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Impact of Oil Price Shocks on Norwegian Macroeconomy:

An empirical analysis on how shocks in the oil price affect the Norwegian macroeconomy from 1990 to 2016

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Forord

Denne masteravhandlingen markerer slutten på et toårig masterprogram innen samfunnsøkonomi på handelshøyskolen ved NMBU.

Siden jeg startet på NMBU allerede på bachelornivå har jeg vært interessert i natur og ressurs-økonomi. Flere av fagene jeg har tatt har fokusert på analyse av energimarkeder, både gjennom oppbygning av markedene samt regulering av dem. Valget av emnet kommer som en følge av min egen faglige spesialisering, i tillegg til at begge mine foreldre jobber i oljeindustrien. Derfor ville jeg se nøyere på følgene av sjokk i oljeprisen og hva det hadde å si for makroøkonomiske variabler i Norge.

Jeg vil rette en stor takk til min hovedveileder Knut Einar Rosendahl og co-veileder Kevin Raj Kaushal som har hjulpet meg gjennom denne prosessen. Jeg er også meget takknemlig for alle professorer ved NMBU som gjennom sine engasjerte forelesninger har lagt grunnlaget for min utdanning.

Til slutt vil jeg takke min kjæreste. Abira. Tusen takk for all støtte og hjelp du har gitt meg underveis. Jeg er evig takknemlig.

Abstract

The impact of oil price shocks on the macroeconomy has been debated since the 1970s. The initial empirical results were that there was a significant negative effect between oil a positive price shocks and GDP in oil-importing countries, but recent studies suggest insignificant relationship oil price shocks and the macroeconomy. This study assesses empirically the effects of oil price shocks on the real economic activity in Norway, by employing a multivariate Vector Autoregressive analysis on both linear and non-linear measures of oil shocks. The results show that a negative oil price shock can affect GDP and net export but based on the impulse response functions and variance decomposition analysis I found that oil price shocks did not have a statistically significant impact on GDP, net export, real effective exchange rate and inflation. Furthermore, I did not find any evidence of Dutch disease in Norway.

Sammendrag

Effekten av sjokk i oljeprisen på makroøkonomiske variabler har blitt diskutert siden 1970 tallet. De første empiriske resultatene fra slike studier viste til en signifikant negativ effekt på BNP hvis prisen på olje gikk opp ut i fra en oljeimportene lands perspektiv. Senere studier på dette feltet viser at denne effekten er ikke er så signifikant likevel. Denne studien fokuserer på effektene på makroøkonomiske variabler i Norge og deres reaksjon på positive og negative sjokk i oljeprisen. Dette er gjort gjennom en multivariabel Vektor Autoregressiv analyse der jeg bruker linære og ikke-linære tilnærminger til sjokk i oljeprisen. Resultatene viser at et negativt sjokk i oljeprisen kan påvirke BNP samt netto eksport, men basert på impuls respons funksjoner og variansanalyse finner jeg at sjokk i oljeprisen ikke har en statistisk signifikant effekt på BNP, netto eksport, valutakurs eller inflasjon. Det er heller ingen antydning i analysen som tilsier at Norge lider av Hollandsk syke.

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Chapter 1 – Motivation of Topic

1.1 Introduction

As a commodity, crude oil is singled out as one of the most dominant energy natural resources and serves as lifeblood of the world economy. Referenced by the USA Energy Information Administration (EIA), during the first half of 2015, the world demand on average of oil and liquid fuels was approximately 93 million barrels per day. Consumption of oil exploded as economic progress was made in the early 21st century. The unique combination of characteristics enable oil to be utilized in different economic sectors, and a sudden disappearance of the commodity would affect a great number of industries, especially the transport sector.

Since the dawn of the 1960s, when the Norwegian oil industry was born, revenues from the petroleum industry have played a key role in the development of today's welfare state in Norway. With proven reserves of 6.6 billion barrels of crude oil, Norway is dependent on the petroleum industry in years to come (IEA, 2017). From the early 1970, Norway has experienced an exploration of oil and gas fields on the Norwegian Continental Shelf. Over time, this turned Norway from an oil-importing to an oil-exporting country (Bjørnland, 1998) The production of oil in Norway has stabilized at around 2 million barrels per day. This is approximately 40% below the peak in 2001 (IEA 2017). IEA's report estimates that only half of the oil resources has been produced. The production is expected to grow to 2.2 million barrels in 2022. In 2017, Norway was the world´s 15th largest producer of petroleum and other liquids (IEA, 2017), and is the world's 9th largest exporter of crude oil. It is estimated that Norway supplies approximately 2% of the global oil demand. In 2016 the total value of oil-export was estimated to NOK 186 billion, which was 25% of the total external trade in goods. The largest trading partners to Norway in terms of percentage of total export are the UK (21%), Germany (14%) and the Netherlands (11%). In terms of market power, Norway is not big enough to effectively change market prices in the petroleum industry.

It is up for debate whether the Norwegian economy is affected directly by fluctuations in the oil price. On one hand, the revenues from the GPFG is directed into the economy through the "budgetary rule" rule. Thus, a sudden drop in the oil price would not affect the use of income as much since the GPFG is diversified among different sectors. On the other hand, 30-40% of the variation in economic growth on the mainland of Norway is related to the oil industry (Iversen og Leonhardsen, 2015).

1.2 Objectives

The aim of this thesis is to analyze Norwegian macroeconomic data against the price path of the oil price and investigate the impact of oil price shocks on the Norwegian economy. This study would help to enlighten the relationship between oil price shocks and the output in a small and open oil-exporting country. It would be intriguing to see if this study follows the conclusions concerning asymmetric effects (which I will return to in a later chapter) and the declining importance of oil prices on the gross domestic product (GDP) and observe if this apply to Norway as well, despite being an oil-exporting country. Depending on the results, I will also comment on the possibility that Norway could suffer from the so-called Dutch disease.

1.3 Hypothesis

My hypothesis is that there is a significant relationship between macroeconomic variables and shocks in the oil price in the Norwegian economy based upon the fact that his is the main source of income in the economy.

1.4 Structure of Paper

The remainder of this paper is structured as follows: The next section contains a brief overview of the Norwegian economy, the introduction of the GPFG and the budgetary rule. Chapter 3 presents the theoretical framework, focusing on the oil market. It will also give a synopsis of the existing literature in this field. Chapter 4 is a compressed introduction to the relevant econometric theory. In chapter 5, the data used, and the methodology is presented. Chapter 6 display the empirical results and discusses them accordingly. Chapter 7 will give a conclusion of the work, point out limitations and give suggestions to further research. The bibliography is presented at the end, followed by the appendix of certain figures.

Chapter 2 – Briefly About the Norwegian Economy

2.1 The Norwegian Economy

In terms of value added, government revenue, investment and export value, the oil and gas-industry are the largest industry in Norway. In total value, oil and gas amounts to approximately 47% of Norway's exports of goods (norskpetroleum.no, 2018). In 2016, Norway exported oil and gas for a total value of NOK 350 billion. NOK 186 billion of the total was form exporting crude oil. The petroleum industry stands for 14 % of Norway's total GDP and 39 % of total export (National Accounts, National Budget 2018). Within these numbers, the service and supply industry are not included. Norway started to produce oil and gas in the early 1970s, and since then these activities has contributed to about NOK 13 500 billion in current NOK to Norway's GDP. Despite of this, IEA reports that only half of the estimated resources on the Norwegian shelf has been produced and sold (IEA, Norway Report, 2017).

Norway can be described as a small, but trade-dependent nation. There are strong pro-stabilization constituency in the form of employees, as well as a strong trade union. Revenues from the oil industry is supposed to ensure that "mainland Norway" and non-oil tradable sectors could maintain long-term competitiveness. This would in turn maintain full employment.

In the 1980s, Norway experienced strong economic growth, spearheaded by the petroleum sector, which was compounded by expansionary fiscal and monetary policies. This resulted in an overheated economy with surging inflation and declining competitiveness in the non-oil tradable sectors, which was reflected by a drop in manufacturing employment. As a direct response, Norway devalued the NOK several times and increased domestic subsidies into the petroleum industry (Bjørnland, 1998).

In the late 1980s, long-term demographic projections showed a rapid aging of the Norwegian population over the coming decades that would result in increasing pension payments and health care expenditures. The government used the projected pension liabilities over the following 30 years and put the oil rents in perspective to create the Government Petroleum Fund Global in 1990. This fund was created for two main purposes: (i) act as a buffer to smooth fluctuations in oil revenue and mitigate exchange rate pressures to avoid Dutch disease and preserve a diversified industrial structure; and (ii) save part of current oil rents to help address aging population and the eventual decline in oil revenues (Davis, et. al, 2003).

As of February 2018, the fund was valued at NOK 8208 billion. The fund is invested in stocks, bonds and property around the world and it is invested in different markets, countries and currencies. It is strictly invested abroad to prevent the economy of "mainland Norway" from overheating and to shield it from the effects of a fluctuating oil price.

2.2 The Budgetary Rule

The structure of the government budget and the focus on social security programs distinguishes the Norwegian economy from others. Despite high revenues from oil, the Norwegian government budget has strict laws on how to spend these revenues. In 2001 the government of Norway implemented "the budgetary rule". This policy was implemented to ensure sustainable management of oil revenues in the Norwegian economy. The fund has an expected return of investment of 3% per year, and the government are only allowed to use the rate of return, not the capital itself. In 2017 the budgetary rule was changed from 4% to 3%. Economists meant that 3% were more suited for the economy and also more realistic in terms of rate of return for the future. The Mork-commission assumed that the rate of return would be approximately 2.3% per year, the next 20 years (e24, 2017). Certain years, spending of the fund will exceed the rate of return, and other years the government will utilize less than the rate of return. The use of oil revenues in Norway will therefore depend on the economic situation.

Since the implementation of the budgetary rule, the prices have been high and market demand from the petroleum industry have been stimulated. This have ensured strong growth in mainland employment and real wages. Immigration of labor has enabled the mainland economy to meet this demand (NOU 2015:9, Chapter1). Through a gradual increase in the use of oil revenues, demand has been boosted along with rising activity in the petroleum-related mainland industries. A direct result of this has been higher wages in Norway, which are considerably higher than in neighboring countries. It is estimated that the spending of petroleum revenues may peak in just a few years' time (NOU 2015:9, Chapter1), but this is largely dependent upon the pace of spending increases in the following years. The peak will be passed as revenues from oil production decline and the economy continues to grow. In addition, it appears that the real return of the GPFG will be low the next 10 to 15 years due to low long-term interest rates on bonds during this period. However, Norway's fiscal policy should be robust facing uncertain returns (NOU 2015:9, Chapter1).

Chapter 3 – Theoretical Framework

3.1 Supply and Demand Influences in the Oil Market

There are different kinds of forces that are influencing the market structure in the petroleum market and thereby influencing the price of oil. These can be divided into supply and demand factors, and when supply and demand are in balance the price and quantity sold for said price will exist. Understanding the mechanisms behind both the supply- and demand side in the oil market is complex. Geopolitical factors, natural disasters, and technological progress are important influences on the future price of oil. Furthermore, uncertainty around future income- and demand elasticities in addition to what the Organization of the Petroleum Exporting Countries (OPEC) are planning makes the market even more unpredictable (Fattouh, 2007).

The aggregate demand for oil can be viewed as a function of price and income, but these variables are not constant over time. In both the short and long run it is difficult to estimate the price - and income elasticities. The aggregate supply is dependent on how much oil that are being produced today compared to how much is available, and these scenarios will change if there are discovered more oil reserves.

Some have claimed that speculators in the commodity market have influenced the demand side of the price of oil. It is more reasonable that the speculators just contributed to more liquidity in the oil market (Iversen and Leonhardsen, 2015). The price of oil in the spot and future market are based on a "random walk", which means that a "herd" mentality will not destabilize the market. The reason for this is that the speculators does not know if they are buying or selling at a low or high price. Accordingly, it is reasonable to assume that speculators do not affect the oil market strongly (Fattouh, 2007)

Supply side

To understand the supply side in the oil market it is important to analyze the behavior of the different producers and the reserves of oil. There are two kinds of producers: members of

OPEC and non-OPEC members. Reserves are separated into discovered and not discovered reserves. To be able to analyze and estimate the future supply in the market it is important to make some assumptions about the future reserves. The relationship between production and reserves changes over time. A reason for this is that the size of current reserves have been underestimated and through newer technology the size and scope of the reserves could be adjusted upwards accordingly (Fattouh, 2007).

Analyzing the behavior of OPEC is important to comprehend the future situation of the oil market. As a major cartel on the market, OPEC has the ability to restrict its production if need be, or vice versa, and these actions have an impact on the supply worldwide. In 2013, non-OPEC countries produced approximately 60% of the total production in the world (Iversen and Leonhardsen, 2015). Non-OPEC producers are basing their economic behavior on how to maximize their profit and compensate their shareholders. Even so, these producers will adjust their investments pending on how much OPEC prefers to produce (Fattouh, 2007).

Demand side

The major force that drives demand for oil is the aggregate global economic activity. High economic activity is believed to increase the demand for oil. Fattouh (2007) summarized results from studies that tried to estimate the price- and income elasticity in the oil market. The price elasticity was found to be low in the short run. In the long run, it was estimated to be more significant, probably because of the prospect of substitutes, and as a consumer you are able to shift your need of energy more in the long run. The income elasticity measures volume demanded relative to change in income. In the case of the studies evaluated by Fattouh (2007), they used GDP to estimate the income elasticity of demand to capture the global economic activity. The results showed that a change in income had a greater impact than a change in price, especially in the long run.

Bjørnland *et.al* (2013) did a study on 33 different countries and compared the effects of demand in emerging economies versus the demand in already developed economies. The main finding of the paper was that 50-60% of the fluctuations in the real price of oil during 1992 to 2009 could be explained by an aggregate demand shock in emerging and developed countries together. Another conclusion drawn from the paper was that a demand shock, especially in Asia, would have twice the impact on the volatility of the oil price and future oil production than in OECD-countries. It can be explained by the fact that India and China during this period where 2 countries which grew a lot, thereby requiring high demand. This shows that changes in demand from specific markets have different impact on the oil price.

