependent and independent variables are co-integrated. For there to be a long run relationship between the variables they must be co-integrated, meaning they share stochastic trends. To test for co-integration, we first regress the dependent variable on the independent variable at level form, which indicates the long-term equilibrium relationship from the co-integrated regression in equation 5. From this regression it is possible to predict the residual values. This can be illustrated as the following equation:

$$\hat{v}_t = Y_t - (\hat{b} + \hat{\beta}X_t) \quad \text{Equation 8}$$

The beta coefficient from equation 5 indicates the long term effect of X_t on Y_t . If the estimated beta is significant and the residuals of the regression are found to be stationary, one can conclude that the given variables are co-integrated.

5.2.1 Co-integration between State income and the petroleum indexes

We first test for co-integration between the total state income and our various indexes. Table 3 shows the co-integrating regression parameters, model diagnostics and the results from the unit root test on the residuals. The columns show the regression results when applying the different indexes in the model.

Regression on Total State Income (Y)				
(X)	<i>FTSE World</i>	<i>FTSE Europe</i>	<i>WIO</i>	<i>FTSE USA</i>
b	-14956** (0.014)	-24315 (0.055)	-18338* (0.003)	1832 (0.730)
β	19.699* (0.000)	21.951* (0.000)	7.192* (0.000)	14.36* (0.000)
Adj. R²	0.68	0.37	0.69	0.61
F (1,74)	159* (0.000)	44* (0.000)	173* (0.000)	117* (0.000)
DFT - $\hat{\nu}$	-2.998** (0.035)	-2.383 (0.147)	-3.379** (0.012)	-1.982 (0.294)

Table 3. Regression Total State Income (Y)

Our results show that the co-integrating regression yields significant beta values for all the different indexes. However, only the predicted residuals when using FTSE World or WIO as independent variables are found to be significant when testing for stationary. This means that only FTSE World and WIO fulfils the prerequisites for being co-integrated with total state income.

Looking at the various constants we see differing degrees of significance. These constants express the estimated value of state income when the index level is zero and are thus not very informative when looking at the relationship between our variables. The Beta values express by what factor the index level affects state income. By multiplying the index level with its beta value one gets the estimated effect on state income in MNOK. To make this clearer, the long term equilibrium relationship between state income and FTSE World is illustrated in equation 9.

$$SI_t = -14,956 + 19.699FTSEWORLD_t$$

$$(0.014) \quad (0.000)$$

Equation 9

$$adj.R^2 = 0.68 \quad F(1,74) = 159$$

The estimated level of state income is based on the value of the constant in MNOK and 19.699 MNOK multiplied by the value of the FTSE World index. However, it is important to keep in mind that our co-integrating regressions are based on non-stationary variables and that inference should be handled with care due to the possibility of biased estimates of the standard errors. This may result in p-values that are questionable.

5.2.2 Co-integration between taxes and fees and the petroleum indexes

We then test for co-integration between taxes and fees and our various indexes. For taxes and fees, the results are quite similar as for total state income as shown in table 4.

Regression on Taxes and Fees (Y)				
(X)	<i>FTSE World</i>	<i>FTSE Europe</i>	<i>WIO</i>	<i>FTSE USA</i>
b	-13635* (0.001)	-19337** (0.024)	-15922* (0.000)	-2462 (0.509)
β	13.031* (0.000)	14.389* (0.000)	4.762* (0.000)	9.484* (0.000)
Adj. R^2	0.67	0.35	0.68	0.59
F (1,74)	151* (0.000)	42* (0.000)	165* (0.000)	110* (0.000)
DFT - \hat{v}	-2.946** (0.040)	-2.370 (0.150)	-3.379** (0.012)	-1.963 (0.303)

Table 4. Regression on Taxes and Fees (Y)

All the indexes' beta values are significant, but only the models including FTSE World and WIO have stationary residuals. This implies that only these indexes are co-integrated with taxes and fees. In this regression the beta values describe the long term relationship between the index level and the cash flow from taxes and fees. To exemplify, the long term relationship between taxes and fees and FTSE World is presented below.

$$T\&F_t = -13,635 + 13.031FTSEWORLD_t$$

(0.001) (0.000)

Equation 10

$$adj. R^2 = 0.67 \quad F(1, 74) = 151$$

The level of the cash flow from taxes and fees is estimated based on the value of the constant in MNOK and the index value multiplied by the beta coefficient of 13.031 MNOK.

5.2.3 Co-integration between SDFI and the petroleum indexes

Finally, we test for co-integration between SDFI and our different indexes. This to see if the income stream from SDFI deviates from the income stream from taxes and fees in regards to their relationship between different indexes.

Regression on SDFI (Y)				
(X)	<i>FTSE World</i>	<i>FTSE Europe</i>	<i>WIO</i>	<i>FTSE USA</i>
b	-1321 (0.593)	-4977 (0.289)	-2415 (0.336)	4294 (0.052)
β	6.668* (0.000)	7.562* (0.000)	2.429* (0.000)	4.879* (0.000)
Adj. R²	0.58	0.32	0.60	0.52
F (1,74)	107* (0.000)	37* (0.000)	113* (0.000)	85* (0.000)
DFT - \hat{v}	-4.291* (0.001)	-3.377** (0.012)	-4.455* (0.000)	-3.591* (0.006)

Table 5. Regression on SDFI (Y)

These results reveal the fact that the income streams at the Norwegian shelf are different when it comes to their relationship with the oil and gas stock market. For SDFI we find that all our indexes have significant beta values. Furthermore, for all our models the residuals are

stationary and it thus seems that all indexes are co-integrated with SDFI. We will therefore proceed with all these indexes when examining SDFI's long-term dynamics. How the cash flow from SDFI is affected by the level of FTSE World, is illustrated by the following relationship:

$$SDFI_t = -1,321 + 6.668FTSEWORLD_t$$

(0.593) (0.000)

Equation 11

$$adj. R^2 = 0.67 \quad F(1, 74) = 151$$

The estimated cash flow from the SDFI is based on the value of the constant in MNOK and the index value of FTSE World multiplied by the beta coefficient of 6.668 MNOK.

5.2.4 Co-integration between State Income and indexes of different industries

Finally, we perform the previous procedure with respect to various non-oil indexes too see whether there might exist a long-term relationship between these and the petroleum related state income. We have chosen to look at four different world indexes, also integrated of order one, representing the sectors consumer services, finance, industrials and consumer goods. In table 6, we present the results from the unit root test performed on the residuals from the co-integrated regressions with petroleum related state income.

Testing for Co-integration between Petroleum state income and industries	
	$DFT - \hat{\nu}$
<i>FTSE World Consumer Services</i>	-1.680 (0.442)
<i>FTSE World Finance</i>	-1.770 (0.396)
<i>FTSE World Industrials</i>	-1.719 (0.421)
<i>FTSE World Consumer Goods</i>	-1.600 (0.484)

Table 6. Testing for Co-integration between State Income and other industries

If we had found a sector index that showed a significant negative long term relationship with state income, it could possibly serve as an appropriate oil-hedging alternative. However, we observe from the table that none of these indexes are co-integrated with petroleum related state income, as the co-integrated regression does not provide stationary residuals.

We have found co-integrated relationships for both total state income and taxes and fees with the indexes FTSE World and WIO. All our oil and gas-indexes are co-integrated with SDFI. This means that these variables have a long term relationship and that we can perform the Engle and Granger error correction model to expose the dynamics of the income streams when changes occur in the value of oil and gas indexes. As the non-oil indexes had no co-integrated relationship with petroleum related income, they will not be evaluated in the Engle and Granger error correction model.

To sum up, the purpose of this section was to identify the beta values describing the long term relationship between the income streams and the index levels, and to test for stationarity in the error term to meet the prerequisites for proceeding with an error correction model.

