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i Stavanger

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Faculty of Social Sciences  
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What Can Explain the Development in the Norwegian  
Krone Exchange Rate?

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Universitetet  
i Stavanger

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## **Abstract**

This thesis analyzes the effects of the oil price, Norwegian CPI, euro area harmonized CPI, interest rate differential, balance of trade and the unemployment rate on the NOK/euro exchange rate. Using an Engle-Granger two-step approach, we were able to estimate the long and short-run effects of these independent variables on the exchange rate. The data set consists of monthly data from 2001-2015. In addition to the main research question, the results from step one of our Engle-Granger approach are discussed in light of the purchasing power parity and the uncovered interest parity theorems.

In the first step of the Engle-Granger two-step approach, we found all of our variables to be significant, which proved them to have a causal relationship with the exchange rate in the long run. Further investigation, the second step of the Engle-Granger procedure found evidence of the speed of correction towards the long-run equilibrium exchange rate level. The second step of the procedure included the lagged independent changes in the variables effects on the exchange rate. However, we did not find significant evidence on the effect of lagged independent variables changes in our estimates. Accordingly, our model was unable to prove the short-run impact on the exchange rate when there is a deviation from the long-run equilibrium level. Moreover, when examining our results in light of purchasing power parity, we did not find support of the theorem. Our estimation did not indicate that the exchange rate equates the purchasing power of a unit currency in the foreign and domestic economy. Discussing the results with regards to uncovered interest parity, we did not find evidence in support of the theorem. As proof of uncovered interest parity is not provided within our estimation, it denotes that there is an opportunity to profit through exchange rate speculation.

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## **Preface**

This thesis is written as a finalization of our Master of Science degree in Business Administration at the University of Stavanger, UiS Business School. The thesis has been time consuming and at times a major concern in our everyday lives, however looking back it has been a steep and exciting learning process.

We would like to thank our supervisor Klaus Mohn for his patience, useful feedback and comments. A special thanks to all our helpers who have supported us and who have contributed with proofreading and tips.

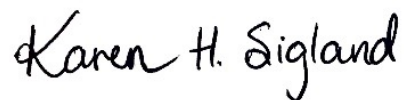
To all our fellow students: thanks for a great time!

Lastly, we want to thank each other for being able to sustain and even strengthen our friendship throughout this process.

Stavanger, June 2016

A handwritten signature in black ink that reads "Karoline Aarhaug". The script is cursive and fluid.

Karoline Aarhaug

A handwritten signature in black ink that reads "Karen H. Sigland". The script is cursive and fluid.

Karen Helene Sigland

# 1 Introduction

There is an unambiguous importance of a country's exchange rate on its economy. Monetary policy affects the Norwegian exchange rate. Furthermore, the Norwegian exchange rate determines competitiveness, foreign and domestic prices. Hence, the exchange rate has a great influence on the demand for Norwegian goods and services, and the return on financial investments in Norway relative to its trading partners. This is particularly important for a small open petroleum economy with floating exchange rates, as Norway is sensitive to shocks in terms of trade. With this in mind, the following research question has been formulated:

*What can explain the development in the Norwegian krone exchange rate?*

There are precarious conditions in the foreign exchange market and it can be difficult to explain or even predict what is driving exchange rate movements. However, economic theory and previous research can help us understand the fundamental forces that influence these trends.

We have decided to look closer at key figures over the last 14 years to examine what forces have driven the exchange rate. We have measured the exchange rate as NOK per one euro, this is because the EU captures 73.4 percent of Norway's trade (European Commission, 2016). Our purpose of this thesis is to achieve a broader understanding of what economic factors drive exchange rate fluctuations. To quantify the relationships and reveal the importance of the various explanatory factors, the krone exchange rate must be estimated econometrically.

The thesis consists of 10 chapters. The first chapter introduces the topic, purpose and research question. Chapter 2 provides theoretical framework in order to give a proper understanding of the market effects, monetary policy effects, the purchasing power parity theory and uncovered interest parity theory. Chapter 3 offers a summary of the development of the Norwegian monetary regimes through history to provide an

understanding of the economic development in Norway. There exist several empirical studies in the field of exchange rate determination. In Chapter 4 a few of these studies are briefly discussed and used as a base for our research. Chapter 5 provides an explanation of the data set that is determined as a result from the enlightenments in the previous chapter. In Chapter 6 the statistical theory is presented. Some empirical results that both support and contradict the theoretical framework and empirical studies are presented in Chapter 7. The empirical results are further discussed in chapter 8 on variable basis and in light of the purchasing power parity and uncovered interest parity theorems. Finally, Chapter 9 draws a conclusion of the thesis.



## **2 Theoretical Framework**

This chapter provides theoretical framework in order to give a proper understanding of the supply and demand in the foreign exchange market. Norway as an inflation-targeting regime and the effect of interest rates are also presented. The construction of the purchasing power parity and uncovered interest parity theorems are presented as a base for further examination of our results.

