Oil Price Shocks and Stock Returns:
Empirical Evidence for the G-7 and Norway

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Executive summary

Following the oil price shocks during the 1970s there was a large increase in the amount of literature concerning the impact of oil price shocks on the aggregate economy. However, the same extent of literature does not exist on the impact of oil price shocks on stock markets. In addition, the literature that do exist do not apply the recent oil price shocks in previous to and following the recent financial crisis. For this reason, I have in this thesis examined the impact of oil price shocks on real stock returns of G-7 and Norway.

To analyze the impact of oil price shocks, a vector autoregression (VAR) model is employed for the period between 1986M01 and 2010M12, where the impulse response and the variance decomposition are estimated. The VAR model contains four variables; interest rate, oil price, industry production and real stock return. The oil price is measured both by the real world oil price and the real national oil price. Furthermore, three different oil price shocks are defined which are; linear, non-linear and asymmetric oil price shock. It is the impact of these oil price shocks which are examined in relations to the real stock returns. Finally, the results are investigated through different robust tests.

There is provided an overview of the major oil price shocks since the 1970s until 2010, and the link between oil price movements and stock markets is discussed. The examined countries are the G-7 (Canada, France, Germany, Italy, Japan, the UK and the US) and Norway. Further, the countries are different in respective to their dependency on oil, as Canada and Norway are net oil exporters and France, Germany, Italy, Japan, the UK and the US are net importers of oil.

The empirical results show little evidence of an impact of linear oil price shock on real stock returns of the G-7 and Norway. France, Germany and Norway are the only countries which yield a statistically significant impact on real stock returns in the same month or within one month, when the oil price is measured by the real world oil price. The results are less significant when the oil price is measured by real national oil prices. Despite the insignificant results, the role of oil in the respective countries seems to be an important factor for whether the responses of real stock returns are positive or negative, with the exception of Japan.
The second analysis investigates the impact of asymmetric oil price shocks on real stock returns. When asymmetric oil price shocks is measured by the real world oil price, the results of the variance decomposition indicate that an increase in oil price have a more powerful impact on the net importing countries and Norway, while for Canada and Japan the impact of a decrease have a more powerful effect. In contrast to these results the chi-square test indicate no evidence of an impact of asymmetric oil price shocks on real stock returns of the G-7 and Norway.

The final evidence indicates that non-linear oil price shocks have an impact on real stock returns of the G-7 and Norway. The empirical results are statistically significant for 5 out of the 8 countries when the oil price is measured by the real world oil price. The countries all have in common that they are net oil importers. Canada is the only country that responds insignificantly positive to a non-linear oil price shock. When the oil price is measured by the real national oil price, the results are less significant, and Japan and Norway are the only countries that respond insignificantly negative.

Overall, little evidence is found of an impact of oil price shocks on real stock returns, however the individual country’s dependency of oil seem to have a great impact on the response of real stock returns.
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1. Introduction

Up until the 1970s the oil price was fairly steady. However, in 1973, during the Yom Kippur war, the Organization of Petroleum Exporting Countries (OPEC) announced an oil price embargo which caused the oil price to quadruple within few months. Following the oil price shock most economies experienced an economic recession, and the crude oil has since this event become more and more essential to the world economy (Sørensen, 2009). As reviewed by the International Energy Agency (2008), oil is by far the most important source of energy in the world, and in addition crude oil is the most actively traded commodity in the world (US Department of Energy, 2006).

Hamilton (1983) was among the first to examine the relationship between the oil price and the economy. He found that post World War II all but one of the US recessions were preceded by a large increase in the oil price. Subsequent to his paper, there has been conducted a considerable amount of literature studying the relationship between the oil price and the economy using alternative data and estimation procedures. Among these are papers by Burbridge and Harrison (1984), Gisser and Goodwin (1986) and more. In addition to these, studies by Mork (1989) and Mork, Olsen and Mysen (1994) examine the possibility of an asymmetric relationship between oil price shocks and the economy. Two more papers by Hamilton (1996, 2003) analyze if there is a non-linear relationship between oil price changes and GDP in the US. The majority of the mentioned papers focus on the US economy, but more recent literature like Eika and Magnussen (2000) Cunado and de Gracia (2003) and Jimenez-Rodriguez and Sanchez (2005) extends the research to Europe and other industrialized countries.

Despite the large amount of studies made on the relationship between the oil price and the economy, relatively few studies have examined the relationship between the oil price and stock markets. To the authors knowledge the paper by Jones and Kaul (1996) is the first to analyze the influence of oil price shocks on the stock market. Huang et al. (1996) found no evidence of correlation between oil futures return and the US stock market. Moreover, a linear and asymmetric relationship between oil price shocks and the US stock return were first examined by Sadorsky (1999). Gjerde and Sættem (1999) and Papaetrou (2001) extend the research to Norway and Greece, respectively. Magyerehe (2004) is the only one to employ the analysis for 22 emerging stock markets. Park and Ratti (2008) employ an empirical research to find if there exist a
linear, non-linear and asymmetric relationship between oil price shocks and stock markets in the US and 13 European countries. To a great extent the same analysis were conducted by Cong et al. (2008) on the Chinese stock market. Ono (2011) examines the impact of oil prices on stock returns for Brazil, China, India, and Russia (BRIC), testing for linear, non-linear and asymmetric relationships.

The purpose of this thesis is to analyze the impact of oil price shocks on the financial markets in the G-7 countries and Norway. There are three different aspects of the impact on stock returns that will be investigated; a linear, non-linear and asymmetric relationship between the oil price shocks and stock markets. The three aspects will be analyzed by employing an unrestricted vector autoregression (VAR) model with monthly data for the period between 1986M01 and 2010M12. The basic VAR model employed in the thesis contain four variables: interest rate, real oil price, industry production and real stock return.

1.1. Problem Statement

A large body of literature has investigated the impact of oil price shocks on the macroeconomy. Despite this fact, relatively few studies have examined the relationship between oil price shocks and stock markets. One reason for the limited numbers of studies might be the relatively short history of a volatile oil price. However, the increasing role of stock markets in the economy has stimulated to more research on the relationship between the oil price and stock markets. Furthermore, the literature that do exist on the relationship between oil price shocks and stock markets, are often investigating the US. It is therefore also interesting to examine the impact on the stock markets in other countries. Another limitation within the existing literature is that, to the author’s knowledge, the only paper that includes observations from the period between 2005 and 2010 is by Ono (2011). They then fail to include a period of high economic growth with an extremely volatile oil price, which also includes two fairly recent oil price shocks.

On the basis of earlier studies this thesis will add to the limited number of studies and the purpose of is to analyze the relationship between oil price shocks and stock markets in the G-7 countries (Canada, France, Germany, Italy, Japan, the UK and US) and Norway between 1986M01 and 2010M12. The analysis is based upon the following problem statement:
Do oil price shocks impact the stock returns in the G-7 and Norway?

The following three sub-questions will assist in answering the problem statement:

1. Do linear oil price shocks have an impact on stock returns of the G-7 and Norway?
2. Do non-linear oil price shocks have an impact on stock returns of the G-7 and Norway?
3. Do asymmetric oil price shocks have an impact on stock returns of the G-7 and Norway?

The outcome of this thesis will hopefully make a qualitative contribution to the limited literature made on the impact of oil price shocks on stock returns.

1.2. Applied methodology

The problem statement will be answered by conducting an empirical analysis. Previous papers that analyze this subject take use of alternative data and estimation procedures. However, the main body of literature employs an unrestricted vector autoregression model (VAR), which will also be employed in this thesis. The statistical method and its specifications will be described in more detail in section 5.

1.3. Delimitations

When examining the impact of oil price shocks on stock markets, the analysis will be limited to the G-7 (Canada, France, Germany, Italy, Japan, the UK and the US) and Norway. The reason for choosing particularly these countries are the access of reliable data, and their high dependency of oil as a commodity. Furthermore, there exist several different benchmark for the oil price, for instance Crude Oil-Brent Dated FOB US$/BBL, Dubai Crude Oil, Crude Oil WTI, OPEC Basket Crude oil price and so on. According to Driesprong (2008), despite the different benchmark for the oil price they are highly correlated, and for this reason I will only employ the Crude Oil-Brent Dated FOB US$/BBL in this thesis. Finally, in order to make the analysis comparable to other important studies, I will apply mostly the same models as in the papers by Sadorsky (1999), Park and Ratti (2008), Cong et al. (2008) and Ono (2011).

This thesis examines the impact of oil price shocks to stock markets, using an unrestricted VAR model. As mentioned there are three types of relationship that are
investigated, which are a linear, non-linear and asymmetric relationship. For this reason, there will not be made any further investigation of the effect of volatility of the oil price to stock markets, following the popular definition of a scaled real oil price change by Lee, Ni and Ratti (1995). Neither will there be made any analysis separating oil price shocks into demand and supply shocks, and to how these different types of shocks might have different effects on stock markets, as documented by Kilian (2006, 2009).

1.4. Structure of the thesis

The structure of the thesis is presented in figure 1. The first chapter gives a short introduction to the background of the chosen subject and the problem statement. Chapter two studies the theoretical background, and chapter three gives an overview of the most important literature. These first three parts leads to the stated hypothesis in chapter four. The next two chapters are answering the hypothesis, with chapter five explaining the statistical methodology that is employed. In chapter six the empirical analysis is conducted. Finally, the conclusion and further research is given in chapter seven.
Figure 1: Structure of the thesis

INTRODUCTION
- Problem statement
- Methodology
- Delimitations
- Structure of the thesis

THEORY
- Definition of oil price shocks
- The variability in oil price
- The link between oil price movements and stock markets
- The dependency of oil in the G-7 and Norway

LITERATUR REVIEW
- The impact of oil price shocks on economic activity
- The impact of oil price shocks on stock markets

HYPOTHESIS

STATISTICAL METHODOLOGY
- Stationarity in time series
- Cointegration
- Vector autoregression

EMPIRICAL ANALYSIS
- Data description
- Descriptive statistics
- Time series analysis
- Vector autoregressive models
- Residual tests
- Discussion

CONCLUSION AND FURTHER RESEARCH
2. Theory

2.1. Definition of oil price shocks

Following the seminal article by Hamilton (1983) there has been developed extensive literature on the topic of oil price shocks, and several different definitions of oil price shocks has emerged. Recently, following the work of Killian (2006) the literature has moved in two different directions, which are described below.

The first perspective focuses on the responses in output to oil price movements. The paper by Hamilton (1983) was among the first to study impact of exogenous oil price shocks on the economy. His research showed that the majority of US recessions were caused by large increases in oil price. Hamilton (1983) used the log difference of nominal oil price (linear specification) to define an oil price shock. The definition has become popular, and is used in a vast part of the literature both on the impact of oil price shocks on the economy, as well as the impact on the stock market.

Mork (1989) extended Hamilton’s analysis and found a weaker relationship between oil prices and output. However, he also concluded that if positive and negative movements in the oil price were treated as separate variables, the relationship became statistically significant. This result suggested that the oil price shock should be defined as oil price increases and oil price decreases, and are characterized as an asymmetric oil price shock.

Lee, Ni and Ratti (1995) on the other hand, argue “that an oil shock is likely to have greater impact in an environment where oil prices have been stable than in an environment where oil price movement has been frequent and erratic” (Lee, Ni & Ratti, 1995, p. 3). Further, they argue that in periods with high volatility in the oil price, the current oil price contains little information about the future and is often soon reversed.

Lee, Ni and Ratti (1995, p. 4) defines a scaled specification of oil price shock by a Generalized Autoregressive Conditional Heteroscedasticity (GARCH) (1,1) model. The model is given by:

\[
op_t = \alpha + \sum_{i=0}^{\alpha} \alpha_i \epsilon_{i-1} + \sum_{i=0}^{\beta} \beta_i Z_{t-1} + \epsilon_t, \quad \epsilon_{t-1} \sim N(0,h_t), h_t = \gamma_0 + \gamma_1 \epsilon_{t-1}^2 + \gamma_2 h_{t-1},
\]
where $\Delta_p t$ is first log difference in real oil price, $\varepsilon_t$ is an error term, and $\{x_{t-i} : i \geq 1\}$ denotes an appropriately chosen vector contained in information set $I_{t-1}$. The notation $p$ and $q$ are the optimally selected lags. This further leads to the definition of a scaled oil price (SOP) (Park & Ratti, 2008, p. 2593):

$$SOP_t = \hat{\varepsilon} / \sqrt{\hat{h}_t}.$$  

Another definition of oil price shocks is net oil price increases (NOPI) introduced by Hamilton (1996). Hamilton (1996, p. 216) argues that after 1986 most increases in the oil price has been immediately followed by an even bigger decrease. He therefore suggest that to correctly measure the impact of oil price changes to the macroeconomy the recent oil price should be compared to what it has been the previous years, rather than looking at the change in the previous quarter (Bjørnland, 2008, p. 9). More specifically, Hamilton (1996) defined NOPI by the value of the current oil price if it exceeds the maximum oil price over the previous four quarters, otherwise it takes the value of zero:

$$NOPI_t = \max(0, \log P_{t-1} - \max(\log P_{t-4}, \ldots, \log P_{t-1}))$$

where $P_t$ is the log level of real oil price at time $t$. This definition has been extensively used in the oil economics research.

The second, and more recent perspective focuses on what the true “shock” in price movements is (Gosh, Varvares & Morley, 2009, p. 222). During the 1970s and 1980s most of the major fluctuations in oil prices were caused by exogenous political events, such as the OPEC oil embargo (Hamilton, 1985). However, subsequent movements in the oil price have for the most part been the result of demand shocks (Barsky & Kilian, 2004). Another paper by Kilian (2009), provides a discussion of the different categories of shocks, and he notes that the source of the shock is vital to determine its effect on macroeconomic aggregates.

The literature that address the source of the shock to determine the effect on stock markets or the economy in general, mostly distinguish between three different types of oil shocks. Kilian and Park (2009) defines these shocks as; First, an oil supply shock defined as an exogenous shift of the oil supply curve that leads to the oil price and oil production moving in opposite direction. These shocks have often been driven by
political events in OPEC countries, such as military conflicts or cartel activity. The second type of shock is an aggregate demand shock. This is a shock on the demand side of the oil market, which will cause the oil production and the oil price to move in the same direction. This is usually the case when demand for oil endogenously increase because of changes in macroeconomic activity that in general induce rising demand for all commodities, in other words an oil demand shock driven by economic activity. An example is the recent increased demand for oil from the emerging economies China and India. The third type of shock is an oil-specific demand shock, which is not driven by economic activity but rather by fear of future oil supply or oil price increases based on speculative motives. Finally, there are also other empirical studies that use similar definitions of oil price shocks. Among them are Kilian (2006), Apergis and Miller (2009) and Peersman and Van Robays (2009).

In this thesis I will employ the oil price shock definition that focuses on the responses in output to oil price movements. More specifically the linear specification by Hamilton (1983), the asymmetric specification by Mork (1989), and finally NOPI defined by Hamilton (1996).

2.2. The variability of Oil price

Major oil shocks have rattled the economy since the 1970s and have had large effects on financial markets (Kubarych, 2005). Oil price shocks were observed during the Yom Kippur war in 1973, and during the Iranian revolution which in 1980 led to the Iran-Iraq war (Sørensen, 2009). However, I will focus my attention the period between 1986 and 2010.

The first oil price shock in this specific period came during the Iran-Iraq war, in which Saudi Arabia voluntarily shut down ¾ of its production in order to prevent a decline in the oil price. However, this was not enough to prevent a 25% decline in the oil price. When the prices kept falling despite the attempts from Saudi Arabia to keep them stable, they left their role as a swinger producer in OPEC in order to increase their own market share. The other OPEC members shortly followed and the market was immediately flooded with oil. As a result of this, in January 1986 the first large decrease in the oil price came as a result of the OPEC collapse. As opposed to earlier oil shocks, this was caused by the oil producing countries. The OPEC collapse is marked in the figure below as the first vertical bar.
Figure 2:
Overview of the real Brent oil price in the period 1986-2010

Notes: The figure plots the real Brent oil price. The vertical bars mark important events that impacted the oil price.

