FRONT PAGE

Universitetet
i Stavanger

UIS BUSINESS SCHOOL

MASTER'S THESIS

STUDY PROGRAM:	THESIS IS WRITTEN IN THE FOLLOWING SPECIALIZATION/SUBJECT:
Business Administration – Master of Science	Applied Finance IS THE ASSIGNMENT CONFIDENTIAL? (**NB**! Use the red form for confidential theses)

TITLE:

The Impact of Change in Oil Price on Inflation in Norway

AUTHOR(S) Akbar Osman		SUPERVISOR: Peter Molnar
Candidate number: 7000 ………………… …………………	Name: Akbar Osman ……………………………………. …………………………………….	

The Impact of Change in Oil Price on Inflation in Norway

(Master thesis)

Universitetet I Stavanger - UIS Business School

Akbar Osman

Candidate nr: 7000

Abstract

In this thesis, I investigated the effect of oil price fluctuation on consumer price inflation in Norway. I applied the vector autoregression (VAR) model – one of the most popular approach in macroeconomic multivariate time series analysis. I added interest rate and exchange rate to the model in addition to oil price and consumer price index. I collected monthly data for a sample period from 2001 to 2016, also 180 observation for each variable. I conducted Granger causality test beside VAR in order to detect short run causality from oil price to inflation. The results indicated that change in oil price has indeed caused change in inflation in the short run, but the effect is very limited. I conducted stability test and system was stable. There is no autocorrelation, but the normality test shows that residuals are not normally distributed. It implies that model has some weaknesses, therefore, results need cautious consideration.

Contents

Introduction

The crude oil was arguably the most important commodity in the last century and still is the main driving force of both domestic and international economy. After the industrial revolution especially post World War II, the share of oil and oil refinery products become more and more significant both in industry and household consumption. Hence the macroeconomic indicators of main industrial economies around the world became more sensitive to the international price movement of oil. The relationship between oil price change and inflation has been an interesting topic and widely discussed among academics as well as policymakers. The oil crisis in 1970s has significantly affected some of the largest oil dependent countries at that time, but there are various studies which came to different conclusions regarding to the effect in the long run. However, since the oil shock both economists and decision makers in the industrial world suggested and took different measures in order to constrain the effect of oil price change on inflation and economy as a whole. These measures include diversifying energy source, improving productivity and efficiency of oil consumption and oil refinery production … and so on.

This trend leads to re-consideration of the relation between oil price change and inflation. Academics who did research on this subject in recent years are mostly agreed upon that the impact of oil price on inflation and other macroeconomic factors are quite limited and become less significant over time. Most of the researches using data from United States and some major European economies such as Germany, France and Spain. Very few of these kinds of researches include Norway and other Scandinavian economies, but the main focus is still on US and EU.

In this paper we will primarily focus on Norwegian economy and study how the oil price change affects the inflation in Norway. We believe that this study will contribute to better understanding the impact of international oil price on inflation in the context of Norwegian economy which is a major oil exporter. In addition to that, policymakers are always interested in controlling and affecting the inflation in an attempt to create economic stability and lay the foundation to the future growth and prosperity. The oil exports contribute significant part of the Norwegian national income and the exchange rate of the Norwegian krone (NOK) seems to be correlated with oil price. Therefore, we hope that this study will help both fiscal and monetary policymakers for better understanding the economic reality and effective decision making in their field.

The rest of the essay has following content: in Part 2) we will introduce some of the previous studies on this topic, Part 3) we collect and prepare data for further analysis, part 4) we will choose the research method, part 5) we discuss and analyze the results and final part is the conclusion on this paper.

Literature Review

Researchers have done abundant studies about oil price movement and its impact on macroeconomic factors such as output, inflation and unemployment. A lot of them were interested how the oil shock pass through inflation. However, the study results are different according to time frame, data and research model they applied, for example the studies done before 1990s generally indicate relative stronger impact of oil shock then the studies done after 1990s ( ). Part of the reason for this may be a structural change including energy diversification, increase in product efficiency in energy sector and change in monetary and fiscal policy. The degree of oil dependency of the countries that included in research data have also largely affected the results of the study. The oil importing countries are always suffering from a dramatic increase in oil price while the oil exporting countries are benefiting from it. Now, we will see some of the studies that examined the relationship between oil price movement and inflation by using different data and approaches

Diminishing effect

The diminishing effect of oil price on inflation is one of the main common findings from previous literature in this field. Though there are some studies that remain skeptical on this conclusion, the majority of the studies between 1990 and 2010 are mostly agreed upon that the effect of oil price on inflation and other macroeconomic factors has been weakened in recent years.

Álvarez, et.al (2010) have examined the impact of oil price changes on Spanish and euro area consumer price inflation. They used time series techniques and MTBE(1) and DSGE(2) model in order to assess both the direct and indirect and second round effect of oil price change on Spanish and EU inflation. At the end, they conclude that the inflationary effect of oil price changes in both economies is limited, even though crude oil price fluctuations are a major driver of inflation variability. The impact of oil price change on Spanish inflation seems to be a bit higher than in the euro area. The lower share of indirect taxes in Spanish retail prices may explain this in some extent. In both economies, direct effects have increased in recent years due to the higher share of household consumption of refined oil products, while indirect and second round effects are becoming less significant.

Chen (2008) uses data from 19 industrialized countries (including Norway) to investigate oil price pass-through into inflation by applying a state space approach. He estimated a time-varying oil price pass-through coefficient and the coefficient confirmed that the effect of oil shock on inflation is declining in recent years. Here are his results for 19 countries about long run oil price pass through into inflation:

Long-run oil price pass-through into CPI inflation

	Constant	β_y	β_o
Australia	−5.617***	2.100***	0.219***
	(0.545)	(0.136)	(0.037)
Austria	0.371	0.855***	0.112***
	(0.271)	(0.072)	(0.027)
Belgium	−4.965***	1.990***	0.149***
	(0.744)	(0.181)	(0.037)
Canada	−2.916***	1.565***	0.152***
	(0.563)	(0.151)	(0.044)
Denmark	−3.320***	1.593***	0.214***
	(0.376)	(0.093)	(0.031)
Finland	−1.038**	1.099***	0.226***
	(0.427)	(0.115)	(0.052)
France	−14.374***	4.065***	0.094
	(1.678)	(0.403)	(0.069)
Germany	−2.334***	1.495***	0.096***
	(0.534)	(0.131)	(0.024)
Ireland	0.981***	0.545***	0.392***
	(0.220)	(0.067)	(0.056)
Italy	−14.194***	4.051***	0.114*
	(1.001)	(0.260)	(0.066)
Japan	0.429*	0.799***	0.161***
	(0.257)	(0.064)	(0.028)
Netherlands	−2.994***	1.557***	0.149***
	(0.933)	(0.236)	(0.046)
Norway	−1.368***	1.251***	0.097***
	(0.158)	(0.052)	(0.024)
Portugal	−10.838***	3.408***	−0.016
	(0.423)	(0.117)	(0.063)
Spain	−11.209***	3.416***	0.094
	(1.055)	(0.265)	(0.078)
Sweden	−8.738***	2.731***	0.254***
	(1.407)	(0.326)	(0.047)
Switzerland	−0.758*	1.084***	0.139***
	(0.403)	(0.099)	(0.026)
U.K.	−11.974***	3.397***	0.343***
	(0.923)	(0.221)	(0.038)
U.S.	−1.921***	1.329***	0.169***
	(0.361)	(0.094)	(0.029)

Table 1. Long term oil price pass through into inflation.

Source: Chen (2008) Oil price pass-through into inflation, Energy Economics 31 (2009) 126–133

According to another study Sek (2017) fount that the consumer price was indirectly affected by oil price change through transmission channels while direct effect was less significant.