3.2 History of the Oil Price Path

Figure 1 – Price path of crude oil

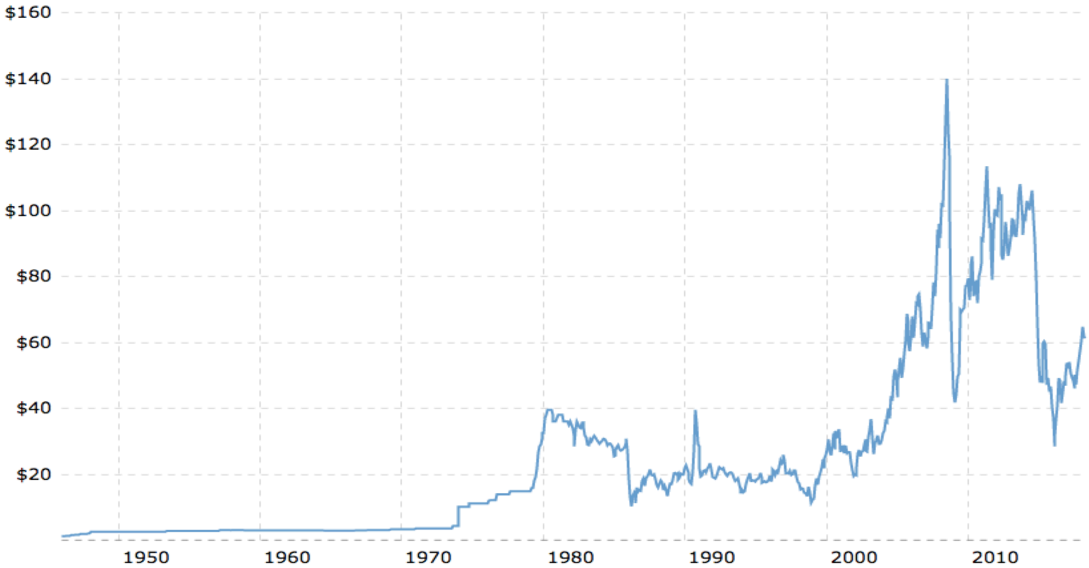

Figure 1.1- Price history of crude oil, Jan 1946 - Feb 2018. These prices are not logged by scale and not inflation adjusted. Gathered from macrotrends.net (5.03.18).

The price of crude oil is determined in a global market, driven by supply and demand. This could be changes in the availability of oil, or shocks in the demand that interrupt the global business cycle. Technological progress makes it cheaper to produce oil in the long run. Demand for crude oil is determined by global economic growth, the forecast of energy intensity within the industrialized economies, the behavior of speculators in the oil market, expectation of major oil producers about the future development of the market and policy changes of major consumers. Oil prices are therefore an exogenous factor for the Norwegian economy.

Figure 1 shows the fluctuations of the crude oil price from 1946 until 2018. Since the early 1970s there has been volatility in the price of oil. Each sudden drop or increase in the price can be related to market mechanisms. OPEC has been a central driving force behind the price of oil since its inception, but the oil price is also affected by exogenous factors.

The first real oil price shock was in 1973. This was a result of OPEC taking a more assertive role in the market. The Arab producers imposed an oil embargo against the U.S., Holland, Portugal and South Africa. Furthermore, they decided to cut production by 25% (5 million barrels per day) (Bhattacharyya, 2011). Prices were close to $12/bbll at the end of 1974. Another historical event that shock the oil price include the Iran-Iraq war between 1979 and 1988, where prices went form $24/bbl in 1979 to $34/bbl. In the late 1970s into the 1980s OPEC lost some of its dominating market power, going from 50% close to 20%. As a result of declining market share and prices, OPEC began a price war. Saudi Arabia did not accept further production cuts and thus sparked a new price shock in 1986.

There were quite a few incidents during the 1990s that affected the oil price: (a) a wave of liberalization and market reconstructing; (b) the collapse of the Soviet Union; (c) the Iraqi invasion of Kuwait, which again sparked greater international operations involving Iraq in the following decades; (d) the Asian economic crises in 1997. At the beginning of the 2000s, prices showed greater volatility and high prices were sustained over a long period of time. An important reason for the low prices in the 1900s was due to poor demand and too much supply entering the market. The price level maintained a steady upward movement since early 2004 and reached 60 US dollars per barrel in late 2005. In July 2008, the prices had risen to 145 US dollar per barrel, which is a high price by any standard. A strong demand from non-OECD countries like China and India was part of the reason for the rise in the oil price. Between 1999 and 2009, China almost doubled their demand for oil. India increased their demand by 50 % during the same period (Bhattacharayya, 2011). At the same time, political unrest in producing areas such as Iraq and Nigeria haltered the certainty of production. In addition, there was hardly any spare capacity available during this period. The spot market prices reacted to these situations, by adding risk a premium to the oil price (IFP, 2007). However, the oil price collapsed during the financial crisis in 2008.

After the price rose to around 100 US dollars from 2010 to 2014, the price plummeted. This time it was due to the innovation of fracking and shale oil. The US began producing a lot more, overflowing the market. Different factors that likely have influenced spikes in the oil price since the start of the 2003 Iraq war include: a weak US dollar; aggressive speculation in the future market of oil and fears around long-term supply abetted by geopolitical tension between Iran and the US (Lorde *et al*, 2009).

3.3 Briefly about Dutch Disease

During the 1960, the Netherlands built up a large manufacturing business because of natural gas discoveries. When building up a new energy sector, it is interesting to observe how this will affect the various sectors in the economy. The manufacturing sector is especially interesting because it is prone to international competition. In the 1970s, the high income generated by the gas industry fell, and because the Dutch manufacturing industry was uncompetitive, the traditional industries could not compensate for the loss of revenue in the energy sector, hence the term Dutch disease.

As an economic phenomenon, Dutch disease has two different main effects: a decrease in the price competitiveness for export of the affected county's manufactured goods and an increase in the quantity of imports. Both of these results contribute to an appreciation of the local currency. It is expected that these factors can contribute to higher unemployment on account of manufacturing jobs moving to lower-cost countries. The non-resource industries are then being hurt by the increase in wealth generated by the resource-based industry.

3.3.1 Dutch Disease in Norway

Bjørnland (1998) did a study on the U.K and Norway analyzing the effect of the oil and gas sector on the manufacturing output, as well as discussing the relevance of Dutch disease in both countries. The main findings form the paper was that there was no sign of Dutch-disease in Norway but that the UK showed signs of it in the long run. This demonstrated that 2 countries that are self-sufficient with oil resources can react differently to external energy shocks. The reasoning for the different results where contributed to different macroeconomic policies during the 1980s. Norway deliberately subsidized the manufacturing sector during the transitional period of North Sea oil, keeping the unemployment rate low during this period. In the U.K a lot of factories closed making the unemployment rate rise and most of the petroleum-revenues went to paying off external debt.

With the use of a Bayesian dynamic factor model (BDFM), Bjørnland and Thorsrud (2013) tried to examine if Norway could be exposed to Dutch disease. The model was exposed to different kinds of shocks: global demand shock, shock in the oil price, shock related to an activity factor and a shock to the mainland economy. The results for shocks in the oil price, output and employment had a significant positive response over time. This is explained by the rent from the petroleum industry manifest itself through high wages and economic surplus in the industry. Concerning the question of Dutch disease, the paper stated that the repercussions of the activities in the petroleum industry was a contributing factor to growth in productivity in both the tradable sectors and the non-tradable sectors. Thus, Norway did not show any sign of Dutch disease.

3.4 Relationship Between Crude Oil Prices and Currency Value in Oil Exporting Country

There are two possible transmission channels that could explain a positive influence of crude oil prices on currency values in an oil-exporting country:

3.4.1 Dutch Disease

The first credible explanation is based on Dutch disease and utilizes the framework developed by Corden and Neary in 1982. In this context Dutch disease refers to an adverse influence on nation's economy as a result of an abrupt and steep surge in foreign currency inflows. As a direct response to this, the country's real exchange rate will experience an appreciation which in turn will inevitably make the cost of other industries' products have an upward trend. This will make these other industries' products less price competitive in the international export market. In the wake of higher oil production, the theory states that an oil exporting country can be divided into 3 sectors, specifically the oil sector, the lagging sector and the non-tradable sector. The lagging sector can produce tradable goods, but not petroleum related goods (Nguyen, 2015). During a sudden resource boom on the economy there are two different effects that can be observed: the spending effect and the resource-based effect.

Spending effect

Economic theory states that with a surplus in wealth the aggregate consumption is stimulated, and the demand is increased by both trade and non-tradable goods in exporting countries. The excess demand for the latter are dealt with locally, but the former is predicted to be observed by increased import (Corden, 1984). The "spending effect" happens because an increase in the oil price will lead to larger profit in the oil sector, thus leading to higher wages which in turn increase the aggregate demand and purchasing power in the economy. The price in the tradable sector (petroleum sector) is determined on the global market and is defined as an exogenous factor, the price of the non-tradable sector is determined locally. In addressing this effect, the non-tradable sector will produce more in response of higher demand, and by increasing the relative price of the non-tradable goods the remainder of the excess demand will be wiped out (Akram, 2000; Nguyen, 2015). Since this is a theoretical framework, I have assumed labor immobility between the oil sector and the non-tradable sector. Therefore, it is assumed no transfers from the oil sector towards the booming service sector. If you assume mobility of the labor force between sectors, then the growing non-tradable sector will attract workers, generating a surge in wages in the tradable sector as well (Farzanegan and Markwardt, 2009). The aggregate effect is that real exchange rate will suffer from appreciation pressure.

Resource based effect
With a boom in the oil price, petroleum companies in exporting countries will accelerate their production for the sake of maximizing their profit. During such a trend, labor recruitment is sparked. The labor force is driven from the lagging and non-tradable sector into the petroleum sector. While this movement of labor is going on, there are also excess labor demand as a cause of the spending effect. These two effects combined can explain a surge in wages in the petroleum sector then followed by higher wages in other sectors (Corden, 1984). In consequence of the labor mobility, the country will observe an upward trend in wages and thereby observing the same in domestic prices of goods and services.

To sum up, the oil windfall renders into an appreciation of currency value of an oil exporting country. It is expected that the resource-based effect is less impactful compared to the spending effect. It is explained by the existence of modern technology in production and further demand of petroleum does not require additional employees (Nguyen, 2015).

3.4.2 Trade Theory
The second explanation is based on a macroeconomic perspective and trade theory. Theoretically, a well-developed small open economy with oil-export being the main source of income and further development in the domestic economy rely on the petroleum sector, a rise in the oil price is followed by appreciation of the home currency (Nguyen, 2015). This could be reasoned with terms of trade and portfolio balance of payments. As mentioned previously, more wealth from oil translate into trade balance surplus and extra foreign holdings of its domestic currency. The relative demand of its domestic currency from foreign trading partners and domestic export sector should experience a positive trend by the combined effect of terms of trade and balance of payments. The magnitude of appreciation is established by

the degree of dependency of the local economy has on petroleum earnings (Bodenstein, et al, 2011; Nguyen, 2015).

3.5 General Theory on Oil Shocks and the Effect on the Macroeconomy

Hamilton (1983) observed that seven out of the eight major recessions since World War II in the United States were preceded by a drastic growth in the oil price. After doing some empirical research, he claimed that oil price shocks might be a contributive factor for some of the economic slumps prior to 1972. In the early stages of the empirical work in this field done by Darby (1982), Hamilton (1983) and Burbidge and Harrison (1984) there was found a significant negative effect between oil price shocks and GDP in oil-importing countries. These results were used as evidence that shocks in the oil price could cause economic recessions (Hamilton, 1983; Mork, 1989).

There are varied ways the oil shock transmits into the economy: supply and demand-side effects, and the effects of terms of trade (Lardic and Mignon, 2006). The classic supply-side effect states that with rising oil prices production will halter because an increased cost in production, thus growth of production of output and effectiveness are lowered. On the demand side, higher oil prices will increase the general level of prices, leading to a reduction in real disposable income for consumption, thus demand falling (Frazanegan and Markwardt, 2009). A rise in the oil price leads to worse terms of trade for oil-importing countries, and a wealth transfer will occur between the oil-importing to the oil-exporting country. Consequently, the purchasing power in the oil-importing countries will decrease compared to the oil-exporting countries.

More recent studies have questioned the importance of oil shocks affecting GDP (Hooker, 1996; Hamilton, 1996) because of 3 features of the oil-macroeconomy relationship. These are (i) the asymmetric effect of oil price shocks, (ii) the declining impact of oil in the economy, and (iii) the role of monetary policy.

Evidence of asymmetries in the link between oil price and GDP were established in studies done by Mork (1989), Lee *et al.* (1995) and Hamilton (1996). Specifically, economic activity in the oil-importing responded asymmetrically to oil price shocks. An increase in the oil price are associated with lower output but if the oil price decreases it would not lead to higher growth of output. The main reasons for such asymmetries have been linked to reallocation effects and adjustment costs. Higher oil prices lead to reduction in supply because firms cut production as a result of higher input costs. At the same time, demand will be lower due to uncertainty of costumers concerning investment and consumer durables (Iwayemi and Fowowe, 2010). With higher oil prices a structural allocation will take place. Resources will move from energy-intensive to energy-efficient sectors of the economy. Combined, these effects will slow down output growth. In the case of a decreasing oil prices, production will be accelerated by the firms and also stimulate consumption by the households. The sectorial reallocation is the other way around now and will slow down growth as well. Furthermore, there will occur adjustment costs in the labor market due to downward rigidity of nominal wages (in the case of increasing oil price, this would have risen) means that nominal wages do not fall while production costs remain high (Iwayemi and Fowowe, 2010). The joint effect of these circumstances is that a decreasing oil price is not followed by an increasing output.

Mork (1989) concluded that for an oil-importing country, rising oil prices appeared to delay the aggregate economic activity more than decreasing oil prices would stimulate it. In light of this these findings, different kinds of non-linear transformation of the oil prices were created to re-establish the previous result of the negative relationship between increases in the oil price and economic downturn (Jiménez-Rodríguez, 2006). Mork (1989) proposed an asymmetric definition of oil prices where you distinguish between negative and positive changes in the oil price. It is defined as this:

$$roilp_t+ = \max\left(0, (roilp_t - roilp_{t-1})\right) \qquad (1.a)$$

$$roilp_t- = \min\left(0, (roilp_t - roilp_{t-1})\right) \qquad (1.b)$$

Where $roilp_t$ is the log of real oil price in time t. In this analysis raging from 1949: Q1 to 1988: Q2, Mork concluded that a positive change in the oil price have a strongly negative effect and significant relationship with changes in the real GDP. A negative change in the oil price did not have a significant effect. In a later study, Mork *et al.* (1994), documented asymmetry in the inverse relationship between oil prices and aggregate economy in the case of Norway and all other G-7 countries but Italy.

Hamilton (1996) had another suggestion on how explore if an asymmetric relationship exists between oil price changes and economic activity. Hamilton declared in his paper that an increase in the oil price simply was a correction of earlier decline. He stated that if you want to study how impactful an increase in the oil price is likely to be for consumers spending habits and firm's decisions it would make more sense to compare the current price with the price during the previous year, not only during the last quarter alone. Therefore, Hamilton (1996) proposed using a model that compared the increase in price with the highest price the last 4 quarters. This non-linear model is the net oil price increase and decrease is defined as follows:

$noilp_t+ = \max\,[0, ((noilp_t) - \max\big((noilp_{t-1}), \ldots, (noilp_{t-4})\big)]$ (2.a)

$noilp_t- = \min\,[0, ((noilp_t) - \min\big((noilp_{t-1}), \ldots, (noilp_{t-4})\big)]$ (2.b)

If the price of oil in period *t* is lower than the price during at least one of the last 4 quarters, then $noilp_t +$ is defined as zero in quarter t. For $noilp_t +$ to be non-zero, the price in *t* has to be larger than all the prices in the last 4 quarters. If this is the case, there has occurred a positive oil price shock. The specific use of non-linear approaches allows one to compare the impact of oil prices rises and fall.