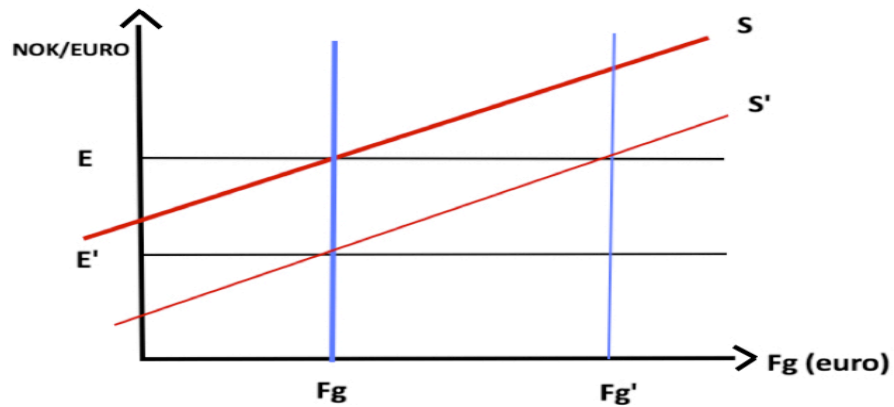
### **2.1 Exchange rates**

The exchange rate is the price of a single foreign currency in terms of the currency of the domestic country in focus. We shall refer to the foreign currency as euro, and the domestic currency as the Norwegian krone (NOK). Thus, the exchange rate is the price of one-unit euro in Norwegian kroner.

#### **2.1.1 The market**

The supply and demand in the foreign exchange market determines the exchange rate. Supply of foreign currency is driven by the net supply of foreign currency by the domestic and foreign general public. The central bank determines the demand of foreign exchange and influences the price on foreign exchange by taking actions that are large enough to affect it. The public acts as price takers when their transactions usually are too small to have a significant influence on the price of foreign exchange. When the price of foreign currency drops, the domestic currency increases in value relative to the foreign currency. Thus, the domestic currency has appreciated. On the other hand, if the price of foreign currency increases, the value of the domestic currency decreases and it depreciates (Rødseth, 2000).

**Figure 1: Supply and demand in the foreign exchange market**



Source: Rødseth 2000, designed in Paint.

### **2.1.2 Fixed exchange rates**

The central bank sets a target exchange rate. The central bank buys or sells the necessary amount of foreign currency to keep the exchange rate at the target rate. The central bank is committed to exchange the Norwegian krone for euro at a given rate. The exchange rate is predetermined as illustrated in Figure 1, fixed at a level  $E$  where price of exchange is the exogenous policy variable. Determined by the supply in the market, quantity follows endogenously. If the supply of foreign currency would increase ( $S'$ ), the central bank would have to buy the excess supply and increase its foreign reserve ( $Fg'$ ) in an effort to keep the exchange rate at the fixed rate. The distinction between fixed and floating rates is often described as a distinction between administratively-determined and market-determined exchange rates.

### **2.1.3 Floating exchange rates**

The central bank sets the quantity, a net amount of foreign currency held by the central authorities, and the price follows from the market. Quantity purchased is the exogenous policy variable and price the endogenous variable. The central bank refrains from action if the supply of foreign currency should increase. Floating exchange rates are

distinguished between having a clean and a managed float. Clean float implies that the central bank is completely passive and never buys or sells foreign exchange. In a managed float the quantity is occasionally adjusted. The result of an increased supply of foreign currency is an appreciation of the Norwegian krone, which leads to a new level ( $E'$ ) as illustrated in Figure 1 (Rødseth, 2000).

## **2.2 Interest rates and Norway as an inflation-targeting regime**

The nominal interest rate is the interest rate before taking inflation into account. The real interest rates corrects for inflation. Interest rates are the cost of borrowing money and the compensation for storing savings. They are the terms at which money or goods today may be exchanged for money or goods at a future time. Economic policy uses interest rates as an instrument. The interest rate is set to achieve a monetary policy objective. Low and stable inflation or price stability is the purpose and the responsibility of the central bank (Norges Bank). The operational target is annual consumer price inflation of 2.5 percent over time. Monetary policy influences the economy with a lag. The policy is set for interest rates to stabilize the inflation over the medium-term, which affects the krone exchange rate (Norges Bank, 2014). When interest rates are high less people will borrow and invest in the krone. Appreciation of the krone will normally be a consequence of high interest rates. Thus imported goods will become less expensive and inflation will decelerate. Exports will dampen and profitability in Norwegian business and industry will be reduced. The effects of a change in the interest rate on exchange rates will vary with shifts in the foreign exchange market (Bergo, 2006).