The next event that caused a spike in the oil price was the Persian Gulf War. The war started in August 1990, after Iraq invaded Kuwait, and ended in February 1991. At the time the two countries accounted for 9% of the world’s oil production, and it was feared that the conflict was going to spread to Saudi Arabia. Prior to the war the oil price was 24US$, but during the war the price spiked at 45US$, before Saudi Arabia increased its production in order to lower the oil price to its previous level. This was an increase and a decrease in the oil price of over 50%, which happened during a fairly short period of time. Up until the 1990s most oil price shocks were driven by wars, conflicts and price and production control implemented by OPEC (Sørensen, 2009; and Hamilton, 2011).

During the 1990s a lot of countries went through a transition from agriculture in to modern industrial economies. In 1998 these newly industrialized economies consumed only 17% of the world’s petroleum, however since then they have accounted for 69% of the increase in the global consumption. Several of these transition economies were in Asia, among them the Asian Tigers (Hong Kong, Singapore, Taiwan and South Korea) and China. Although these economies at the time had a modest contribution to world oil consumption, the belief that their consumption was to increase also lifted the oil price.
during the mid 1990s. However, when the East Asian crisis started in the summer of 1997, there was a flight from the currency of several Asian countries as well as distress in the financial system. The belief in continuing growth in Asia disappeared and the real oil price fell from 21 dollar to 11 dollar in the end of 1998. As can be seen in the figure above this was the lowest price observed in the period between 1986 and 2010.

During 1999-2000, the Asian crisis ended and the oil consumption in the region continued to grow as before the crisis. The oil price tripled and reached US$ 35 at the end of 2000. However, by the tenth postwar US recession which started in March 2001 and the terrorist attack in September 2001, the oil price fell once again.

In December 2002 and January 2003, a general strike broke out in Venezuela. The oil production stopped, eliminating the 2.1 millions of barrels that were produced each day. The strike in Venezuela was followed by the Iraq war. At the time Iraq was producing 2.2 millions of barrels per day, and this production was suspended in the period between April and July in 2003. Despite the loss of the production it had little apparent effect on global oil supplies. The result was a modest short lived spike in the oil price between November 2002 and February 2003.

These events were followed by global economic growth in 2004 and 2005, which also impacted the demand for oil. The consumption of oil grew with 5 million barrels a day, or 3% per year. The strong demand was also reflected in the oil price which steadily increased over the period. Until 2005 there was excess capacity enough to keep the production growing along with the demand. However after 2005, several oil fields that were contributing to sustain earlier production reached their maturity with rapidly decline rates. Furthermore, Saudi Arabia which historically had contributed to increased oil production when there was need to stabilize the oil price, did not increase their production. Simultaneously, there were ongoing instability in Iraq and Nigeria. All the mentioned factors contributed to the oil price shock in this period. In contrary to several other historical oil shocks, this one stands out as not being associated with any dramatic geopolitical event (Hamilton, 2011).

As a result to the economic growth the demand for oil continued to grow throughout 2006 and 2007. Hamilton (2011, p. 23) suggests that the return to negative ex post real interest rates in August 2007, and the large flows of investment dollars into commodity futures markets contributed to a speculative bubble in the price of oil. The oil price went

When the recent global financial recession hit the markets in late 2008 the oil price plunged until it hit US$39 in December 2008. This was equally the worst oil price drop in modern history. The leading contributor to this oil price drop was the financial crisis rather than any oil related disruptions. Subsequent to the financial crisis the oil price has been growing steadily until the end of 2010 (Hamilton, 2011).

2.3. The link between oil price movements and stock markets

The International Monetary Fund (2000, p. 13) argues that changes in the oil price affects economic activity, corporate earnings, inflation and monetary policy which also have implications for asset prices of a company and thereby also the financial markets. In the following there will be given a short introduction to the efficient market hypothesis and the link between oil price movements and the stock market.

Bjørnland (2008, p.6) argues that it is current and future information about the economic conditions facing the firm that determine the asset prices on the stock market. There is extensive literature that study how efficient stock markets are to process new information. The most famous studies are made by Fama (1970) which suggests that a market is efficient when the asset price fully reflect all the information available of current and future returns (Fama, 1970, p. 383). Based on this hypothesis of efficient markets, it would be reasonable to expect that in companies where oil is either an input or an output, the stock market would quickly absorb new information of an oil price change, and incorporate it into the stock price. Further, it is also assumed that the asset prices are calculated by taking the present discounted value of future net earnings of the firm. In these cash flows the current and future impacts of oil price changes are incorporated, and thereby also incorporated into the stock prices (Bjørnland, 2008).

In this thesis I assume that the financial markets are efficient and that changes in the oil price are incorporated in the stock prices.

2.3.1. Oil price shocks and the stock market

There are different channels in which an oil price shock may affect the stock price. Seen from a microeconomic perspective, the most obvious is the fact that for a lot of companies, oil is an important resource and essential input in the production of goods.
In this way a change in the oil price will certainly have an impact on the costs, as any other input variable, and changes in expected costs further impacts the stock price (Huang, Masulis & Stoll, 1996, p. 5). A study by Nandha and Faff (2008) analyzes 35 global industry indices for the period between 1983 and 2005. Their findings show that oil prices have a negative impact on equity returns for all the industries except mining, and oil and gas industries. Faff and Brailsford (1999) obtain the same negative impact of oil price shock on industries like paper and packaging, banks and transport. Furthermore, there are some industries that are in a better position to pass on the extra costs inflicted by an increasing oil price, and thereby minimizing the negative impact on their profitability. In addition, the financial markets offer great opportunities for hedging against a higher oil price (Nandha & Faff, 2008).

Although the above literature suggest that higher oil prices are generally bad news for stock returns in most industries, the same is not true for the oil industry in which oil is an output of the production. Assumed that a company is able to uphold the same level of sales as before an increase in the oil price, the revenue of the company would be expected to rise. Therefore it would make a large difference whether oil is an output instead of an input in a company. A paper by El-Sharif et al. (2005) examines the relationship between the price of crude oil and the equity prices in the oil and gas industry in the UK. Their evidence shows that there exist a positive relationship between the two factors, and that it is often significant and reflects a direct impact of volatility in the price of oil on equity prices. Similarly, other studies made by Huang, Masulis and Stoll (1996), Faff and Brailsford (1999), Nandha and Faff (2008), Cong et al. (2008), and Mohanty, Nandha and Bota (2010) reach the same conclusion on the relationship between the price of oil and the oil and gas industry for several different countries.

Seen from a more macroeconomic perspective Basher and Sadorsky (2006, p. 225) argue that as a consequence to an oil price hike, importers of oil will have less disposable income to spend on other goods and services and for this reason needs to search for alternative energies. Furthermore, they argue that the non-oil producing countries will face higher costs and risks because of the uncertainty that follows with a volatile oil price, which also will affect the stock prices and reduce wealth and investment. On the other hand Le and Chang (2011, p. 6) argue that for oil exporting countries an oil price increase will have a positive impact in the form of higher incomes.
and wealth effects. Bjørnland (2009, p. 5) also argues that “higher oil prices represents an immediate transfer of wealth from oil importers to oil exporters”. Furthermore, she argues that if governments use the additional income to purchase goods and services domestically, this would result in an improving economy which would also have a positive effect on the stock markets.

A more indirectly channel in which a change in the expected oil price may have an effect on stock returns, is via the discount rate. The expected discount rate is composed by taking the expected inflation rate and the expected real interest rate. Further, both of these may also depend on the expected oil price. Huang, Masulis and Stoll (1996) suggest that by considering a country that is a net importer of oil, a higher oil price will have a negative effect on the trade balance. This will in turn put a downward pressure on the foreign exchange rate, and an upward pressure on the inflation rate. Consequently, an increase in the inflation rate, results in a higher discount rate and hence lower stock returns. Further, Huang, Masulis and Stoll (1996, p. 5) suggest that since the oil price is a commodity, the oil price can be used as a proxy for the inflation rate. Cologni and Manera (2008) confirms the results of Huang, Masulis and stoll (1996) arguing that unexpected oil price shocks are followed by an increase in inflation rates.

Furthermore, Huang, Masulis and Stoll (1996, p. 5) suggest that the oil price has an influence on the real interest rate. This assertion is based on that a higher oil price, relative to the general price level, cause an increase in the real interest rate. This in turn increases the hurdle rate on corporate investments, and thereby causes a decline in the stock prices. Hence, it can be assumed that a higher oil price by itself can put an upward pressure on the real interest rate (Huang, Masulis & Stoll, 1996). This connection between the oil price and the interest rate is also found in the paper by Park and Ratti (2008). They find that an increase in the real world oil price significantly raises the short-term interest rate in the US and eight European countries. This is also consistent with the result in the paper by Sadorsky (1999) and Papapetrou (2001). They argue that a higher oil price increases the costs of production and puts inflationary pressure on the economy, which in turn bring an upward pressure on interest rate.

Based on the discussion in this section it is expected that fluctuations in the oil price have an impact on stock returns.
2.4. The dependency of oil in the G-7 and Norway

Having examined the link between the oil price and stock markets, I will in the following discuss the dependency of oil in the G-7 and Norway.

2.4.1. Oil importing countries

Table 1 gives an overview of oil production, oil consumption, export of crude oil and import of crude oil. For France, Germany, Italy, Japan, the UK and the US the table indicate that in addition to being among the largest economies in the world, they are also largely dependent on oil as a commodity. In addition, they are all net importing countries which will be discussed in this section, while the net exporting countries Canada and Norway will be discussed in the next section.

The column reporting the oil consumption for the respective countries shows that they are all among the 15 largest consumers of oil in the world. The lowest consumption is reported for Italy which consume 1,813.67 (bbl/day). The US consumes as much as 18,631.91 (bbl/day), which is actually more than the other mentioned countries combined. Furthermore, for Germany, Italy and Japan the consumption has steadily declined since the late 1990s, while for France, the UK and the US it has declined since the mid 2000s1.

Table 1
Oil production (bbl/day), oil consumption (bbl/day) and export/imports of crude oil (bbl/day) for the G7 countries and Norway.

<table>
<thead>
<tr>
<th>Country</th>
<th>Oil production (bbl/day)</th>
<th>Rank</th>
<th>Oil consumption (bbl/day)</th>
<th>Rank</th>
<th>Export of crude oil (bbl/day)</th>
<th>Rank</th>
<th>Import of crude oil (bbl/day)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>2,655.35</td>
<td>6</td>
<td>1,964.49</td>
<td>9</td>
<td>965.73</td>
<td>14</td>
<td>678.03</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>98.26</td>
<td>56</td>
<td>1,925.93</td>
<td>12</td>
<td>-</td>
<td></td>
<td>1,500.36</td>
<td>7</td>
</tr>
<tr>
<td>Germany</td>
<td>124.81</td>
<td>46</td>
<td>2,742.56</td>
<td>6</td>
<td>20.17</td>
<td></td>
<td>1,993.87</td>
<td>4</td>
</tr>
<tr>
<td>Italy</td>
<td>128.50</td>
<td>42</td>
<td>1,813.67</td>
<td>15</td>
<td>7.13</td>
<td></td>
<td>1,526.17</td>
<td>10</td>
</tr>
<tr>
<td>Japan</td>
<td>99.64</td>
<td>45</td>
<td>5,225.08</td>
<td>3</td>
<td>-</td>
<td></td>
<td>3,870.44</td>
<td>3</td>
</tr>
<tr>
<td>Norway</td>
<td>2,533.29</td>
<td>11</td>
<td>211.75</td>
<td>52</td>
<td>2,013.71</td>
<td>5</td>
<td>22.61</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>2,277.15</td>
<td>55</td>
<td>1,759.60</td>
<td>13</td>
<td>1,259.71</td>
<td></td>
<td>849.80</td>
<td>8</td>
</tr>
<tr>
<td>US</td>
<td>9,336.65</td>
<td>3</td>
<td>18,631.91</td>
<td>1</td>
<td>77.06</td>
<td></td>
<td>7,526.94</td>
<td>1</td>
</tr>
</tbody>
</table>

Notes: The table provides data on oil production, oil consumption and export/import of crude oil measured in thousand barrels per day for the G7 countries and Norway. The oil production and oil consumption are measured as the average for the period between 1986 and 2010, while for the export and import of crude oil the average for the period between 1986 and 2009. The columns with rank, shows the ranking the respective countries had in 2009.

Source: The International Energy Statistics from EIA.

1 See Appendix A for graphs of the oil production, oil consumption and export and import of oil
When it comes to oil production the UK and the US are the only two countries which have an oil production of any actual size. The UK rank as the 55th largest producer of oil in the world with 2,277.15 (bbl/day), and the US is the 3rd largest producer of oil with 9,336.65 (bbl/day). The remaining countries have a fairly small oil production. The production of oil in the UK peaked in 1999, while the US has managed to keep the production stable since 1986 (U.S. Energy Information Administration, 2011).

The table further shows that the countries are all amongst the ten largest importers of crude oil. This is because the large consumption of oil requires them to import a large fraction of the consumption from abroad. For this reason, the high oil price that has been witnessed in periods represents a substantial burden on these economies. This is especially true for Germany which relies on import of 90% of its crude oil demand (Encyclopedia of Earth, 2010). Furthermore, the UK was a net exporter of crude oil until 2005, where it became a net oil importer. However, because of the favorable characteristics of the oil produced in the UK to foreign buyers, they continued to export crude oil (U.S. Energy Information Administration, 2011).

The net import of crude oil for most of the countries peaked around 2005, and is declining. In addition, Norway is a major source of import of oil for France, Germany and the UK, while the majority of imported crude oil in the US comes from Canada.

### 2.4.2. Oil exporting countries

Canada and Norway are also largely dependent on oil, but not in the same way as the countries described above. Table 1 shows that Canada is the 9th largest consumer of oil in the world with 1,964.49 (bbl/day). On the other hand, Norway is a fairly small nation compared to the other countries, and only consumes 211.75 (bbl/day). The largest consumption observed for Canada and Norway is in 2005 and 2006, respectively, and has been declining ever since.

Furthermore, Canada and Norway are also among the largest producers of oil in the world. Canada is the 6th largest producer with 1,655.35 (bbl/day), with the largest production observed in 2010. In addition they also have the 3rd largest proven oil reserve in the world. Norway is the 11th largest producer in the world with 2,277.15 (bbl/day). They also have a proven oil reserve of 5.67 billion barrels. This is the largest production and proven oil reserve in Western Europe.
The large production of oil compared to the consumption, makes them able to export the excessive oil to other countries. Canada rank as the 14th largest exporter of crude oil in the world. Due to the short proximity to the US, they have been the main market for export of crude oil (99 percent). Norway is the 5th largest exporter of crude oil in the world. Their main markets for export have been the UK, France, Germany and the US. Furthermore, the large export of crude oil has contributed significantly to both countries’ economy (U.S. Energy Information Administration, 2011).

3. Literature review

The oil price was relatively steady until the major oil price shocks in the 1970s. These price shocks were followed by a large amount of literature on the impact of oil price shocks on the aggregate economy. In this section there will be given an overview of the most important literature. Further, the literature will be divided into literature on the impact of oil price shocks on the overall economy and the impact of oil price shocks on stock markets.

3.1. The impact of oil price shocks on economic activity

One of the first to study the impact of oil price shocks on the economy was Hamilton (1983). By employing a six variable vector autoregression (VAR) model he shows that all but one of the US recessions since the World War II were preceded by a large increase in the oil price. However, Hamilton does not believe that the oil shocks caused the recessions, but finds a statistically significant correlation supporting the fact that oil shocks were a contributing factor to some of the recessions.

Burbidge and Harrison (1984) are performing a seven variable VAR model to analyze the impact of oil price shocks on the systems of equations. The study is made on the US, Japan, Germany, the UK and Canada for the period between January 1961 and June 1982. They find that the oil price has a significant influence on the industry production of the US and the UK, while the responses of the remaining countries are rather small.