The declining importance of oil in the economy was first discussed in the 1980s. When the oil price dropped in the second half of the 1980s, the effect on the economic activity were found to be smaller than the linear model had predicted. An explanation of this could relate to that before 1985 oil price shocks where mainly positive but after 1985 oil price shocks have both been positive and negative. As noted earlier, only an increase in the oil price had a significant effect on output, so the combination of rising oil prices with falling prices have convoluted the relationship between macroeconomic activities and the oil price. Furthermore, this asymmetric effect of oil prices has ended up undermining the oil-macroeconomy relationship. Another reason is that the share of oil production has been declining since the 1980s, due to technological progress and changes within the production structure, resulting in countries being less oil-dependent compared to the 1970s (Iwayemi and Fowowe, 2010). In 2007, Blanchard and Gali examined and compared the responses of inflation and output in a bundle of industrialized economies to of the those in 1970s. They found a much weaker response in the economy in recent years and concluded this with smaller energy intensity, greater flexibility in the labor market and improvement in monetary policies.

The role of monetary policy has changed over the years. In the 1970s, the credibility of the banks where lower compared to the beginnings of the 2000s. I particular, in recent years the central banks have had stronger commitment to maintain a low and stable rate of inflation. This is reflected by the widespread adoption of an inflation targeting strategy, which may lead to a better policy tradeoff during an impact of a given oil price increase on both inflation and output simultaneously (Blanchard and Gali, 2007).

3.6 – Existing Literature on Oil-Exporting Countries

As mentioned, most of the theory developed in this field is related to oil-importing countries, therefore it is an abundance of empirical studies for such countries. In comparison, there is a lack of empirical studies on oil-exporting countries. Lately, a few studies have tried to undertake this task and has been done by Olomoa and Adejumo (2006) for Nigeria, Mehrara (2008) for 13 countries[1], Jbir and Zouari-Ghorbel (2009) for Tunisia, Lorde et al (2009) for Trinidad and Tobago, Farzanegan and Markwadt (2009) for Iran and Iwayemi and Fowowe (2010) for Nigeria. Norway have been included in a larger study by Jiménez-Rodríguez and Sánchez (2005) which included both oil-importing and oil-exporting countries[2].

Iwayemi and Fowowe (2010) applied an unrestricted VAR model in levels to investigate the effect oil price shocks have on the macroeconomy in Nigeria. In the analysis, quartaly data from 1985 to 2007 on variables such as real GDP, government expenditure, net export, inflation and real effective exchange rate where used to represent the macroeconomy. They used the Granger-causality test, impulse response functions and variance decomposition analysis as tools to answer the research question. It is hard to explore the results of the analysis further since the authors did not present any robustness tests of their model. In addition to this, the authors did not comment on the significance of impulse response functions. The results of their analysis implied that shocks in the oil price did not play a major role in affecting their macroeconomic variables, but they did not comment on the statistical significance of the results.

A more thorough analysis was done by Farzanegan and Markwardt (2007) on Iran. They applied an unrestricted VAR model in levels as well. In addition to present a Granger-causality test, impulse response functions and results from a variance decomposition test, Farzanegan and Markwardt also investigated the long run relationship among the variables by preforming cointegration tests. The variables utilized in this paper was real industrial GDP per

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[1] These countries include Algeria, Colombia, Ecuador, Indonesia, Iran, Kuwait, Libya, Mexico, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela.

[2] These countries include the U.S. Japan, Canada, France, Italy, Germany, Norway, the U.K and an aggregated Euro area.

capita, real public consumption expenditures, real imports, real effective exchange rate and inflation. Furthermore, they included dummy variables that represented specific historical events that affected the oil price and looked at the reaction in the variables. To further investigate the robustness of the model they employed rolling bivariate VARs. This approach allows for a steady change in the predicted effects of oil price shocks, without demanding a discrete break in a single period (Farzanegan and Markwardt, 2007). The results showed that oil price shocks had a significant effect on most of the variables. There was evidence of asymmetric effects since both positive and negative shocks significantly increased inflation. Presence of Dutch disease was also found through significant real effective exchange rate appreciation.

Norway was part of large study done by Jiménez-Rodríguez and Sánchez (2005). Both oil-importing and oil-exporting countries where involved in this analysis. The base of the analysis was a VAR model, but there have been used different kind of oil price shock variables in this paper. Jiménez-Rodríguez and Sánchez utilized the scaled oil price variable formulated by Lee *et al.* (1995) in addition to the asymmetric (Mork) and net change (Hamilton) specifications. The main focus of the analysis was to check if oil price shocks affected GDP, real effective exchange rate, real wage, inflation and short and long-term interest rates. Among the oil-exporting countries, Norway had different results compared to the U.K. A positive oil price shock had a positive effect on GDP in Norway, but the U.K did not benefit from it. This result is related to the presence of Dutch disease in the U.K. Oil price hikes led to a large real effective exchange rate appreciation of the pound (Jiménez-Rodríguez and Sánchez, 2005). Norway does also show a real effective exchange rate appreciation, but it is much weaker than in the case of the U.K, hence a mild, but positive impact of oil shocks in Norway. Adjustments in the real wages and interest rates is a contributing factor to why the results differ in Norway and the U.K. In Norway, the real wages rose after an oil price increase, but the opposite happened in the U.K. As estimation tools, Granger-causality tests, impulse response functions and variance decomposition where used.

Chapter 4 – Econometric Framework

4.1 Econometrics

The purpose of econometrics is to combine economic theory with empirical data to formulate models that can give estimations on economic relations. Within econometric theory you use statistical theory and mathematical statistics to develop your models. A well-defined model has certain properties, such as, unbiasedness, efficiency and consistency. Ordinary least squares (OLS) is most often used to obtain estimators, since it provides the "best linear unbiased estimators" under the Gauss-Markov assumptions. If the Gauss-Markov assumptions are violated or other model specifications are required, there are other ways of estimation tools available. These techniques are maximum likelihood estimation, generalized method of moments or generalized least square. In econometrics you can study cross-sectional, time series or panel data. This study will use time series data.

4.2 Time Series Data

When formulating a time series model, you aim to identify the nature of phenomenon represented over time, and you would like the model to help with forecasting. To achieve this, you have to describe and analyze the pattern in the time series. The formulation of a time series model looks like:

$$Y_t = \alpha + \beta_1 X_{1t} + \beta_2 X_{2t} + \varepsilon_t \qquad (3.a)$$

and this model has to be obtained by a stochastic process:

$$[(X_{t1}, X_{t2}, \ldots, X_{tk}, Y_t) : t = 1,2, \ldots, n]$$

In the equation (3.a) ε is the sequence of errors or disturbance, t depicts the specific time period. Altogether there are *k* different explanatory variables. For the model to be unbiased it has to have zero conditional mean, as well as no perfect collinearity. No perfect collinearity implies that one independent variable can't be determined by another variable. Zero conditional mean is expressed as:

$$E(\varepsilon_t | X_{t1}, \ldots, X_{tk}) = 0, t = 1,2, \ldots, n$$

This assumption means that the error in period *t* is uncorrelated with the explanatory variable in every time period. This assumption automatically holds if the error term, ε_t, is independent of X_{tk} and when $E(\varepsilon_t) = 0$. Furthermore, for the model to be BLUE (best linear unbiased estimator), the has to be homoscedasticity and no serial correlation. Homoscedasticity implies a constant variance, $Var(u_t) = \sigma^2$, and conditional on all the X's, the variance of u_t is the same for all *t*. No serial correlation means that conditional on all the X's, the error in two different time periods are uncorrelated: $Corr(u_t, u_k | X_{t1}, X_{t2}, \ldots, X_{tk}) = 0, for\ all\ t \neq k$ (Wooldridge, 2014).

4.3 VAR Model

In 1980, Christopher Sims provided a new macroeconomic framework to analyze large scale models. The framework of a VAR model has the advantage over other large-scale macroeconomic models in that the results are easily interpreted and available. Sims indicated that the use of VARs are more systematic as an approach when it comes to imposing restrictions and this in turn could lead one to capture empirical regularities which remain hidden to standard procedures.

Within the framework of this analysis, a vector autoregressive (VAR) model is going to be used. Most economic data have trends. VAR model is designed to capture the joint dynamics of multiple time series. In a VAR model you model several series in terms of their own past. VAR models treat every endogenous variable as a function of lagged values of all the endogenous variables within the model. This type of model is mainly used for forecasting and structural analysis. Structural VAR models can be used to analyze response to shocks. Let Y_t represent a vector of n variables at time *t*, then the VAR model formally can be written as:

$$Y_t = \alpha + \sum_{i=1}^{n} x_i y_{t-i} + \varepsilon_t \qquad (4.a)$$

Y_t is a function of its past realizations Y_{t-i} and a vector (n x 1) of stochastic error term ε_t. Y_t represent a (n x 1) vector of endogenous variables. $x_i$is the *i*th (n x n) matrix of autoregressive coefficients. ε_t should be serial uncorrelated with mean zero and have a finite variance (Wooldridge, 2014).

4.4 Stationarity

When analyzing a time series, it is important to check for stationarity. A stationary time series process has a stable probability distribution over time. Test this by take any random collection of variables in the sequence and then shift that sequence ahead *h* time periods. The joint probability distribution must remain unchanged (Wooldridge, 2014). Formally, a stationary process can be represented like this: A stationary process is strongly stationary if for every collection of time indices $1 \leq t_1 \leq t_2 \leq \cdots \leq t_n$ the joint distribution of $(x_{t1}, x_{t2}, \ldots, x_{tm})$ is the same as the joint distribution of $(x_{t1+h}, x_{t2+h}, \ldots, x_{tm+h})$ for all integers $h \geq 1$. This implies that for at any given point in the time series (x_1, x_2) must have the same joint distribution as (x_1, x_{1+t}). x_1 and x_2 can be correlated, but the nature of that correlation must be the same over time.

4.4.1 Unit root - Augmented Dicky-Fuller Test and Phillips-Perron Test

There has been debate over macroeconomic time series and their properties over time. Nelson and Plosser (1982) did a study that found that most macroeconomic variables have the presence of unit root. Furthermore, this study argued that under the unit root hypothesis, random shocks have a lasting effect on the business cycle. This is opposed to the view that business cycles are fluctuations around a stable trend. Perron (1989) concluded in his study that most macroeconomic time series are not characterized by the presence of a unit root and the fluctuations are transitory. As a further notice, Perron stated that only two events had a permanent effect on the macroeconomic variables: The Great Crash (1929) and the oil price shock of 1971.To check for stationarity in the variables it is normal to check for unit root. If unit root is present in a variable over time, that variable shows a stochastic trend, a systematic pattern that is unpredictable. This is sometimes called a random walk with drift. There are a couple of different test to choose from when checking for unit root. I will use the Agumented Dicky Fuller test (ADF), and the Phillips-Perron test (PP).

4.5 Granger-Causality

When estimating any type of time series model, it is important to determine whether one time series is useful in forecasting another. If a series of t-tests and f-tests on the lagged values is proven to be statistically significant, a time series X_t is said to Granger cause Y_t . Alternatively, X_t is Granger causal for Y_t if X_t helps predict Y at any point in the future (Sørensen, 2005). If a variable Y affects a variable X, the former should help improving the predictions of the latter variable. If X_t can be predicted more efficiently if the information in the Y_t process is taken into account as well as all other information in the universe, then Y_t is Granger-causal for X_t. A serious practical problem when determining if a variable Granger-causes another is the choice of information set Ω_t. $\Omega_t\ (x_t : s\ \leq t)$ is the set containing all relevant information in the universe except for the information in the past and present of the X_t process. All the relevant information in the universe about the set Ω_t is not available and, thus, the optimal predictor given Ω_t cannot be determined. For this reason, a less demanding definition of causality is used in practice. This means that only the information in the past and present of the process is found relevant. Rather than using optimal predictors, optimal linear predictors are compared.

It is important to check for a Granger causal relationship between the variables in case the true relationship is spurious. Spurious correlation is a term in which two or more variables are not causally related, but it may be interpreted that they are.

4.6 Cointegration

Cointegration is a statistical property of a collection $(x_1, x_2, \dots, x_k)$ of time series variables. The notion of cointegration makes regression involving $I(1)$ variables potentially meaning (Wooldridge, 2014). If (*x*, *y*, *z*) are *I*(1) processes, and there exist coefficients *a, b, c* such that $a\mathbf{x}$ + $b\mathbf{y}$ + $c\mathbf{z}$ is integrated of order zero, then *x***,** *y*, *z* are cointegrated. Cointegration has become an important part of analyzing time series data. Standard regression analysis, such as interpreting R^2 as a sign of cointegration of non-stationary variables fail, thereby leading to spurious regression, which suggest relationships even when there are none. For example, if you regress two independent random walks against each other, and test for a linear relationship. By using standard Ordinary Least Squares (OLS) statistics, you would interpret the results as if there were a linear relationship between the two random walks, which would be wrong.

By using the Engle-Granger test, you can detect cointegration. First you check that both X_t and Y_t are both *I*(1). Then you estimate the cointegrating relationship $Y_t = \alpha X_t + \varepsilon_t$ by using OLS. Last, you check that the cointegrating residuals t are stationary by using the ADF-test.

4.7 Impulse Response Functions

Granger-causality may not tell us all there is to know about the interactions between the variables in the system. In applied work, there is an interest to recognize the response of one variable to a sudden impulse, also called innovation or shock, in another variable within a system that includes a number of other variables as well. We may say that a variable, X_t, is causal on another, Y_t, when X_t is reacting to an impulse in Y_t.

Before starting to estimate the impulse response functions, it is vital to check the covariance matrix of the estimated residuals in the VAR model. There you have to check if the residuals are correlated across the equations. If the shocks are correlated across equations, it would be enigmatic to talk about a shock in the GDP-equation when the error terms are correlated across equations. A common way to address this problem is to suppose there are underlying structural shocks u_t, which are (by definition) uncorrelated, and that these shocks are linked to the reduced-form shocks defined by the subsequent relationship:

$$\varepsilon_t = Au_t$$

$$E(u_t u_t') = I$$

You can denote the correlation matrix of the error terms as ∑, and the **A** matrix is related to ∑ by:

$$\begin{aligned} \Sigma &= E(\varepsilon_t \varepsilon_t') \\ &= E(Au_t u_t' A') \\ &= E(Au_t u_t')A' \\ &= AA' \end{aligned}$$

When running the VAR system, you estimate ∑-hat, the problem is to construct Â from

∑-hat = ÂÂ'   (5.a)

A lot of **A** matrices satisfies (5.a). A possible way to ensure that is to assume that **A** is a lower-triangular matrix. An example of a lower-triangular matrix would be the error correlation matrix of the VAR model. **A** can be found specifically by Cholesky decomposition of ∑. This is a common approach and the calculation is featured directly in both STATA and ENviews when running a VAR model, so the results can be accessed directly postestimation.

