THE NORWEGIAN KRONE AND BRENT CRUDE OIL

DETERMINANTS & BEHAVIOR DURING OIL PRICE SHOCKS

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May 11, 2018

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Abstract

In this thesis, we investigate how a change in the oil price affects the Norwegian krone, using the interest rate differentials, the lagged real exchange rate, and the US dollar as control variables. The Norwegian krone is measured against the euro, Great British pound, and the US dollar, and is based on two separate datasets, one monthly and one weekly, from April 2001 to December 2017.

We further split the dataset into two subsamples, where we investigate whether the dynamics of our independent variables change during the financial crisis in 2008, and the oil price crisis in 2014. The empirical analysis of the relationship between the Norwegian krone and the oil price is implemented using OLS regressions and Engle-Granger Co-integration.

From the Engle-Granger Co-integration test, we do not find any co-integrated relationship between the NOK-exchange rates and the oil price. This is neither found for any of our independent variables. Therefore, we proceed by estimating an OLS regressions based on the concepts represented in the Augmented Dickey Fuller test. From the full dataset, we find both the oil price and the interest rate differential to be important determinants for the Norwegian krone. These results are robust for changes in the US dollar.

The analysis of the subsamples reveals that changes in the oil price were relatively more important during the financial crisis, while changes in the interest rate differential were relatively more important during the oil price crisis. Additionally, we find that the relationship between the oil price and the exchange rates is not driven by abnormally large changes in the oil price. This emphasizes that there is a *general* relationship between the oil price and the Norwegian krone.

Contents

1 Introduction

1.1 Researching the Norwegian Krone

January 2016 marked the end of a one-and-half year prolonged fall in the oil price, reaching its lowest level since 2004. Increased production of unconventional oil and a reluctance from OPEC to cut production, caused the oil price to decrease by more than 70 percent from its peak level in June 2014. Simultaneously, the Norwegian krone depreciated against its major trading partners. This was expected given the Norwegian economy's dependence on the oil industry; a dependence which had grown larger after almost a decade with unprecedented high oil prices.

Nevertheless, in the years after the fall in the oil price, the relationship between the Norwegian krone and the oil price is perceived by experts as weaker than before. In general, the krone seems to adjust at a lower rate, indicating that the sensitivity to changes in demand and supply for oil might have reduced its importance to the Norwegian economy. We find it interesting considering that the co-movement between the Norwegian krone and the oil price seemed to follow stronger patterns during the financial crisis in 2008. This apparent opposite effect motivated our research question:

"How does the relationship between the oil price and the Norwegian krone differ during a demand- and supply shock in the oil market?"

In order to answer this research question, the thesis will be organized in a particular matter. In section two, we introduce theory regarding the exchange rate market, the oil market, and the Norwegian economy. The first subsection will mainly include key concepts and simple theoretical models with respect to exchange rates. Next, we introduce the determinants of supply- and demand for oil, and investigate the dynamics and patterns of the oil price during the last thirty years. Lastly, we will introduce the characteristics of the Norwegian economy, and how it has developed since the discovery of oil in 1969. This subsection will also include an analysis of the Norwegian Government Pension Fund and how revenues from the oil sector are phased into the economy.

In section three we review previous literature that looks into the relationship between the oil price and exchange rates. The section will be augmented by reviewing papers that solely look at the Norwegian krone against its trading partners. Next, in section four we present to the reader our empirical research about the relationship between the Norwegian krone and oil price. So to study the relationship, we start by estimating a baseline model in which we include several independent variables based on the theory and literature reviewed in preceding sections. In order to study how different shocks in the oil market affects the Norwegian krone, we use a weekly dataset which we split into two different subsamples, and subsequently analyze differences in the determinants of the Norwegian krone. Lastly, in chapter five we discuss various topics concerning the oil price, Norwegian krone, and Norwegian economy, before presenting our conclusion and suggestions for future research.

1.2 Scope and Limitations

Firstly, this thesis will only look at historical data from April 2001 to December 2017, which might be perceived as a short timespan considering Norway discovered oil in 1969. Doing so might exclude some important events and data that can limit our ability to draw a general conclusion outside our time frame. However, because the inflation target was introduced in March 2001, we have seen it necessary, so to avoid our results picking up potential effects of changes in the monetary policy. Our dataset should therefore be sufficient enough. It also contains the two events of interest, namely the financial crisis in 2008 and the oil price crisis in 2014.

Our analysis only includes a subset of variables affecting exchange rates which, based on theory and previous research, is hypothesized to be the most important determinants for the Norwegian krone. Some variables are left out from the analysis because of the difficulty of finding reliable and comparable data, or that the frequency of data does not match our criteria. Hence, we do not argue that any of the regression models in this thesis represents the true exchange rate model. However, since the relationship between the oil price and the Norwegian krone is the main topic of this thesis, the exclusion of some variables should not limit our ability to study the potential impact a change in the oil price might have on the Norwegian krone.

Further, we do not test for the direction of causality when analyzing the relationship between the Norwegian krone and the oil price, as our research is focusing on the Norwegian krone and not one of the major currencies in the world. Taking into consideration the trading volume of the krone and the size of the Norwegian economy, it seems unlikely that changes in the Norwegian krone should have any large impact on the oil price. If the analysis was directed towards the US dollar and the US economy, we would have been required to consider the direction of causality.

For the empirical analysis of this thesis, we apply OLS regressions to study how shocks in the oil price have affected the Norwegian krone. We conducted several tests and used heteroskedastic- and autocorrelation consistent standard errors in order to ensure the validity of our findings. Nevertheless, we wish to point out that our approach is quite simple, and that there are other more advanced methods for doing this type of research. However, we believe our approach should provide satisfactory answers to our research question. An additional benefit of using a more simple approach is that it improves the understanding of the findings from the empirical analysis.

Lastly, we only use the price of Brent crude oil in our analysis. We have not tested the results against other benchmarks, such as the WTI or Dubai, on the basis of two arguments. First, the movements of the different oil prices tend to be very similar, and the Brent crude is globally perceived as the most important benchmark. Second, the Brent crude oil price is the most important oil price with respect to Norway, as the oil produced in the North Sea is Brent.

2 Theories

To put our paper into a theoretical framework, we will present the reader concepts regarding the exchange rate market, the oil market, and the Norwegian economy. We begin the first section by introducing fundamental theories about the foreign exchange market and essential principles concerning exchange rates and -regimes. Afterward, we explain the dynamics of the oil market by looking at the determinants for demand- and supply of oil, as well as give comments to the most important events during the development of the oil price. We conclude this chapter by looking at the Norwegian economy, and how it has evolved since the discovery of oil in 1969. Additionally, we take a quick glance at the monetary policy in Norway, the government pension fund and the budgetary rule for managing oil revenues.

2.1 Exchange Rates

An exchange rate can be defined as the price of one nation's currency in terms of another currency. An exchange rate has two components, the domestic currency and foreign currency, and can be quoted in two ways: *directly* and *indirectly.* The former expresses the price of a unit of foreign currency in terms of domestic currency, whereas the latter expresses the cost of a unit of domestic currency in terms of the foreign currency. Direct quotations, also known as the *nominal* exchange rate (NER), is the most common quotation method in large financial markets. We will therefore exclusively apply this quotation method in this thesis. As an example, on January 1st, 2018, the price of one US dollar (USD) in terms of Norwegian krone (NOK) was NOK/USD = 8.1794. The USD is usually the base currency in direct quotations, but when a currency quote does not include the USD in either the denominator or the numerator, the currency is called a *cross currency.*

The aforementioned NER is also known as the bilateral exchange rate. However, to understand the change in the value of a currency, we need to use a *multilateral* exchange rate. The nominal effective exchange rate (NEER) is a measure of a country's currency against a average-weighted basket of several foreign currencies (IMF, 2018a). Both the

Organization for Economic Co-operation and Development (OECD) and the International Monetary Fund (IMF) publishes NEER-indices for all major currencies. The interpretation of the NEER is that if the trade-index of a country increases, the value of that currency *appreciates* (becomes more valuable) so that you need less domestic currency to pay for foreign currency. On the other hand, if the trade-index decreases, the value *depreciates* and it becomes more expensive to buy foreign currency.

The *real* exchange rate (RER) measures the value of a country's goods against those of another country, i.e., it measures a country's trade competitiveness. It is calculated as the product of the nominal exchange rate and the ratio of the two countries' consumption baskets (Meese and Rogoff, 1988). Its logarithmic form can be expressed as:

$$q_t = s_t + p_t^* - p_t. \tag{2.1}$$

Here, as well as in the rest of the paper, an asterisk indicates the foreign country. Further, as an extension of the NEER, the real effective exchange rate (REER) measures the *inflation-adjusted* value of a currency against an average-weighted basket of several foreign currencies. An increase in the REER-index for a given country implies that exports are more expensive relative to imports (IMF, 2018b). This could either be a result of a depreciation of the domestic currency or an increase in the relative price level. Overall, an increase in the REER implies a loss in trade competitiveness.

Foreign exchange rate *exposure* is said to be prevalent when the value of future domestic holdings are dependent on the value of foreign currency. Commonly, the exposure is classified into three types: transaction-, translation- and economic exposure (Borad, 2018). The former of the three states that if you have purchased a commodity from a foreign country, and payment will occur sometime in the future, you may ultimately pay more than the current price should the domestic currency depreciate. Translation exposure, or accounting exposure, is the risk of translating books of accounts into the home currency. Economic exposure, on the other hand, states that the market value of domestic holdings, notably the operating assets of a firm, will be affected by unexpected changes in foreign exchange rates. Firms typically use the foreign exchange market to hedge the exchange rate risk and to minimize their exposure.

2.1.1 The Foreign Exchange Market

The global foreign exchange market (FX-market) is a 24-hour over-the-counter and dealer's market, in which traders buy and sell different currencies. An FX-trade is nothing more than a contract between two parties, and there are three main types of trades: spot-, futures-, and swap trades. In the *spot* market, currencies are traded at the current exchange rate for two-day settlements. In the *futures* market, currencies are traded forward at an agreed-upon price. The *swap* market, on the other hand, includes both spot and future settlements. A swap trade implies that one party buys a currency on the spot market, while simultaneously sells the same amount in the forward market (BIS, 2007). Market participants use the futures- and swap markets to hedge their exchange rate risk.

In most countries, the central bank is the governing agency that monitors the FX-market and enforces the monetary policy of a country. However, the level of intervention in the FX-market depends heavily on the country's exchange rate regime. For instance, towards the end of the Second World War, the British and American governments established the IMF, which was intended to police a system of *fixed*-exchange-rates known as the Bretton Woods system (Copeland, 2014). Under this type of regime, the central bank of a country ties their currency to some widely-used commodity or currency.

In the 1944 Bretton Woods Agreement, countries agreed to peg all currencies to the US dollar. The central bank would thus buy and sell its domestic currency at a specified price and maintain the level by, for instance, changing the domestic interest rate or influencing the inflation level. A more recent example of this *fixed-pegged* exchange regime would be Denmark's fixed-exchange-rate policy against the euro. The Danish central bank keeps the Danish krone stable against the euro by dynamically changing their monetary policy. As stated by the central bank, they defend this currency regime as it enforces low and stable prices in the country (Nationalbanken, 2018).

Today, nevertheless, most countries follow a *floating*-exchange-rate regime. We distinguish between two different floating regimes: free-floating regime and managed-floating regime (Principles of Macroeconomics, 2016). Under the former, the central bank does not participate in the FX-market and allow market forces to determine the exchange rate. The primary difficulty with the free-floating-exchange-rate regime is its unpredictability, which makes international transactions more costly and risky. In practice, all central banks intervene in the FX-market to some extent. Therefore, the concept of this type of exchange rate regime is merely theoretical.

In a managed-floating-exchange-rate regime, on the other hand, the central bank of a country tend to appreciate or depreciate their exchange rates, by buying or selling their domestic currency. Exchange rates are still free-to-float, as opposed to the fixed-exchange-rate regime, but the purpose of intervention is to prevent unanticipated large swings in the value of a nation's currency, and to stabilize and sustain economic growth.

2.1.2 Balance of Payment

The fundamental of the Balance of Payments (BP) theory is based on the trade between a country and its trading partners and measures the inflows and outflows of goods and capital in the economy (Moffett et al., 2013). The BP is divided into four elements and can be illustrated as:

$$BP = (X - IM) + (CI - CO) + (FI - FO) + FXB. \tag{2.2}$$

Here, $(X - IM)$ is the current account balance (CA), where X is exports and IM is imports. The CA includes all transactions with income or payment-flows occurring within the current period and states whether a country has a trade balance deficit, or -surplus. The second part, $(CI - CO)$, refers to the capital account balance (KA), where CI is the capital inflows, and CO is the capital outflows. The KA shows credit and debit entries (net change) for non-produced, non-financial assets and capital transfers between countries (IMF, 2018c). Further, $(FI - FO)$ is the financial account balance (FA), where FI is the financial inflows and FO is the financial outflows. The FA is composed of direct investments, portfolio investments, and other investments. Finally, the term FXB is the official monetary reserves of the central bank, which usually include gold and foreign currencies. The central bank uses the capital of the FXB when intervening in the FX-market.

Bringing it all together, the BP-model is based on double-entry bookkeeping with debit and credit, implying that for the BP to be in equilibrium, $CA + KA + FA + FXB$ must sum to zero (Moffett et al., 2013). The consequence of a disequilibrium depends on what exchange rate regime the country follows. In a country with a fixed-exchange-rate, the government has the responsibility of holding the BP close to zero. In cases where the sum of CA, KA, and FA deviates from zero, the central bank has to intervene in the FX-market, either by buying or selling foreign currency reserves, so to maintain the exchange rate at its fixed level.

When the sum of the CA and KA is negative, the respective domestic currency is in excess supply in the world market. The central bank must, therefore, purchase domestic currency with foreign currency to guide the market back to its old equilibrium path. Hence, with a fixed-exchange-rate regime, it is essential for the central bank to maintain significant reserves of foreign currency. Through history, we have seen examples of countries who were required to give up their fixed-exchange-rate regime because they were not able to hold enough foreign currency to defend their peg. This was the case when Norway and Sweden were required to give up their regime as a consequence of the banking crisis in the early 90s (Norges Bank, 2014).

With a managed-floating-exchange-rate regime, the central bank allows market forces to determine the day-to-day exchange rate. However, interventions will be done whenever the exchange rate diverges too far from the prespecified exchange rate interval. Instead of intervening directly in the market, the central bank will try to influence the exchange rate through changes in the motivation for market activity. The most common tool for doing so is by changing the key policy rate. By increasing (decreasing) the interest rate level, the central bank attracts (deters) foreign investors to invest in the home country.

Thus, the central bank uses the KA through capital inflows and outflows to counteract any disequilibrium in the CA (Moffett et al., 2013).

Lastly, with a free-floating-exchange-rate, market forces will either cause the exchange rate to depreciate or appreciate depending on whether there is a BP surplus or deficit. Since the central bank does not intervene in the market under such a regime, the FXB is zero. Thus, if a country runs a CA surplus, and the KA and FA sums to zero, there will be a BP surplus. As domestic exporters need to buy domestic currency with foreign currency, the BP surplus will result in excess demand for domestic currency. Since the exchange rate is completely floating, market forces will cause the domestic currency to appreciate so to balance the CA. However, in the currency market, there are some delays in the short-to-medium run. The dynamics of these delays can be explained through the J-curve (ibid.).

As shown in figure 1, the J-curve consists of three periods, the currency contract period; the exchange rate pass-through period and; the quantity adjustment period. In the *currency contract period*, the impact is ambiguous; because exports and imports are based on contracts, changes will not occur immediately. In the case of an unexpected depreciation of the currency, where exports are denominated in domestic currency and imports are denominated in foreign currency, the trade deficit would increase at t_1. Imports become more expensive, while at the same time, income from exports remains unchanged (ibid.).

In the *exchange rate pass-through period*, the changes in the exchange rate are passed through to the prices of the importers and exporters. For instance, a foreign producer will have to increase its prices to cover the local currency costs, raising prices for domestic consumers. At the same time, domestic products become relatively cheaper in foreign markets compared to foreign products. However, if a large quantity of the raw materials is imported, it will impact the producer negatively as they would be required to keep prices higher to cover their expenses in the foreign currency.

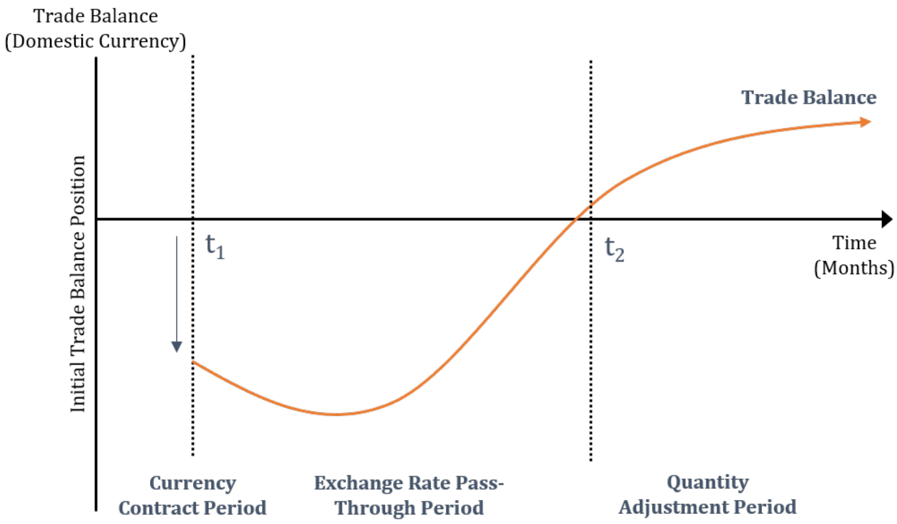

Figure 1: *The J-curve (Moffett et al., 2013)*

The last period is the *quantity adjustment period*, in which the adjustment of the trade balance concludes. The depreciation makes domestic exports cheaper for the foreign country, making the volume of exports rise as foreign investors can now afford to buy more at the same price. At the same time, imports become more expensive compared to domestic products. Imports begin to fall which, combined with the increased exports, reduces the trade deficit.

2.1.3 Mundell-Fleming Model

The Mundell-Fleming model (MF-model) is an extension of the IS-LM-model, which shows how the market for goods (IS) interacts with the money market (LM) (Melvin and Norrbin, 2012). The short-term equilibrium between interest rates and output is thus where the IS and LM curves intersect. The difference between the IS-LM-model and MF-model is that the former analyses a *closed* economy, whereas the latter analyses a *small open* economy.

The global economy can itself be considered a closed economy, but most individual countries and regions must be regarded as open due to extensive cross-border trades. Norway, in particular because of its dependence on natural resources and international trade, must be categorized as a small and open economy. In such a global economic condition, the relationship between the IS and LM is far more complicated. In this context, the government cannot solely focus on inflation- or unemployment levels, but should also take into consideration exchange rates, capital flows, and trade when deciding on their monetary- and fiscal policy. The MF-model extends the IS-LM-model by including the BP in the short-term equilibrium. We will next present the dynamics of the MF-model, before analyzing the effects of a change in the monetary- and fiscal policy in equilibrium.

The Goods Market Equilibrium (IS-curve)

The IS-curve reflects the goods market and shows the relationship between the interest rate (i) and total income (y) in the economy (ibid.). Equilibrium in the goods market is thus achieved when income received from producing goods and services equals total spending in the economy. We further divide total income into domestic savings (S); taxes (T) and; imports (IM). As well, we separate total spending as investment spending (I); government spending (G) and; exports (X). The relation can be presented as

$$S + T + IM = I + G + X. \tag{2.3}$$

The IS-curve represents the different combinations of i and y in which the income from production equals total spending. The relationship between the interest rate and total income is found to be negative. For instance, a lower interest rate is associated with higher total income and increased investments and spending. Thus, the IS-curve will have a negative slope.

The Money Market Equilibrium (LM-curve)

The LM-curve represents the money supply curve and shows the combinations of i and y in which the demand and supply of money equalize (ibid.). The MF-model assumes that the money supply is constant, as it is set by the central bank independent of the interest rate. Money demand, on the other hand, is the amount of money consumers are willing to hold relative to interest-bearing assets. This relationship is negative because a higher interest rate increases the alternative cost of holding money. For instance, if there occur a positive shift in the total income of the economy, it will cause a positive change in the demand for money. Since the money supply is constant, this will lead to a higher interest rate in the economy. Hence, the LM-curve will have a positive slope in the MF-model.

The Balance of Payments (BP-curve)

The BP-curve represents the relationship between i and y that yield balance of payments (ibid.). We have an equilibrium in the BP when the current account surplus (CS) is equal to the capital account deficit (KD). In this model, the KA is considered constant for a given interest rate level because it is assumed to be unrelated to total income. As for the CA, the relationship to total income is negative; lower total income reduces imports, which increases the CA.

In the case of an increase in the interest rate level, the KD will be reduced. To offset this, total income has to increase so to reduce the CS. Thus, to satisfy the relationship between the interest rate and total income, the BP-curve has to be upward-sloping. However, note that this dynamic is only possible in the case of rigidities in the capital market. In the case of perfect capital mobility, the BP-curve is horizontal because investors would be able to pull their assets out of a country instantly, so to invest in other markets.

Equilibrium and Dynamics

For the economy in the MF-model to be in equilibrium, all three markets mentioned above must be in equilibrium. In the goods market, total production must equal total spending; in the money market, the money supply must equal money demand and; the balance of payments must be zero. The aggregated dynamics is represented in figure 2, where the equilibrium is represented in point e, with an income level of Y_e and interest rate of i_e.

For our further discussions, we will assume perfect capital mobility as Norway has relatively few restrictions. Imposing this assumption will not restrict our analysis of the Norwegian economy. On the contrary, it will simplify our discussions and allow us to explain the dynamics more precisely. Additionally, we will assume that domestic and foreign financial assets are perfect substitutes, and most of our discussion will revolve around the dynamics of a floating-exchange-rate regime.

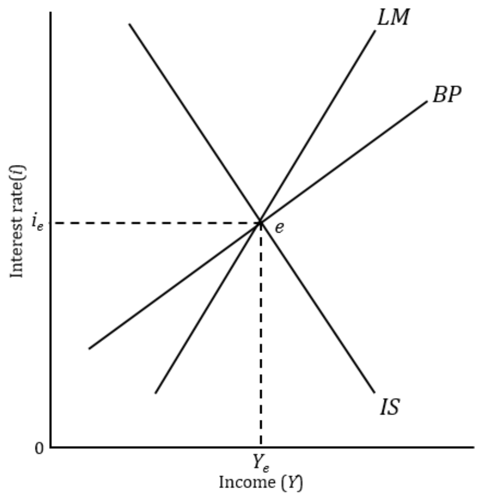

Figure 2: *Equilibrium in the MF-model (Melvin and Norrbin, 2012)*

Under a floating-exchange-rate regime, a country can conduct an independent monetary policy as they do not need to intervene in the FX-market or change the money supply to keep the exchange rate fixed. Since the floating-exchange-rate will keep the CS equal to the KD, the central bank is free to set the money supply as they desire.

The assumption of perfect capital mobility and perfect asset substitutability will also make the BP-curve horizontal. Here, the IS-curve will shift whenever the exchange rate changes, as it affects imports and exports of a country. A depreciation of the domestic currency, keeping the prices of goods and services fixed, will cause the IS-curve to shift outwards as exports become more affordable for foreigners. An increase in exports would thus increase total spending in that economy.

To further explain the dynamics of the monetary policy, we look at an example where there is an increase in the money supply. As shown in figure 3, when the central bank increases the money supply there will be a downward shift in the LM-curve, which will shift the equilibrium to point e'. However, since the lower interest rate level will cause investors to pull their money out of the country, the KD would be larger than the CS, and the BP will become nonzero. This depreciates the domestic currency, which can be represented by an outward shift in the IS-curve as exports increases. We reach a new equilibrium, point e'', where the IS-curve, LM-curve, and BP-curve intersect. At this point, we will have the same interest rate level, but total income will have increased. In the case of a contraction in the money supply, the opposite will occur.

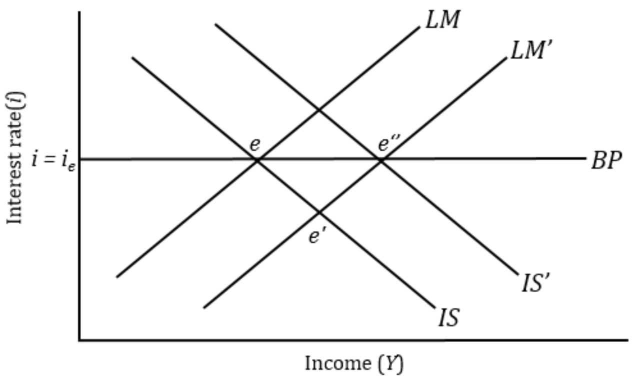

Figure 3: *Increase money supply under floating-exchange-rate (Melvin and Norrbin, 2012)*

Comparing the latter with a fixed-exchange-rate regime, we see that the benefit of the floating-exchange-rate regime is that it allows for independent monetary policy, as market forces will adjust the exchange rate to balance a country's payments. On the other hand, the volatility of the exchange rate can potentially be large and can create some uncertainty about future exchange rates. Hence, an economy should ideally have both an independent monetary policy and a fixed exchange rate. However, to achieve this, the country would be required to close its economy and abandon free capital mobility. The central bank would then have total control over the money supply and could run a fully independent monetary policy. The fact that it is impossible for an economy to have a fixed-exchange-rate, an independent monetary policy, and free capital mobility is called the Mundell-Fleming trilemma (The Economist, 2016b).

Under a floating-exchange-rate regime, should the government decide on an expansionary fiscal policy, the IS-curve would shift to the right, and the new equilibrium between the goods and money market will be at e', as shown in figure 4. However, this would eventually reduce the KD because the interest rate at e' is now higher than in foreign countries. Since capital will begin to flow into the country, demand for domestic currency will increase and eventually begin to appreciate. Domestic goods will thus become more expensive to foreigners, which will eventually decrease total exports.