5.3 Results from the Engle and Granger Error Correction Model

Recall the Engle and Granger error correction model presented in equation 7, which can be expressed the following way:

$$\Delta Y_t = \delta + \beta_1 * \Delta X_t + \beta_2 * \Delta Y_{t-1} + \beta_3 * \Delta X_{t-1} + \beta_4(\hat{v}_{t-1}) + u_t$$

To estimate the coefficients, we regress the above equation. This is our full-blown error correction model and contains both contemporary and lagged differences of our independent and dependent variables. If any variable is found to be insignificant, we remove them one by one until all included variables are significant. Having performed the regression on all our various variables we have found that our appropriate E&G error correction model boils down to equation 12.

$$\Delta Y_t = \delta + \beta_4(\hat{v}_{t-1}) + u_t \quad \text{Equation 12}$$

The above equation represents our final error correction model. As shown, we have only found the error correction term to be significant when explaining changes in our dependent variables, indicating that all the short term effects are insignificant. When analysing the long-term convergence of the time series we only use the time series that are co-integrated and integrated of level one.

5.3.1 Engle and Granger Error Correction Model on State Income

The table below shows the results when using the E&G error correction model with the change in State income as the dependent variable. The columns show each model's regression results and diagnostics. In addition to our final results we present the outcome of the full-blown error correction model, to illustrate that the short term effects are insignificant. Recall that only FTSE world and WIO are co-integrated with state income, thus we only proceed with these indexes.

	Engle & Granger Two-Step ECM - State income (ΔY)			
	FTSE World Full-blown	FTSE World Final	WIO Full-blown	WIO Final
δ	668.13 (0.535)	566.64 (0.572)	566.62 (0.588)	557.98 (0.569)
β_1	0.806 (0.807)	- -	0.216 (0.847)	- -
β_2	-0.041 (0.734)	- -	-0.039 (0.744)	- -
β_3	-1.847 (0.602)	- -	-0.171 (0.887)	- -
β_4	-0.174** (0.026)	-0.167** (0.014)	-0.208* (0.008)	-0.208* (0.002)
R^2	0.09	0.09	0.12	0.12
F()	F(4,69) = 1.62 (0.179)	F(1, 73) = 6.28** (0.014)	F(4, 69) = 2.38 (0.060)	F(1, 73) = 9.89* (0.002)
Normality	Chi ² (2) = 1.54 (0.467)	Chi ² (2) = 1.70 (0.443)	Chi ² (2) = 0.43 (0.806)	Chi ² (2) = 0.42 (0.810)
Hetero	Chi ² (1) = 0.00 (0.467)	Chi ² (1) = 0.12 (0.730)	Chi ² (1) = 0.24 (0.628)	Chi ² (1) = 0.46 (0.499)
Autocorrelation	Chi ² = 4.49** (0.034)	Chi ² = 0.228 (0.633)	Chi ² = 4.24** (0.040)	Chi ² = 0.151 (0.698)

Table 7. Engle and Granger Two-Step ECM – State income (ΔY)

As observed in table 7, the full-blown error correction models provide no significant variables except for the error correction term. Having reduced the model, removing one variable at the time, we find our final error correction model. Our results show that the rate of error correction, β_4 , is significant for both our indexes. We see that the rate of error correction is -0.208 for WIO and -0.167 for FTSE World suggesting that the deviation from equilibrium is corrected more rapidly for WIO than FTSE World. This means that a shock to for example WIO, next period will lead to a change in State income corresponding to 21% of the estimated effect from the long term equation. State income will each following period change by 21% of the remaining deviation from the long term equilibrium.

The E&G error correction model is also significant for both indexes as shown by the joint significance tests. Testing for normality we find that normality in residuals cannot be rejected. We have also performed Durbin's alternative test for autocorrelation and the Breusch-Pagan test for heteroskedasticity. The observed statistics for these tests yield high p-values which suggest that we cannot reject the null-hypothesis stating that it is no autocorrelation nor heteroskedasticity present. Finally, we observe that the explanatory power is higher for WIO than for FTSE World, suggesting that for WIO the error correction term explains more of the variation of changes in state income.

To understand the error correction mechanism, it is useful to illustrate an example graphically with an impulse response function. From our error correction model described in equation 12, the predicted error term contains the deviation from the long term equilibrium equation. Thus could the error correction model be stated as in equation 13.

$$\Delta Y_t = \delta + \beta_4(Y_{t-1} - (\hat{b} + \hat{\beta}X_{t-1})) + u_t \quad \text{Equation 13}$$

We first assume that at $t-2$ the variables are stable in their long-term equilibrium, meaning the error correction term is equal to zero. At $t-1$ however, the index value has experienced a shock which leads to a deviation from the long term equilibrium. This implies adjustment in Y to get back to long term equilibrium. The dynamics of these adjustments depend on the rate of error correction, β_4 .

Figure 10 illustrates the state income's long-term dynamics when it occurs a shock in one of the two indexes FTSE World and WIO. An experienced shock in an index represents an increase/decrease of 1 unit between $t-2$ and $t-1$, which leads to a deviation from equilibrium. This deviation will lead to a long-term adjustment in State income towards the level described by the long-term equilibrium. In period t , State cash flow will experience an increase/decrease of around 3 MNOK due to the shock in FTSE World, while the increase/decrease will be around 1.5 MNOK by a corresponding shock in WIO. Next period the effect of the shock on State income is smaller with an increase/decrease of around 2.7 MNOK and 1.1 MNOK from FTSE World and WIO respectively. As time passes the adjustment-effect will gradually, and to a lesser and lesser extent, increase/decrease the State income each period until the deviation from the long-term equilibrium is neutralized.

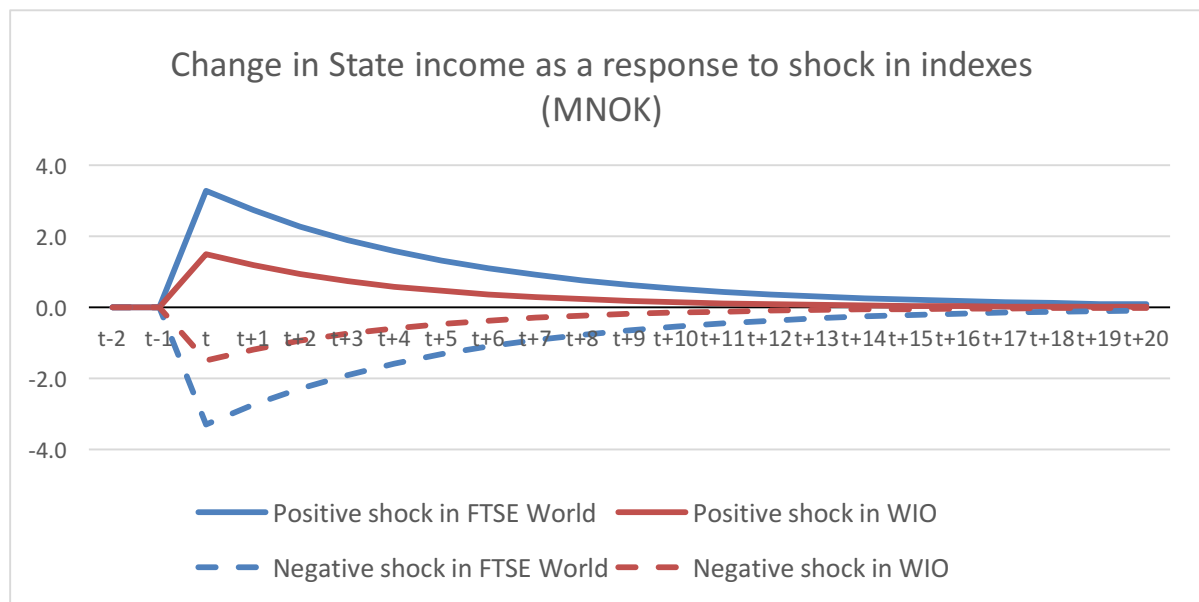


Figure 10. Change in State income as a response to shock in indexes

One can also show how the long term effect of the deviation from equilibrium is distributed over time as fractions of total deviation. From figure 11 we see that the deviation from equilibrium is corrected in period t by 20.8% and 16.7% for deviations caused by WIO and FTSE World respectively, which is equal to the rates of error correction. In the following periods the rate of error correction yields lower distributions of total deviation as the deviation from equilibrium gradually diminishes. This figure more precisely illustrates the differences in the speed of adjustment. We see that in the case of state income, a shock to WIO is more rapidly absorbed than for FTSE World. As we can see for both indexes only a

small fraction (20.8% and 16.7%) of the deviation is corrected for in period t , while 79.2% and 84.3% are corrected for in the longer run.