The assumption that **A** is lower-triangular establishes an ordering on the variables within the VAR system. Different orderings will cultivate different **A**. In the context of analyzing the economics effects the ordering is important. The relevance of the ordering can be explained by that the shock to any one equation affects the variables later in the ordering contemporaneously but that each variable in the VAR is contemporaneously unaffected by the shocks above it (blog.stata.com, 2018). The ordering in this VAR model will be discussed further in chapter 5.

Chapter 5 - Data and Methodology

5.1 Variables and Sources of Data

This thesis aims to analyze the impact of oil price shocks on the Norwegian economy. This analysis made use of quarterly data from 1990: Q1 to 2016: Q4. I choose this time frame because it stretches from when Norway introduced the GPFG up until now. In the VAR model, I will limit my use of macroeconomic variables to 4 different variables. It will consist of real GDP, inflation (INF), real effective exchange rate (REER) and net exports (NEX). In addition, I have the real price of crude oil (OIL) to capture the price shock within the model. I choose these variables and this time period because of availability, and I consider these variables to represent the macroeconomic activity in Norway to say something about the research question. The main objective of this thesis is to analyze the effect of real oil shock prices on GDP growth in Norway. GDP will serve as the main measurement of economic activity. The other variables are included to capture some of the transmission channels, which fluctuations in the oil price may affect indirectly, in parts done by changes in economic policy. These channels include effects of oil prices on exchange rates and inflation, which in turn induce changes in real economic activity.

The data on GDP is real and seasonally adjusted. I downloaded it from DataStream, which found the data from Statistics Norway. Inflation is measured as percentage change in the Consumer Price Index over the given period of time. I collected this data directly from Statistics Norway. The REER is a weighted average of Norway's currency relative to a basket of other major currencies which is adjusted for the effects of inflation. The most relevant currencies are the US Dollar, the Euro and Japanese Yen. The REER is derived by taking the nominal effective exchange rate and adjusting it to include price indices and other trends. REER is defined such that an increase in the indicator means a real appreciation of the Norwegian currency. An appreciation of the real exchange rate is expected to hurt the country's external competitiveness (Jiménez-Rodríguez and Sánchez, 2006). Data on REER was downloaded from the web page of the Bank of International Settlements which was last updated 14.02.18. Net export is computed as the difference between total export and total imports, and both were seasonally adjusted. These numbers include all export from the petroleum-industry. Data on the balance of trade has been collected from DataStream, which has extracted it from Statistics Norway. The oil price shocks are computed using the global price of WTI crude, which are seasonally adjusted. Data on the real oil price was gathered from the online database of the Federal Reserve Economic Data (2018).

Some of the variables (real GDP, REER, real oil prices and net export) will be expressed in logs, while inflation will be reported in levels. This is essentially done due to simplification of interpretation of the results. It is worth noting that by doing this you impose a restriction of the model which says that there will be a constant percentage effect of all the variables at all levels.

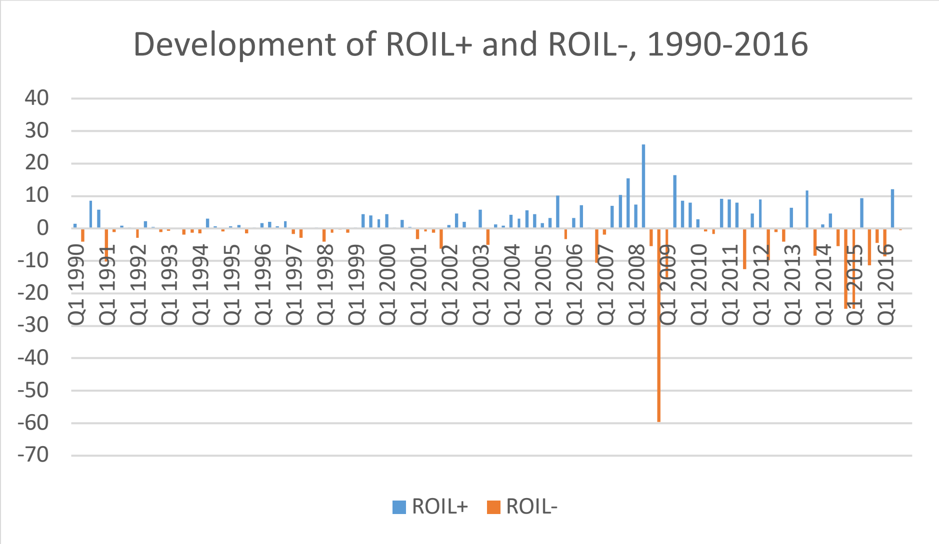
5.2 – Development of Variables

The figures of the development of GDP, net export and the real effective exchange rate can be found in the appendix (figure A.6, A.8 and A.9 respectively). We observe that real GDP have been steadily growing in the period of 1990 to 2016. The first half of the 1990s, the growth was stagnating because of unusually high unemployment rate. By some degree, this was due to a banking crisis that followed the boom and financial deregulation of the mid-1980s (Cappelend and Mjøset, 2009). When "full employment" was reached during the second half of the 1990s, the economy showed rapid growth. The growth in real GDP from the mid 1990s can be followed by the surge in the oil price until the financial crisis in 2008, then a drop in the real GDP in Norway followed for a couple of years.

The development of net export in Norway has a similar path as the real GDP in the beginning. Probably because of the peak in oil price before the financial crises the net export began to decrease some years before the crises hit, although the trade balance was always positive. After the financial crises economic growth in Norway's trading partners has slowed down, which can be a reason for the declining trend since 2005.

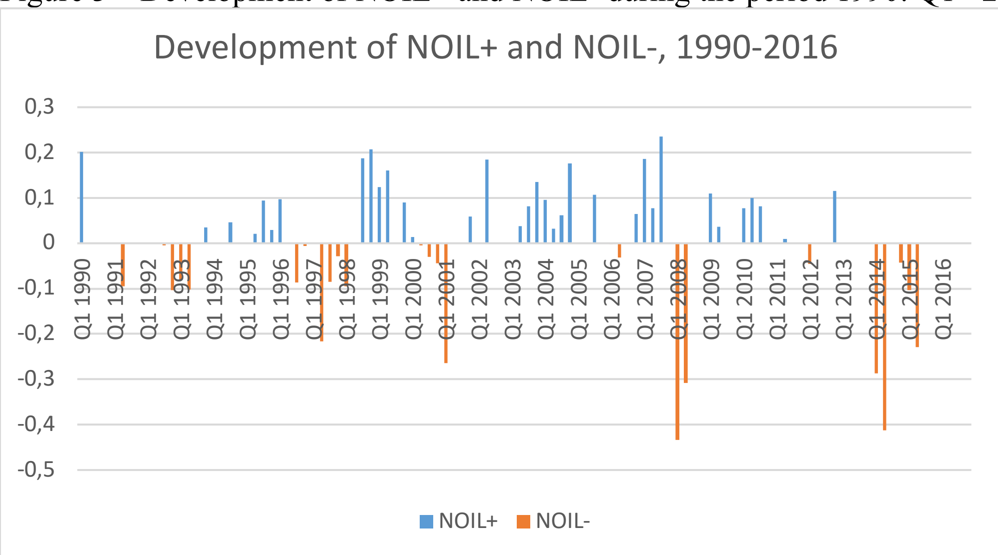
During the 1990s, it became apparent that a fixed exchange rate regime was not optimal, thereby adapting a "free-flowing" currency along with an inflation-adjusted monetary policy aiming for a stable inflation rate of 2.5%. Because of the huge petroleum industry, Norway has become a "dual economy". The offshore sector is generating high income and export surpluses which is almost unaffected by the international financial crises, but the export- and import competing industries at the "mainland sector" are struggling. Thereby creating a monetary policy dilemma in Norway: Norges Bank have to balance between interest of the offshore and mainland sector. It is a choice between stabilizing the exchange rate an inflation targeting (Schewe, 2015). For the most part the real effective exchange rate has followed the price path of the oil price and other financial crises, following a sharp depreciation after the financial crises and after the drop in the oil price in 2014.

Figure 2 – Development of ROIL+ and ROIL- during the period 1990: Q1 - 2016: Q4



In figure 2 above, we can observe the development of the positive and negative oil price shocks over time, represented with variables Mork (1989) suggested, ROIL+ and ROIL-. In this figure the x-axis is time, and the y-axis is change in price in real terms. A positive shock in the oil price is represented as the rate of change in the real oil price from *t* compared to *t-1*. A negative oil price shock is found if the price at time *t* is less than in *t-1*. This means that when ROIL+ is zero, ROIL- is non-zero. In the figure, we can observe that the magnitude of the oil price shocks was not very big from 1990 to 2007. The price is not very volatile during this period. In 2008, following the finance crises, we can observe that ROIL- is very large. Leading up to the financial crises ROIL+ was steady rising. On average, there are more periods where the price has been rising in the whole period, but the magnitude of the negative price shocks has been greater.

Figure 3 – Development of NOIL+ and NOIL- during the period 1990: Q1 - 2016: Q4



Here is the figure which shows the development of the positive and negative oil price shock variables suggested by Hamilton (1996), NOIL+ and NOIL-. In this figure the x-axis is time, and the y-axis is percentage change. NOIL+ is defined to the amount by which (the log of) oil prices in quarter t, $noilp_t$, exceed the maximum value over the previous 4 quarters, and 0 otherwise. For a negative oil price shock, it is the opposite. With the formulation of these variables, it is possible for the variables to be 0 at the same time. As we can see in the figure, there are periods where the oil price is more or less stable, especially after 2010 if we do not include the major negative shock in 2014. For the most part up until the financial crisis, there have been more positive oil price shocks than negative, but again, the magnitude of the negative shocks outweighs the positive ones.

5.3 Methodology

First, I conduct tests to examine the variables in the time series analysis for properties of unit root. The augmented Dicky-Fuller (ADF) and the Phillips-Perron tests are used to determine the order of integration of the variables. If some variables are $I(1)$, the way to proceed is to examine the long-run relationship between the variables. I do this by using the Johansen cointegration test. A necessary condition to conduct the Johansen cointegration test is that all the variables must be integrated at the same order. If needed, further estimation could include making use of a vector error correction model (VECM), which is a restricted form of an VAR. If there is cointegration, imposing this restriction will yield more efficient estimates by using VECM instead of VAR. Studies has shown that making use of an unrestricted VAR perform better in the short run compared to VECM. Naka and Tufte (1997) established the advantages of unrestricted VAR by investigating impulse response functions in cointegrated systems. They performed Monte Carlo analysis that indicates that the loss of efficiency when using VAR is not critical because of the commonly used short time horizons. In this thesis, I will construct an unrestricted VAR model to analyze the impact of shocks in the oil price on macroeconomic variables. In a VAR model, all variables are treated as jointly endogenous, therefore it is free of a priori restrictions on structural relationships (Farzanegan and Markwardt, 2008).

When the VAR is estimated, I will make use of the Granger-causality test to investigate if oil price shocks have had any effect on the Norwegian macroeconomy. In this context, causality suggest that the lagged values of a variable, for example x, have explanatory power in the regression of a variable *y* on lagged values of *y* and *x*. Variable *x* is said to Granger-cause variable *y* if inclusion of past values of *x* better help to predict variable *y* (Greene, 2003; Iwayemi and Fowowe, 2010). Given a two-variable VAR such as equations (6.a) and (6.b) below,

$$y_t = a(L)y_{t-k} + b(L)x_{t-k} + \varepsilon_t \qquad (6.a)$$

$$x_t = c(L)y_{t-k} + d(L)x_{t-k} + v_t \qquad (6.b)$$

then, x_t does not Granger-cause y_t if $b(L) = 0$. In general terms with a VAR which has *n* variables, variable *x* is said to Granger-cause variable *y* (*y* is the dependent variable) as long as the coefficients of lagged values of variable *x* is able to be set equal to zero.

Thenceforth, I will use the unrestricted VAR model to make impulse response functions to examine the dynamic response of macroeconomic variables to a shock in different oil measures. Variance decomposition analysis is finally utilized to explore the relative importance of oil price shocks in contributing to fluctuation in the different macroeconomic variables.

Chapter 6 - Empirical Results

6.1 Optimal Lag Length

The first step of the analysis is to determine a sensible lag length. I utilize the "varsoc" command to run lag-order selection diagnostics. This test displays the result of a battery of lag-order selection tests. It is possible to determine the lag length a priori, and check if the results are independent of for example the Akaike information criterion afterwards. By choosing a too large lag length relatively to the number of observations would typically lead to poor and inefficient estimates of parameters. If the lag length is too short, it could prompt spurious significance of the parameters because the unexplained information is left in the disturbance term (Bjørnland, 2000). Both the Akaike Information Criterion (AIC) and the Likelihood Ratio (LR) test recommend 8 lags in table 1. This criterion is recommended to apply by Bjørnland (2000). Other publications, such as Iwayemi and Fowowe (2010) recommend using the Schwarz's Bayesian Information Criterion (SBIC). For all models, SBIC selected lag order of 1. I will use the recommendation LR and AIC criterion and employ 8 lags in the VAR system.