Gisser and Goodwin (1986) test some of the notions introduced by Hamilton (1983). They analyze the impact of oil price shocks on the macroeconomy of the US from 1961 to 1982. Their results indicate that the crude oil price has had a significant impact on several macroeconomic indicators. Further, they find that the relationship between the oil price and the macroeconomic variables has been stable over the whole period.
Finally, the oil price shocks shift the supply curve causing large real effects, but weak direct price effects, whereas the monetary policy shifts the demand curve causing strong price effects but long run-neutrality with the respect to real GNP.

Like Hamilton (1983), Mork (1989) also employ a six variable VAR model with quarterly data. However, he extends the sample period to also include the oil price collapse in 1986, to examine if the strong relationship between oil price increases and the GNP holds. His results confirm the same negative correlation between oil price increases and the GNP. Furthermore, he also finds what appear to be a an asymmetric relationship, as the correlation between oil price decreases and the GNP are different from those of oil price increases.

Mork, Olsen & Mysen’s (1994) show that the correlations between GDP and oil price increases are significantly negative for US, Canada, Japan, Germany, France and the UK, but positive for Norway. They argue that the reason probably is the relative large oil producing sector in the economy. For most of the countries the correlations with oil price decreases are for the majority positive, but only significant for the US and Canada. Finally, all the countries but Norway showed evidence of asymmetric effects.

Hamilton (1996) argues that Mork’s (1989) proposal of an asymmetric relationship where suggested based on unsatisfactory data. In response he suggested a non-linear relationship between the oil price and the GDP in the US, and defines the oil price as what he calls a net oil price increase. Hamilton then finds a highly significant negative relation between the GDP in the US and the net oil price increase.

Eika and Magnussen (2000) examine the effects of the high oil prices on the Norwegian economy in the first half of the 1980s. They utilize two large scale macroeconomic models; NIGEM and KVARTS on high oil prices from 1979 to 1985. The results indicate that the higher oil price had a rather persistent effect on the trading partners of Norway, which lowered the demand for Norwegian export goods. There was also an increase in interest rate. However, Norway received a windfall gain from the increase in oil price due to the extent of production and export of oil. The expansionary fiscal policy, based on prudent spending strategy, more than outweigh the negative impulses from abroad and the GDP then had an average increase of 1.3% over the period 1979-1993.
Cunado and de Gracia (2003) analyze the relationship between oil prices and macroeconomic variables such as the economic activity for European countries from 1960 to 1999. They use three specifications for oil price changes; real oil price changes, net oil price increases (NOPI), and scaled oil price increases (SOPI). When performing a Granger causality test they find that the oil price changes are found to Granger cause the industry production index (IPI), although the relationship is not the same for the whole period. They also find that the oil price increase has a negative significant effect on the IPI growth rates, but the opposite does not hold for oil price decreases. The oil price increases are also likely to have a larger impact on the IPI following a period of lower price increase. Finally, they do not find evidence of that the oil price impact on the macroeconomy is dependent on the volatility of the oil price.

Hamilton (2003) does also analyze the nonlinear relation between oil price changes and GDP growth in the US economy. As some of the other studies mentioned above, he as well finds quite strong evidence supporting a nonlinear relationship. Further his results show that an increase in oil price has a greater impact than oil price decreases, and that following a period with volatile oil price the oil prices are less useful for forecasting of the GDP.

Jimenez-Rodriguez and Sanchez (2005) distinguish between net oil importing and net exporting countries and studies the effects of oil price shocks on the real economic activity. The study is made by using a VAR with seven variables for the G7, Norway and Euro area from 1972 to 2001. Further a VAR model is estimated, as in the article by Cunado and Gracia (2003), for both a linear and three non-linear approaches: an asymmetric specification, a scaled specification and a net specification. The results show that both linear and nonlinear models of oil price increases have a negative impact on GDP for the oil importing countries. The exception is Japan where it is found a positive association between the oil price and the GDP. The Exception is Japan where it, to the authors’ surprise, is found a positive association between the oil price and the GDP. For the net oil exporters, Norway benefit from an oil price increase, while the UK is negatively affected. Their results for the non-linear models also suggest the oil price increases to have a larger impact on the GDP than an oil price decline.
3.2. The impact of oil price shocks on stock markets

To the authors' knowledge, one of the first articles to analyze the impact of oil price shocks on the international stock markets of the US, Canada, Japan, and the UK, are the paper by Jones and Kaul (1996). They use a standard cash flow/dividend valuation model to study the rationality of stock prices as to whether they react to the impact of news on current and future real cash flows in the postwar period. They find that the reaction of both the US and Canadian stock prices are rational as changes in the oil price significantly affect their current and expected future real cash flows. However, the results for Canada and Japan are not as strong, as they are unable to explain the effects of oil price shocks on the stock returns.

Huang, Masulis, and Stoll (1996) study the relationship between oil futures returns and stock returns in the U.S. during the 1980s. By using a multivariate vector autoregression, they examine the linkages between oil prices and the stock market on three different levels; first for the stock price index S&P 500, second, for 12 stock price indices, and third for 3 different oil companies. They do not find the oil future returns to have much impact on the S&P 500, but find that oil futures do lead some individual oil company stock returns.

Sadorsky (1999) investigates the relationship between oil price and stock returns using an unrestricted VAR for the U.S. The analysis is made by using monthly data between 1947 and 1996, and the variables included in the model are industry production, interest rate, stock returns, and oil price. Sadorsky run three different tests to study the relationship between the oil price and stock returns. First, he studies the impact of oil price shocks on stock returns. Second, he tests for asymmetric oil price shocks. Third, he examines if there is asymmetric oil price volatility shocks. The evidence shows that the oil price shocks have a statistically significant negative impact on stock returns. Further the results suggest that positive oil price shocks have a large impact on the stock returns than the negative stock returns. Finally, he finds asymmetric effects between oil price volatility shocks and the stock return.

Gjerde and Sættem (1999) investigate the relationship between macroeconomic variables and stock return in Norway. They employ a multivariate VAR model over a period of 20 years from 1974 to 1994, which includes eight variables. Their findings
show a strong dependency between the oil price and the stock return. The stock return are responding in a rationally fashion to an oil price change.

Ciner (2001) is testing for both linear and nonlinear linkages between the stock return in the U.S. and oil futures return. The test is made by conducting a Granger causality test within the context of a VAR model. Results from the 1980s and the 1990s do not indicate a linear Granger causality between oil futures and stock returns. On the other hand the results provide evidence of a nonlinear relationship between the U.S. stock return and the oil future returns.

Papaetrou (2001) use a multivariate VAR model to investigate the dynamic relationship between oil prices, economic activity and employment in Greece. The empirical analysis is conducted with monthly data for the period 1989-1999. The variables employed in the VAR models are real oil price, interest rate, real stock return, industrial production and industrial employment. The empirical results shows that oil price shocks have an immediate negative impact on the stock market. Therefore a positive oil shock will have a negative impact on stock returns.

In contrast to the majority of the other papers Maghyereh (2004) examines the relationship between oil price shocks and stock markets in 22 merging economies. He employs a VAR model, but instead of monthly data he uses daily data in the analysis for the period between 1 of January 1998 to 31 of April 2004. The empirical results suggest that oil price shocks do not have a significant impact on stock markets. Furthermore, he finds that oil price shocks explains very little of the forecast error variance.

Park and Ratti (2008) use a multivariate VAR analysis to study the effects of oil price shocks and oil price volatility on the stock returns of the US and 13 European countries from 1986 to 2005. As in the paper made by Cunado and de Gracia (2003), they also use three different proxies for oil price change: the linear oil price shock, and two nonlinear oil price variables given by a scaled real oil price change, and a net oil price increase. Park and Ratti use four different variables in their VAR analysis: stock prices, short-term interest rates, industrial production, and the oil price. Their findings show that for the majority of the countries the linear oil price shock have a statistically significant negative impact on stock returns. One of the exceptions is the stock return of Norway which is positively impacted by an oil price shock. The same results are also true when the scaled oil price is used as the oil price variable. When the net oil price
variable is used as oil price variable, the results are only statistically significant negative for a minority of the countries. Further they find that in all the countries but the US an increase in the oil price volatility significantly depress the stock returns. Finally, despite the findings for the US and Norway, there is little evidence that suggests an asymmetric effect on real stock returns of positive and negative oil price shocks for oil importing countries.

Cong et al. (2008) investigate the relationship between oil price shocks and the Chinese stock market. They implement a multivariate VAR model for the period 1996-2007. In the VAR model they include 5 different variables: short term interest rate, industrial production, real oil price, consumer price index and real stock returns. As opposed to some of the earlier studies they do not find a statistically significant impact on the stock returns. Neither do they find any statistically significant asymmetric effects on stock return, or any significant impacts from an increased oil volatility.

Bjørnsland (2008) study the effect of an oil price shock to the stock return in Norway in the period 1993-2005. She uses a structural VAR model that includes seven variables, and defines four different proxies for oil price change. The evidence shows that an increase in the oil price of 10%, immediately increase the stock returns by 2-3%. The maximum effect is reached after 14-15 months where it has increased by 4-5%, after this it eventually dies out. The results are also robust for transformations into different linear and nonlinear oil prices.

Odusami (2009) employ an asymmetric GARCH-jump model to analyze the relationship between crude oil price and the U.S. stock market. He uses daily data from January 1996 to December 2005, and finds a significant nonlinear negative relationship between oil price shocks and US stock returns.

Finally, Ono (2011) examines the impact of oil prices on real stock returns for Brazil, Russia, India and China (BRIC). He utilizes a VAR model with data from January 1999 through September 2010 to test the responses to linear, non-linear and asymmetric oil price shocks. The results suggest that the real stock returns of China, India and Russia responded statistical significant positively to some of the oil price indicators, while the results were not statistical significant for Brazil. Furthermore, the paper found a statistically significant asymmetric effect for India, while in the cases of Brazil, China and Russia no asymmetric effects were found.
4. Hypothesis

Until now I have tried to create an understanding of the concept of oil price shocks, the connection between oil price shocks and stock markets, and the importance of oil in the G-7 countries and Norway, as well as give an overview of the literature within the subject. This section will introduce the hypotheses that will be examined in this thesis.

Hamilton (1983), Gisser and Goodwin (1986), Sadorsky (1999), Gjerde and Sættem (1999), Ciner (2001), and Park and Ratti (2008) are some of the articles that examine the impact of a linear oil price shock on either the economy or the stock markets in various countries. Their results suggest that a linear oil price shock has a statistically significant impact on the economies or stock markets. This thesis employs an analysis of the impact of linear oil price shocks on the stock markets in the G-7 and Norway. The investigation of the dependency of oil in the countries that are analysed, suggest that the countries are highly dependent on the oil, and for this reason it is expected that this investigation will obtain the same result. The first hypothesis suggests the following:

**Hypothesis 1:** Linear oil price shocks have an impact on stock markets in the G-7 and Norway.

Mork (1989) and Mork, Olsen and Mysen (1994) find an asymmetric relationship between oil price change and the economy. However, Park and Ratti (2008), Cong et al. (2008) and Ono (2011) find little evidence of an asymmetric relationship between oil price shocks and stock markets. Based on the fact that this thesis analyzes the impact of oil price shocks on the stock markets and not the economies, it is expected not to find an asymmetric relationship between. The second hypothesis suggests the following:

**Hypotesis 2:** Assymetric oil price shocks do not have an impact on stock markets in the G-7 and Norway.

Hamilton (1996, 2003) found a non-linear relationship between oil price shocks and the economy. The results reported in the literature review on this relationship between non-linear oil price shocks and stock markets are on the other hand mixed. Although, Sadorsky (1999) and Ciner (2001) find evidence of a non-linear impact of oil price shocks on stock markets. Park & Ratti (2008) and Ono (2011) find a statistically significant impact of non-linear oil price shocks on stock returns for some countries, while it is not significant in others. Overall, most of the articles show evidence of a non-
linear relationship and we expect to obtain the same results here. The final hypothesis suggest the following:

**Hypothesis 3: Non-linear oil price shocks have an impact on stock markets in the G-7 and Norway.**

The above hypotheses will be examined by employing unrestricted VAR models and chi-square tests, which will be further introduced below.

### 5. Statistical methodology

The following section outlines the methodology used to perform the empirical analysis in this research.

#### 5.1. Stationarity in time series

When performing statistical analysis with time series it is a necessary condition that the variables are stationary. For a time series \( y_t \) to be stationary it is required that its mean and variance are constant over time. In addition, the covariance between two values only depends on the distance across time separating the two values, and not at the time at which the variables actually are observed (Carter, Griffiths & Lim, 2011, p. 476).

This means that the time series \( y_t \) is stationary when:

\[
E(y_t) = \mu \quad \text{(Constant mean)}
\]

\[
\text{var}(y_t) = \sigma^2 \quad \text{(Constant variance)}
\]

\[
\text{cov}(y_{t}, y_{t+s}) = \text{cov}(y_{t}, y_{t-s}) = \gamma_s \quad \text{(Covariance depends on } s, \text{ not } t)\]

If the time series contains a stochastic trend or a deterministic trend, there is a violation of the stationary series, and the time series become non-stationary. If the time series \( y_t \) is non-stationary it may result in spurious regressions. A consequence of this is that the \( t \)-statistics are not reliable, and the results may spuriously indicate a significant relationship, even when this not the case (Carter, Griffiths & Lim, 2011, p. 483).

##### 5.1.1. Unit root test

There are several methods to test whether the time series is stationary. The method that will be used in this paper is the Dickey-Fuller test (Dickey & Fuller, 1979). When performing the test for stationarity I consider an AR(1) model with a constant term:
\[ y_t = \alpha + \rho y_{t-1} + v_t \]  
\[ (1) \]

Before carrying out the test \( y_{t-1} \) is subtracted from both sides of the equation to make it more convenient, and where \( \gamma = \rho - 1 \) and obtain:

\[ \Delta y_t = \alpha + \gamma y_{t-1} + v_t \]  
\[ (2) \]

To test for stationarity it is necessary to examine the value of \( \rho \). If the value of \( \rho \) is one or significantly less than one, the series become non-stationary. The hypothesis is:

\[ H_0 : \gamma = 0 \quad \text{and} \quad H_1 : \gamma < 0 \]

The null hypothesis is that the series is non-stationary, which means if the null hypothesis is not rejected the series is non-stationary, while if it is rejected the series is stationary (Carter, Griffiths & Lim, 2011, p. 484).

To test for stationarity in models with a more complicated dynamics, an augmented Dickey-Fuller test is performed. The extended test equation is now expressed by:

\[ \Delta y_t = \alpha + \gamma y_{t-1} + \sum_{i=1}^{m} a_i \Delta y_{t-i} + v_t \]  
\[ (3) \]

where \( \Delta y_{t-1} = (y_{t-1} - y_{t-2}), \Delta y_{t-2} = (y_{t-2} - y_{t-3}),... \) The first difference lags are added to ensure the residuals are not autocorrelated. The hypothesis for stationarity is the same as expressed above (Carter, Griffiths & Lim, 2011, p. 485). One drawback with the Dickey-Fuller test is that the t-statistics no longer is a t-distribution, and Dickey and Fuller (1979) have tabulated new critical values that are applicable to the Dickey-Fuller test (Wooldridge, 2009, p. 631).

A stationary time series is said to be integrated of order zero, I(0). A series that is non-stationary can be made stationary by taking the first difference, then it is said to be integrated of order one, I(1). The order of integration of a series tells the number of unit roots contained in the series (Carter, Griffiths & Lim, 2011, p. 488).

### 5.2. Cointegration

After the employment of the stationarity test it is probable that the results will suggest that some of the variables are non-stationary, and should not be used in the model.
However, if one or more variables are cointegrated the problem of spurious regressions will disappear.