## **2.3 Purchasing power parity and uncovered interest rate parity**

### **2.3.1 Purchasing power parity**

The theory of purchasing power parity (PPP) was first introduced by Cassel (1928). Cassel recognized that there are a number of factors, such as interest rate differentials, transportation costs and foreign exchange market interventions, preventing an exchange rate from always being at its PPP-defined value (MacDonald & Marsh, 1999).

The *PPP exchange rate* is the nominal exchange rate that equates the purchasing power of a unit of currency in the foreign economy and the domestic economy.

The absolute PPP relation can be written in algebraic terms as shown in equation (2.1)

$$P_t = P_t^* S_t \quad (2.1)$$

Where,  $P_t$  and  $P_t^*$  are the domestic and foreign prices of identical market baskets of goods, respectively; and  $S_t$  is the nominal exchange rate, the price in domestic currency of a unit of the foreign currency. For absolute PPP to hold the exchange rate that prevails in the market between two countries should be equal to the two countries price levels.

The relative PPP is an analogous but weaker version of PPP, which posits a one-to-one relationship between changes in domestic and foreign price levels expressed in terms of a common currency.

This can be written in arithmetic form as shown in equation (2.2)

$$P_{t+1}/P_t = (P_{t+1}^* S_{t+1}) / (P_t^* S_t) \quad (2.2)$$

Exchange rates will change to compensate for inflation differentials (Melvin, 2000).

A way to think about PPP is with an application of the law of one price. The law of one price implies that similar goods should sell for the same price in different locations, once converted to the same currency at the going exchange rate, since otherwise arbitraging the price difference could make a profit. However, that raises a set of objections.

Transportation costs across countries differ and are important for certain goods. Many services and other goods may not be internationally traded. Tariffs and trade barriers might draw a wedge between prices. Consumer preferences are not the same across countries, for that reason price levels may also differ (Lothian & Taylor, A Primer on Exchange Rate Behavior, 2012).

Evidence shows that PPP holds better when and where inflation is high and over long run as opposed to short run. Over the short-run exchange rate changes move more quickly than price levels to economic shocks. Reason is that exchange rate is an asset price determined in organized market. So in periods with major news or unexpected events, will be periods with large short-run PPP deviations (Lothian & Taylor, A Primer on Exchange Rate Behavior, 2012).

### **2.3.2 Uncovered interest parity**

The theory of uncovered interest parity (UIP) has been a puzzle to economist since the work of Fama (1984). The theory postulates that the interest rate differential between two countries should equal the expected exchange rate (Chaboud & Wright, 2003).

Uncovered interest parity is a relation linking the interest differential and the expected change in the exchange rate as stated in equation (2.3). If the parity does not hold, there is an opportunity to make a profit.

$$i_t - i_t^* = (E[S_{t-1}] - S_t) / S_t \quad (2.3)$$

Where, a spot exchange rate  $S_t$  is the rate of a foreign-exchange contract for immediate delivery, and  $E[S_{t-1}]$  is the expected level of the exchange rate the next period and  $i_t$  and  $i_t^*$  are the one-period interest rates in the two countries. (Melvin, 2000)

Irving Fisher viewed UIP and the within-country relation between interest rates and inflation as two facets of a more general relation linking interest rates in different standards, in his terminology, the relation between “appreciation and interest” (Lothian, 2015).

### **3 Retrospective of the Norwegian Economy**

As a background for the thesis, a summary of the development in the Norwegian economy since 1900 is provided in this chapter. This is to obtain an understanding and overview of the monetary policy development in Norway, especially concerning the exchange rate policy.

#### **3.1 The Norwegian monetary policy since 1900**

The gold standard replaced the silver standard in Norway in 1873. This standard required the Norwegian central bank to buy gold for a fixed price amount of kroner. The gold standard did not withstand when World War I started in 1914.

In an attempt to increase the value of the krone, Norway ran deflation politics. In 1920, Norwegian monetary policy attempted to revert to the gold system with the same exchange rate value they had prior to the war, the “paripolitikk.” In April 1928, the gold standard was again in operation (Mestad, 2002)

Norway was badly affected by the great depression in 1931 (Grytten , 2008). The depression was an outcome of the crash originating in New York. As a result of this, Norway had to give up their gold standard (Mestad, 2002).

In an effort to reach price stability in Norway in August 1933, the Norwegian government fixed the krone to the British pound. This exchange regime was called “skillingskrona.” In 1939, the Norwegian krone switched its peg to the US dollar, which was still attached to the value of gold. This regime has been called the gold exchange standard. As a part of the reconstruction after World War II, Norway joined the Bretton Woods Agreement in 1945. Due to the Bretton Woods Agreement collapse in 1971 and the oil price shock in 1973, developed economies struggled with prolonged recessions and slow growth (Grytten , 2008).

In 1971, Norway joined the “Smithsonian Agreement”, to reduce undesired fluctuations. The European Economic Community formed an agreement that would reduce the

fluctuation margins by half, and it was referred to as, “the snake in the tunnel.” This agreement led to floating exchange rates for the participating countries.