Table 1 – Selection of lag length

```
Selection-order criteria
Sample:  1992q1 - 2015q4                     Number of obs      =        96
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	163.912				3.2e-13	-3.22733	-3.13015	-2.98692
1	412.058	496.29	81	0.000	9.9e-15	-6.70954	-5.73777	-4.30546*
2	516.336	208.56	81	0.000	6.4e-15	-7.19451	-5.34815	-2.62676
3	662.086	291.5	81	0.000	1.8e-15	-8.54346	-5.82252*	-1.81205
4	763.707	203.24	81	0.000	1.5e-15*	-8.97305	-5.37752	-.07797
5	844.801	162.19	81	0.000	2.2e-15	-8.97502	-4.50489	2.08373
6	947.056	204.51	81	0.000	2.7e-15	-9.41782	-4.07311	3.8046
7	1058.24	222.36	81	0.000	4.2e-15	-10.0466	-3.82728	5.3395
8	1246.74	377*	81	0.000	2.6e-15	-12.2862*	-5.19228	5.26358

```
Endogenous:  djgdp dlnnex lnreer dlnoil roilp roiln noilp noiln inf
 Exogenous:  _cons
```

This table shows what lag length that should be included in the unrestricted VAR system. Based on the LR and AIC criterion, I will employ 8 lags when estimating the VAR system.

6.2 Unit root test

Table 2 - Unit root tests – ADF and PP

Variables	ADF Levels		ADF First difference		PP Levels		PP First difference		Decision
	Constant	Constant + Trend	Constant	Constant + Trend	Constant	Constant + Trend	Constant	Constant + Trend	
GDP	-0.756	-1.285	-12.172*	-12.157*	-0.748	-1.491	-12.014*	-11.997*	*I*(1)
INF	-13.234*	-13.180*	-20.819*	-20.721*	-13.154*	-13.097*	-32.109*	-31.963*	*I*(0)
REER	-2.489	-2.585	-8.852*	-8.808*	-2.731***	-2.840	-8.774*	-8.728*	*I*(0)/*I*(1)
NEX	-1.285	-2.654	-14.563*	-15.047*	-0.785	-2.270	-14.904*	-16.003*	*I*(1)
OIL	-1.386	-1.850	-8.932*	-8.906*	-1.418	-2.059	-8.849*	-8.819*	*I*(1)
ROIL+	-8.396*	-8.921*	-17.219*	-17.142*	-8.559*	-8.977*	-23.623*	-23.483*	*I*(0)
ROIL-	-7.703*	-7.990*	-14.041*	-13.976*	-7.636*	-7.862*	-17.533*	-17.431*	*I*(0)
NOIL+	-7.903*	-7.866*	-15.757*	-15.712*	-8.062*	-8.025*	-17.353*	-17.278*	*I*(0)
NOIL-	-7.112*	-7.135*	-12.512*	-12.454*	-6.984*	-6.996*	-15.073*	-14.988*	*I*(0)

*Significance level at 1%
**Significance level at 5%
***Significance level at 10%

The results of the unit root tests are presented in table 2. I have reported the test of stationarity in both levels and in first difference and made use of the tests with both a constant, and a constant with trend. The Augmented Dickey-Fuller and the Philip-Perron tests shows that inflation and all the measures of oil shocks (ROIL+, ROIL-, NOIL+ and NOIL-) are *I*(0). The result of REER is not as clear cut. The ADF test suggest it is *I*(1), but the PP test implies that it is *I*(0) at a 10 % significance level. GDP, net export (NEX) and real oil price (OIL) is only supported to be stationary in first difference *I*(1). This series in not integrated at the same order, and it is therefore inadvisable to conduct the cointegration test. Furthermore, most of the variables are *I*(0), which means that differencing would be inappropriate (Hamilton, 1994). I will therefore follow both Farzanegan and Markwardt (2009) and Iwayemi and Fowowe (2010) in applying an unrestricted VAR model in levels.

With variables and lag length in hand, there are two objects to estimate: the coefficient matrices and the covariance matrix of the error term. The coefficient matrices can be modeled by estimating least squares, equation by equation, or just running a VAR for all of them. The covariance matrix of the errors can be predicted from the sample covariance matrix of the residuals. By performing VAR, the table of coefficients is displayed by default and the covariance matrix of the error terms can be obtained in the stored results e(Sigma). I will also apply the option of “dfk” and “small” in my VAR model. This command applies small-sample corrections to the large-sample statistics that are reported by default.

6.3 Testing for presence of Autocorrelation and nonlinearity

Before moving on I will perform some basic tests on the model to deduce if it is well specified. The first test I conduct to validate this as a well specified model is to check for the presence of autocorrelation. Autocorrelation is a representation of the degree of similarity between a given time series and a lagged version of itself over successive time intervals. By testing for autocorrelation, you may observe how much impact past values of variables have on the future values on said variable. You do not want the presence of autocorrelation in you VAR system because it can result in a myriad of problems, such as: inefficient OLS-estimators, exaggerated goodness to fit, too small standard errors, t-statistics become too large, regression coefficients can appear to be statistical significant when they are not. By employing the Lagrange Multiplier (LM) test in Stata, I can observe if there are any autocorrelation in the VAR system.

Table 3 – LM test for autocorrelation

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	86.4227	81	0.31953
2	74.1390	81	0.69227
3	95.3524	81	0.13160
4	88.9098	81	0.25646
5	90.5707	81	0.21884
6	88.7251	81	0.26087
7	90.0310	81	0.23065
8	85.6713	81	0.34004

H0: no autocorrelation at lag order

H0: no autocorrelation at lag order (p)
H1: presence of autocorrelation at lag order (p)

The null hypothesis states that there is no autocorrelation at lag order (p). Based on the p-values in table 3. I cannot reject the null hypothesis at any lag order. It is important to note that by using a high number of lags in the model, the more likely it is to reject the null hypothesis. At different lag length, autocorrelation could be present, so it is dangerous to dismiss the idea of autocorrelation within the model.

Another test that has to be performed on the VAR system to determine if it is satisfactory or not, is to test for normality in the residuals. I have used graphical tools to investigate if the residuals in the system is normally distributed. The first graph, A.1, is a histogram that shows the accumulated probability density of the residuals. When examining the graph, the residuals look somewhat normally distributed, only being slightly positive skewed. The second graph, A.2, compares the distribution of the residuals with a normal distribution. This graph shows that the residuals is very close to normally distributed, having some outliers. Both of these graphs can be found in the appendix.

6.4 Granger causality test

Table 4 – Granger-causality test, 1990: Q1 – 2016: Q4

	Null hypothesis: oil price does not Granger-cause Alternative hypothesis: oil price does Granger-cause				
Variable	OIL	NOIL+	NOIL-	ROIL+	ROIL-
GDP	2.08 (0.1525)	0.03(0.8581)	3.54(0.073) ***	0.005(0.9396)	9.46(0.0027) *
NEX	3.88(0.0517) ***	0.27(0.6034)	3.21(0.084) ***	1.01(0.3164)	7.54(0.0072) *
REER	0.004(0.9497)	0.92(0.3396)	0.83(0.362)	1.44(0.2318)	0.03(0.8441)
INF	0.36(0.5464)	2.70(0.1037)	0.0003(0.985)	2.74(0.1010)	0.026(0.8708)

The variables are chi-square (Wald) statistics and the values in () are p-value.
The variables GDP, NEX and OIL are in log first-differences.
*indicates significance at 1% level.
**indicates significance at 5% level.
***indicates significance at 10% level.

The results of the Granger-causality test can be found in table 4, presented above. The oil shocks that are represented are the linear benchmark (OIL), net price increase and decrease (NOIL+ and NOIL- respectively), positive and negative real oil price increase (ROIL+) and negative real oil price decrease (ROIL-). It can be observed that for real exchange rate (REER) and inflation (INF) the null hypothesis that oil shocks do not Granger - cause these macroeconomic variables cannot be rejected. In other terms this fits with what earlier studies have concluded with, which is that oil price shocks have not had any significant effect on macroeconomic variables since 1985 (Hooker, 1996; Hamilton, 1996).

In this model for Norway we find that a negative shock in the oil price can Granger-cause GDP as well as net export. Both of the negative oil shock variables, NOIL- and ROIL- support this. The net price decrease variable, NOIL-, can be rejected at a 10 % significance level for GDP and net export. The asymmetric variable, ROIL-, shows significance at a 1 % level for GDP and net export. This is in contrast with results obtained by studies on other advanced economies. The general results in these studies show a small or no effect at all on the macroeconomic variables during a negative price shock (Mork, 1989), but it is important to remember that these findings are related to oil-importing countries. Jiménez-Rodríguez and Sánchez (2005) found the same, a negative shock in oil price could Granger-cause GDP at a 10% significance level. The difference between the NOIL-and ROIL- is that NOIL- is a less volatile variable, compared to ROIL-. This result may be tribute to the recent decline in the oil price in 2014. At the same time, crude petroleum sources represent 26 % of total export earnings in Norway (OEC, 2018), meaning a shock in the oil price could affect the trade balance.

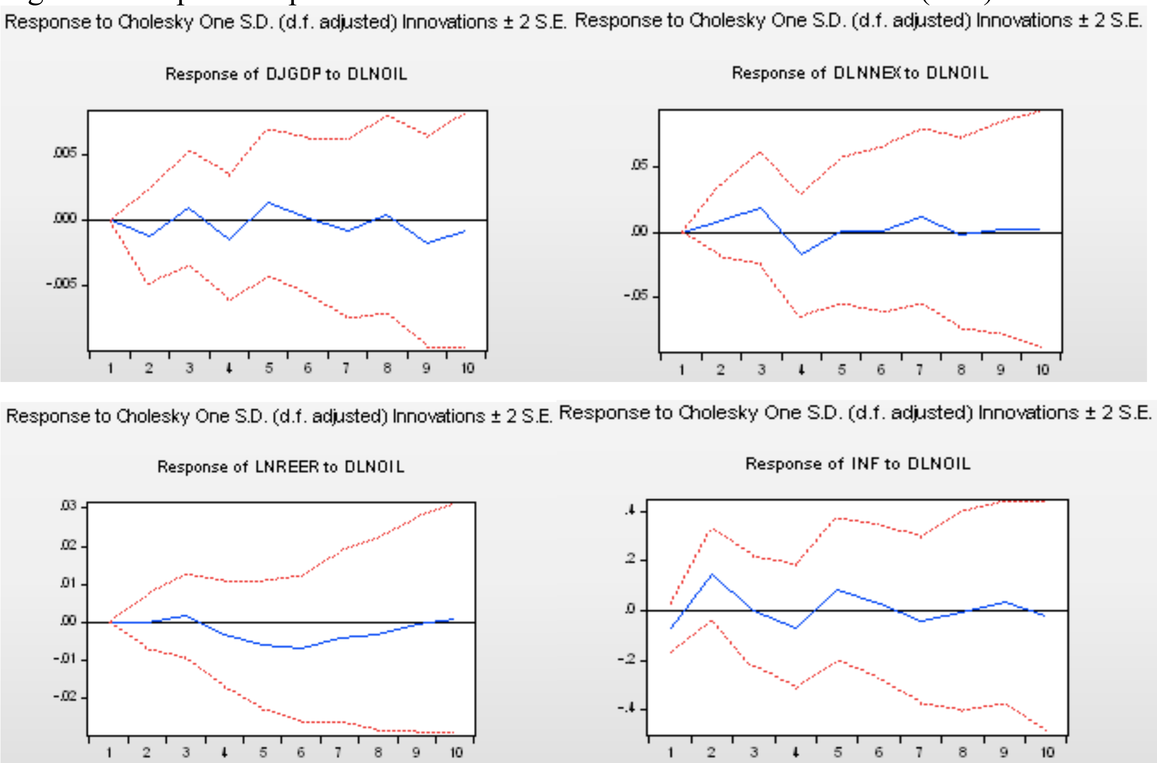
6.5 Impulse response functions