LeBlanc & Chinn (2004) estimated the effect of oil price change on inflation by using an augmented Phillips curve framework. The study focusses on big industrial countries such as United States, United Kingdom, Germany, French and Japan and time between 1980 and 2000. LeBlanc & Chinn (2004) wanted to measure the inflationary effect of oil prices. Since oil price is a component in their Phillips curve model, the effect can be directly measured from test estimates, but they also have considered the nonlinear and asymmetric effect of oil price and tried to compare the effects for different countries.

At the end of the test they conclude that, the inflationary effect of oil price between 1980 and 2000 has weakened than before, especially from oil shock in 1970s. Their result shows that 10 percentage point increase in oil price is contributed to about 0.1-0.8 percentage point increase in inflation in US and Europe.

Mark A. Hooker (2002) estimated the effect of oil price changes on US inflation by using Phillips Curve model and considered some asymmetric and nonlinear effects that can be found in real world. The study suggested that there was a significant direct effect on core inflation in the US before 1980s, and the direct effect or pass through would become less or not significant after that time.

José De Gregorio, Oscar Landerretche, and Christopher Neilson (2007) have investigated the degree of pass through from the price of oil to the general price level. The evidence from their study suggested that the oil price pass through into inflation has been declined significantly in recent demands. Gregorio, et al (2007) applied two different approaches in their analysis. First, they used augmented Phillips curve approach which included oil price and test for structural breaks. The model indicates a diminishing pass through effect for industrial countries. Second, they used vector autoregression model in order to estimate the effect of oil price changes on inflation by driving impulse response functions. The results confirmed that the effects of oil shock have been weakened in recent years. Gregorio, et al (2007) not only focused on big industrial economies such as United States and Europe, but also collected data and investigated across countries and concluded that during last three decades, the declining effect of oil price on economy has been a worldwide phenomenon.

Olivier J. Blanchard, Jordi Gali (2007) have researched the relationship between oil price and macroeconomic factors including inflation and output. The study focused on how the effects of recent oil shocks (in 1990s and 2000s) on GDP growth and inflation in the industrialized world differ from the oil shock in 1970s. Blanchard & Gali (2007) applied structural vector autoregressive model (SVAR) to estimate the effects of oil shocks across episodes and impulse responses to these shocks. They also used some alternative approaches including bivariate VARs which allows them to estimate the effects of gradual changes in oil shocks without breaking the time periods. The analysis of the study summarized that although the oil shock in 1970s is only responsible part of the stagflation at that time, the effect of oil price change has been significantly reduced since then.

Structural change

Another main topic which discussed in previous literature is that the diminishing effect of oil price change on overall economy can be explained by a structural change in the economic system. The structural change means change and restructuration of economic fundamentals that are often related to oil and energy intensity in economic activities, monetary policy and real wage rigidity.

Mark A. Hooker (2002) had introduced which he called “the structural break” in his study. The “break” implies before 1980s and after 1980s. The results of the study show that there is no strong evidence to claim that decreasing energy intensity and deregulation within energy sector are partly responsible for that diminishing effect of oil price change on inflation, but the monetary policy may help to create an environment where the inflation is less sensitive to oil price change.

Chen (2008) came to similar conclusion. According to the study, this weakened effect of oil price change could partly attributed to a structural change. The study concluded that, a more efficient monetary policy helped to control the inflation. More trade openness and the appreciation of the domestic currencies in these economies may be the factors to explain this diminishing effect. Contrary to other similar researches, the study found that energy intensity may played a minor role on this issue.

LeBlanc & Chinn (2004) The study didn’t find any robust evidence to support the traditional claim about inflation in EU is more sensitive than in US. According to their explanation, the higher energy intensity in the US economy may be offset by strong wage pressure from more powerful unions in EU.

Gregorio, et al (2007) had suggested some possible explanations of this diminishing effect of oil price change. According to Gregorio, et al (2007) the declining oil intensity in recent years both in industrial and emerging economies, has played a significant role to weaken this pass-through effect. Another important factor that partly responsible for this diminishing effect is the reduction in the effects of exchange rate changes on inflation. There are also some additional factors with non-sufficient empirical support can help to explain this weak pass through. They are respectively, the present low inflation environment, more effective monetary policy and the oil shock that characterized by strong world demand (Gregorio, et al, 2007).

Another research that support the role of structural break was done by Blanchard & Gali (2007). The possible explanation of this change according to Blanchard & Gali (2007) is increasing real wage adjustments, more effective monetary policy and decreasing oil dependency both in production and consumption.

Effect on a net oil exporter

Early studies on the relationship between oil price and macroeconomic factors or the overall economy have been mainly focused on oil importing countries. However, more recent studies give some attention on the oil exporting countries as well. Hilde C. Bjørnland (2008) especially focus on Norwegian economy and measured how oil price change can affect stock market return in Norway. Siok Kun Sek (2017) studied the relationship between oil price change and main domestic price indexes in Malaysia, also an oil exporting country. Jimenez-Rodriguez and Sanchez (2005) empirically tested the effects of oil price shocks on the real economic activity of the main industrialized countries including two oil exporting countries – United Kingdom (UK) and Norway.

Hilde C. Bjørnland (2008) analyzed the effects of the oil price changes on stock market returns in Norway. Her study investigated the relationship between oil price and macroeconomic behavior of an oil exporting country by using structural VAR model. The study concluded that 10% increase in oil price causes 2.5% increase in stock returns and oil price increase have positive effect on overall economy.

Dr. Siok Kun Sek (2017) applied linear and nonlinear autoregressive distributed lag (ARDL) models to investigate the impact of oil price changes on domestic price inflation in Malaysia at disaggregated levels. The study also highlights the fact that Malaysia is an oil exporting country with increasing oil dependency. In her study, she examined both symmetric and asymmetric pass-through effect of oil price changes on four domestic price indices in Malaysia including consumer price index (CPI), producer price index (PPI), import price index (IMP), and industrial production index (IPI) The main objective of her work is to compare how oil price changes affect domestic prices at different levels (production/output, consumer price, producer price, and import price) across sectors. (a similar characteristic with Norway in some extent). While majority of other studies solely focus on oil importing countries and examine the effect of oil shock on domestic demand and supply of energy demanding economic activities, it is more complicated to measure the impact on oil exporting countries. On the one hand, increase in oil price give a boost to national income and net export, on the other hand, the sectors with high energy dependency will suffer from this due to increase in input price. This leads to higher production price and consequently lower demand, if we assume a significant demand elasticity. The study found some evidence that indicates the positive effects of oil price increase on output growth. However, the study also concluded that higher oil price leads to higher import and production price in the long run by affecting the cost structure on the other hand, oil price changes have a limited direct effect on consumer prices in the long run.

Jimenez-Rodriguez and Sanchez (2005) applied Multivariate VAR analysis by using both linear and non-linear models to test the impact of oil price changes on GDP growth of G7 countries, Norway, and Eurozone as a whole. They expected to get different results from net oil importing and net oil exporting countries under the assumption that considerable increase in oil price negatively impact the real economic activities of a net oil importing country because of additional cost, and positively impact the real economic activities of a net oil exporting country because of extra income in export. As they expected, the results indicated that an increase in oil price negatively impacted the GDP growth in all net oil importing countries except Japan. When it comes to net oil importing countries namely, UK and Norway, the test generated different results. The study found that Norwegian GDP growth positively impacted by oil shocks while economic activities of UK was negatively affected from it. The results show that Norwegian output gain increased from 1% to more then 2% from a 100% oil price hike. Under the same circumstances, output loss in UK increased around 2% and in US between 3.5% to 5% Jimenez-Rodriguez and Sanchez (2005).