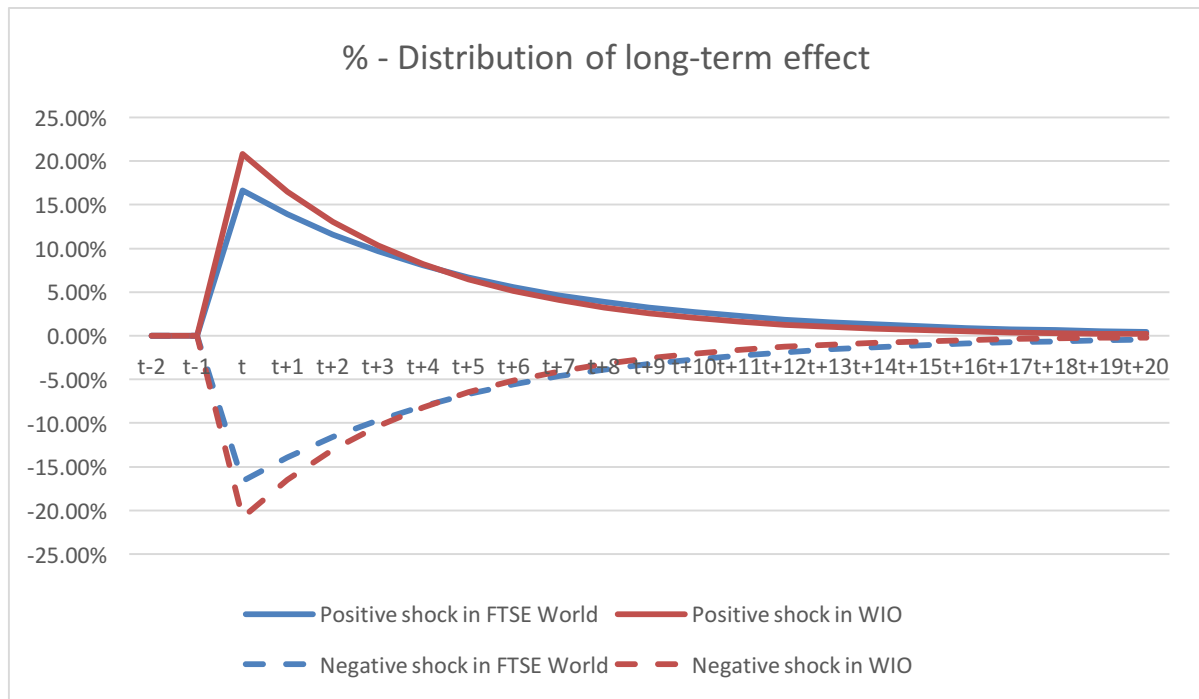


Figure 11. Percentage distribution of long-term effect

Figure 12 illustrates the state income's convergence towards the long-term equilibrium at *level form*. This implies a description of the long-term path of the petroleum related state income when a shock occurs in the oil and gas indexes. The origin value⁹ represents the equilibrium level of total state income before a shock in the stock market has occurred. As one can observe, a positive shock¹⁰ in the FTSE World index lead to a higher level of petroleum state income in future time periods. The State Income will keep on increasing until it reaches its long-term equilibrium relationship with this index, which in this case is approximately 20 MNOK above the old equilibrium level. For an equivalent shock in the WIO index, state income will increase until the deviation from the long term equilibrium is corrected. This happens when the level of state income is 7 MNOK higher than its previous level.

⁹ Marked with zero in the vertical axis

¹⁰ One-unit increase in the index value

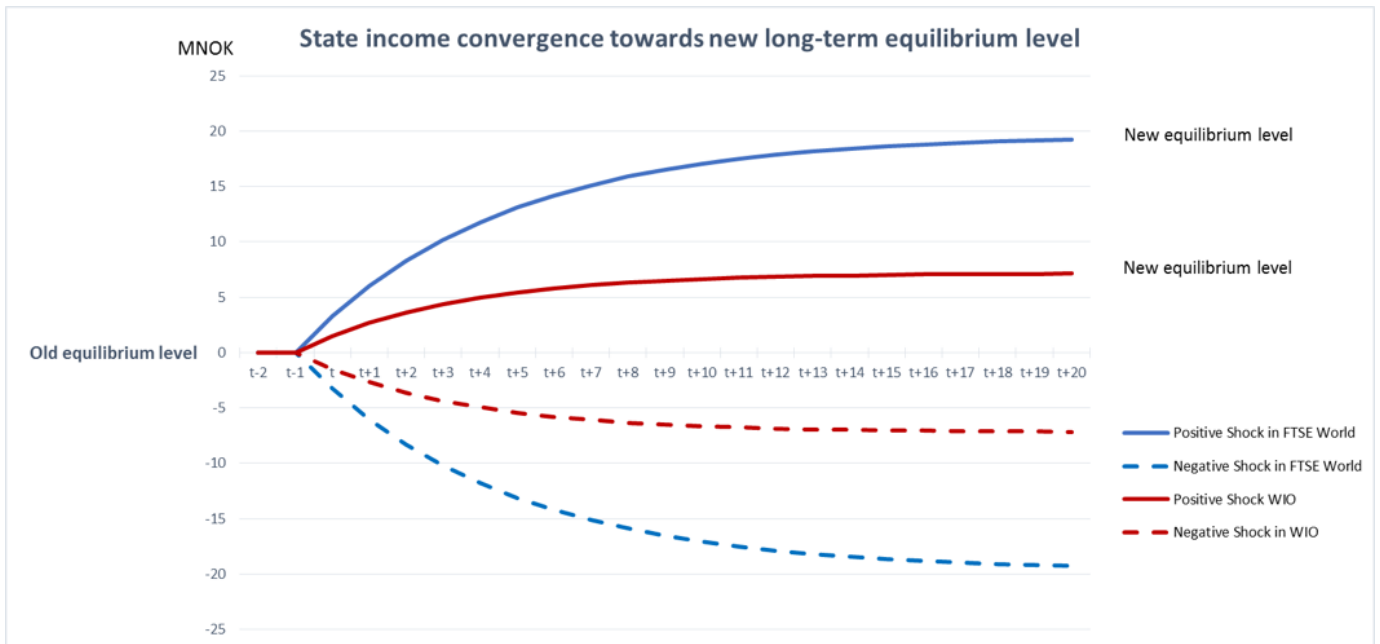


Figure 12. State income convergence towards new long-term equilibrium level

The difference in State income's new equilibrium level when interpreting both a shock in FTSE World and in WIO is due to the difference in index values. A one-unit increase does not represent an equal percentage change in the index. However, to study the differences in the state income's accumulated adjustment towards new equilibrium level when looking at different indexes, one may look at the percentage change in state income as a share of the estimated long-term effect, as shown in appendix 1.1.