If it is assumed that the following regression model give the relationship between \( y_t \) and \( x_t \):  
\[
y_t = \alpha + \beta x_t + e_t.
\]
When two variables \( y_t \) and \( x_t \) both are non-stationary variables I(1), it would also be expected that their difference or a linear combination of them also is I(1). Intuitively this also means that the error term \( e_t \) is non-stationary. Furthermore, non-stationary variables have no tendency to revert to the mean in the long run. On the other hand, there is one exception in the case where \( e_t = y_t - \beta_1 - \beta_2 x_2 \) in fact is a stationary I(0) process. The series \( y_t \) and \( x_t \) are then said to be cointegrated as they share a common stochastic trend. The non-stationarity in \( y_t \) and \( x_t \) will then cancel each other out, and the error term \( e_t \) will be stationary (Carter, Griffiths & Lim, 2011, p. 488). When the two variables are said to be cointegrated, the relationships will exhibit long run equilibrium (Veerbek, 2008, p.329).

### 5.2.1. Johansen cointegration test

In order to test if the non-stationary variables are cointegrated there will be employed a Johansen test. This test follows from a VAR model of order \( p \), given by:

\[
y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + u_t
\]

where \( y_t \) is a vector of non-stationary variables, and \( u_t \) is a vector of innovations. By subtracting \( y_{t-1} \) is from both sides of the equation:

\[
\Delta y = \pi y_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta y_{t-i} + u_t
\]

where \( \pi = -(1 - \sum_{i=1}^{p} A_i) \) and \( \pi_i = - \sum_{j=i+1}^{p} A_j \). If \( \pi = 0 \), then there does not exist any significant cointegrating relationship. However, if \( \pi = n \), then any linear combination is stationary. The Johansen test the number of cointegrating relationships by checking the characteristic roots of \( \pi \) (Greasly & Oxley, 2010, p. 24).
The Johansen method proposes two test statistics for cointegration, the first one being a trace test. First, the ordered \( n \) characteristics roots of the matrix \( \pi \) are denoted \( \lambda_1 > \lambda_2 > \lambda_3 > ... > \lambda_n \). The trace test is given by:

\[
\hat{\lambda}_{\text{trace}}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i) \tag{6}
\]

The second test is the maximum eigenvalues test:

\[
\hat{\lambda}_{\text{max}}(r, r+1) = -T (\ln(1 - \hat{\lambda}_{r+1})) \tag{7}
\]

The null hypothesis of the trace test tests whether the number of distinct eigenvalues is \( \leq r \), while the maximum eigenvalues tests null of \( r \) cointegrating relationships against \( r+1 \) (Greasly & Oxley, 2010, p. 25).

5.3. Vector autoregression

5.3.1. The basic framework of the vector autoregressive model

The vector autoregressive models (VAR) were introduced by Sims (1980), and is an econometric model often used to capture the relationship between the economic variables that are interesting studying. More specifically, a VAR model is a system of equations where all the variables are treated as endogenous. Thus, each variable in the system is expressed as a linear combination of its own lagged values and the lagged values of all the other variables in the system (Baltagi, 2003).

In general, given a set of \( K \) time series variables, a VAR of order \( p \), where \( p \) represents the number of lags, can be expressed as:

\[
y_t = A_1 y_{t-1} + ... + A_p y_{t-p} + u_t \tag{8}
\]

Where \( y_t = [y_{t_1} ... y_{t_K}] \) is a column vector of observations of the past values of all the variables in the model, \( A_i \) are \( K \times K \) matrices of the coefficients, and \( u_t = (u_{t_1}, ..., u_{t_K}) \) is a column vector of an unobservable error term. The error terms are assumed to be a zero-mean independent white noise process with time-invariant, positive definite covariance matrix. Further, the \( u's \) are uncorrelated, but may be contemporaneously correlated (Baltagi, 2003, p. 680).
One advantage with the model is that on the right side of the equation only the lagged values appear, and the OLS estimation yields consistent estimates. Even if the innovations $u_t$ are contemporaneously correlated, OLS will be efficient (Quantitative Micro Software, 2007, p. 347).

5.3.2. Lag length selection

One of the issues by using the VAR model is how to choose the optimum lag length. It is necessary to be precise when choosing the lag length, because too short lag length could cause autocorrelation of the error terms, and thereby significant and inefficient estimators. On the other hand a larger lag length increase the number of parameters, which further decrease the degrees of freedom, implying large standard errors and therefore wide confidence intervals for model coefficients (Füss, 2007).

Verbeek (2008, p. 337) suggest the use of Akaike’s information criteria (AIC) or Schwarz’s Bayesian information criteria (BIC) to select the appropriate lag length, and will be use in this thesis. To prevent misspecification of the model the number of lags which minimizes the value of the information criteria is chosen.

5.3.3. Impulse response analysis

The general VAR($p$) model may contain many parameters, that makes it difficult to interpret the interactions between the variables in the model. For this reason an impulse response function is used to examine the dynamic interactions between the variables in the model.

If the process $y_t$ is I(0) the VAR model can be written as a vector moving average (VMA):

$$y_t = \Phi_0 u_t + \Phi_1 u_{t-1} + \Phi_2 u_{t-2} + ...,\quad (9)$$

where $\Phi_0 = I_K$, and $\Phi_s$ is given by:

$$\Phi_s = \sum_{j=1}^{s} \Phi_{s-j} A_j, \quad s=1,2,....\quad (10)$$

The $(i,j)$th elements of the matrices $\Phi_s$ show the expected response of $y_{t,s+1}$ to a unit change in $y_{jt}$ holding all past values of $y_t$ constant. A one unit increase in the
innovation $u_t$ will impact the $y_t$ given $\{y_{t-1}, y_{t-2}, \ldots\}$. Therefore, the elements of $\Phi_s$ represents the impulse responses of the components of $y_t$ with respect to the $u_t$ innovations. In the case where $I(0)$, as $s$ becomes infinite, the $\Phi_s$ will become 0, hence the impulse will vanish over time.

However, one weakness of the impulse response function is that it is implausible to think that the shocks are occurring in isolation, when components of $u_t$ are instantaneously correlated. Baltagi (2003) argues that a solution to the referred problem is to use the orthogonal innovations. In this thesis the innovations will be transformed into orthogonal innovations by employing a Cholesky decomposition of the covariance matrix. The orthogonal shocks will then be given by $\varepsilon_t = P^{-1}u_t$. From equation (9) the stationary case is:

$$y_t = \Psi_0 \varepsilon_t + \Psi_1 \varepsilon_{t-1} + \ldots,$$

where $\Psi_i = \Phi_i P (i = 0, 1, 2, \ldots)$, and $\Psi_0 = P$ is a lower triangular. In other words a $\varepsilon$ shock in the first variables will have an immediate impact on the other variables, while a shock in the second variables will not have an immediate impact on $y_{it}$, but only to the remaining variables. The orthogonalized innovations are then uncorrelated across both time and equations. One drawback with the transformation to orthogonalized innovations is that the ordering of the residuals may have a large effect on the shocks (Baltagi, 2003, p. 693-694).

5.3.4. Variance decomposition

Another tool for interpreting VAR models is the forecast error variance decomposition. Brooks (2003, p. 242) describes the variance decomposition as “the proportion of the movements in the dependent variables that are due to their ‘own’ shocks, versus shocks to the other variables”.

The forecast error variance decomposition is calculated by starting with the VAR equation where $T$ is the forecast origin and the $h$-step ahead forecast is given by:

$$y_{T+hf} = A_1 y_{T+h-1f} + \ldots + A_p y_{T+h-pf} + e_{T+h}$$

where $h > 1$. Further, the corresponding forecast errors is
\[ y_{T+h} - y_{T+h|T} = u_{T+h} + \Phi_1 u_{T+h-1} + \ldots + \Phi_{h-1} u_{T+1} \]  \hspace{1cm} (13)

Also here the variance decomposition is employed to find the orthogonal innovations
\[ \varepsilon_t = (\varepsilon_{i_t}, \ldots, \varepsilon_{k_t}) = P^{-1} u_t, \] where P is a lower triangular matrix giving \( PP' = \sum_u \)
\[ y_{T+h} - y_{T+h|T} = \Psi_0 \varepsilon_{T+h} + \Psi_1 \varepsilon_{T+h-1} + \ldots + \Psi_{h-1} \varepsilon_{T+1} \]  \hspace{1cm} (14)

Further, the \((i, j)th\) element of \(\psi_n\) is denoted by \(\psi_{ij,n}\), and based on the assumption that the \(\varepsilon_{ij}\) are contemporaneously and uncorrelated, this further leads to the forecast error variance:
\[ \sigma^2_k(h) = \sum (\psi_{k1,n}^2 + \ldots + \psi_{kk,n}^2) = \sum_{j=1}^K (\psi_{kj,0}^2 + \ldots + \psi_{kj,h-1}^2) \]  \hspace{1cm} (15)

The term \((\psi_{kj,0}^2 + \ldots + \psi_{kj,h-1}^2)\) gives the contribution of the variable \(j\) to the \(h\)-step forecast variance of variable \(k\). The \(\varepsilon_{ij}\) is interpreted as shocks in variable \(i\). Finally, equation (15) can be divided by \(\sigma^2_k(h)\)
\[ w_{ij}(h) = \psi_{kj,0}^2 + \ldots + \psi_{kj,h-1}^2 / \sigma^2_k(h) \]  \hspace{1cm} (16)

This gives the percentage contribution of variable \(j\) to the \(h\)-step forecast error variance of variable \(k\). As with the impulse response function the variance decomposition forecast error variance is affected by the ordering of the residuals (Baltagi, 2003, p. 695-696).

6. Empirical analysis

In the following there is given a description of the data and the descriptive statistics, followed by an investigation of the properties of the time series by employing a unit root test and cointegration test. The main analysis will be conducted by employing a vector autoregressive model to examine the impact of linear, non-linear and asymmetric oil price shocks on real stock returns. The empirical results are then discussed in effort to state the reasons for the obtained results.
6.1. Data and model description

6.1.1. Data description

The literature review reveals the use of a variety of different data series, countries, time periods and also methodology. In this thesis, I will examine how oil price shocks impact stock returns in the G-7, which includes Canada, France, Germany, Italy, Japan, the UK and the US, and in addition Norway. These countries are chosen based on their dependency on oil as a commodity, and availability of data. This research will be extended, compared to earlier studies, by including more recent data. The time series that are used are monthly data from 1986M01 to 2010M12.

Sadorsky (1999), Papapetrou (2001), Park and Ratti (2008) and Cong et al. (2008) are all papers that use a vector autoregressive model containing four variables in their investigation of the impact of oil price shocks on stock returns. These variables are real stock return, industry production, interest rate and oil price, and will also be employed in this study. The real stock returns used are the difference between the continuously compounded return on stock price index and the inflation rate given by the log difference in the consumer price. The stock price indexes are all MSCI indices collected from Thomson Reuters Datastream (DS). As a measure of economic activity the industry productions are used. The data for all the countries are from OECD. The short term interest rate collected for Canada is the Treasury Bill Auction 3mth from DS, for France the PIBOR 3mth from OECD, for Germany, Italy, Norway and UK the Interbank 3mth from DS, for Japan the Money Market Rate from International Monetary Fund (IMF), and for the US the US Treasury Bill Sec Market 3mth rate from DS. The last variable is the oil price, which will be further elaborated in the next section.

Other variables used are the consumer price index and exchange rate. As a measure of inflation rate the CPI is used. For Canada, France, Italy, and the UK, the data are from OECD. For Germany, Japan, Norway and the US, the data are from DS. The nominal exchange rate is the exchange rate of USD into each country’s currency, and is for all the countries collected from DS.

For a more detailed description of the data sources see Appendix B.
The notations that are used in the study are:

- $r_{sr}$: Real stock returns
- $ip$: Industry production
- $log(ip)$: log of industry production
- $dlog(ip)$: first log difference of industry production
- $ir$: Interest rate
- $log(ir)$: log of interest rate
- $dlog(ir)$: first log difference of interest rate
- $cpi$: consumer price index
- $log(cpi)$: log of consumer price index
- $dlog(cpi)$: first log difference of consumer price index

### 6.1.2. Oil price variables

In this thesis the benchmark that will be used for the oil price is the Crude Oil-Brent Dated FOB U$/BBL, collected in nominal price from DS. The real world oil price is calculated by deflating the oil price using the CPI of the G7 countries. The national real oil prices are calculated by deflating the oil prices using the CPI of each of the countries, and then by multiplying with the respective country’s exchange rate of US$ into the local currency.

Empirical research has used several definitions of oil price shocks when studying the impact on stock returns. In this paper three of these definitions will be used, which are; 1) linear, 2) non-linear and 3) asymmetric.

1) **Linear specification**

Hamilton (1983) was among the first to study the impact of oil price shocks on the economy. He used the first log difference of a nominal oil price, as a specification for a linear relationship between the oil price shock and the economy. In accordance to Hamilton, the real oil price variables will be transformed into the first log difference (linear specification). This transformation will be made for both the real oil price in US dollar and in local currency.
The notations are as follows:

- $op$: real Crude Oil-Brent Dated FOB U$/BBL
- $\log(op)$: log of real Crude Oil-Brent Dated FOB U$/BBL
- $d\log(op)$: first log difference of real Crude Oil-Brent Dated FOB U$/BBL

2) Asymmetric specification

Mork (1989) found that an oil price increase had a greater impact on a country’s macroeconomy than an oil price decrease. This leads to the second specification, an asymmetric oil price shock. The real oil price is separated into positive and negative oil price changes:

$$d\log(opp) = \max(0, d\log(op))$$
$$d\log(opn) = \min(0, d\log(op))$$

Where, $d\log(opp)$ represents the positive oil price changes, and $d\log(opn)$ represents the negative oil price changes.

3) Non-linear specification

Later Hamilton (1996) introduced another oil price specification, the net oil price increase (NOPI). This specification argues that if one wants a measure of how unsettling an increase in the oil price is likely to be for the spending decisions of consumers and firms, it seems more appropriate to compare the current price of oil with where it has been over the previous months, rather than the previous month alone. Hamilton considered a 4 quarter horizon as an appropriate construction of a net oil price increase measure. However, in this thesis there is used a monthly frequency, and it is for this reason not possible to make the same definition. Instead the definition employed by Park and Ratti (2008, p. 2594) and Cong et al. (2008) is used to examine the non-linear relationship.

$nopi$ is defined as:

$$nopi_t = \max(0, \log(op)_t - \max(\log(op)_{t-1}, \ldots, \log(op)_{t-p}))$$

Hamilton (1996) claimed that if the difference is negative, then there has not occurred an oil shock.
6.2. Descriptive statistics

Before moving on to the VAR estimation of the impact of oil price shocks on real stock returns, the descriptive statistics are presented.

Table 2 gives the summary statistics for the alternative measures of oil price shocks. The summary statistics for the real oil price change have a slightly positive mean, indicating that the oil price increases have been slightly larger than the oil price decreases. The highest increase of oil was of 45.892% and appeared in August 1990. As mentioned earlier, this increase was a response to the first Gulf War. The highest decrease in the sample of -30.311% was in November 2008. This decrease was a response to the recent financial crisis. It is obvious from the table that with a standard deviation 9.452% the oil price has a fairly high volatility.

### Table 2
Summary statistics for the alternative measures of oil price shocks

<table>
<thead>
<tr>
<th></th>
<th>dlog(op)</th>
<th>dlog(opp)</th>
<th>dlog(opn)</th>
<th>NOPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.280</td>
<td>3.728</td>
<td>-3.448</td>
<td>1.7834</td>
</tr>
<tr>
<td>Maximum</td>
<td>45.892</td>
<td>45.893</td>
<td>0</td>
<td>29.421</td>
</tr>
<tr>
<td>Minimum</td>
<td>-30.311</td>
<td>0</td>
<td>-30.311</td>
<td>0</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>9.452</td>
<td>5.5272</td>
<td>5.744</td>
<td>3.987</td>
</tr>
<tr>
<td>Skewness</td>
<td>0.006175</td>
<td>2.826394</td>
<td>-2.153701</td>
<td>3.127018</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>5.298108</td>
<td>16.87947</td>
<td>7.86238</td>
<td>15.67266</td>
</tr>
<tr>
<td>Nr. of observations</td>
<td>299</td>
<td>299</td>
<td>299</td>
<td>294</td>
</tr>
</tbody>
</table>

Notes: The table presents summary statistics for the different alternative measures of oil price shocks (real world oil price): real oil price change (dlog(op)), positive real oil price change (dlog(opp)), negative real oil price change (dlog(opn)) and net oil price increase (nopi). The mean, maximum, minimum and std. dev. are denoted in percent.