International oil market and Norwegian economy

Global oil industry truly began in 1837 when the first commercial oil refinery was established in Baku. This was followed by other oil discoveries in Eastern Europe, United States and Canada. From mid-19th century to the end of the WWII, the oil industry experienced several booms and busts, the oil price have also fluctuated over time, reflected the constant change between supply and demand. In this period, the large number of oil resources and pricing power mainly controlled by big oil companies. But this had gradually changed after WWII, a lot of countries had nationalized its oil industry. In 1960, some of the oil exporting countries including Iran, Iraq, Saudi Arabia, Kuwait and Venezuela were meeting in Baghdad and established the Organization of the Petroleum Exporting Countries (OPEC) in order to secure their interest in global oil market and gradually taking control of pricing power from international oil companies. Thereby OPEC become an important player in the world oil market. OPEC membership later expanded to Qatar, United Arab Emirates, Libya, Algeria, Nigeria, Ecuador and Angola (OPEC, 2012). In 1970s some major events have further shaped the global oil industry. First, the Saudi oil embargo and middle east crisis caused to oil price jump up from 2-3$ in 1972 to 11-12$ in 1974 per barrel. In response to this oil shock some oil importing countries established the International Energy Agency (IEA) in 1974 to help these countries to co-ordinate a collective response to major disruption in supply of oil and enhance the reliability, affordability and sustainability of energy in its member countries and beyond (IEA, 2018).

Another important event in this period is the discovery of oil resource in the North Sea, which helped United Kingdom and Norway to become oil exporting countries.

The discovery of oil resource on the Norwegian continental shelf was began in late 1960s and production started at the beginning of 1970s. Some major discoveries were soon followed up. The oil and gas sector have eventually become the dominant sector in Norwegian export and played an essential role in developing and maintaining the high standard of Norwegian welfare state. According to the Norwegian Petroleum Directorate and the Ministry of Petroleum and Energy, since production started on the Norwegian continental shelf in the early 1970s, petroleum activities have contributed to more than 14 000 billion NOK to Norway's GDP. Now, the petroleum sector accounts approximately 14% Norwegian GDP, 17% of state's revenue and 40% of total export (National Accounts, National Budget 2018).

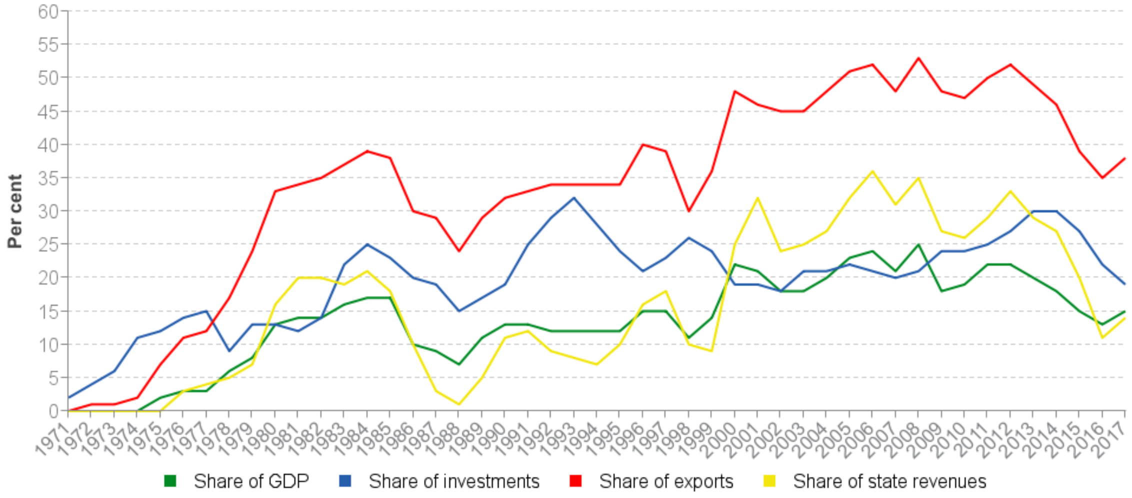

Figure 1. Macroeconomic indicators for the petroleum sector, 1971-2018

Source: https://www.norskpetroleum.no/en/framework/norways-petroleum-history/

Within the petroleum sector, the crude oil is the most important commodity in export and play an important role in Norwegian economy. In 2017, the total export value of crude oil is about, 210 billion NOK, represents 25% of total external trade in goods (norskpertolium.no, 2018). These facts and figures illustrate that the oil industry has significant weight in Norwegian economy, therefore the price movement of oil can arguably affect the macroeconomic indicators including consumer price index. On the upcoming sections we will examine weather this notion is empirically true.

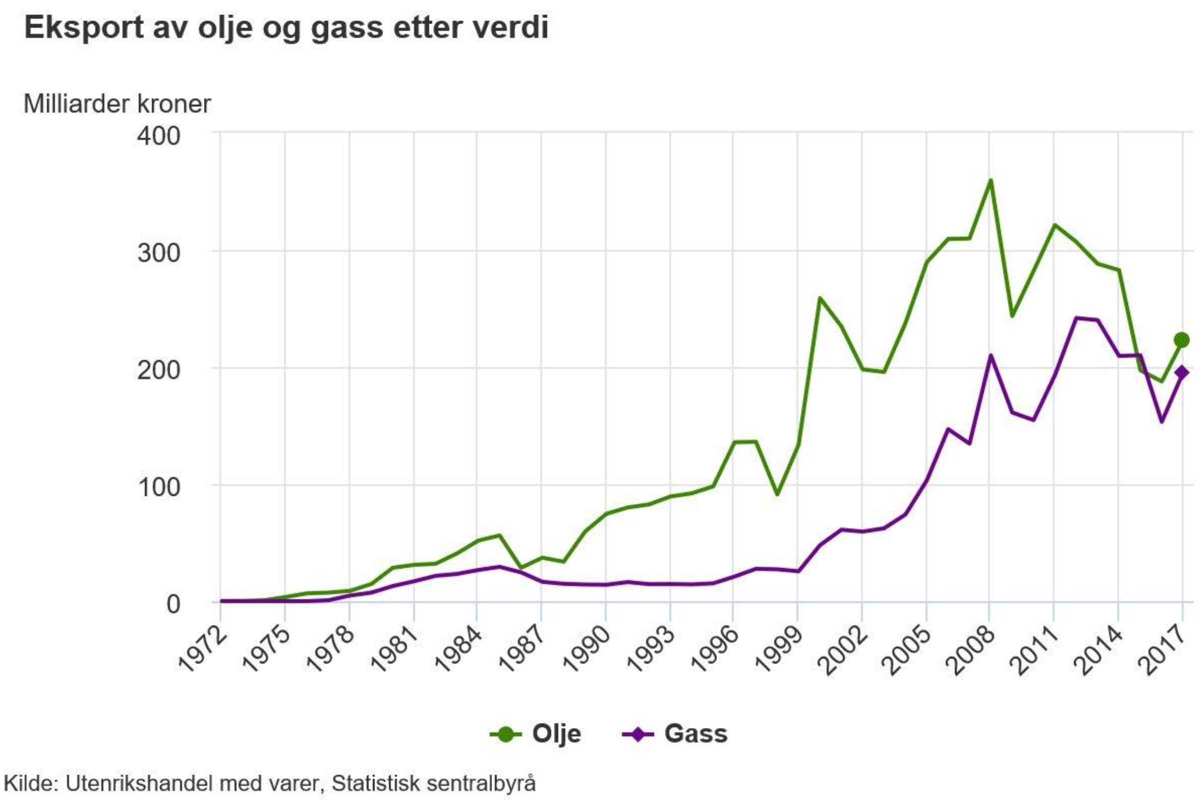

Figure 2. export of oil and gas by value

Source: https://www.ssb.no/nasjonalregnskap-og-konjunkturer/faktaside/norsk-naeringsliv#blokk-1

Data

After studying previous researches that discussed above, we have some insights about how to choose and develop data and methodology for our research question. As indicated in our topic, we are interested to study the effect of oil price change on consumer price inflation in Norway, particularly for the last decade. Therefore, oil price and inflation are the main variables in our study. However, we added some additional variables in order to analyze the effect more thoroughly. Because consumer price inflation is not an exogenous variable that only depend on international oil prices, there are too many factors than influence the inflation both directly and indirectly. Based on previous studies (Bjørnland , 2008) and our macroeconomic intuition, we assume that monetary policy and exchange rate of local currency can be considered important factors among them. Hence, we included two additional variables that represent these factors. Here are brief description about these variables and data collection.