Ordering of the variables in the VAR system when performing analysis of impulse response functions is important. To identify innovations in each of the macroeconomic variables and the dynamic response over time to such innovations, the Cholesky decomposition method suggested by Doan (1992) are used. Impulse response functions are dependent of an *a priori* ordering of the variables in the Cholesky decomposition. The ordering in this field is set to be output, prices, money and interest rates. This ordering is commonly found in the existing literature (Naka and Tufte, 2006). Policy measures, such as monetary policy and management of the interest rate is placed last, since it takes more time before these measures are affected. Money proceeds interest rates because it is generally concluded that interest rates are a more dominant source of output. In this paper the ordering is set as GDP, NEX, OIL, REER, and INF.

Reporting impulse response functions without standard error bars is equivalent to not reporting t-statistics from a regression analysis. As the indication of significance, I have estimated the confidence interval to be 68% for the impulse response functions. This was obtained by running 1000 Monte Carlo simulations when obtaining the impulse functions (see Sims and Zha, 1999). The middle line in the impulse response figure represent the impulse response function and the dotted lines above and under represent the confidence interval. If the confidence interval falls into the horizontal line then you have to reject the null hypothesis - oil price shocks has no effect on macroeconomic variables (Farzanegan and Markwardt, 2009).

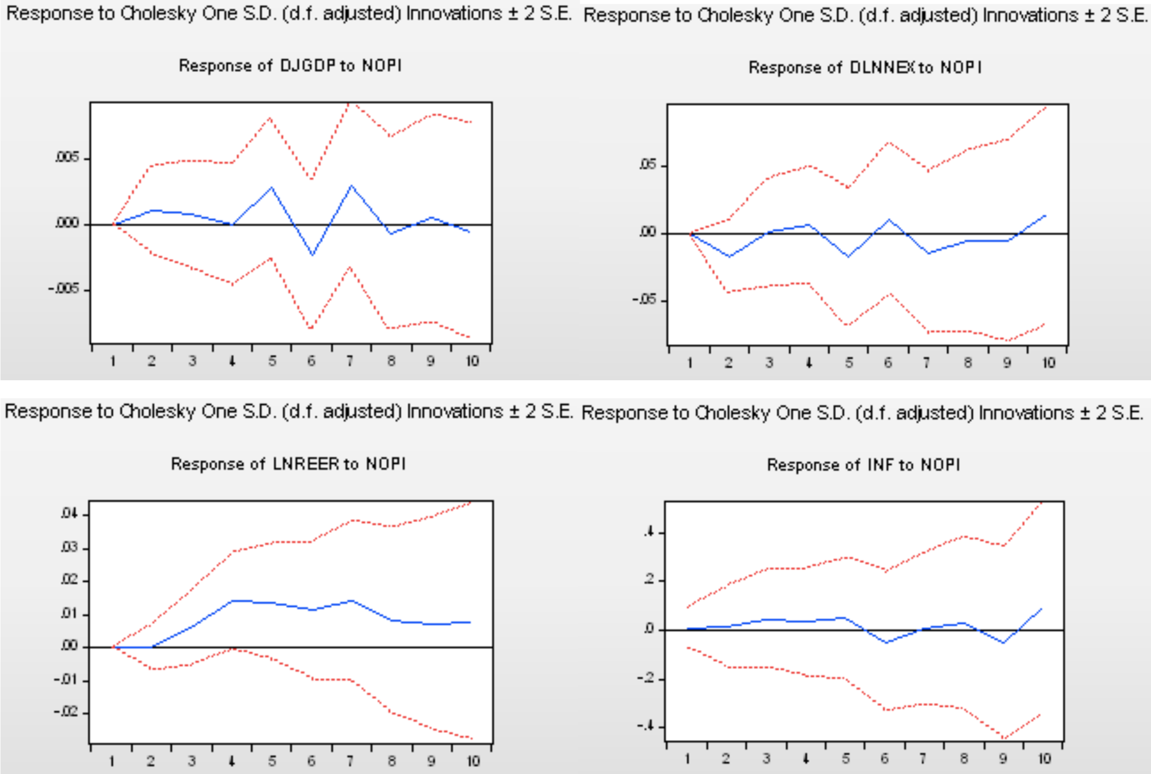
Figures 4 – 8 contain the impulse response functions for the responses of the macroeconomic variables to the different oil price shocks in the period 1990: Q1 – 2016: Q4. In each figure, there are traced an effect of a one-time shock to current and future values of the endogenous macroeconomic variables.

Figure 4 – Impulse response functions of innovations to linear measure (OIL)



In the figure above (figure 4), the response of the macroeconomic variables to an innovation or shock to the linear benchmark (OIL) is showed. The results show that the level of output, reflected by GDP, is thought to have a varying effect throughout the 10 periods after the initial shock to the oil prices. This indicates that an uncertain effect on output when there is a shock in the oil price. The response in net export are positive in the first 3 quarters, but over time is negative until quarter 5. So, the initial response is positive but is later corrected back to zero a after year the price shock. REER seems to not be affected before quarter 3, then being affected negatively, suggesting that the real effective currency is depreciate in the long run. Based upon the Monte Carlo confidence bands, none of the results shown in figure 4 are statistical significant.

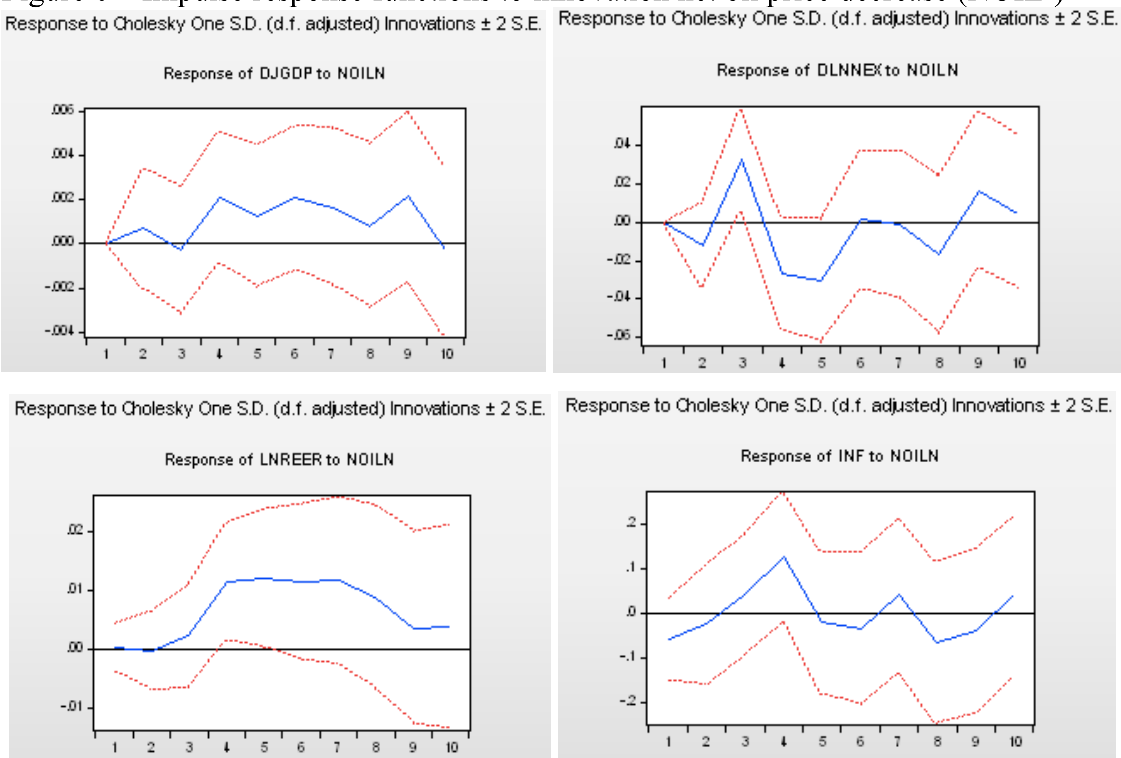
Figure 5 – Impulse response functions to innovation in net oil price increase (NOIL+)



In figures 5 and, the one standard deviation shock to the net price increase of oil for the period of 1990: Q1 – 2016: Q4 are shown. The variable NOIL+ is estimated be the percentage increase in the current price compared to with the price the last 4 quarters and is based upon the model created by Hamilton. GDP have a mild positive effect after a positive oil price shock. In later periods, GDP have a more volatile response. This result is in line with the findings of Bjørnland and Thorsrud (2013). The response in real effective exchange rate is positive for all periods, thereby indicating an appreciation. This result is also reported by Jiménez-Rodríguez and Sanchez (2005) which did a study of different countries, including Norway.

By first glance this could mean that there are some inflationary effects of positive oil price changes in Norway. Thereby implying evidence of Dutch disease. The inflationary effect can be explained by the *spending* effect or by the AD-AS model (more on AD-AS model see Romer, 2012). The spending effect was explained in an earlier chapter. The AD-AS model suggests that increasing oil revenues would lead to a higher level of government expenditure (Farzanegan and Markwardt, 2009). In countries like Iran or Nigeria where the oil revenues are funneled more directly into the economy it is argued is that higher oil prices lead to higher revenues. In turn this will stimulate capital expenditure and in addition more net foreign reserves into the central bank will lead to higher money supply. The increased money supply and government expenditure shifts the demand curve upward. This effect is not as strong in Norway, probably because of the BPFG and the presence of the budgetary rule, which makes higher oil revenues have less impact on the economy (Bjørnland and Thorsrud, 2013). As none of the variables are statistical significant, there is no evidence of Dutch disease in Norway. As inflation are concerned, there are a mild positive response in inflation in the first year and thereafter it circulates around 0. The net export has a sharp drop the first 2 quarters before turning positive. Neither of these are statistical significant, which means that these macroeconomic variables are not affected by a positive oil price shock.

Figure 6 – Impulse response functions to innovation net oil price decrease (NOIL-)



In figure 6 we have the impulse response functions for the negative oil shock measure NOIL-. We can observe that the response to GDP is very mild positive response the first two quarters, before surging between quarter 3 and 4 and stabilize at this level until quarter 10. Net export has a more volatile response over the 10 quarters. The immediate response is negative, but by quarter 3 it is positive, before plummeting again. For a brief period during the 3 quarter the response function is statistical significant. This result is related to the Granger – causality test implied that there would be some more response in GDP and net export by a negative oil shock. Although, in the long run, neither of them is statistical significant considering the coincidence intervals. Surprisingly, the real effective exchange rate is increasing as a response to a negative oil price shock. This is in contrast to previous findings. Inflation have a volatile reaction to a negative oil price shock, fluctuation between -1 and 1% during the whole period after the initial shock.

Figure 7 – Impulse response functions to innovation in oil price increase (ROIL+)

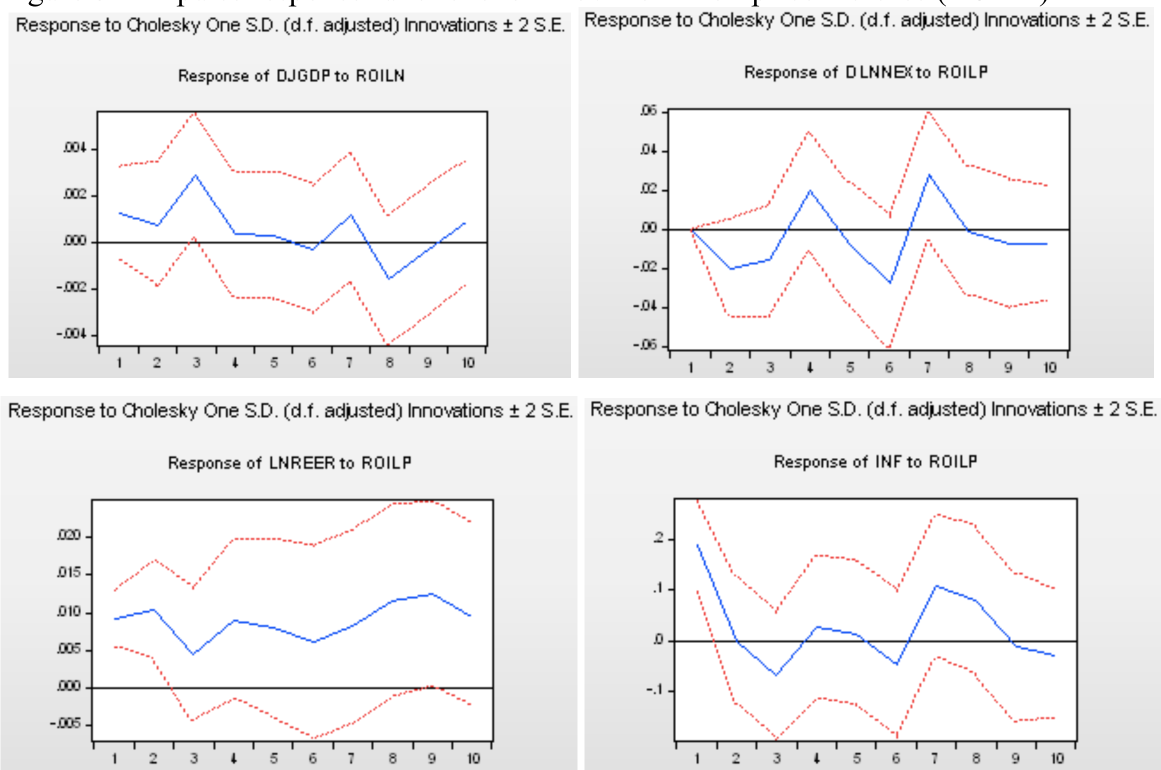


Figure 7 is the results of the response in the macroeconomic variables during a positive oil shock, now represented by the asymmetric model by Mork. A positive shock in the oil price makes the output have a sharp increase the first 2 periods before slowly decreasing and reaching its minimum in period 8. In this model as well are the real effective exchange rate found to appreciate over the whole period after the oil price shock.

The response in real effective exchange rate is statistical significant the first 2 quarters. Confirming the findings of earlier studies on this topic – higher oil price leads to an appreciation in the national currency. Not as expected from an oil-exporting country point of view, the response of net export to a negative shock of real oil price is negative, but it is not permanent. As price-elasticity of demand is not high in the short run, this is an unexpected result. Inflation is positive the first 2 quarters and statistically significant. In the long run, inflation behave more volatile. None of these responses to a one standard deviation shock to positive change in the oil price for the period 1990: Q1 – 2016: Q4 are statistical significant.

Figure 8 – Impulse response functions to innovation in oil price decrease (ROIL-)

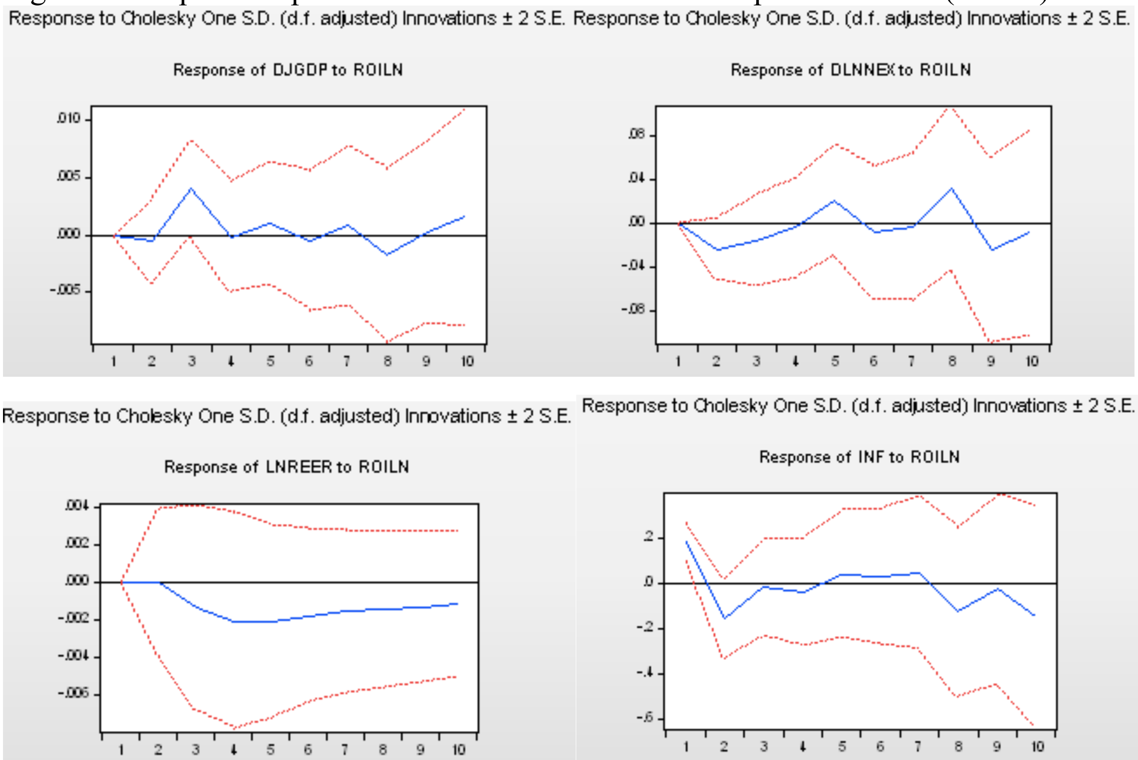


Figure 8 shows the impulse response function to a shock to negative changes in the real oil price. The response of the real effective exchange rate to a decreasing oil price is negative. The minimum is reached at the 3 quarter and stays negative for all periods. A reduction in the real effective exchange rate would mean that the Norwegian currency (NOK) would depreciate. The result is not statistically different from zero. As expected, the response of net export to a negative oil price shock is negative, but it is not permanent. After 4 quarters, the effect is positive, meaning it takes one year to adjust. In this model, the immediate response in output is positive, and it stays positive for the majority of the 10 periods. This is a not as excepted, considering Norway is reliant on oil in their economy. A possible explanation for the positive response in GDP could be that the aggregate demand of oil is higher following a downfall in the oil price. The responses in the macroeconomic variables to a shock in the negative oil price shock, ROIL-, are not statistical significant.