When it comes to the positive and the negative real oil price change, the dlog(opp) has a slightly higher mean than the dlog(opn). This confirms the above suggestion of the oil price increase being larger than the decreases. The volatility is somewhat higher for the dlog(opn) than the dlog(opp). The net oil price increase variable (nopi) has for obvious reasons a positive mean. The maximum net oil price increase is observed in the same month as dlog(opp).

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3 Appendix C table 15 show summary statistics for dlog(op) measured by the real national and real world oil price
The distributional properties show signs of being non-normal, especially in the dlog(opp), dlog(opn) and nopi which have high values for skewness. The Kurtosis is also above three for all the variables, indicating a leptokurtic distribution.

In figure 3 the graphs to the oil price shocks are plotted. It is obvious, from the plotted graph of the four alternative measures of oil price shocks, that the historical events mentioned earlier are evident with extreme high or low values of the change in real oil price.
Figure 3:
Alternative measures of oil price shocks

Notes: The figure presents the four different alternatives of oil price shocks. The first top left figure shows the real oil price change \((d\log(\text{op}))\), the top right shows the net real oil price increase \((\text{nopi})\), the bottom left shows the positive real oil price change \((d\log(\text{opp}))\), and the bottom right the negative real oil price change \((d\log(\text{opn}))\).
The correlation coefficients are showed in table 3 below. It is observed that the real oil price change is highly correlated with both the positive and negative real oil price change variables, with above 80%. A high correlation is also found between dlog(op) and nopi.

**Table 3:**
Correlation coefficients among alternative measures of oil price shocks

<table>
<thead>
<tr>
<th></th>
<th>dlog(op)</th>
<th>dlog(opp)</th>
<th>dlog(opn)</th>
<th>nopi</th>
</tr>
</thead>
<tbody>
<tr>
<td>dlog(op)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>dlog(opp)</td>
<td>0.840</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>dlog(opn)</td>
<td>0.836</td>
<td>0.404</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>nopi</td>
<td>0.579</td>
<td>0.701</td>
<td>0.267</td>
<td>1</td>
</tr>
</tbody>
</table>

*Notes:* The table presents correlation coefficients for the different alternative measures of oil price shocks (real world oil price); real oil price change (dlog(op)), positive real oil price change (dlog(opp)), negative real oil price change (dlog(opn)) and net oil price increase (nopi).

Table 4 presents the summary statistics for the real stock returns of the G-7 countries and Norway. It is apparent form the table that the mean returns are positive for all the variables, with Canada having the highest mean of them all and Japan the lowest. The highest reported standard deviation is found in Norway, while the lowest one is found in Canada. The standard deviation of the oil real oil price change (dlog(op)) exceeds the ones reported for the stock markets. The high standard deviation found both for the Norwegian stock market and dlog(op) might indicate a large impact of the oil price on the real stock return of Norway.

As with the oil price shock measures, there is also found evidence of the real stock returns having non-normal distributional properties. The skewness for all the countries is negative, with the exception of Italy. In addition, the Kurtosis is above three for all the countries, indicating a leptokurtic distribution.

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4 Appendix C table 16 show the summary statistics for dlog(ir), dlog(ip), dlog(cpi) and dlog(er)
Table 4:
Summary statistics for the real stock returns (rsr)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Maximum</th>
<th>Minimum</th>
<th>Std. Dev.</th>
<th>Skewness</th>
<th>Kurtosis</th>
<th>Nr. of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.375</td>
<td>11.565</td>
<td>-25.012</td>
<td>4.657</td>
<td>-1.260640</td>
<td>7.603622</td>
<td>299</td>
</tr>
<tr>
<td>France</td>
<td>0.349</td>
<td>19.887</td>
<td>-25.057</td>
<td>5.888</td>
<td>-0.527068</td>
<td>4.187298</td>
<td>299</td>
</tr>
<tr>
<td>Germany</td>
<td>0.187</td>
<td>18.362</td>
<td>-28.674</td>
<td>6.516</td>
<td>-0.901241</td>
<td>5.350735</td>
<td>299</td>
</tr>
<tr>
<td>Italy</td>
<td>0.038</td>
<td>23.686</td>
<td>-17.617</td>
<td>6.717</td>
<td>0.199863</td>
<td>3.705370</td>
<td>299</td>
</tr>
<tr>
<td>Japan</td>
<td>0.052</td>
<td>18.649</td>
<td>-23.551</td>
<td>5.897</td>
<td>-0.355399</td>
<td>4.258362</td>
<td>299</td>
</tr>
<tr>
<td>Norway</td>
<td>0.312</td>
<td>14.877</td>
<td>-35.860</td>
<td>7.334</td>
<td>-1.287719</td>
<td>6.409891</td>
<td>299</td>
</tr>
<tr>
<td>UK</td>
<td>0.239</td>
<td>12.548</td>
<td>-30.839</td>
<td>4.805</td>
<td>-1.224212</td>
<td>8.329823</td>
<td>299</td>
</tr>
<tr>
<td>US</td>
<td>0.364</td>
<td>11.662</td>
<td>-24.420</td>
<td>4.667</td>
<td>-1.033266</td>
<td>6.022525</td>
<td>299</td>
</tr>
</tbody>
</table>

Notes: This table presents summary statistics for the real stock return (rsr) for the G-7 countries and Norway. The mean, maximum, minimum and std. dev. are denoted in percent.

The pairwise correlation between real stock returns and the different measures of oil price shocks are showed in table 5. The table indicates that the rsr of Canada, Japan and Norway are positively correlated with the dlog(op). For the rest of the rsr are negatively correlated with the dlog(op).

The results from the correlation between dlog(opp) and rsr indicate that for Canada, Japan and Norway the rsr are positively correlated with both dlog(opp) and dlog(opn), while the opposite is true for the rest of the countries. The output then indicate that the real stock returns of Canada, Japan and Norway increase when the oil price increases, and decreases when there is a decrease in the oil price. For the rest of the countries the rsr decrease when the oil price increases, and increase when the oil price decreases.

Examination of the correlation between nopi and rsr, indicate similar results as with dlog(op). Norway and Canada are now the only countries which show evidence of a positive correlation between nopi and rsr. For the net importing countries the results indicate a negative correlation with nopi.

The results above might be explained by the fact that Canada and Norway are exporters of crude oil, while the rest of the countries are importers of crude oil. However, the result is somewhat surprising for Japan, being among the largest importers of crude oil.

5 Appendix C figure 9 show the graphs of the real stock returns of the G-7 and Norway
in the world, which would suggest that the rsr of Japan would also be negatively correlated to an oil price increase.

Table 5:
Pairwise correlation between real stock return and the different oil price shock measures.

<table>
<thead>
<tr>
<th></th>
<th>Canada</th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Japan</th>
<th>Norway</th>
<th>UK</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>dlog(op)</td>
<td>0.129</td>
<td>-0.078</td>
<td>-0.101</td>
<td>-0.096</td>
<td>0.072</td>
<td>0.158</td>
<td>-0.046</td>
<td>-0.037</td>
</tr>
<tr>
<td>dlog(opp)</td>
<td>0.074</td>
<td>-0.075</td>
<td>-0.127</td>
<td>-0.105</td>
<td>0.027</td>
<td>0.109</td>
<td>-0.064</td>
<td>-0.061</td>
</tr>
<tr>
<td>dlog(opn)</td>
<td>0.143</td>
<td>-0.056</td>
<td>-0.041</td>
<td>-0.055</td>
<td>0.093</td>
<td>0.156</td>
<td>-0.013</td>
<td>-0.001</td>
</tr>
<tr>
<td>nopi</td>
<td>0.038</td>
<td>-0.128</td>
<td>-0.197</td>
<td>-0.153</td>
<td>-0.035</td>
<td>0.004</td>
<td>-0.108</td>
<td>-0.097</td>
</tr>
</tbody>
</table>

Notes: The table presents pairwise correlation coefficients between real stock returns (rsr) and the different oil price shock measures; real oil price change (dlog(op)), positive real oil price change (dlog(opp)), negative real oil price change (dlog(opn)), and net real oil price change (nopi).

6.3. Time series analysis

In order to apply an unrestricted VAR model, it is necessary that the variables are stationary. The properties of the times series will in the following be analyzed by employing a unit root test and a cointegration test.

6.3.1. Unit root tests

To test whether the variables are stationary there will be conducted an Augmented Dickey Fuller test (ADF). The null hypothesis is that the series is non-stationary. The Schwartz information criterion is employed in order to choose the optimal lag used in the ADF. The ADF test is conducted in E-views and the results are reported in table 6.

Table 6 reports the results for five of the variables used in this thesis; real oil price, net oil price, interest rate, industry production and real stock return, with and without a trend. The outcome of the tests on log level with a constant indicate that the null hypothesis of non-stationarity cannot be rejected at the 5% level of significance for the variables real oil price, interest rate and industry production. There is however an exception for the industry production in Japan where the null hypothesis is rejected at the 5% level. Furthermore, the outcome of the tests on log level with a constant and a trend for the variables real oil price, interest rate and industry production are somewhat more indecisive.
In response to the results above showing evidence of the variables containing unit roots, the same tests are conducted for the variables in first log difference. The outcome of the tests on first log level for the variables real oil price, interest rate and industry production indicate that the null hypothesis of non-stationarity are rejected at the 1% level of significance. The tests on log level are rejected at the 1% significant level for the variables real stock return and net oil price.

It is accepted that in log levels real oil price, interest rate, and industrial production for the most part are $I(1)$ processes. Real stock returns and net oil price, and first log difference of real oil price, interest rate, and industry production are $I(0)$ processes.

Table 6:  
Unit root tests – Augmented Dickey Fuller test

<table>
<thead>
<tr>
<th>Country</th>
<th>Real oil price</th>
<th>Net oil price increase</th>
<th>Real stock return</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log level</td>
<td>First log level</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C</td>
<td>C&amp;T</td>
</tr>
<tr>
<td>World</td>
<td>-1.594(1)</td>
<td>-2.850(1)</td>
<td>-13.815(0)</td>
</tr>
<tr>
<td>Canada</td>
<td>-1.994(1)</td>
<td>-1.859(1)</td>
<td>-14.647(0)</td>
</tr>
<tr>
<td>France</td>
<td>-1.634(1)</td>
<td>-3.460(1)</td>
<td>-14.917(0)</td>
</tr>
<tr>
<td>Germany</td>
<td>-1.631(1)</td>
<td>-3.318(1)</td>
<td>-14.915(0)</td>
</tr>
<tr>
<td>Italy</td>
<td>-1.989(1)</td>
<td>-3.193(1)</td>
<td>-14.895(0)</td>
</tr>
<tr>
<td>Japan</td>
<td>-1.633(1)</td>
<td>-2.886(1)</td>
<td>-14.044(0)</td>
</tr>
<tr>
<td>Norway</td>
<td>-1.762(1)</td>
<td>-3.341(1)</td>
<td>-15.283(0)</td>
</tr>
<tr>
<td>UK</td>
<td>-1.527(1)</td>
<td>-2.951(1)</td>
<td>-14.829(0)</td>
</tr>
<tr>
<td>US</td>
<td>-1.725(1)</td>
<td>-2.871(1)</td>
<td>-13.864(0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Industry production</th>
<th>Interest rates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Log level</td>
<td>First log difference</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>C&amp;T</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada</td>
<td>-1.571(3)</td>
<td>-1.301(3)</td>
</tr>
<tr>
<td>France</td>
<td>-2.171(4)</td>
<td>-2.274(4)</td>
</tr>
<tr>
<td>Germany</td>
<td>-1.239(3)</td>
<td>-3.078(3)</td>
</tr>
<tr>
<td>Italy</td>
<td>-2.256(3)</td>
<td>-1.820(3)</td>
</tr>
<tr>
<td>Japan</td>
<td>-3.387(2)</td>
<td>-3.486(2)</td>
</tr>
<tr>
<td>Norway</td>
<td>-4.733(3)</td>
<td>-2.395(3)</td>
</tr>
<tr>
<td>UK</td>
<td>-2.455(1)</td>
<td>-1.016(1)</td>
</tr>
<tr>
<td>US</td>
<td>-1.656(4)</td>
<td>-1.907(4)</td>
</tr>
</tbody>
</table>

Notes: The table presents the results of a unit root test – Augmented Dickey Fuller test (Dickey & Fuller, 1981). Schwartz information criterion is used to choose the optimal lag of maximum 12 lags. The lag used is denoted in the parenthesis. C denotes constant, and C&T denotes constant and trend. Subscripts $^a, ^b, ^c$ denote rejection of the null hypothesis of a unit root at the 1%, 5%, and 10% level of significance, respectively. The critical values are obtained from MacKinnon (1996) one-sided p-values.
6.3.2. Cointegration test

Since the ADF test indicate that some of the variables contain a unit root, it is necessary to conduct a cointegration test to examine whether these variables have a common stochastic trend. The cointegration test is based on the methodology of Johansen and Juselius (1990), and is employed on the variables that in log level contained a unit root. These variables were real oil price, interest rate and industry production. To test for cointegration there is here employed both the maximum eigenvalue and the trace statistics. The optimal numbers of lags is chosen by estimating a VAR model, and then use the Akaike information criterion to find the appropriate lag length. The cointegration test is conducted in E-views and the results are reported in table 7.

The results reported suggest that in most cases there is not found any cointegration among real oil price, interest rate and industry production. However, the null hypothesis of no cointegration is rejected at the 5% level of significance for France, Japan and the UK using the real national oil price. Further, the table also shows that by using the real world oil price the null hypothesis is rejected at the 5% level of significance for France, Norway and UK. Although, the majority of the cointegration tests suggest that there is no cointegration, it still raises the question of what to do where there are cointegrated vectors. Maghyereh (2004, p. 33) suggests that several papers argues for the use of a vector error correction model (VECM), if the variables are integrated of $I(1)$. They suggest that the cointegrating vectors are binding the variables long run behavior, and for this reason the use of VECM, which is expected to produce a more accurate reflection of the relationship between the variables in the impulse response analysis and the variance decomposition, than the standard unrestricted VAR.

On the other hand, studies by Engle and Yoo (1987), Clements and Henry (1995), and Hoffman and Rasche (1996) argue that unrestricted VAR is superior, in terms of forecast variance, to a restricted VECM at short horizons. Further, a study by Naka and Tufte (1997) also shows evidence of the unrestricted VAR performing better than VEC in the short run (Maghyereh, 2004, p. 33).