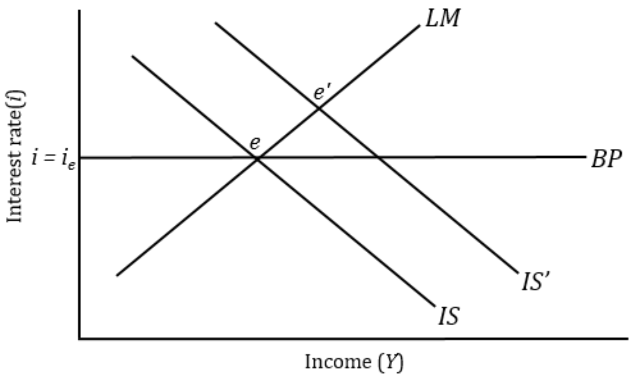

Figure 4: *Fiscal expansion under floating-exchange-rate regime (Melvin and Norrbin, 2012)*

Thereafter, total spending in the economy will fall, and the IS-curve will shift back to its old equilibrium level. In other words, the appreciation of the domestic currency decreases exports to a level that offsets the increase in government spending. Thus, both an expansionary and a contractionary fiscal policy has a *crowding effect*, and no long-term effect on total income.

2.1.4 Interest Rate Differentials

The theory of interest rate parity states that the domestic interest level should equal the foreign interest level, plus the expected change in the exchange rate (Chinn, 2006). The Covered Interest Rate Parity (CIP) is a condition in which a foreign investment should yield the same return as a domestic investment, ex-post exchange rate differences. Thus, the CIP states that the forward spread should equal the interest rate differential between two given countries:

$$f_{t,t+k} - s_t = (i_{t,k} - i^*_{t,k}). \tag{2.4}$$

Here, $f_{t,t+k}$ is the logarithm of the forward exchange rate at time t for k periods ahead; s_t is the logarithm of the spot exchange rate at time t and; $i_{t,k}$ and $i^*_{t,k}$ are the k-period domestic and foreign nominal interest rates at time t. An investor who converts her domestic funds at the spot rate, invest them in a foreign country and simultaneously signs a forward agreement at the spot forward rate $f_{t,t+k}$, should achieve the same return as an investor who invests her funds domestically. The relationship states that if the interest rate differential is positive, i.e. the domestic interest rate level is higher than the foreign interest rate level, the forward rate at time t should be higher than the spot rate. Thus, when the financial markets are in equilibrium, there is no arbitrage opportunities in the CIP relationship.

According to equation (2.4), the forward rate $f_{t,t+k}$ is defined as the spot rate plus the interest rate differential. This relationship is only true when investors are assumed to be risk-neutral. However, to the degree that investors are risk-averse, the forward rate will include a risk premium, η, that compensates investors for the additional risk from holding foreign assets instead of domestic assets:

$$f_{t,t+k} = s^e_{t,t+k} + \eta_{t,t+k}. \tag{2.5}$$

Substituting equation (2.5) into equation (2.4) yields that the expected change in the exchange rate equals the interest rate differentials, less the risk premium:

$$\Delta s^e_{t,t+k} = (i_{t,k} - i^*_{t,k}) - \eta_{t,t+k}. \tag{2.6}$$

Assuming the risk premium is zero, i.e. $\eta_{t,t+k} = 0$, equation (2.6) represents the Uncovered Interest Rate Parity (UIP). As opposite to the CIP, *uncovered* refers to the position remaining unhedged from exchange rate risk. The UIP hypothesizes that a high interest rate currency is expected to depreciate by the interest rate differential, should all investors be risk-neutral.

Equation (2.6) is not directly testable when expectations about future exchange movements are excluded. Including the rational expectation theory, which states that market participants make decisions based on the best available information (Taylor, 1983), realized future spot rates equals the expected value today, plus a white-noise error term:

$$s_{t+k} = s^e_{t,t+k} + \xi_{t,t+k}. \tag{2.7}$$

The error-term (ξ) is assumed to be uncorrelated with all information known at time t, including the interest rate differential and the spot exchange rate. Equation (2.6) is thus extended to

$$\Delta s^e_{t,t+k} = (i_{t,k} - i^*_{t,k}) - \eta_{t,t+k} + \xi_{t,t+k}, \tag{2.8}$$

where the left-hand-side represents the realized change in the exchange rate. According to Chinn (2006), the last two terms of the right-hand-side are assumed to be orthogonal to the interest rate differential. Thus, in a regression equation (2.8) simply becomes

$$\Delta s_t = \alpha + \beta(i - i^*)_t + v_t. \tag{2.9}$$

Assuming rational expectations and risk-neutrality, α should equal zero, and β should equal one such that the UIP holds. However, the UIP has been rejected by Fama (1984) and subsequent empirical studies with consistently negative or insignificant coefficients in the short-term. Most literature has focused on short maturities because interest rates are likely to conform to the assumptions necessary for interest parity that have maturities of less than one year. Nevertheless, Chinn and Meredith (2004) and Alexius (2001) examine long-term bond rates with various maturities and find weak evidence.

2.1.5 Inflation Differentials

In 1918, Swedish economist Gustav Cassel developed the modern theory of the Purchasing Power Parity (PPP) in his book about abnormal deviations in international exchange rates (Cassel, 1918). He defined the *absolute* PPP as an equilibrium condition in which the exchange rate between two countries equals the ratio of domestic and foreign price levels. In logarithmic form, this can be expressed as

$$s_t = p_t - p_t^*. \tag{2.10}$$

Here, s_t is the spot exchange rate, and p and p^* are the domestic and foreign price levels, respectively. Equation (2.10) is called the absolute PPP as it assumes a world without transportation costs and taxes. It postulates that a domestic consumer should be indifferent between purchasing a uniformed basket of goods at home or abroad, given the current exchange rate. The idea is built on the Law of One Price (LOP), which argues that the price of a single commodity should be the same in all countries when we compare them in a common currency. Even though transaction costs and taxes exist in the real world, the concept of absolute PPP stipulates that the actual exchange rate between two countries should *converge* towards the implied PPP exchange rate in the long-run.

To practically compare the price levels of countries, we would be required to allocate comparable and uniformed basket of goods. As an alternative measurement, The Economist publishes 'The Big Mac Index' every year. Here, they compare the price of a McDonald's Big Mac from multiple countries in a common currency, usually the US dollar (The Economist, 2018). As Big Mac's are more or less identical all over the world, comparing its price would yield an indication of whether a currency is over- or undervalued (Taylor and Taylor, 2004). As an example, let us compare the Norwegian krone against the euro with the implied exchange rate given by the Big Mac Index. As of January 2018, a Big Mac in Norway cost NOK49.00, whereas it cost €3.95 in the Eurozone. According to equation (2.10), the implied exchange rate would be

$$\exp(s_{nok/eur}) = \exp[\ln(49.00) - \ln(3.95)] = 12.41. \tag{2.11}$$

Assuming the price levels were captured at the beginning of January 2018, the actual exchange rate at that time was NOK/EUR = 9.82. This would imply that the Norwegian krone was overvalued by 26 percent compared to the euro. Hence, according to the absolute PPP, we should expect the Norwegian krone to depreciate by 26 percent in the long-run.

The *relative* PPP, on the other hand, is defined as the equilibrium condition in which the change in the exchange rate equals the inflation differentials. In logarithmic form, this can be expressed similarly as equation (2.10) above:

$$\Delta s_t = \Delta(p_t - p_t^*). \tag{2.12}$$

This version of the PPP is also called *weak* as it allows for taxes and transportation costs, assuming that these costs are constant over time (Giovannetti, 1987):

$$s_t = \mu(p_t - p_t^*). \tag{2.13}$$

Here, μ is the constant cost-parameter. For simplicity, we assume forthcoming that these costs remain constant at one. Equation (2.12) intuitively states that should the inflation differentials be x percentage points, then the currency of the high-cost country should depreciate by x percent in the long-run. Leaving the theoretical aspects aside, testing the relative PPP could be done by following the practical framework presented by Jacob A. Frenkel (1981):

$$\Delta s_t = \alpha + \beta\Delta(p - p^*)_t + v_t. \tag{2.14}$$

The null hypothesis, as according to relative PPP, is that α equals zero and β equals one. Equation (2.14) then allows us to test for the deviation between the exchange rate and price levels. There has, however, been disagreements towards the validity of the PPP. For instance, Adler and Lehmann (1983) find no evidence to support the long-run convergence implied by the PPP, but both papers written by Frankel and Meese (1987) and Engel and Rogers (1996) do find some empirical evidence that the PPP should hold in the long-run.

Taylor and Taylor (2004) discuss that over short periods, nominal exchange rate volatility is higher than the volatility implied in price level fluctuations, which cause deviations from the equilibrium condition presented in equation (2.12). This is closely related to the Overshooting Model introduced by Rudiger Dornbusch, which states that the short-term real exchange rate may overshoot its long-term equilibrium value due to price-stickiness (Frankel, 1979). The dynamics of this model suggest that the exchange rate converges towards its long-term equilibrium at a constant adjustment-rate.

Jeffrey Frankel (ibid.) augmented the paper by Dornbusch by including the inflation differential in the original equilibrium equation. He argued that once the real exchange rate is on its long-term equilibrium value, the exchange rate is expected to change at a rate equal to the inflation differential. The Frankel-Dornbusch Model thus stipulates that the PPP should only hold in the long-run. Using the Real Interest Rate Differential model presented by Frankel and Dornbusch as grounds, we will in the next section discuss the dynamics of real exchange rates and real interest rate differentials, and how we can empirically analyze its components.

2.1.6 Real Exchange Rate

According to Baxter (1994), "the real exchange rate is the level of the relative price of one county's goods in terms of another's." In section 2.1, we presented the RER as

$$q_t = s_t + p_t^* - p_t, \tag{2.1}$$

where s_t is the logarithm of the nominal exchange rate, and p_t and p_t^* are the logarithms of the domestic and foreign price levels. In the sticky-price model presented by Dornbusch (1976), a temporary deviation of the RER from its long-run equilibrium-state in equation (2.1) is expected to diminish by a constant rate (Meese and Rogoff, 1988). This can be expressed as:

$$q_{t,t+k}^e - \bar{q}_{t,t+k}^e = \theta^k (q_t - \bar{q}_t), \quad 0 < \theta < 1. \tag{2.15}$$

Here, $\bar{q}_t$ is the RER under a fully-flexible price system; e is the expectation denotation; and θ is the speed-of-adjustment parameter. One of the restrictions of equation (2.15), however, is that θ is unaffected by market disturbances, such as money shocks, which implies that $\bar{q}^e_{t,t+k}$ will not equal $\bar{q}_t$ unless there are no real shocks or all shocks follow a random walk (Meese and Rogoff, 1988). Thus, the model further assumes that

$$\bar{q}^e_{t,t+k} = \bar{q}_t. \tag{2.16}$$

By substituting equation (2.16) into equation (2.15), we find that

$$q_t = \bar{q}_t + \alpha \Delta q_{t,t+k}, \tag{2.17}$$

where $\alpha = 1/(\theta^k - 1) < -1$ and $\Delta q_{t,t+k} = (q^e_{t,t+k} - q_t)$. The model further incorporates the concepts of UIP, which we repeat here for convenience:

$$\Delta s^e_{t,t+k} = (i_{t,k} - i^*_{t,k}). \tag{2.6}$$

Following the Fisher equation (Fisher, 1930), we know that

$$i_{t,k} = r_{t,k} + \Delta p_{t,t+k}, \tag{2.18}$$

where $r_{t,k}$ is the real interest rate; $i_{t,k}$ is the nominal interest rate and; $\Delta p_{t,t+k}$ is the expected inflation rate. Substituting equation (2.18) in equation (2.6), we find that

$$\Delta q_{t,t+k} = r_{t,k} - r^*_{t,k}. \tag{2.19}$$

Lastly, substituting the latter into equation (2.6) we get that

$$q_t = \bar{q}_t + \alpha(r_{t,k} - r^*_{t,k}). \tag{2.20}$$

The relation in equation (2.20) states that the RER is a function of the flexible-price RER and the real interest rate differential. The difficulty with testing the equation above, however, is that “the test requires a measure of $\bar{q}_t$, which will be sensitive to the exact specification of the model. Thus, many ex-post empirical tests do not distinguish between the actual RER, q_t, and the RER under flexible prices, $\bar{q}_t$” (Baxter, 1994). Thus, for simplicity forthcoming, we change equation (2.16) to

$$q^e_{t,t+k} = q_t, \tag{2.21}$$

which implies that we can empirically test equation (2.19) by stating that

$$\Delta q_t = \alpha + \beta(r - r^*)_t + v_t. \tag{2.22}$$

This simplified specification assumes that prices are fully flexible and that the RER should be equalized across all countries. In other words, it assumes that prices are fully flexible. Equation (2.22) deviates from the Dornbusch-Frankel model as it neither incorporate the speed-of-adjustment parameter θ, nor the ex-ante purchasing power that $\bar{q}^e_{t,t+k} = \bar{q}_t$. Going forward, we will nevertheless use the simplified model presented in equation (2.22), as previous empirical evidence indicates that using ex-ante purchasing power characteristics in an ex-post study could yield imprecise and poor findings (ibid.).

2.2 The Oil Market

Crude oil is a nonrenewable resource comprised of organic materials that can be refined and separated into various petroleum products, such as gasoline and kerosene (EIA, 2017). There are many different types of crude oil produced worldwide, but the market value of a barrel of oil is typically determined by the quality characteristics of the oil, namely its density and sulfur content (EIA, 2012b).

First, crude oil can either be defined as *heavy* or *light*, depending on the degree of API gravity of the oil. Heavy crude oil, i.e., lower degrees of API gravity, is said to be more difficult to refine as the content of the raw oil must be processed through several refining units before being shipped. Second, crude oil can be either categorized as *sweet* or *sour* depending on the level of sulfur. It is said that sweet crude oil, i.e., low sulfur content, is priced higher than sour crude oil because "gasoline and diesel fuel, which typically sell at a significant premium to residual fuel oil and other low-end products, can be more easily produced using sweet crude oil" (Lipow, 2012). In aggregate, we would expect light and sweet crude oil to sell at a premium over heavy and sour crude oil.

The market price for crude oil tends to follow one of three main industry benchmarks. Dubai is the benchmark for crude oil in the Middle East; Brent crude is the North Sea produced crude oil which is used as a benchmark in Europe and; West Texas Intermediate (WTI) is the market crude benchmark for the Western Hemisphere crude oil (ibid.). The Brent and WTI are both known for being light and sweet, whereas the Dubai has a higher content of sulfur and is thus considered more sour. Comparing the Brent and WTI, we find that the WTI is a bit sweeter and exhibits a higher API gravity of 39.60 compared to 38.06 (Energy & Capital, 2017). Thus, we would expect WTI to be sold at a premium considering its premium characteristics. Historically, we have observed that this is in fact true. However, we have seen that after the financial crisis, Brent crude oil is selling at a premium over the WTI.

In this thesis, we will solely focus on Brent crude oil, as this is the price at which Norway exports their crude oil. As well, Brent is perceived as a better indicator for global oil prices than both the WTI and Dubai, as two-thirds of all internationally traded oil follows this benchmark (ICE, 2018). But the question is: who sets the benchmark price? Crude oil is a global commodity and its price reflects the interactions of many buyers and sellers, each with their view of the demand and supply of oil. These interactions occur both in the physical- and futures market, which in aggregate decides the oil price.

The Supply Chain

Total production in the world was around 92 million barrels per day in 2016 (BP Plc, 2017a). After extracting the crude oil from either land or sea, the crude is usually stored at a short-term storage center before being transferred through pipelines to refineries. The short-term storage center acts as a staging area to adjust its supply should the demand change. At the refinery, the crude oil is transformed into various consumable products and stored at terminals close to transportation hubs. From here, the refined fuel will be transported to its final point of sale, for instance, airports or gas stations.

Refineries primarily secure its crude oil through term contracts. They do not want to heavily rely on spot supplies, as these may be unreliable and exhibit high price volatilities. The end users, such as airports or gas stations, secure their consumable products similarly. For instance, an airline company would secure supplies at airports from term suppliers rather than entering the spot market to fuel its fleets. Therefore, the majority of crude oil and refined fuel is sold through term contracts, where the volume is agreed with a specified tolerance over a defined period. This tolerance allows either the buyer or seller to ship more or less than the contracted amount (World Energy Council, 2016).

2.2.1 The Determinants of Oil Demand

With the technological breakthrough of the 20th century, oil became the preferred energy source. Essential for the transformation were the electric bulb and the automobile. Automobile ownership and demand for electricity grew exponentially and with them the demand for oil (EKT Interactive, 2014). During the last 51 years, the average yearly growth in oil demand has been 2.3 percent, as depicted in figure 5. The worldwide consumption increased from 30 billion barrels per year to 96 billion barrels per year, where growth in the Asia Pacific regions accounted for 30 billion barrels. Today, the demand for oil is a composite of several determinants. For simplicity, we will discuss the most relevant ones for this thesis, namely, world gross domestic product (GDP) growth, substitutions, and speculations (Bizfluent, 2017).

The global economy is growing at an average rate of 3.4 percent per year; the population is expected to increase from 7.4 billion to 9 billion in 2040 and; growth within emerging markets underpin future growth in demand for oil. The largest contribution to the growth in demand for oil comes from India and the Southeast Asia region, where the latter is growing twice the pace of China (IEA, 2017b). Overall, developing countries in Asia account for two-thirds of global energy growth. Based on figure 5, there is a perceived positive correlation which indicates that an increase in the world GDP results in higher demand for oil, and thus a higher price for oil. Therefore, as emerging economies are catching up with the western countries, the future demand is expected to grow.

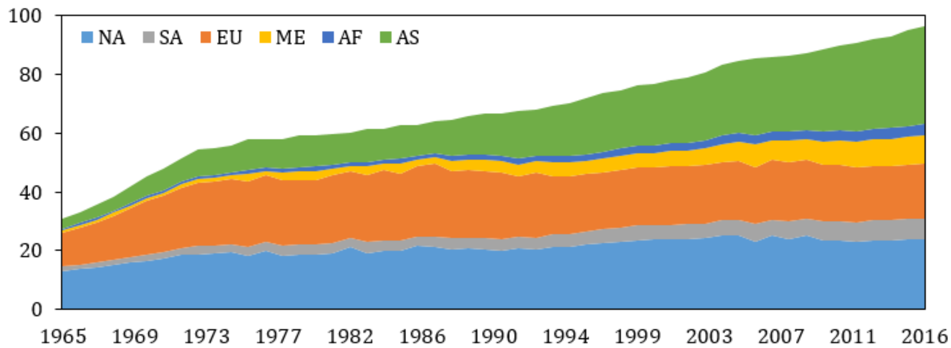

Figure 5: *Oil Consumption*[1] *(BP Plc, 2017b) NA: North America; SA: South America; EU: Europe; ME: Middle East; AF: Africa; AS: Asia*

For industrialized economies, energy is imperative to economic growth. In 2016, oil consumption accounted for 32 percent of the total global energy consumption (Enerdata, 2017). When the world economic activity increases, as captured by world GDP, the de-

[1]The numbers used for the illustration can be found in Appendix I

mand for energy and oil is also expected to increase. From figure 6, we find the relation between the growth in world GDP and changes in the consumption of oil.

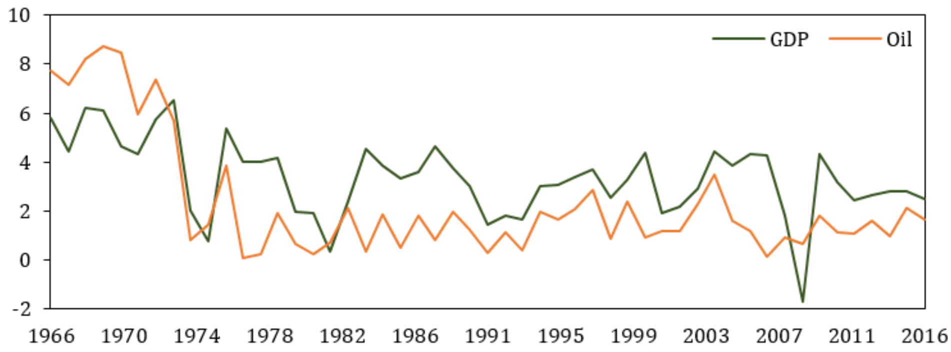

Figure 6: *World GDP vs. Oil Consumption*[2] *(The World Bank, 2018)*

According to the IMF Working Paper on oil prices and the global economy, effects towards oil substitution and conservation are dominant forces in shaping the oil market (Arezki et al., 2017). The biggest new competitor to oil in the transportation sector is arguably natural gas. For instance, more extensive use of electric vehicles could alter the transportation industry to become more *electrified*, making natural gas central to provisions of energy to that sector. Since 2000, natural gas consumption has increased by 47 percent, whereas crude oil has only increased by 23 percent (Ritchie and Roser, 2018). Estimations suggest that natural gas consumption will increase significantly in the medium term, at the expense of oil, with developing economies accounting for the bulk of the growth.

Another critical determinant for the demand of oil and, consequently, the oil price, is speculations in the financial markets. Commodity traders fall into two categories. The first category is composed of companies who buy oil for delivery at a future date at a fixed price, so to hedge risk exposure. The second is composed of actual speculators. Their only motive is to make money from changes in the price of oil (The Balance, 2017b).

Speculative activities might include holding oil inventories for future sales or trading in the oil futures market. For instance, former Federal Reserve Chairman Alan Greenspan stated

[2]The numbers used for the illustration can be found in Appendix L

that one possible source for the surge in the oil price at the beginning of the 21st century, was speculators who influenced the market by taking significant positions in crude oil futures (Anderson and Buol, 2005). This consequently decreased the volume demanded by both refineries and end-consumers. On the other hand, IEA noted that speculations might have had an effect on oil prices, but they stated it is difficult to distinguish between 'speculation' and 'investment' (Knittel and Pindyck, 2016). However, the consensus is that high levels of speculations were one of the primary reasons for the fall in the oil price during the financial crisis in 2008 (Watts, 2009).

2.2.2 The Determinants for Oil Supply

According to IMF, the supply of oil can be determined by proven reserves, unconventional oil reserves, and political influences (Arezki et al., 2017). Proven reserves are those quantities of petroleum which can be estimated with reasonable certainty to be recoverable, from a given date forward, from known reservoirs, and under current conditions (SPE International, 2018). Unconventional oil refers to oil reserves that cannot be feasibly accessed using conventional drilling techniques. These reserves, notably tight- and shale oil, must be extracted using novel methods. Advances in technology will most likely make the unconventional oils conventional in the future (StudentEnergy, 2018).

'The Peak Oil Theory', a theory by Marion King Hubbert, propose that the production of any finite resource, such as oil, gas or coal, follows a bell-shaped curve. At some point, output reaches a peak and afterwards begins to decline. The peak production rate and timing of the peak depend on total reserves that exist and are yet to be discovered. During the last 30 years, oil production has increased by 53 percent, with an annual average growth rate of 1.6 percent. However, over the previous ten years, the intensity of production has stagnated, and the current average growth rate has actually decreased by 50 basis points (Towler, 2014).

According to BP Statistical Review (2017a), the current estimates of world oil reserves show that if production were to continue at the current rate, we have enough oil to accommodate the current world demand for the next 50 years. These estimates have remained relatively stable since 1986, but some experts argue that production peaked in the 70s based on the theory mentioned above, implying that we are on the declining path (Towler, 2014). However, according to EIA, the unconventional oil production will increase to more than 6 million barrels per day in the coming decade and remain relatively stable until 2040. As industry actors are adapting to extracting shale- and tight oil, fewer experts believe that we are on the declining part of the bell curve (EIA, 2018a).

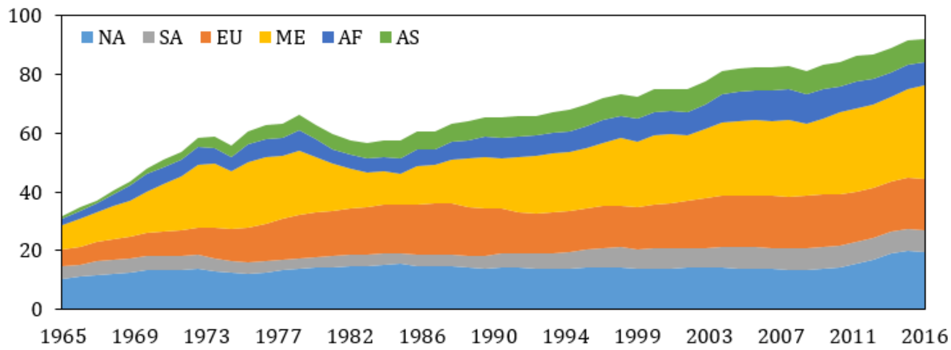

Figure 7: *Oil Production*[3] *(BP Plc, 2017b) NA: North America; SA: South America; EU: Europe; ME: Middle East; AF: Africa; AS: Asia*

Bearing in mind that the world oil reserves are scattered among different regions, country-specific politics highly influence world oil supply. As stated in BP Statistical Review (2017a), the Middle East accounts for 48 percent of total proven reserves, whereas South America, who has the second largest proven reserves, only accounts for 19 percent. Making the Middle East responsible for the largest portion of the world reserve.

If we include other OPEC countries from Africa and South-America, OPEC in total accounts for more than 70 percent of the total oil reserves. Such a concentration of reserves increases the reliance on the Middle East and OPEC. Sudden abruption in production and supply from these countries could affect the global availability and price for oil. Thus, changes in monetary- and fiscal policies are important determinants for the oil supply. This is particularly important in the Middle East, which is historically a politically turbulent region.

[3]The numbers used for the illustration can be found in Appendix J

Looking at the *production* of oil, we illustrate in figure 8 a selection of the major producers in the world. Russia, Saudi Arabia, and the United States are the three largest producers and account in aggregate for roughly 36 percent of global production.

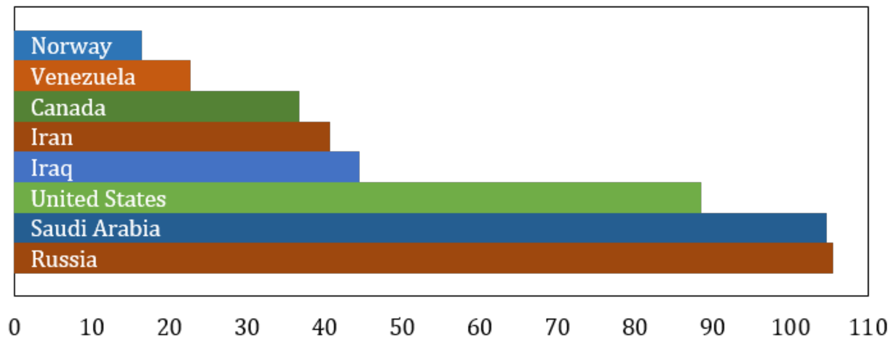

Figure 8: *Major Oil Producers (CIA, 2018a)*

Norway, as the 15th largest producer of oil, contributes to only two percent of total production level. With respect to OPEC, total production level for all members is almost 44 percent of overall production, with Saudi Arabia being responsible for 13 percent alone.