Consumer price index (CPI)

The consumer price index is measure of change in average consumer prices of goods and services in a certain period. It often represents the rate of inflation. We gathered the consumer price index from the official site of Statistikk sentralbyrå (Statistic Norway). We used the monthly observations from the period January 2001 to January 2016. We have a sample of 180 observations. Since we are more interested in how inflation has changed over time than the actual rate of inflation, we calculated logarithmic change of monthly indexes and labeled it in our dataset as logCPI.

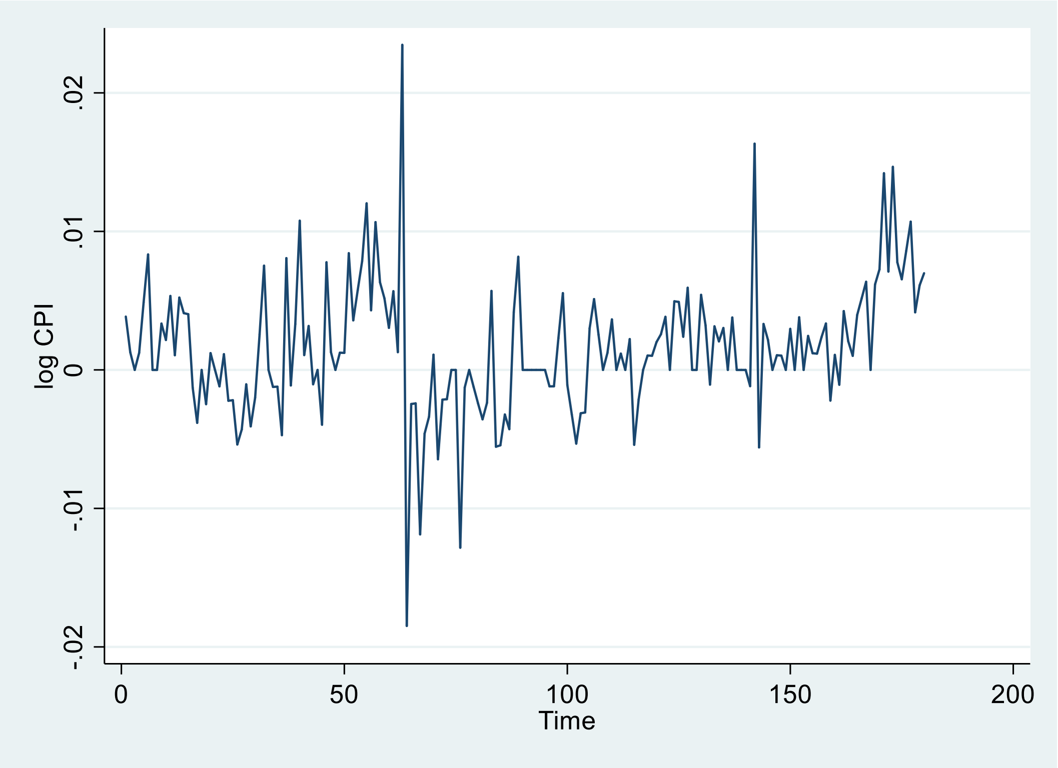

Figure 3. time series plot of logCPI

Source: Stata

Brent Crude

When it comes to international oil price, there are many different oil price benchmarks depending on its place of production and quality of the product. WTI crude oil (Nymax), Brent crude (ICE) and Crude oil (Tokyo) are the most common among them. We choose to use Brent crude as a proxy for oil price in our paper. Because Brent crude is extracted from the North Sea and most related to the Norwegian economy. We download the monthly Brent spot price from Bloomberg.com, a high profile financial information and data service. The sample period is between January 2001 and January 2016. We collected the monthly price and calculated logarithmic change. We labeled it as logCrude.

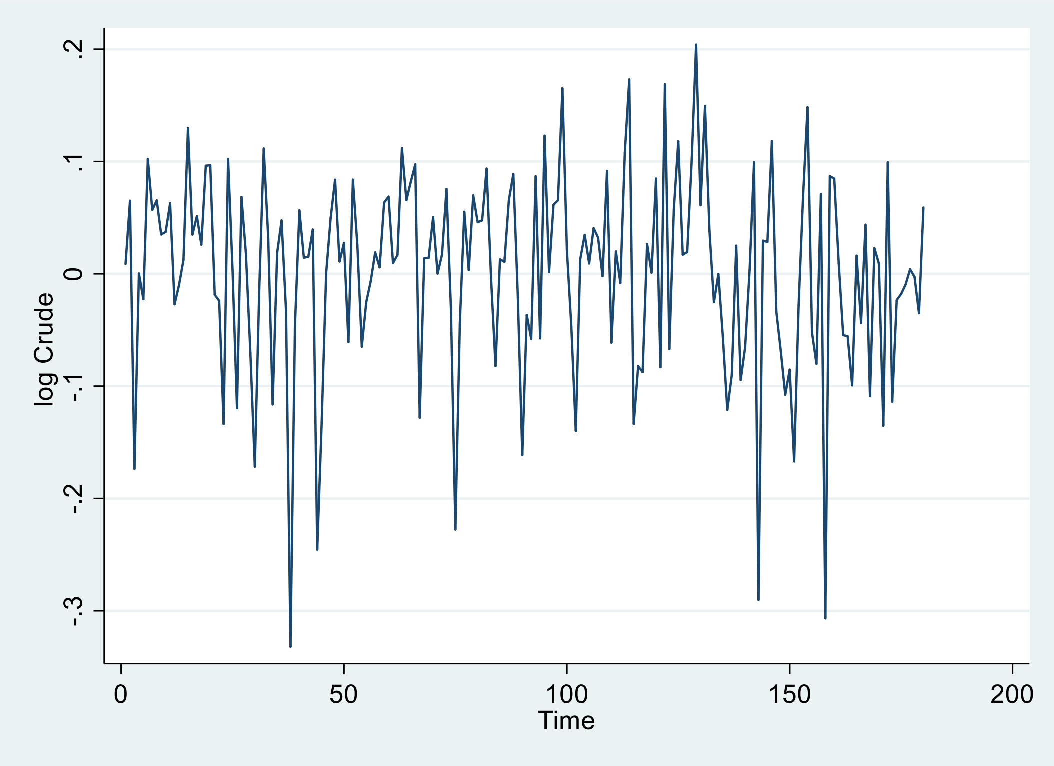

Figure 4. time series plot of logCrude

Source: Stata

Interest Rate

The monetary policy is arguably one of the most important factors than influences inflation. Policymakers have always tried to make effective monetary policies in order to regulate inflation. The interest rate that is set by central bank is the main instrument in monetary policy. In Norway, the key policy rate (styringsrente) is the interest rate on bank's reserves up to a specified quota in Norges Bank. Changes in Norges Bank's key policy rate will normally have a strong impact on the shortest money market rates and on bank's deposit and lending rates (NorgesBank.no 2018). Thus, we consider the Norges Bank's key policy rate is an appropriate proxy for monetary policy. We download monthly data from Norges Bank's database.