When the European monetary system (EMS) was introduced in 1978, Norway resigned and changed to what was called, “korgsystemet.” With the new “korgindex,” they aimed to stabilize the krone exchange rate in relation to average currencies that scaled the most in Norwegian foreign trade.

In autumn 1990, the country wanted to establish an even more ambitious stabilizing policy than the earlier “kurvsystemet.” This system indicated that the Norwegian krone’s international value was expressed as the krone value of the European Currency Unit (ECU). The goal here was to hold the krone exchange rate fixed, and keep it part of the integration project in Europe.

In 1992, the European monetary union was in crisis, and Norway was not spared. The situation was not sustainable, and December 10<sup>th</sup> it was decided that “Norges Bank” no longer was committed to buying and selling kroner in relation to ECU anymore.

In the period 1997-99, the interest rate was used as an important tool in the exchange stabilization policy. In May 1998, the government decided not to change the exchange policy in relation to the introduction of the euro. Thereby the guidelines for Norwegian exchange policy were indirectly related to the exchange policy of the European Central Bank, where price stability was the overall goal (Mestad, 2002).

In 2001, monetary policy went from interest rates solely aiming at maintaining a stable exchange rate against the euro. Instead there was a move to an inflation-targeting regime, where the stability in exchange rate, output and employment also would be emphasized. Fiscal policy would as before, act as an instrument for stabilizing the economy and at the same time gradually phase in “oil revenues” in the Norwegian economy. This would be an underlying expansionary fiscal policy. The use of "oil revenues" is defined, as the deficit in the government budget should over time correspond to the expected real return on “statens pensjonsfond utland”. This is called “handlingsregelen”. A formalization of

the level of the underlying budget balance would help to ensure fiscal discipline in a time when people expected that petroleum revenues would be very high and the current government budget surpluses including petroleum revenues enormous.

Both the Norwegian and international economy had experienced four years of high growth before the financial crisis hit in 2008. High and rising oil prices had provided a basis for significant growth in demand from the petroleum industry, as well as a stimulating fiscal policy in Norway. This contributed to the growth in activity in Norway being particularly strong.

The financial crisis represented weaker growth in Norwegian export markets. Import growth among Norway's trading partners remained at a stable low during the following year, after an immediate fall and partial recovery in the crisis aftermath. The negative impulse this entailed for the Norwegian economy was offset by the activity in the Norwegian petroleum sector remaining relatively high. The Norwegian economy enforced a successful stabilization policy therefore avoiding a deep recession. It did not take long before oil prices were back to previous highs and more, which contributed to major allocations for “statens pensjonsfond utland.” The expansionary fiscal policy could thus continue, and be well within the fiscal rule. It was more important that activity in the petroleum activities were not only sustained but also increased gradually.

The growth in demand from the petroleum sector from 2007 to 2013 corresponded, as an annual average, 0.6 percent of GDP mainland Norway, while the increase in the structural non-oil deficit (fiscal stimulus) in the period on average was equivalent to 0.4 percent. This meant that the Norwegian economy after a year of decline, and a half-year of strong recovery, could grow close to trend growth. This made it possible to maintain a stable, and in international comparison, very low unemployment.

Towards the end of 2013 there was a turnaround in demand from the petroleum activities. Oil companies came to a realization that profitability was unsatisfactory because the costs had become too high, therefore the companies initiated a downsizing of demand. The fall



in oil prices in autumn 2014 intensified investment decline and contributed to a turnaround in summer 2014. Economic trends went from neutral to a marked decline. The definition of a recession is a period where growth in mainland Norwegian gross domestic product (GDP) is below trend growth. Over the past year, from Q2 2014 to Q2 2015, according to preliminary seasonally adjusted figures from “kvartalsvisnasjonalregnskap” GDP grew by almost 1 percent. Unemployment measured by “Arbeidskraftundersøkelsen” has until the summer of 2015 risen by around one percentage point from the level it was in financial crisis and until the downturn in 2014. Oil prices seem to remain clearly lower than the level in the last four or five years into the future. In SSB’s latest forecasts from September 2015, continued investment in the petroleum industry is predicted to fall through 2018, with a decreasing rate (Eika, 2015).

## **4 Summary of Previous Research**

To lay a good foundation for further empirical investigation it is important to study previous research. This chapter presents a brief summary of relevant previous empirical papers. We have considered articles with Norwegian writers, and similar approach to the research question. The variables in our analysis are mainly based on prior research and economic theory, so our findings can thereby be compared with the following research.

### **4.1 Previous research**

Bjørnstad & Jansen (2006) and Bernhardsen & Røisland (2000), find in independent researches, that the oil price, interest rate differential and inflation seem to play a role in the movements of the krone. They find the same impacting factors with different modeling and some varying results.

