BI Norwegian Business School - campus Oslo

GRA 19502

Master Thesis

Component of continuous assessment: Thesis Master of Science

The role of world oil price and precious metals prices shock on the exchange rate in Norway

Navn:	Xuemeng Chen

Start:	02.03.2017 09.00
Finish:	01.09.2017 12.00

-Master Thesis-

The role of world oil price and precious metals prices shock on the exchange rate in Norway

Hand-in date:
24.08.2017

Campus:
BI Oslo

Examination code and name:
GRA 19502 Master Thesis

Programme:
Master of Science in Business, major in Finance

CONTENT

Abstract

This study investigates the relationship between world oil price, four precious metal prices (gold, silver, platinum and palladium prices) and Norwegian krona-US dollar exchange rate in both long run and short run. This study examines the long run relationship in Granger Causality test and tests the short run relationship in generalized impulse response function. Depending on Granger Causality test, the long run relationship exists between world oil price and exchange rate. There is also included a link among precious metals in long-term. From the result of generalized impulse response function, the short-term impacts among these time series are meaningful.

1. Introduction

Compared to traditional portfolios of stocks and bonds, investing in some commodities such as crude oil and precious metals, are considered as the alternative investments for individual investors for hedging over the last decade (Batten, Ciner et al. 2010). It becomes a popular diversified portfolio for hedging and other investment these years, especially after the Global Financial Crisis of 2008.

Crude oil production is a part of essential energy sources on the world scene. Given the important role of oil production in the world economy, the movement of oil prices affects by the economic factors has been the subject matter of great concern in many kinds of research. There is a surge in interest in the impact of oil prices on macro-economy. A lot of studies had paid more attention to the relationship between crude oil prices and the major financial variables, such as exchange rate.

Norway is one of the major oil exporting countries around the world. It began to explore the oil and gas offshore in the mid-1960s (Heum 2008). The economy in Norway has a huge portion of oil production. As an oil exporting country, Norway has a positive effect on stock price in Norway (Park and Ratti 2008). According to Bjørnland (2009), when oil price has a 10% increase, there was an approximately two point 5% increase in the Norwegian stock market.

In the precious metal market, gold not only is considered as jewellery but also has been provided for storage and monetary exchange during the Bretton Woods period (Jain and Ghosh 2013). Both investors and governments hold gold as part of their reserves due to the stability in monetary exchange. In addition, silver also serves as an effective hedge portfolio.

Recently, there is a nearly 50% drop in the world oil price during the end of 2014 (Volkov and Yuhn 2016). It subsequently leads to a reduction in the value of the currencies of several oil exporting countries such as Norway. Currently, the foreign exchange rates in Norway have exhibited volatility.

This study mainly focuses on the impact of world commodity price shocks from the Norwegian exchange rate. This study will investigate the long run relationship among the world oil price, four precious metal prices (gold, silver, platinum and palladium prices) and Norwegian krona-US dollar (NOK/USD) exchange rate in the Granger causality test. This study also uses generalized impulse responses for the short-term relationship.

The structure of the paper is organized as follows. In the next section, it will present a review of the literature on the relationship between commodity prices (crude oil price and precious metal price) and exchange rate. Section 3 mainly introduces the relative economic theories and the hypothesis for this study. After that, Section 4 illustrates the econometric methodologies. In Section 5, it will describe in the data and statistics. In Section 6, the empirical results will be presented. The final two parts are the conclusion and the limitation.

2. Literature review

This section reviews the literature on the relationship between the commodity prices (crude oil prices and precious metal prices) and the exchange rate. Although the role of these commodity prices on the exchange rate is not a new topic, it has never been remarkable on hedging strategies than it is today. Thus, it is necessary to analyse the dynamics of world oil prices, precious metal prices, and exchange rate.

In Sari, Hammoudeh et al. (2010), they examine the relationship among oil prices, four precious metal prices (gold, silver, platinum, and palladium) and US dollar-euro exchange rate in both long run and short run. All data used in Sari, Hammoudeh et al. (2010) are daily time series data, from January 4th, 1999 to October 19th, 2007. All commodities in this study are traded in US dollars. They use ADF (Dickey and Fuller 1979), PP (Phillips and Perron 1988), DF-GLS (Elliott, Rothenberg et al. 1992), KPSS (Kwiatkowski, Phillips et al. 1992) and NP (Ng, Perron et al. 2001) for unit root test. Because the result shows that all the time series are I(1), they use both ARDL bound test and the JJ method for cointegration test. For lag length selection, it determined by Akaike information criterion (AIC). From ARDL bound test, there is no cointegration among all variables, which has the same result in the JJ test. They utilize generalized-forecast error variance decomposition and generalized impulse response function for short run relationship analysis.

From the results of generalized forecast error variance decomposition, Sari, Hammoudeh et al. (2010) discover that most variables are resulting in their own innovation. The relationship between oil and silver is bi-directional and strong, while there is a weak relationship between oil and gold. This result may be because of the low volatility of gold and the high volatility of oil. Thus, they point out that gold can be considered as a safe haven for hedging strategies. Additionally, the relationship between oil and palladium, and the relationship between oil and platinum is also weak. On the other hand, there is a strong relationship between the gold price and other precious metal prices. Gold can also explain the dollar-euro exchange rate in the long run.

In the short run, there is evidence that the relationship between precious metal prices and the dollar-euro exchange rate is strong. Therefore, traders can get benefit from the information in the precious metal market and foreign exchange market. Nevertheless, arbitrage cannot hold for a long time in trading between precious metal market and exchange market, it will adjust and get equilibrium within two more days.

Soytas, Sari et al. (2009) investigate the co-movement and information transmission among the world oil prices, Turkish lira-US dollar exchange rate, domestic spot gold and silver prices and interest rate in both long term and short term. The data in their study are daily time series data from Turkish Istanbul Gold Exchange (IGE) and the bond market spanning from May 2ed, 2003 to March 1st, 2007. The variables employed in testing are the variables after logarithmic transformation. They follow the Toda-Yamamoto procedure (Toda and Yamamoto 1995) to access each variable reacts to changes in other variables. In the first stage, there are five different methods they used for testing unit root, which include the ADF (Dickey and Fuller 1979), PP (Phillips and Perron 1988), DF-GLS (Elliott, Rothenberg et al. 1992), KPSS (Kwiatkowski, Phillips et al. 1992) and NP (Ng, Perron et al. 2001). The consequence of unit root tests reveals that all variables are I(1). Base on the final prediction error and the Akaike information criterion (AIC), likelihood ratio test, the maximum lag length is 3, whereas the Schwarz-Bayessian information criterion (SBC) and Hannan-Quinn information criterion show 2 as the optimal order of lag. For Granger causality test, they employed six different tests to verify the robustness of their results. The results in Breusch-Pagan-Godfrey, ARCH and White tests are significant. Thus, they choose the Newey-West corrected standard errors to ensure the Granger Causality testing be valid.

According to their results, the relationships are very weak among world oil price, Turkish spot gold and silver prices, interest rate and exchange rate in the long run. They stress that gold and silver prices, interest rate and exchange rate in Turkey cannot provide a prediction for the world oil prices as they expected. On the other hand, the world oil price also fails to explain much of the Turkish precious metal prices in the long run. This result is similar to the result of Hammoudeh, Yuan et al. (2010), which focused on developed countries such as the United State in the study. Similarly, the domestic interest rate fails to explain much of the world oil prices.

In addition, Soytas, Sari et al. (2009) illustrate that the domestic interest rate in Turkey seems to Granger cause the exchange rate, spot gold, and silver prices uni-directionally. That means domestic interest rate plays an important role for both exchange rate market and precious metal market. When the interest rate rises, there is a depreciation in Turkish lira. Moreover, from the generalized impulse response results, there is a positive influence on the movement of world oil prices and Turkish interest rate in Turkish spot precious metals prices in the short run, but these effects cannot exist for a long time. This information may benefit the investors who invest gold and silver in their portfolio.

Jain and Ghosh (2013) examine the transmission of information among the world oil price, three precious metal prices (gold, platinum, and silver), Indian Rupee-US Dollar exchange rate in the long run. Daily time series data is used in this study from January 2ed, 2009 to 30th December 2011. All variables in this study are expressed in natural logarithms. For cointegration test, they use Autoregressive Distributed Lag (ARDL) technique to utilize the bounds testing approach. And they used Toda-Yamamoto procedure (Toda and Yamamoto 1995) in Granger causality test, which used the same method in Soytas, Sari et al. (2009). Before doing ARDL test, they use ADF (Dickey and Fuller 1979), PP(Phillips and Perron 1988), KPSS (Kwiatkowski, Phillips et al. 1992) and NP (Ng, Perron et al. 2001) to check the order of integration of the variables, which is necessary for the Toda-Yamamoto procedure. All of them suggest that the maximum order of integration is 1. Then they select 1 as the optional lag length base on Schwarz-Bayessian (SBC) information criteria and Akaike Information Criterion (AIC) for cointegration test. The results of the ARDL test show that there is no cointegration exist when the oil, silver, and platinum have been taken as the dependent variables, which support the results in Awokuse and Yang (2003), Lucey and Tully (2006), Baffes (2007), Shafiee and Topal (2010) and (Sari, Hammoudeh et al. 2010). From the results of TY procedure (Toda and Yamamoto 1995) for Granger causality test, all variables are not significant at 5% level. However, results for generalized-forecast error variance decomposition show most variables of forecast error variance (FEV) can be explained by their own shocks.

The significance of the results provided by Jain and Ghosh (2013) lies in the fact that the exchange rate plays an important part in determining the commodity prices in the Indian domestic market. From non-cointegration relationship, the results demonstrate that exchange rate and gold are dependent on other variables. There is a cyclicity between exchange rate and commodity prices, which might cause asset bubbles and volatility in the exchange rate.

3. Theory and hypothesis

3.1.Theory

Many of economic theories have been successful in explaining the dynamic of the crude oil market, precious metal market and the exchange rate market. This essay will examine the long run and the short run relationship among the world oil price, world precious metal prices and Norwegian krona-US dollar exchange rate.

From the theory purchasing power parity (PPP) by Cassel (1918), it demonstrates that different currencies should have the same purchasing power in a constant equilibrium level. Thus, changing the exchange rate should follow the movement of relative prices of goods. However, Meese and Rogoff (1983) point out that both real and nominal exchange rate follows a random work in three decades. This result is against the PPP theory.

Several empirical studies successfully explained the relationship between the terms of trade fluctuations and the changes in the real exchange rate, especially for good exporting countries (Gruen and Wilkinson 1994, Amano and Van Norden 1995, Cashin, Céspedes et al. 2004). Cashin, Céspedes et al. (2004) illustrate that a large share of movements in their terms of trade might be explained by the world commodity prices. Thus, the relationship might exist in the exchange rate and world commodity prices.

Changing in world oil prices might be expected to result in inflation and exchange rate shocks for the countries which import or export oil for a huge portion. As a stated in Amano and Van Norden (1998), the US real exchange rate movement remains stable, and there is an uni-directional causality relationship between oil price and the real exchange rate over the post-Bretton Woods period. Oil price can provide information to forecasting the US exchange rate, but the US exchange rate cannot provide information for the oil price. In this paper, the authors also suggest that energy prices such as oil prices may play a significant role in the exchange rate in future research. Lizardo and Mollick (2010) provide a thorough description of the link between real oil price and value of the US dollar against major currencies of both oil exporters and oil importers during the period of 1970 to 2008. From the result, they find that the causality relationship exists between oil price and US exchange rate, which is similar to Amano and Van Norden (1998). For the currencies in oil exporter countries like the Canadian dollar, Mexican peso, and Russian ruble, the real oil price rise will lead to a significant depreciation in the US exchange rate, but for other foreign currencies like Japanese yen will suffer a depreciation. In the literature written by Frenkel (1982), there was a widely oil-related shock on the international monetary system in the 1970s. There is sufficient empirical evidence indicates that the oil price in different countries indeed influences the exchange market. The exchange rate had a broad fluctuation and experienced a floating rate in this period. In this literature, it’s also concluded that both spot and forward exchanges have high volatility, which takes the intrinsic characteristic into consideration. In accordance with Sari, Hammoudeh et al. (2010), there is no long run relationship between oil price and exchange rate. Thus, it may increase the gap between oil price and exchange rate.

Apart from oil prices, precious metal prices like gold price and silver prices, also are considered as one of the determinants of exchange rate changes. Many previous papers focus on the relationship among precious metal prices, exchange rate, and domestic interest rate. From the article of Hammoudeh, Yuan et al. (2010), it indicates that the precious metals have strong volatility sensitivity to US exchange rate. They also point out that gold is the safest haven in the dollar to precious metals trading. However, the reverse volatility spillovers are weak from the precious metal to US exchange rate. Batten, Ciner et al. (2010) state that volatility of gold only can be explained by monetary variables, such as inflation, interest rate and growth rate of the money supply. However, these money variables cannot explain for silver volatility.