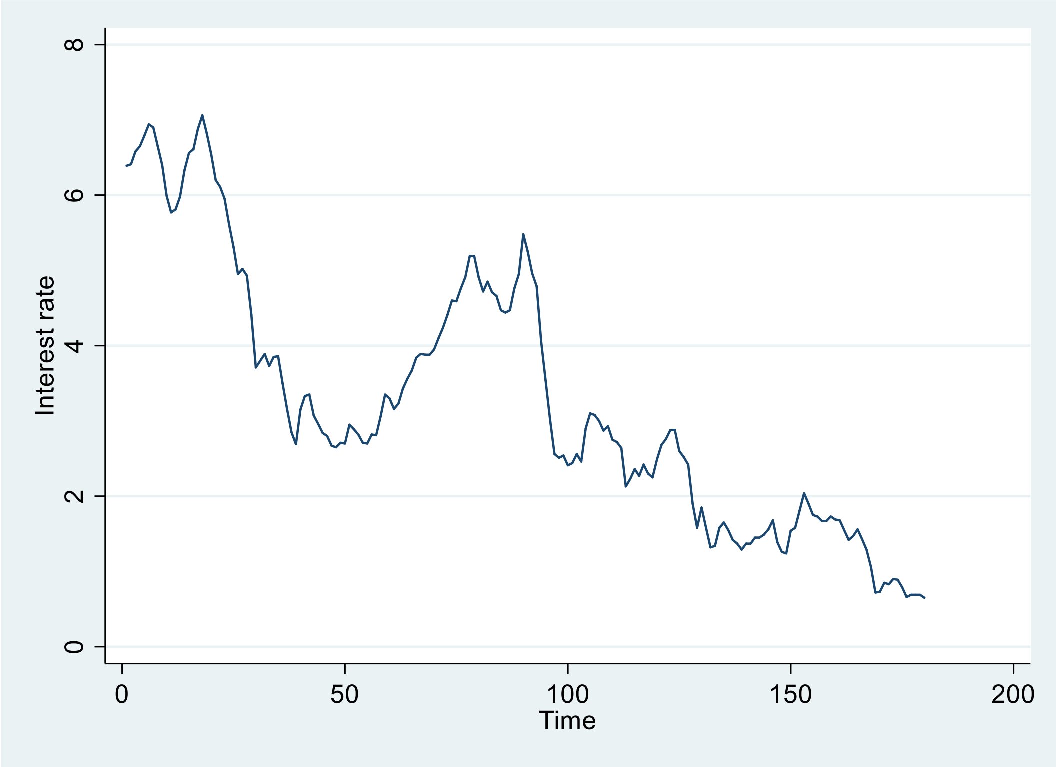

Figure 5. time series plot of interest rate

Source: Stata

Exchange rate

The last variable in our model is the exchange rate for Norwegian Krone (NOK). The exchange rate directly affected the capital flow and according to some economists, may also have direct effect on domestic inflation (Dornbusch, 1976). In addition to that, there are also some other studies suggested that Norwegian exchange rate and oil price have negative relationship in some extent, see (Bjørnland, 1998a) and (Akram (2004). Therefore we considered exchange rate between US dollar and Norwegian Krone is particularly important and should be included in our research model. We gathered the monthly observation for the exchange rate (NOK/USD) from Bloomberg for the same time period, also between 2001 and 2016.

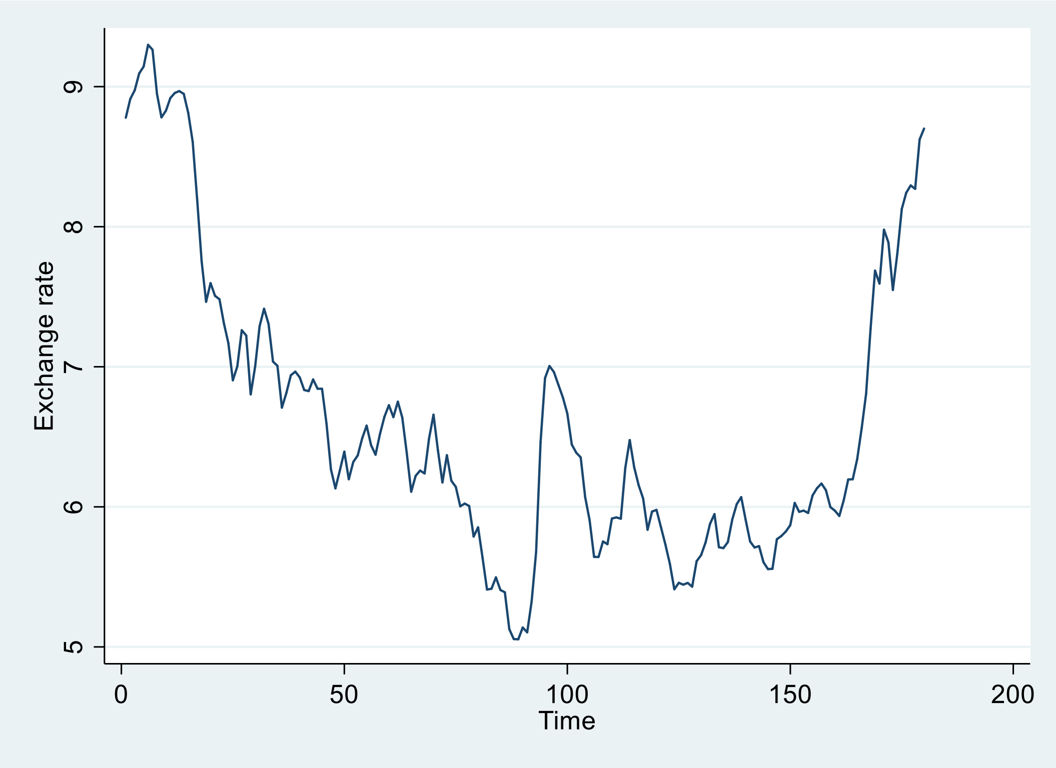

Figure 6. time series plot of exchange rate

Source: Stata

Methodology

As we discussed in previous section, the researchers applied different models and approaches to study the effect of oil price changes on inflation. The augmented Philipps curve framework and the restricted or structural vector autoregression model are two of the most frequently used among them. In our study, we chose to apply vector autoregression model.

Vector autoregressive model

When we speak about different models and tools for analyzing time series, the vector autoregression model is definitely come in to main focus in this subject. The methodology of vector autoregression is first introduced by Christopher A. Sims in his article (Macroeconomics and Reality) at "Econometrica" in January 1980. In the article, he criticized the existing strategies within econometrics related to macroeconomic time series analysis. He suggested vector autoregression (VAR) approach as an alternative for better understanding the relationships between macroeconomic variables (Sims 1980). The vector autoregression model is a generalization of autoregressive model that explain the variables in the model by an equation which included its own lag and lagged value of other variables and error term. The model provides framework for analyzing and forecasting multivariate time series.

The VAR is formally expressed as:

$$y_t = C + A_1 y_{t-1} + A_2 y_{t-2} + \ldots. + A_i y_{t-i} + e_t$$

in this equation, y_t represents the k×1vector of endogenous variables, where the i- period back in observation y_{t-i} is called i-th lag of y. C denotes the k×1vector of constants , also called exogenous variables, e_t is the k×1vector of error terms with zero mean [$E(e_t) = 0$] in a sample time period t = (1,2…T). A is the k×k coefficient matrix (Lütkepohl, 2011).

The process of VAR analysis has three main steps. The first step is about data transformation and model specification, such as unit root test and selecting optimal lag length and order. The second step is selecting appropriate model for further analysis, for example if data is stationary and integrated in order zero, then vector autoregression (VAR) model is appropriate for analysis, but if the data is non stationary and there happen to be cointegration among variables, a vector error correction model (VECM) should be applied. The last step is about implementing analysis and testing the robustness of results and interpreting them. This step includes stability test, innovation accounting and impulse response function…etc.

Stationary test

Applying VAR model requires that time series need to be stationary. It means that statistical properties of the time series are constant over time. If a time series are non-stationary, then we have problem of Spurious regressions in a regression process. The spurious regression occurs when for example two time series have a trend over time, also non-stationary, the regression of one variable on another could results a high correlation because of trending, even though they don't have actual correlation (Phillips & Perron, 1988).

In order to evaluate whether a time series are stationary or not, we will conduct a unit root test. If a time series have not unit root, also integrated at order zero I(0), then it indicates that time series are stationary. If a time series contain one unit root, it is integrated in order one I(1) and considered non-stationary. In this case, the time series have to be differenced to induce stationarity. If a time series have two unit root, indicating that it integrated in order two I(2) and we have to difference it twice.