2.2.3 Historical Oil Prices

In this section, we analyze the historical background and reasons for much of the oil price changes during the last thirty years. Hopefully, this will aid the reader to understand some of the dynamics underlying the fluctuations in the oil price. We split up figure 9 into three main time periods; 1985-1998; 1999-2009 and; 2010-2018, as the volatility of the oil price during these periods differs from one another.

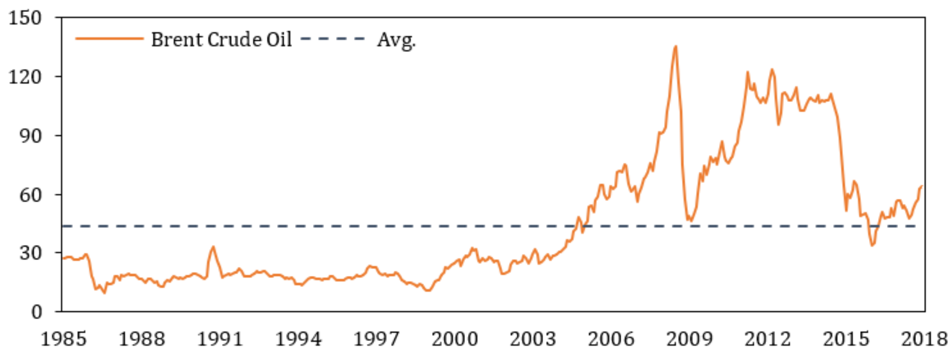

Figure 9: *Oil Price 1985-2018 (Reuters)*

Oil Price Development 1985-1998

Until the end of 1985, the oil price had increased and remained relatively stable at around $30 per barrel (pb) for three consecutive years. The high price had consequently reduced world oil consumption, and the competition between OPEC and non-OPEC producers had intensified. The combination of OPEC cutting their production level to support the high price, and non-OPEC producers increasing their output, resulted in a decrease in market shares for OPEC producers. In November 1985, OPEC was tired of cutting their production to maintain the price level and decided to flood the market. By August 1986, the oil price plunged to $9.30 pb (Morgan Stanley, 2015).

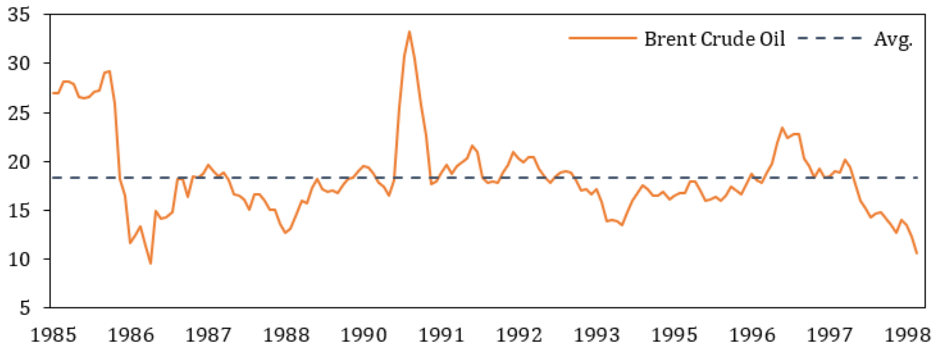

Figure 10: *Oil Price 1985-1998 (Reuters)*

At the beginning of the 1990s, OPEC producers initiated an internal negotiation for cutting production so to increase the market price. Before the cut in production occurred, the oil price increased from $17 to $20 pb as the market feared excess demand in the future. On top of this, a short time after the negotiation, Iraq's invasion of Kuwait knocked out two of the world's largest oil producers at the time. The United Nation (UN) initiated sanctions against both countries, which forbade any country to import oil from the two countries. Overall, the aggregated effect of the aforementioned resulted in a reduction in oil supply by seven percent, and a significant increase in the oil price, as seen by the spike in figure 10 (Henderson, 2014). However, the conclusion of the Gulf-War in 1991 counteracted the massive spike in the oil price caused by the UN sanctions.

From 1990 to 1997, global oil consumption had increased with 6.2 million barrels per day as a result of strong US economy and booming economies in the Asia-Pacific region. Asia accounted for all but 300,000 barrels per day. This allowed the oil price to stabilize at $24 pb in early-1997. Nevertheless, because of the Asian financial crisis in late-1997, and OPEC underestimating its effect, the rapid growth of Asian-Pacific economies came to a halt. The combination of lower consumption and oversupply from OPEC producers, sent the oil price into a downward spiral, reaching its lowest price $9.85 pb since the oil price crisis in 1986 (Williams, 2011).

Oil Price Development 1999-2009

With minimal Y2K problems[4] and a growing world economy, the oil price began to grow from the beginning of 1999. By the year 2001, Russia began to dominate the market as the largest non-OPEC producer. They were alone responsible for most of the non-OPEC production growth at the beginning of the new millennium (ibid.).

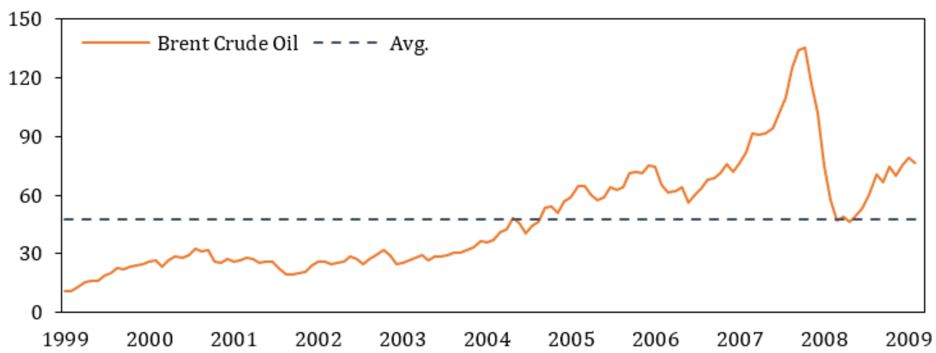

Figure 11: *Oil Price 1999-2009 (Reuters)*

In September 2001, the United States experienced a terrorist attack which directly decreased the oil price by 13 percent within one month. In January 2003, both the PDVSA[5]-strike in Venezuela, and OPEC's reduction in oil supply to accommodate the decline in demand after the 9/11-terror attack, boosted the oil price to new levels. Two months later, just as production in Venezuela was picking up, military actions in response to the terror attack commenced in Iraq. Together with increased OPEC supply to meet growing

[4]Expectations that computer systems would fail at the change of the millennium
[5]Petróleos de Venezuela, S.A.

global demand, the loss of production capacity in Iraq and Venezuela led to an erosion of excess production capacity. Starting from 2002, excess capacity fell continuously from six million to one million barrels per day in 2005.

Further, a weaker US dollar and continued growth in Asia increased overall oil consumption. However, because of the low excess production levels, substantial risk premiums were added to the price per barrel, which explains much of the higher prices in the following years. Additionally, Hurricane Katrina and the 2005 US-refinery problems associated with the conversion from MTBE[6] to ethanol as an additive, reduced production and consequently the oil price. From the end of 2006 and through most of 2007, the price increase can be explained by OPEC's fear of growth in OECD oil reserves, leading them to cut production levels even further. Eventually, this led the oil price to reach its all-time-high of $143 pb in July 2008 (ibid.).

Only two months later, the oil market would experience a significant drop as the Lehman Brother were about to file for bankruptcy as a consequence of the financial crisis (The Balance, 2017a). Spare capacities fell below a million barrels per day, and speculations in the oil futures market were exceptionally strong. The overall consequence of the recession was a fall real demand for oil, which made the oil price fall throughout the year until December 2008. On the positive side, a cut in production by OPEC of 4.2 million barrels per day, and rising demand in the Asia-Pacific region, steadily rose the oil price to $70 pb by the end of 2009.

Oil Price Development 2010-2018

Most of the price increase during 2011 was reflected by the tightness in world excess-production, which began in early-2010, marking the highest oil price since 2008. Even though the European debt crisis slowed down the economic growth, the civil war in Libya and growth in emerging markets, notably China and the Middle East, kept the oil price at a high level until 2012 (EIA, 2012a).

[6]Hydrolysis of tert-Butyl Methyl Ether

Even though there was some turbulence with production levels from 2012 to 2014, the oil price had remained relatively stable during this period. However, starting from the end of 2014, the oil price was about to experience its third largest drop in history (Baffes et al., 2015). According to Euan Mearns (2014), demand for oil, notably in China, Japan, and Europe, had softened as a consequence of an overall slowdown in the world economy. Together with this, the immense increase in production of unconventional oil in the US had resulted in the country shifting from being a net-importer of oil to be a net-exporter (Baffes et al., 2015).

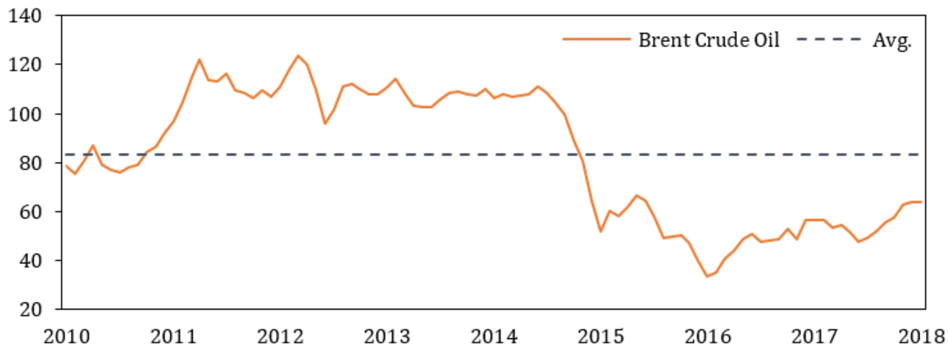

Figure 12: *Oil Price 2010-2018 (Reuters)*

During 2014, the US flooded the market as aggregated tight-oil production increased by roughly 35 percent, leading to a dramatic decrease in the price for oil. During an oil-glut, it has usually been up to Saudi Arabia, the world's largest exporter at that time, to adjust their production levels to stabilize prices. However, Saudi Arabia was reluctant in doing so and rather went against OPEC by flooding the market to obtain market shares, triggering a price war. The second motivation for doing so, as according to Rashid Abanmy[7], was that flooding the market would put pressure on Iran's nuclear program, and Russia's support for Bashar al-Assad in Syria (AA, 2014).

From mid-2014 to the early-2015, the US dollar appreciated by more than 10 percent against major currencies in trade-weighted nominal terms. This was mainly triggered by a diverging monetary policy in the US, Eurozone, and Japan, but also because of specula-

[7]President of the Riyadh-based Saudi Arabia Oil Policies and Strategic Expectation Center

tions in the futures market, and increased excess supply of tight oil (The Balance, 2018). At the end of 2015, Iran, Saudi Arabia, and Iraq ramped up production, and the US's ban on oil-exports was lifted[8], leading to an even greater decrease in the oil price (CNN Money, 2016a).

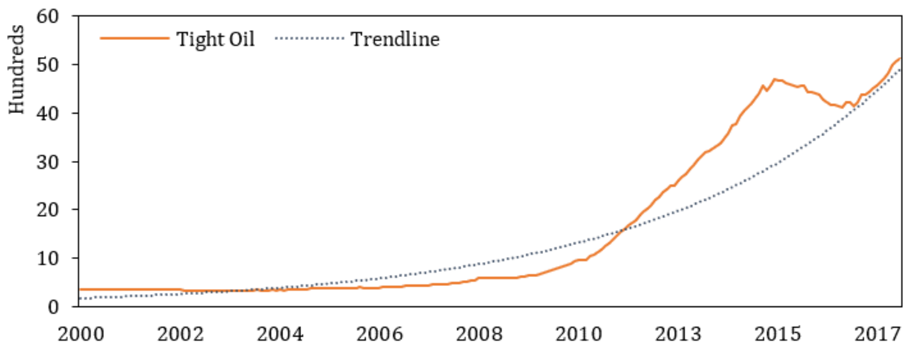

Figure 13: *Tight-Oil Production*[9] *(EIA, 2018c)*

Experts believed that the overall decline in the oil price would increase global demand, but a strong US dollar, unchanged interest rates, and changes in market trends let experts to predict a slowdown in the global economy (CNN Money, 2016b). The overall excess supply of crude oil decreased the oil price down to $33 pb in 2016, the lowest price since 2004.

Lastly, because of an internal agreement between OPEC members, Russia, and nine other producers to limit production through 2018, the oil price began to increase in late 2016, reaching $67 pb at the end of 2017. EIA believes that the market is balancing as demand is growing in developing economies and OPEC's compliance level reached its highest in late August (CNN Money, 2017).

[8]The ban was put in place in 1975 as a response to OPEC members' ban on export to the US in 1973
[9]The numbers used for the illustration can be found in Appendix K

2.3 The Norwegian Economy

With a GDP per capita of roughly $74,600[10], Norway is recognized as one of the wealthiest and most stable countries in the world (SSB, 2017c). By comparison, Norway's GDP per capita is about 50 percent larger than the average country in the European Union (EU). The Norwegian economy is, nevertheless, perceived as relatively small. It can be characterized as a blend of capitalism and strong government interventions. As well, because of few trade restrictions and intense exports, the economy is considered open as stated in 2.1.3.

As the 14th largest exporter of crude oil (EIA, 2018b), and the second largest exporter of natural gas (IEA, 2017a), Norway's economy is vastly reliant on the petroleum industry. The fall in the oil price in 2014, however, has somewhat reduced the importance of this sector as the petroleum share of Norway's GDP has fallen from 20 percent in 2013 (SSB, 2014) to 11 percent in 2016 (SSB, 2017b). As well, the employment in the petroleum sector fell from 8.7 percent to 7.5 percent during 2013 to 2015 (SSB, 2015).

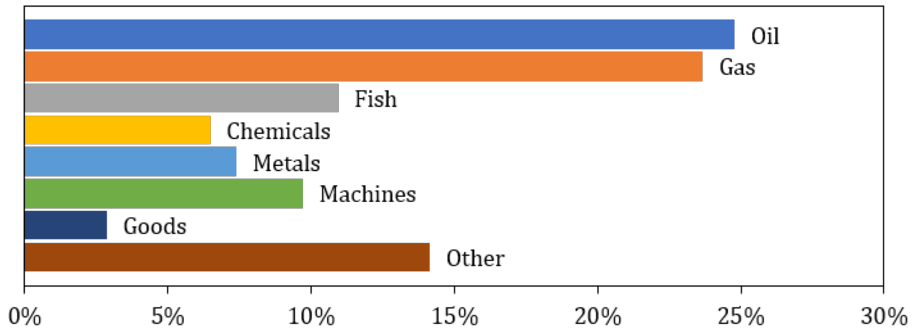

Figure 14: *Exports by-product groups*[11]

Nevertheless, as we can see from figure 14, Norway is still highly dependent on the petroleum sector, as crude oil accounted for about 25 percent of total export in 2017. In addition to oil and gas, a large portion of Norway's GDP consists of other natural resources from the North Sea. In 2017, 11 percent of total exports was exports of fish

[10]Calculated using NOK/USD = 8.3250
[11]Calculations based on table 08792 (SSB, 2018a) and table 08806 (SSB, 2018b) from Statistics Norway. The numbers used for the illustration can be found in Appendix M

and other sea products. As well, the high supply of clean energy has made Norway's western regions suitable for energy-intensive industries, such as aluminum production. Consequently, the exports of aluminum and other metals accounted for approximately 7 percent of total exports in 2017.

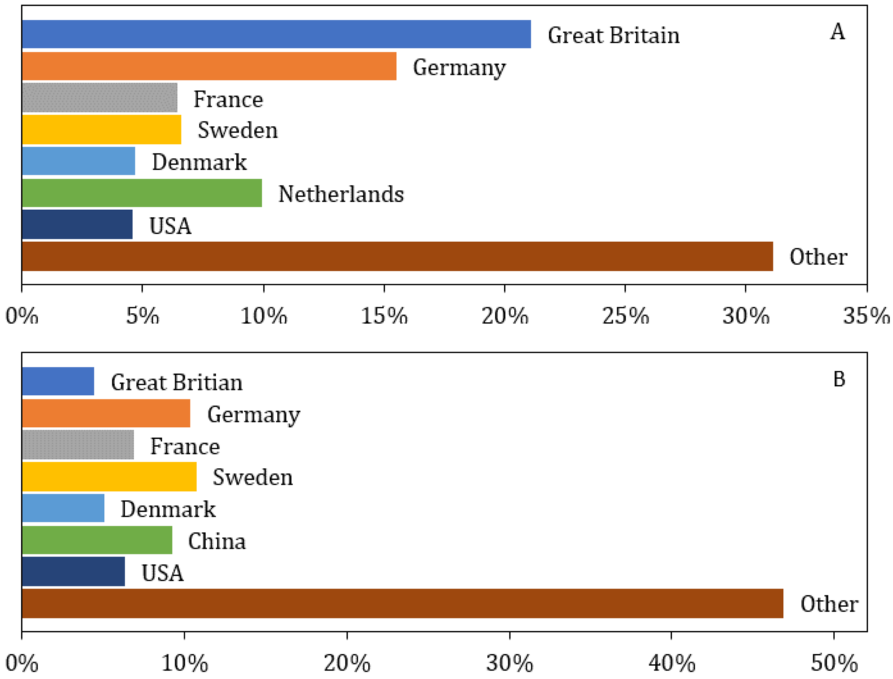

Figure 15: *Chart A: Exports by countries; Chart B: Imports by countries*[12] *(SSB, 2018b)*

Due to the large export of petroleum products, Norway has been running a trade surplus over the last couple of decades. The EU is the most important importer, as roughly 80 percent of total exports are directed at this market. Within this market, as shown in figure 15, 21 percent of total exports is to Great Britain, making this the most important country for Norwegian exports. With the upcoming Brexit[13] in March 2019, maintaining and creating new trade agreements with Great Britain will be an important subject for the Norwegian government. Lastly, if we consider both imports and export, Germany is *overall* the most important trade partner, as 10 percent of total imports and 16 percent of total exports are with Germany.

[12]The numbers used for the illustration can be found in Appendix M

[13]Abbreviation for Great Britain's exit from the European Union

2.3.1 Economic History

Historically, Norway has been considered a relatively small and poor country. Initially, few believed that there were any significant petroleum resources in the North Sea. However, when natural gas was discovered outside of Groningen in the Netherlands, the sentiment was changed (Regjeringen, 2009). In 1962, Philips Petroleum tried to get exclusive rights to search for oil and gas, but the government declined their request as one single private company should not claim complete ownership over the continental shelf. Thus, in the following year, the government proclaimed sovereignty over the Norwegian continental shelf. Hereafter, only the king in council could grant licenses to explore, drill and produce oil and gas.

Two years later, Norway, Denmark, and Great Britain agreed to divide the continental shelf based on the *median line principle*[14]. During the same year, the very first license to drill and explore was approved. After drilling for three consecutive years, oil was finally struck on December 23rd, 1969. In hindsight, the discovery of oil at *Ekofisk*[15] stands as the most significant shift for the Norwegian economy. In the years to follow, large international oil companies were awarded contracts and licenses to further explore and produce on the continental shelf. In order to be part of the growing industry, one of Norway's largest companies, Norsk Hydro, expanded their business to include a department solely dedicated towards petroleum. Moreover, the company Statoil was created by the Norwegian government during the same year (ibid.).

The Norwegian government has ever since 1969 maintained full control over its discovered oil resources, which have allowed them to charge high taxes on revenues from the petroleum sector[16]. In the years after Ekofisk, many new oil fields have been discovered and sat into production, which ultimately has increased the petroleum revenues of the government. The aftermath of the increased national wealth allowed the government to

[14] Approach to divide at the mid-point between two places. Often used when nations agree upon borders
[15] Name given to the first oil field where oil was discovered in 1969
[16] 78 percent: 24 percent base tax and 54 percent special tax

improve much of Norway's social system, such as better worker rights, universal health-care systems, and free education. However, the vast spending by the government caused an economic contraction in the late 70s.

During the 1980s, the loan restrictions of Norwegian banks were relaxed, which quickly fueled growth in private consumption, and allowed the Norwegian economy to boom (Norgeshistorie, 2018). However, when the oil price fell in 1986, oil revenues diminished and the government was required to cut back on its expenditures. The combination of a low oil price, a public austerity policy, and significant consumer debt, led to one of the deepest economic crises Norway has experienced. Since the pre-crisis boom was mainly caused by expectations of substantial revenues from the petroleum sector, we were able to observe Norway's reliance on oil revenues after the fall in 1986.

In 1990, the Norwegian parliament decided to create a pension fund[17] which would retain earnings from the petroleum sector. The first transfer was completed six years later. After an immense growth after the millennium change, the pension fund is today the largest sovereign wealth fund in the world (CIA, 2018b). As reflected during the 2008 financial crisis, the fund put Norway in a unique economic position. Research shows that the Norwegian economy barely showed signs of a recession, with the unemployment rate as most evident. In the EU, unemployment rose with 2.6 percentage points, whereas unemployment rose only with 1.1 percentage points in Norway from 2008 to 2010 (Eurostat, 2017).

Followed by the oil price collapse in 2014, the unemployment rate in Norway rose by 1.1 percentage points to 4.5 percent, which is the highest level since the early 90s (SSB, 2017d). Employment in Norway was therefore more affected by the oil price crisis than the financial crisis in 2008. This again reflects how sensitive Norway can be to changes in the oil price. Investments in the petroleum sector fell by 27 percent from 2014 to 2016 (SSB, 2018c). Since the majority of the oil sector is located in the western part of

[17] In Norwegian: Statens Pensjonsfond Utland.

Norway, this region was the most affected by the fall in investments. With time, the crisis had a ripple effect that slowed down the economy, and led to an annual GDP growth of only one percent in 2016 (The World Bank, 2017). However, the lower oil price, rising unemployment, and low inflation caused a depreciation of the Norwegian krone against major currencies. Consequently, as Norwegian products became cheaper for foreigners, the exports of other products, such as metals and fish, began to increase. The increase in net exports dampened the impact from the oil price shock, and reduced the need for government interventions.

2.3.2 Current Situation

From June 2014 to January 2016, the oil price fell from $114 to $30 per barrel. During this period, the Norwegian government issued rescue packages to affected regions, notably the west coast, to boost demand and avoid a long-term recession. Today, the Norwegian economy is recovering from the economic downturn. The focus over the last couple of years, however, has not only been towards the low oil price, but also the booming housing market. Over a twelve-month period, starting in February 2016, the housing prices in the Oslo-region grew by a massive 24 percent (E24, 2017). This led analysts and expert to fear that the Oslo market was facing a housing bubble, which could send the Norwegian economy into a severe recession.

This fear was mostly based on the fact that roughly 77 percent of households in Norway own their house (SSB, 2017a). As most of their wealth is tied to their house, should the housing market burst private consumption and the Norwegian economy could then enter into a negative spiral. In order to slow down the housing market, the government required banks to put restrictions on issuing new debt to their customers (Regjeringen, 2016). The effects of these restrictions began to emerge later in 2016, which eventually resulted in declining housing prices. The twelve-month national growth rate was -2.1 percent in December 2017, and -6.2 percent in Oslo specifically (Eiendom Norge, 2017).

After a lower economic growth for the mainland in 2016, the economy began to recover in 2017 with lower unemployment and higher employment.[18] During 2017, the unemployment rate further decreased in all parts of Norway, where the gross unemployment rate was at 3.1 percent in November 2017 (Norges Bank, 2017). Most industries have also increased their employment, and the oil industry seems to be concluding its downsizing caused by the oil price shock in 2014. Nevertheless, there is still spare capacity in the economy, which makes future growth possible. Growth was 1.9 percent in 2017, and the central bank estimates the growth to increase by 40 basis points in 2018, but thereafter begin to slow down from the beginning of 2019.

Fueled by the increase in employment and growth in real wages, consumption growth increased from 1.6 percent in 2016 to 2.4 percent in 2017 (ibid.). However, the central bank expects the weak development in the housing market to dampen the growth somewhat in the coming years. Investments in the housing markets have been the primary driver for the economy the last couple of years. However, it is expected that the investment level will decrease going forward, before eventually becoming flat within 2020. On the other side, the central bank expects the growth in business investments and mainland exports to continue to grow, which would reduce the impact of reduced housing investments.

During the last quarter of 2017, the Norwegian krone experienced an unusual development. Even though the oil price increased to its highest level since May 2015, the Norwegian krone *depreciated* against the dollar, euro, and pound. As the interest rate difference remained, for the most part, unchanged, this might indicate there has occurred an increase in the risk premium for the krone. This increase can at least partly be explained by the aforementioned fear of a collapse in the housing market. Nevertheless, in the next couple of months, the central bank expects this risk premium to decline, and we should thus expect an appreciation of the Norwegian krone (ibid.).

[18] Lower unemployment rates combined with higher employment rates is a sign that the lower unemployment rate is caused by more people getting a job, and not by people that stop looking for a job.

2.3.3 The Monetary Policy

The Norwegian central bank (Norges Bank) was established in 1816 and is the Norwegian government's executive body and advisor in the monetary policy. They have the responsibility to issue money, facilitate currency transfers, and monitor the money-, credit- and currency market. According to the central bank regulation of 2001, it is the central bank's role to promote a monetary policy which ensures long-term stability in the value of the krone (Lovdata, 2018). Further, the monetary policy should support the financial policies in terms of stabilizing the employment- and production level (Regjeringen, 2014).

In 2001, an explicit inflation target was introduced through a *white paper*[19] to the parliament. It stated that the central bank should aim at a low, but stable inflation rate. The target is today defined as a two percent[20] increase in the CPI, and should not deviate by more than one percentage point in either direction. Additionally, the monetary policy should be forward-looking, and not take into consideration temporary fluctuations that do not affect the underlying growth in CPI.

In order to make the decision-making process and monetary policy decisions as transparent as possible, the central bank publishes annual and quarterly monetary policy reports. These discuss various issues regarding the Norwegian economy and appraisals of the monetary policy. Its purpose is to avoid unanticipated shocks to the economy, as the market might act irrationally to changes in the monetary policy. In the decision-making process of the central bank, both the variability in inflation and output should be taken into consideration, allowing the inflation target to be flexible (Norges Bank, 2018).