According to Hammoudeh, Yuan et al. (2010), the precious metals have strong volatility sensitivity to their own past shocks in the long term, especially for silver. In comparison with other precious metals, the volatility of gold is the lowest. In addition, in the short run, the sensitive of volatility is moderate to own information and the responses from other metals are weak. Moreover, they also point out that gold and silver have one of the highest conditional correlation among other pairs of the precious metals. The results from Batten, Ciner et al. (2010) show that the volatility spillovers among precious metals are significant.

They also argue that silver volatility can be explained by other precious metals volatility.

3.2.Hypothesis

Consistent with many theories and literatures, the hypotheses in this thesis that will be examined are:

Hypothesis 1:

H_0: There is no link among world oil prices, precious metal price and Norwegian krona-US dollar exchange rate in the long run.

H_1: There is a link among world oil prices, precious metal price and Norwegian krona-US dollar exchange rate in the long run.

Hypothesis 2:

H_0: There is no link among world oil prices, precious metal price and Norwegian krona-US dollar exchange rate in the short run.

H_1: There is a link among world oil prices, precious metal price and Norwegian krona-US dollar exchange rate in the short run.

4. Methodology

The aim of this chapter is to establish the methodology used to assess the relationship among crude oil prices, precious metal prices, and exchange rate. This study is based on the articles of Jain and Ghosh (2013), Sari, Hammoudeh et al. (2010) and Soytas, Sari et al. (2009).

In the article of Jain and Ghosh (2013), they use ARDL bound test for cointegration and use TY procedure (Toda and Yamamoto 1995) of Granger Causality test and generalized forecast error variance decomposition (GFEVD) among oil price, precious metal prices and Indian exchange rate. Sari, Hammoudeh et al. (2010) examine the relationship among oil price, precious metal prices and euro-dollar exchange rate in both long-term and short-term. In methodology part, they also use ARDL model for cointegration test, GFEVD for the long-term relationship and generalized impulse responses function for the short-term relationship. In Soytas, Sari et al. (2009), they test the information transmission among world oil price, Turkish interest rate, exchange rate and domestic precious metal prices in both long-term and short-term by TY procedure (Toda and Yamamoto 1995) of Granger causality test and generalized impulse responses function.

In this study, Granger causality test is used to examine the long run relationship between commodity prices and the exchange rate and generalized impulse responses for short-term relationship analysis. In general, before doing Granger Causality test, it should ensure that all the variables are non-cointegrated. However, this study uses TY version of Granger Causality test, it is no matter whether the time series are cointegrated or not.

4.1.ARDL test for cointegration

Before being able to examine the long-term relationship among each time series, this study will consider whether these time series are cointegrated or not. Cointegration can be defined as a long run relationship exists between two or more variables. In some situations, the variables are non-stationary, but the linear combination of these variables is stationary. These variables may deviate in the short run, but the long-term association would exist in their relationship. From Engle and Engle and Granger (1987), a VAR in first differences will be dissatisfied if two non-stationary variables are cointegrated.

For cointegration test, both Jain and Ghosh (2013) and Sari, Hammoudeh et al. (2010) choose the Autoregressive Distributed Lag (ARDL) bound testing approach developed by Pesaran and Pesaran (1997) and Pesaran, Shin et al. (2001). Sari, Hammoudeh et al. (2010) also use JJ method developed by Johansen (1995) and Johansen and Juselius (1990). The JJ approach requires that all the series must be I(1), while the bounds testing approach is not necessary for the same order of integration. In addition, there is no cointegration test in Soytas, Sari et al. (2009) since they use TY procedure of Granger Causality test. It says there is no matter the time series are non-cointegration or not.

This study follows the ARDL bound testing approach used in Sari, Hammoudeh et al. (2010) and Jain and Ghosh (2013) for non-cointegration test. When the variables are non-stationarity, it should utilize the first differences of the variables in the modelling process. Moreover, the computed F-statistics provided by Pesaran, Shin et al. (2001) cannot be used in the presence of I(2) variables (Ouattara 2004). It should make sure that all the time series are I(0) or I(1) before Granger Causality test for the long run relationship. However, it is no matter whether the time series are I(0), I(1) or I(2) in this study. One of the advantages of TY procedure in this study is that it is valid in all situations of cointegration test.

The optimal order of lags for ARDL cointegration tests in this study is selected determined by five different criteria, which are the likelihood ratio test (LR), final prediction error (FPE), the Akaike information criterion (AIC), the Schwarz information criterion (SC) and Hannan–Quinn information criterion (HQ).

ARDL testing is structured as following equations:

$$\Delta LOIL_t = a_{0LOIL} + \sum_{i=1}^{n} b_{iOIL} \Delta OIL_{t-i} + \sum_{i=1}^{n} c_{iOIL} \Delta LEX_{t-i} + \sum_{i=1}^{n} d_{iOIL} \Delta LGOLD_{t-i} + \sum_{i=1}^{n} e_{iOIL} \Delta LSILV_{t-i} + \sum_{i=1}^{n} f_{iOIL} \Delta LPLAT_{t-i} + \sum_{i=1}^{n} g_{iOIL} \Delta LPAL_{t-i} + \sigma_{1OIL} LOIL_{t-1} + \sigma_{2OIL} LEX_{t-1} + \sigma_{3OIL} LGOLD_{t-1} + \sigma_{4OIL} LSILV_{t-1} + \sigma_{5OIL} LPLAT_{t-1} + \sigma_{6OIL} LPAL_{t-1} + \varepsilon_{1t}$$

$$\Delta LEX_t = a_{0LEX} + \sum_{i=1}^{n} b_{iEX} \Delta LOIL_{t-i} + \sum_{i=1}^{n} c_{iEX} \Delta LEX_{t-i} + \sum_{i=1}^{n} d_{iEX} \Delta LGOLD_{t-i} + \sum_{i=1}^{n} e_{iEX} \Delta LSILV_{t-i} + \sum_{i=1}^{n} f_{iEX} \Delta LPLAT_{t-i} + \sum_{i=1}^{n} g_{iEX} \Delta LPAL_{t-i} + \sigma_{1EX} LOIL_{t-1} + \sigma_{2EX} LEX_{t-1} + \sigma_{3EX} LGOLD_{t-1} + \sigma_{4EX} LSILV_{t-1} + \sigma_{5EX} LPLAT_{t-1} + \sigma_{6EX} LPAL_{t-1} + \varepsilon_{2t}$$

$$\Delta LGOLD_t = a_{0LGOLD} + \sum_{i=1}^{n} b_{iGOLD} \Delta LOIL_{t-i} + \sum_{i=1}^{n} c_{iGOLD} \Delta LEX_{t-i} + \sum_{i=1}^{n} d_{iGOLD} \Delta LGOLD_{t-i} + \sum_{i=1}^{n} e_{iGOLD} \Delta LSILV_{t-i} + \sum_{i=1}^{n} f_{iGOLD} \Delta LPLAT_{t-i} + \sum_{i=1}^{n} g_{iGOLD} \Delta LPAL_{t-i} + \sigma_{1GOLD} LOIL_{t-1} + \sigma_{2GOLD} LEX_{t-1} + \sigma_{3GOLD} LGOLD_{t-1} + \sigma_{4GOLD} LSILV_{t-1} + \sigma_{5GOLD} LPLAT_{t-1} + \sigma_{6GOLD} LPAL_{t-1} + \varepsilon_{3t}$$

$$\Delta LSILV_t = a_{0LSILV} + \sum_{i=1}^{n} b_{iSILV} \Delta LOIL_{t-i} + \sum_{i=1}^{n} c_{iSILV} \Delta LEX_{t-i} + \sum_{i=1}^{n} d_{iSILV} \Delta LGOLD_{t-i} + \sum_{i=1}^{n} e_{iSILV} \Delta LSILV_{t-i} + \sum_{i=1}^{n} f_{iSILV} \Delta LPLAT_{t-i} + \sum_{i=1}^{n} g_{iSILV} \Delta LPAL_{t-i} + \sigma_{1SILV} LOIL_{t-1} + \sigma_{2SILV} LEX_{t-1} + \sigma_{3SILV} LGOLD_{t-1} + \sigma_{4SILV} LSILV_{t-1} + \sigma_{5SILV} LPLAT_{t-1} + \sigma_{6SILV} LPAL_{t-1} + \varepsilon_{4t}$$

$$\Delta LPLAT_t = a_{0PLAT} + \sum_{i=1}^{n} b_{iPLAT}\Delta LOIL_{t-i} + \sum_{i=1}^{n} c_{iPLAT}\Delta LEX_{t-i} + \sum_{i=1}^{n} d_{iPLAT}\Delta LGOLD_{t-i} + \sum_{i=1}^{n} e_{iPLAT}\Delta LSILV_{t-i} + \sum_{i=1}^{n} f_{iPLAT}\Delta LPLAT_{t-i} + \sum_{i=1}^{n} g_{iPLAT}\Delta LPAL_{t-i} + \sigma_{1PLAT}LOIL_{t-1} + \sigma_{2PLAT}LEX_{t-1} + \sigma_{3PLAT}LGOLD_{t-1} + \sigma_{4PLAT}LSILV_{t-1} + \sigma_{5PLAT}LPLAT_{t-1} + \sigma_{6PLAT}LPAL_{t-1} + \varepsilon_{5t}$$

$$\Delta LPAL_t = a_{0PAL} + \sum_{i=1}^{n} b_{iPAL}\Delta LOIL_{t-i} + \sum_{i=1}^{n} c_{iPAL}\Delta LEX_{t-i} + \sum_{i=1}^{n} d_{iPAL}\Delta LGOLD_{t-i} + \sum_{i=1}^{n} e_{iPAL}\Delta LSILV_{t-i} + \sum_{i=1}^{n} f_{iPAL}\Delta LPLAT_{t-i} + \sum_{i=1}^{n} g_{iPAL}\Delta LPAL_{t-i} + \sigma_{1PAL}LOIL_{t-1} + \sigma_{2PAL}LEX_{t-1} + \sigma_{3PAL}LGOLD_{t-1} + \sigma_{4PAL}LSILV_{t-1} + \sigma_{5PAL}LPLAT_{t-1} + \sigma_{6PAL}LPAL_{t-1} + \varepsilon_{6t}$$

where n is the lag length. b, c, d, e, f and g denote the short run coefficients while σ is the long run coefficients. Δ is the first difference operator. The null hypothesis of non-cointegration among the variables in each equation is:
H_0: $\sigma_1 = \sigma_2 = \sigma_3 = \sigma_4 = \sigma_5 = \sigma_6 = 0$

The null hypothesis is examined by F-test. The cointegration exists if the hypothesis can be rejected, otherwise, there is no cointegration among the time series.

4.2. Granger Causality test

In order to recognize how the time series responds to innovations in other variables in the long run, this study will utilize the Granger Causality test to examine the variables in time series analysis.

The Granger causality test (Granger 1969) is used to examine the cause-effect relationship among the time series. It determines whether one time series can predict another or not. There are two fundamental principles from Granger (1980) which cited in Eichler (2012):

1) the effect does not precede its cause in time;
2) the causal series contains unique information about the series being caused that is not available otherwise.

In Granger Causality test, F-statistics is used to examine whether the hypothesis can be rejected or not among the time series in this study. If the null hypothesis can be rejected, the variable X Granger causes the dependent variable Y. Otherwise, there is no Granger causality relationship.

From the empirical literature, Soytas, Sari et al. (2009) and Jain and Ghosh (2013) use Toda-Yamamoto version (Toda and Yamamoto 1995) of Granger Causality test. It employs a modified Wald test for the restriction on the optimum lag length k. The augmented VAR($k + d$) includes the optimal lag length k determined by Information Criterion and the maximal integration order d. Wald statistic follows an asymptotic chi-square distribution with degrees of freedom equal to k.

In TY procedure, it is valid regardless of whether a series is no-cointegrated or cointegrated. Hence, the TY procedure could avoid the bias for cointegration test. In addition, under the TY version, it allows running a VAR model in levels. This study also utilizes TY procedure for Granger Causality test.

4.3. Generalized impulse response

Since Granger Causality test only examines the long run relationship between Norwegian exchange rate and global commodity price, it is not able to assess the reaction of each time series to changes in other variables.

In order to evaluate the short run relationship, the model used in both Sari, Hammoudeh et al. (2010) and Soytas, Sari et al. (2009) is generalized impulse response. This study also utilizes Generalized impulse response approach developed by Koop, Pesaran et al. (1996), Pesaran and Pesaran (1997), and Pesaran and Shin (1998) analyse the short run relationship among world oil price, precious metal prices and the Norwegian krona-dollar exchange rate.

y_t can be represented by following VAR:

$$y_t = \alpha + \sum_{i}^{1} \phi y_{t-1} + \varepsilon_t$$

where y_t is an $m\times1$ vector of endogenous variables joint determined. α is a vector of constants. ϕ are $m\times m$ matrices of coefficients to be estimated. t is linear time trend. ε_t is an $m\times1$ vector well-behaved disturbances with covariance $\sum = \sigma_{ij}$.