From the results above I can deduce that oil price shocks do not have a significant impact on macroeconomic variables such as GDP, net export, real effective exchange rate and inflation in Norway. From the Granger-causality test it was shown that a negative price could Granger-cause GDP and net export. The impulse functions of ROIL- and NOIL- did not show consistent results, whereas NOIL- showed that GDP decreasing slightly, and that net export had a mild negative response but a shock in ROIL- resulted in an increment in output. The responses in real effective exchange rate where also different after a negative shock. In addition to this, following a negative oil price shock the qualitative response in these variables where not significant.

6.6 Variance decomposition

Table 5 – Variance decomposition analysis

Dependent variable	Period	OIL	NOIL+	NOIL-	ROIL+	ROIL-
GDP	4	0.2449	0.1367	3.2362	0.5075	4.0382
	8	0.2493	0.1604	3.2410	0.5499	4.0185
	12	0.2497	0.1652	3.2436	0.5535	4.0107
NEX	4	0.1506	0.0822	1.3530	0.0289	1.8130
	8	0.1523	0.0883	1.4677	0.0356	1.8229
	12	0.1528	0.0919	1.4981	0.0385	1.8227
REER	4	0.3650	0.9100	0.3252	1.4766	0.3968
	8	0.3732	1.1504	0.5638	1.4826	0.8155
	12	0.3772	1.2200	0.6285	1.4911	0.9196
INF	4	4.7963	4.2206	0.7408	3.3465	0.6209
	8	4.7923	4.2261	0.7412	3.3446	0.6259
	12	4.7915	4.2256	0.7421	3.3444	0.6260

The impulse response functions highlight the qualitative response of the variables in the VAR system to shocks in the oil price. By exploring the forecasting error variance decomposition, we can establish the proportion of movement in the time series that are explained by shocks in their series compared to shocks in other variables. Because I am mainly focusing on how the macroeconomic variables respond the oil price shock, I have only included the variance decomposition of the different variables associated with oil shocks in table 5 above.

The results in table 5 corroborate the findings from the previous Granger-causality test, which demonstrated that oil price shocks accounts for only a small amount of explanatory power in the forecast variation of most of the macroeconomic variables in the model. I have included period 4, 8 and 12, observing the forecast error variance in the oil shocks measures over three years. I have not included the first quarter because it was reported as 0 in almost all instances.

Column 3 in table 5 contains the variance decomposition of the linear oil shock benchmark (OIL). It is sees that oil price shocks only contributes 0.25% to variation in GDP over the cause of the 3 next years. Oil shocks accounts for approximately 0.15% and 0.36% to variation in net export and real effective exchange rate respectively. The variation in inflation is the exception, where about 4% of the variation are accounted for by an oil shock. Overall, oil price shocks do not have a statistical significant explanatory power of the proportion of variation in macroeconomic variables.

Columns 4 and 6 present the results of the variance decomposition of the positive oil shocks. Overall, we find that a positive oil shock does not explain a significant proportion of variation in macroeconomic variables, especially in GDP and net export where it ranges from 0.03 to 0.55%. Although, a positive oil price shock explains on average 3.7% of the variation in inflation.

Interestingly, there are different effects of the asymmetric specifications of oil, represented by column 5 to 7. As presented previously, the variance decomposition of positive oil price shocks does not account for a lot of variation in macroeconomic variables. On the other hand, negative oil shocks show a more noticeable impact on GDP and net export. The variation explained in GDP are on average 4% following a negative oil price shock (ROIL-). It is observed that negative oil shocks explain 1.3-1.8% of the variation in net export which is significantly higher compared to the variation following a positive shock. This could mean that there are some asymmetric effects in Norway ant that the macroeconomic variables are more sensible to a negative shock than a positive oil price shock.

6.7 Robustness Tests

Alternative orderings

When operating with a VAR system, the ordering of variables within the system becomes a debatable point. By re-estimating the impulse response functions with different orderings, I can check the stability of my results. I will compare the impulse responses obtained by innovation in positive price (ROIL+) and in the alternative ordering OIL, REER, INF, GDP, NEX to the original ordering. I will also employ the ordering REER, NEX, OIL, INF, GDP when examining the impulse responses by a negative price shock. These orderings were suggested in the paper by Farzanegan and Markwardt (2009). The results of the figures can be seen in the appendix.

The results obtained (see figure A.3 in the appendix) by innovation in positive oil price growth in the alternative ordering is very similar to the responses found using the original ordering. The magnitude of the response is the same and none of the results are statistical significant. The only difference is the response in GDP, which start out as negative and have a more volatile response in the long run in the alternative ordering model. The response in real effective exchange rate and inflation is significant the first 2 quarters in both orderings.

In the second alternative ordering the results are a bit more contrasting (see figure A.4 in the appendix). First and foremost, the response of real effective exchange rate is different. Whereas in the original ordering the response was clearly negative, in the alternative ordering, it is only decreasing mildly the first 3 quarters before becoming positive. In the long run, the alternative order suggests an appreciation in NOK following a negative oil price shock. The other variables have more or less the same response, but the magnitude of the response is greater in the alternative ordering.

Dropping 2014 -16 period

When checking for consistent results during econometric analysis, it can be helpful to drop some of the variables to estimate if the model will yield the same result without them. If the estimations are significantly different, it could mean that the model is not well specified. In the sections above, the only significant finding was that a negative price shock could Granger-cause net export and GDP to some degree. In order to check if this result is consistent, I am going to drop the period from 2014 to 2016 of the data set, and re-estimate the VAR system. Dropping this time period will exclude the recent drop in the oil price. I am using the original ordering for this analysis and I am only looking at the response in the variables ROIL+ and ROIL- as oil price definitions. Running the VAR system with the same ordering and same variable specifications as the previous VAR system gave these Granger-causality results:

Table 6 – Granger-causality test, 1990: Q1 – 2013: Q4.

	Null hypothesis: oil price does not Granger-cause:	
Variables	ROIL+	ROIL-
GDP	1.8201 (0.1025)	1.7364 (0.1206)
NEX	1.181 (0.3351)	2.0425 (0.0664) ***
REER	1.7102 (0.1268)	0.248 (0.9784)
INF	0.80448 (0.6025)	1.6816 (0.1339)

The variables are chi-square (Wald) statistics and the values in () are p-value.
The variables GDP and NEX are in log first-differences.
*indicates significance at 1% level.
**indicates significance at 5% level.
***indicates significance at 10% level.

The result in the full sample model suggested that ROIL- Granger-caused GDP at a 1% significance level, but in the table above, we can observe that a negative price shock does not Granger-cause GDP any longer. We can observe that the net export is still caused by a negative oil price shock but at a less significance level. Now a drop in the oil price only Granger causes net export at a 10% significance level compared to a 1% level in the full sample. Still a significant factor by determining net export, ROIL- has lost a lot of its explanatory power over the macroeconomic variables by dropping the last 3 years. Similar to the results from the original model, an increase in the oil price does not Granger-cause any of the macroeconomic variables. As the significance of ROIL- drops, so does the asymmetric effect, because now both ROIL+ and ROIL- have almost no impact on the macroeconomic variables in Norway. A reason for the weaker results in this model compared to the original could be related to the drop in oil price in 2014, which is excluded from the new model.

By re-estimating the impulse response functions (see figure A5 and A.6 in the appendix), we can observe that the results are reasonably similar to the original response functions. The impulse response functions can be found in the appendix. In the response function to an innovation in oil price increase, the response in GDP and net export are almost identical, but the net export response is less volatile in the reduced model. The big difference is between the responses in real effective exchange rate by a negative oil price shock. In the original model, the currency is shown to appreciate over all periods, but in the reduced model the results show a depreciation in the currency during the first 5 quarters. The response in inflation to a positive oil price shock is almost identical.