The most important monetary policy task of the central bank is to manage the key policy rate, which is the interest rate banks in Norway are given when depositing money at the central bank. This rate directly affects the short-term money market interest rate and

[19] A white paper is a government paper used to present government policies

[20] The inflation target was changed from 2.5 percent 02.03.2018 (Regjeringen, 2018a). However, there are uncertainties whether this will remain as the new target

is, along with the expectation for the development of the key policy rate, an important determinant of bank's interest rates and bond yields. Because of its importance, the central bank publishes forecasts for the future interest rate path in a fan-chart.[21] Besides being transparent in its decision-making process, the central bank publishes the fan-chart because of the lag in the monetary policy. Since changes in the key policy rate occur gradually, the forecast path becomes an important signaling tool in the monetary policy. With respect to the inflation rate, when the central bank sets the key policy rate, they set a level which will keep the inflation close to the target so to allow for flexibility (ibid.).

As mentioned in section 2.1.1, one of the tasks of the central bank is to intervene in the FX-market. The central bank will buy or sell currencies if it believes the NOK-exchange rate deviates more than what was estimated from underlying fundamentals. They might also intervene should the current exchange rate affect the central bank to reach its inflation target, or if there are liquidity issues in the market. However, interventions are rare and occurred last time in January 1999.

2.3.4 The Government Pension Fund

To meet the expected rise in government obligations in the coming years, and to manage the petroleum revenues in the long-run, the Norwegian government pension fund was established in 1990. The pension fund consists of two parts: the Government Pension Fund Global (GPFG) and the Government Pension Fund Norway (GPFN). The GPFG is the largest of the two with a market value of 8.5 billion NOK (NBIM, 2018a), whereas the market value of the GPFN was 240 billion NOK, as of December 2017 (Folketrygdfondet, 2017). We will hereafter solely direct our focus towards the GPFG.

The inflows of cash to the GPFG are state revenues claimed from taxes in the petroleum sector and accumulated interest on current holdings. Cash outflows are mainly transfers to the state which covers the non-oil deficit[22] on the fiscal budget (SNL, 2017). Norges

[21] Similar to the *River of Blood* fan chart published by the Bank of England (The Telegraph, 2014).

[22] This is the deficit of the Norwegian state budget, excluding revenues from the oil sector, adjusted for the underlying effects of the economic activity level

Bank Investment Management (NBIM) manages the GPFG on behalf of the Norwegian government. The investment-mandate is given by the ministry of finance, which is responsible for the management of the fund (Regjeringen, 2018b). The goal of the fund is to have diversified investments that yield the highest possible return, subject to the constraints given in the guidelines by the ministry. Based on practical experience and analysis, the investment strategies of NBIM has evolved over time. However, should there occur any significant change to the current investment strategies, the change would need to be approved by the parliament (NBIM, 2017a).

The investment guidelines both determine in which markets the fund can invest and how the investments should be allocated between equities, fixed income and unlisted real estate. The strategy follows an accumulated benchmark index that is based on reference-indices from both the FTSE Group and Bloomberg Barclays. Currently, the equity share of the *benchmark* index is 62.5 percent, but the ministry of finance has decided to gradually increase the benchmark to 70 percent. Fixed income and unlisted real estate make up the remaining 37.5 percent, where unlisted real estate is capped at 7 percent (ibid.).

Due to market movements, the actual benchmark index might deviate from the strategic benchmark index. This deviation, however, should not exceed the expected relative volatility of 1.25 percentage point, as this is the maximum allowed volatility of the benchmark index. There would be a deviation, should the equity share in the actual benchmark index significantly overshoot, or undershoot, the allocation in the strategic benchmark index. To manage the risk, asset allocations in the actual benchmark index will be rebalanced continuously. Even though NBIM is required to follow the guidelines, they can under certain circumstances allocate their assets differently than the benchmark index, so to exploit the characteristics of the fund (ibid.).

Today, the allocation of investments in the fund are 66.6 percent equities, 30.8 percent fixed income and 2.6 percent unlisted real estate (NBIM, 2018a). The investment return of the GPFG in 2017 was 13.7 percent, in which the return on equity was 19.4 percent;

the return on fixed income was 3.3 percent and; the return on unlisted real estate was 7.5 percent. In order to diversify their portfolio and expose the fund to economic growth, investments in the pension fund are allocated across most markets and currencies in the world.

As a consequence of being the largest sovereign wealth fund in the world, the GPFG needs to take into consideration the ethical obligations that follow. The fund has three focus areas when investing in a company: children's rights; climate change and; water management. In order to put these areas in focus, NBIM reviews and measures all companies they invest in. If the risks regarding the environment, corporate governance or social issues are deemed too high, they can act in two different ways. They can either liquidate their assets in full or put pressure on the firm to change their current situation. The latter is often done should the investment in the company be too significant. It is also often the better option than disinvesting, should the costs associated with the intervention be lower than the expected future returns (NBIM, 2017b).

Together with the aforementioned ethical guidelines, for NBIM to include companies in their portfolio, certain criterion are required to be met. Should a company fail to fulfill these requirements, it will either be excluded in total or put under observation. The criterion for being placed under observation, or on the exclusion list, is often linked to the products the company, or their affiliates, produce. For instance, a weapon manufacturer that violates any fundamental humanitarian principle is directly put on the list. A company can also be excluded should it be deemed that the risk of any unethical behavior is too high. The decision-maker of the exclusion list is the central bank's executive board, which follows recommendations and guidelines set by the council of ethics in the ministry of finance (NBIM, 2018b).

2.3.5 The Budgetary Rule

The budgetary rule constrains the use of the capital in the GPFG to ensure that the fund will benefit future generations (Regjeringen, 2017). The rule first came into place in 2001 by the Norwegian parliament and is based on various principles. For instance, the use of the fund should focus on smoothing the fluctuations in the economy and ensure capacity utilization and low unemployment. Also, the use of petroleum reserves should follow the expected real rate of return from the GPFG over time, which today is set at three percent.[23]

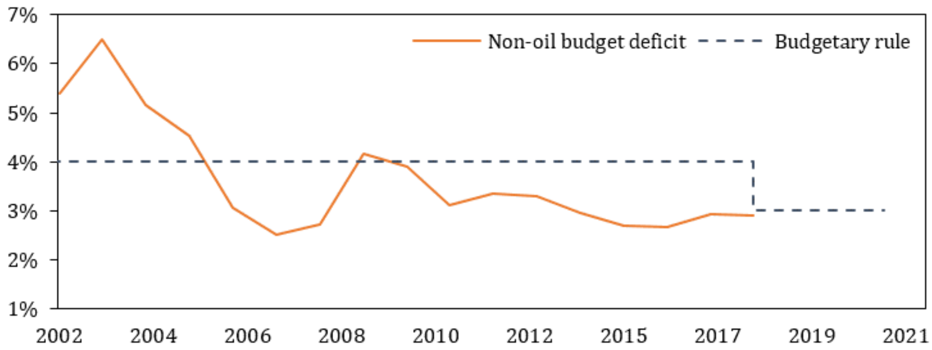

Figure 16: *The Budgetary Rule and GPFG.*[24]

The budgetary rule states that the use of oil revenues should in the *long-run* equal three percent, implying that the fund is a countercyclical mechanism in the economy. During recessions, the use of the fund can be above three percent, while during booms it should be below. Thus, enforcing the real rate of return will ensure that the capital in the fund does not decrease over time (ibid.). As shown in figure 16, the non-oil budget deficit, which measures the use of funds from the GPFG, has been below the budgetary rule since 2014, regardless of the economic downturn caused by the oil price crisis.

The budgetary rule is supposed to facilitate a stable development of the Norwegian economy, which is mainly achieved through various policies and economic mechanisms. Because the use of capital from the GPFG is based on the value at the beginning of the

[23]The expected real rate of return was changed from 4 to 3 percent in 2017.

[24]Calculations based on Non-oil budget deficit (National Budget, 2018) and market value of the GPFG (NBIM, 2018a)

year, the budgetary rule avoids exposing the budget to significant fluctuations in the oil price, or the value of the fund.

The rule is also formed in such a way that the *automatic stabilizers* in the economy are efficient, as using more or less than three percent of the fund can stabilize output and employment. The fact that revenues are invested globally, and not in Norway, stabilizes the Norwegian krone. Since revenues from the petroleum sector are denoted in US dollars and converted to kroner, an increase in oil revenues would increase the demand for Norwegian kroner, and consequently, cause an appreciation. Thus, holding the revenues in foreign currencies reduces potential fluctuations in the krone from changes in the oil price (ibid.).

2.3.6 Norway and the Dutch Disease

The Dutch Disease refers to the income shock a country will experience from finding non-renewable resources, or from sudden price changes of current natural resources. For instance, a positive price shock will cause an appreciation of the real exchange rate, factor reallocation and de-industrialization (Magud and Sosa, 2010). Since the supply of labor and capital remains relatively constant in the short-run, an increase in demand for both labor and capital will make the price for both increase. Whether the Dutch Disease is harmful to the economy is a widely discussed topic. Some fear the concept because an appreciation of the real exchange rate is thought to hamper economic growth. Others, however, are more critical and believe the instability of the real exchange rate in itself is the reason for economic downturns (Cordon and Neary, 1984).

In order to reduce the risk of the Dutch Disease, a country can use different types of policies. The paper by Magud and Sosa (2010) states that the main objective of policymakers is to maximize the positive effects of the income shock while reducing the negative effects of the export-sector and subsequently long-term economic growth. Norway is a country who successfully implemented different policies to cope with the adverse effects of the Dutch Disease.

First, through a centralized wage formation system, where the export industry is set as the wage leader, wage increases have been limited, which has reduced the loss in trade competitiveness. The paper also points out that the formation of the GPFG has helped to reduce the pressure on the Norwegian krone. By holding the majority of oil revenues in foreign currencies, and subsequently investing them in foreign markets, has allowed the surplus of the CA to increase at a slower pace, which has kept the BP relatively stable. Additionally, the budgetary rule, social norms, transparent democracy, and effective juridical systems have contributed to reducing the adverse effects of the Dutch Disease.

Nevertheless, the Norwegian economy has experienced some of the adverse effects of the Dutch Disease during recent years. IMF points out that Norway has become more dependent on the oil sector as most of the productive parts of the mainland economy are closely tied to the petroleum sector (IMF, 2013). They state that the recent surge of fiscal stimulus has been necessary to ensure a steady growth in the non-oil sector. However, to reduce the effects of the Dutch Disease in the future, the fiscal spending should be decreased as the growth approaches its trend. As the population is aging, the reduction in the budgetary rule from four to three percent was a necessity to meet the future challenges in the economy (IMF, 2017a).

3 Literature Review

Our purpose in this section is to introduce to the reader different methodologies that can be implemented when investigating the dynamics of the Norwegian krone. The papers presented below are the ones we found most relevant to the topic of this thesis and will be used as the foundation for many of the variables and economic reasonings shown in the empirical analysis. These will also allow us to cross-compare our findings later on.

3.1 The Oil Price

Literature about the relationship between the oil price and exchange rates dates back several decades. One of the first theoretical studies was done by Krugman (1980), who derived a model that explained the relationship between changes in the oil price and the exchange rate of oil-exporting countries. His findings indicated that, theoretically, an increase in the oil price should cause oil-exporting currencies to appreciate. The research in this field has in modern years been extensive, and the consensus seems to be that there is a clear relationship between the oil price and exchange rates.

Recent empirical research regarding the relationship between the oil price and exchange rates supports Krugman's theory, as several papers yield robust and significant relationships. Chen and Chen (2007) use in their paper a monthly dataset from 1972 to 2005 in which they find the real oil price to be one of the most important determinants for movements in real exchange rates. They reveal a co-integrated relationship between the real oil price and real exchange rates, a relationship also found by Amano and Van Norden (1998). The link seems to hold for other commodities as well.

Chen and Rogoff (2003) find that the Australian dollar and New Zealand dollar are closely connected to the world price of commodities the respective countries are exporting. They also find a long-term co-integrated relationship between the commodity price of the most important Canadian export and the Canadian dollar. However, the relationship is weak and does not hold in the short-term.

Another line of research investigates whether changes in the USD affects the oil price and other commodity prices. This is an important issue to consider when dealing with commodities denominated in USD, such as oil. As changes in the value of USD can potentially affect both the demand- and supply-side of the commodity market, it is an important driver of commodity prices. Blomberg and Harris (1995) found that the US dollar is an important determinant for changes in commodity prices. Their findings dictate that a depreciation of the USD increased the purchasing power of the US dollar in terms of other currencies, leading to an increase in the demand for oil. Both Akram (2008) and Zhang et al. (2008) reveal a similar relationship between the USD and the oil price. They point to the weak USD as an important factor behind the surge of the oil price at the beginning of the 21st century. Akram specifically emphasizes that the Law of One Price is important in order to explain the relationship, as the weak US dollar leads to the increased purchasing power of oil importers.

3.2 The Norwegian Krone

Based on previous research, the oil price, interest rates and inflation rates seem to be some of the most important determinants of the NOK-exchange rate. Various papers have used different approaches to model the dynamics of the Norwegian krone, and the results are somewhat varying with respect to which variables that have the most explanatory power. Nevertheless, all papers find the oil price to be the most important determinant. When investigating previous research papers, it is important to remember that the monetary policy has changed in Norway over the last 30 years. The most important change occurred in 2001 when Norway implemented the inflation target along with the budgetary rule for the use of the capital in the GPFG. Therefore, results from papers using the same approach on different sample periods might reveal different relationships.

Berhardsen and Roisland (2000) study both the long-term and short-run relationship between the Norwegian krone and the German mark, and the effective krone exchange rate. In the long-term, they find that the NOK-exchange rate depends on the oil price and price level differences between Norway and other countries. Changes in the oil price are still significant when analyzing the short-run relationship, but because of turbulence in international financial markets, changes in interest rate differentials now dictate a high explanatory power. They find that the impact of financial turbulence has become stronger after 1997, which indicates that the volatility in the financial market might have as much explanatory power as the oil price. Their theory is that some of this can be explained by the fact that the Norwegian krone has become an object for speculation.

As mentioned, the Norwegian monetary policy changed in 2001 after the introduction of inflation targeting. In their paper from 2007, Bjørnstad and Jansen study how this change has influenced the underlying factors of the NOK-exchange rate. Their findings conclude that the underlying factors of the krone-euro relationship were the most affected by the change in monetary policy. They also find that simultaneous changes in the CPI does not affect the long-term nominal exchange rate, but find that it has a minimal short-run impact. The only exception was when the shock increased the core inflation, which increased the interest rates and appreciated the Norwegian krone. This effect would, however, disappear after only two quarters. Additionally, it was found that interest rate differentials had a significant impact on the exchange rate. For instance, a one percentage point decrease in the interest rate differential increased the exchange rate by 1.9 percentage points in the long-run. Lastly, the oil price was found to be an important determinant for the Norwegian krone, as a one percent permanent decrease in the oil price caused a depreciation of the krone by 50 basis points in the long-run.

Several papers have also looked into potential nonlinearities in the relationship between the Norwegian krone and the oil price. Akram (2004) was the first to do this type of research, where he tries to explain the large fluctuations in the Norwegian exchange rate by applying nonlinearities to the effect of the oil price on monthly observations from 1971 to 1997. He hypothesizes that a central bank, which tries to stabilize the exchange rate, will not make changes to the interest rate as long as the shock is within a range of $14 to $20 pb. Shocks outside this range might imply particularly high- or low-interest rates that could potentially destabilize the economy. This would make the gains from letting the exchange rate float be higher than the benefits from stabilizing. Hence, in cases with high or low oil prices, Norges Bank might abandon the commitment to a stable NOK-exchange rate.

The relationship between the oil price and the Norwegian krone is thus expected to be particularly high in cases when the oil price is outside its ‘normal’ range. Akram further assumes that the cost of resisting a depreciation is higher than resisting an appreciation, implying that we mostly observe this type of relationship when the oil price is low. In conclusion, Akram finds a strong nonlinear relationship between the trade-weighted NOK-exchange rate and the oil price. Specifically, the oil price is found to have the strongest impact when it is below \$14 pb, and when the price is on a downward price path.

Similar research to Akram has been done in a Norges Bank staff-memo by Ellen (2016), who investigate the nonlinear relationship between the effective nominal NOK-exchange rate (I44) and the oil price on a monthly dataset from 2001 to 2015. The results from the analysis show that both changes in the oil price and changes in the interest rate differential are statistically significant at a one percent level, with the expected signs. She finds the most important oil price threshold to be \$75 pb, which is about five times larger than the threshold found by Akram. This is mainly because Ellen and Akram use different sample periods. However, testing whether the impact of changes in the oil price is stronger when falling below a certain threshold, yield similar significant results. Another distinction between Akram and Ellen is that Ellen applies an inflation target regime instead of a regime aimed at stabilizing the exchange rate.

Additionally, Ellen states in her paper that there is a nonlinear relationship between the I44 and the oil price, as there are periods in which the relationship is strong and other periods where the relationship is nonexistent. First, she is looking into potential asymmetric- and magnitude effects. As for the asymmetric effect, she finds no evidence of such an effect. However, she does find some weak evidence for magnitude effect, which indicate that large changes in the oil price are associated with a larger impact on the

NOK-exchange rate than smaller changes in the oil price. During the sample period, she finds that the threshold of $75 pb changes with time, stating that the GPFG might be the main reason. When there occurs a small drop in the oil price, the fund might be able to smooth out the economic impact. However, when the oil price drops below a certain threshold level, the fall will have a greater impact on the economy.

4 Empirical Analysis

4.1 Introduction

We have so far shown the reader basic concepts of exchange rates, the dynamics of the oil market, the Norwegian economy, and previous relevant literature. The consensus should at this point be that the aggregated dynamics are complex and that the exchange rate can be determined in multiple ways. However, our focus throughout this thesis has been to introduce the concepts we find most relevant – namely the oil price, interest rate differentials, and price level differentials. As we presented in section 3, previous research strengthen this hypothesis with significant evidence that the latter three independent variables have explanatory power over the exchange rate.

Before we introduce our dataset and discuss its reliability and characteristics, we will briefly present some of the basic, but important, OLS assumptions which need to be fulfilled for our analysis. Afterward, we will build our empirical model by augmenting previously discussed theory, reviewed literature, and empirical concepts, such as the Dickey-Fuller and Engle-Granger Co-integration tests.

4.1.1 Assumptions for OLS Time-Series Regressions

In this thesis, we will run time-series regressions based on the concept of Ordinary Least Squares (OLS), which minimizes the square errors of a regression output to best-fit a dataset. For our OLS to be the Best Linear Unbiased Estimator (BLUE), several assumptions need to be fulfilled. We will present the most relevant for this thesis, namely no perfect multicollinearity; zero-conditional mean; homoscedasticity and; autocorrelation. Afterward, we introduce to the reader the concept of stationary in time-series regressions.

First, when two or more independent variables are correlated, we say the regression exhibits *multicollinearity*; the variables move in either the same direction (positive correlation) or opposition direction (negative correlation). *Perfect* multicollinearity is the case when two independent variables are a perfect linear function of one another (Wooldrigdge, 2013). In this case, the coefficients cannot be estimated using OLS, as the variables are impossible to distinguish. OLS can still estimate the independent variables should the correlation be *close* to perfect, but when the variables are highly correlated, we might experience inflated standard errors and biased estimates. The easiest fix to reduce the issues caused by (perfect) multicollinearity is to reduce the number of highly correlated independent variables in the regression model.

Second, the *zero-conditional mean* assumption states that the expected value of the error term v_t, given the independent variables, is zero for all times (ibid.). Intuitively, this implies that the independent variables have to be uncorrelated with the error term in every time-period, and must be strictly exogenous. This also implies that past and future values of the independent variables are uncorrelated with v_t.

Third, the *homoscedasticity* assumption is satisfied when the variance of the error term is constant over the sample period, conditional on the independent variables. If the variance of the error term changes with time, the homoscedasticity assumption is violated, and the errors are said to be heteroscedastic (ibid.). In this case, the standard errors will be biased, and OLS is no longer be BLUE. Thus, we can no longer rely on standard t-tests and F-tests. Considering we are dealing with macroeconomic data in this thesis, there is a high probability that the error terms in our regressions will exhibit heteroscedastic tendencies. To address this issue, we will apply the Heteroscedastic and Autocorrelation Consistent (HAC) standard errors, as presented by Newey and West in 1987.

Forth, *autocorrelation* is found in datasets where the ordering of the data has a particular meaning. This is specifically evident in time-series data, as error terms of chronological observations are often correlated with each other (Studenmund, 2014). Intuitively, if the error term is positive in one period, and the error term for the same variance is on average positive, then the error term in the next period will on average be positive.

We observe autocorrelation in most economic time-series, and because this causes the OLS to no longer be BLUE, it is important to address this issue. The most applied method to test for autocorrelation is the Durbin-Watson test (DW-test), which yields a value between 0 and 4, where 2 implies no autocorrelation and 0 or 4 implies positive or negative autocorrelation, respectively. In our regression outputs in the upcoming sections, we will present the DW-test for each regression. Autocorrelation itself does not bias the OLS coefficients, but rather bias the standard errors, which makes the t-test and F-test unreliable. To control for autocorrelation, we apply Newey-West HAC standard errors as presented above.

Let us next explain the concept of *stationarity* by introducing a simple example. It is known that the real GDP per capita of a country tends to increase with time. This implies that the mean and variance of a country's real GDP per capita will change over time. A time-series with such properties is said to be nonstationary and would possess a random stochastic trend, also known as a 'random walk with drift' (Granger and Swanson, 1997). Because this also applies to the error term of the variable, an independent variable with heteroscedastic standard errors is also said to be nonstationary.

By not addressing the issue of nonstationarity, we can experience spurious regressions and biased t-statistics that do not follow the standard t- and F-distribution. This is mainly caused by the estimation method by OLS, which attributes to nonstationary changes in y_t to x_t that are actually caused by a factor, such as time-trend, that affects both y_t and x_t. In other words, the two variables move together, but this is caused by nonstationarity in the time-series and not by any causal relationship between them. In order to determine if the variables are nonstationary, the Augmented Dickey-Fuller test is applied, which we will introduce in section 4.2.1.

4.1.2 Data Collection, Reliability and Description

The data used in this thesis is time-series data from a sample of four currencies – the Norwegian krone (NOK), euro (EUR), British pound (GBP) and US dollar (USD) – over the time-period 01.04.2001 to 31.12.2017. We begin the dataset from April 2001, as Norway implemented the inflation target in their monetary policy in March 2001. Including data before this time might bias our estimates, as the monetary policy and the intensity of government interventions by the central bank might differ. When analyzing exchange rates against volatile variables, such as crude oil, one would assume that the relationship is not constant over a given period. In figure 17, we illustrate how the 12-month correlation between the NOK-exchange rates and the oil price has evolved over our sample period.

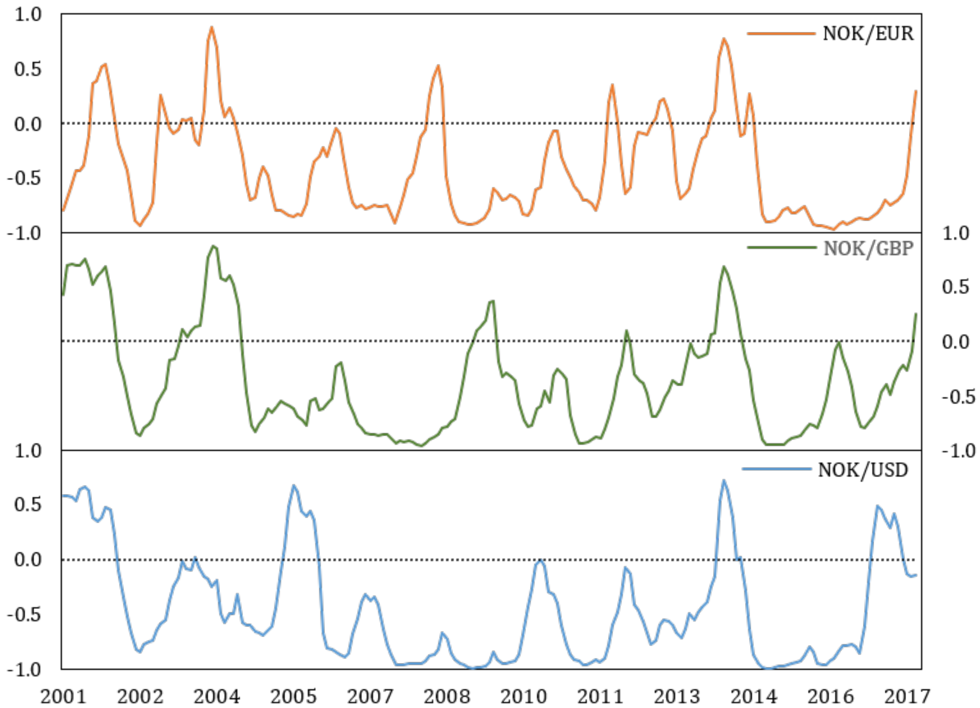

Figure 17: *Rolling 12-Month Correlation between the oil price and exchange rates*

Particularly during the period from 2002 to 2004, and from 2013 to 2014, we find that all exchange rates portray similar patterns. However, we observe that the repercussion of the financial crisis in 2008 seems to differ between the currencies. Therefore, investigating the impact of the oil price during certain historical events is of great interest. For this thesis, we will split our dataset such that we analyze both the financial crisis and the oil price crisis, as both were seen as two major historical events that came as a shock to the market. This will be further discussed in section 4.3.3.

Thus, the almost sixteen year-long regression will hereafter be based on both monthly and weekly observations. For the monthly dataset, we collect a total of 201 observations, whereas for the weekly dataset we collect a total of 874 observations. The latter allows us to obtain enough observations to perform reliable subsample regressions for the financial- and oil price crisis. The monthly observations are monthly averages of daily observations, and the weekly observations are spot observations.

Our focus when collecting data has been towards reliability and comparability. Our data is collected from Federal Reserve Economic Data (FRED), Norges Bank and Thomas Reuters DataStream (Reuters). FRED is an online database containing economic data, collected from multiple independent external sources. All data collected from FRED are originally from OECD's database. Norges Bank offers general statistics, such as inflation rates, key policy rates, monetary policies and exchange rates. Thomson Reuters DataStream is a large macroeconomic database that collects much of their data from global institutions, such as the European Banking Federation. All three databases are considered reliable providers of macroeconomic data, so we feel content with using these in our thesis. Lastly, in some cases when neither FRED nor Norges Bank offer weekly observations for our variables, we have used data from Reuters.