The term of $\left(M_n \sum e_j\right)\left(\sigma_{ij}\right)^{-1}$ represents generalized impulse responses of y_{t+n} with respect of a unit standard deviation shock on j-th variable at time t, where $M_n = \phi_1 M_{n-1} + \phi_2 M_{n-2} + \cdots + \phi_p M_{n-p}, n = 1, 2, \cdots,\ M_o = I, M_n = 0$ for $n < 0$ and e_j is $m\times1$ selection vector with unity as its j-th element and zero elsewhere.

5. Data description

5.1.Data

Since there is a significant drop in world oil price in 2014. This study will use the data in recent years. Time series data in Sari, Hammoudeh et al. (2010) spans from January 1999 to October 2007. Moreover, the period of the data is taken from May 2003 to March 2007 in Soytas, Sari et al. (2009) and is from January 2009 to December 2011 in Jain and Ghosh (2013). All the time series data employed in these studies are daily time series data and modelled in natural logarithms. This study will take 5-year daily time series data (5 working days per week) in natural logarithm, spans from the beginning of 2012 to the end of 2016 (January 2ed, 2012 –December 30th, 2016).

For data collection, this study will use the daily time series data for Brent spot oil prices, four precious metal prices, Norwegian krona/US dollar (NOK/USD) exchange rate. The four precious metals prices considered in this study are gold, silver, platinum, and palladium. For gold prices, silver prices, platinum prices, and palladium prices, both crude oil price and precious metal prices in this study are world prices and denominated in US dollar currency. All the commodity prices in this essay are download from Datastream. Norwegian krona-US dollar exchange rate has been collected from Central Bank of Norway.

5.2.Data description

Table 1 & 2 summarize the descriptive statistics of the raw and logged variables, respectively. There are total 1305 observations during the test period (47 data of silver price was missed). From the data before logged, the gold price has the highest mean which is 1350.71 in all commodity variables, and the mean of the platinum price is 1291.54 which is also higher in these commodities. Silver has the lowest price and the mean is 21.35. For volatility statistics, the coefficient of gold price and platinum price are significantly higher than other commodity prices, which are 198.04 and 249.98 respectively. NOK/USD exchange rate has the lowest volatility which is only 1.14.

Volatility after logarithmic transformation is much distinct from the volatility before logging. After logarithmic transformation, the coefficient of standard deviation indicates that the global oil price has the highest standard deviation in the result, which is 0.412616. This result may be reflected by a wide fluctuation in world oil price from 2014. On the other hand, gold price and palladium price have the lowest standard deviation in all commodity variables, which are 0.141024 and 0.133860 respectively. Additionally, Norwegian krona-US dollar exchange rate variable also has a lower standard deviation in this study.

Table 3 is the descriptive statistics of the first difference data. The coefficient of standard deviation indicates that Norwegian krona-dollar exchange rate has the lowest standard deviation in this paper. The standard deviation of oil is the highest among other variables. It indicates the same result in levels.

5.3.Correlation matrix

Table 4 & 5 report the correlation coefficients among the variables in levels and in first difference. In levels, gold and silver prices have the highest positive level of correlations (0.98) as expected, which may because both gold and silver are used in the jewellery market. Platinum holds the highest positive correlation with the oil price, which is 0.94. Moreover, the correlations between exchange rate and commodity variables are negative. The highest negative correlations are the correlation between exchange rate and oil price (-0.97) and the correlation between exchange rate and platinum price (-0.97). As indicated above, the exchange rate has strong relationships with other commodity prices, but in opposite direction.

In first difference, the correlations between exchange rate and commodity prices are negative, which is similar to the results in levels above. Platinum has the highest correlation with other precious metals. Nevertheless, all the precious metal prices have low correlations with the oil price in first difference.

6. Empirical result

6.1. Unit root test analysis

Before doing a cointegration test, at first, there are five different unit root tests employed to determine the order of integrations of the variables. These five models are ADF(Dickey and Fuller 1979), DF-GLS (Elliott, Rothenberg et al. 1992), PP (Phillips and Perron 1988), KPSS (Kwiatkowski, Phillips et al. 1992) and NP (Ng, Perron et al. 2001). The results are presented in Table 6.

According to the results, all the five different models show that the null hypothesis cannot be rejected in the original logarithms level, but it can be rejected in first differences level. It indicates that the maximum order of integration is 1. Hence, Autoregressive Distributed Lag (ARDL) bound test can be used in cointegration test.

6.2. ARDL bound test analysis

Table 7 reports the results of ARDL bound test for cointegration. In the results, it shows that F-statistics values in oil (2.48), exchange rate (2.89), palladium (1.09) are lower than 3, which is the upper bound of F-critical value at 10% level. It indicates that there is no cointegration among these variables. On the other hand, F-statistics value in gold (3.20) is higher than the upper bound of F-critical value at 10% level and F values in silver (4.04) and platinum (3.77) variables are higher than the critical value at 5% level (3.38). The results suggest that the long run cointegrating relationship would exist in the situation when gold, silver, and platinum are dependent variables.

6.3. Lag selection

For maximum lag length selection, there are five criteria in this study, which are the likelihood ratio test (LR), final prediction error (FPE), the Akaike information criterion (AIC), the Schwarz information criterion (SC) and Hannan–Quinn information criterion (HQ). The result is reported in table 8. LR shows a maximum lag length is 4. For FRE and AIC, the optimal lag length is 3, where SC and HQ present 2 as optimum lag length k. Because AIC is the most common information criterion for lag selection. 3 is used as optimum lag length k in this study.

From the result above, the maximum integration order d is 1, and the optimum lag length k is 3, the augmented vector auto-regression VAR($k + d$) in TY procedure of Granger Causality test is adopted as LA-VAR(4).

6.4. Granger Causality test

Table 9 shows the result of the Granger causality test for all the time series in the long run. For exchange rate variable, the results have interesting implications.

There is a strong feedback relationship between oil prices and krona-dollar exchange rate in bi-direction as expected. The null hypothesis of non-causality can be rejected between exchange rate and oil. However, in Sari, Hammoudeh et al. (2010), Soytas, Sari et al. (2009) and Jain and Ghosh (2013), they get the opposite consequences. They find that the relationship between oil and exchange rate is ineffective in the long run. The reason why might be that Norway is the country whose economy heavily depends on oil export. On the other hand, uni-directional causality is observed running from world gold prices to Norwegian exchange rate. Gold can Granger cause the exchange rate while the exchange rate cannot Granger cause gold. That means the global gold price can explain krona-dollar exchange rate while krona-dollar exchange rate cannot explain much on gold prices. The result indicates that gold is a safe reserve currency with low volatility from the fluctuation in the world oil price. This finding supports the results breached by Sari, Hammoudeh et al. (2010), Soytas, Sari et al. (2009) and Jain and Ghosh (2013). From the Granger Causality test, platinum also has a long run relationship with the exchange rate. In addition, there is not any Granger causality among exchange rate and palladium, exchange rate and silver. Long-term relationships between exchange rate and these two precious metals are extremely weak.

For commodity variables, the long run relationships exist between the world oil price and most of the precious metal prices. There is a strong mirror-image causality relationship between world oil price and the silver price. The long run relationship also exists between world oil price and the platinum price. However, the long run causality relationship is weak between world oil price and the gold price. The oil price does not Granger cause the gold price while the gold price can explain the oil price at 10% level.

Among four precious metal prices, gold price hardly can be predicted by other precious metal prices. The null hypothesis of Granger Causality test for gold cannot be rejected from most variables in this study. In addition, palladium price also cannot be explained by other precious metal prices except gold price. These results may indicate that gold and palladium are the least volatile precious metals. The low standard deviation of the gold price and palladium price in Table 2 & 3 also shows that gold and palladium can be considered as safe haven assets with low volatility. This result supports the finding in Sari, Hammoudeh et al. (2010). For the silver price, it can be predicted by other three precious metal prices and platinum can be predicted by gold price and palladium price.

6.5. Generalized impulse response

Since all the time series are I(1), the first differenced data is used in the generalized impulse response. Table 10 and Figs. 1-6 are the results of generalized impulse response function of each variable within a week (5 working days). Table 10 shows that all the generalized responses of each variable are significant at 1% level.

In Fig.1, the oil price initially responds positively to four precious metal prices, while the responses are negative on the fourth day. The responses of all precious metal prices on oil price are similar in a short run. In addition, the initial response of the exchange rate on the oil price is negative, which is opposite to the short-term responses of precious metal prices.

The responses of the exchange rate to an unexpected shock in commodity prices are presented in Fig. 2. All the responses to commodity prices are initially positive. The short-term responses in silver, platinum and palladium prices die out immediately after the first day. In the case of oil and gold, the impacts tend to stable on the third day.

Fig.3 reveals that the short-term responses of the gold price to other three precious metal prices are similar. These impacts are positive on the initial day and die out directly on the second day. The response of the exchange rate is negative on the first day, however, the impact is positive on the fourth day.

Fig. 4 shows the responses of silver price to oil price, exchange rate, and other precious metal prices. The impacts are initially positive on other commodity prices and initially negative on the exchange rate, which has similar results to the responses of the gold price in Fig. 3. There are also similar responses of platinum price and palladium price in Fig. 5 and Fig. 6.

The results above indicate that there is a short run relationship among Norwegian krona-US dollar exchange rate, world oil price, and precious metal prices. It is supported the study of Sari, Hammoudeh et al. (2010), which also argues that the responses of the exchange rate to changes in spot precious metal prices are significant.

7. Conclusion

This study investigates the relationships among world oil price, four precious metal prices (gold, silver, platinum and palladium prices) and Norwegian krona-US dollar exchange rate in both long run and short run. This study examines the long run relationship in Granger Causality test and examines the short run relationship in generalized impulse response function. ARDL is used for cointegration.

According to Granger Causality test, world oil price and Norwegian krona-US dollar exchange rate have a long-term relationship. World oil price can provide information for Norwegian exchange rate prediction. This result is dissimilar from the result in Sari, Hammoudeh et al. (2010) and Soytas, Sari et al. (2009). They find there is a weak relationship in the long run. One reason is that the data for precious metal prices in this study are global spot prices, and the data in Soytas, Sari et al. (2009) are domestic spot price. Another reason is that the country analysed in this paper is Norway. As the world major oil producer, Norway can be influenced significantly in its currency by the world oil price changing. When the oil price rises, there is appreciation in Norwegian krona. And it will be depreciation when the oil price falls. In addition, the dynamic of the gold price can provide information for forecasting the Norwegian exchange rate. This result indicates that gold is the important financial asset which is widely used in many investment portfolios. Other precious metal prices cannot explain the Norwegian krona-US dollar exchange rate in the long run.

For the long-term relationships among commodity prices, world oil price can also provide information for predicting silver and platinum prices in the long run. In addition, compared with other precious metal, gold can be less influenced by other commodities. Palladium price also cannot be explained by other commodity prices except gold price. Moreover, the standard deviation of both of gold and silver are low in levels and first differenced. It may imply that gold and palladium are the non-sensitive financial assets with low volatility in investment. Thus, both gold and palladium can be regarded as safe haven assets for investors. In silver and platinum, these two precious metals prices can be explained by gold and palladium prices.

From the results of generalized impulse responses, the relationships among Norwegian krona-US dollar exchange rate, world oil price, and precious metal prices are significant in short-term. This result supports the findings in Soytas, Sari et al. (2009). Theoretically, there is an arbitrage among trade in the Norwegian krona-US dollar exchange rate and these world commodities in the short run. However, these responses among exchange rate, world oil price, and precious metal prices will not last for a long time. Generally, these impacts will disappear within one or two days. Thus, arbitrage is not easy to put into practice.

For general investors, shocks in the oil market have a strong negative influence on Norwegian foreign exchange rate. Norwegian krona will be depreciation when the oil price decreases. In the precious metal market, gold and palladium can be thought of as safe haven assets in the investment portfolios. In addition, investors may get benefit from the information of short-term reaction, but these influences will not last for a long time.

8. Limitations

The data in this study span from the beginning of 2012 to the end of 2016, which include 5-year time series. However, the 5-year time series data is short for cointegration test. Thus, the result of this study provides weak evidence for non-cointegration among these variables.

Reference

Amano, R. A. and S. Van Norden (1995). "Terms of trade and real exchange rates: the Canadian evidence." Journal of International Money and Finance **14**(1): 83-104.

Amano, R. A. and S. Van Norden (1998). "Oil prices and the rise and fall of the US real exchange rate." Journal of International Money and Finance **17**(2): 299-316.

Awokuse, T. O. and J. Yang (2003). "The informational role of commodity prices in formulating monetary policy: a reexamination." Economics Letters **79**(2): 219-224.

Baffes, J. (2007). "Oil spills on other commodities." Resources Policy **32**(3): 126-134.

Batten, J. A., et al. (2010). "The macroeconomic determinants of volatility in precious metals markets." Resources Policy **35**(2): 65-71.

Bjørnland, H. C. (2009). "Oil price shocks and stock market booms in an oil exporting country." Scottish Journal of Political Economy **56**(2): 232-254.