5.3.2 Engle and Granger Error Correction Model on the SDFI

We now apply the E&G error correction model with SDFI as the dependent variable. In table 8 we only present our results from the final error correction model. As mentioned earlier, all the indexes were found to be co-integrated with SDFI.

Engle & Granger Two-Step ECM - SDFI (ΔY)				
	WIO Final	FTSE World Final	FTSE USA Final	FTSE Europe Final
δ	189.39 (0.733)	202.86 (0.719)	214.30 (0.711)	167.04 (0.772)
β_4	-0.390* (0.000)	-0.359* (0.000)	-0.297* (0.001)	-0.249* (0.001)
R^2	0.21	0.18	0.14	0.14
F()	F(1, 73) = 19.34* (0.000)	F(1, 73) = 16.19* (0.000)	F(1, 73) = 11.77* (0.001)	F(1, 73) = 12.29* (0.001)
Normality	Chi ² (2) = 1.29 (0.525)	Chi ² (2) = 3.54 (0.170)	Chi ² (2) = 7.40** (0.025)	Chi ² (2) = 0.00 (0.998)
Hetero	Chi ² (1) = 4.62** (0.033)	Chi ² (1) = 5.52** (0.020)	Chi ² (1) = 5.76** (0.017)	Chi ² (1) = 1.03 (0.310)
Autocorrelation	Chi ² = 0.10 (0.752)	Chi ² = 0.127 (0.772)	Chi ² = 0.118 (0.731)	Chi ² = 0.037 (0.848)

Table 8. Engle & Granger Two-Step ECM – SDFI (ΔY)

Our results related to this component of the state cash flow are interesting. The rate of error correction is significant and quite high for all indexes, especially when comparing the rate of error correction of FTSE World and WIO with those estimated for State income. This means that deviations from these equilibrium relationships are corrected much more rapidly and thus are more speedily absorbed in changes in the cash flow from SDFI. We can also see that the explanatory powers of FTSE World and WIO are higher than for State income, suggesting that shocks to these indexes explain more of the long term adjustments for SDFI than for state income. Furthermore, we observe that the joint significance test for all models are proven significant and that non of the models contain autocorrelation. The assumption of normality seems to be rejected only for the model containing FTSE USA. However, the OLS method will still provide unbiased estimators. The Breusch-Pagan test does imply that only FTSE Europe can reject the null-hypothesis of no heteroskedasticity. However, when applying the robust function¹¹ in STATA, we find that the change in standard errors are

¹¹ The function estimates robust standard errors that takes into account issues concerning heterogeneity. Such standard errors are used to allow the fitting of a model that does contain heteroskedastic residuals.

miniscule, indicating that the degree of heteroskedasticity seems to be really low. Furthermore, the output from the robust regression does not alter our conclusion and we therefore choose to proceed with the regression output stated above.

5.3.3 Engle and Granger Error Correction Model on Taxes and Fees

We then perform the E&G error correction model with the cash flows from Taxes and Fees as the dependent variable. Here as well, we only present the final error correction models. As for the regression done with state income, we only consider the indexes FTSE World and WIO since only these are co-integrated with Taxes and Fees.

Engle & Granger Two-Step ECM - Taxes and Fees (ΔY)		
	WIO Final	FTSE World Final
δ	377.01 (0.579)	381.16 (0.581)
β_4	-0.207* (0.003)	-0.168** (0.016)
R^2	0.11	0.08
F()	F(1, 73) = 9.35* (0.003)	F(1, 73) = 6.06** (0.016)
Normality	Chi²(2) = 1.42 (0.492)	Chi²(2) = 2.04 (0.361)
Hetero	Chi²(1) = 2.05 (0.152)	Chi²(1) = 1.48 (0.224)
Autocorrelation	Chi² = 0.448 (0.503)	Chi² = 0.686 (0.408)

Table 9. Engle & Granger Two-Step ECM – Taxes and Fees (ΔY)

The results show that the rate of error correction is significant for both indexes and are relatively close in magnitude to those found related to total State income. Shocks in FTSE World or WIO lead to a deviation from equilibrium and the estimated long term effect is

corrected for by 16% or 21% each following period until the long-term equilibrium is reached. We find that both models are significant according to the joint significance tests and that in neither model can the null-hypothesis of normality in the residuals be rejected. We also observe that neither of the models seem to contain autocorrelation or are subject to heteroskedasticity.

The purpose of this section was to present our empirical findings achieved when applying the Engle and Granger two-step error correction model. In further chapters we will complete a more thorough discussion of these findings and their implications.

6 Thorough discussion of findings

The following chapter will provide a more thorough interpretation of our findings in relevance to the main objective of the thesis. This includes discussions and evaluations related to our empirical findings and how the results coincide with previous research referred to in this thesis.

6.1 The relationship between State income and development in oil and gas stocks

In this thesis we have performed an analysis of the relationship between the State's cash flow from the petroleum sector and the returns on oil and gas indexes. Through our analysis we have identified a co-integrated relationship between petroleum related state income and the indexes FTSE World and WIO, which suggests that there exists a long-term relationship between these variables. This means that in the long run, the level of petroleum related state income will fluctuate with the development in these indexes. The GPFG holds assets all over the world in the oil and gas industry and owns stocks in most of the integrated oil and gas companies represented in the WIO-index. These results imply that exclusion of oil and gas stocks represented in these indexes may reduce the GPFG's portfolio's exposure to the oil and gas industry when considering the inflow of petroleum related state income. This is described in the section regarding Modern Portfolio Theory¹², where a solution to achieve a more diversified portfolio would be to reduce their stake in oil and gas stocks and rather invest in assets that are negatively correlated with petroleum related income, and in this way one can possibly achieve a higher return-to-risk ratio.

A possible explanation for a long term relationship between oil and gas indexes and the petroleum related state income, could be that fluctuations in the oil and gas indexes are due to changes in expectations of oil and gas companies' future profitability. An increase in an oil and gas index could intuitively mean that there are higher expectations of future cash flows. Higher expectations might lead to increased investments and more activity on the Norwegian shelf over time and in that way affect the petroleum state income.

¹² Section 2.2

Studying the explanatory power of WIO and FTSE World in the long-term equilibrium equation indicates that they explain 70% and 68% of variations in state cash flow, respectively. This is quite high and could be a supporting argument to exclude oil and gas stocks in the GPFG, especially as a long-term relationship has been identified. However, one has to be careful to base investment decisions on these estimates due to the issue of spurious results in the long term equation, which is a consequence of non-stationary variables as explained in the methodology section. The E&G error correction model, which provides more reliable output due to stationary variables, shows explanatory powers for WIO and FTSE World suggesting that shocks to the indexes explain 12% and 9% of the long term adjustment in State income.

Even though the explanatory powers are quite low, the long term effect of a shock in the indexes has a significant impact on the petroleum related state income. However, we see that there are other factors influencing the changes in petroleum related state income. To get a better basis for discussing the question related to exclusion of oil and gas stocks, we should shed light on the individual components of state cash flow.

6.2 The relationship between components of the state income and the indexes

According to our findings all the presented oil and gas indexes have a long term relationship with the cash flow from SDFI. For taxes and fees, our results are quite different as we only find long term relationships with the indexes FTSE World and WIO.

6.2.1 Differences in dynamics

Apart from the differences in long term relationships with the various indexes, our findings also imply that the income streams from the Norwegian shelf have different dynamics when it occurs a shock in one of the indexes. Our ECM model indicates that almost 40% of the estimated long-term effect caused by a shock in the index for WIO are adjusted for in the next period when looking at the income related to SDFI. This speed of adjustment is significantly higher than what's the case for income from taxes and fees, where a larger portion of the long-term effect is adjusted for in future periods, as shown in figure 13.