Concerning the reliability of the independent variables, Hobdari (2012) introduces in his book about statistical analysis multiple tests one can perform to check whether certain independent variables can be included in the same regression. One of the simplest methodologies is the correlation matrix. This is performed by analyzing the correlation between all independent variables, and see whether the correlation exceeds a predetermined exclusion threshold. This is done so to reduce the possibility of collinearity, which we introduced in section 4.1.1. Hobdari further suggests using a correlation threshold of +/- 0.8, which we will adapt in this thesis as well. In Appendix C, we present the correlation matrix, which indicates that none of our independent variables exhibit a correlation above (below) this threshold. Even though this does not exclude the possibility of collinearity, the results should ease our minds on the reliability of our data. Next, we present to the reader the statistics and descriptions for all included variables.

Brent Crude Oil

As mentioned in section 2.2, this thesis will solely focus on Brent crude oil, as this is globally perceived to be the better benchmark for global oil prices. In table 1, we have summarized the statistics from the weekly data collected from Reuters.[25] The price for oil is in US dollar.

Statistics	**N**	**Mean**	**St.Dev**	**Min**	**Max**
Brent Crude Oil	874	67.63	30.64	18.46	143.96

Table 1: *Descriptive Oil Price (Weekly data)*

Exchange Rates

This thesis will present an analysis of the Norwegian krone against the EUR, GBP and USD. In table 2, we present the descriptive statistics for all bilateral exchange rates used in the empirical analysis.

Statistics	**N**	**Mean**	**St.Dev**	**Min**	**Max**
NOK/EUR	874	8.24	0.59	7.24	9.90
NOK/GBP	874	10.89	1.29	8.50	13.29
NOK/USD	874	6.79	1.11	4.96	9.40
EUR/USD	874	0.82	0.12	0.63	1.18
GBP/USD	874	0.62	0.08	0.48	0.82

Table 2: *Descriptive Exchange Rates (Weekly data)*

The data in the two first rows of table 2 are collected from Norges Bank, whereas the data in the three last rows are collected from Reuters. All exchange rates are denoted

[25]Descriptive statistics for the monthly dataset can be found in Appendix E

as the number of domestic currencies per one unit of foreign currency. We include the euro, as the Eurozone is Norway's most important trading partner, as we introduced in section 2.3. Considering that the British pound is one of the most traded currencies in the world, and the importance of the British market to Norwegian exports, makes it central to include it in our analysis. Lastly, we include the US dollar not only because it is the most important currency in the world, but also because the price for a barrel of oil is denoted in dollars. Additionally, in some parts of the analyses, where we analyze the Norwegian krone against the euro and pound, we include the dollar-euro and dollar-pound bilateral exchange rate as control variables.

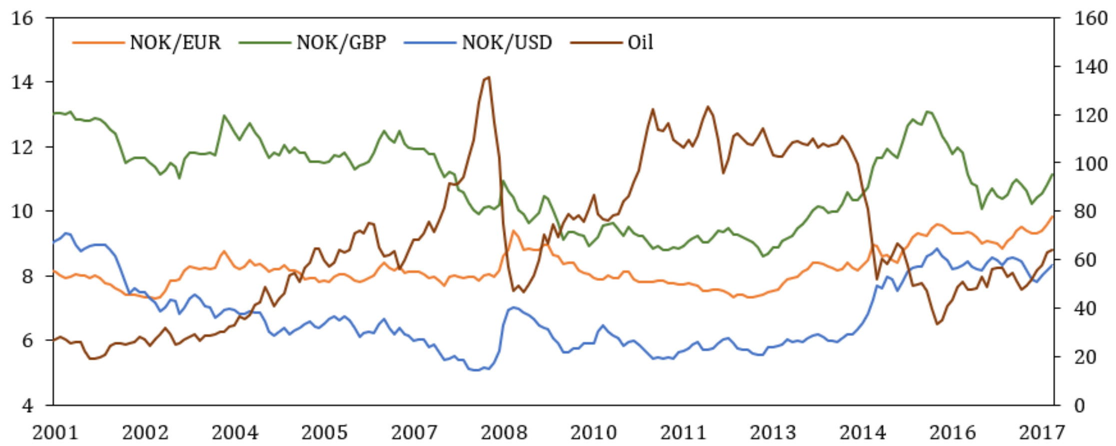

Figure 18: *The oil price (Reuters) and exchange rates (Norges Bank)*

In figure 18, we observe that the exchange rates follows the oil price with some divergences. During the period from 2001 to 2008, the Norwegian krone continuously appreciated against the US dollar and the British pound, which coincides the increasing oil price. The pattern is not as clear for the NOK/EUR-exchange rate, but we observe a moderate appreciation from 2004 to 2008. Further, during the financial crisis in 2008 we find that, while the oil price decreased the Norwegian krone depreciated against the euro, pound and dollar. The same pattern can also be observed during the oil price crisis in 2014. However, we notice that, during the last year or so, this relationship is no longer as apparent. An increase in the oil price has on average been associated with a depreciation of the Norwegian krone against the euro, pound and dollar.

Interest Rates

To see how changes in interest rates might affect the exchange rate, it is important to include a volatile interest rate. Thus, we have decided to use three-month interbank rates, as this is a more fluctuating interest rate than, for instance, the key policy rate. Additionally, as this thesis will focus more towards the short-term impact on the Norwegian krone, the three-month interbank interest rate serves as a better proxy than the 10-year government bond. We present the descriptive statistics in table 3.

Statistics	**N**	**Mean**	**St.Dev**	**Min**	**Max**
NIBOR	874	2.99	1.94	0.73	7.88
EURIBOR	874	1.72	1.62	-0.33	5.38
LIBOR(GBP)	874	2.59	2.14	0.28	6.90
LIBOR(USD)	874	1.71	1.69	0.22	5.70

Table 3: *Descriptive Interest Rates (Weekly data)*

For Norway, we have used the Norwegian Interbank Offered Rate (NIBOR); for the Eurozone, we have used the European Interbank Offered Rate (EURIBOR) and; for the United Kingdom and the United States, we have used the London Interbank Offered Rate (LIBOR), denoted in British pounds and US dollars respectively. The first two columns in table 3 are collected from Reuters, while the last two columns are collected from FRED. All should be appropriate proxies for the overall interest rate level in the respective countries.

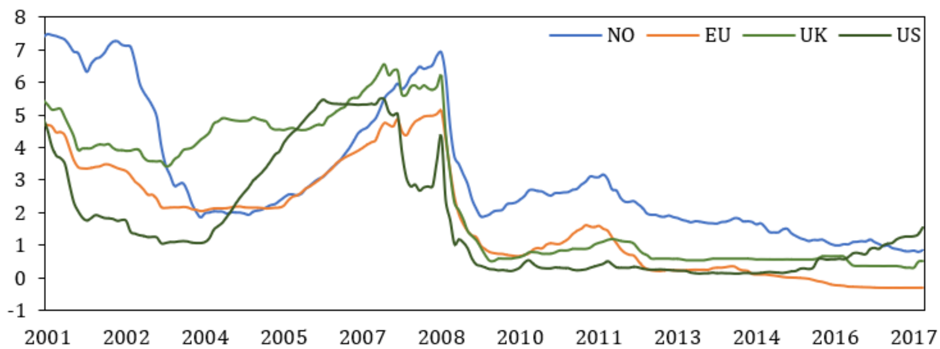

Figure 19: *Interest Rates (Reuters and FRED)*

We show the trend of all interest rates in figure 19. The interest rate differentials for Norway was at its largest during the 2001 to 2003 time period. However, the most important observation is the overall increase in the interest rate level for all countries in the years prior to the financial crisis of 2008, and the immediate drop that followed. Thereafter, until the beginning of 2017, the interest rate differentials for Norway has been positive, but falling at a steady pace. The interest rate level in the US has increased mostly because of their growing economy relative to its trading partners, and the level has decreased in the EU to below zero due to periods of low inflation.

Price Levels

In order to proxy for the price level of the included countries, we use a cross-comparable consumer price index (CPI), in which all countries follow the same base year (=2015). As opposite to the descriptive statistics given above, it is not possible to collect price levels on a weekly basis. Therefore, we can only present monthly observations in table 4. All CPI's are collected from FRED.

Statistics	**N**	**Mean**	**St.Dev**	**Min**	**Max**
Norway	201	97.90	9.17	83.94	115.21
Eurozone	201	98.21	8.30	83.25	110.08
United Kingdom	201	98.43	11.40	82.07	117.29
United States	201	98.14	9.87	81.03	113.19

Table 4: *Descriptive Price Levels (Monthly data)*

4.2 Building the Empirical Model

4.2.1 Augmented Dickey-Fuller Test

If a macroeconomic time-series, say the log of GDP of Norway, is such that its first difference is stationary, then the pure log time-series is said to have a unit root. In econometrics, we define such a time-series to be an $I(1)$ variable. The simple Augmented Dickey-Fuller test (ADF-test), examines the null hypothesis that the time-series have a unit root by following the first-lagged autoregressive model (Wooldrigdge, 2013):

$$\Delta y_t = \alpha + \delta t + \theta y_{t-1} + v_t \tag{4.1}$$

In this thesis, we restrain our scope by analyzing the stationarity of a variable with and without the deterministic trend (i.e. $\delta = 1$ or 0). A deterministic trend is a nonrandom function of time, and we will drop this term from equation (4.1) should it be insignificant during our testing. Since we expect our time-series to be stationary after taking the first log difference, we run equation (4.1) using the level-form of our variables. The first column in table 5 presents the t-statistics when the variables are in levels; the second column shows the t-statistics when the deterministic trend is dropped from equation (4.1) and; the third column presents the t-statistics when we take the first difference of the variable.

Variables	**Level Trend**	**Level Drift**	**ΔTrend**
$s_{nok/eur}$	-2.115	-	-9.883***
oil	-1.840	-1.945	-8.072***
$(i - i^*_{eur})$	-1.918	-1.992	-7.878***
$(p - p^*_{eur})$	-1.623	-	-10.999***
$q_{nok/eur}$	-2.832	-	-10.475***
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 5: *ADF-test (Monthly data)*

The alternative hypothesis of stationary states that $\theta < 0$, implying the ADF-test is a one-sided test. The critical values are somewhat larger than the standard OLS t-statistics, as these represent how regressors with a stochastic trend can have non-normal distributions.[26] In table 5, we present only an excerpt of the ADF-test, as all our variables become stationary when we take the first difference. The complete table can be found in Appendix B. Let us analyze if the interest rate differentials between Norway and the Eurozone at time t, has a stochastic trend. Running the test on the level-form of the variable, we find that the t-statistics is -1.918, which is less negative than the 10 percent critical value of -3.12. During the same testing, we see that the deterministic trend is insignificant. This would imply that we fail to reject that the interest rate differentials follows a deterministic trend.

Dropping the trend from the regression and retesting, yields a new t-statistics of -1.992. Thus, we fail to reject the null hypothesis that the interest rate differentials between Norway and the Eurozone have a unit-autoregressive root. Taking the first difference and retesting, yields a t-statistics of -7.878, which is more negative than the 1 percent critical value of -3.96. In other words, the variable has a stochastic trend and follows a $I(1)$ process. We can now reject the null hypothesis of a unit root, and use this first-differenced variable in our analysis forthcoming. In the next section, we introduce the concept of Engle-Granger Co-Integration Test as an augmentation to the ADF-test.

4.2.2 Engle-Granger Co-Integration Test

When time-series are nonstationary, a regression including the level form of $I(1)$ variables can yield a non-causal relationship, and give spurious results. Above, we suggested to solve this issue by taking the first difference of the $I(1)$ variable. However, when we use the first difference we might lose some information that limits what we can analyze; we can only say something about how Δx_t affects Δy_t, but nothing meaningful about the relationship of x_t and y_t in level terms. In order to solve this issue, Engle and Granger (1987) introduced the co-integration approach (Wooldrigdge, 2013).

The standard for $I(1)$ variables is that they tend to deviate as time goes to infinity, mostly because their unconditional variance is proportional to the time trend. Thus, it

[26]The critical values are given in Appendix F

might appear that $I(1)$ variables will not exert any short-term or long-term equilibrium relationship. However, it is possible for a particular combination of two $I(1)$ variables to be an $I(0)$ variable. Should this be the case, it is said that the two $I(1)$ variables are co-integrated, and should exert a long-term equilibrium relationship (ibid.). A more practical example is presented by Wooldridge, who illustrate the concept by using US treasury bills. He first fails to reject the null hypothesis that the three-month and six-month US treasury bills have unit roots. However, when he subtracts the three-month from the six-month bill, i.e. the time-spread, he rejects the null. In other words, even though the three-month and six-month treasury bills are independently $I(1)$ variables, the time-spread is said to be an $I(0)$ process, and the two treasury bills are co-integrated.

The time-spread co-integration example makes economic sense; should the time-spread between the two treasury bills become too large, investors would then prefer the three-month bill over the six-month bill and market forces would converge the time-spread back to its mean value. However, in cases with less economic reasoning, it is more difficult to test for co-integration. In those cases, we would be required to use OLS to estimate the regression:

$$y_t = \hat{\alpha} + \hat{\beta} x_t + \hat{\upsilon}_t. \tag{4.2}$$

In cases when y_t and x_t are co-integrated, the OLS regression is consistent and x_t has a causal effect on y_t. The first step in the two-stage Engle Granger Co-Integration test (EG-test) is thus to estimate the OLS-regression, and run an ADF-test on the residuals. We do this by rewriting equation (4.2) as:

$$\hat{\upsilon}_t = y_t - \hat{\alpha} - \hat{\beta} x_t. \tag{4.3}$$

The null hypothesis is that the error term, $\hat{\upsilon}_t$, is nonstationary, similar to the hypothesis presented in section 4.2.1. To conclude that two time-series are co-integrated, we would need to reject the null hypothesis of a unit root in the residuals (ibid.). As a difference from the standard ADF-test, the critical values when testing for a unit root in the residuals are different. We present these in Appendix F. By rejecting the null, we find evidence of the residuals being an $I(0)$ process, despite both variables being independently $I(1)$

processes. As mentioned, this would entail the two variables to exert a long-term equilibrium relationship. If we fail to reject the null, the two variables are not co-integrated, and we would be running a spurious regression.

From our dataset, we have let the log of exchange rates be y_t, and the log of oil price, interest rate differential and price level differential be x_t in equation (4.2). We do not run the EG-test with all explanatory variables simultaneously, as it makes economic sense that the oil price, interest rate and price level follow different trends. From our ADF-test results presented in table 5, we failed to reject the H_0 of a unit root for all our variables, and concluded that they follow an $I(1)$ process. In our first EG-test, as shown in table 6, we test for co-integration between exchange rates and the oil price.

Variables	$\boldsymbol{\alpha}$	$\boldsymbol{\beta}$	$\boldsymbol{t}$**-stat**
$\hat{v}_{eur}$	0.00	-0.02	-1.215
$\hat{v}_{gbp}$	0.00	-0.06	-2.681
$\hat{v}_{usd}$	0.00	-0.03	-1.630

Table 6: *EG-test: FX and Oil (Monthly data)*

We find no significant residuals between the two time-series, which implies that there is no long-term equilibrium relationship. This might seem puzzling as Norway is considered an oil-intensive exporting country. However, Mensah et al. (2017) also find little empirical evidence of a long-term relationship between the oil price and bilateral exchange rates in their study of co-integration between the US dollar and oil-dependent currencies. The only significant results were found for Russia and Nigeria, where oil accounted for 70 and 90 percent of total exports, respectively. Keeping in mind that Norway's oil exports only account for roughly 25 percent of total exports, it is not surprising that we find little evidence for a long-term equilibrium relationship.

In table 7, we run an EG-test for co-integration between exchange rates and the interest differential, and find similar results as the previous test. Considering the least negative critical value to reject the null hypothesis is -3.04, we find no long-term equilibrium relationship between the exchange rates and interest differentials. Thus, the EG-test shows that the concept of UIP might not hold in the long-term for our dataset. Considering we are using short-term interest rates, this is not surprising as previous research only finds weak evidence for the UIP when using long-term interest rates.

Variables	$\boldsymbol{\alpha}$	$\boldsymbol{\beta}$	$\boldsymbol{t}$**-stat**
$\hat{v}_{eur}$	0.00	-0.02	-1.193
$\hat{v}_{gbp}$	0.00	-0.03	-2.460
$\hat{v}_{usd}$	0.00	-0.02	-2.030

Table 7: *EG-test: FX and Interest Differentials (Monthly data)*

With respect to price levels, i.e. the absolute PPP, we see in table 8 that the t-statistics is somewhat more negative than previously, but still too positive for us to reject the null of no co-integration. Since we are testing the absolute PPP, Jore et al. (1993) state in their paper that empirical evidence for co-integration between bilateral exchange rates and price levels could be non-existent, should the sample period be too short. It could take several years, even longer than our sample period of 16 years, to restore deviations from the absolute PPP.

Variables	$\boldsymbol{\alpha}$	$\boldsymbol{\beta}$	$\boldsymbol{t}$**-stat**
$\hat{v}_{eur}$	0.00	-0.07	-2.875
$\hat{v}_{gbp}$	0.00	-0.04	-2.395
$\hat{v}_{usd}$	0.00	-0.07	-2.788

Table 8: *EG-test: FX and Price Levels (Monthly data)*

The second step in the two-step EG-test is to create an Error Correction Model, which allows us to study the short-run dynamics in the relationship between y_t and x_t. However, developing such a model should only be done if y_t and x_t are co-integrated. As we have seen, this is not the case for any of our variables. Thus, Wooldridge (2013) suggests that we can simply create a short-term dynamic model by taking the first difference of the $I(1)$ processes to make them stationary, and remove potential spurious results:

$$\Delta y_t = \alpha + \phi_1 \Delta y_{t-1} + \beta_1 \Delta x_t + \beta_2 \Delta x_{t-1} + v_t. \tag{4.4}$$

Here, we assume that v_t has a zero mean, given Δy_{t-1}, Δx_t, Δx_{t-1} and further lags. This is similar to the concepts introduced in section 4.2.1, where we found that all our variables became stationary after only taking the first difference. This implies that going forward, we will mostly focus on the *short-term* relationship between the exchange rates, oil price, interest differential and price differentials:

$$\Delta s_t = \alpha + \beta_1 \Delta \mathrm{oil}_t + \beta_2 \Delta (i - i^*)_t + \beta_3 \Delta (p - p^*)_t + v_t. \tag{4.5}$$

As we stated above, using the first difference might limit our ability to draw concrete conclusions for our variables in level terms. However, going forward with variables in the level-form will bias our estimates to such an extent that we cannot draw any conclusion at all. Therefore, we follow equation (4.5) and state that the change in the log exchange rate can be determined by the change in the log oil price; the change in interest rate differential and; the change in the logarithm of the price level differential. This equation represents the first step in building our baseline model for exchange rate determination.

4.2.3 Baseline Model

As we have introduced in previous sections, exchange rates can be determined by basic theoretical models. First, in the interest rate differential model, we dictated that the expected exchange rate is determined by the difference in the domestic and foreign interest rates, the idiosyncratic risk-premium, and a white-noise error term. For simplicity of testing, we assumed that the latter two equaled zero. We will, therefore, incorporate equation (2.9) in our baseline model. Second, in the inflation differential model, we stated that the exchange rate is a function of the product of the price level difference between two countries, and a constant cost parameter. Again, for simplicity of testing, we assumed that this cost equaled one.

As introduced in section 3, the two aforementioned theoretical models have been implemented in several research papers. Nevertheless, during empirical testing, there are several ways one can tweak these models to create various specifications. For this thesis, we found from our EG-test that we will include the concept of the relative PPP and a modified version of the interest rate parity model. With respect to the latter, we will also alter the definition of equation (4.5), so to coincide with previous research and economic intuition. For simplicity, we introduce the baseline model here.

$$\Delta s_t = \alpha + \beta_1 \Delta \mathrm{oil}_t + \beta_2 \Delta (i - i^*)_t + \beta_3 (i - i^*)_{t-1} + \beta_4 \Delta q_{t-1} + v_t. \tag{4.6}$$

Here, all variables are in logarithmic form, except for the interest rate differentials. The Δ refers to the first-difference from time $t-1$ to time t. Descriptive calculations are given in Appendix A. The *modified* version of the interest rate parity is the second beta coefficient in equation (4.6), as we here do not check the level change in interest difference. Thus, we include the third regressor in order to comply with the UIP and to control for whether the interest rate differential initially is large or small. However, we emphasize that we only include this as a control variable, as its coefficients could be spurious from the variable being nonstationary.

As we showed in section 2.1.6, $q_{t-1} = s_{t-1} + p^*_{t-1} - p_{t-1}$ and represents the real exchange rate. Including this as a control variable in our baseline model allows us, for the most part, to control for price level differences between two countries, but also see whether the lagged nominal exchange rate has a deterministic power over the current exchange rate.[27] This is backed up by papers written by Bernhardsen and Roisland (2000), Akram (2004) and Chen and Chen (2007), who all include the RER in their empirical analysis to study the impact on the exchange rate from changes in a country's competitiveness. Moreover, as we introduced in section 2.1.6, including the price level difference together with the nominal interest rate allows us to incorporate the effect of real interest rate changes.

Using lagged values for the change in price levels contradicts the relative PPP, as this states we should use contemporary variables in the regression model. However, if we were to include contemporary price levels, we would also need to include the contemporary nominal exchange rate in our calculations. Hence, if we do not lag the real exchange rate we would end up using the same variable as both a dependent- and independent variable.

[27] In the full ADF-test given in Appendix B, we show that the level-form of the real exchange rate is nonstationary for all exchange rates and we are required to take the first difference.

Additionally, we can reasonably assume that the lagged inflation rate differentials should signal the market on future expected price level differences, which would alter the demand and supply of currencies. Therefore, going forward we will assume that the exchange rate can be determined by the change in the oil price; the change in the interest rate differential; the lagged interest differentials and; the lagged change in the real exchange rate. In the next section, we will introduce to the reader our empirical results, as well as additional control variables included in our baseline model.

4.3 Findings

In order to determine the general relationship between the NOK-exchange rate and our independent variables, the first part of this section will focus on the three aforementioned exchange rates and the baseline model presented above. Afterward, we will include exchange rate effects (FX-effects) as a control variable into our model. Lastly, we will move away from our monthly dataset and rather work with weekly observations, where we will analyze the subsamples we specified in section 4.1.2.

4.3.1 Baseline Output

All output tables forthcoming indicate the number of observations, the adjusted R^2, and the DW-test presented in section 4.1.1. The adjusted R^2 shows how well our model fits the dataset, after adjusting for the number of independent variables included in the specification. The standard errors are calculated using Newey-West HAC standard errors and are presented in parentheses below the coefficients.

The empirical results from running the model with the NOK/EUR-exchange rate as the dependent variable are summarized in table 9. In column (1), we run the most basic specification with only the change in the oil price as the explanatory variable, i.e., setting $\beta_2 = \beta_3 = \beta_4 = 0$ in equation (4.6). From this, we find that a positive 1 percent change in the oil price is associated with a 0.082 percentage appreciation of the Norwegian krone against the euro.

Further, from our baseline model in column (4), we find that a 1 percent change in the oil price leads to a 0.083 percentage appreciation of the Norwegian krone. The coefficient is significant at the 1 percent level. Comparing with other papers, this relationship seems quite reasonable, as Ellen (2016) estimates that a 1 percent change in the oil price caused the Norwegian krone to appreciate by 0.066 percent against the I44.[28]

	Dependent variable:			
	ΔNOK/EUR			
	(1)	(2)	(3)	(4)
Δoil_t	-0.0822***	-0.0842***	-0.0850***	-0.0831***
	(0.0166)	(0.0139)	(0.0128)	(0.0144)
$\Delta(i - i^*)_t$		-0.0516***	-0.0520***	-0.0506***
		(0.0087)	(0.0095)	(0.0103)
$(i - i^*)_{t-1}$			-0.0006	-0.0006
			(0.0006)	(0.0006)
Δq_{t-1}				0.0387
				(0.0558)
Constant	0.0013	0.0009	0.0018	0.0017
	(0.0012)	(0.0009)	(0.0014)	(0.0013)
Observations	201	201	201	201
Adjusted R^2	0.162	0.349	0.347	0.345
Durbin-Watson	1.567	1.650	1.657	1.703
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 9: *Baseline Model NOK/EUR (Monthly data)*

The most important observation from table 9 is that the coefficient for changes in the oil price remains relatively stable and statistically significant at one percent, after including our control variables. This is also similar for changes in the interest rate differential. For instance, we observe in column (4) that a 1 percentage point change in the interest rate differentials, corresponds to a 5.06 percent change in the value of the Norwegian krone. In general, the findings from this regression indicate that the change in the oil price and changes in the interest rate differentials are two important determinants for the NOK/EUR-exchange rate.

[28]The trade-weighted Norwegian nominal effective exchange rate.

Lastly, the adjusted R^2 in the baseline model states that the included variables explain roughly 35 percent of the variability of the NOK/EUR-exchange rate, in which β_1 and β_2 account for the majority. The DW-statistics is increasing with the added regressors and comes close to 2 in the baseline model, implying that there are low levels of positive autocorrelation.

The findings from the analysis of the NOK/GBP-exchange rate can be found in table 10. Similar to the analysis of the euro, changes in the oil price and interest rate differential remain the most important determinants for the NOK/GBP-exchange rate. Both are statistically significant in all model specifications. As a difference to the euro, we find in column (4) that changes in the lagged real exchange rate is statistically significant at the 1 percent level. It states that a 1 percent loss in trade competitiveness is associated with a 0.14 percent depreciation of the Norwegian krone.

	Dependent variable:			
	ΔNOK/GBP			
	(1)	(2)	(3)	(4)
Δoil_t	-0.0678***	-0.0761***	-0.0778***	-0.0682***
	(0.0211)	(0.0183)	(0.0183)	(0.0195)
$\Delta(i - i^*)_t$		-0.0432***	-0.0437***	-0.0419***
		(0.0086)	(0.0083)	(0.0079)
$(i - i^*)_{t-1}$			-0.0007	-0.0006
			(0.0007)	(0.0006)
Δq_{t-1}				0.1395***
				(0.0494)
Constant	-0.0004	-0.0008	-0.0004	-0.0004
	(0.0017)	(0.0015)	(0.0015)	(0.0014)
Observations	201	201	201	201
Adjusted R^2	0.056	0.178	0.177	0.192
Durbin-Watson	1.588	1.636	1.642	1.871
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 10: *Baseline Model NOK/GBP (Monthly data)*

Further, we find that changes in the oil price has, on average, less impact on the NOK/GBP-exchange rate than the NOK/EUR-exchange rate. Here, a 1 percent positive change in the oil price is, on average, followed by a 0.068 to 0.078 percent appreciation of the Norwegian krone, depending on the model specification. As well, the impact from a change in the interest rate differential is smaller, as a 1 percentage point increase yields, on average, a 4.19 percent decrease in the exchange rate for the baseline model in column (4). Lastly, we observe in column (1) that the explanatory power of the oil price is much lower for the NOK/GBP-exchange rate, as it only explains 5.6 percent of the exchange rate variation.