There are several ways to conduct a unit root test. Augmented Dickey Fuller test (ADF) is one of the most commonly used approaches. In ADF, null hypothesis will be: H_0: series contains a unit root, and alternative hypothesis is: H_1: series are stationary (don't contain a unit root).

We conducted ADF test for all four variables – Brent spot price, CPI, Interest rate and NOK/USD exchange rate. The results from the test are following:

Variables	Test value	P-value	Status
Log.Crude	-6.4534	< 0.01	Stationary
Log.CPI	-6.5146	< 0.01	Stationary
Log.IR	-3.6	0.03511	Stationary
Log.EXR	-7.8676	< 0.01	Stationary

Table 2. results from ADF test. Conducted in Rstudio.

From the table, we can clearly see that null hypothesis should be rejected at 5% significance level. Both for Log.Crude, Log.CPI and Log.EXR have P-value lower then 0.01 and Log.IR has highest P-value among variables, but still lower than 0.05, therefore considered statistically insignificant. The results from ADF test indicates that all the variables are stationary and we are ready to estimate VAR.

Ordering of the variables in VAR

When we construct a VAR model, it is important to construct it with appropriate ordering. Because the ordering of the variables in the VAR, can play critical role on the results of impulse response functions. Cholesky ordering is the generally accepted way of ordering of the variables. In Cholesky ordering, we order the variables based on their exogeneity, which means the most exogenous variable – the variable that not affected by development of other variables in the model should take the first place. Then comes the second variable which is less exogenous than the first variable and more exogenous than other variables and so on. In order to determine the degree of exogeneity of the variables, we used basic economic understanding and suggestions of the previous studies that dealt with similar situations.

We applied an small and open economy assumption for Norwegian economy as the case for other studies (Bjørnland 2008). According to this assumption, it is plausible to assume that international oil price will not be affected by macroeconomic indexes of Norwegian economy. Therefore, it is reasonable to place the oil price as first variable. When it comes to inflation as represented by consumer price index, it can arguably come after oil price, but before monetary policy and exchange rate. Because as a small, open economy that huge portion of export and economic activities, as well as national income are related to oil and gas, the economic activities will be affected by oil price and thus both production and consumer prices (in which extent is a subject of further discussion). The monetary policy then will be introduced and implemented as a reaction to the change in the economic environments, namely keep the inflation under control in this case. It will certainly take some time to affect inflation through monetary policy. Therefor interest rate comes after inflation (CPI). This is also the common assumption made by previous studies (see Christiano et al 1999) and (Bjørnland 2008).

The exchange rates are directly affected by interest rates. Some studies also suggest that Norwegian exchange rates was influenced by oil prices (Akram 2004). So, it is plausible to place the exchange rates at last.

Lag length selection

Another important procedure we have to notice when we use a VAR approach is the selection of lag length of the variables. If the lags are too short, it may cause autocorrelation in error terms and if there are too large number of lags, then it leads to insignificant results and it will press the degree of freedom. We conducted a pre-estimation lag order (length) selection statistics in Stata. The test results are shown in Appendix (). We determined the appropriate lag length based on some information criteria applied in test. The FPE (final prediction error) and AIC (Akaike information criterion) suggested the lag length of 3, while HQIC (Hannah-Quinn Information Criterion) and SBIC (Schwarz's Bayesian information criterion) suggest one and zero lag respectively. We decided to select three lags because it is selected by both AIC and FPE and AIC is more suitable our sample size (Xu, 2010).

```
. varsoc logCPI logCrude logEXR logIR, maxlag(12)

   Selection-order criteria
   Sample:  13 - 180                                Number of obs      =       168
```

lag	LL	LR	df	p	FPE	AIC	HQIC	SBIC
0	1769.22				8.8e-15	-21.0145	-20.9844	-20.9402*
1	1792.15	45.855	16	0.000	8.1e-15	-21.097	-20.9461	-20.7251
2	1833.9	83.511	16	0.000	6.0e-15	-21.4036	-21.1319*	-20.7342
3	1857.37	46.922	16	0.000	5.5e-15*	-21.4924*	-21.1	-20.5255
4	1862.3	9.8653	16	0.874	6.2e-15	-21.3607	-20.8475	-20.0962
5	1874.83	25.06	16	0.069	6.5e-15	-21.3194	-20.6855	-19.7574
6	1884.36	19.061	16	0.266	7.1e-15	-21.2424	-20.4877	-19.3829
7	1895.11	21.507	16	0.160	7.5e-15	-21.1799	-20.3045	-19.0229
8	1909.98	29.741*	16	0.019	7.7e-15	-21.1665	-20.1703	-18.7119
9	1921.66	23.351	16	0.105	8.2e-15	-21.115	-19.9981	-18.3629
10	1926.63	9.939	16	0.870	9.4e-15	-20.9837	-19.746	-17.9341
11	1934.16	15.065	16	0.520	1.1e-14	-20.8829	-19.5244	-17.5358
12	1944.31	20.305	16	0.207	1.2e-14	-20.8132	-19.3341	-17.1686

```
   Endogenous:  logCPI logCrude logEXR logIR
    Exogenous:  _cons
```

Table 3. Lag order selection results

Source: Stata

Analysis & Results

After data transformation and model specification, we are finally ready to run our VAR model. The vector autoregression model carried out by Stata. The VAR treats all variables as endogenous, but however we also conducted another VAR analysis where oil price selected as exogenous variable. The order of the variables and lag length were selected based on the methodology and reasoning which discussed in previous part.

Short run analysis

The results from the VAR model are shown in table 4 give us some insights about short run effects of oil price. The reason that the effect is considered to be short run is first, the variables are not cointegrated and second, there are only three lags included.

According to the results from model, we can conclude that there are no significant effect of oil price on inflation in the first lag, because p-value is greater than 0.05, so the coefficient is statistically insignificant. Possible explanation might be that the change in oil price will not immediately affect the inflation, it may take some time to pass through (1-2 months). We discovered a negative effect on inflation in the second lag order. But the effect is small, 10% increase (or decrease) in oil price causes 0.08% decrease (or increase) in consumer price inflation. the p-value is 0.009, also less than 5%, therefore, we consider this effect is statistically significant. Except this, we didn't find other significant effect of oil price change on other variables, namely exchange rate and interest rates.

The percentage change in consumer price index (CPI) can partly be explained by change in oil price as discussed above and strongly dependent on its own lag, which is not surprising, because inflation in a certain period can determine the expected inflation in next period and this hugely affects the actual rate of inflation. another interesting point that model indicated is the relationship between inflation and interest rate in the short run. According to the model, the change in inflation can in fact affect the interest rate, but we didn't discover any significant impact made by change in interest rate on inflation. This leads some skepticism about the effectiveness of the monetary policy in the short run.

. var logCrude logCPI logIR logEXR, lags(1/3)

Vector autoregression

Sample: 4 - 180		Number of obs	= 177
Log likelihood =	1963.793	AIC	= -21.60218
FPE =	4.88e-15	HQIC	= -21.22375
Det(Sigma_ml) =	2.71e-15	SBIC	= -20.66907

Equation	Parms	RMSE	R-sq	chi2	P>chi2
logCrude	13	.087471	0.0688	13.07197	0.3638
logCPI	13	.00371	0.4599	150.7305	0.0000
logIR	13	.060524	0.1652	35.02663	0.0005
logEXR	13	.003148	0.1688	35.9368	0.0003