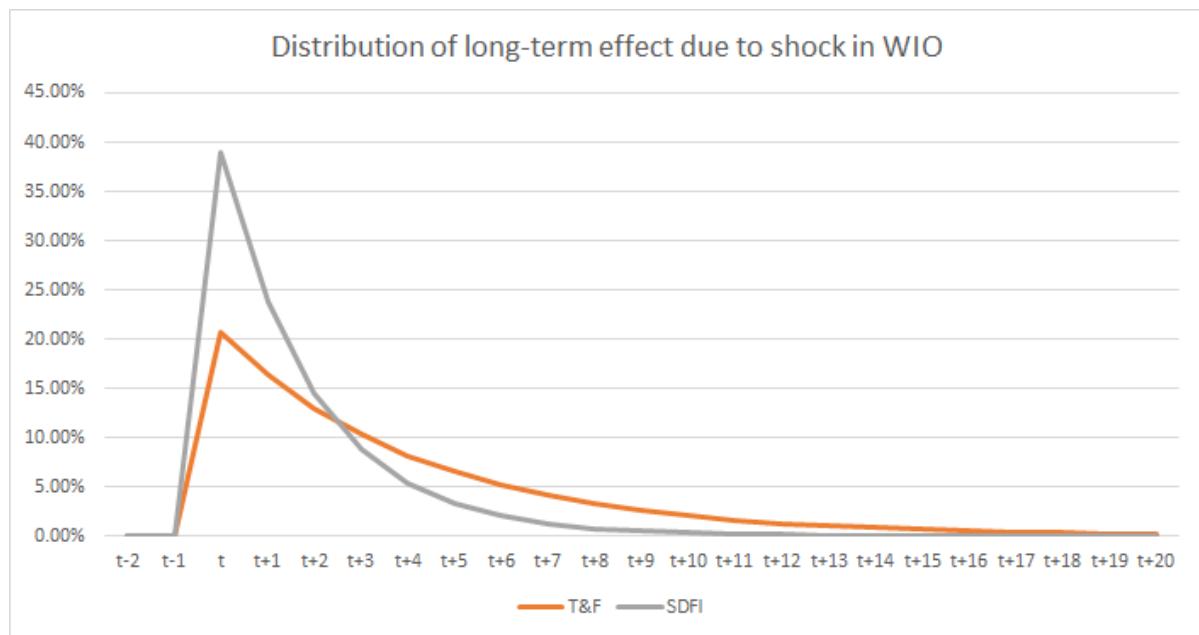


Figure 13. Distribution of long-term effect due to shock in WIO

Another way to display the differences in dynamics is presented in figure 14. It shows how much time it takes (in quarters) for each cash flow to completely¹³ correct the deviation from the long term equilibrium, caused by a shock in the index. One can see that the error correction process for SDFI is completed twice as fast as for taxes and fees. A description of the cash flows convergence to equilibrium at level form in absolute terms is further illustrated in appendix 1.2.

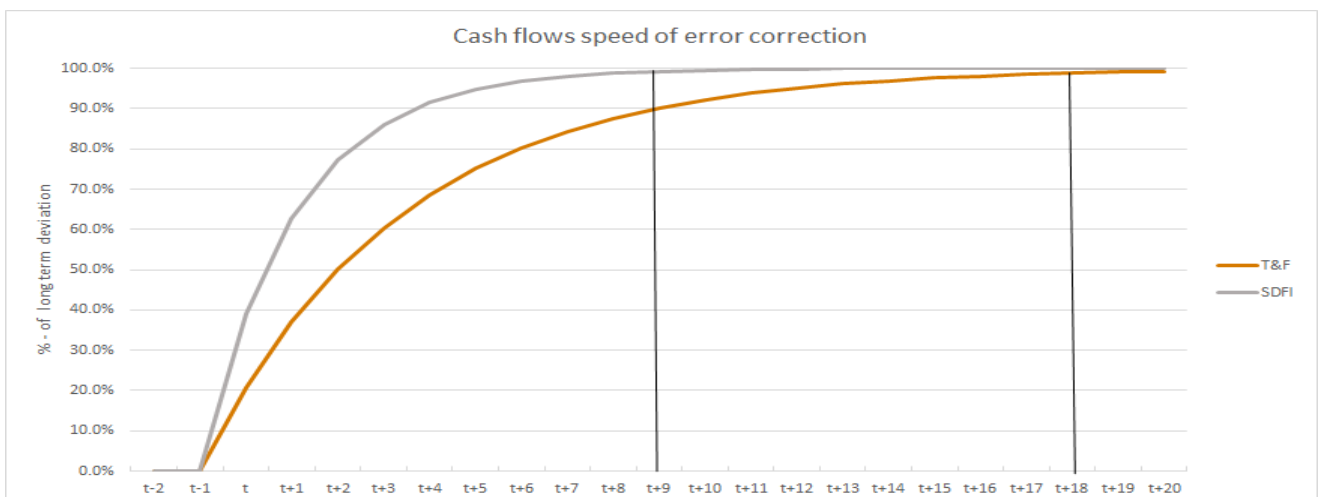


Figure 14. Cash flows' speed of error correction

¹³ "completely" represents a correction of 99% of the experienced deviation at t-1 from the long term equilibrium

The difference in dynamics is quite difficult to explain. However, recall equation 2 and 3 in section 2.2.3 illustrating the calculation of a company's free cash flow, and how estimates of future cash flows can be used to find the share price of a company. As previously explained it's reasonable to describe the FCF of Petoro to be quite similar to the FCF of other integrated oil companies operating at the Norwegian shelf. One theory may be that if the expected FCF of Integrated oil companies, which also are present at the Norwegian shelf, goes down, their share price will fall implying the index WIO to decrease. This illustrates that share prices are based on expectations. However, if these expectations turn out to be right and the FCF for the companies in the next period actually decreases, it will also lead to a fall in the income from SDFI the next period. This as we assume that the FCF of Petoro is similar to other integrated oil companies. Our findings confirming that there exists an especially strong long-term relationship between SDFI and WIO supports this assumption.

From equation 2 one can see that when a decrease in FCF of the oil and gas companies is due to decreased earnings, it should also imply reduced income from Taxes. However, our impulse response function illustrates that Taxes and Fees have a relatively slow adjustment to changes in the oil and gas stock market compared to SDFI. This might be due to the complexity of the tax system. The petroleum tax scheme allows for linear depreciation of investments and deductions of relevant costs related to exploration, R&D and financing, to name a few. To shield normal returns, these companies also have rights to additional yearly deductions of 5.5% called uplift in the extraordinary petroleum tax base. Furthermore, non-profitable oil-companies carry losses forward. This might serve to illuminate why the income streams from these two channels are not affected in the same way by the development in the oil and gas market as these factors largely effects the calculation of EBIT for taxable companies. Another reason could be the fact that it's hard to precisely allocate the right amount of tax income to the right time period as taxes in the past have not been paid too frequently. One last reason can be the fact that petroleum taxes are attained also through companies that differ from Petoro¹⁴, and from companies operating at other oil fields with different potential and profitability.

¹⁴ Companies related to other parts of the value chain

6.2.2 Differences in explanatory powers

Reviewing the results from our E&G error correction model it seems that the long-term dynamics of SDFI is better explained by the various indexes than for State income. The explanatory power of WIO is as high as 21% and is the index that has the highest rate of error correction. As Petoro is a large oil and gas company that is involved in all phases of their projects, from exploration to development and operations, it shares the attributes of large integrated oil companies. Petoro is involved in the most profitable oil fields on the Norwegian shelf and collaborates to a large degree on these oil fields with other integrated oil companies, suggesting proportional profits between Petoro and these companies on the Norwegian shelf.