Based on the above discussion the problem of cointegration will be ignored and it will in the following be employed an unrestricted VAR model.
### Table 7: Johansen and Juselius cointegration test results

<table>
<thead>
<tr>
<th>Country</th>
<th>Hypothesis</th>
<th>$r=0$</th>
<th>$r&lt;1$</th>
<th>$r&lt;2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real national brent oil price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada (lags = 4)</td>
<td>trace test</td>
<td>27.273</td>
<td>6.782</td>
<td>1.937</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>20.491</td>
<td>4.845</td>
<td>1.937</td>
</tr>
<tr>
<td>France (lags = 4)</td>
<td>trace test</td>
<td>30.653$^b$</td>
<td>6.62</td>
<td>0.093</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>24.033$^b$</td>
<td>6.527</td>
<td>0.093</td>
</tr>
<tr>
<td>Germany (lags = 4)</td>
<td>trace test</td>
<td>26.101</td>
<td>12.635</td>
<td>0.363</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>13.467</td>
<td>12.272</td>
<td>0.363</td>
</tr>
<tr>
<td>Italy (lags = 5)</td>
<td>trace test</td>
<td>26.412</td>
<td>5.931</td>
<td>0.489</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>20.481</td>
<td>5.442</td>
<td>0.489</td>
</tr>
<tr>
<td>Japan (lags = 3)</td>
<td>trace test</td>
<td>31.931$^b$</td>
<td>9.214</td>
<td>3.151</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>22.716$^b$</td>
<td>6.063</td>
<td>3.151</td>
</tr>
<tr>
<td>Norway (lags = 4)</td>
<td>trace test</td>
<td>31.532$^b$</td>
<td>11.384</td>
<td>1.439</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>20.148</td>
<td>9.945</td>
<td>1.439</td>
</tr>
<tr>
<td>UK (lags = 5)</td>
<td>trace test</td>
<td>35.246$^b$</td>
<td>3.927</td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>31.319$^b$</td>
<td>3.878</td>
<td>0.049</td>
</tr>
<tr>
<td>US (lags = 7)</td>
<td>trace test</td>
<td>19.621</td>
<td>3.628</td>
<td>0.002</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>15.993</td>
<td>3.626</td>
<td>0.002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Hypothesis</th>
<th>$r=0$</th>
<th>$r&lt;1$</th>
<th>$r&lt;2$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Real world brent oil price</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canada (lags = 4)</td>
<td>trace test</td>
<td>25.882</td>
<td>5.708</td>
<td>2.243</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>20.173</td>
<td>3.465</td>
<td>2.243</td>
</tr>
<tr>
<td>France (lags = 4)</td>
<td>trace test</td>
<td>30.418$^b$</td>
<td>4.426</td>
<td>0.093</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>25.992$^b$</td>
<td>4.332</td>
<td>0.093</td>
</tr>
<tr>
<td>Germany (lags = 4)</td>
<td>trace test</td>
<td>22.987</td>
<td>8.799</td>
<td>0.363</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>14.187</td>
<td>8.436</td>
<td>0.363</td>
</tr>
<tr>
<td>Italy (lags = 8)</td>
<td>trace test</td>
<td>28.21</td>
<td>10.167</td>
<td>3.616</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>18.043</td>
<td>6.551</td>
<td>3.616</td>
</tr>
<tr>
<td>Japan (lags = 3)</td>
<td>trace test</td>
<td>29.473</td>
<td>7.253</td>
<td>3.043</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>22.220$^b$</td>
<td>4.21</td>
<td>3.043</td>
</tr>
<tr>
<td>Norway (lags = 4)</td>
<td>trace test</td>
<td>33.433$^b$</td>
<td>11.759</td>
<td>0.757</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>21.673$^b$</td>
<td>11.002</td>
<td>0.757</td>
</tr>
<tr>
<td>UK (lags = 5)</td>
<td>trace test</td>
<td>35.505$^b$</td>
<td>3.527</td>
<td>0.046</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>31.978$^b$</td>
<td>3.481</td>
<td>0.046</td>
</tr>
<tr>
<td>US (lags = 7)</td>
<td>trace test</td>
<td>19.511</td>
<td>3.62</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>$\lambda$ max test</td>
<td>15.891</td>
<td>3.618</td>
<td>0.001</td>
</tr>
</tbody>
</table>

*Notes:* The table presents the test statistics of the Johansen and Juselius (1990) cointegration test. $r$ indicate the number of cointegrating vectors. Akike information criterion is used to choose the optimal lag of a maximum lag of 12, and is shown in the parenthesis. Subscripts $^b$ denotes rejection of the null hypothesis at the 5% level of significance.
6.4. Vector autoregressive models

In this section the impact of oil price shocks on real stock returns will be examined. The analysis will be divided into three parts, studying each of the three types of oil price shocks; linear, nonlinear and asymmetric, separately.

The impact of oil price shocks on real stock returns is analyzed using an unrestricted autoregressive model (VAR). This model has been frequently used since the work of Hamilton (1983). The system used in this thesis is identified by using Choleski factorization. As mentioned earlier the unrestricted VAR model is given by:

$$y_t = A_1 y_{t-1} + \ldots + A_p y_{t-p} + u_t$$

The main model that will be investigated contain four different variables; first log difference of interest rate (dlog(ir)), first log difference of the oil price (dlog(op)), first log difference of industrial production (dlog(ip)) and real stock return (rsr). The $y_t$ will then be $y_t = [dlog(ir), dlog(op), dlog(ip), rsr]'$. The first log difference of oil price will be exchanged with the other oil price specifications, depending on what relationship that are examined. $A_p$ is a 4x4 matrix of unknown coefficients. The number of lags that are used is denoted by $p$. The $u_t$ is the vector of innovations to the disturbances $(u^{dlog(ir)}, u^{dlog(op)}, u^{dlog(ip)}, u^{rsr})$ with $E(u_t u_t') = \Sigma$. The disturbances $u^{dlog(ir)}, u^{dlog(op)}, u^{dlog(ip)}$ and $u^{rsr}$ will be interpreted as shocks to interest rate, the oil price specification, industrial production and real stock return, respectively. Although, only the shock to $u^{dlog(op)}$ will be discussed in this thesis.

The ordering of the variables follows the earlier studies by Sadorsky (1999), Cong et al. (2008) and Park and Ratti (2008). This ordering assumes that monetary policy shocks are independent of contemporaneous disturbances to the other variables. It also assumes that changes in interest rates influences oil prices. Real stock returns are placed last in the ordering (Sadorsky, 1999, p. 455). The order of the variables in the VAR model will be indicated by the notation. To prevent over-parameterization the number of lags is chosen to be the lowest one reported by the Akaike information criteria and the Schwartz information criteria. Finally, Monte Carlo constructed standard errors from 1000 replications is employed. The VAR models will be conducted in E-views.
To study the impact of oil price shocks on stock returns the impulse response function and variance decomposition will be examined.

6.4.1. Linear oil price shocks

Based on the definition by Hamilton (1983) the following section seeks to analyze the impact of linear oil price shocks on real stock returns. The VAR model is given by VAR (dlog(ir), dlog(op), dlog(ip), rsr), and are employed with both a real world and real national oil prices. Schwartz information criterion suggests the use of one lag in the model.

Impulse response function

First, the impact of linear oil price shocks on stock real stock returns in terms of orthogonalized impulse response functions is assessed. Figure 4 and figure 5 show the orthogonalized impulse response function curves of real stock returns from a one standard deviation shock of the world oil price and national oil prices, respectively. The outer bounds give the 95% confidence bounds constructed by Monte Carlo to assess the statistical significance of the impulse response function. The impulse response graphs indicate that the significant impact of oil price shocks on real stock returns give various results amongst the different countries. The orthogonalized impulse responses become less significant and return to zero within 12 months. Table 8 summarize the results of the orthogonalized impulse response of real stock returns to real oil price shocks contemporaneously and/or within one month. In the table n(p) indicates a negative(positive) orthogonalized impulse response, while the superscripts ***, **, and * denote statistical significance at the 1%, 5% and 10% level, respectively.

Table 8 and figure 4 show the impulse responses of real stock returns to linear world oil price shocks. The results indicate that the real world oil price shock has a statistically significant negative impact on the real stock return of France and Germany, contemporaneously and/or within a month, at the 10% level, while having a significant positive impact at the 5% level on the real stock return of Norway. For the remaining countries the impulse responses are not significant. As already pointed out Canada and Norway are the only net exporting countries in the sample of countries, while the other countries are net importers of crude oil. However the trend is, although not being statistically significant for all the countries, that there is a distinction between the net exporting and net importing countries. It is obvious that the real stock returns of Canada
and Norway both react positively to a shock in the real oil price. For the net oil importing countries the fact is that 5 out of the 6 importing countries show a negative response of the real stock returns to oil price shocks, with the exception being Japan.

Table 8 and figure 5 indicate the orthogonalized impulse response of real stock returns to linear real national real oil price shock. Compared to the results using a real world real oil price, these accumulated responses are in general less significant. Norway is now the only country where the real stock return is responding statistically significant at a 5% level to a real national oil price shock contemporaneously and/or within a month. In addition, the results indicate that a real oil price shock has a negative insignificant impact on the real stock return of Canada, as opposed to earlier where it was positive.

<table>
<thead>
<tr>
<th>Real world oil price</th>
<th>Canada</th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Japan</th>
<th>Norway</th>
<th>UK</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock to op n(p)</td>
<td>p</td>
<td>n*</td>
<td>n*</td>
<td>n</td>
<td>p</td>
<td>p**</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Accumulated response</td>
<td>0.004187</td>
<td>-0.006196</td>
<td>-0.006783</td>
<td>-0.004841</td>
<td>0.002745</td>
<td>0.010445</td>
<td>-0.002419</td>
<td>-0.002281</td>
</tr>
<tr>
<td>Standard errors</td>
<td>(0.00268)</td>
<td>(0.00342)</td>
<td>(0.00380)</td>
<td>(0.00378)</td>
<td>(0.00334)</td>
<td>(0.00418)</td>
<td>(0.00277)</td>
<td>(0.00265)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real national oil price</th>
<th>Canada</th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Japan</th>
<th>Norway</th>
<th>UK</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock to op n(p)</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>p</td>
<td>p**</td>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Accumulated response</td>
<td>-0.000107</td>
<td>-0.004335</td>
<td>-0.005141</td>
<td>-0.002488</td>
<td>0.004393</td>
<td>0.008807</td>
<td>-0.000501</td>
<td>-0.002667</td>
</tr>
<tr>
<td>Standard errors</td>
<td>(0.00268)</td>
<td>(0.00345)</td>
<td>(0.00386)</td>
<td>(0.00384)</td>
<td>(0.00346)</td>
<td>(0.00424)</td>
<td>(0.00286)</td>
<td>(0.00274)</td>
</tr>
</tbody>
</table>

Notes: The table presents the orthogonalized impulse responses of the real stock returns to real oil price shocks: VAR (dlog(ir), dlog(op), dlog(ip), rsr). Subscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% level of significance, respectively. n(p) indicates a negative(positive) impulse response contemporaneously and/or with a lag of one month. The standard errors are the Monte Carlo standard errors from 1000 replications. The model is performed with 1 lag.
Figure 4:
Orthogonalized impulse response function of real stock returns to linear real world oil price shocks in VAR (dlog(ir), dlog(op), dlog(ip), rsr).

Notes: The figures shows the response of real stock returns to a Cholesky one standard deviation oil price shock. The model is fixed to see the response in a period of 12 months. The two outer lines are Monte Carlo constructed 95% confidence bounds. The model is performed with 1 lag.
Figure 5: Orthogonalized impulse response function of real stock returns to linear real national oil price shocks in VAR (dlog(ir), dlog(op), dlog(ip), rsr).

Canada  France  Germany  Italy  Japan  Norway  UK  US

Notes: The figures show the response of real stock returns to a Cholesky one standard deviation oil price shock. The model is fixed to see the response in a period of 12 months. The two outer lines are Monte Carlo constructed 95% confidence bounds. The model is performed with 1 lag.
**Variance decomposition**

Table 9 gives the output of the variance decomposition of forecast error variance in real stock return of real world oil price and real national oil prices after 12 months. The numbers gives the percentage of how much of the unanticipated changes of real stock returns that are explained by the real world/national oil price over a period of 12 months. The table gives the results of the VAR model (dlog(ir), dlog(op), dlog(ip), rsr).

The results show that the contribution of the real world oil price shock range from 0.81% for the real stock return of Canada to 4.93% for the real stock return of Italy. The results are similar for the contribution of the real national oil price, with the contribution to the Canadian real stock return being 0.04% and for the Italian real stock return 4.43%. Once again it is evident that the contribution of the real national oil price is lower than the one from the real world price.

**Table 9:**
Variance decomposition of forecast error variance in real stock return due to real world oil price and real national oil price after 12 months.

<table>
<thead>
<tr>
<th>Country</th>
<th>Shock to real world oil price</th>
<th>Shock to real national oil price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.813044</td>
<td>0.038652</td>
</tr>
<tr>
<td></td>
<td>(1.17486)</td>
<td>(0.68064)</td>
</tr>
<tr>
<td>France</td>
<td>2.122901</td>
<td>1.411914</td>
</tr>
<tr>
<td></td>
<td>(1.79087)</td>
<td>(1.64587)</td>
</tr>
<tr>
<td>Germany</td>
<td>2.125091</td>
<td>1.327576</td>
</tr>
<tr>
<td></td>
<td>(1.76674)</td>
<td>(1.45153)</td>
</tr>
<tr>
<td>Italy</td>
<td>4.925853</td>
<td>4.437077</td>
</tr>
<tr>
<td></td>
<td>(2.48862)</td>
<td>(2.33635)</td>
</tr>
<tr>
<td>Japan</td>
<td>1.073768</td>
<td>1.660392</td>
</tr>
<tr>
<td></td>
<td>(1.42476)</td>
<td>(1.47954)</td>
</tr>
<tr>
<td>Norway</td>
<td>2.027148</td>
<td>1.438478</td>
</tr>
<tr>
<td></td>
<td>(1.62670)</td>
<td>(1.42904)</td>
</tr>
<tr>
<td>UK</td>
<td>0.945071</td>
<td>0.604875</td>
</tr>
<tr>
<td></td>
<td>(1.30058)</td>
<td>(1.10350)</td>
</tr>
<tr>
<td>US</td>
<td>0.883955</td>
<td>0.868889</td>
</tr>
<tr>
<td></td>
<td>(1.16900)</td>
<td>(1.19459)</td>
</tr>
</tbody>
</table>

*Notes:* The table presents variance decomposition of forecast error variance, of the VAR model (dlog(ir), dlog(op), dlog(ip), rsr) with 1 lag, in real stock returns due to both real world oil price and real national oil price after 12 months. Monte Carlo constructed standard errors are shown in the parenthesis.
**Alternative VAR specifications**

In the following section there are conducted various alternative VAR models as a robustness check of the results of the impact of oil price shocks on real stock returns.

In the original model, the Schwartz information criterion suggests that the model is conducted with 1 lag. However, the Akaike information criterion suggests a lag of 3. The first alternative model that is examined is VAR(dlog(ir), dlog(op), dlog(ip), rsr) with 3 lags. The results are given in appendix D.1 and are in both the models with real world oil price and real national oil price less significant than in the original model. For instance in the model employing the real world oil price, Canada and Norway are the only countries with statistically significant result at a 10% level. By using a real national oil price, all the results indicate a statistically insignificant impact on real stock returns. When it comes to the variance decomposition showed in appendix D.1 the estimates are higher than in the original model. One reason for this might be the larger number of lags used in this model.

The next alternative model introduce the variable consumer price index (dlog(cpi)), and the basic model consist of 5 variables VAR(dlog(ir), dlog(op), dlog(ip), dlog(cpi), rsr). Appendix D.2 gives essentially the same results for the orthogonalized impulse response function contemporaneously and/or within one month, as in the basic model. However, the result for Canada is statistically significantly positive at a 10% level, when the model is conducted with the real world oil price. Furthermore, the results for Norway are statistical significant at a 5% level in the model with the real national real oil price. There are few differences reported in the variance decomposition of real stock returns.

One drawback with using Cholesky in the transformation to orthogonalized innovations is that the ordering of the residuals may have a large effect on the shocks. For this reason, the final robust check is conducted with an alternative ordering of the variables. The VAR model used is now VAR(dlog(op), dlog(ir), dlog(op), rsr). The results reported in appendix D.3 is here essentially the same for the orthogonalized impulse response function contemporaneously and/or within a month, as for the basic model. In the results for the variance decomposition of real stock returns there is also observed few differences.
6.4.2. Asymmetric oil price shocks

An asymmetric relationship between the macroeconomy and oil price shocks was found by Mork (1989). His definition will be used to examine if there exists an asymmetric relationship between oil price shocks and real stock returns. An asymmetric relationship suggests that the impact of oil price increases and oil price decreases are not the same. In the VAR model an oil price increase are denoted \( \text{dlog}(\text{opp}) \) and an oil price decrease \( \text{dlog}(\text{opn}) \). This gives the following VAR model: \( y, [\text{dlog}(\text{ir}), \text{dlog}(\text{opp}), \text{dlog}(\text{opn}), \text{dlog}(\text{ip}), \text{rnr}] \). This is a 5x5 matrix of unknown coefficients. Here as well the VAR model will be conducted with both a real world oil price and a real national oil prices. The Schwartz information criterion is used to find the optimal number of lags, which is one.