	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
logCrude						
logCrude						
L1.	.1046213	.0737439	1.42	0.156	-.039914	.2491567
L2.	-.0083098	.0747118	-0.11	0.911	-.1547422	.1381227
L3.	-.1269967	.0754924	-1.68	0.093	-.2749591	.0209657
logCPI						
L1.	-3.869625	1.633339	-2.37	0.018	-7.070911	-.6683393
L2.	.2115826	1.422039	0.15	0.882	-2.575562	2.998727
L3.	2.281376	1.477757	1.54	0.123	-.6149741	5.177725
logIR						
L1.	-.0964595	.1086248	-0.89	0.375	-.3093602	.1164412
L2.	-.0499576	.1054104	-0.47	0.636	-.2565582	.1566429
L3.	.1198814	.1056673	1.13	0.257	-.0872226	.3269855
logEXR						
L1.	-.8360414	2.076796	-0.40	0.687	-4.906487	3.234404
L2.	1.592064	2.100501	0.76	0.448	-2.524843	5.708971
L3.	2.75255	2.327725	1.18	0.237	-1.809707	7.314808
_cons	.0030584	.0073962	0.41	0.679	-.0114378	.0175546
logCPI						
logCrude						
L1.	.001142	.0031278	0.37	0.715	-.0049883	.0072724
L2.	-.0083058	.0031688	-2.62	0.009	-.0145166	-.002095
L3.	-.0045049	.0032019	-1.41	0.159	-.0107806	.0017708
logCPI						
L1.	.1768797	.0692767	2.55	0.011	.0410998	.3126596
L2.	.2455875	.0603146	4.07	0.000	.1273731	.363802
L3.	.1651249	.0626778	2.63	0.008	.0422786	.2879711
logIR						
L1.	-.001502	.0046072	-0.33	0.744	-.010532	.007528
L2.	-.0016326	.0044709	-0.37	0.715	-.0103954	.0071302
L3.	.0022624	.0044818	0.50	0.614	-.0065218	.0110465
logEXR						
L1.	.0370112	.0880856	0.42	0.674	-.1356333	.2096558
L2.	.7284563	.089091	8.18	0.000	.5538411	.9030715
L3.	-.5093879	.0987285	-5.16	0.000	-.7028923	-.3158835
_cons	.0006171	.0003137	1.97	0.049	2.21e-06	.0012319
logIR						
logCrude						
L1.	-.0961573	.0510257	-1.88	0.059	-.1961657	.0038512
L2.	.0357161	.0516954	0.69	0.490	-.0656051	.1370372
L3.	-.0116072	.0522355	-0.22	0.824	-.113987	.0907725
logCPI						
L1.	-2.498787	1.130158	-2.21	0.027	-4.713855	-.2837182
L2.	2.057274	.9839523	2.09	0.037	.128763	3.985785
L3.	-1.032212	1.022505	-1.01	0.313	-3.036286	.9718612
logIR						
L1.	-.1166257	.0751609	-1.55	0.121	-.2639383	.0306869
L2.	-.254523	.0729367	-3.49	0.000	-.3974764	-.1115697
L3.	.0619797	.0731144	0.85	0.397	-.081322	.2052814
logEXR						
L1.	1.602178	1.436999	1.11	0.265	-1.214288	4.418645
L2.	.0202638	1.453402	0.01	0.989	-2.828351	2.868879
L3.	1.799476	1.610625	1.12	0.264	-1.357291	4.956242
_cons	-.0148374	.0051176	-2.90	0.004	-.0248678	-.004807
logEXR						
logCrude						
L1.	-.0005153	.0026544	-0.19	0.846	-.0057178	.0046872
L2.	-.0008107	.0026892	-0.30	0.763	-.0060815	.0044601
L3.	-.0027416	.0027173	-1.01	0.313	-.0080675	.0025842
logCPI						
L1.	-.0206386	.0587915	-0.35	0.726	-.1358679	.0945907
L2.	.0564899	.0511858	1.10	0.270	-.0438325	.1568123
L3.	.0503187	.0531914	0.95	0.344	-.0539345	.1545719
logIR						
L1.	.0036683	.0039099	0.94	0.348	-.003995	.0113316
L2.	.0030016	.0037942	0.79	0.429	-.004435	.0104381
L3.	.0032652	.0038035	0.86	0.391	-.0041895	.0107198
logEXR						
L1.	.1985409	.0747536	2.66	0.008	.0520264	.3450553
L2.	.1401055	.0756069	1.85	0.064	-.0080813	.2882924
L3.	.1159819	.0837858	1.38	0.166	-.0482352	.2801989
_cons	.0001192	.0002662	0.45	0.654	-.0004026	.000641

.

Table 4. Results from VAR model

Source: Stata

Granger causality test

Granger causality test was introduced by Granger, C. W. J (1980), it is a statistical hypothesis test that tests one variable can be the cause of another variable. In the context of multivariate analysis, by fitting Grander causality in our vector autoregression model, we can formulate the null hypothesis for example as: H_0: there are no short run causality from lagged variable logCrude to logCPI. In other words, change oil price and its lags jointly does not cause change in inflation. in table 5, we see the results from a Granger causality test performed by Stata. Results are indicated that when logCrude is excluded while logCPI is the dependent variable, the p-value is 0.02, also less then 5%. In this case, we will reject the null hypothesis, this means change in oil price can in fact causes change in inflation. according to the results, the change in exchange rate can also explain changes in inflation (p-value is zero). We can also reject the null hypothesis that there are no short run causality from all other variables (oil price, interest rate and exchange rate) to CPI. It means change in oil price, interest rate and exchange rate are jointly explaining the change in inflation.

However, there are no short run causality from any other variables, jointly or separately to oil price, which is also plausible that as a small, open economy, the economic conditions in Norway does not significantly affect the international oil price.

Table 5. Granger causality test

Source: Stata

```
. vargranger

   Granger causality Wald tests
```

Equation	Excluded	chi2	df	Prob > chi2
logCrude	logCPI	6.4687	3	0.091
logCrude	logIR	3.1003	3	0.376
logCrude	logEXR	2.4105	3	0.492
logCrude	ALL	10.787	9	0.291
logCPI	logCrude	9.8151	3	0.020
logCPI	logIR	.6502	3	0.885
logCPI	logEXR	82.547	3	0.000
logCPI	ALL	95.763	9	0.000
logIR	logCrude	3.8214	3	0.281
logIR	logCPI	10.234	3	0.017
logIR	logEXR	3.2143	3	0.360
logIR	ALL	18.199	9	0.033
logEXR	logCrude	1.2429	3	0.743
logEXR	logCPI	2.5441	3	0.467
logEXR	logIR	1.6108	3	0.657
logEXR	ALL	4.9095	9	0.842

Model diagnostics and tests

It is always useful to apply some diagnostic techniques and tests in order to examine stability, robustness and other limitations of the model. There are some tests that can help us to do that.

Stability test – we run a stability test to check the stability condition of VAR estimates. VAR satisfies the stability condition if all roots (Eigenvalues) is inside the unit circle. We can clearly see from figure 7 that there are no roots outside the unit circle, thus, over model is stable.