Even though the WIO-index consists of integrated oil companies all over the world, not only on the Norwegian shelf, it is natural that it shares a stronger long-term relationship with SDFI, than the other indexes. The structure of large integrated oil companies such as Petoro makes these companies better equipped to meet changes in the oil and gas market, and could explain the similar development in the long run.

When testing the dynamics of taxes and fees, the explanatory powers from the E&G error correction model is 8% and 11% for FTSE World and WIO respectively, which is significantly lower than the comparable explanatory powers of 18% and 21% related to SDFI. This indicates that taxes and fees share a weaker long-term relationship with these indexes. As mentioned when interpreting the dynamics, it is difficult to explain the exact reason for differences in relation to income streams. However, the cash flow achieved from Taxes and SDFI are structured in different ways and do not have a proportional development as illustrated in figure 8¹⁵, and explained in the previous section.

6.3 Findings in relation to previous research

As stated in the section for previous empirical studies there have been quite a few analyses performed with the purpose to identify a possible industry which can be used as a hedge against shocks in the oil price. In this thesis we have focused primarily on the work done by Henriksen & Kværner (2015) and El Hedi & Fredj (2010), and their results regarding the

¹⁵ Section 3.2.2

stock markets relation to fluctuations in the oil price. Our thesis also refers to Cochrane's (2013) discussion regarding the complications of including outside income in Modern Portfolio Theory, which is highly relevant in the case of GPFG.

According to the studies performed by Gold (2013), fluctuations in the oil price has a different effect on company's revenues, earnings and stock price, depending on their place in the value chain. This can to some extent coincide with our findings as we see that earnings on the Norwegian Shelf have a different degree of relationship depending on the composition of the indexes used in the analysis. Gold's analysis indicates that E&P companies' stock prices are the most correlated with fluctuations in the oil price. We find however that earnings on the Norwegian Shelf have the strongest long-term relationship with the development of integrated oil companies' stock prices. This might serve to show that the stock price of different oil companies don't have the same relationship with the petroleum related state income, as with the oil price.

Both Henriksen & Kværner (2015) and El Hedi & Fredj (2010) find empirical evidence for a negative long-term relationship between the oil price and industries related to consumer goods, implying that this industry serves as a robust hedge for oil wealth. However, when testing for a relationship between the oil related state income and five of the sectors¹⁶ representing the largest share of investments done by the GPFG, we only revealed a significant long-term relationship between state income and the stock performance of the oil and gas industry. These findings differ from the analysis done by El Hedi & Fredj (2010), and illustrate the implications of using the oil price as an indicator of the petroleum related state income, as stated by Holden & Hoel.

Our result's deviation from previous empirical studies may also be due to the choice of indexes. In our analysis we wanted to include two indexes that were very similar to indexes used in previous empirical studies, FTSE USA and FTSE Europe, to see how our results deviated from these findings. We found that the choice of index clearly had an effect when identifying the long-term relationship between the cash flow and the stock price development. Both FTSE USA and FTSE Europe only had a significant long term

¹⁶ Including the consumer goods sector

relationship with the SDFI. The two remaining indexes, which we included due to the fact that they were global indexes and thus better represents the investments done by the GPFG, were found to have a long-term relationship with petroleum related state income.

As pointed out by our findings the indexes differ in regard to their relationship with the Norwegian petroleum related state income, as they include different samples of oil and gas companies. FTSE Europe and FTSE USA only includes geographical parts of the world's oil and gas market, while both FTSE World and WIO have a more global perspective. Our findings indicate that there may exist some "local movement" within the American and European oil and gas industry that deviates from the development on the Norwegian shelf.

We find it quite hard to identify the exact causes of these deviations, but during the analysed time period there have been isolated fluctuations in the different parts of the global economies that may have rubbed off on the oil and gas companies that originates from these fluctuating markets. For instance may the recent development in US shale oil have increased the attractiveness of many American oil and gas companies represented in the FTSE USA causing the index to rise¹⁷, while it has rather the opposite effect on petroleum related state income as the rise in shale oil have increased the supply of oil and gas causing the oil price to fall.

When it comes to the European oil and gas companies, one reason for the deviation may be the uncertainty and pessimistic view regarding the economic growth in the European union. It may be a bit naive stating that this uncertainty directly affects European oil and gas stocks. However, if it influences the expectations related to future cash flows, economic theory suggests that the share price will go down as well. If such is the case it will deviate from the performance at the Norwegian shelf as the cash flow here have been stable in this period due to constant high oil prices and activity.

However, it seems that when comparing the petroleum related state income with more global indexes like FTSE World and indexes which represents leading integrated oil companies in the world economy, we find a significant relationship. These findings are of interest as they

¹⁷ As illustrated in figure 10, section 3.2.3

suggest that the development in performance on the Norwegian shelf are not directly comparable to geographical markets like the European, but is more easily explained by the general development in the world's oil and gas industry, especially the development in the biggest integrated oil and gas companies. This can be due to the fact that license agreements on Norwegian oil fields are primarily given to the leading integrated oil companies. This of course, is excluding the licenses given to Petoro and Statoil with the purpose to maintain Norwegian interests in its petroleum industry. The presence of these world integrated oil companies at the Norwegian shelf might also suggest that the performance of these companies will have an effect on the level of state income.

The petroleum related state income represents an *outside income* for the GPF. One objective for this thesis was to uncover whether there is a relationship between this outside income and the oil and gas investments done by the fund and to see if the investment strategy of GPF implies an extra exposure towards the oil and gas sector. As Cochrane (2013) mentions, there are difficulties and limitations regarding the inclusion of outside income when using the modern portfolio theory to find the optimal asset allocation. This is due to problems identifying the outside income's current total value and exact relationship with investment opportunities. However, our opinion is that by identifying whether the relevant outside income has a significant positive long-term relationship with a special industry, one could argue that investments in this industry represent a *diversification risk*. Our findings show that such is the case for Norway's outside income and investments done in the oil and gas industry.

The difficulty occurs however when trying to identify the scope and impact of the long term relationship, as there is considerable uncertainty related to the value of the outside income. In our analysis we use historical values of the petroleum state income to identify the relationship, and we assume that these past values could be representative for the future income. But as described in the section concerning the uncertainty related to the size of the petroleum wealth, the estimates are based on strict assumptions regarding factors like future production, cost and oil price. The sensitivity analysis done in Ministry of Finance (2014b) also shows that wrong assumptions regarding the oil price leads to huge deviations in the predicted value of petroleum wealth.

7 Conclusion

7.1 Summary of findings

This thesis is a response to the White Paper of 2014 and the Ministry of Finance's assessment of oil price risk related the GPFG's current investment strategy and Norway's petroleum wealth. In their analysis they found no long-term relationship between the oil price and the development in oil and gas stocks, and concluded on this basis that there were no strong arguments to alter the investment strategy of the GPFG regarding its holdings in petroleum equities. Holden & Hoel criticized these results as a foundation for evaluating this issue and argued that a more relevant factor as a basis for GPFG's investment decisions was the relationship between oil and gas stock prices and the state's petroleum income, not the oil price exclusively as factors like cost and productivity development should be integrated in the assessment.

The purpose of this thesis has therefore been to uncover whether there is a relationship between the petroleum related state income of the Norwegian state and the performance of oil and gas companies' stock prices, and if so, whether it justifies a change in the GPFG's investment strategy concerning its oil and gas investments. In our thesis we have applied the Engle and Granger two-step procedure to determine if there exist a long-term relationship between our various oil and gas indexes, and the petroleum state income and its components. The Engle and Granger error correction model has been performed to uncover the dynamics between these variables.