Bernhardsen & Røisland (2000) examine how the krone exchange rate is influenced by factors such as oil price and turbulence in the international markets. The article interprets the krone exchange rate against the old German mark (now the euro, from 1999) and developments in the trade-weighted exchange rate index. The data is collected monthly for the time period 1993 -2000, sub period 1997-2000, this to provide short and long term exchange rate movements. Key findings are that oil price, international financial turbulence, USD/DEM exchange rate affect the NOK/DEM exchange rate. In addition, the price differential and interest rate differential between Norway and Germany seem to play a role. To measure international financial turbulence, they used an indicator which measures expected volatility in three major currencies, US dollar, mark (euro), And the Japanese yen. The global hazard indicator (GHI), is based on prices for currency options. To examine these relationships, the krone exchange rate has been estimated econometrically using an error correction model.

The results show that in the long term there is a systematic tendency for the krone exchange rate to depend on the price differential between Norway and other countries and on the oil price. This means that an increase in the price level in Norway leads to a

weaker krone in the long run, and a sustained rise in the oil price leads to an appreciation of the krone. In the short term they find that the krone exchange rate is influenced by international financial turbulence, the interest rate differential and the oil price. The analysis also highlights that price inflation was substantially higher in Norway compared to euro area in the late 90s. The study points out that the control lies outside of Norges Bank, and that the changes in the oil price and turbulence in international financial markets will continue to influence the exchange rate.

Following March 2001 when Norges Bank introduced the interest rate as a tool to stabilize the inflation there were large fluctuations in the exchange rate. The article by Bjørnstad & Jansen (2006) examines the relationship between NOK/euro exchange rate and the underlying factors, after the policy change. They used the theoretical part from the exchange rate model as a foundation and also the results from the model by Bjørnland & Hungnes (2006), an analysis focusing on exchange rate modeling under the previous exchange rate targeting policy. Bjørnstad & Jansen use quarterly data from the second quarter of 2001 and including the third quarter of 2006. The model used explains the big fluctuations in the exchange rate with dissimilar development in interest rate in Norway compared to the euro area. Findings show that there is a certain relationship between oil price and the exchange rate. According to the model, the long-term level of real NOK exchange rate against the euro depends on the real interest rate differential and the oil price. As a change in real interest rates and oil price will change the real exchange rate, they find the theory of purchasing parity power not to hold. They also found proof of the short-term interest differential having a clear effect on the real exchange rate. Beside of these factors Bjørnstad & Jansen also finds that changes in price levels to affect the exchange rate equivalent already after two quarters.

Naug (2003) finds the most important influencing exchange rate factor to be the interest rate, by using a flexible dynamic model for the period from May 2000 to November 2003. The effective krone exchange rate appreciated considerably during the period May 2000 and June 2003. He analyzed the factors behind the appreciation of the NOK using an estimated model of the krone exchange rate utilizing the trade-weighted exchange rate

index based on monthly data. The model included effects of global hazard indicator, the oil price, US share prices and the interest rate differential. He also included unobserved variables that could connect the unrest in Middle East to the appreciation. There was a strong rise in the interest rate differential in Norway against other countries. The wider interest rate differentials may explain 40% of the appreciation. This caused the krone to strengthen as result of expectations of lower fluctuations between the major currencies and the fall in international stock markets. The remainder of the appreciation can be explained by a shift in exchange rate expectation and/or a fall in the risk premium krone investment. The sharp increase in the oil price and the krone's status as a safe haven currency during the unrest in the Middle East is also related to the appreciation. The key findings were that share prices and expected fluctuations between the major currencies fell over the appreciation period, it meant that the krone became more sensitive to interest rate changes. Therefore, the krone can be highly volatile when Norway is different cyclical phase than other countries.

Kloster, Lokshall, & Røisland (2003) also find the interest rate to be one of the main influencing factors. Their study has the overall conclusion that changes in the interest rate differential can explain some of the movements in the exchange rate, but also other factors have played a role. In their article they examine how much of the exchange rate movements since November 2001 can be ascribed to the interest rate differential. To investigate this they divided the period into two sub-periods, November 1<sup>st</sup> 2001 - November 4<sup>th</sup> 2002 and November 4<sup>th</sup> 2002 - March 23<sup>rd</sup> 2003, using daily data. This dividing of periods is partly caused due to available data but also because of the characterization of the periods. In the first period there was an appreciation of the krone and an increase in the interest rate differential. Second period is characterized the opposite of first period with a fall in the exchange rate and a decline in the interest rate differential. They analyze the relationship between the krone exchange rate and the interest rate differential within the theoretical framework of uncovered interest parity. Results from the study suggest that according to the framework, the residue of the appreciation is caused by a combination of a reduction in the risk premium on investments in the krone and the expectations of a stronger long-term real exchange rate

of the krone. They saw that the risk premium on investments in Norwegian krone was reduced through the same period were the krone was appreciated. They also found that the entire fall in the exchange rate in the second period could potentially be explained by the narrowing of the interest rate differential in the first period. This estimates is however found to be sensitive to which assumptions that are made consider the relevance of long term forward rate differentials to the krone exchange rate.