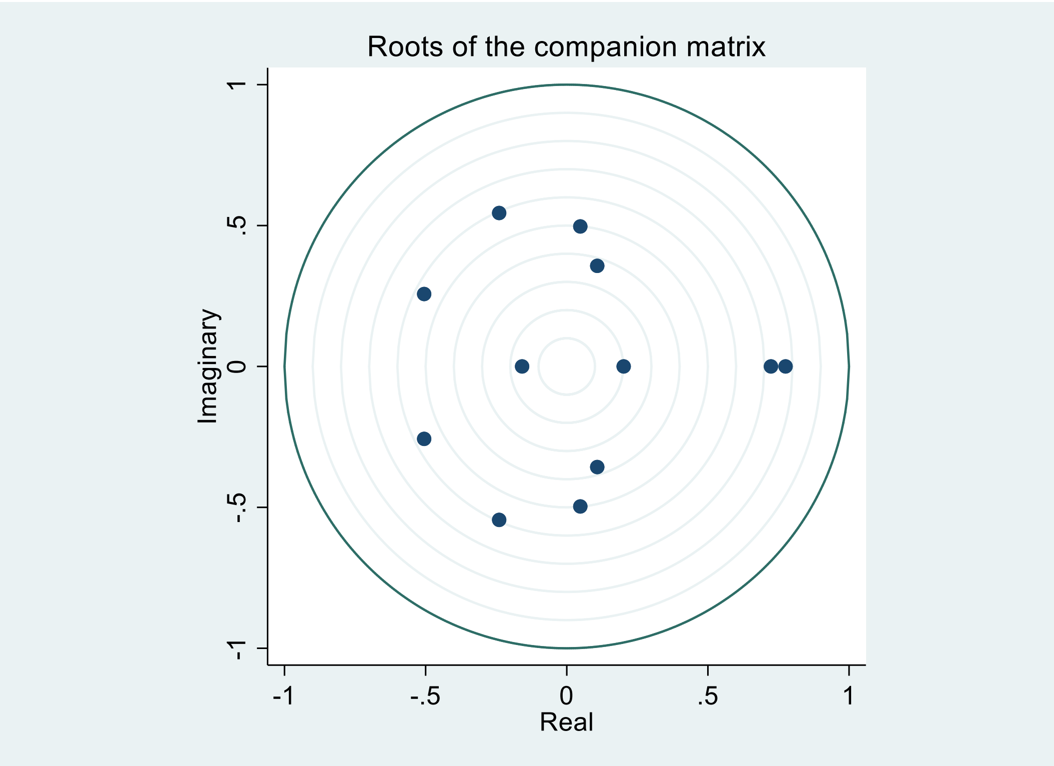

Figure 7. the stability graphs

Source: Stata

Test for autocorrelation – we tested the residual autocorrelation by applying Lagrange multiplier test. The null hypothesis from the test is H_0: there are no autocorrelation at lag order. The results from the Lagrange multiplier test indicates that, we are failed to reject the null hypothesis. It means that there is no autocorrelation.

Lagrange-multiplier test

lag	chi2	df	Prob > chi2
1	9.8686	16	0.87340
2	11.5146	16	0.77667
3	20.6325	16	0.19307

Table 6. Lagrange multiplier test

Source: Stata

3). Test for normally distributed disturbance – in this test we will examine whether the residuals normally distributed. The Jarque-Bera test was applied. The null hypothesis will be H_0: residuals are normally distributed. But in this case, we rejected the null hypothesis since p-value of all the variables are zero. Hence, we concluded that residuals are not normally distributed.

Table 7. Jarque-Beta test

Source: Stata

Jarque-Bera test

Equation	chi2	df	Prob > chi2
logCrude	34.524	2	0.00000
logCPI	32.520	2	0.00000
logIR	142.050	2	0.00000
logEXR	3.5e+04	2	0.00000
ALL	3.5e+04	8	0.00000

Conclusion

In this thesis, we wanted to answer the question about how changes in oil price has affected the inflation in Norway in recent years. In the beginning, we introduced some previous studies that are relevant and insightful for our topic. We presented some of the main conclusions that previous literature has offered and how it relates to our research question. We also discussed how international oil market and Norwegian oil industry has developed over time and how they are connected to each other.

We collected monthly observation of oil price, consumer price index, interest rate and exchange rates. We then modified and transformed the data to apply for our analysis. We chose vector autoregression (VAR) model for our research method since it is most commonly used in empirical works related to macroeconomic time series analysis. We tested the stationarity of the data, selecting lag length and did other preparational work before we run VAR.

We applied vector autoregression model, Granger causality test and some other diagnostics and tests. By analyzing and discussing the results, we formed some conclusions for our research question. First, the change in oil price arguably can cause some change in inflation in the short run. However, the effect is very limited. The results from VAR shows that 10% increase in oil price can decrease the inflation rate by 0.08%, only in the second lag. Some of the previous studies reported that oil price shock will actually contributed to a higher inflationary environment in the net oil importing economies. As a net oil exporter, Norway is expected to do the opposite, so the results are plausible. Second, even though our model is stable, and no autocorrelation has discovered, there are still some limitations and weaknesses in the model, according to Jarque-Bera test, the residuals are not normally distributed. In addition to that our sample period is relative short comparing with other empirical studies.

In conclusion, there are very limited negative effect of oil price fluctuation on Norwegian consumer price inflation has been detected. But, we need a more robust and thorough analysis to suggest this proposition.

Reference:

Akram, Q.F. (2004), "Oil prices and exchange rates - Norwegian evidence", Econometric Journal, December 2004, , Volume7, Issue2 Pages 476-504

Christiano, L.J., Eichenbaum, M. and C.L. Evans (1999), "Monetary Policy Shocks: What Have we Learned and to What End?," in J.B. Taylor and M. Woodford, eds., Handbook of Macroeconomics. Volume 1A. n., pp. 1-48.

Christopher A Sims, (1980), "Macroeconomics and reality", Econometrica, Vol. 48, No. 1, Ja

Dr. Siok Kun Sek (2017) "Impact of oil price changes on domestic price inflation at disaggregated levels: Evidence from linear and nonlinear ARDL modeling", Energy (2017) 204-217

"General Information - Organization of the Petroleum Exporting Countries" (2012), available at: https://www.opec.org/opec_web/static_files_project/media/downloads/publications/GenInfo.pdf

Granger, C.W.J. (1980). "Testing for causality: A personal viewpoint". Journal of Economic Dynamics and Control. 2: 329–352

Hilde C. Bjørnland 1998. "Economic Fluctuations in a Small Open Economy – Real versus Nominal Shocks", Discussion Papers No. 215, March 1998 Statistics Norway, Research Department

Hilde C. Bjørnland (2008), "Oil price shocks and stock market booms in an oil exporting country", Scottish Journal of Political Economy, Volume56, Issue2, Pages 232-254

Jimenez-Rodriguez and Sanchez (2005) "Oil Price Shocks and Real GDP Growth – Empirical Evidence for Some OECD Countries", Applied Economics, 2005, vol. 37, issue 2, 201-228

José De Gregorio, Oscar Landerretche, and Christopher Neilson (2007). "Another Pass-Through Bites the Dust? - Oil Prices and Inflation", Economía, Brookings Institution Press, Volume 7, Number 2, Spring 2007, pp. 155-208

Luis J. Álvarez, Samuel Hurtado, Isabel Sánchez and Carlos Thomas (2010) "The impact of oil price changes on Spanish and euro area consumer price inflation", Economic Modelling 28(1-2):422-431

Lütkepohl H. (2011) Vector Autoregressive Models. In: Lovric M. (eds) International Encyclopedia of Statistical Science. Springer, Berlin, Heidelberg

Mark A. Hooker (2002) "Are Oil Shocks Inflationary?: Asymmetric and Nonlinear Specifications versus Changes in Regime", Journal of Money, Credit, and Banking, The Ohio State University Press, Volume 34, Number 2, May 2002, pp. 540-561

Michael LeBlanc & Menzie D. Chinn (2004) "Do High Oil Prices Presage Inflation? The Evidence fromG-5 Countries", Santa Cruz Department of Economics, Working Paper Series

"Norway's petroleum history" (2018), available at:

https://www.norskpetroleum.no/en/framework/norways-petroleum-history/

"Our Mission – International Energy Agency" (2018), available at:

https://www.iea.org/about/ourmission/

Olivier J. Blanchard, Jordi Gali (2007) "The Macroeconomic Effects of Oil Shocks, Why are the 2000s So Different from the 1970s?", NBER Working Paper No. 13368, Issued in September 2007, Revised in November 2007

Peter C. B. Phillips & Pierre Perron (1988) Testing for a unit root in time series regression , Biometrika, Volume 75, Issue 2

(Key policy rate – Norges Bank" (2018), available at:

https://www.norges-bank.no/en/Monetary-policy/Key-policy-rate/

Rudiger Dornbusch, "Expectations and Exchange Rate Dynamics," Journal of Political Economy 84, no. 6 (Dec., 1976): 1161-1176.

Shiu Sheng Chen (2008) "Oil price pass-through into inflation", Energy Economics 31 (2009) 126–133

Xu, Changjiang, "Model Selection with Information Criteria" (2010). *Electronic Thesis and Dissertation Repository*. 46