Our results show that there is a statistical significant long-term relationship between the petroleum related state income and the two global oil and gas indexes. As the GPFG is invested in oil and gas companies all over the world these are relevant and interesting findings. When dividing the petroleum related state income into components of taxes and fees and cash flow from SDFI, we have found distinct differences with regards to their relationship with the various indexes and their dynamics. For taxes and fees, we only discovered a long-term relationship with the global indexes. On the other hand, our econometric analysis shows that the cash flow from SDFI has a long-term relationship with all indexes, also the more geographically concentrated indexes of FTSE USA and FTSE Europe. Our findings from the error correction model further indicate that the effect of

shocks in the global indexes are much more rapidly absorbed by the cash flow from the SDFI, than for taxes and fees.

Both total state income and each of the individual components taxes and fees and SDFI, has the strongest long term relationship with the WIO index representing global integrated oil companies. The relationship is most solid relating to the cash flow originating from the SDFI as its long-term dynamics are best explained by the index, with an explanatory power of 21%.

7.2 Implications

We found it interesting to test whether one get the same results when interpreting the stock market's relationship with oil related state income instead of the oil price. This as previous research done by Killian & Park (2009) and Ready (2014) reveals that the effect of oil price fluctuations on the stock market is inconsistent due to whether the underlying cause of the oil price shock is demand or supply driven. This inconsistent relationship, and the arguments provided by Holden & Hoel (2014), might imply that the Ministry of Finance should use oil related state income rather than the oil price, when testing for its outside income's long-term correlation with the stock market. Our findings give rise to implications as they to some extent deviates from the conclusions reached in the White Paper of 2014. These implications might also be more far-reaching when considering the wider national wealth perspective.

7.2.1 Implications concerning outside income

Our main findings states that there is a significant long term relationship between the petroleum related state income and the development in stocks issued by global oil and gas companies. This implies that the GPFG is invested in tradable assets that are positively correlated with its outside income.

According to Rystad (2014) there have been significant negative developments related to costs and productivity at the Norwegian shelf the last two decades. These developments were confirmed by Moen (2014), which refer to a cost increase of 400% in the case of Petoro. This will have a direct effect on the state income both through taxes and SDFI. As our findings imply that there is a relationship and convergence towards a long-term equilibrium between this outside income, and the performance of international oil and gas companies, it

could indicate that matters of increasing costs and lower productivity also have been present in the global petroleum industry.

Furthermore, our results have revealed that there are substantial differences in how taxes and fees and the cash flow from SDFI are affected by oil and gas indexes in the long run. Especially, there seems to be a relatively strong relationship between SDFI and the development of the WIO-index. This might suggest that a potential diversification strategy for the GPFG could be to sell its shares in global integrated oil companies, as the performance of these companies seems to correlate with the cash flow from SDFI over time. An alternative suggestion might be for the Norwegian government to consider a divestment of the SDFI licenses and in this way canalize more of their petroleum related state income through the tax system. We consider this to be a less realistic option as the Norwegian government seems determined to maintain its direct involvement in the activities on the Norwegian shelf.

As our findings do not reveal any significant relationship between the Petroleum related state income and indexes representing more geographically concentrated oil and gas companies, a suggestion could be to keep investing in smaller oil and gas companies operating in different geographical markets, and divest from the more global oil and gas companies. In that way the GPFG do not need to exclude the entire oil and gas sector from their benchmark portfolio which the Ministry of Finance (2014a) stated as a concern due to increased risk exposure to other sectors.

In this thesis we included theories and suggestions related to the presence of an outside income, to come up with a solution for the high exposure towards the oil and gas industry implied by our results. Cochrane (2013) suggested that investors with an outside income should try to identify tradable assets that are negatively correlated to shocks in the future outside income and invest in these assets to hedge this outside income. The GPFG could also handle the significant relationship between their oil and gas investments and outside income by implementing the *two-fund separation strategy* suggested by Scherer (2009). This strategy¹⁸ implies that the GPFG should be separated in into two parts, one which is entirely

¹⁸ As mentioned in section 2.1.7

driven by optimizing the Sharpe ratio, while the second portfolio is structured in a way that hedges shocks related to the oil wealth. The set-up of the first portfolio is similar to the composition of GPFG's equity portfolio, while the oil hedging portfolio does not include assets that are positively correlated with petroleum wealth. Our findings can only suggest that the oil and gas sector should be excluded from the oil-hedging portfolio when using the two-fund separation strategy. This as we have not found any sector to have a negative long-term relationship with the petroleum related state income.

Another option is to follow the strategy laid out by Bremer et al (2014). They suggest a financial portfolio that takes the petroleum wealth into account, and argue for an increased share of oil-hedging assets funded by leverage. As stated by the Ministry of Finance (2014b) the value of the petroleum wealth is almost 60% of the value of GPFG. The combined portfolio of petroleum and financial wealth would therefore according to our findings indicate an overexposure to the development of the oil and gas sector. Thus it would have been of interest to exploit the diversification possibilities the implementation of this strategy offers. However, the current GPFG investments strategy is subject to short sale restrictions that need to be lifted for this strategy to be possible, which might be unlikely.

The essence of the mentioned strategies has been to place the financial assets in oil hedging portfolios. However, we have not managed to find a sector that has a negative long-term relationship with petroleum related state income, and in that way can act as a hedge for petroleum wealth. Not even the consumer goods sector, which empirical studies have shown to be a robust oil-price hedge, did we find to be negatively related to petroleum state income over time. Our findings could on the contrary suggest that the sale of certain parts of the GPFG's oil and gas portfolio is recommendable, as a positive long-term relationship with petroleum related state income has been identified. This result is interesting as it shows the differing effect of using state income instead of oil price as the basis for diversification decisions.

As there are limitations in our completed analyses, this paper does not exclude the possibility that there exists a portfolio that has a negative long term relationship with petroleum related state income. One opportunity is to derive the oil hedging sectors by looking at the relationships with fluctuations in the oil price, as it's a key driver for the oil related state income. Both Henriksen & Kværner (2015) and El Hedi & Fredj (2010) find empirical

evidence for the consumer goods sector to be negatively correlated with the oil price. This implies an inclusion of the consumer goods sector when trying to follow the previously mentioned strategies related to an oil-hedging portfolio. However, it's important that a “oil-hedge strategy” is based on long-term correlations, as the GPFG has a long run investment perspective.

7.2.2 Wider implications

The financial wealth accumulated in the GPFG and the remaining petroleum wealth only constitutes 8% of national wealth, and is vastly overshadowed by the estimated contribution of human capital at 82%. The importance of diversification regarding the GPFG’s oil and gas investments might therefore in a wider national wealth perspective seem small, especially since we only find a significant long term relationship with small fractions of national wealth. It is however important to take into account the studies performed by the International Research Institute of Stavanger (2015) stating that about 13% of the Norwegian labor market is directly or indirectly related to the petroleum industry. This means that the development of the Norwegian petroleum industry also will affect a considerable part of human capital. A downturn in the petroleum sector could thus lead to increased unemployment, which represents both a cut in Norway’s human capital and increased welfare costs.

One can assume that the level of petroleum related state income to some extent serves as an indication of the activity and performance of the Norwegian petroleum industry. As we have found that the development of global oil and gas indexes have a long term relationship with petroleum related state income, it implies that it also shares a long term relationship with the human capital connected to the industry. One could therefore assume that the *actual value* of petroleum wealth constitutes a larger share of the national wealth than what is described by the Ministry of Finance (2014b). This implies that a bigger part of the national wealth is exposed to the developments in the oil and gas market, both through the GPFG’s investments in oil and gas stocks and through the activity on the Norwegian Shelf.