Lane & Milesi-Ferretti (2002) found the balance of trade to have an effect on the exchange rate. They examine the link between the net foreign position, the trade balance and the real exchange rate. The empirical analysis focuses on a sample of OECD economies for the period 1970-1998. They use a variety of data, specifications and methods in their analysis. They deconstruct the impact of a country's external wealth position on its long-run real exchange rate into two mechanisms: the relationship between the trade balance and the exchange rate, and the relationship between net foreign asset position and the trade balance. They also provided evidence that the relative price of nontradables is an important channel linking the real exchange rate and the trade balance. The approach is empirical and focused on a long-run relation between these variables. In conclusion, they establish a negative long-run association between the trade balance and real exchange rate. They find that the magnitude of the trade balance is increasing with country size.

The unemployment is one of the most closely watched statistics because a rising rate is seen as a sign of a weakening economy and that may call for cuts in interest rate. A falling rate indicates a growing economy, which is usually accompanied by higher inflation rate and may call for increase in interest rate (Business Dictionary, 2016). Feldmann (2011) finds that higher exchange rate volatility increases the unemployment rate. Using monthly percentage data on industrial countries from 1982 to 2003 and controlling for various factors. The magnitude of the effect is small but the results are robust. Andersen & Sørensen (1988) also link exchange rates and the unemployment rate. They discuss that if trade unions are strong, volatile exchange rates may lead to excessive wage hikes, lowering unemployment

## 5 Discussion of the Data Set

The purpose of this thesis is to examine different forces to see if they have an effect on the NOK/euro exchange rate. Our analysis is based on economic theory and previous research to select variables. As presented in previous research, there are variables that seem to have a substantial effect on the exchange rate. These include crude oil price, Norwegian CPI, euro area harmonized CPI, Nibor (3-month money market rate), Euribor (3-month money market rate), the Norwegian balance of trade and the Norwegian unemployment rate. All variables mentioned are deducted in the following sections, this is to create an understanding of the variables behavior and descriptive statistics.

### 5.1 Dependent variable

#### 5.1.1 NOK/euro exchange rate

The exchange rate is represented as NOK per 1 euro. Norges Bank's exchange rates are middle rates, the mid-point between buying and selling rates in the interbank market at a given time. The exchange rates are only intended to serve as an indication, and are not binding on Norges Bank or other banks (Norges Bank, 2016). The exchange rate is given as monthly average of daily values and is collected from Norges Bank.

Table 1 represents the descriptive statistics of the exchange rate (*E*).

**Table 1: Descriptive statistics of E**

| Variable | Observations | Min | Max | Average | Std. Err. |
|----------|--------------|-----|-----|---------|-----------|
| E        | 180          | 7.3 | 9.5 | 8.1     | 0.4       |

Figure 2 represents the development in the NOK/euro exchange rate for the time period 2001 - 2015. We observe from the graph that there have been major fluctuations. The NOK was its strongest against the euro in 2002 and reached nearly the same level in 2012. From 2008 we can see that the krone weakened substantially before changing trend in early 2009 where the krone appreciated until 2012. The last 3 years the NOK has depreciated considerably against the euro.

**Figure 2: NOK/euro exchange rate 2001-2015**



Source: Norges Bank

It is important to consider that, there is no single definitive krone exchange rate, since the exchange rate depends on the currency or basket of currencies against which the krone is measured. For instance, the krone may appreciate against the euro and depreciate against the dollar simultaneously.

## 5.2 Independent variables

### 5.2.1 Oil price

The price of oil is measured by per barrel of crude oil and is given in USD. The oil price is measured as monthly average and collected from the Federal Reserve Bank. Oil is the world's most actively traded commodity. It is used as a pricing benchmark because of its excellent liquidity and transparency (Trading Economics , 2016). Oil is one of the most important sources of energy in the world and a scarce resource.