Cashin, P., et al. (2004). "Commodity currencies and the real exchange rate." Journal of Development Economics **75**(1): 239-268.

Cassel, G. (1918). "Abnormal deviations in international exchanges." The Economic Journal **28**(112): 413-415.

Dickey, D. A. and W. A. Fuller (1979). "Distribution of the estimators for autoregressive time series with a unit root." Journal of the American statistical association **74**(366a): 427-431.

Eichler, M. (2012). "Causal inference in time series analysis." Causality: Statistical perspectives and applications: 327-354.

Elliott, G., et al. (1992). Efficient tests for an autoregressive unit root, National Bureau of Economic Research Cambridge, Mass., USA.

Engle, R. F. and C. W. Granger (1987). "Co-integration and error correction: representation, estimation, and testing." Econometrica: journal of the Econometric Society: 251-276.

Frenkel, J. A. (1982). Flexible exchange rates, prices and the role of 'news': Lessons from the 1970s. Exchange Rate Policy, Springer**:** 48-100.

Granger, C. W. (1969). "Investigating causal relations by econometric models and cross-spectral methods." Econometrica: journal of the Econometric Society: 424-438.

Granger, C. W. (1980). "Testing for causality: a personal viewpoint." Journal of Economic Dynamics and control **2**: 329-352.

Gruen, D. W. and J. Wilkinson (1994). "Australia's real exchange rate–is it explained by the terms of trade or by real interest differentials?" Economic Record **70**(209): 204-219.

Hammoudeh, S. M., et al. (2010). "Precious metals–exchange rate volatility transmissions and hedging strategies." International Review of Economics & Finance **19**(4): 633-647.

Heum, P. (2008). "Local Content Development: Experiences from oil and gas activities in Norway."

Jain, A. and S. Ghosh (2013). "Dynamics of global oil prices, exchange rate and precious metal prices in India." Resources Policy **38**(1): 88-93.

Johansen, S. (1995). "Identifying restrictions of linear equations with applications to simultaneous equations and cointegration." Journal of econometrics **69**(1): 111-132.

Johansen, S. and K. Juselius (1990). "Maximum likelihood estimation and inference on cointegration—with applications to the demand for money." Oxford Bulletin of Economics and statistics **52**(2): 169-210.

Koop, G., et al. (1996). "Impulse response analysis in nonlinear multivariate models." Journal of econometrics **74**(1): 119-147.

Kwiatkowski, D., et al. (1992). "Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?" Journal of econometrics **54**(1-3): 159-178.

Lizardo, R. A. and A. V. Mollick (2010). "Oil price fluctuations and US dollar exchange rates." Energy Economics **32**(2): 399-408.

Lucey, B. M. and E. Tully (2006). "The evolving relationship between gold and silver 1978–2002: evidence from a dynamic cointegration analysis: a note." Applied Financial Economics Letters **2**(1): 47-53.

Meese, R. A. and K. Rogoff (1983). "Empirical exchange rate models of the seventies: Do they fit out of sample?" Journal of international economics **14**(1-2): 3-24.

Ng, S., et al. (2001). "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power," Econometrica 69: 6."

Ouattara, B. (2004). Foreign aid and fiscal policy in Senegal, Mimeo University of Manchester Manchester.

Park, J. and R. A. Ratti (2008). "Oil price shocks and stock markets in the US and 13 European countries." Energy Economics **30**(5): 2587-2608.

Pesaran, H. H. and Y. Shin (1998). "Generalized impulse response analysis in linear multivariate models." Economics Letters **58**(1): 17-29.

Pesaran, M. H. and B. Pesaran (1997). "Working with microfit 4.0." Camfit Data Ltd, Cambridge.

Pesaran, M. H., et al. (2001). "Bounds testing approaches to the analysis of level relationships." Journal of applied econometrics **16**(3): 289-326.

Phillips, P. C. and P. Perron (1988). "Testing for a unit root in time series regression." Biometrika **75**(2): 335-346.

Sari, R., et al. (2010). "Dynamics of oil price, precious metal prices, and exchange rate." Energy Economics **32**(2): 351-362.

Shafiee, S. and E. Topal (2010). "An overview of global gold market and gold price forecasting." Resources Policy **35**(3): 178-189.

Soytas, U., et al. (2009). "World oil prices, precious metal prices and macroeconomy in Turkey." Energy Policy **37**(12): 5557-5566.

Toda, H. Y. and T. Yamamoto (1995). "Statistical inference in vector autoregressions with possibly integrated processes." Journal of econometrics **66**(1): 225-250.

Volkov, N. I. and K.-h. Yuhn (2016). "Oil price shocks and exchange rate movements." Global Finance Journal **31**: 18-30.

Appendix

Table 1: Descriptive Statistics (raw)

	Oil	NOK/USD	Gold	silver	Platinum	Palladium
Mean	83.64638	6.897736	1350.712	21.35126	1291.544	695.2977
Std. dev	30.08521	1.149117	198.0448	6.108214	249.9822	90.51132
Skewness	-0.3132667	0.378972	0.743649	0.817326	-0.224100	-0.158672
Kurtosis	1.370807	1.393421	2.267578	2.345310	1.733819	2.448781
Jarque-Bera	165.6705	165.4047	149.4495	168.6007	98.09783	21.99737
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observation	1305	1258	1305	1305	1305	1305

Table 2: Descriptive Statistics (log)

	Oil	NOK/USD	Gold	silver	Platinum	Palladium
Mean	4.348886	1.917663	7.198196	3.023526	7.143653	6.535569
Std. dev	0.412616	0.163464	0.141024	0.268915	0.203104	0.133860
Skewness	-0.523964	0.318150	0.580262	0.528111	-0.426697	-0.443002
Kurtosis	1.708586	1.351120	2.158498	2.039517	1.847704	2.625328
Jarque-Bera	150.3960	163.7329	111.7375	110.8235	111.7987	50.31772
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Observation	1305	1258	1305	1305	1305	1305

Table 3:Descriptive Statistics (first differences)

	DLOIL	DLEX	DLGOLD	DLSILV	DLPLAT	DLPAL
Mean	-0.000496	0.000250	-0.000236	-0.000423	-0.000315	4.72E-05
Std. dev	0.018281	0.007126	0.010195	0.016919	0.012069	0.015996
Skewness	0.438918	0.146784	-0.755843	-0.494392	0.163468	-0.114752
Kurtosis	6.598922	5.840924	12.79929	9.263959	3.856292	4.565768
Jarque-Bera	745.6075	417.7081	5342.108	2189.008	45.64670	136.0670
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 4: Correlation Matirx (in levels)

	LOIL	LEX	LGOLD	LSILV	LPLAT	LPAL
LOIL	1.000000	-0.973388	0.672171	0.768101	0.942232	0.477251
LEX	-0.973388	1.000000	-0.738636	-0.816217	-0.965313	-0.399872
LGOLD	0.672171	-0.738636	1.000000	0.978989	0.789457	0.004888
LSILV	0.768101	-0.816217	0.978989	1.000000	0.851606	0.086646
LPLAT	0.942232	-0.965313	0.789457	0.851606	1.000000	0.472362
LPAL	0.477251	-0.399872	0.004888	0.086646	0.472362	1.000000

Table 5:Correlation Matrix (in first differences)

	DLOIL	DLEX	DLGOLD	DLSILV	DLPLAT	DLPAL
DLOIL	1.000000	-0.255423	0.108795	0.130754	0.195401	0.207808
DLEX	-0.255423	1.000000	-0.191330	-0.340444	-0.330460	-0.267523
DLGOLD	0.108795	-0.191330	1.000000	0.485847	0.542665	0.342453
DLSILV	0.130754	-0.340444	0.485847	1.000000	0.581790	0.425700
DLPLAT	0.195401	-0.330460	0.542665	0.581790	1.000000	0.631220
DLPAL	0.207808	-0.267523	0.342453	0.425700	0.631220	1.000000

Table 6: Unit Root Test

		ADF	DFGLS	PP	KPSS	NP Z
Intercept	LOIL	-0.829017 (0)	-0.054382 (0)	-0.903593	3.614512***	-0.06834 (0)
	LEX	-0.487185 (0)	0.232905 (0)	-0.418948	4.025831***	0.78910 (0)
	LGOLD	-1.362627 (0)	-0.293359 (0)	-1.352915	3.138731***	-0.51315 (0)
	LSILV	-1.268458 (0)	-0.172771 (0)	-1.253854	3.503826***	-0.26115 (0)
	LPLAT	-0.430942 (0)	-0.135166 (0)	-0.587953	3.734422***	-0.27737 (0)
	LPAL	-2.206350 (0)	-1.796065 (0)*	-2.389776	0.783600***	-6.48960 (0)*
Int. and trend	LOIL	-1.599327 (0)	-1.288988 (0)	-1.778811	0.520637***	-3.47364 (0)
	LEX	-2.478147 (0)	-1.406850 (0)	-2.408208	0.569362***	-3.62102 (0)
	LGOLD	-2.144384 (0)	-2.121961 (0)**	-2.153212	0.665127***	-9.00482 (0)**
	LSILV	-2.093041 (0)	-2.055062 (0)**	-2.108107	0.622385***	-8.62303 (0)**
	LPLAT	-3.169271 (0)*	-1.337681 (0)	-3.367348*	0.396281***	-3.86022 (0)
	LPAL	-2.298073 (0)	-1.970212 (0)**	-2.479469	0.639456***	-7.76258 (0)**
Intercept	DLOIL	-34.29056 (0)***	-1.420554 (14)	-34.38488***	0.134863	-2.89826 (14)
	DLEX	-36.58748 (0)***	-2.402776 (8)**	-36.63224***	0.129898	-10.4041 (8)**
	DLGOLD	-36.89444 (0)***	-1.447058 (12)	-36.89365***	0.059916	-3.39712 (12)
	DLSILV	-38.91512 (0)***	-1.889033 (12)*	-38.81944***	0.072107	-5.09458 (12)*
	DLPLAT	-36.21096 (0)***	-0.923367 (10)	-36.30192***	0.138543	-1.64294 (10)
	DLPAL	-35.44152 (0)***	-1.055894 (9)	-35.49585***	0.060031	-1.63567 (9)
Int. and trend	DLOIL	-34.27780 (0)***	-3.840404 (9)***	-34.37240***	0.136204	-15.5251 (9)***
	DLEX	-36.58051 (0)***	-3.107230 (8)***	-36.63020***	0.096896	-14.3834 (8)***
	DLGOLD	-36.88092 (0)***	-2.915112 (12)***	-36.88018***	0.055491	-8.16204 (12)***
	DLSILV	-38.90256 (0)***	-3.618960 (12)***	-38.80787***	0.059582	-10.5253 (12)***
	DLPLAT	-36.22187 (0)***	-2.448582 (9)**	-36.30662***	0.056142	-7.74465 (9)**
	DLPAL	-35.42854 (0)***	-2.427020 (9)**	-35.48303***	0.042602	-6.58897 (9)**

*** significant at the 1% level
** significant at the 5% level
* significant at the 10% level

Table 7: ARDL Bound Test

	F-statistics	
F(LOIL|LEX,LGOLD,LSILV,LPLAT,LPAL)	2.478710	
F(LEX|LOIL,LGOLD,LSILV,LPLAT,LPAL)	2.892614	
F(LGOLD|LOIL,LEX,LSILV,LPLAT,LPAL)	3.195164*	
F(LSILV|LOIL,LEX,LGOLD,LPLAT,LPAL)	4.036242**	
F(LPLAT|LOIL,LEX,LGOLD,LSILV,LPAL)	3.767535**	
F(LPAL|LOIL,LEX,LGOLD,LSILV,LPLAT)	1.086604	
	I(0)	I(1)
*F-critical at 10% level	2.08	3
**F-critical at 5% level	2.39	3.38
***F-critical at 1% level	3.06	4.15

Table 8: Lag Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	7482.850	NA	3.17E-14	-14.05423	-14.02620	-14.04361
1	19652.94	24180.05	3.94E-24	-36.86268	-36.66650	-36.78834
2	19800.17	290.8588	3.20E-24	-37.07175	**-36.70742***	**-36.93370***
3	19836.65	71.65364	**3.20E-24***	**-37.07265***	-36.54017	-36.87088
4	19865.47	**56.29439***	3.24E-24	-37.05916	-36.35853	-36.79368
5	19890.16	47.94011	3.31E-24	-37.03790	-36.16192	-36.70870
6	19913.51	45.07710	3.39E-24	-37.01412	-35.97719	-36.62121
7	19932.71	36.86321	3.50E-24	-36.98256	-35.77748	-36.52593
8	19950.36	33.64731	3.62E-24	-36.94804	-35.57481	-36.42769

Table 9: Granger Causality Test

Dependent Variables	LOIL	LEX	LGOLD	LSILV	LPLAT	LPAL
LOIL	-	3.92058***	3.36794***	2.63571**	3.61388***	0.39884
LEX	5.78923***	-	5.26695***	1.5992	2.13336*	1.68295
LGOLD	0.97168	1.58545	-	1.04767	0.25805	2.05418*
LSILV	3.61388***	1.65919	72.7079***	-	10.1060***	6.15056***
LPLAT	5.91962***	3.30716**	11.8883***	0.91349	-	2.42771**
LPAL	2.17177*	0.70631	2.47436**	0.96458	0.76393	-