Looking at table 11, we find yet again that changes in the oil price and interest rate differentials are two important determinants for the NOK/USD-exchange rate. Both are statistically significant at the 1 percent level across all specifications.

	Dependent variable:			
	ΔNOK/USD			
	(1)	(2)	(3)	(4)
Δoil_t	-0.1799***	-0.1783***	-0.1798***	-0.1577***
	(0.0321)	(0.0295)	(0.0300)	(0.0292)
$\Delta(i - i^*)_t$		-0.0175***	-0.0178***	-0.0178***
		(0.0062)	(0.0061)	(0.0049)
$(i - i^*)_{t-1}$			-0.0007	-0.0006
			(0.0011)	(0.0008)
Δq_{t-1}				0.2176***
				(0.0510)
Constant	0.0004	0.0001	0.0012	0.0009
	(0.0020)	(0.0018)	(0.0017)	(0.0012)
Observations	201	201	201	201
Adjusted R^2	0.292	0.313	0.312	0.349
Durbin-Watson	1.429	1.451	1.458	1.777
Note:		*p<0.1; **p<0.05; ***p<0.01		

Table 11: *Baseline Model NOK/USD (Monthly data)*

The most important finding from table 11 is that changes in the oil price has a significantly greater impact on the krone-dollar relationship than the two other relationships. From column (4), we see that a 1 percent positive change in the oil price would appreciate the Norwegian krone by 0.158 percent, which is approximately twice the impact of the krone-euro and krone-pound relationships. On the other hand, a change in the interest rate differential has a smaller impact, where a 1 percentage point change is, on average, associated with a 1.78 percent change in the NOK/USD-exchange rate.

Similar to the NOK/GBP-exchange rate findings, changes in the lagged real exchange rate is statistically significant at the 1 percent level. It states that a 1 percent increase in the real exchange rate corresponds to a 0.22 percent depreciation of the Norwegian krone. Lastly, in general, the explanatory power of the NOK/USD-baseline model is relatively higher than the two other specifications.

Comparing across all three baseline models, we can conclude that the change in the oil price and the change in the interest rate differential are the most important determinants for the exchange rate. We find that, in general, the change in the oil price has a greater impact on the NOK/USD-exchange rate than both the NOK/EUR- and NOK/GBP-exchange rates. As well, changes in the interest rate differentials are more important for determining the krone-euro and krone-pound relationships. In the next section, we will test our baseline model for robustness, by controlling for FX-effects.

4.3.2 FX Effects

Even though the regression outputs presented above make economic and intuitive sense, there is still a risk that the coefficients in the baseline model are biased. First, because the price of oil is denoted in US dollar, changes in the value of the dollar will have an impact on the demand and supply of oil. For instance, a depreciation of the dollar against the euro would, for a given price, allow the Eurozone to import higher quantities of oil. This would consequently increase the price of oil. Because of this potential effect the USD has on the oil price, it is important that we control for changes in the value of the dollar.

Second, since the dollar is the most important currency in the world, changes in its value can have spillover effects on other currencies as well. In order to control for the two issues, we have included the EUR/USD- and GBP/USD-exchange rates in the krone-euro and krone-pound baseline models, respectively. For the krone-dollar model, we have included the EUR/USD-exchange rate, as the trade- and investment relationship between the EU and the US is the largest bilateral relationship in the world (EC, 2018). We can thus rewrite equation (4.6) as:

$$\Delta s_t = \alpha + \beta_1 \Delta \text{oil}_t + \beta_2 \Delta (i - i^*)_t + \beta_3 (i - i^*)_{t-1} + \beta_4 \Delta q_{t-1} + \beta_5 \Delta f x_t + v_t. \tag{4.7}$$

Here, the FX-effecs are included in the term $\Delta f x_t$. The regression outputs from this new specification is presented in table 12.

	Dependent variable:		
	ΔNOK/EUR (1)	ΔNOK/GBP (2)	ΔNOK/USD (3)
Δoil_t	-0.0967***	-0.1085***	-0.0989***
	(0.0161)	(0.0198)	(0.0163)
$\Delta (i - i^*)_t$	-0.0448***	-0.0308***	-0.0191***
	(0.0081)	(0.0060)	(0.0054)
$(i - i^*)_{t-1}$	-0.0008	-0.0006	-0.0003
	(0.0007)	(0.0007)	(0.0004)
Δq_{t-1}	0.0607	0.1771***	0.0368
	(0.0556)	(0.0423)	(0.0622)
$\Delta f x_t$	-0.1498***	-0.3959***	0.7809***
	(0.0343)	(0.0947)	(0.0593)
Constant	0.0018	0.0001	0.0012
	(0.0015)	(0.0013)	(0.0011)
Observations	201	201	201
Adjusted R^2	0.381	0.310	0.743
Durbin-Watson	1.692	1.778	1.798
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 12: *FX-Effects (Monthly data)*

We find that the signs of the FX-effects are negative for both the NOK/EUR and NOK/GBP, while it is positive for the NOK/USD. Keep in mind that the $\Delta f x_t$ is different for the NOK/USD. Here, an increase in the $\Delta f x_t$ indicates that the foreign currency in the dependent variable appreciates, i.e. the USD appreciates. However, an increase in the $\Delta f x_t$ for NOK/EUR and NOK/GBP is the same as a depreciation of the foreign currency in the dependent variable. Hence, the signs of the $\Delta f x_t$ are consistent.

We find that a 1 percent positive change in the EUR/USD-exchange rate, is associated with a 0.7809 percent increase in the NOK/USD-exchange rate. The impact for the euro and pound is smaller, where a 1 percent increase yields a 0.1498 and 0.3959 percent decrease of the NOK/EUR and NOK/GBP, respectively. These findings give evidence in support of the spillover effect previously mentioned.

The most important finding from table 12 is that the change in the oil price is robust to changes in the Δfx_t. The coefficients for all exchange rates stay statistically significant at the 1 percent level, but the magnitude of the coefficients changes. With respect to the euro and pound, the coefficient for changes in the oil price becomes larger for both; the NOK/EUR model experiences an increase of roughly 1.36 basis points, and the coefficient for the NOK/GBP model is 4.03 basis points higher than in the baseline model. This is mainly caused by changes in the oil price initially picking up the effects from changes in the EUR/USD and GBP/USD. By not controlling for this FX-effect, the impact from changes in the US dollar will dampen the effect from changes in the oil price, and the coefficients will be downward biased.

For the US dollar, the impact of changes in the oil price is reduced by 5.88 basis points, the opposite to what we observed for both the NOK/EUR- and NOK/GBP-exchange rates. Since the oil price is denoted in US dollar, the relationship between the NOK/USD and the oil price seems strong when we do not control for changes in the US dollar. When the oil price increases, including the EUR/USD-exchange rate we control for a dollar depreciation against other currencies, as well as the spillover effect it has on the NOK/USD-exchange rate. Hence, when we control for the value of the dollar, the coefficient for changes in the oil price should become smaller.

The impact from changes in the interest rate differential is reduced for both the NOK/EUR- and NOK/GBP-exchange rates, but increased somewhat for the NOK/USD-exchange rate. However, the change is minimal and all coefficients remain statistically significant at the 1 percent level. Including the Δfx_t also increases the adjusted R^2 for all exchange rates, particularly for the NOK/USD-exchange rate where it increases to 0.743. As for the DW-statistics, it remains relatively unchanged, implying that the new specifications still include some autocorrelation. In conclusion, we find that our baseline model is relatively robust in its specification. Going forward, we will continue to include Δfx_t as a control variable, so to control for the issues pointed out in this section. Next, we will introduce to the reader how the impact from changes in the oil price differs during a supply and demand shock.

4.3.3 Demand- and Supply Shocks

As the rolling correlation in section 4.1 indicated, the relationship between the oil price and exchange rates varies over time. To further investigate this, we will run regressions for two different subsamples. We will, from this point forward, use our weekly dataset, so to have a sufficient amount of observations to include in our regressions. The downside of doing so is that we are unable to include the real exchange rate coefficient, as the CPI is only recorded on a monthly basis. Nevertheless, we deem that analyzing a higher frequency dataset offsets the negative side of excluding the real exchange rate as a control variable. Thus, equation (4.7) can be rewritten as:

$$\Delta s_t = \alpha + \beta_1 \Delta \text{oil}_t + \beta_2 \Delta (i - i^*)_t + \beta_3 (i - i^*)_{t-1} + \beta_4 \Delta fx_t + v_t. \tag{4.8}$$

As mentioned in section 2.2.3, the fall in the oil price during the financial crisis in 2008 and the oil price crisis of 2014, were caused by different underlying factors. The former was, on a broad level, a result of a decline in the real demand for oil, where the latter was caused by an increase in the supply of oil. Out of interest to investigate the behavior of the Norwegian krone, we define the first subsample as the *demand-shock* sample and the second subsample as the *supply-shock* sample. The first subsample has its period from July 2007 to January 2012[29], and the second has its period from June 2014 to December 2017. In all upcoming tables, we present in column (1) the full dataset; in (2) the demand-shock sample and; in (3) the supply-shock sample.

[29]This is to include the whole fall in the oil price, which actually started before the collapse of Lehmann Brothers.

In table 13, we have summarized the regression output for the supply- and demand shock on the NOK/EUR-exchange rate. Comparing column (1) with column (1) in table 12, we find that the coefficients are smaller for both changes in the oil price and changes in the interest rate differentials. This is most likely due to the higher level of noise in weekly data. For instance, in a weekly dataset there can be cases where the oil price or interest rate differential increases, but the Norwegian krone depreciates because of factors our model does not pick up. Hence, it makes sense that the coefficients are a bit smaller. Nevertheless, both the signs and level of significance remain unchanged, which is more important going forward.

	Dependent variable:		
		ΔNOK/EUR	
	(1)	(2)	(3)
Δoil_t	-0.0871***	-0.1439***	-0.1113***
	(0.0123)	(0.0142)	(0.0187)
$\Delta(i - i^*)_t$	-0.0227***	-0.0171***	-0.0679***
	(0.0042)	(0.0057)	(0.0218)
$(i - i^*)_{t-1}$	-0.0001	0.0015	-0.0013
	(0.0003)	(0.0020)	(0.0049)
Δfx_t	-0.1315***	-0.2064***	-0.1721**
	(0.0427)	(0.0679)	(0.0825)
Constant	0.0004	-0.0021	0.0025
	(0.0004)	(0.0030)	(0.0065)
Observations	874	184	184
Adjusted R^2	0.184	0.318	0.305
Durbin-Watson	2.306	2.568	2.190
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 13: *Demand and Supply shocks NOK/EUR (Weekly data)*
(1) Full dataset; (2) Demand shock; (3) Supply shock

Looking into our subsamples, we observe from column (2) and (3) that the coefficients for a change in the oil price *increases* relative to the full dataset. For instance, a 1 percent increase in the oil price was associated with a 0.144 percent appreciation of the Norwegian krone during the financial crisis, and a 0.111 appreciation during the oil price crisis. This finding would suggest that changes in the oil price is a more important determinant for the NOK/EUR-exchange rate in the case of a demand shock for oil.

With respect to the change in the interest rate differentials, we find that its impact has slightly decreased during the financial crisis, but significantly increased during the oil price crisis. Here, a one percentage point change corresponded to a 6.79 percent change in the Norwegian krone. The FX-effect remains statistically significant for all periods, but the coefficient increases during crisis periods, implying that the Norwegian krone is more sensitive to changes in the EUR/USD-exchange rate during volatile periods. The FX-effect is largest during the demand shock, where a 1 percent depreciation of the euro against the dollar was associated with a 0.21 percent appreciation of the Norwegian krone against the euro. The adjusted R^2 is higher during both crises, which might be explained by the increasing importance of the oil price during these periods. Additionally, we see that our DW-statistics are no longer below two, implying that our weekly dataset includes some negative autocorrelation.

The empirical output for the NOK/GBP-exchange rate is given in table 14. Here, we find that the signs of the coefficients remain the same, but their impact has changed.

	Dependent variable:		
	ΔNOK/GBP		
	(1)	(2)	(3)
Δoil_t	-0.0940***	-0.1569***	-0.0986***
	(0.0150)	(0.0280)	(0.0262)
$\Delta(i - i^*)_t$	-0.0157***	-0.0048	-0.0416**
	(0.0056)	(0.0053)	(0.0207)
$(i - i^*)_{t-1}$	-0.0001	0.0006	0.0045
	(0.0002)	(0.0019)	(0.0043)
Δfx_t	-0.3413***	-0.4232***	-0.5774***
	(0.0549)	(0.0823)	(0.1137)
Constant	-0.00002	-0.0010	-0.0023
	(0.0004)	(0.0031)	(0.0031)
Observations	874	184	184
Adjusted R^2	0.154	0.156	0.295
Durbin-Watson	2.130	2.316	2.102
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 14: *Demand and Supply shocks NOK/GBP (Weekly data)*
(1) Full dataset; (2) Demand shock; (3) Supply shock

Similar to the NOK/EUR-exchange rate, we observe that changes in the oil price have a bigger effect on the krone-pound relationship during crises. However, we see that the change is only marginal during the oil price crisis, in which a 1 percent increase in the oil price only appreciates the Norwegian krone with 5 more basis points. On the other side, changes in the interest rate differential have become more important during the oil price crisis, as the coefficient decreased from -0.0157 to -0.0416. Lastly, the FX-effect seems to be more important during the oil price crisis, but this might be attributed to Brexit and the substantial depreciation of the pound following the referendum.

During the financial crisis, changes in the oil price increased its impact on the krone-pound relationship, as a positive 1 percent change in the oil price was, on average, associated with a 0.15 percent appreciation of the krone. Additionally, changes in the interest rate differential were found to not be statistically significant during this period, implying that only the oil price and the FX-effect had any explanatory power over the NOK/GBP-exchange rate.

Next, we find in table 15 the output for the NOK/USD-exchange rate. The results are similar to the results of the two previous regression outputs. For instance, comparing column (1) and (2), we find that the impact of a 1 percent positive change in the oil price increases from a 0.0961 to a 0.1597 percent appreciation of the Norwegian krone. The impact from changes in the interest rate differentials drops marginally, but remains statistically significant at the 1 percent level. With respect to the FX-effect, we see that the coefficient falls somewhat during the demand shock, but keeps the same sign and remains statistically significant at the 1 percent level.

Looking at column (3), during the supply shock, the coefficient for changes in the oil price has decreased from -0.0961 to -0.1150. As with the other exchange rates, we can see that the impact from changes in the interest rate differential has become greater, as a one percentage point change yields a 6.55 percent change in the NOK/USD-exchange rate.

	Dependent variable:		
	ΔNOK/USD		
	(1)	(2)	(3)
Δoil_t	-0.0961***	-0.1597***	-0.1150***
	(0.0119)	(0.0150)	(0.0145)
$\Delta(i - i^*)_t$	-0.0193***	-0.0156***	-0.0655***
	(0.0035)	(0.0044)	(0.0192)
$(i - i^*)_{t-1}$	-0.0001	0.0001	-0.0004
	(0.0001)	(0.001)	(0.0010)
Δfx_t	0.8712***	0.7950***	0.8260***
	(0.0422)	(0.0741)	(0.0653)
Constant	0.0003	-0.0005	0.0003
	(0.0003)	(0.0024)	(0.0009)
Observations	874	184	184
Adjusted R^2	0.675	0.753	0.597
Durbin-Watson	2.243	2.472	2.043
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 15: *Demand and Supply shocks NOK/USD (Weekly data)*
(1) Full dataset; (2) Demand shock; (3) Supply shock

4.3.4 Abnormal Changes

To analyze the subsamples more thoroughly, we investigate how the size of the change in the oil price could differ in its influence on the Norwegian krone. More precisely, we look at potential magnitude effects, which will yield an answer on whether the Norwegian krone is more sensitive to abnormal changes in the oil price. To test for such effects, we have included a dummy variable for large changes in the oil price that interacts with changes in the oil price. Equation (4.8) then becomes:

$$\Delta s_t = \alpha + \beta_1 \Delta \text{oil}_t + \beta_2 \text{oil}_t \times D^{\text{big}} + \beta_3 \Delta(i - i^*)_t + \beta_4 (i - i^*)_{t-1} + \beta_5 \Delta fx_t + \beta_6 D^{\text{big}} + v_t \quad (4.9)$$

Here, we define a large change in the oil price to be twice the size of the average absolute change in the oil price, over the preceding 24 weeks. Because changes in the oil price are likely to change depending on the period we are analyzing, defining the dummy variables as such will allow the average abnormal change to be dynamic. Hence, the dummy variable (D^{big}) will be given the value 1, if

$$\text{Abs}\left\{\left(\frac{\text{oil}_t}{\text{oil}_{t-1}}\right) - 1\right\} > 2 \times (\text{average absolute return of oil during last 24 weeks}),$$

and 0 otherwise. The upcoming regression outputs are divided into the different subsamples, similar to section 4.3.3. In table 16, we present the results from abnormal changes for the NOK/EUR-exchange rate. Interestingly, we observe that during the demand shock, large changes in the oil price had, in general, greater influence on the Norwegian krone than smaller changes. For instance, should the change in the oil price be abnormal, the value of the Norwegian krone would then change by an additional 0.075 percent. This is statistically significant at the 1 percent level. On the other hand, we find no empirical evidence for neither the full dataset nor the oil price crisis. This might suggest that the impact of abnormal changes does in fact depend on the type of shock.

	Dependent variable:		
		ΔNOK/EUR	
	(1)	**(2)**	**(3)**
Δoil_t	-0.0783***	-0.1082***	-0.0882***
	(0.0105)	(0.0201)	(0.0147)
$\Delta\text{oil}_t \times D^{Big}$	-0.0168	-0.0745***	0.0387
	(0.0204)	(0.0273)	(0.0307)
$\Delta(i - i^*)_t$	-0.0228***	-0.0183***	-0.0655***
	(0.0046)	(0.0058)	(0.0203)
$(i - i^*)_{t-1}$	-0.0001	0.0005	-0.0019
	(0.0003)	(0.0020)	(0.0050)
Δfx_t	-0.1325***	-0.1918***	-0.1658**
	(0.0410)	(0.0685)	(0.0834)
D^{big}	0.0024*	0.0027**	0.0045*
	(0.0017)	(0.0013)	(0.0025)
Constant	0.0001	-0.0012	0.0027
	(0.0004)	(0.0030)	(0.0067)
Observations	874	184	184
Adjusted R^2	0.188	0.335	0.318
Durbin-Watson	2.321	2.536	2.179
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 16: *Abnormal changes NOK/EUR (Weekly data)*
(1) Full dataset; (2) Demand shock; (3) Supply shock

In general, the most important finding from this regression is that the change in the oil price coefficient is robost for large changes. In all sample periods, Δoil_t remains significant at the one percent level. This indicates that the effect we observe from changes in the oil price is not only determined by large changes, but that there is a general relationship between the oil price and Norwegian krone. Further, we observe that changes in the interest rate differentials and FX-effect remain significant, and relatively unaffected by large changes in the oil price. As for the regression statistics, the adjusted R^2 and DW-statistics remain relatively constant.

The results for the NOK/GBP-exchange rate are presented in table 17. As opposite to the NOK/EUR-exchange rate, we do not find for any of our sample periods that abnormal changes in the oil price have a statistically significant impact, different from small changes.

	Dependent variable:		
		ΔNOK/GBP	
	(1)	**(2)**	**(3)**
Δoil_t	-0.0836***	-0.1184***	-0.0774***
	(0.0157)	(0.0273)	(0.0268)
$\Delta\text{oil}_t \times D^{Big}$	-0.0191	-0.0659	-0.0379
	(0.0256)	(0.0462)	(0.0476)
$\Delta(i-i^*)_t$	-0.0162***	-0.0067	-0.0401*
	(0.0056)	(0.0050)	(0.0209)
$(i-i^*)_{t-1}$	-0.0001	0.0006	0.0036
	(0.0002)	(0.0017)	(0.0042)
Δfx_t	-0.3409***	-0.3825***	-0.5791***
	(0.0543)	(0.0753)	(0.1046)
D^{big}	0.0039**	0.0087**	0.0031
	(0.0016)	(0.0036)	(0.0034)
Constant	-0.0005	-0.0021	-0.0021
	(0.0004)	(0.0029)	(0.0030)
Observations	874	184	184
Adjusted R^2	0.162	0.187	0.295
Durbin-Watson	2.142	2.308	2.120
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 17: *Abnormal changes NOK/GBP (Weekly data)*
(1) Full dataset; (2) Demand shock; (3) Supply shock

Nevertheless, the change in the oil price coefficients remain significant at the 1 percent level. Thus, the NOK/GBP-exchange rate is only affected by general changes in the oil price, and not by abnormally large changes. Lastly, the interest rate differentials and FX-effect remain similar to what we observed in section 4.3.3. However, the interest rate differentials during the supply shock is now only significant at the 10 percent level. This is, nonetheless, most likely caused by the Brexit referendum.

Looking at the results from the NOK/USD-exchange rate, we observe that, just like for the euro, there is an additional effect from large changes in the oil price during the demand shock. Here, an abnormal change has an additional 0.086 percent effect from a 1 percent change in the oil price. We also find that large changes had an additional impact during the supply shock, but this was only 0.046 percent point greater than small changes. As well, the coefficient during this period is only significant at the 10 percent level, implying that we only have weak evidence for any additional impact from abnormal changes.

	Dependent variable:		
	ΔNOK/USD		
	(1)	(2)	(3)
Δoil_t	-0.0838***	-0.1171***	-0.0892***
	(0.0113)	(0.0251)	(0.0142)
$\Delta\text{oil}_t \times D^{Big}$	-0.0237	-0.0859***	-0.0458*
	(0.0221)	(0.0332)	(0.0269)
$\Delta(i - i^*)_t$	-0.0197***	-0.0182***	-0.0645***
	(0.0035)	(0.0042)	(0.0171)
$(i - i^*)_{t-1}$	-0.0001	-0.0001	-0.0008
	(0.0001)	(0.0009)	(0.0010)
Δfx_t	0.8703***	0.8129***	0.8371***
	(0.0416)	(0.0752)	(0.0696)
D^{big}	0.0027**	0.0026*	0.0042**
	(0.0012)	(0.0015)	(0.0021)
Constant	-0.0001	-0.0005	-0.0001
	(0.0003)	(0.0023)	(0.0007)
Observations	874	184	184
Adjusted R^2	0.678	0.761	0.608
Durbin-Watson	2.251	2.467	2.035
Note:			*p<0.1; **p<0.05; ***p<0.01

Table 18: *Abnormal changes NOK/USD (Weekly data)*
(1) Full dataset; (2) Demand shock; (3) Supply shock

In general, the base impact from changes in the oil price remain robust even when we control for large changes. This indicates that the relationship we observe between the oil price and NOK/USD-exchange rate is not only dependent on large changes in the oil price, but changes in the oil price in general. Lastly, the change in interest rate differential and FX-effect both remain significant at the one percent level for all sample periods.

4.4 Subconclusion

Through our empirical analysis, we found the relationship between the change in the oil price and NOK-exchange rates to be relatively strong. In general, an increase in the oil price is associated with an appreciation of the Norwegian krone. Next, a change in the interest rate differential between Norway and foreign markets was found to be an important determinant for the exchange rate. Here, an increase in the differential was, in general, associated with an appreciation of the Norwegian krone. Lastly, both determinants were robust when controlling for changes in the US dollar.

During a crisis period, the Norwegian krone was found to be more sensitive to changes in the oil price. Of the two we analyzed, we found the impact to be the greatest during the financial crisis. This could then indicate that the Norwegian krone is more sensitive when a fall in the oil price is caused by a fall in demand, rather than an increase in the supply of oil. With respect to the interest rate differentials, a change seemed to impact the Norwegian krone less during the financial crisis, where the coefficient for the NOK/GBP-exchange rate even became insignificant. During the oil price crisis, on the other hand, changes in the interest rate differential became relatively more important. This is in line with the fact that the co-movement between the oil price and the NOK-exchange rate has become less apparent.

Finally, the investigation into abnormal oil price changes revealed that there is an additional effect for large changes in the oil price during the financial crisis for both the NOK/EUR- and NOK/USD-exchange rates. As well, we also found for the NOK/USD-exchange rate weak evidence for this effect during the oil price crisis. However, in general, the base effect from changes in the oil price is robust after controlling for abnormal changes.

5 Discussions

Considering that the underlying factors of the Norwegian krone vary over time, researchers and analysts often disagree on which factors that explain the short-term behavior of the krone. We begin this section by presenting the reader with discussions of the general behavior of the Norwegian krone, based on this thesis' theory and empirical findings. Thereafter, we discuss Norway's dependency on the petroleum sector, as well as the short-term behavior of the Norwegian krone.

5.1 A Fall in the Oil Price and the Norwegian Economy

With a floating-exchange-rate regime, Norway's small and open economy can be affected by changes in the oil price through several channels: competitiveness of Norwegian exports; employment levels; the value of the GPFG and; the monetary policy. As well, according to Bjørnland and Thorsrud (2014), a 25 percent fall in the oil price would, on average, cause a reduction of the Norwegian GDP. The magnitude of the reduction, however, is dependent on the source of the price fall. For instance, a fall triggered by a general fall in global activity would lead to a fall between 2 and 2.5 percent. While, a fall triggered by an increase in the supply of oil would only cause GDP to fall by 50 basis points. The marginal fall of the latter is because an increase in the oil supply usually benefits oil-importing countries, which could increase the demand for other exporting products.

The oil-sector is one of the most important sectors for the Norwegian economy, as the sector alone accounts for roughly 25 percent of total export, and directly employs between 7 and 8 percent of the total workforce. Thus, changes in the oil industry will affect several parts of the economy, as we experienced during the financial crisis and the oil price crisis. This was most apparent during the former, where the profitability of oil companies severely declined, leading to major cost and workforce reductions. Other industries, such as the fish and aluminum industry, were also affected by the fall in the oil price. The oil revenues have made Norway a country with a high wage and cost level, which has led to outsourcing due to diminishing competitiveness of businesses located in Norway.