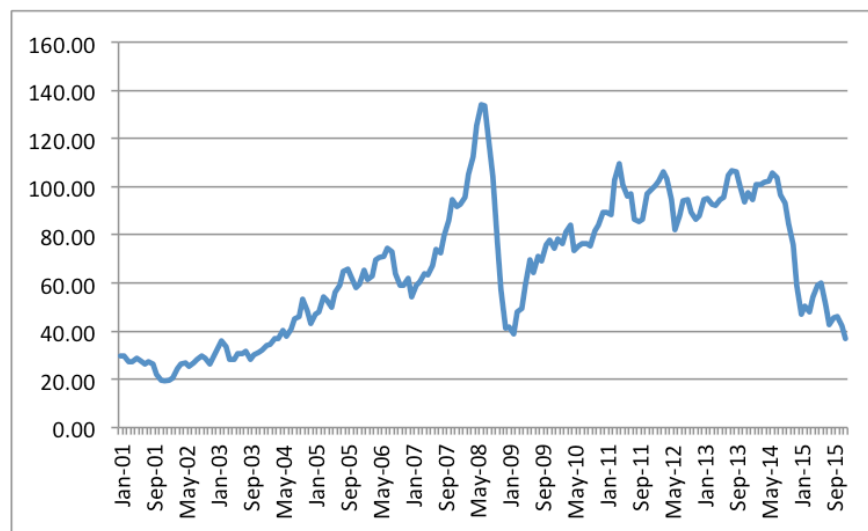
Table 2 represents the descriptive statistics of the oil price (*O*).

**Table 2: Descriptive Statistics of O**

| Variable | Observations | Min  | Max   | Average | Std. Err. |
|----------|--------------|------|-------|---------|-----------|
| <b>O</b> | 180          | 19.4 | 133.9 | 65.9    | 28.1      |

From Figure 3 we can see that the price of crude oil has varied to an extraordinary degree during the last decade. The price of oil had a clear increasing trend until June 2008, reaching its all-time monthly peak of \$133.8, before dropping to \$39.09 in the month of February 2009. The oil price had again an increasing trend from February 2009 until August 2013, since August the oil price has had a decreasing path leading to a low monthly average of \$37.19 in December 2015.

**Figure 3: Price of crude oil measured in USD 2001-2015**



Source: FRED

We believe that a sustained rise in oil prices will result in more favorable terms of trade for an oil-exporting country such as Norway. In isolation, this implies a strengthening of the Norwegian krone. Thus, having a negative relationship with the exchange rate against the euro as we pay fewer kroner per euro.

### 5.2.2 Norwegian consumer price index

The consumer price index (CPI) is a measure that examines the weighted average of prices of a basket of consumer goods and services. The purpose is to measure the actual development in the price trend of goods and services demanded by households (SSB, 2016). CPI is one of the main price indexes that measure inflation. Inflation is the rate at



which the general price level of goods and services is rising in a country. Hence, the rate at which the purchasing power of a country is falling (Melvin, 2000). The CPI is measured as the 12-month percentage change and is from SSB.

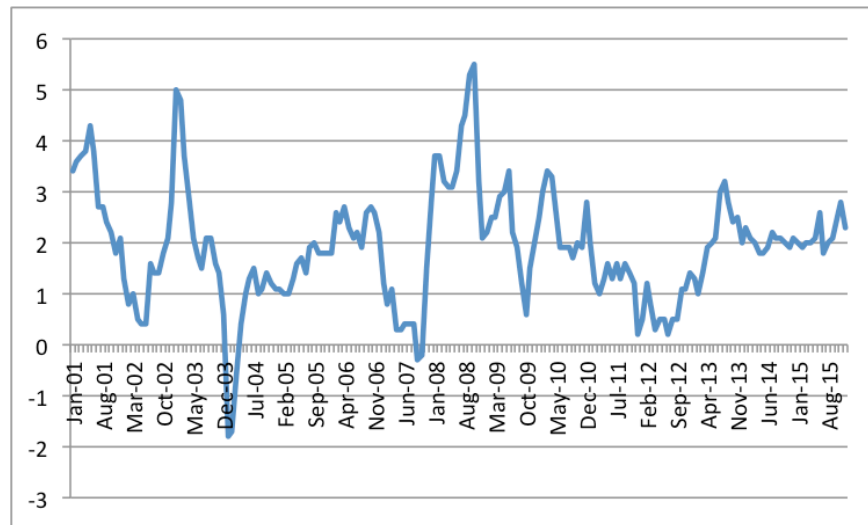
Table 3 represents the descriptive statistics of the Norwegian CPI (*P*).

**Table 3: Descriptive Statistics of P**

| Variable | Observations | Min  | Max | Average | Std. Err. |
|----------|--------------|------|-----|---------|-----------|
| <b>P</b> | 180          | -1.8 | 5.5 | 1.9     | 1.1       |

The variable Norwegian CPI depicts fluctuations. Reaching its lowest point of -1.8% in January 2004 and apex of 5.5% in October 2008. Since 2008 the Norwegian CPI has stabilized to some extent compared to earlier values as pictured in Figure 4 below.

**Figure 4: Norwegian CPI 12-month percentage change 2001-2015**



Source: SSB

CPI can be a measure of inflation reflecting a country's price level. We expect that if the Norwegian price levels increase the exchange rate will increase which means that the Norwegian krone will depreciate.