*** significant at the 1% level
** significant at the 5% level
* significant at the 10% level

Table 10: generalized impulse responses

response of D(LOIL)

Period	D(LEX)	D(LGOLD)	D(LSILV)	D(LPLAT)	D(LPAL)
1	-0.004394***	0.001839***	0.002006***	0.003039***	-0.003337***
2	-0.000201***	-7.01E-05***	-0.000944***	-0.000113***	-4.98E-06***
3	-0.000460***	0.000422***	-0.000318***	-0.000249***	-2.44E-05***
4	-0.000906***	-0.001506***	1.44E-05***	-0.001209***	-0.000695***
5	3.10E-05***	0.000205***	-0.000178***	-2.53E-05***	0.000132***

response of D(LEX)

Period	D(LOIL)	D(LGOLD)	D(LSILV)	D(LPLAT)	D(LPAL)
1	-0.001687***	-0.001387***	-0.002185***	-0.002190***	-0.001857***
2	-0.000856***	-0.000653***	0.000322***	-0.000216***	5.17E-05***
3	-8.44E-05***	-0.000262***	9.48E-05***	-6.99E-05***	0.000220***
4	2.34E-05***	2.95E-05***	-0.000214***	-6.79E-05***	-0.000197***
5	2.86E-05***	-3.14E-05***	8.03E-05***	4.83E-05***	4.09E-05***

response of D(LGOLD)

Period	D(LOIL)	D(LEX)	D(LSILV)	D(LPLAT)	D(LPAL)
1	0.001037***	-0.002037***	0.005578***	0.005837***	0.003697***
2	0.000284***	-0.000183***	-0.000374***	0.000169***	-7.97E-05***
3	-0.000219***	-4.48E-05***	-0.000407***	-2.15E-05***	8.38E-05***
4	-0.000390***	0.000646***	0.000178***	0.000140***	-0.000270***
5	-4.47E-05***	-7.01E-05***	4.05E-05***	2.14E-05***	-2.28E-05***

response of D(LSILV)

Period	D(LOIL)	D(LEX)	D(LGOLD)	D(LPLAT)	D(LPAL)
1	0.001712***	-0.004855***	0.008438***	0.009022***	0.006794***
2	0.001685***	-0.000821***	0.005300***	0.001779***	0.001393***
3	9.93E-05***	-0.000125***	-0.000178***	0.000347***	-0.000527***
4	-0.000361***	-0.000165***	0.000269***	0.000246***	-1.10E-05***
5	-0.000173***	0.000554***	0.000262***	1.64E-05***	-7.60E-05***

response of D(LPLAT)

Period	D(LOIL)	D(LEX)	D(LGOLD)	D(LSILV)	D(LPAL)
1	0.001970***	-0.003698***	0.006711***	0.006856***	0.007444***
2	0.001617***	-0.000609***	0.001718***	3.51E-05***	-0.000182***
3	5.45E-05***	-0.000537***	0.000136***	0.000193***	0.000230***
4	-0.000211***	0.000243***	0.000458***	0.000497***	-0.000401***
5	3.67E-06***	0.000105***	0.000219***	6.81E-05***	3.74E-05***

response of D(LPAL)

Period	D(LOIL)	D(LEX)	D(LGOLD)	D(LSILV)	D(LPLAT)
1	0.002955***	-0.004283***	0.005808***	0.007054***	0.010169***
2	0.001052***	2.04E-05***	0.001004***	-0.000257***	8.55E-05***
3	0.000588***	-0.000526***	-0.000485***	9.49E-05***	-0.000181***
4	2.02E-05***	7.90E-05***	-0.000390***	0.000433***	0.000163***
5	7.50E-05***	8,29E-05***	0.000379***	8.40E-05***	1.70E-05***

*** significant at the 1% level

Fig. 1. Response of LOIL to generalized one S.D, innovations ±2 S.E.

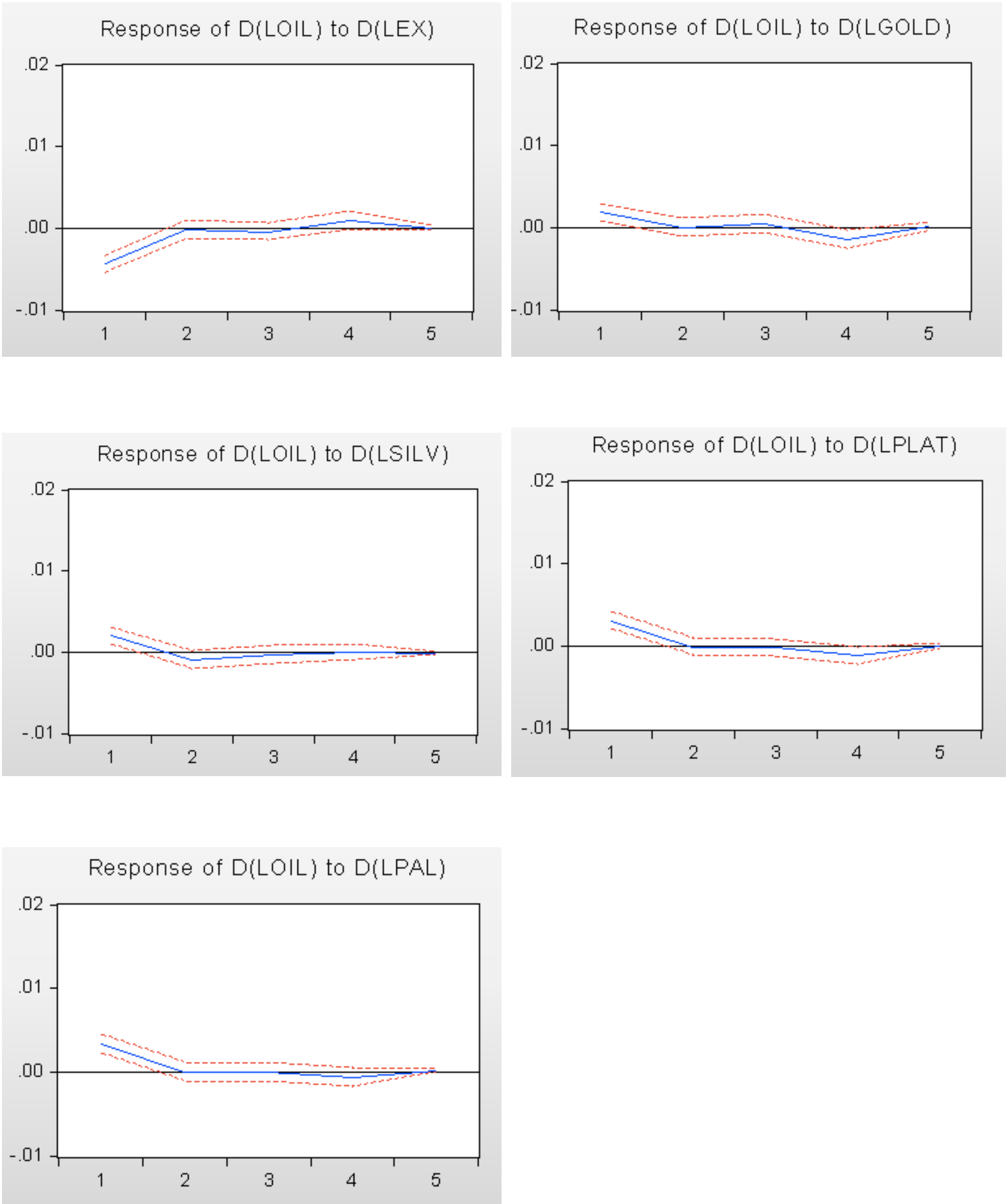


Fig. 2. Response of LEX to generalized one S.D, innovations ±2 S.E.

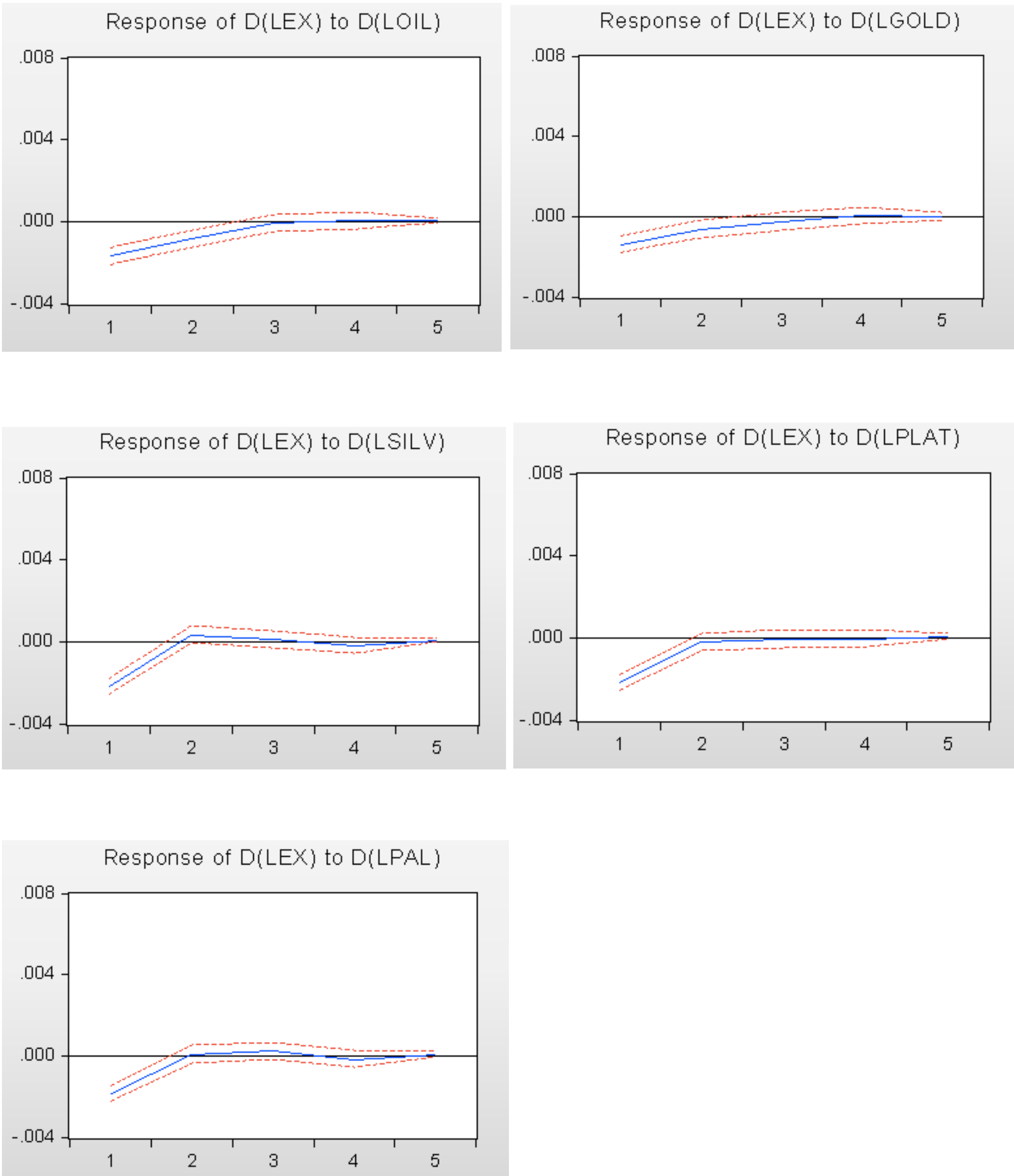


Fig. 3. Response of LGOLD to generalized one S.D, innovations ±2 S.E.