Considering the negative oil price shock, we observe that over the 10 quarters the response in GDP is more volatile in the reduced model compared to the original model. In the reduced model the response in GDP is considered significant between quarter 2 and 3, similar to the original model. Unlike the original model that had a clear negative response in net export following a negative oil price shock, the reduced model shows a more moderate response in net export. The response in net export has a mild negative trend only the first 2 quarters before returning to 0 in the medium run. In the original model, a negative shock in the oil price resulted in depreciation in all 10 quarters. This is not the case in the reduced model. In the original model, the depreciation of real effective exchange rate might be a reason why the real output of the economy stays positive in the long run, by increasing the competitiveness in the non-petroleum sector of the Norwegian economy in the global market. However, in the reduced model, the long-term trend of real output is slightly negative, and the response in real effective exchange rate is mildly positive.

6.8 Policy implications

The results from the analysis above have some implications for economic policy in the future. In the econometric analysis it was shown that with the exceptions of net export, macroeconomic variables did not react considerable succeeding a shock in the oil price. As oil exports represent 26% of Norway's export earnings, this is not a surprise (OEC, 2018). However, the fact that oil shocks do not have a significant effect on macroeconomic variables in the short or long run highlight an important characteristic of the Norwegian economy, which is the presence of the GPFG. The states net petroleum revenues are transferred to the GPFG, while the spending of these revenues over time reflects the expected real return on the Fund's capital (NOU 2015:9 Chapter 1). As a result, the fiscal budget is secluded against short-term variation in petroleum revenues. It is assumed that the State will continue to receive large revenues from the petroleum industry for years to come, and it is expected that the GPFG will continue to grow for several decades. Nonetheless, as a proportion of the mainland GDP, the Fund's contribution to financing public expenditures is anticipated to begin declining in 15 to 20 years (Regjeringen.no, 2013).

The sudden decline in the oil price in 2014 has served as reminder that flexible, productive and competitive mainland economy in addition to a floating exchange rate are central to buffer external shocks that may influence the petroleum income. With reference to this, it is concerning that Norway's mainland economy has experienced a secular decline in productivity growth and fall in international competitiveness the last 10-15 years (OECD, 2016). To compete this, it is suggested to utilize structural policies to ensure stronger productivity growth and international competitiveness, and then to smooth the adjustments towards less medium-term dependence on petroleum. This means shifting away from petroleum related activities, and focusing on other well established non-oil sectors, such as shipping and energy-intensive activities that tap into Norway's abundance of hydropower. For now, these activities only account for a small share of non-oil activity (OECD, 2016).

Following the drop in the oil price in 2014, monetary policy was enforced to combat a cyclical downturn. Interest rate is often the first line of defense since it is possible to change it swiftly. The key policy rate in Norway is now at 0.5%, which is a record low, so there is not much room to maneuver to further stimulate consumption (National Budget, Summary, 2017). Having a very low interest rate over time will entail risk of mounting financial imbalances and the financial sector could be motivated to take more risk. Low oil prices have brought real exchange rate depreciations, shown in the model, and in a survey done by OECD (2016). The survey suggested that exports of non-oil goods trended slightly upwards as a result of the falling oil price.

In the analysis it is shown that negative oil shocks affect macroeconomic variables more than positive oil shocks. This is similar results obtained by Mehrara (2008) and Iwayemi and Fowowe (2010), and it implies that negative oil shocks dominate positive oil shocks. This is an indicator of Dutch disease, where following a positive oil shock output experiences little to no increase, however, following a negative oil price shock output declines significantly (Mehrara, 2008). This is not the case in Norway, a negative oil shock does not make output decline significantly, thereby confirming other studies that concluded that Norway do not suffer from Dutch disease. This is attributed to the presence of the GPFG. In countries like Nigeria, that showed sign of Dutch disease, policies like diversification of the economy, reduction of government debt and handling oil revenues through an oil fund was suggested to combat this. In Norway, prudence in government expenditure have been a priority since the start of the 2000s.

Chapter 7 – Summary and Conclusion

7.1 – Conclusion

In this thesis I have tried to conduct an empirical analysis of the impact oil price shock has on the Norwegian macroeconomy. By doing this to an oil-exporting country this study departs from most of the existing literature. I have looked at variables such as real GDP, net export, real effective exchange rate and inflation. By the use of an unrestricted VAR model, I performed a Granger-causality test, made impulse response functions and looked at the variance decomposition of the variables. The results from Granger-causality test showed that a negative oil price shock cause net export and GDP. This is in contrast to other studies, which found that negative oil shocks have no effect on macroeconomic variables. The linear oil shock measure and the positive oil shock measures do not cause GDP, net export, inflation and real effective exchange rate. By not being able the preform the cointegration test, I was not able to analyze the long-term relationship between the variables.

The results from the impulse response function and the variance decomposition analysis largely confirmed the findings in the Granger-causality. From the variance decomposition, it was found that positive oil price shocks contributed less than 1% to the variation in GDP and net export, whereas a negative oil price shock contributed to 3-4% of the variation in these variables. Evidence of asymmetric effects could be made as negative oil price shocks have a more definite impact on the macroeconomy. In the robustness test of the model, when I excluded the last 3 years, it was shown that the negative oil price shock had less impact on GDP and net export, meaning that the negative shock of 2014 may have had a real impact on the Norwegian economy. Although, none of the oil shocks where statistical significant in the impulse response functions. Thereby, showing that oil price shocks do not have a significant impact on the macroeconomic variables in Norway. I did not find any evidence that Norway suffers from Dutch disease.

7.2 – Further Research

It is clear that the model I have utilized could be modified so we can do further research. A possibility is to include other variables, such as government expenditure, interest rates, unemployment and real wages. You could even expand on the time horizon, starting in 1970 for example. Inclusion of dummy variables could also be interesting, since my model does most likely suffer from exogeneity in terms of other shocks that influences the global economy which in turn have an impact on both oil prices and macroeconomic variables.

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APPENDIX OF FIGURES

Figure A.1 and A.2 – Histogram of accumulated probability density of residuals and plotted residuals against normal distribution

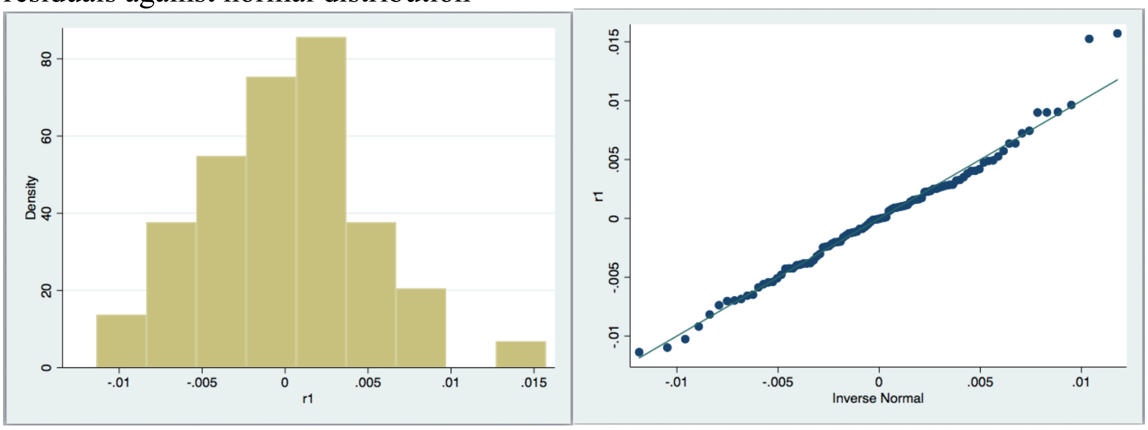
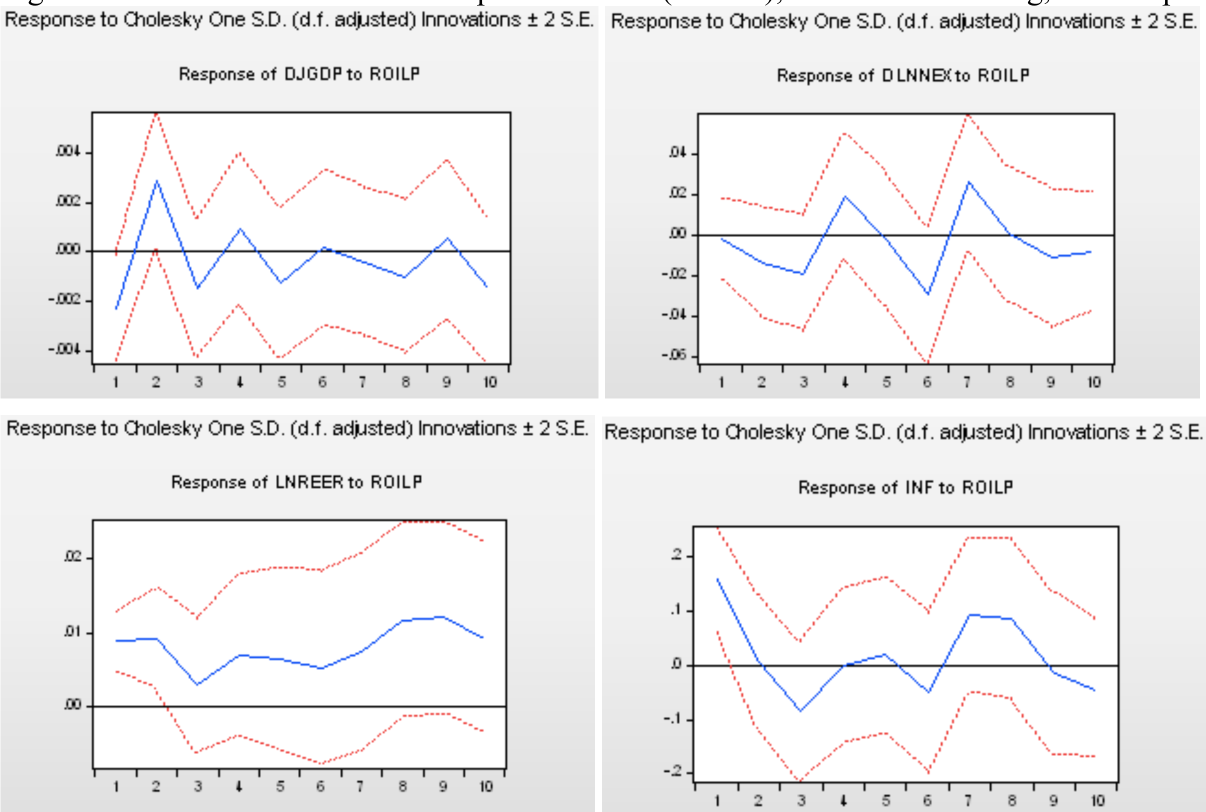
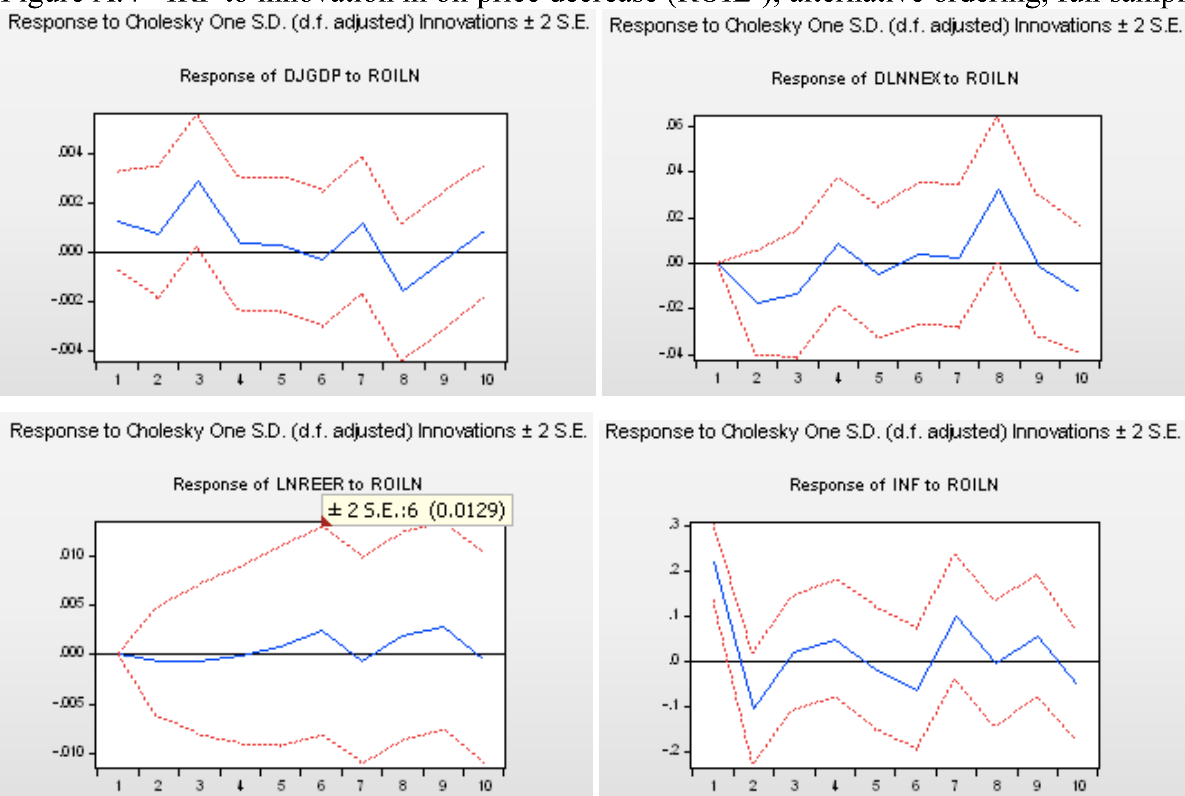


Figure A.3 - IRF to innovation in oil price increase (ROIL+), alternative ordering, full sample.



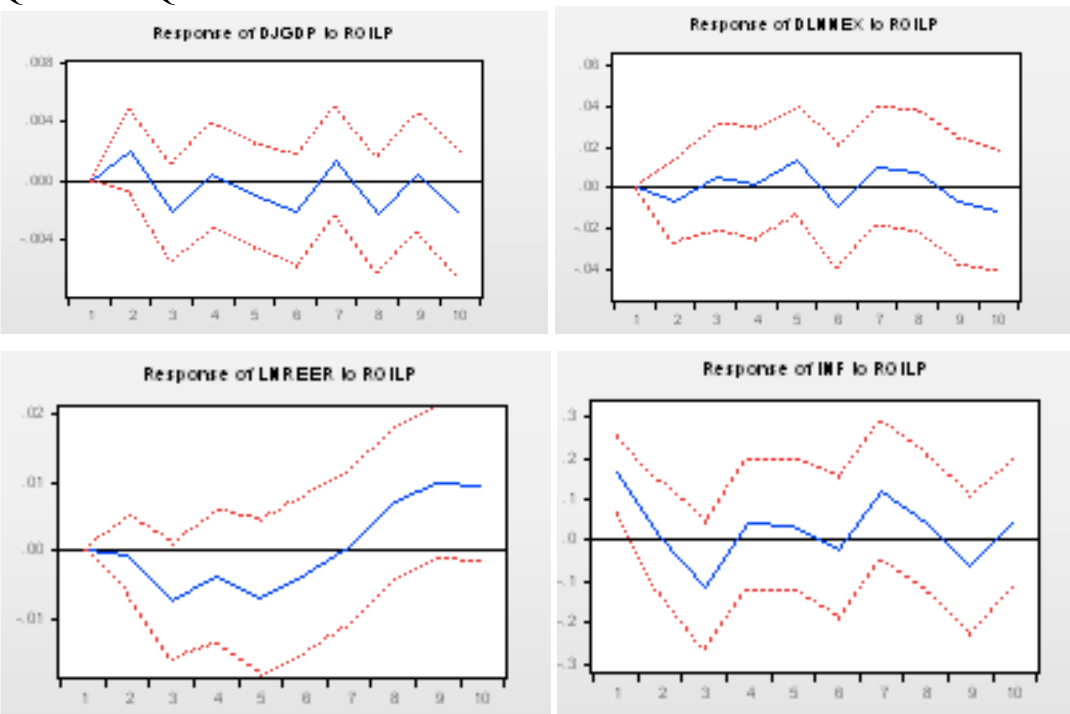
IRF ROIL+, alternative ordering, full sample.

Figure A.4 - IRF to innovation in oil price decrease (ROIL-), alternative ordering, full sample.



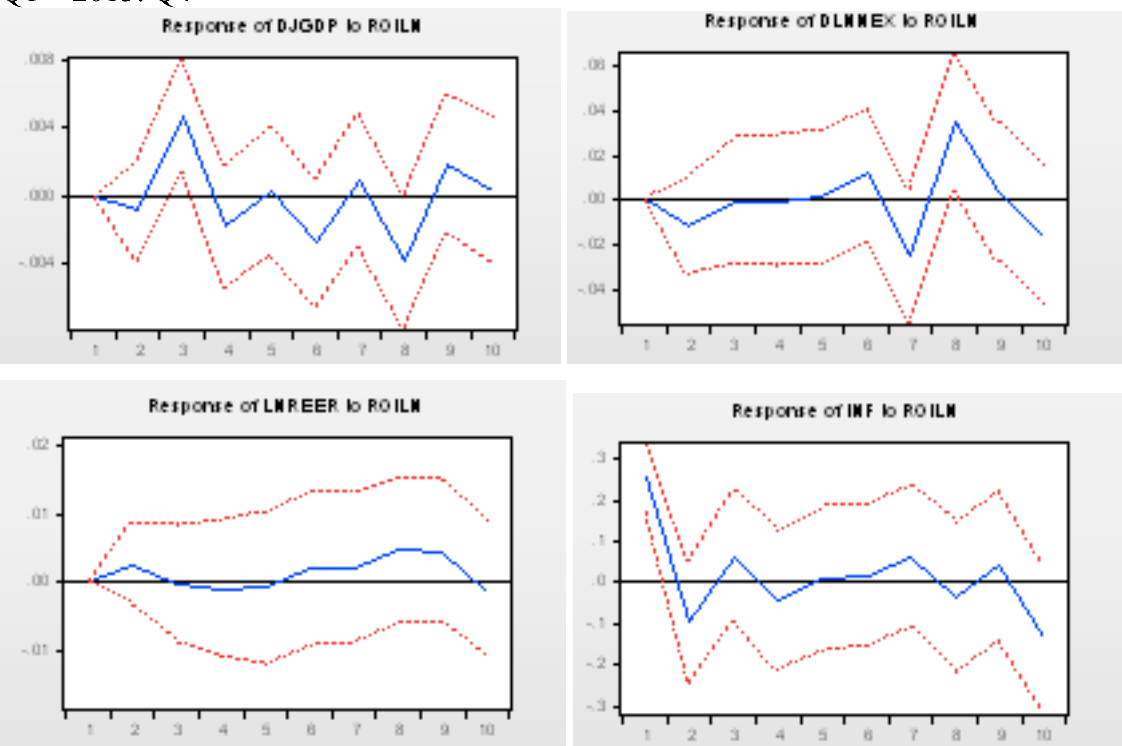
IRF ROIL-, alternative ordering, full sample.

Figure A.5 IRF to innovations in oil price increase (ROIL+), original ordering, sample 1990: Q1 – 2013: Q4



IRF ROIL+, original ordering, sample 1900: Q1 – 2013: Q4

Figure A.6 IRF to innovations in oil price decreace (ROIL-), original ordering, sample 1990: Q1 – 2013: Q4



IRF ROIL+, original ordering, sample 1900: Q1 – 2013: Q4

Figure A.7 – Development of GDP, 1990: Q1 – 2013: Q4

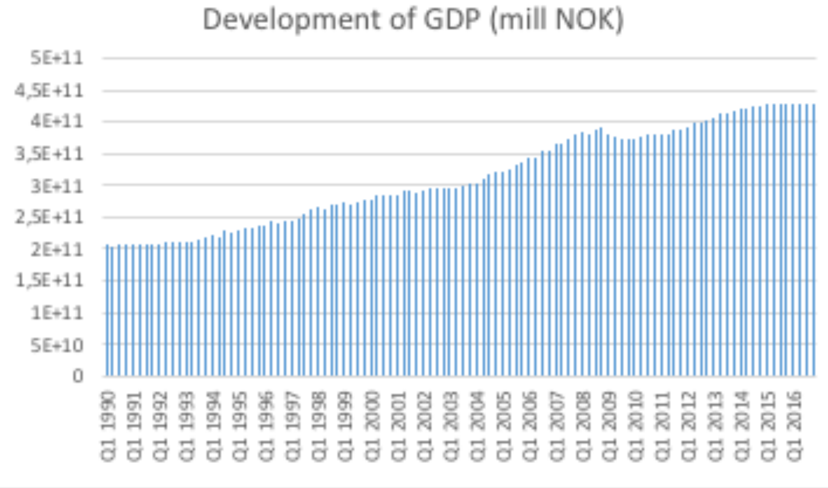


Figure A.8 – Development of NEX, 1990: Q1 – 2013: Q4

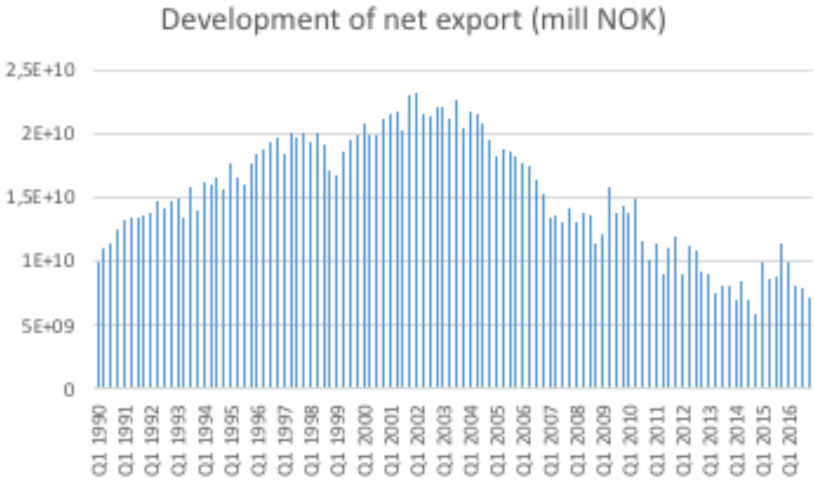
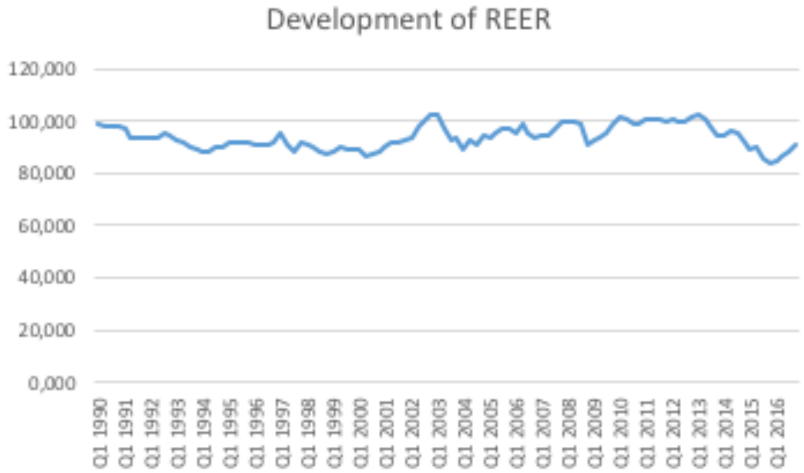


Figure A.9 – Development of REER, 1990: Q1 – 2013: Q4



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