As found in the empirical analysis, the competitiveness of the Norwegian krone is strongly dependent on the oil price. We further investigate this by analyzing the dynamics of the CA. Assuming that a negative change in the oil price was caused by an increase in the supply of oil, we know empirically that the Norwegian krone will depreciate. This would, consequently, increase the competitiveness of Norwegian exports as commodities are now cheaper for foreign countries to import. Hence, we will expect the higher demand to increase the CA. However, even though this effect would in isolation increase the CA, a depreciation of the Norwegian krone would also imply that the relative value of exports, in terms of Norwegian kroner, would decrease. Thus, we would simultaneously expect the CA to decrease. Depending on whether the market is in equilibrium, should the effect of an increase in demand be larger than the offsetting effect of a value deterioration, we should expect an aggregated increase in the CA.

With respect to the Norwegian government budget, a large portion of the budget is based on withdrawals from the GPFG. As the government revenues from the oil industry are placed in the fund, its value will be highly dependent on the oil price. A lower oil price will, intuitively, decrease the transfers into the fund. However, in the short-run, the impact is likely to be small, as the government is allowed to use more than the three percent budgetary rule. On the other hand, in the long-run the value of the GPFG is essential to the fiscal policy, as a lower value of the fund will decrease the capital available to cover the non-oil budget deficit. This limits the government's ability to run a countercyclical fiscal policy. Additionally, even though investments are fairly diversified across multiple markets, the fund is still exposed to exchange rate risk, as the value of interest to the government is the value in terms of Norwegian kroner.

Based on our empirical findings, the impact of a change in the oil price will have two opposing effects. A lower oil price will decrease the transfers into the fund, but the value of the transfers, in terms of Norwegian kroner, will increase due to the depreciation of the krone. In 2016 and 2017, this effect accounted for about 1,000 billion NOK, or about one-eighth of the value of the GPFG (NBIM, 2018a).

Norges Bank base much of their monetary policy on the inflation target introduced in section 2.3.3. It is therefore important to discuss it in this thesis. As mentioned, a fall in the oil price will have both negative and positive effects on the Norwegian economy; a reduction in the oil price will decrease the economic activity in the oil sector and other closely-tied sectors, consequently leading to a decline in inflation. In order to reduce the drop in output, and to increase the inflation level, the central bank can lower the key policy rate, which will affect the money market interest rate as well. As our empirical analysis revealed, a negative change in the interest rate differentials leads to a depreciation of the Norwegian krone, which benefits the competitiveness of other sectors. As the krone depreciates, imported-inflation is likely to increase, but due to price stickiness and contracts this effect would be more apparent in the long-run.

The discussion has so far only considered external factors for the relationship between the Norwegian economy and the oil price. We could therefore ask the question of whether Norway is able to affect the oil market. The simplest perceived way for an oil-exporting country to affect the oil market is to change the supply and production level of oil. Considering Norway is the largest producer of oil in Europe[30], cutting production should, hypothetically, increase the price of oil in Europe. However, Norway's production is only 2 percent of *total* global production, with 10 other countries having similar production levels (CIA, 2018a). Keeping in mind the intense competition in the industry, a cut in Norwegian production would yield minimal effects, as producers with spare capacity, like Saudi Arabia or Russia, would likely increase their production to meet excess demand. Cutting production would only hurt the Norwegian economy, as it would lead to loss of market shares. In conclusion, we must assume that Norway is not able to manipulate the market alone.

[30]Disregarding Russia

5.2 Differences between Demand- and Supply Shocks

The main difference between the two sample periods' characteristics, with respect to the focus of this thesis, is that we observe a decline in the demand of oil during the financial crisis, and an increase in the supply of oil during the oil price crisis. Both of these resulted in a decrease in the oil price, and a depreciation of the Norwegian krone. Before we dig deeper into this topic, we find it important to explain to the reader some of the underlying reasons for the krone depreciation and fall in the oil price, during these two scenarios.

Underlying reasons for the demand- and supply shocks

The negative demand shock for oil during the financial crisis in 2008, can be backed up by the appreciation of the US dollar, and changes in the financial activity of the futures market. First, McCauley and McGuire (2009) state in their article that one of the major reasons for the appreciation of the dollar was the increase in demand for dollars, caused by investors disinvesting their assets for dollars. Since most investors wish to hold the most usable currency in the world during crises, we should expect the US dollar to appreciate as a general reaction to a crisis.

Second, in section 2.2.1, we introduced the world GDP and market speculations as two important determinants for the demand of oil. We stated that the level of global oil consumption is positively correlated with the world income level. However, even though there was a negative growth of 1.7 percent in global GDP from 2008 to 2009, oil consumption *increased* by 0.67 percent.[31] This give indications that, over a short period world income poorly explains the demand of oil. It might also imply that the demand for oil can be better determined the activity level in the financial market. Other empirical evidence has indeed shown that "financial activity in the futures market can significantly affect the spot oil price" (Watts, 2009). Oil as a commodity, was becoming an investment vehicle for many financial institutions in the years before the financial crisis. Therefore, the liquidation of assets and increased risk-aversion in the financial market strengthen the economic slowdown, and resulted in a real decline in the demand for oil.

[31] Here, we use the level of oil consumption as a *proxy* for the actual demand for oil.

The positive supply shock can mainly by explained by the increase in US shale oil production and Saudi Arabia's reluctance to cut their production. First, the increase in the US production of shale oil was 35 percent during 2014. Second, Saudi Arabia tried to compete US shale oil out of the market to reap back market shares, and therefore flooded the market with their excess capacity. Moreover, the strong growth in the US economy relative to their major trading partners, and consequently the stronger US dollar, somewhat decreased demand for oil. In aggregate, this caused the oil price to drop (IMF, 2017b).

The determinants of the Norwegian krone during shocks

As mentioned, the pound suffered a great depreciation after the Brexit referendum in mid-2016, and the US dollar appreciated during mid-2010 as the oil price began to recover from its fall at the end of 2008. Nevertheless, we find from figure 18 that the pattern for the Norwegian krone is, in general, similar for all currencies. With respect to our subsamples, we find that the volatility of both the Norwegian krone and the oil price has been, on average, higher during the financial crisis than the oil price crisis. Considering the relationship between the oil price and the value of the US dollar, we would expect the Norwegian krone to fluctuate more against the dollar during the demand shock period.

Building on this, we know from our previous discussion that the level of oil production in the US has changed the price of oil dramatically. As presented in figure 13, the slope of the curve is more than four times as large during the oil price crisis than the financial crisis. Graphing this against the NOK/USD-exchange rate, we observe that the correlation between the two variables has increased from negative 7 to positive 26 percent.[32] However, because of the booming US economy relative to their trading partners, this relationship might be biased. Nevertheless, considering the production level in the US has increased such that the country is no longer a net-importer of oil, this relationship might dictate that the Norwegian krone has become more dependent on the overall production level in the US.

[32] See Appendix H for figure.

Next, our empirical analysis found the Norwegian krone to be negatively correlated with the oil price. However, the rate at which the krone depreciated due to a fall in the oil price differed between the two shock periods. This finding might imply that the change in the interest rate differential, or other variables not included in our model, has become more important in determining the exchange rates. When an economy experiences an economic recession, we would expect the government and the central bank to intervene with monetary- and fiscal policies to stabilize the market.

From figure 19, we observe immediately before the financial crisis, a sudden increase in the interest rate level for all countries. This was, most likely, a small premium that was added to the market rates to compensate for the brewing risks of the market. After the outbreak of the crisis, most central banks, including Norges Bank, decreased their interest rates to boost economic activity. During the oil price crisis, however, we see a more ambiguous pattern. Here, the increase in the interest rate in the US represents their increased economic growth, and the negative interest rates in the Eurozone represent the central bank's struggle with low inflation. However, the general trend is that Norwegian interest rates decreased relative to foreign interest rates during this period.

Further, our empirical analysis revealed that during a demand shock, the Norwegian krone is, in general, more sensitive to changes in the oil price relative to changes in the interest rate differentials. This might be explained by the increased number of risk-averse investors, as they tend to worry more about potential downsides than upsides from investment decisions, a larger interest rate differential, therefore, might not affect their decision-making. Hence, it makes economic sense that the coefficient for changes in the interest rate differential becomes smaller, as the change in the oil price crowded out the effect from the interest rate. Finally, interest rates likely became more important during the oil price crisis as a lower oil price is positive for oil importers. As Norwegian interest rates decreased relative to foreign, investors pulled out their assets to invest in other higher-yielding markets. Hence, the importance of changes in the interest rate differentials increased relative to the oil price.

The out crowding effect during the financial crisis, can be further backed up with our empirical results from section 4.3.4. Even though the consensus from this analysis is that abnormal changes in the oil price do not drive the Norwegian krone, we did nevertheless, observe that the krone was more sensitive to large changes during the financial crisis. As found by Cashin et al. (2012), oil demand disturbances have, on average, a more long-run effect on real output than a supply-driven oil price shocks. Considering the real demand for oil fell during the financial crisis, and the fact that the Norwegian economy is strongly dependent on the petroleum sector, it makes economic sense that changes in the oil price will have a relatively higher impact on the value of the Norwegian krone during a demand shock.

Lastly, together with changing the key policy rate, another government tool for stabilizing the economy is changing government spending. For Norway, this mostly implies changing the spending of the capital in the GPFG. In the period from 2008 to 2009, the spending increased from 2.7 to 4.2 percent so to accommodate the upcoming downturns expected from the crisis.[33] During the oil price crisis, however, we do not observe such a significant change in the use of the capital in the GPFG.[34] This might indicate that the level of intervention by the government is stronger during a demand shock than a supply shock.

The latter might be a result of the expected repercussions from the two crisis periods. In general, the expected economic downturn was deemed greater during the financial crisis than the oil price crisis. This was mostly because of expectations of a large fall in global demand, which would consequently decrease the overall economic activity in Norway. Thus, the increase in government spending was intended to stimulate demand and minimize the potential negative effects from the recession.

[33] The budget for the 2009 fund-spending was proposed in October 2008 by the government. We, therefore, experience a lagged effect for the change in government spending.

[34] Keep in mind that a two percent usage of the GPFG in 2015 is 80 percent larger than a four percent usage in 2008, but the change between the periods is smaller during the oil price crisis.

Between 2014 and 2015, on the other hand, the majority of the increase in government spending was to finance bailout-packages to the most affected areas in Norway, specifically the west coast (NRK, 2018). The main reason for the generally lower level of intervention, was because the fall in the oil price was this time triggered by a positive supply shock that benefited oil-importing countries. Since the Norwegian krone depreciated after the fall in the oil price, demand for other Norwegian exports increased, which reduced the need for government intervention. In conclusion, we would assume that the change in the oil price would have a greater impact on the Norwegian economy, and exchange rate, during a demand shock. This is evident from our empirical findings.

5.3 Changes in the Co-movement

As we can see from figure 18, the co-movement between the oil price and the NOK-exchange rates has decreased somewhat since the oil price crisis. Even though the oil price has recovered somewhat from its fall in 2014, the Norwegian krone seems to not appreciate at the same rate as before. From the rolling-correlations in section 4.1.2, starting in 2016 we find that the correlation is much lower for all exchange rates. Immediately, this might seem strange given the fact that the latest of the two crises is a crisis triggered by the oil market itself, while the former is triggered by a fall in global demand. However, analyzing the underlying factors of the oil price crisis, this abnormal behavior will make economic sense.

Because the oil price crisis was triggered by increasing production levels and OPEC's reluctance to cut production, the overall expectation in the financial market was that the oil price would remain low until OPEC eventually would reduce their production. However, when the members finally reached an agreement, it lacked credibility; OPEC's compliance record for production cuts is traditionally poor, and the agreement contained no section about sanctioning members who did not comply with the agreement (CNBC, 2016). The consequence of this dampened the expectations of an increase in the oil price, even though there was a cut in production.

Next, due to the growth in the production of unconventional oil in the years before the oil price crisis, the US has become one of the swing-producers in the global oil market. By allowing the oil price to drop, OPEC hoped this would push the US shale oil out of the market, allowing them to reap back some of the lost market shares. However, their efforts were not completely successful. The aftermath from this made the market afraid that, in the case of a future increase in the oil price, the production of shale oil would increase and limit the increase in the oil price (The Economist, 2016a).

In aggregate, the aforementioned made the market less convinced that the oil price would remain at a high level for an extended period. This likely caused concerns about the future value of the GPFG and Norwegian economy. Combined with the relative growing importance of the interest rate differentials, and expectations of continued low oil prices, this might explain why the co-movement between the Norwegian krone and the oil price is not as apparent as before the supply shock. As well, this can give reasons to why we observe in our empirical analysis that the impact of a change in the oil price is lower during the oil price crisis, and why the additional effect of abnormal changes disappear.

6 Conclusion and Future Research

One of the significant findings from this thesis is that the link between the oil price and the Norwegian krone has become less apparent after the oil price crisis in 2014. Even though the oil price increased above $60 pb in late-2017, the krone has remained weak compared to its major trading currencies. This is the opposite of what we observed during the financial crisis in 2008.

Understanding the dynamics between the oil price and the Norwegian krone is essential for various stakeholders. For government institutions, such as the financial department and the central bank, research into this area is of importance for the development of fiscal and monetary policies. As well, private companies, especially those within the export sector, would benefit from this as alterations in the value of the Norwegian krone could have significant implications for the company's competitiveness in foreign markets. Moreover, the decision-making process for hedging exchange rate risk will be affected by changes in the underlying factors that influences the krone.

In accordance with the theory presented, and previous research on the relationship between the oil price and the exchange rate, this thesis found a statistically significant correlation between the oil price and the NOK-exchange rate. For all sample periods, we found that an increase in the oil price was associated with an appreciation of the Norwegian krone. This study also found the change in the interest rate differential to be an essential determinant. Here, an increase in the differential was associated with an appreciation of the Norwegian krone, which is in line with the concept of the UIP introduced in section 2.1.4.

This thesis further investigated how a change in the US dollar can affect the oil price and the NOK-exchange rate. First, considering that the price for a barrel of oil is invoiced in US dollars, changes in the relative value of the dollar could have implications for the demand- and supply of oil. Second, because of the importance of the US dollar in the

FX-market, changes in its value can have spillover effects on other currencies. The findings from this thesis suggest that both of these effects are present.

To get a more profound understanding of how the oil price could affect the Norwegian krone, we studied its impact during the financial crisis in 2008 and the oil price crisis in 2014. Similar to other research papers, the relationship between the oil price and the NOK-exchange rates is tighter during the former crisis. We also find that abnormal changes in the oil price have an additional effect compared to smaller changes for the NOK/EUR- and NOK/USD-exchange rates. This tight relationship seems to have an out-crowding effect on interest rates, as the impact from the interest rate differentials appears to be less important during this crisis period. Next, we find that changes in the oil price during the oil price crisis has, on average, a smaller impact on the Norwegian krone. Together with weak evidence for abnormal changes, changes in the interest rate differential seem to have a more significant impact during this period. The latter two findings might explain why the co-movement between the oil price and the NOK-exchange rate is not as apparent as before.

In general, a fall in the oil price might not have entirely negative repercussions for the Norwegian economy. On the one hand, a fall in the oil price might increase unemployment and decrease investments in the oil sector, which could have ripple effects on the Norwegian economy in aggregate. This would decrease transfers into the GPFG, which in the long-run could impact the ability of the government to uphold a countercyclical fiscal policy.

On the other hand, a fall in the oil price would cause a depreciation of the Norwegian krone, which will increase the competitiveness of other export products and potentially reduce the ripple-effect from a slowdown in the oil sector. To boost the economic activity, the central bank would cut the key policy rate, which would further depreciate the krone and increase the competitiveness of other exports. Because of the depreciation, the value of the GPFG, in terms of Norwegian kroner, increases, and the adverse effect on the fiscal policy is reduced. In general, the most important positive impact from this is its effect on trade competitiveness. This has made Norway less dependent on the oil industry, as measured in percent of GDP.

Concerning the different subsamples in this thesis, the decrease in the oil price during the financial crisis had an out crowding effect over the other determinants, as the marked was biased towards safe-haven currencies. This made the interest rate differential appear less important for investors' decision-making. The opposite occurred during the oil price crisis. Firstly, the decrease in the interest rate level in Norway gave investors incentives to pull out their investments for other high-yielding markets. As the relationship between the krone and the oil price weakened, the market seemed to react more to changes in the interest rate levels. Additionally, the reduced belief in OPEC's ability to cut production levels and the increased production of tight oil, caused the market to expect the oil price to remain at a low level. This consequently decreased the belief in the Norwegian economy, and the GPFG's ability to be a countercyclical buffer in future crises.

This thesis has shown how the oil price affected the NOK-exchange rates during different types of oil price shocks. Future research in this field could go in multiple directions. One of which, is studying whether the change in the relationship between the oil price and the Norwegian krone is only temporary. Another would be to include more independent variables by changing the frequency of the dataset to either monthly or quarterly. The two latter could only be performed once there are enough empirical observations after the fall in the oil price in 2014. Lastly, it would be interesting to investigate, and cross-compare, the use of government funds in commodity-dependent economies during different crisis periods.

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List of Abbreviations

ADF	Augmented Dickey Fuller
BP	Balance of Payments
CA	Current Account
CIP	Covered Interest Rate Parity
CPI	Consumer Price Index
DW	Durbin-Watson
EUR	Euro
EURIBOR	European Interbank Offered Rate
EG	Engle Granger Co-integration
FRED	Federal Reserve Economic Data
FX	Foreign Exchange
GBP	Great British Pound
GDP	Gross Domestic Product
GPFG	Government Pension Fund Global
GPFN	Government Pension Fund Norway
HAC	Heteroskedastic and Autocorrelation Consistent
I44	Effective Nominal NOK-Exchange Rate
IMF	International Monetary Fund
KA	Capital Account
LIBOR	London Interbank Offered Rate
NBIM	Norges Bank Investment Management
NEER	Nominal Effective Exchange Rate
NER	Nominal Exchange Rate
NIBOR	Norwegian Interbank Offered Rate
NOK	Norwegian Krone
Norges Bank	Norwegian Central Bank
OECD	Organization for Economic Co-operation and Development
OLS	Ordinary Least Squares
pb	per barrel
PPP	Purchasing Power Parity
REER	Real Effective Exchange Rate
RER	Real Exchange Rate
UIP	Uncovered Interest Rate Parity
USD	US Dollar

Appendices

Appendix A Calculation of Variables

$\Delta s_t = \ln(s_t) - \ln(s_{t-1})$

$\Delta \mathrm{oil}_t = \ln(\mathrm{oil}_t) - \ln(\mathrm{oil}_{t-1})$

$\Delta(i - i^*)_t = (i - i^*)_t - (i - i^*)_{t-1}$

$\Delta q_{t-1} = \Delta(s_{t-1} + p^*_{t-1} - p_{t-1})$

$\Delta p_{t-1} = \ln(p_{t-1}) - \ln(p_{t-2})$

$\Delta fx_t = \ln(s_{t,eur/usd}) - \ln(s_{t-1,eur/usd})$

Δ refers to the first difference

Appendix B Complete Augmented Dickey-Fuller Test

Variables	Level Trend	Level Drift	ΔTrend
$s_{nok/eur}$	-2.115	-	-9.883***
$s_{nok/gbp}$	-1.724	-2.006	-9.575***
$s_{nok/usd}$	-2.099	-	-8.690***
$s_{eur/usd}$	-2.395	-2.708	-9.273***
$s_{gbp/usd}$	-2.433	-	-8.339***
oil	-1.840	-1.945	-8.072***
$(i - i^*_{eur})$	-1.918	-1.992	-7.878***
$(i - i^*_{gbp})$	-1.588	-1.401	-6.780***
$(i - i^*_{usd})$	-1.282	-1.247	-6.545***
$(p - p^*_{eur})$	-1.623	-	-10.999***
$(p - p^*_{gbp})$	-1.486	-1.318	-9.840***
$(p - p^*_{usd})$	-1.972	-2.280	-8.555***
$q_{nok/eur}$	-2.832	-	-10.475***
$q_{nok/gbp}$	-2.06	-2.253	-9.842***
$q_{nok/usd}$	-2.195	-	-9.066***
Note:			*p<0.1; **p<0.05; ***p<0.01

ADF-test (Monthly data)

Variables	Level Trend	Level Drift	ΔTrend
$s_{nok/eur}$	-2.023	-	-21.627***
$s_{nok/gbp}$	-1.824	-2.058	-21.961***
$s_{nok/usd}$	-1.776	-	-21.425***
$s_{eur/usd}$	-2.087	-2.419	-20.649***
$s_{gbp/usd}$	-2.171	-	-20.984***
oil	-1.448	-1.755	-21.164***
$(i - i^*_{eur})$	-1.771	-1.848	-22.884***
$(i - i^*_{gbp})$	-1.490	-1.266	-20.617***
$(i - i^*_{usd})$	-0.892	-0.787	-19.289***
Note:			*p<0.1; **p<0.05; ***p<0.01

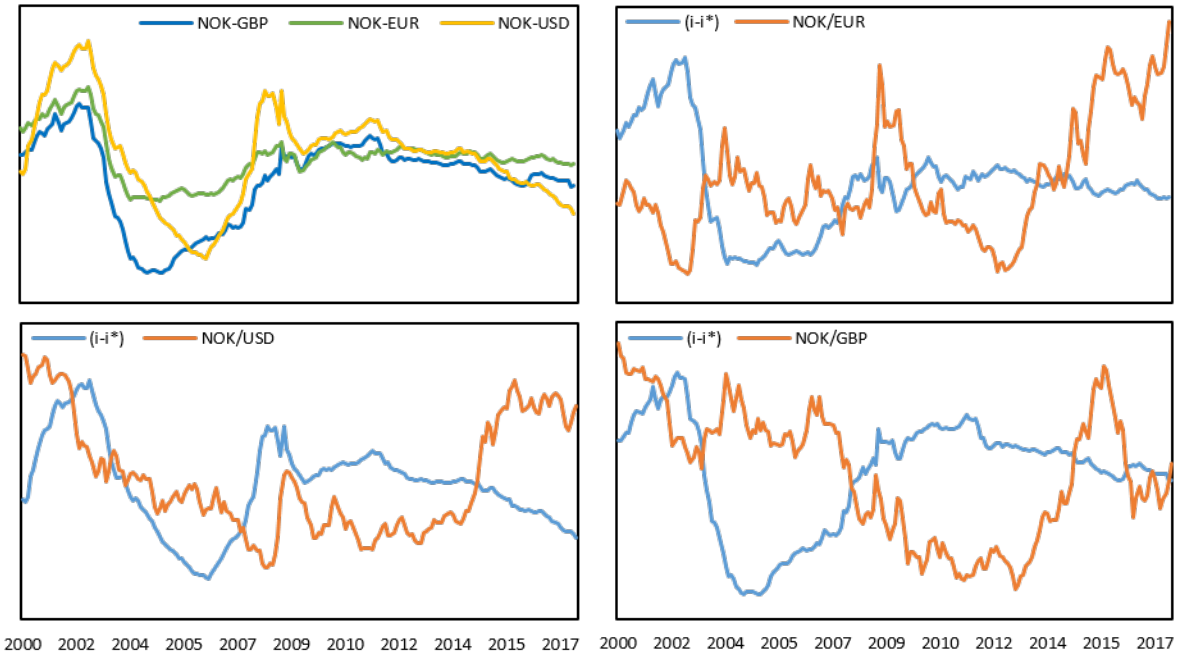
ADF-test (Weekly data)

Appendix C Correlation Matrix

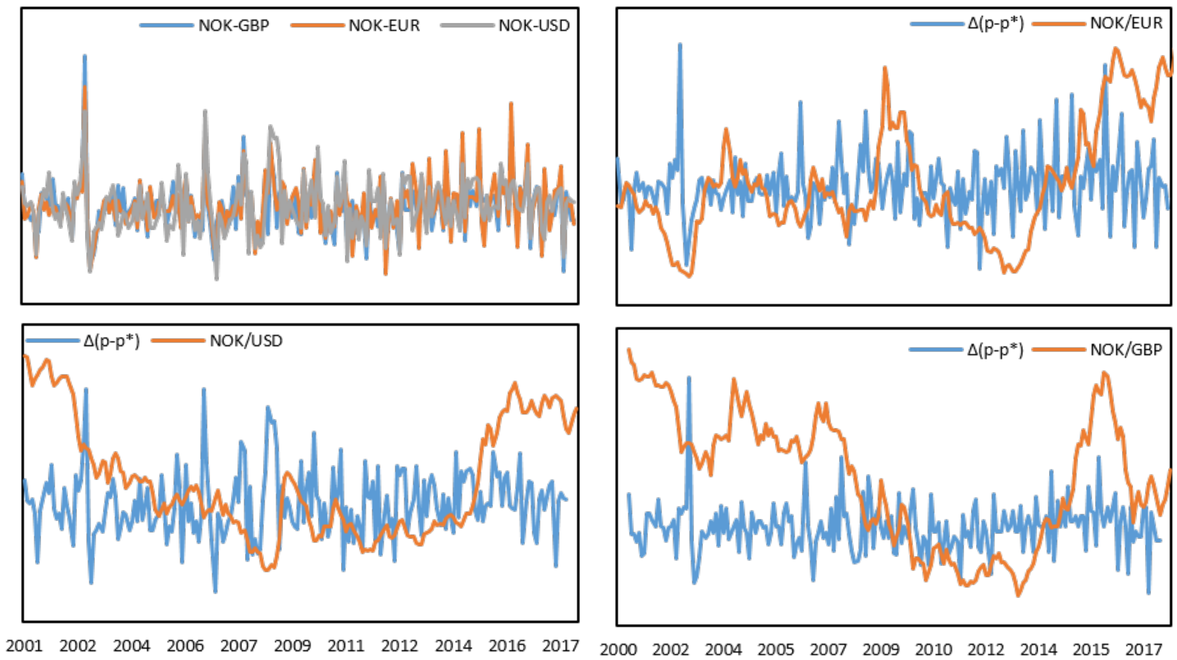
	Δoil_t	$\Delta(i - i_{eur})_t$	$\Delta(i - i_{gbp})_t$	$\Delta(i - i_{usd})_t$	$(i - i_{eur})_{t-1}$	$(i - i_{gbp})_{t-1}$	$(i_{-}i_{usd})_{t-1}$	$\Delta(q_{eur})_{t-1}$	$\Delta(q_{gbp})_{t-1}$	$\Delta(q_{usd})_{t-1}$	$\Delta eur/usd$	$\Delta gbp/usd$
Δoil_t	1.000											
$\Delta(i - i_{eur})_t$	-0.227	1.000										
$\Delta(i - i_{gbp})_t$	-0.0844	0.7824	1.000									
$\Delta(i - i_{usd})_t$	0.0316	0.6512	0.7395	1.000								
$(i - i_{eur})_{t-1}$	-0.1077	-0.1032	-0.1005	0.0470	1.000							
$(i - i_{gbp})_{t-1}$	-0.0898	-0.0501	-0.0735	0.0519	0.9003	1.000						
$(i_{-}i_{usd})_{t-1}$	-0.2294	-0.1420	-0.1668	-0.0429	0.8777	0.8109	1.000					
$\Delta(q_{eur})_{t-1}$	-0.2272	-0.2983	-0.1068	-0.0712	-0.0106	-0.0178	-0.0010	1.000				
$\Delta(q_{gbp})_{t-1}$	-0.3125	-0.1412	-0.0799	-0.0371	-0.0577	-0.0237	-0.0532	0.5850	1.000			
$\Delta(q_{usd})_{t-1}$	-0.3363	-0.0090	0.0944	-0.0065	-0.0363	-0.0008	-0.0265	0.4627	0.6000	1.000		
$\Delta eur/usd$	-0.4134	0.2096	0.1251	0.0086	-0.0475	0.0108	-0.0144	0.1088	0.2448	0.3382	1.000	
$\Delta gbp/usd$	-0.3362	-0.0287	0.2569	0.0521	0.0121	0.0200	0.0338	0.1191	0.1638	0.3538	0.6775	1.000