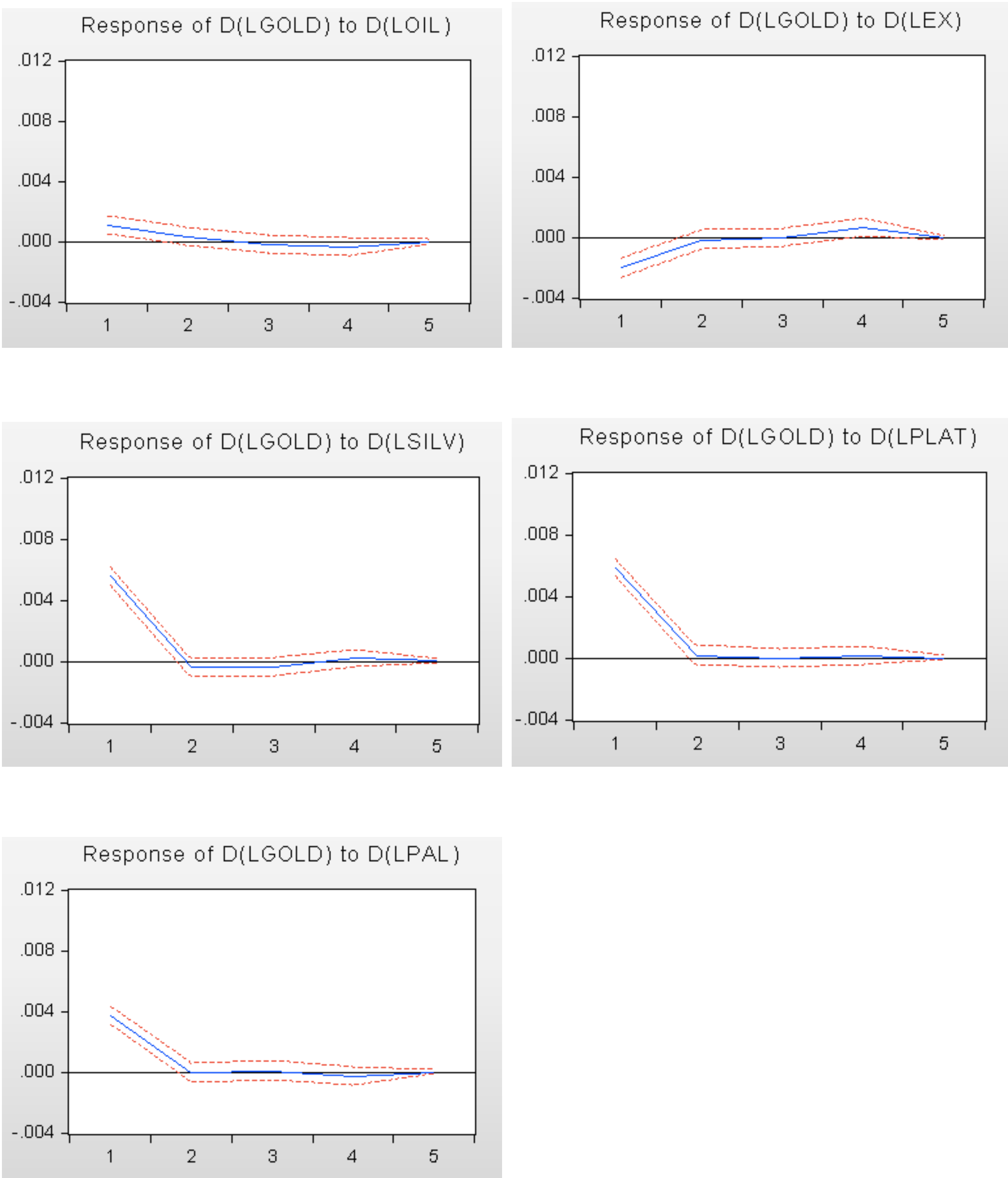


Fig. 4. Response of LSILV to generalized one S.D, innovations ±2 S.E.

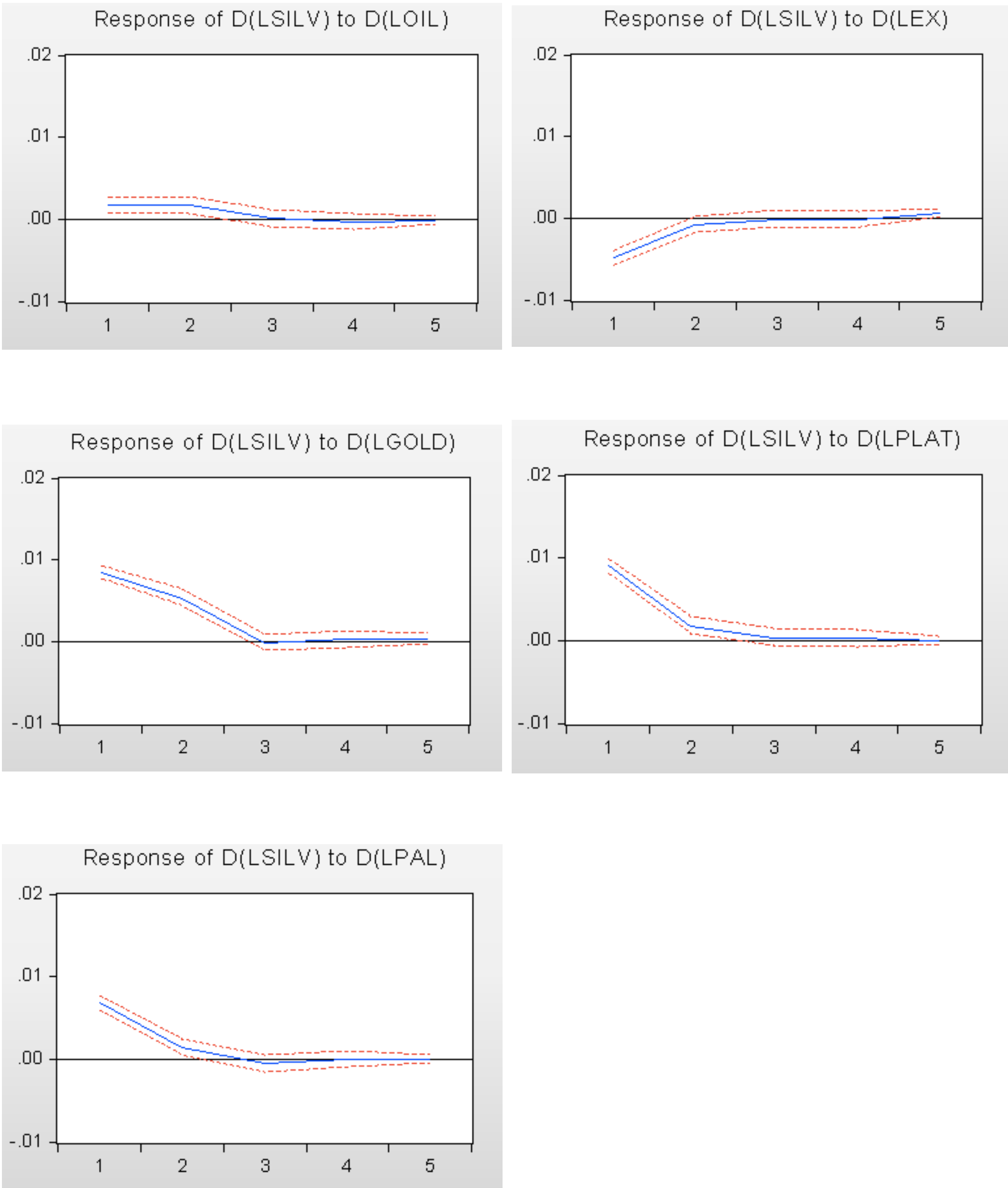


Fig. 5. Response of LPLAT to generalized one S.D, innovations ±2 S.E.

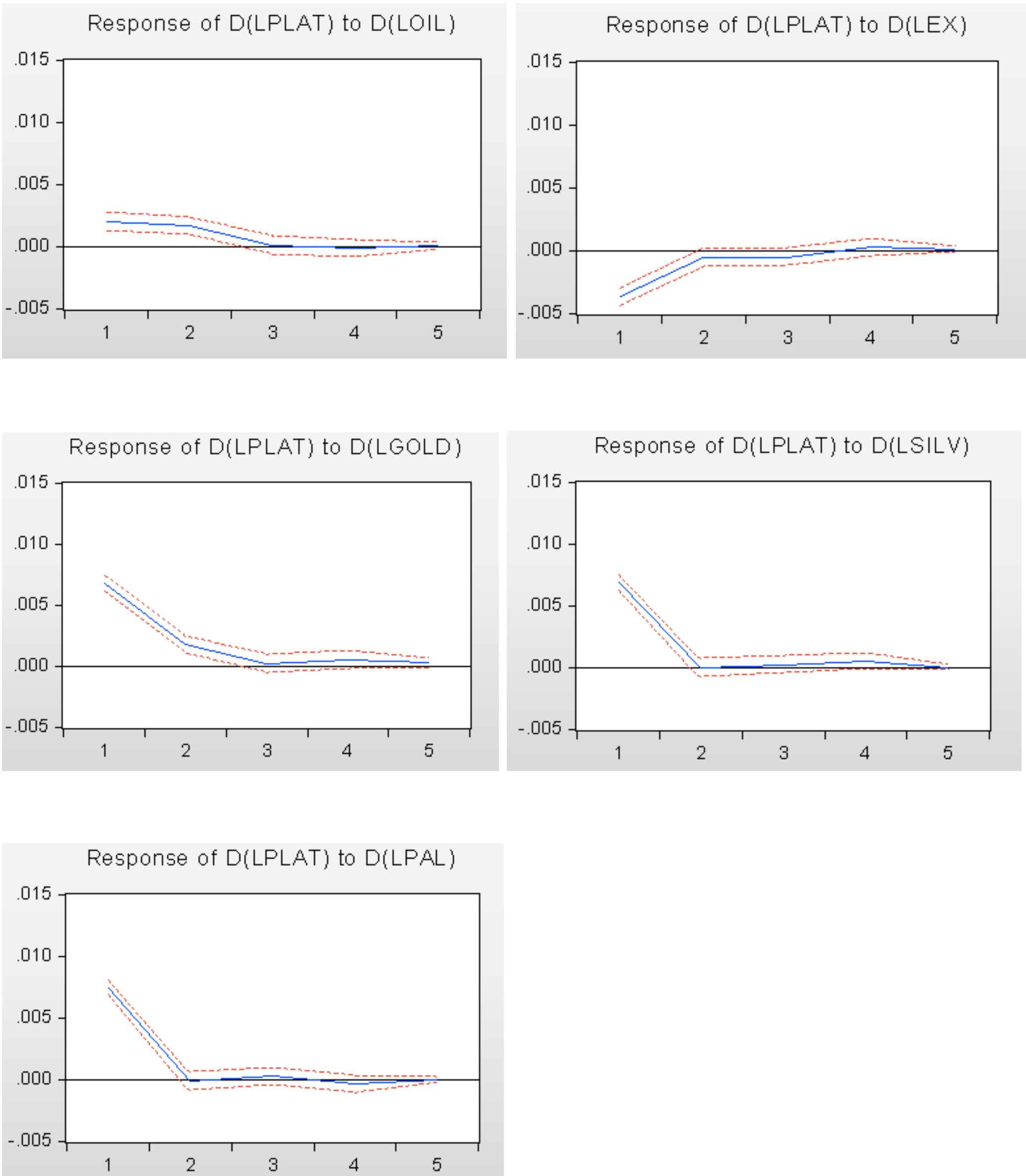
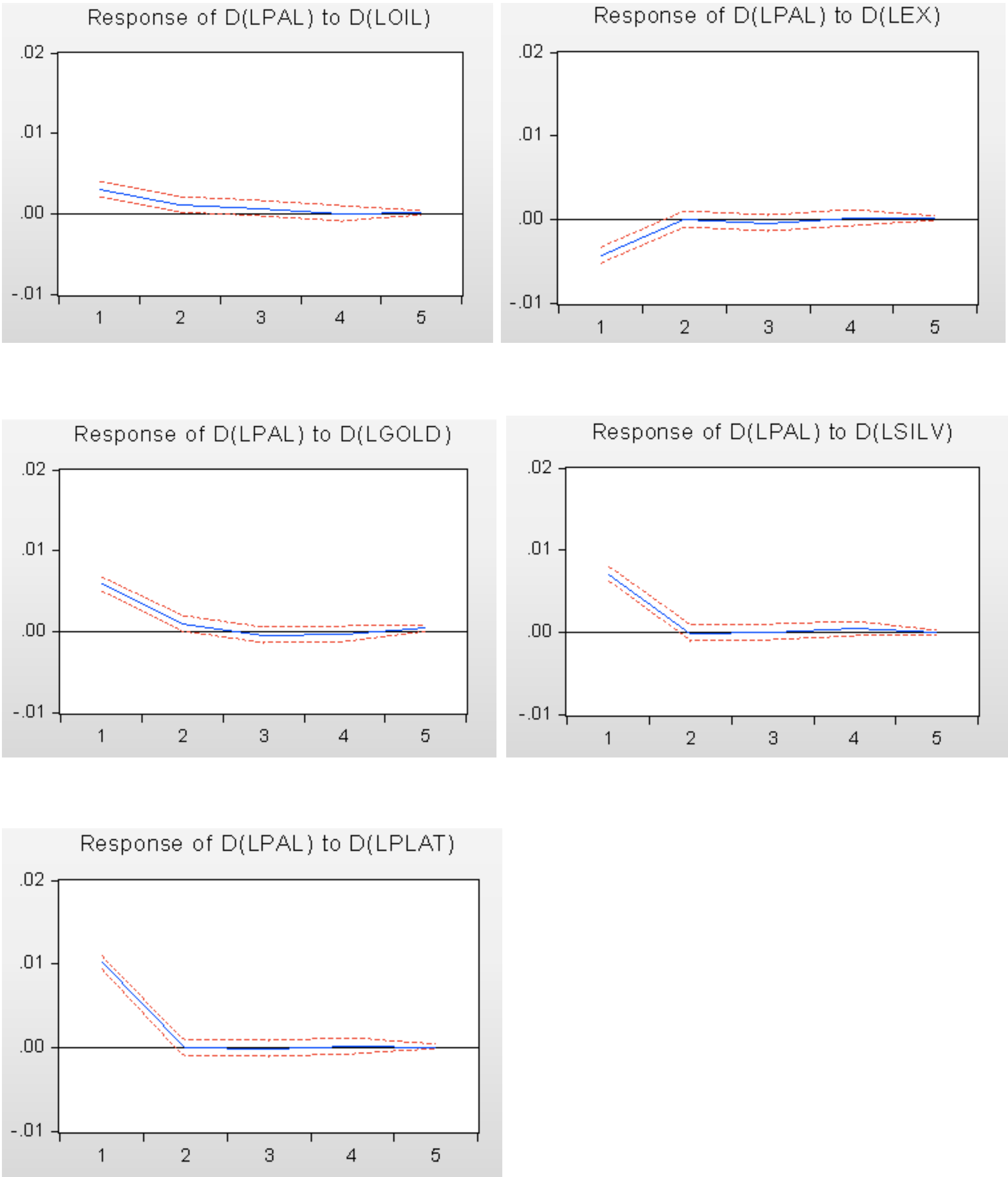


Fig. 6. Response of LPAL to generalized one S.D, innovations ±2 S.E.