**Variance decomposition**

The output of the variance decomposition of the forecast error variance in real stock return of real world oil price and real national oil price after 12 months is given in table 10.

Both the real world oil price and real national oil prices are divided into a variable for the oil price increases \( \text{dlog}(\text{opp}) \)) and a variable for the oil price decreases \( \text{dlog}(\text{opn}) \). It is evident from the table that there are six occasions where the impact of an oil price increase is greater than that of an oil price decrease on real stock returns. Only in two occasions the oil price decrease has a greater impact than an oil price increase. By examining the real world oil price, the trend is that for five out of six net oil importing countries, a positive oil price shock has a greater impact on real stock returns than a negative oil price shock. Of the net oil exporting countries, the Canadian stock market is more affected by an oil price decrease than by an oil price increase, while the opposite is true for Norway.
Table 10:
Variance decomposition of forecast error variance in real stock return due to real world oil price and real national oil price after 12 months.

<table>
<thead>
<tr>
<th>Country</th>
<th>Real world oil price shock</th>
<th>Real national oil price shock</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dlog(opp)</td>
<td>dlog(opn)</td>
</tr>
<tr>
<td></td>
<td>dlog(opp)</td>
<td>dlog(opn)</td>
</tr>
<tr>
<td>Canada</td>
<td>0.297957</td>
<td>0.839729</td>
</tr>
<tr>
<td></td>
<td>(0.98218)</td>
<td>(1.21358)</td>
</tr>
<tr>
<td>France</td>
<td>1.524318</td>
<td>0.592517</td>
</tr>
<tr>
<td></td>
<td>(1.54963)</td>
<td>(1.09917)</td>
</tr>
<tr>
<td>Germany</td>
<td>2.963979</td>
<td>0.001008</td>
</tr>
<tr>
<td></td>
<td>(2.08619)</td>
<td>(0.66921)</td>
</tr>
<tr>
<td>Italy</td>
<td>3.747091</td>
<td>1.916224</td>
</tr>
<tr>
<td></td>
<td>(2.10832)</td>
<td>(1.52719)</td>
</tr>
<tr>
<td>Japan</td>
<td>0.595532</td>
<td>0.649858</td>
</tr>
<tr>
<td></td>
<td>(1.01611)</td>
<td>(1.09538)</td>
</tr>
<tr>
<td>Norway</td>
<td>1.223977</td>
<td>0.887379</td>
</tr>
<tr>
<td></td>
<td>(1.41914)</td>
<td>(1.26475)</td>
</tr>
<tr>
<td>UK</td>
<td>0.961157</td>
<td>0.154676</td>
</tr>
<tr>
<td></td>
<td>(1.23175)</td>
<td>(0.7335)</td>
</tr>
<tr>
<td>US</td>
<td>0.869864</td>
<td>0.314304</td>
</tr>
<tr>
<td></td>
<td>(1.27999)</td>
<td>(0.76971)</td>
</tr>
</tbody>
</table>

Notes: The table presents variance decomposition of forecast error variance, of the VAR model (dlog(ir), dlog(opp), dlog(opn), dlog(ip), rsr) with one lag, in real stock return due to both asymmetric real world oil price and real national oil price after 12 months. Monte Carlo constructed standard errors are shown in the parenthesis.

Coefficient test for asymmetric effect

In addition to the VAR model, there is also used a traditional chi-square ($\chi^2$) test to compare the coefficients of oil price increase and oil price decrease. The regression model is given by:

$$rsr_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{i}ir_{t-i} + \sum_{i=1}^{p} \alpha_{2i}opp_{t-i} + \sum_{i=1}^{p} \alpha_{3i}opn_{t-i} + \sum_{i=1}^{p} \alpha_{4i}ip_{t-i} + \sum_{i=1}^{p} \alpha_{5i}rsr_{t-i} + u_t$$

(17)

The chi-square ($\chi^2$) tests the null hypothesis that the coefficients of positive and negative oil price shocks in the VAR are equal to each other at each lag ($p$), and is given by:

$$H_0 : \alpha_{2i} = \alpha_{3i} \quad H_1 : \alpha_{2i} \neq \alpha_{3i} \quad i = 1,..., p$$

By separating the variable real world oil price into positive (dlog(opp)) and negative (dlog(opn)) oil price changes, it is observed that over the period 52.8% of the oil price
changes are positive, and 47.2% are negative. The mean values for these two variables are given in the descriptive statistics to be 3.728 for dlog(opp) and -3.448 for dlog(opn). This indicates that there are more positive shocks than negative, and that the average positive shock are approximately 8% larger than the negative one.

The table below gives the chi-square ($\chi^2$) test results, which are obtained by conducting a Wald coefficient test in E-views. In all cases the null hypothesis cannot be rejected at the 5% level of significance. Although the results from the variance decomposition above indicate that the impact of an oil price increase is a little dominant, the results from the chi-square ($\chi^2$) test obtain no evidence for asymmetric effects of oil price shocks on real stock returns for the G7 and Norway.

**Table 11:**
Coefficient test of asymmetric effect of real world oil price shocks and real national oil price shocks on real stock return.

<table>
<thead>
<tr>
<th></th>
<th>Real world oil price shock</th>
<th>Real national oil price shock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>1.483945</td>
<td>1.589605</td>
</tr>
<tr>
<td>France</td>
<td>0.136857</td>
<td>0.054312</td>
</tr>
<tr>
<td>Germany</td>
<td>1.119359</td>
<td>0.777589</td>
</tr>
<tr>
<td>Italy</td>
<td>0.471686</td>
<td>0.344563</td>
</tr>
<tr>
<td>Japan</td>
<td>0.059164</td>
<td>0.026645</td>
</tr>
<tr>
<td>Norway</td>
<td>0.046277</td>
<td>0.109773</td>
</tr>
<tr>
<td>UK</td>
<td>0.007264</td>
<td>0.925008</td>
</tr>
<tr>
<td>US</td>
<td>0.097518</td>
<td>0.086016</td>
</tr>
</tbody>
</table>

*Notes:* The table presents Chi-square ($\chi^2$) test results of $H_0: \alpha_{2i} = \alpha_{yi}, i = 1, \ldots, p$. The equation is given in equation (17) showed above, and is carried out with one lag. ** denotes a statistical significance at the 5% level.

*Alternative VAR specifications*

As a robustness check the same alternative models as earlier, is conducted for the impact of oil price shocks on real stock returns.

The Akaike information criterion here suggests a lag of two, and the first alternative model that is examined is VAR(dlog(ir), dlog(op), dlog(ip), rsr) with two lags. The results from the variance decompositions of real stock returns are showed in appendix E.1. It is evident from the table that by using the real world oil price there are five occasions where the impact of an oil price increase is greater than an oil price decrease.
on real stock returns, and three occasions where the opposite is true. For the real national oil price there are only three occasions where the impact of an oil price increase is greater than oil price decrease, and five occasions where the decrease is greater than the increase. The results of the chi-square ($\chi^2$) test give the same result as before.

In the next alternative model the consumer price index is introduced as an extra variable in the VAR model. The results in appendix E.2 are to a large extent the same as in the original model. The reported results of the chi-square test obtain no evidence for asymmetric effects of oil price shocks on real stock returns of the G7 and Norway.

The final alternative model uses an alternative ordering of the variables by switching places between $d\log(ir)$ and $d\log(ip)$. These results as well show little differences from the original model (appendix E.3). The chi-square test shows no evidence of an asymmetric relationship between oil price shocks and real stock returns.

### 6.4.3. Non-linear oil price shocks

The final relationship that will be examined was introduced by Hamilton (1996). He suggests that for an oil price increase to be defined as a shock, it needs to be larger than what it has been in the preceding months, rather than the previous month alone. The oil price increase is denoted $nopi$, and the following VAR model is used $y_t [d\log(ir), nopi, d\log(ip), rsr]'$. This is a 4x4 matrix of unknown coefficients. The Schwartz information criterion suggests one lag. The VAR model is conducted with a real world price and real national oil prices.

**Impulse response function**

The impact of real world oil price shock and real national oil price shocks is here assessed by examining the orthogonalized impulse responses with a non-linear oil price specification.

Table 12 and figure 6 summarize the results of the impulse responses of real stock returns from a one standard deviation shock. The 95% confidence bound are provided in the parenthesis in the table and as the outer bounds in the graphs, in order to assess the statistical significance of the impulse response function. The results indicate that in five out of eight of the countries a real world net oil price has a statistically significant negative impact on real stock returns instantaneously and/or in one month. Canada is the
only country in which the real stock return is positively impacted by a net oil price shock, however the result is statistically insignificant.

Table 12: Orthogonalized impulse response of real stock returns to real net oil price shocks: VAR (dlog(ir), nopi, dlog(ip), rsr).

<table>
<thead>
<tr>
<th>Real world oil price</th>
<th>Canada</th>
<th>France</th>
<th>Germany</th>
<th>Italy</th>
<th>Japan</th>
<th>Norway</th>
<th>UK</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock to op</td>
<td>p</td>
<td>n**</td>
<td>n***</td>
<td>n***</td>
<td>n</td>
<td>n</td>
<td>n*</td>
<td>n*</td>
</tr>
<tr>
<td>Accumulated response</td>
<td>0.001297</td>
<td>-0.00845</td>
<td>-0.012695</td>
<td>-0.010736</td>
<td>-0.00192</td>
<td>-0.000526</td>
<td>-0.005183</td>
<td>-0.00483</td>
</tr>
<tr>
<td>Standard errors</td>
<td>(0.00268)</td>
<td>(0.00336)</td>
<td>(0.00391)</td>
<td>(0.00276)</td>
<td>(0.00357)</td>
<td>(0.00425)</td>
<td>(0.00282)</td>
<td>(0.00278)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Real national oil price</th>
<th>Sign of statistically significant effect on real stock return of shock to non-linear oil price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shock to op</td>
<td>n</td>
</tr>
<tr>
<td>Accumulated response</td>
<td>-0.0002261</td>
</tr>
<tr>
<td>Standard errors</td>
<td>(0.00265)</td>
</tr>
</tbody>
</table>

Notes: The table presents orthogonalized impulse responses of real stock returns to real net oil price shocks: VAR (dlog(ir), nopi, dlog(ip), rsr). Subscripts ***, **, and * denote the statistical significance at the 1%, 5%, and 10% level of significance, respectively. n(p) indicates a negative(positive) impulse response contemporaneously and/or with a lag of one month. The standard errors are the Monte Carlo standard errors from 1000 replications. The model is performed with 1 lag.

In table 12 and figure 7 it is shown when the real national net oil price shock is applied the results are somewhat less significant. The only countries where the net oil price shocks have a statistically significant impact on the real stock returns are for Germany and the US. Furthermore, the response of the real stock return in Canada switch from being positive to negative, while the responses of real stock returns in Japan and Norway become positive.

All the orthogonalized impulse responses revert to zero within one year, which gives a transitory impact from the net oil price shock.
Figure 6:
Orthogonalized impulse response function of real stock returns to non-linear real world net oil price shocks in VAR (dlog(ir), nopi, dlog(ip), rsr).

Notes: The figures shows the response of real stock returns to a Cholesky one standard deviation net oil price shock. The model is fixed to see the response in a period of 12 months. The two outer lines are Monte Carlo constructed 95% confidence bounds. The model is performed with 1 lag.
Figure 7:
Orthogonalized impulse response function of real stock returns to non-linear national net oil price shocks in VAR (dlog(ir), nopi, dlog(ip), rsr).

Notes: The figures shows the response of real stock returns to a Cholesky one standard deviation net oil price shock. The model is fixed to see the response in a period of 12 months. The two outer lines are Monte Carlo constructed 95% confidence bounds. The model is performed with 1 lag.
Variance decomposition of real stock returns

In table 13 the variance decomposition forecast error variance in real stock return due to real world net oil price and real national net oil price are reported. The highest reported unanticipated change in real stock return due to net oil price shocks is in Germany where 4.08% are explained by net oil price shocks. One interesting aspect is that the two net oil exporting countries in the sample, Canada and Norway, report the lowest contribution of a net oil price shock to the real stock returns.

The reported results are here also less significant in the VAR model conducted with a real national net oil price. Still, the contribution is lowest for the two net oil exporting countries.

It is obvious from table 13 that the contribution of a net oil price shock is greater for the net importing countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Shock to real world net oil price</th>
<th>Shock to real national net oil price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>0.078239</td>
<td>0.254817</td>
</tr>
<tr>
<td></td>
<td>(0.77347)</td>
<td>(0.87370)</td>
</tr>
<tr>
<td>France</td>
<td>2.142341</td>
<td>0.574578</td>
</tr>
<tr>
<td></td>
<td>(1.72551)</td>
<td>(1.10350)</td>
</tr>
<tr>
<td>Germany</td>
<td>4.079866</td>
<td>1.718089</td>
</tr>
<tr>
<td></td>
<td>(2.35933)</td>
<td>(1.51864)</td>
</tr>
<tr>
<td>Italy</td>
<td>3.265926</td>
<td>1.195806</td>
</tr>
<tr>
<td></td>
<td>(2.00054)</td>
<td>(1.37562)</td>
</tr>
<tr>
<td>Japan</td>
<td>0.549015</td>
<td>0.53247</td>
</tr>
<tr>
<td></td>
<td>(1.05438)</td>
<td>(1.06362)</td>
</tr>
<tr>
<td>Norway</td>
<td>0.257677</td>
<td>0.148425</td>
</tr>
<tr>
<td></td>
<td>(0.92530)</td>
<td>(0.79975)</td>
</tr>
<tr>
<td>UK</td>
<td>1.303004</td>
<td>0.260056</td>
</tr>
<tr>
<td></td>
<td>(1.52226)</td>
<td>(0.83115)</td>
</tr>
<tr>
<td>US</td>
<td>1.068692</td>
<td>1.013072</td>
</tr>
<tr>
<td></td>
<td>(1.37722)</td>
<td>(1.27148)</td>
</tr>
</tbody>
</table>

Notes: The table presents variance decomposition of forecast error variance, of the VAR model (dlog(ir), n opi, dlog(ip), rsr) with one lag, in real stock return due to both real world net oil price and real national net oil price after 12 months. Monte Carlo constructed standard errors are shown in the parenthesis.
Alternative VAR specifications

As robustness checks the first alternative model conducted is VAR(dlog(ir), nopi, dlog(ip), rsr) with three lags. Appendix F.1 shows the impulse response of real stock returns to non-linear world oil price shock, and report pretty much the same results as in the basic model. In addition, the impulse response to a non-linear national oil price yield a statistically significant result for Italy at the 10% level, while the result for the US has become insignificant. The result for Norway has become insignificantly negative instead of positive. The variance decomposition of real stock returns gives a somewhat higher impact from the oil price shocks than in the original model.

The second alternative model includes the extra variables cpi, and the examined VAR model is VAR(dlog(ir), nopi, dlog(ip), dlog(cpi), rsr). The reported results in appendix F.2 obtain in a large degree the same results for both the impulse response to non-linear oil prices and the variance decomposition of real stock returns, as in the basic model.

The final alternative model places nopi ahead of dlog(ir), which gives a change in the ordering of the variables, and the VAR model that is examined is VAR(nopi, dlog(ir), dlog(ip), rsr). This model as well, essentially obtain the same results for the impulse response to non-linear oil price shocks and the variance decomposition of real stock returns (appendix F.3).