If the level of petroleum related state income is a good indication of the activity and demand for labor on the Norwegian shelf, it suggests that welfare costs would increase when petroleum related state income decreases, since a fall in activity results in reduced need for

labor. An increase in welfare costs may lead to larger deficits in the national budget, and as illustrated in figure 7, these deficits will be covered by the returns from the GPFG in accordance to the fiscal policy rule. A decrease in the returns of GPFG's oil and gas investments may therefore lead to an outflow from the fund larger than 4% to cover the increased budget deficit due to a rise in unemployment.

The need for diversification of petroleum related risk could thus be even greater as the implications of negative developments in the oil and gas markets might not only be reduced returns on GPFG's oil and gas investments and decreased state income, but also a reduction in human capital and increases in welfare costs.

7.3 Limitations and Suggestions for further studies

Our empirical study is based on relatively few observations and on a single explanatory variable. As the oil and gas industry currently experiences drastic developments in regard to fall in revenue and activity level, it would be of interest to run our analysis with a broader time-span in the future to see whether the long-term relationship still holds, and whether one can find an industry that can serve as a hedge for petroleum wealth. An analysis with a data sample reaching over a longer time period and with the possibility of controlling for more variables would give a wider dimension in explaining the development in petroleum related state income.

As mentioned, a key indicator to quantitatively define the extent of Norway's exposure towards shocks in the oil and gas stock market is to estimate the *actual value* of the petroleum wealth. This should include, in addition to the predicted value of petroleum reserves, more precise estimates of the value of human capital associated with the petroleum industry. A more complete analysis with this in mind would be helpful when evaluating Norway's exposure to the oil and gas industry.

Another limitation with our findings is the fact that they only reveal a long-term relationship between the petroleum related state income and indexes that serves as proxies for the financial oil and gas investments done by the GPFG. These proxies do not perfectly match the GPFG's oil and gas portfolio, it therefore would be of interest to perform a similar analysis with an index composed of the actual oil and gas investments done by the GPFG.

In our thesis we only look at the possible reduction in risk achieved by excluding the oil and gas sector. However, the drop of one sector implies larger investments in the remaining sectors. It would therefore be of interest to evaluate whether this *overweight* of remaining sectors in reality would increase the total risk of GPFG's portfolio.

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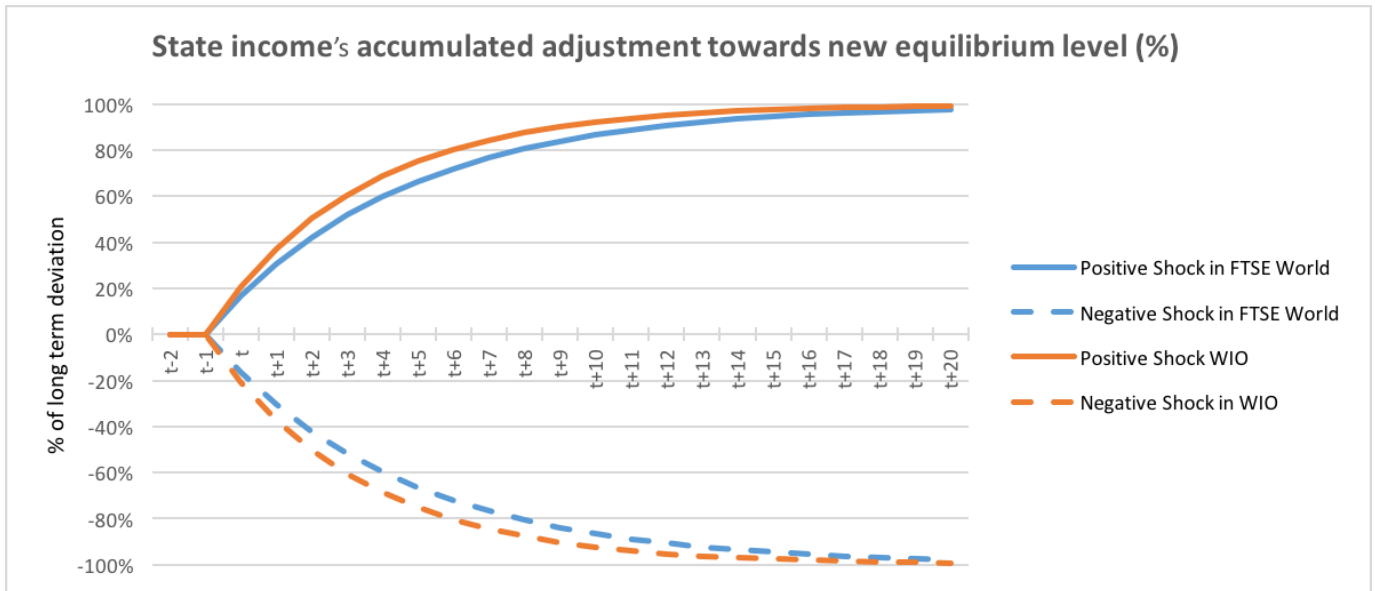
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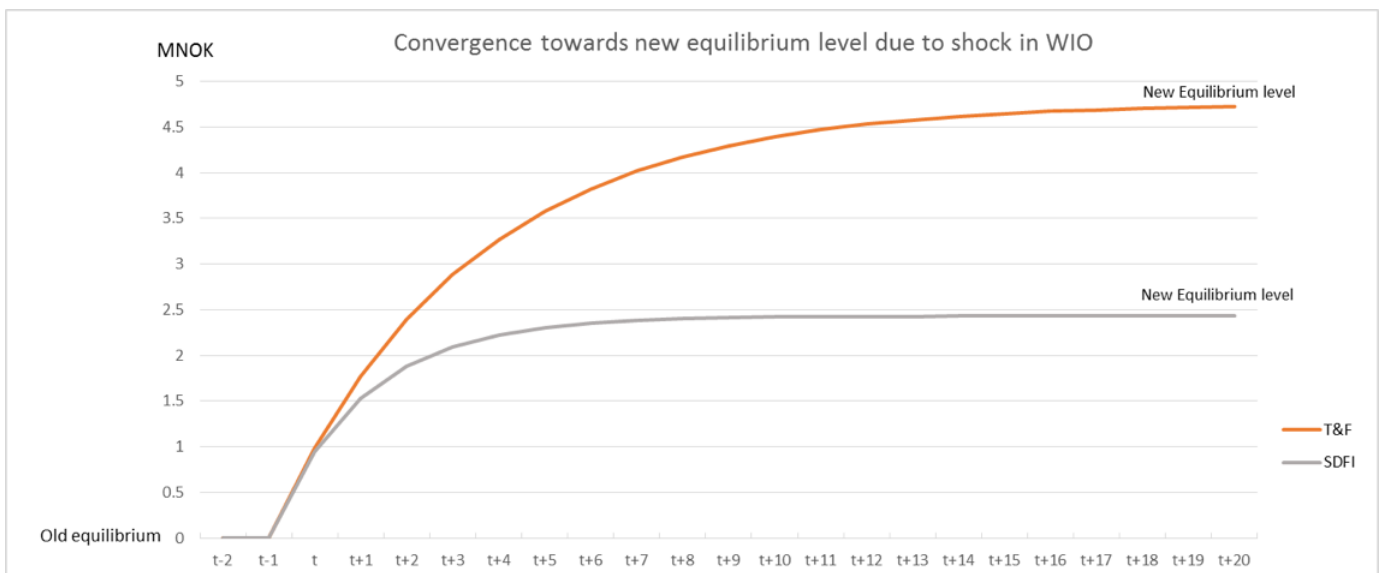
Appendix

1.1



State income's accumulated adjustment towards new equilibrium level (%)

1.2



Convergence towards new equilibrium level due to shock in WIO