ID number: 0977456

ID number: 0897500

Preliminary Thesis Report

Oil Prices and Industry Stock Returns

15.01.2017

BI Oslo

GRA 19502 Master Thesis

Master of Science in Business, Major Finance

Contents

Introduction

Oil has been the most important source of energy in the last seventy years. Its products are used for production, transportation and heating, and through its extensive supply chain the industry provides a large number of work places.

Because of the great importance of oil, the impact of oil price changes on the world economy is a popular object for research in finance. Though few studies examine the relationship in a small, open, oil exporting economy like Norway.

Narayan and Sharma (2011) studied 560 US firms listed on New York Stock Exchange and found that only two out of fourteen sectors experienced a rise in return while oil prices increased (Narayan and Sharma 2011). Further, Driesprong, Jacobsen and Maat (2008) examined market indices of 48 countries, demonstrating that a rise in oil prices significantly lowers future stock returns (Driesprong, Jacobsen and Maat 2008). Both studies also found evidence that there is a lagged effect between oil price and firm returns.

This paper is motivated by the two pioneering works mentioned above, and aim to examine how oil price fluctuations influence Oslo Stock Exchange. More precisely we will look at how changes in the oil price affect different industries, both obviously, oil-dependent industries like the energy sector and others, like the health sector. Because of particularities of a small, open, oil exporting economy, the evidence from major markets may not be replicated on Norwegian data. Based on this, we aim to study how the Norwegian market react on oil price changes, and compare it with earlier research in other markets.

This paper will be twofold. First, we will examine how stock returns of different industries on Oslo Stock Exchange are affected from crude oil price changes. Secondly, we want to see if there is a lagged affect, and if those effects are different from industry to industry.

Literature review

Numerous studies have examined the relationship between oil price and stock returns, documenting that oil price has a negative impact on the macro economy as a whole (see e.g. (Hamilton 1983, 2003, 2009), (Kilian and Park 2009), (Cashin et al. 2014) and (Birol 2004) among others). Overall the literature suggests that oil exporters, like Norway, benefiting from a rise in oil prices, while oil importers losing from an increase in prices. Few studies have examined the relationship on firms listed on Oslo Stock Exchange. However, a study conducted by Gjerde and Saettem (1999), found that Norway's strong dependency on oil is reflected in the stock market, which responded rationally into oil price changes (Gjerde and Saettem 1999, 73). Though, they were using monthly observation assessing the causal relations among several macroeconomic variables and stock return in the small and open Norwegian economy. To further illuminate our research question and gain a greater understanding on how oil price affect the economy, earlier research on the field will be chronological presented below. The methodology and research questions vary in some extent, but they are all acknowledged papers regarding the relationship between oil price and stock returns. Because our study is based on the articles of Narayan and Sharma (2011) and Driesprong, Jacobsen and Maat (2008), these are described in more detail.

"Striking oil: Another puzzle?" was published by Driesprong, Jacobsen and Maat in 2008. They are the first to document statistically and economically significant predictability of stock returns using oil price changes. The authors used a basic regression model with the log returns from monthly value-weighted market indices as the dependent variable, and the one month lagged oil price log return as explanatory variable. The analysis includes market indices from 18 developed countries, including Norway, and a world market index with data from October 1973 until April 2003. They have also included indices from thirty emerging markets, starting in 1988 or later. As independent variable, they used several oil price series in the analysis: Brent, Texas, and Dubai. In addition, Arabian Gulf Arab Light Crude Oil Spot Price and two future series (NYMEX and IP(ICE)) was used. The results are robust across the different oil price series, however, to save space they focus on Arabic Light crude oil, which gives a good indication of the average. For the developed markets, they find that a 10 percent increase in oil price, the next month world market index decreases by 1 percent. In all countries, the coefficient is negative, also for Norway, implying that a decrease in this month's oil price indicates a higher stock market return next month.

Further, the authors build a simple buy-and-hold trading strategy to test the economic significance of the results. For developed markets, they take the following approach; splitting the sample into two, estimating the model with the first half and using this estimation together with the last oil price change to predict returns in the first month of the second half. Next, they re-estimate the model updating it with the last month of observations. If the expected return is higher than risk-free rate they fully invest in the market portfolio, if not it is invested in short-term bills. The results from the trading model shows economic significance with an average Jensen's alpha of about 4 percent per annum, including switching costs of 10 basis points.

Driesprong, Jacobsen and Maat also examine two possible explanations of the results; the underreaction hypothesis (Hong and Stein 1999) and a time-varying risk premium. To examine the first one, they used daily data creating new monthly oil price series, with a delay of one up to 17 trading days. The result of the test is perfectly in in line with a delayed reaction of investors. For a lag of 6 trading days the regression has the highest explanatory power, for lags larger, the R^2 and t-values are quickly decreasing. The result is consistently in a large number of countries, and strengthen their findings are a consequence of information gradually diffusing among investors. The results for Norway is not significant at any lags. They also tested sector differences, finding weakest predictability in the energy sectors, suggesting that investor have difficulty assessing effect of oil price changes on stocks not directly related to energy. Further, the authors tested for time-varying risk premium, and the result do not support this hypothesis. (Driesprong, Jacobsen and Maat 2008)

The paper "Does crude oil move stock markets in Europe? A sector investigation" was published by Arouri (2011). The aim of the article was to investigate the responses of European sector stock markets to oil price changes, and creating a broader understanding of the short-term relationship at sector level using different econometric techniques. The time series was weekly, spanning from 1 January 1998 – 30 June 2010, applying different techniques including quasi-maximum likelihood (QML) method to estimate GARCH (p,q). His findings suggest a strong negative relationship between oil price changes and stock return in

Financials. Further, he found negative relationship in six more sectors; Food & Beverage, Health Care, Personal & Household Goods, Utilities, Technology, and Telecommunication. A strong positive relationship in Oil and Gas was found, in addition he found positive relationship in Basic Materials and Consumer Services. The results for the Industry sector suggest only a weak causality from oil to stock returns. In conclusion, there is a strong relationship between oil price changes and stock returns in most European sector. In addition, the coefficients in GARCH(p,q) model was significant, indicating that the model satisfies the dynamics of returns.

Narayan and Sharma (2011) examined the relationship between oil price and firm returns for 560 US firms listed on the NYSE. The dataset is daily, and spans the period 5 January 2000 – 31 December 2008. Their focus was at a micro-level, testing four hypotheses that previously have not been tested at firm-level. They estimate two different GARCH (1,1) models, with stock return of each firm as dependent variable. In the first model two explanatory variables is included; growth rate in crude oil prices and the market return. The second model also includes the short-term US interest rate and the US-Euro nominal exchange rate. After testing all the firms, they are categorized into 14 different sectors. Their findings suggest that oil price affects firms differently, both in terms of sign and magnitude. Only two sectors, the two that is most dependent on oil, experienced a rise in return while oil prices increased; energy and transportation. In the energy sector the effect of oil prices on returns was positive and statistically significant for 90 % of the firms. For the remaining 12 sectors the relationship is negative and significant. Further they tested if oil price changes affect firm returns with a lag. In the model the authors included eight lags of oil price and the market return in time t, finding strong evidence of oil price having a statistically significant effect on firm returns with lags for all 14 sectors. Around 20 – 30 percent of the firms in seven sectors the one-period lagged oil price showed significant effect, for six sectors the lagged effect is maximized at two lags, which was the most common lag at which oil price significantly and negatively affects firm returns. The second most common lag is five. In addition, they find that the relationship between oil price and firm returns is dependent on the size of the firm. (Narayan and Sharma 2011)

"Oil price and stock returns of consumers and producers of crude oil" was published by Phan, Sharma and Narayan (2015). The article investigate how differently stock returns of oil producers and oil consumers are affected from oil price changes. They used daily time series from firms listed under NYSE, NASDAQ and S&P500 and followed Arouri (2011) and (Narayan and Sharma 2011) to estimate a GARCH(1,1) regression model with oil price return and stock market return as explanatory variables. They also investigate if there is a lagged effect of oil price changes on stock returns. As they expected, they found that the coefficient on oil price returns for the producer sector turns out to be positive, while it is negative for the consumer sector. An analyze on the sub-sectors shows that oil price changes does not affect the Construction sector. Further their findings suggest that the impact of oil price varies in a large extent and provides evidence that consumer sub-sectors are heterogeneous in their response to oil price changes. For the producer sector, oil price returns predict stock return at lags one and two, and the findings is not significant for further lags. However, when they analyze the sub-sectors they find that the lagged effect is stronger for Petroleum, which was affected up to eight lags. For consumer sector, at aggregated level, none of the lags of oil price returns predict stock returns. However, examining the sub-sector, they found that oil price predicts stock return up to seven and eight lags for Truck Transport, Construction and Chemical Manufacturing.

In our research, we do expect to find that different industries react differently on oil price changes, though we do not expect to find negative relationship in as many industries as Narayan and Sharma (2011). The Norwegian economy is highly dependent of oil, hence it will be interesting to see how oil consuming industries react on oil price changes.

From a market efficiency point of view, we should not expect to find that investors either under- or overreact to information in oil price. However, because earlier research find lagged effect analyzing the relationship, there is a probability that we will get similar findings. However, Driesprong, Jacobsen and Maat (2008) suggest that investors do better in assessing the relationship in oil related sectors. Based on this, it will be interesting to see how the relationship is for the industries we are going to study. Oslo Stock Exchange is highly oil dependent, and maybe investors on average is better to estimate the impact on oil price changes in several sectors, also those with no directly connected to the oil industry. As mentioned earlier Gjerde and Saettem (1999) found that the Norwegian stock market responded rationally into oil price changes (Gjerde and Saettem 1999, 73). This finding might not be surprising since they were using monthly observations. In this paper, we consider whether the Norwegian stock market also responds rationally when daily data is used.

Methodology

As described earlier, this paper is motivated by the articles of Driesprong, Jacobsen and Maat (2008) and Narayan and Sharma (2011). Driesprong et al aimed to construct a forecast model in their study, hence they only included oil price log return as explanatory variable. We aim to assess the relationship between oil price and industry stock return, hence our model will be inspired by the two multifactor regression models used by Narayan and Sharma.

In general terms, a regression model aim to describe and evaluate the relationship between a given variable and one and more other variables (Brooks 2014). The purpose in our research is to analyze how oil price changes influences industry stock return. The stock return is the variable we aim to explain, and it is also called the dependent variable. The variables that are included to explain the dependent variable are called independent or explanatory variables, which in our case is the oil price. Nevertheless, to avoid omitted variable bias, it may be necessary to include more explanatory variables. If a relevant variable for explaining the stock return has been left out of the estimated regression equation it could lead to biased inference on the remaining parameters (Brooks 2014).

Ordinary least squares (OLS) is the most common approach that is used to estimate linear regression models. It chooses the regression coefficients so that the estimated regression line is as close as possible to the observed data, where closeness is measured by the sum of squared mistakes made in predicting Y given X (Stock and Watson 2012). In our case, the industry stock return is denoted by Y, and the oil price change is denoted by X. The general equation for a straight line, including random disturbance term, is used to describe the relationship:

$$Y_t = \alpha + \beta X_t + \mu_t$$

The intercept α and the slope β are the coefficients of the regression line, where β is the change in Y associated with a unit change in X and the intercept is the point where X is equal to zero and where the regression line intersects the Y axis. The random disturbance term μ, also denoted the error term, incorporates all the factors besides X that determine the value of the dependent variable Y.