6.5. Residual tests

It is discussed in that in the VAR model, the right hand sides of the equations only show the lagged values of the endogenous variables. This indicates that Ordinary Least Squares (OLS) yields consistent estimates, and that simultaneity is not an issue. Furthermore, even if the innovations $\varepsilon_t$ are contemporaneously correlated, OLS will be efficient. Residual tests are employed in order to determine whether or not the OLS assumptions are fulfilled.

Autocorrelation LM test

The first OLS assumption that is tested is the assumption of no autocorrelation. No autocorrelation is the case when the error term is not correlated at a specific point in time with another error term at another point of time (Gujarati, 2003).
An autocorrelation LM test is used in order to test for autocorrelation. The test is carried out for all the different models used in this thesis. The conclusion is that the null hypothesis of no autocorrelation for the most models is rejected. However, there are some models and countries where the null hypothesis of no autocorrelation cannot be rejected.

Some of the consequences with autocorrelation are that the coefficients remain unbiased, but they are inefficient. This causes the standard errors to be incorrect and lead to invalid inference (Brooks, 2003, p.166).

**Normality test**

The assumption of normality is fulfilled when the error terms \( u_i \) are independent drawings from a normal distribution with mean zero and variance \( \sigma^2 \). A Bera-Jarque residual normality test is conducted in order to test for normality.

The results of the Bera-Jarque test, carried out on the different models in this thesis, all rejects the null hypothesis of normality. Since this is a financial model it is likely that non-normality is caused by observations in the different variables that are outliers (Brooks, 2003, p. 182). Non-normality might invalidate the test statistics, however, this problem is often ignored in samples with a great number of observations.

**White heteroscedasticity test**

The final assumption that is tested is the assumption of homoscedasticity. To satisfy the assumption of homoscedasticity each error term must have a constant variance. If the assumption is not satisfied it is said to be heteroscedastic. A White heteroscedasticity test with no cross terms is conducted in order to test for heteroscedasticity (Brooks, 2003, p. 147).

The White heteroscedasticity test is conducted for every model, and they all reject the null hypothesis of homoscedasticity. Heteroscedasticity still yields unbiased coefficients estimates, but they will no longer provide the estimate with the smallest variance. In addition, the standard errors are biased in the present of heteroscedasticity, and hence any inference made could be misleading. The author is here aware of the issue, but still chooses to ignore the problem of heteroscedasticity (Brooks, 2003, p.150).
6.6. Discussion

In the following section the mentioned theory and earlier empirical studies on the impact of oil price shocks on stock markets and the economy, in order to analyze the empirical results in effort to state the reasons for the obtained results in this thesis. Furthermore, the stated hypothesis will be answered.

6.6.1. Linear oil price shocks

The first main findings suggest that a linear oil price shock measured by the real world oil price has a statistically significant negative impact on real stock returns of France and Germany at the 10% level, while having a significant positive impact at the 5% level on the real stock return of Norway. The findings further indicate that when a linear oil price shock is measured by real national oil price, the real stock return of Norway is the only one where the result is statistically significant at the 5% level. The results for the remaining countries are not statistically significant.

The results obtained in this thesis are then not very consistent with earlier studies like Hamilton (1983), Cunado and de Gracia (2003) and Jimenez-Rodriguez and Sanchez (2005) which find that linear oil price shocks have a significant impact on industry production index or GNP. Furthermore, studies by Sadorsky (1999), Gjerde and Sættem (1999), Papaetrou (2001), Bjørnsland (2008), Park and Ratti (2008) and Ono (2011) also find a significant impact of linear oil price shocks on real stock returns in various countries.

In addition to the empirical results obtained in earlier literature, and the high dependency of oil in the G-7 and Norway that are analyzed in this thesis, the results seem somewhat unexpected.

However, there is literature by Burbridge and Harrison (1984), Jones and Kaul (1996), Ciner (2001) and Cong et al. (2008), which obtain similar results as in this thesis, these articles differs in either the data that are used, the time period or statistical method that are employed.

There may be several reasons for the lack of statistically significant results obtained in this thesis. The first reason might be, with the exception of the paper by Ono (2011), that none of the other papers employ any recent data. They then also fail to include the two most recent oil price shocks, occurring previous to and in the beginning of the latest
financial recession. Furthermore, the trend is also that the consumption of oil in Germany, Italy, Japan and the UK has been declining since the end of the 1990s, while for the rest of the countries since the mid 2000s. This in turn might be explained by the fact that the high oil prices have forced these counties to focus on alternative energy sources, and thereby becoming more resilient to oil price changes. Even though the oil consumption of these countries still are among the highest ones in the world, this may have an impact causing less significant results, compared to earlier studies.

Another reason might be the number of lags which are included in the VAR model. In other papers the number of lags used for the most part varies between 4 and as much as 12 lags. Sørensen (2009, p. 9) argues that the oil and gas industry cannot be predicted by a change in oil prices, because this information will be incorporated to the share price rather instantly. However, in other industries where the role of oil is more uncertain it may take more time to incorporate the new information concerning the oil price into the share price. For this reason he argues for the inclusion of more lags. In addition the more indirectly affects that the oil price have through the inflation rates and the real interest rates, may also use some time to be incorporated into the share prices. In this thesis however, the VAR models are only employed with 1 lag, and it is therefore possible that the models are not able to catch all of the indirect effects of the oil price.

Finally, the simple fact that the different empirical studies employ different statistical methods as well as different time series variables, may also explain why this thesis not obtain the same results as a majority of the literature.

Despite the results not being statistically significant, the real stock returns of the G-7 and Norway respond in the same direction as the literature employing a similar VAR model. The oil exporting countries, Norway and Canada, respond positively to a linear oil price shock measured by the real world oil price, while the importing countries respond negatively. The exception is Japan which responds positively to linear oil price shocks. Similar unexpected results for Japan are also found in the article by Jimenez-Rodriguez and Sanchez (2005). They as well find evidence of a positive reaction of Japanese GDP growth to an oil price increase. Jimenez-Rodriguez and Sanchez argue that despite its large dependency on oil, the Japanese economy is rather resilient to oil
shocks. Several other studies, among them Jones and Kaul (1996) also find weak results for the impact of oil price shocks on the real stock return of Japan.

The results might be justified by the fact that the oil importing countries all are among the top ten largest importers of crude oil in the world. In addition, Norway and Canada are ranked as number 5 and 14 of the largest exporters of crude oil in the world, respectively. Jones and Kaul (1996, p. 688) and Maghyereh (2004, p. 36) argue that the response of the individual country are likely to vary considerably to the effects of oil price shocks depending on the role of oil in their production and consumption. Furthermore, on a macro level changes to the oil price would imply a transfer of income between net importers and net exporters of oil.

On a more micro level this would suggest that companies in which oil is a cost in production, will incur larger costs which further reduce the earnings of the company and a decline in the share price. On the other hand, companies in which oil is an output will experience higher earnings and a rise in share price. It is also expected that stock markets where a larger fraction of the quoted companies use oil as an output, will also have a larger probability of having a positive response to an oil price increase. Mork, Olsen and Mysen (1994) states this as one of the reasons for the large increase in Norway. This is also evident in the fact that the oil and gas industry constituent 41.49% of the FTSE Norway 30 index (FTSE, 2010). The significant results are also obtained in this thesis where Norway is the only country in which a linear oil price shock measured as real oil price, has a statistically significant impact at a 5% level.

When it comes to the results from the variance decomposition in real stock returns these are also somewhat lower than the results obtained by Sadorsky (1999), Park and Ratti (2008) and Ono (2011). However, this might be explained by lower number of lags utilized in this thesis. In addition I have only used a period of 12 months in the variance decomposition, while others use more because of the larger number of lags.

The above analysis suggest that linear oil price shocks do not have a statistically significant impact on real stock returns, and for this reason there is found little evidence that verify the first hypothesis.
6.6.2. Asymmetric oil price shocks

The second main finding suggests no asymmetric effects of oil price shocks on real stock returns of the G-7 and Norway. Although the results from the variance decomposition in six out of eight occasions indicate that an oil price increase explain a higher percentage of the unanticipated change of real stock returns, the chi-square tests reject the null hypothesis of the positive real oil price being significantly different from the negative real oil price. Thereby also indicating that asymmetric oil price shocks not have a statistically significant effect on real stock returns.

These results are not consistent with the results obtained by Mork (1989), Mork, Olsen and Mysen (1994), Lee, Ni and Ratti (1995), Cunado and de Gracia (2003), Hamilton (2003) and Jimenez-Rodriguez and Sanchez (2005). These argue for an asymmetric relationship between oil price shocks and macroeconomic indicators, which indicate that economic effects from oil price increases are larger than the effects from oil price decreases. The same obvious relationship between asymmetric oil price shocks and stock returns are not found in the articles by Park and Ratti (2008), Cong et al. (2008) or Ono (2011), which conduct a more similar analysis to the one employed in this thesis.

Although the results from the chi-square test are not significant the results from the variance decomposition indicate that the impact of oil price increases measured by the real world oil price, is slightly larger than that oil price decreases. This seems particularly to be true for the net oil importing countries. More specifically, this means that for the net crude oil importing countries the bad news of an oil price increase have a greater impact on real stock returns than the good news of an oil price decrease. Canada and Japan are the only two countries where an oil price decrease explains a higher percentage of the unanticipated change of real stock returns. These results are similar to the results indicated by linear oil price shocks. Being a net oil exporter of crude oil the results are somewhat unexpected for Norway where an oil price decrease explained a higher percentage of the unanticipated change of real stock returns in Norway. However, this might be explained by the fact that the oil and gas industry constituent 41.49% of the FTSE Norway 30 index (FTSE, 2010), and that an oil price decrease thereby largely affect these companies revenue.

When the oil price is measured by the real national oil price, an oil price increase explains a higher percentage of the unanticipated change of the real stock return in
Japan. For the UK on the other hand, an oil price decrease now explains a higher percentage of the unanticipated change of the real stock return. The change in the UK might be explained by the fact that until 2005 they were actually a net exporter of oil.

The above analysis suggests that asymmetric oil price shocks do not have an impact on stock markets in the G-7 and Norway, this is in accordance to the third hypothesis.

6.6.3. Non-linear oil price shocks

The third main finding suggest that non-linear oil price shocks measured by the real world oil price has a statistically significant negative result on real stock returns of France, Germany, Italy, the UK and the US. By employing non-linear oil price shocks measured by real national oil price, the real stock returns of Germany and the US are the only countries in which the results are statistically significant. The results for the remaining countries are not statistically significant. These results indicate that non-linear oil price shocks measured by the real world oil price are more significant than when measured with the real national oil price.

The definition of non-linear oil price shocks are also popular and have been investigated in several papers. Hamilton (1996) finds evidence of impact of non-linear oil price shocks on GDP growth in the US. Other papers that confirm this relationship are Cunado and de Gracia (2003) and Jimenez-Rodriguez and Sanchez (2005). Furthermore, Sadorsky (1999), Ciner (2001), Cong et al. (2008), Park and Ratti (2008), Bjørnsland (2008), Odusami (2009), and Ono (2011) all finds evidence of a non-linear impact of oil price shocks on stock returns.

Once again the respective countries dependency on oil seems to be an important factor to whether real stock returns responds negative or positive to an oil price shock. The countries in which the real stock returns are responding statistically significantly negative to net oil price shocks are all large importers of oil. As mentioned earlier these significant results might be explained by the large burden implied the transfer of income between net importers and net exporters of oil. Furthermore, on a micro level it is expected that in the majority of the companies the oil act as an input, and therefore by a large increase in the oil price represented by nopi, the companies may not be able to pass on the extra costs to the consumers, as might be the case with a smaller oil price change.
Canada as an exporter of crude oil reacts insignificantly positive, when nopi is measured by the real world oil price. While to the author’s surprise both Norway and Japan react negatively to a non-linear oil price shock. When the oil price shock is measured by the real national oil price, the response in Canada turns negative and positive in Japan and Norway. The fact that the results for Canada, Japan, and Norway are somewhat indecisive and insignificant when an oil price shock is measured by nopi, might indicate that these countries are more robust to large increases in the oil price.

The results of the variance decomposition of real stock returns are also here lower than those reported by Sadorsky (1999), Park and Ratti (2008) and Ono (2011). Still these results can partly be explained by the lower number of lags, and that is only used a period of 12 months in the variance decomposition. In addition the results indicate that Norway and Canada as the only net exporters of oil, both report the lowest contribution of a net oil price shock to real stock return. This indicates that the oil exporting countries are more robust to the larger oil price shocks.

The above analysis suggests that non-linear oil price shocks do have a statistically significant impact on real stock returns, at least when it is measured by a real world oil price. This is in accordance to the second hypothesis.

It is obvious that the results in general are less significant when oil price shocks are measured by real national oil prices compared to when it is measured by the real world oil price. One probable reason for this is that movements in the exchange rates offset a part of the oil price shocks.

Finally, although the results are mostly insignificant, the results obtained in this thesis indicate that the respective countries dependency on oil seems to play a crucial role on the impact of real stock returns to oil price shocks.

7. Conclusion

There exist extensive literature establishing a connection between oil price shocks and the economy. Less literature has been produced for the impact of oil price shocks on stock markets. In this thesis, I have studied the impact of oil price shocks to real stock returns in the G-7 and Norway. The analysis is made by investigating the impact of three different definitions of oil price shocks. These are a linear, non-linear and
asymmetric oil price shocks. In order to examine the impact there is employed an unrestricted VAR model on the period between 1986M01 and 2010M12. The aim of the study is to contribute to the already existing literature on the subject.

The first finding indicates little evidence of an impact of linear oil price shocks on real stock returns of the G-7 and Norway. The empirical results show that the stock returns of France, Germany and Norway are the only countries where there is found a statistically significant impact of linear oil price shocks, when measured by a real world oil price. The results are even weaker when the linear oil price shocks are measured by the real national oil price. Even though the results are statistically insignificant the output indicate that with the exception of Japan the dependency of oil in the respective countries seem to play a vigorous part in whether the response of the real stock returns are positive or negative.

The second finding indicates that variance decomposition of real stock returns, suggest that asymmetric shocks measured by the real world oil price, show that for the net crude oil importing countries an increase in the oil price have a stronger impact on the unanticipated changes in the real stock return. The exception is Norway where an increase also has a stronger impact than a decrease. For Canada and Japan the results indicate the opposite. When the asymmetric oil price shock is measured by the real national the results are almost the same. On the other hand the chi-square test suggests that there is no evidence that indicate an impact of asymmetric shocks on real stock returns of the G-7 and Norway, which are consistent with earlier studies.

The third finding, indicate that non-linear oil price shocks have an impact on real stock returns of the G-7 and Norway. The empirical results show that for 5 out of the 8 countries there are found evidence of a statistically significant negative impact on the real stock returns. The mentioned countries are all net importers of crude oil. Only Canada has a positive response to non-linear oil price shocks. When the non-linear oil price shock is measured by the real national oil price, the results are less significant, and Japan and Norway are now the countries that have a positive response. These results are also in consistent with earlier studies.

In all the mentioned findings the evidence suggests that the individual country’s dependency on oil seem to have a great impact on the response of the real stock returns.
7.1. Further research

After having summarized the results obtained in this thesis, the results are not as statistically significant as it might have been expected. For this reason, it would be interesting to divide the full sample period that are used into sub sample periods, in order to analyze if there exists any obvious differences over the period. Another suggestion would be to perform a similar analysis by including more lags to see what the effect this would be.

As mentioned earlier Barsky and Kilian (2004) and Kilian (2006, 2009) discuss the different categories of shocks, and notes that the source of the shocks is vital to determine its effects on macroeconomic aggregates. Based on this notion is would also be interesting to examine in what extent the source of the shocks is vital to determine its effect on real stock returns.

Finally, the definition of a scaled oil price (SOP) by Lee, Ni & Ratti (1995) could also be employed in order to investigate if the oil shock have a greater impact in an environment where the oil price have been fairly stable, than in an environment where the oil price have been more volatile.

8. References


**Database and statistical software**

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