Correlation Matrix for Independent Variables. We follow the concepts introduces by Hobdari (2012)

Appendix D Co-movements interest- and price level differences



Exchange Rates and Interest Differentials



Exchange Rates and Price Differentials

Appendix E Descriptive Statistics Monthly

Statistics	**N**	**Mean**	**St.Dev**	**Min**	**Max**
NOK/EUR	201	8.23	0.59	7.30	9.84
NOK/GBP	201	10.89	1.28	8.61	13.10
NOK/USD	201	6.78	1.10	5.05	9.30
EUR/USD	201	0.82	0.12	0.63	1.17
GBP/USD	201	0.62	0.08	0.48	0.81

Descriptive Exchange Rates (Monthly data)

Statistics	**N**	**Mean**	**St.Dev**	**Min**	**Max**
Brent Crude Oil	201	67.66	30.61	19.27	135.68

Descriptive Oil Price (Monthly data)

Statistics	**N**	**Mean**	**St.Dev**	**Min**	**Max**
NIBOR	201	3.08	1.96	0.78	7.48
EURIBOR	201	1.72	1.62	-0.33	5.11
LIBOR(GBP)	201	2.56	2.11	0.30	6.54
LIBOR(USD)	201	1.64	1.71	0.11	5.49

Descriptive Interest Rates (Monthly data)

Appendix F ADF Critical Values

	1pct	**5pct**	**10pct**
With Trend	-3.96	-3.41	-3.12
Without Trend	-3.43	-2.86	-2.57

ADF Critical Values for explanatory variables (Wooldrigdge, 2013)

	1pct	**5pct**	**10pct**
Critical values	-3.90	-3.34	-3.04

Asymptotic critical values for Co-integation test (Wooldrigdge, 2013)

Appendix G Engle-Granger Co-integration weekly data

Variables	α	β	t-stat
$\hat{v}_{eur}$	0.00	-0.01	-1.130
$\hat{v}_{gbp}$	0.00	-0.02	-2.629
$\hat{v}_{usd}$	0.00	-0.01	-1.581

EG-test: FX and Oil (Weekly data)

Variables	α	β	t-stat
$\hat{v}_{eur}$	0.00	-0.01	-1.082
$\hat{v}_{gbp}$	0.00	-0.01	-2.454
$\hat{v}_{usd}$	0.00	-0.01	-1.712

EG-test: FX and Interest rate differential (Weekly data)

Appendix H Tight Oil Production and NOK/USD

Tight-Oil Production and NOK/USD

Appendix I Numbers for Oil Consumption

Year	North America	South America	Europe & Eurasia	Middle East	Africa	Asia Pacific	World
2016	23,843.23	6,976.07	18,793.26	9,431.23	3,936.59	33,577.49	96,557.87
2015	23,753.16	7,139.35	18,450.02	9,300.32	3,866.19	32,493.72	95,002.76
2014	23,420.59	7,170.84	18,287.11	9,180.25	3,771.26	31,194.67	93,024.71
2013	23,364.45	7,073.34	18,370.27	8,949.73	3,720.04	30,635.80	92,113.63
2012	22,893.86	6,825.70	18,594.16	8,759.98	3,570.78	30,030.90	90,675.38
2011	23,305.35	6,665.70	19,063.82	8,381.73	3,392.98	28,919.91	89,729.49
2010	23,499.18	6,424.39	19,244.31	8,101.70	3,483.01	27,969.12	88,721.72
2009	25,089.31	5,831.40	20,202.22	6,949.38	3,041.76	26,047.36	87,161.42
2008	23,839.88	6,099.62	20,110.29	7,418.31	3,202.77	25,906.75	86,577.62
2007	24,981.83	5,553.57	20,452.11	6,725.61	2,912.08	25,151.90	85,777.12
2006	22,940.28	6,093.81	19,299.78	7,778.55	3,316.07	26,262.13	85,690.63
2005	25,109.69	5,373.02	20,229.24	6,509.72	2,900.45	24,556.02	84,678.14
2004	25,022.83	5,194.89	20,063.93	6,049.94	2,752.13	24,266.41	83,350.12
2003	24,175.30	4,999.76	19,948.23	5,746.47	2,633.46	23,046.24	80,549.45
2002	23,797.21	5,103.33	19,660.63	5,538.20	2,558.63	22,118.68	78,776.67
2001	23,681.22	5,099.05	19,769.04	5,400.60	2,510.29	21,403.72	77,863.91
2000	23,709.27	4,996.76	19,442.90	5,161.27	2,464.74	21,171.44	76,946.38
1999	23,467.08	5,078.27	19,659.89	5,011.33	2,453.62	20,594.14	76,264.32
1998	22,787.92	5,005.56	19,754.86	4,886.67	2,368.78	19,680.39	74,484.17
1997	22,359.67	4,817.39	19,595.62	4,699.02	2,307.43	20,077.27	73,856.40
1996	21,918.96	4,556.47	19,442.30	4,577.37	2,232.31	19,064.70	71,792.11
1995	21,263.18	4,462.36	19,696.15	4,524.66	2,185.26	18,200.18	70,331.78
1994	21,265.93	4,312.08	19,891.46	4,513.01	2,108.83	17,115.22	69,206.53
1993	20,405.02	3,989.12	22,115.63	3,934.92	2,021.16	15,417.64	67,883.49
1992	20,620.73	4,074.53	20,589.45	4,105.83	2,057.52	16,161.44	67,609.49
1991	20,032.98	3,775.64	22,792.26	3,783.96	1,987.58	14,470.42	66,842.85
1990	20,315.94	3,735.11	23,142.92	3,598.93	1,984.69	13,872.20	66,649.79
1989	20,598.60	3,768.25	22,979.16	3,491.53	1,941.98	13,060.92	65,840.43
1988	20,399.83	3,725.29	22,954.48	3,357.88	1,872.10	12,256.29	64,565.86
1987	21,319.95	3,424.96	24,734.78	2,115.39	1,335.50	11,118.12	64,048.70
1986	21,479.00	3,259.96	24,226.55	1,864.15	1,258.16	10,817.98	62,905.80
1985	19,712.97	3,683.51	22,875.27	3,214.20	1,786.41	11,318.32	62,590.68
1984	20,008.08	3,537.66	23,983.23	1,994.12	1,422.46	10,490.16	61,435.72
1983	19,211.04	3,573.78	22,725.46	3,048.33	1,698.17	10,982.29	61,239.08
1982	21,010.19	3,095.45	22,935.61	1,712.69	1,196.94	10,007.27	59,958.15
1981	19,020.21	3,514.79	23,104.02	2,175.32	1,509.85	10,226.20	59,550.39
1980	18,626.84	3,322.57	22,147.32	3,044.18	1,722.60	10,557.92	59,421.42
1979	18,544.65	3,337.95	22,098.25	2,865.24	1,677.41	10,507.33	59,030.82
1978	18,131.06	3,437.46	22,401.11	2,383.00	1,588.90	9,983.65	57,925.18
1977	19,979.66	2,965.42	22,682.90	1,509.09	1,133.67	9,527.49	57,798.23
1976	17,955.17	3,342.12	22,045.03	2,634.75	1,643.01	10,150.92	57,770.98
1975	19,515.02	2,759.32	22,071.37	1,282.79	934.85	9,068.53	55,631.87
1974	18,931.85	2,836.55	21,735.82	1,368.85	967.48	9,006.29	54,846.85
1973	18,678.91	2,827.67	21,578.81	1,327.49	1,015.31	8,974.55	54,402.75
1972	18,450.38	2,516.79	20,506.28	1,185.05	868.52	7,949.98	51,476.99
1971	17,168.68	2,345.93	19,131.09	1,106.02	801.76	7,403.00	47,956.47
1970	16,593.03	2,084.52	18,155.25	1,050.81	714.04	6,654.95	45,252.61
1969	15,915.70	1,997.45	16,410.84	1,000.21	645.74	5,741.91	41,711.85
1968	15,088.18	1,893.42	14,862.13	965.22	629.83	4,927.45	38,366.24
1967	14,143.71	1,771.65	13,675.20	936.22	598.41	4,323.17	35,448.36
1966	13,576.95	1,713.36	12,577.46	906.59	599.93	3,713.50	33,087.80
1965	12,926.66	1,613.19	11,524.37	881.40	548.33	3,223.33	30,717.29

Oil Consumption (BP Plc, 2017b)

Appendix J Numbers for Oil Supply

Year	North America	South America	Europe & Eurasia	Middle East	Africa	Asia Pacific	World
2016	19,269.84	7,473.64	17,716.13	31,788.60	7,891.59	8,010.28	92,150.07
2015	19,732.79	7,761.26	17,479.30	30,065.20	8,296.78	8,368.94	91,704.27
2014	18,833.28	7,658.50	17,206.21	28,514.76	8,306.65	8,306.65	88,826.05
2013	16,947.74	7,407.04	17,174.41	28,213.03	8,611.77	8,252.28	86,606.28
2012	15,545.05	7,375.58	17,126.54	28,517.69	9,246.54	8,372.02	86,183.42
2011	14,317.01	7,436.23	17,387.20	28,136.07	8,464.25	8,285.31	84,026.06
2010	13,840.66	7,404.10	17,694.17	25,821.82	10,064.73	8,425.75	83,251.22
2009	13,443.93	7,384.50	17,753.52	24,764.53	9,837.92	8,037.60	81,221.99
2008	13,156.32	7,429.70	17,573.90	26,429.73	10,218.17	8,086.10	82,893.93
2007	13,628.41	7,333.64	17,794.59	25,347.61	10,267.77	7,962.19	82,334.20
2006	13,722.37	7,498.44	17,582.24	25,764.66	10,013.69	7,937.94	82,519.35
2005	13,706.34	7,341.18	17,515.58	25,548.58	9,815.72	7,980.59	81,908.00
2004	14,160.06	7,185.25	17,560.56	24,882.48	9,375.49	7,848.52	81,012.37
2003	14,165.47	6,720.36	16,991.68	23,582.15	8,450.61	7,765.57	77,675.85
2002	14,075.89	6,763.50	16,310.96	21,991.26	7,965.27	7,854.70	74,961.59
2001	13,965.49	6,821.88	15,498.66	23,209.13	7,863.73	7,815.47	75,174.36
2000	13,890.95	6,696.41	14,989.31	23,717.17	7,771.08	7,869.13	74,934.05
1999	13,687.55	6,654.78	14,465.10	22,341.33	7,590.22	7,482.32	72,221.30
1998	14,181.77	6,875.39	14,186.26	22,955.03	7,647.81	7,558.80	73,405.05
1997	14,264.81	6,494.57	14,216.78	21,730.32	7,778.26	7,599.98	72,084.72
1996	14,044.50	6,159.95	13,994.84	20,689.06	7,447.14	7,500.51	69,836.02
1995	13,778.53	5,779.22	13,811.31	20,226.01	7,118.24	7,269.76	67,983.07
1994	13,805.87	5,345.69	13,645.59	20,117.64	7,010.00	7,139.21	67,064.00
1993	13,887.02	5,043.79	13,536.53	19,591.34	6,970.26	6,947.32	65,976.26
1992	14,031.98	4,845.49	14,209.83	18,735.18	7,009.55	6,879.75	65,711.78
1991	14,158.68	4,749.15	15,220.49	17,286.85	6,886.35	6,899.92	65,201.45
1990	13,822.82	4,507.20	16,073.76	17,540.24	6,730.50	6,709.62	65,384.13
1989	14,017.53	4,166.67	16,693.03	16,425.22	6,216.62	6,477.33	63,996.40
1988	14,644.11	4,111.80	17,102.63	15,233.93	5,750.89	6,260.75	63,104.10
1987	14,731.75	3,928.84	17,212.27	13,219.15	5,451.91	6,194.81	60,738.72
1986	14,794.26	3,984.31	16,923.06	13,145.89	5,443.22	6,137.74	60,428.49
1985	15,305.17	3,720.91	16,435.57	10,645.40	5,432.75	5,915.89	57,455.69
1984	15,225.95	3,719.42	16,575.81	11,300.71	5,178.62	5,690.49	57,691.00
1983	14,837.67	3,538.51	16,358.83	11,841.12	4,865.27	5,173.00	56,614.41
1982	14,789.53	3,571.37	15,847.94	13,472.84	4,813.83	4,816.36	57,311.87
1981	14,343.57	3,725.05	15,409.89	16,180.35	4,981.10	4,906.71	59,546.66
1980	14,062.63	3,746.54	15,096.38	18,882.41	6,224.90	4,945.44	62,958.29
1979	13,577.53	3,902.18	14,653.49	22,020.55	6,793.13	5,112.96	66,059.83
1978	13,198.44	3,647.90	13,836.91	21,473.09	6,206.67	4,975.21	63,338.22
1977	12,555.56	3,639.45	12,926.94	22,529.60	6,316.00	4,747.95	62,715.50
1976	12,227.64	3,659.00	11,838.27	22,352.19	5,997.39	4,334.71	60,409.21
1975	12,548.74	3,697.39	10,987.76	19,732.87	5,046.91	3,807.99	55,821.65
1974	13,107.21	4,368.75	10,158.54	21,894.12	5,507.59	3,578.19	58,614.39
1973	13,584.95	4,792.36	9,544.68	21,197.13	5,984.29	3,356.16	58,459.57
1972	13,519.90	4,494.54	8,935.25	18,185.68	5,722.47	2,803.64	53,661.47
1971	13,223.78	4,722.77	8,451.55	16,352.64	5,700.51	2,387.08	50,838.33
1970	13,256.85	4,829.09	7,974.19	13,904.22	6,111.90	1,979.50	48,055.74
1969	12,594.67	4,702.34	7,412.79	12,390.96	5,094.42	1,431.71	43,626.89
1968	12,232.74	4,681.73	7,000.76	11,257.97	4,016.90	1,239.77	40,429.87
1967	11,736.25	4,570.85	6,586.24	10,013.98	3,142.73	1,062.74	37,112.78
1966	10,961.24	4,291.28	6,100.37	9,360.76	2,847.67	1,002.15	34,563.47
1965	10,296.15	4,333.81	5,643.51	8,387.00	2,239.54	898.59	31,798.59

Oil Supply (BP Plc, 2017b)

Appendix K Numbers for Tight Oil Production

Date	Oil	Growth	Date	Oil	Growth	Date	Oil	Growth	Date	Oil	Growth
31-12-2017	5,123.14	1.253%	30-06-2013	2,911.87	2.570%	31-12-2008	591.84	-1.945%	30-06-2004	340.29	0.458%
30-11-2017	5,059.77	1.462%	31-05-2013	2,838.90	4.019%	30-11-2008	603.58	4.070%	31-05-2004	338.74	-0.510%
31-10-2017	4,986.88	3.056%	30-04-2013	2,729.21	1.812%	31-10-2008	579.98	7.671%	30-04-2004	340.47	0.176%
30-09-2017	4,839.01	2.136%	31-03-2013	2,680.65	3.146%	30-09-2008	538.66	1.423%	31-03-2004	339.88	-0.063%
31-08-2017	4,737.82	1.737%	28-02-2013	2,598.89	4.298%	31-08-2008	531.10	1.609%	29-02-2004	340.09	0.388%
31-07-2017	4,656.92	2.067%	31-01-2013	2,491.80	0.123%	31-07-2008	522.69	2.393%	31-01-2004	338.77	-0.453%
30-06-2017	4,562.62	0.776%	31-12-2012	2,488.74	3.033%	30-06-2008	510.48	2.342%	31-12-2003	340.31	0.785%
31-05-2017	4,527.48	2.079%	30-11-2012	2,415.48	1.454%	31-05-2008	498.80	1.493%	30-11-2003	337.66	0.281%
30-04-2017	4,435.29	1.361%	31-10-2012	2,380.87	5.000%	30-04-2008	491.46	0.583%	31-10-2003	336.72	0.821%
31-03-2017	4,375.73	0.038%	30-09-2012	2,267.49	3.007%	31-03-2008	488.61	3.754%	30-09-2003	333.97	1.639%
28-02-2017	4,374.06	3.755%	31-08-2012	2,201.29	4.403%	29-02-2008	470.93	1.740%	31-08-2003	328.59	-0.497%
31-01-2017	4,215.78	1.635%	31-07-2012	2,108.46	3.942%	31-01-2008	462.88	0.359%	31-07-2003	330.23	0.844%
31-12-2016	4,147.95	-1.940%	30-06-2012	2,028.50	2.823%	31-12-2007	461.22	1.216%	30-06-2003	327.47	-0.118%
30-11-2016	4,230.01	0.297%	31-05-2012	1,972.81	4.343%	30-11-2007	455.68	0.938%	31-05-2003	327.85	-0.458%
31-10-2016	4,217.48	2.478%	30-04-2012	1,890.70	6.258%	31-10-2007	451.45	2.601%	30-04-2003	329.36	-0.706%
30-09-2016	4,115.52	-0.419%	31-03-2012	1,779.35	2.842%	30-09-2007	440.00	0.182%	31-03-2003	331.70	-0.478%
31-08-2016	4,132.82	-0.836%	29-02-2012	1,730.17	3.821%	31-08-2007	439.20	1.180%	28-02-2003	333.30	-0.207%
31-07-2016	4,167.64	-0.143%	31-01-2012	1,666.49	3.802%	31-07-2007	434.08	1.316%	31-01-2003	333.99	0.013%
30-06-2016	4,173.62	-1.130%	31-12-2011	1,605.44	3.424%	30-06-2007	428.44	-1.747%	31-12-2002	333.95	-1.042%
31-05-2016	4,221.31	-1.001%	30-11-2011	1,552.29	6.114%	31-05-2007	436.06	1.096%	30-11-2002	337.46	2.074%
30-04-2016	4,263.99	-2.514%	31-10-2011	1,462.85	5.650%	30-04-2007	431.33	2.483%	31-10-2002	330.61	-0.047%
31-03-2016	4,373.97	-0.625%	30-09-2011	1,384.62	5.180%	31-03-2007	420.88	6.022%	30-09-2002	330.76	-0.006%
29-02-2016	4,401.47	-0.988%	31-08-2011	1,316.43	5.878%	28-02-2007	396.98	-2.139%	31-08-2002	330.78	0.809%
31-01-2016	4,445.40	0.029%	31-07-2011	1,243.35	6.594%	31-01-2007	405.65	-1.765%	31-07-2002	328.13	-1.706%
31-12-2015	4,444.12	-2.570%	30-06-2011	1,166.44	4.346%	31-12-2006	412.94	-1.084%	30-06-2002	333.82	-1.712%
30-11-2015	4,561.35	0.123%	31-05-2011	1,117.86	4.796%	30-11-2006	417.47	1.865%	31-05-2002	339.63	-0.442%
31-10-2015	4,555.74	0.289%	30-04-2011	1,066.70	1.695%	31-10-2006	409.82	1.521%	30-04-2002	341.14	-0.066%
30-09-2015	4,542.63	-0.710%	31-03-2011	1,048.92	8.411%	30-09-2006	403.68	3.154%	31-03-2002	341.37	-0.961%
31-08-2015	4,575.10	-0.477%	28-02-2011	967.54	-0.355%	31-08-2006	391.34	0.402%	28-02-2002	344.68	-0.590%
31-07-2015	4,597.01	-0.388%	31-01-2011	970.99	1.188%	31-07-2006	389.77	0.186%	31-01-2002	346.73	0.181%
30-06-2015	4,614.91	-1.243%	31-12-2010	959.59	2.159%	30-06-2006	389.05	-0.668%	31-12-2001	346.10	0.242%
31-05-2015	4,672.98	0.115%	30-11-2010	939.31	5.608%	31-05-2006	391.67	0.697%	30-11-2001	345.26	-1.312%
30-04-2015	4,667.61	-0.764%	31-10-2010	889.44	2.759%	30-04-2006	388.95	-1.817%	31-10-2001	349.85	0.316%
31-03-2015	4,703.53	2.704%	30-09-2010	865.55	4.561%	31-03-2006	396.15	2.413%	30-09-2001	348.75	0.008%
28-02-2015	4,579.69	2.381%	31-08-2010	827.80	4.094%	28-02-2006	386.82	-0.351%	31-08-2001	348.72	1.004%
31-01-2015	4,473.18	-1.951%	31-07-2010	795.24	2.320%	31-01-2006	388.18	0.930%	31-07-2001	345.26	0.687%
31-12-2014	4,562.19	3.383%	30-06-2010	777.21	2.972%	31-12-2005	384.61	-0.654%	30-06-2001	342.90	-1.218%
30-11-2014	4,412.90	2.428%	31-05-2010	754.77	5.065%	30-11-2005	387.14	0.287%	31-05-2001	347.13	-0.727%
31-10-2014	4,308.31	2.617%	30-04-2010	718.39	1.571%	31-10-2005	386.03	3.149%	30-04-2001	349.67	-0.675%
30-09-2014	4,198.42	1.785%	31-03-2010	707.28	4.240%	30-09-2005	374.25	-0.996%	31-03-2001	352.05	-0.427%
31-08-2014	4,124.81	2.033%	28-02-2010	678.51	4.823%	31-08-2005	378.01	1.842%	28-02-2001	353.56	0.043%
31-07-2014	4,042.61	2.769%	31-01-2010	647.29	1.729%	31-07-2005	371.17	-0.862%	31-01-2001	353.40	1.451%
30-06-2014	3,933.70	3.996%	31-12-2009	636.29	-0.487%	30-06-2005	374.40	-0.512%	31-12-2000	348.35	-0.985%
31-05-2014	3,782.56	1.314%	30-11-2009	639.40	3.046%	31-05-2005	376.33	-0.442%	30-11-2000	351.81	-1.797%
30-04-2014	3,733.50	4.377%	31-10-2009	620.50	0.581%	30-04-2005	378.00	-1.065%	31-10-2000	358.25	1.876%
31-03-2014	3,576.95	2.796%	30-09-2009	616.92	2.197%	31-03-2005	382.07	2.050%	30-09-2000	351.66	0.335%
28-02-2014	3,479.67	2.837%	31-08-2009	603.66	1.703%	28-02-2005	374.39	2.384%	31-08-2000	350.48	0.358%
31-01-2014	3,383.67	2.010%	31-07-2009	593.55	0.338%	31-01-2005	365.67	1.432%	31-07-2000	349.23	-2.131%
31-12-2013	3,317.00	1.630%	30-06-2009	591.55	0.642%	31-12-2004	360.51	0.458%	30-06-2000	356.84	-1.031%
30-11-2013	3,263.81	1.435%	31-05-2009	587.77	0.606%	30-11-2004	358.87	1.844%	31-05-2000	360.55	-1.287%
31-10-2013	3,217.62	0.918%	30-04-2009	584.23	-1.262%	31-10-2004	352.37	1.773%	30-04-2000	365.25	1.506%
30-09-2013	3,188.35	2.411%	31-03-2009	591.70	0.522%	30-09-2004	346.23	1.719%	31-03-2000	359.83	-1.387%
31-08-2013	3,113.30	3.032%	28-02-2009	588.62	1.465%	31-08-2004	340.38	0.528%	29-02-2000	364.89	0.243%
31-07-2013	3,021.70	3.772%	31-01-2009	580.13	-1.979%	31-07-2004	338.59	-0.500%			

Tight Oil Production (EIA, 2018c)

Appendix L Numbers for World GDP

Date	World
2016	2.4988
2015	2.8257
2014	2.8136
2013	2.6326
2012	2.4426
2011	3.1739
2010	4.3131
2009	-1.7381
2008	1.8186
2007	4.2503
2006	4.3166
2005	3.8445
2004	4.4435
2003	2.9108
2002	2.1529
2001	1.9300
2000	4.3923
1999	3.2567
1998	2.5226
1997	3.7040
1996	3.3795
1995	3.0464
1994	3.0093
1993	1.6284
1992	1.7861
1991	1.4283
1990	3.0094
1989	3.7511
1988	4.6482
1987	3.5753
1986	3.3103
1985	3.8689
1984	4.5290
1983	2.4005
1982	0.3573
1981	1.9253
1980	1.9571
1979	4.1482
1978	3.9946
1977	4.0120
1976	5.3678
1975	0.7728
1974	1.9936
1973	6.5424
1972	5.7620
1971	4.3346
1970	4.6571
1969	6.1296
1968	6.1921
1967	4.4199
1966	5.7922
1965	5.5612

World GDP (The World Bank, 2018)

Appendix M Numbers for Norwegian Export and Import

Exports by products	Percent	Value
Crude Oil	24.78%	208,983
Natural Gas	23.67%	199,639
Fish and Other Seaproducts	10.95%	92,312
Chemical Products	6.48%	54,649
Metals	7.39%	62,346
Machines and Vehicles	9.72%	81,935
Various Finished Goods	2.86%	24,110
Other	14.15%	119,312
Total	100%	843,286

Country (Export)	Percent	Value
Great Britain	21.11%	177,985
Germany	15.52%	130,846
France	6.42%	54,143
Sweden	6.61%	55,724
Denmark	4.70%	39,618
Belgium	4.78%	40,274
Netherlands	9.94%	83,814
USA	4.59%	38,698
Other	26.35%	222,184
Total	100%	843,286

Country (Import)	Percent	Value
Great Britian	4.45%	32,484
Germany	10.39%	75,801
France	6.89%	50,252
Sweden	10.75%	78,457
Denmark	5.05%	36,868
Netherlands	3.61%	26,315
China	9.21%	67,195
South Korea	6.34%	46,239
USA	6.35%	46,347
Other	36.97%	269,743
Total	100%	729,701

Norwegian Export and Import (Statistics Norway: Table 08806 and 08792)