R-squared (R^2) measure how well the OLS regression line fits the data, it ranges between 0 and 1 and explains the fraction of variance in Y that is explained by the independent variables (Stock and Watson 2012). If the correlation between Y and X is high, the model fits the data well, while if the correlation is low (close to zero), the model is not providing a good fit to the data (Brooks 2014). Adding one or more variables to the model will increase R^2, but the increase does not necessarily reflect improvements of the model, hence R^2 gives an inflated estimate of how well the regression fits the data. Because of this, inference are rather made by looking at adjusted R^2, which is R^2 deflated by a factor (Stock and Watson 2012).

The population values that the describe the true values of the relationship between X and Y is primarily of interest, however, those values are never available. A hypothesis test is a statistical test used to determine if there enough evidence in the available data to infer that a certain condition is true for the entire population. First, a null hypothesis (H_0) is specified, which is the statement being tested. Further the data is used to compare H_0 to a second hypothesis called the alternative hypothesis (H_1). Test statistics are used to determine whether to reject the null hypothesis or not. The p-value gives the marginal significance level where one would be indifferent between rejecting and not rejecting the null hypothesis. A small p-value indicates that the null hypothesis is false. One could also use critical values, which is specified by the type of test that is applied and the significance level. (Stock and Watson 2012)

In this paper, we aim to examine how stock returns of different industries on Oslo Stock Exchange are affected from crude oil price changes. We also want to see if there is a lagged affect, and if those effects are different from industry to industry. Based on this we propose two hypotheses that we want to test, these are as follows:

Hypothesis 1. Changes in oil price affects firm returns differently, depending on which industry they belong.

Hypothesis 2. There is a lagged effect of oil price changes on firm returns

Changes in oil price affects firm returns differently, depending on which industry they belong

To examine the hypothesis, we rely on the two models applied by Narayan and Sharma (2011). The statistical significance of the variables proposed in their model is based on the procedure proposed by Bollerslev and Wooldridge (1992), which developed the GARCH model in 1986. Because our research will be conducted on industries noted on Oslo Stock Exchange, the models are adjusted to fit the Norwegian market.

If the explanatory variable, in this case oil price growth rate, is correlated with one or more variables that has been omitted from the model and that determines, in part, the industry stock return, then the OLS estimator will have omitted variable bias (Stock and Watson 2012). To avoid this, other relevant variables are included.

$$\text{Model 1: } R_t = \alpha + \beta_1 gOP_t + \beta_4 Rm_t + \varepsilon_t$$

$$\text{Model 2: } R_t = \alpha + \beta_1 gOP_t + \beta_2 IR_t + \beta_3 ER_t + \beta_4 Rm_t + \varepsilon_t$$

Variance equation:

$$h_t^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1}^2 \qquad \varepsilon_t = h_t \vartheta_t \qquad \vartheta_t \sim N(0,1)$$

$\mathbf{R_t}$ is the sector return on day t; $\mathbf{gOP_t}$ is the growth rate in crude oil prices; $\mathbf{IR_t}$ 3 month NIBOR; $\mathbf{ER_t}$ is the NOK-USD exchange rate; $\mathbf{Rm_t}$ stock market return S&P 500 on day t

Interest rate

In our research the daily 3-month NIBOR will replace the short-term US interest rate from the model applied by Narayan and Sharma (2011). Gjerde and Saettem (1999) examined the relationship between several macroeconomic variables and found that stock returns immediately react negatively to changes in real interest rates.

Exchange rate

In addition, we have decided to include the NOK-USD exchange rate. The oil industry has a large impact on the Norwegian economy, and oil are traded mainly in US dollars. Further, most of the industries that are listed on Oslo Stock

Exchange operates internationally, hence their cash flows will be sensitive to changes in exchange rates.

Market return

Because the world economy is highly globalized it may be appropriate to include other stock markets in the analysis. It is reasonable to assume that large economies have great impact on the world economy, which further affects the Norwegian economy. Based on this the Standard & Poor's 500 (S&P 500) index is included in the model. S&P 500 is an American stock market index based on the market capitalizations of 500 large companies listed on NYSE or NASDAQ. The index is designed to reflect the US market, hence the market return in our model comes from the largest economy in the world.

Variance equation

The OLS estimation technique assumes that the variance of the errors in the regression model is constant, also known as the assumption of homoscedasticity. If the errors do not have a constant variance, they are said to be heteroscedastic, and standard errors are not reliable basis for hypothesis testing, leading to wrong inference about the coefficients. It is likely that financial time series are heteroscedastic, hence we will adopt the variance equation conducted by Narayan and Sharma (2011). The GARCH model allows the conditional variance to be dependent upon previous own lags. In order to estimate models from the GARCH family, another technique known as maximum likelihood is employed. Essentially, the method works by finding the most likely values of the parameters given the actual data (Brooks 2014). If the GARCH model is correctly, then the estimated standardized residual ε_t should behave like classical regression residuals, and we are able to make correct inference about the intercept and slope coefficients (Zivot 2008).

There is a lagged effect of oil price changes on firm returns

To examine whether there is a lagged effect, the same GARCH model as Narayan and Sharma (2011) is applied. As explanatory variables, the growth in oil price at time t and the market return of S&P 500 are included, in addition to eight lags of oil price growth.

$$\textit{Model 3: } R_t = \alpha + \beta_1 gOPt + \beta_2 gOPt_{-1} + \beta_3 gOP_{t-2} + \beta_4 gOP_{t-3} + \beta_5 gOP_{t-4} + \beta_6 gOP_{t-4} + \beta_7 gOP_{t-5} + \beta_8 gOP_{t-6} + \beta_9 gOP_{t-7} + \beta_{10} gOP_{t-8} + \varepsilon_t$$

Variance equation:

$$h_t^2 = \gamma_0 + \gamma_1 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1}^2 \qquad \varepsilon_t = h_t \vartheta_t \qquad \vartheta_t \sim N(0,1)$$

R_t is the sector return on day t; **gOP_t** is the growth rate in crude oil prices; **Rm_t** stock market return S&P 500 on day t

Data

In this section, we will specify and describe the regression parameters in the models presented above. All of the time series will be daily closing prices/rates, and because Industry Sector Indices are available from 1997, all the time series will span from 1997 to the end of 2016.

Dependent variable

Oslo Stock Exchange have been using the Global Industry Classification Standard (GICS) to group companies into industry sectors since 1997. Narayan and Sharma (2011) examined oil price impact on US firms and later dividing them into sectors, we have chosen to use industry sectors directly as a dependent variable. The next page comprises an overview of all the sectors, including a short description. The information is obtained from the official websites of Oslo Stock Exchange. Daily closing prices will be collected and estimated as daily price differences.

Industry sectors (GICS) Oslo Stock Exchange		
OSE10GI	Energy	Comprises companies whose businesses are dominated by either of the following activities: The construction or provison of oil rigs, drilling equipment and other Energy related service and equipment, including seismic data collection. Companies engaged in the exploration, production, marketing, refining and/or transportation of oil and gas products, coal and other consumable fuels
OSE15GI	Materials	Encompasses a wide range of commodity-related manufacturing industries. Included in this sector are companies that manufature chemicals, construction materials, glass, paper, forest products and related packaging products, and metals, minerals nd miningcompanies, including producers of steel.
OSE20GI	Industrials	Includes companies whose businesses are dominated by one of the following activities: The manufacture and distribution of capital goods, including aerospace & defense, construction, engineering & building products, electrical equipment and industrial machinery. The provison of commercial services and supplies, including printing, employment, environmental and office services. The provision of transportation services, including airlines, couriers, marine, road & rail and transportation.
OSE25GI	Consumer discretionary	Encompasses those industries that tend to be the most sensitive to economic cycles. Its manufacturing segment includes automotive, household durable goods, textiles & apparel and leisure equipment. The services segment includes hotels, restaurants and other leisure facilities, media production and services and consumer retailling.
OSE30GI	Consumer staples	Comprices companies whose businesses are less sensitive to economic cycles. It includes manufacturers and distributors of food, beverages and tobacco and producers of non-durable household goods and personal products. It also includes food & drug retailing companies as well as hypermarkets and consumer super-centers.
OSE35GI	Health Care	Encompasses two main industry groups. The first includes companies who manifacture health care equipment and supplies or provide health care related services, including distributors of health care products, providors of basic heath-care services, and owners and operators of health care facilities and organizations. The secon regroups companies primarily involved in research, development, production and marketing of pharmaceuticals and biotechnology products.
OSE40GI	Financials	Contains companies involved in activities such as banking, mortage finance, specialized finance, investment banking and brokerage, asset management and custody, corporate lending, insurance and financial investment.
OSE45GI	Information technology	Contains companies involved in internet software and services. It also includes areas such as communication equipment, technology hardware, semiconductor equipment and electronic equipment and services.
OSE50GI	Telecommunications services	Contains companies that provide communications services primarly through a fixed-line, cellular, wireless, high bandwidth and/or fiber optic cable network.
OSE55GI	Utilities	Contains companies engaged in electric (nuclear and non-nuclear), gas or water utilities. It also includes companies within the renewable electricity business using sources such as geothermal, biomass, and solar energy, as well as hydro and wind power.
OSE60GI	Real estate	Includes compnies incolved in real estate, such as real estate investment trusts, real estate developers and estate agents.

Explanatory variables

The oil price will be defined as Brent, which includes North Sea Oil. We have not decided where to collect data yet, but we will use daily closing prices to estimate daily change in oil price. We also consider to include WTI which is listed on NYMEX and serves as a global benchmark. Whether to include it or not will depend on the correlation between Brent and WTI, if both will be used we are planning to run two regression for each industry sector; one with Brent and one with WTI. As interest rate, we are planning to use 3-month Norwegian Interbank Offered Rate (NIBOR). NIBOR is intended to reflect the interest rate level a bank require for unsecured money market lending in NOK to other banks. It is calculated and published by Oslo Stock Exchange, hence we will obtain daily data from them. The exchange rate will be defined as NOK/USD, we plan to collect daily closing rates from the Central Bank of Norway. We have not decided where to collect data for S&P 500 yet.

Time plan for completing the thesis

February	Collect data and start to work on the theory-part. Include more relevant articles in Literature review.
March	Become familiar with the data and the software program that we will use. Start doing regressions in software program. Start to work on the methodology-part and continue with the theory.
April	Finish work with regressions in software program, gather results and get an overwiev of these. Finish the methodology part. Start to present the results and work on the analysis
May	Continue on the results/analysis. Finish the theory-part.
June	Finish work with results/analysis. Start to work on the conclusion.
July	Finish the conclusion and work on the totality.
August	Work on the totality and completing the thesis.
September	Submit the final thesis.

References

Arouri, Mohamed El Hedi. 2011. "Does crude oil move stock markets in Europe? A sector investigation." *Economic Modelling* 28 (4): 1716-1725.

Birol, Fatih. 2004. "Analysis of the impact of high oil prices on the global economy." *IEA, Paris, France*.

Bollerslev, Tim and Jeffrey M Wooldridge. 1992. "Quasi-maximum likelihood estimation and inference in dynamic models with time-varying covariances." *Econometric reviews* 11 (2): 143-172.

Brooks, Chris. 2014. *Introductory econometrics for finance*: Cambridge university press.

Cashin, Paul, Kamiar Mohaddes, Maziar Raissi and Mehdi Raissi. 2014. "The differential effects of oil demand and supply shocks on the global economy." *Energy Economics* 44: 113-134.

Driesprong, Gerben, Ben Jacobsen and Benjamin Maat. 2008. "Striking oil: Another puzzle?" *Journal of Financial Economics* 89 (2): 307-327.

Gjerde, Øystein and Frode Saettem. 1999. "Causal relations among stock returns and macroeconomic variables in a small, open economy." *Journal of International Financial Markets, Institutions and Money* 9 (1): 61-74.

Hamilton, James D. 1983. "Oil and the macroeconomy since World War II." *The Journal of Political Economy*: 228-248.

———. 2003. "What is an oil shock?" *Journal of econometrics* 113 (2): 363-398.

———. 2009. *Causes and Consequences of the Oil Shock of 2007-08*: National Bureau of Economic Research.

Hong, Harrison and Jeremy C Stein. 1999. "A unified theory of underreaction, momentum trading, and overreaction in asset markets." *The Journal of Finance* 54 (6): 2143-2184.

Kilian, Lutz and Cheolbeom Park. 2009. "The impact of oil price shocks on the US stock market." *International Economic Review* 50 (4): 1267-1287.

Narayan, Paresh Kumar and Susan Sunila Sharma. 2011. "New evidence on oil price and firm returns." *Journal of Banking & Finance* 35 (12): 3253-3262.

Oslo Stock Exchange. "https://www.oslobors.no/." Accessed 10 Jan 2017.

Phan, Dinh Hoang Bach, Susan Sunila Sharma and Paresh Kumar Narayan. 2015. "Oil price and stock returns of consumers and producers of crude oil." *Journal of International Financial Markets, Institutions and Money* 34: 245-262.

Stock, J.H. and M.W. Watson. 2012. *Introduction to Econometrics*: Pearson Education, Limited. https://books.google.no/books?id=vyGncQAACAAJ.

Zivot, Eric. 2008. "Practical Issues in the Analysis of Univariate GARCH models." *Handbook of Financial Time Series*.