### 5.2.3 Euro area harmonized consumer price index

The primary purpose of the euro area harmonized consumer price index is international comparisons of prices and the data is collected from SSB. In 1991, the Maastricht Treaty adopted convergence requirements of the treaty enhancement of comparable consumer price indices for EU member states. An international collaboration started in 1993 where one wanted to get a comparable measure of inflation. The international cooperation where Norway also participated resulted in a concrete proposal on how a harmonized index of consumer prices should be prepared. It was first published in 1997. The euro area consists of the EU countries participating in the Eurozone: Austria, Belgium, Germany, Greece, Spain, France, Finland, Italy, Ireland, Netherlands, Portugal, Luxembourg, Cyprus, Malta, Slovakia, Slovenia, Estonia, Latvia and Lithuania. (SSB, 2016)

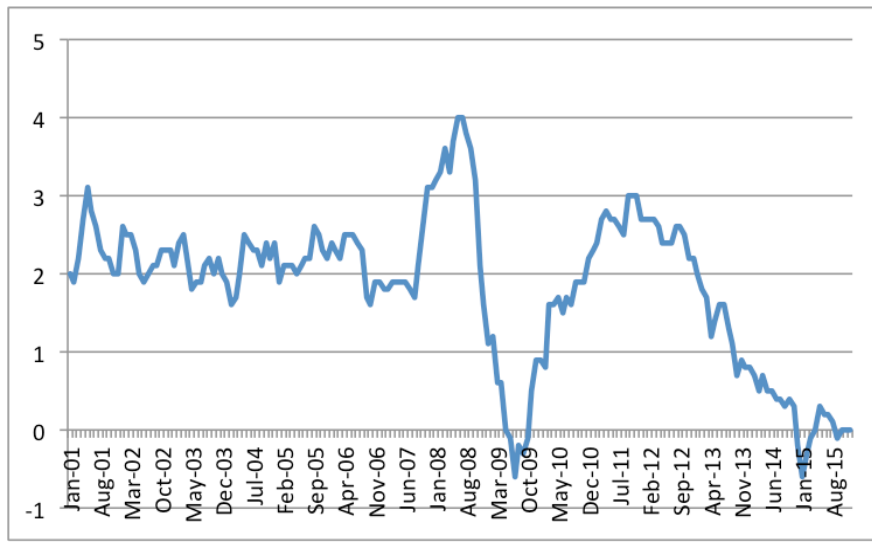
Table 4 represents the descriptive statistics of the euro area harmonized CPI ( $P^*$ ).

**Table 4: Descriptive statistics of  $P^*$**

| Variable | Observations | Min  | Max | Average | Std. Err. |
|----------|--------------|------|-----|---------|-----------|
| $P^*$    | 180          | -0.6 | 4.0 | 1.8     | 1.0       |

Illustrated in Figure 5, we find that the euro area harmonized index has experienced two major changes. First it reached a high point of 4% in June 2008 then dropping to -0,6% July 2009. Secondly, in August 2009 the CPI represent an increase until April 2011, before again dropping to -0,6% in January 2015.

**Figure 5: Euro area harmonized CPI 12-month percentage change 2001-2015**

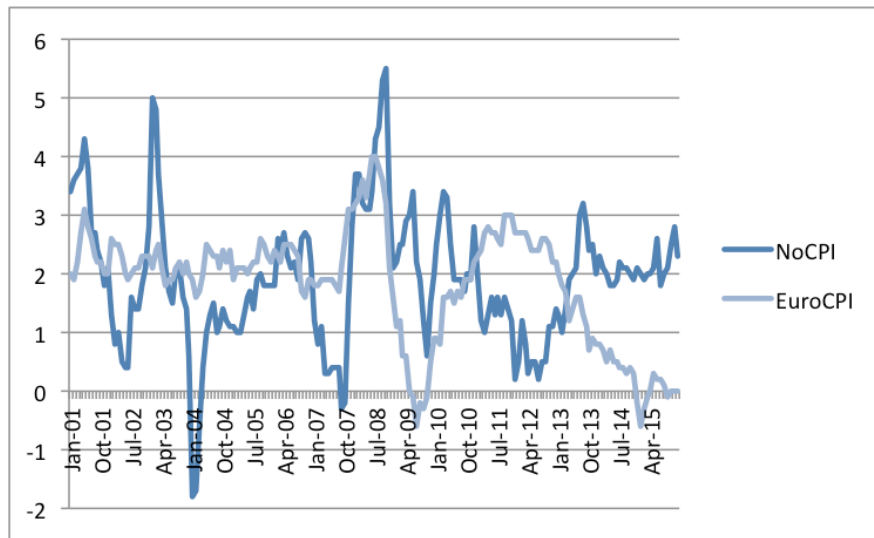


Source: SSB

The euro area harmonized CPI can be used as a measure of inflation in euro currency countries. We believe that a decrease in the index will cause the exchange rate to decrease in value causing the NOK to appreciate against the euro.

Figure 6 compares the differences in the Norwegian and the euro area CPI. There is somewhat a pattern between the indexes, the Norwegian CPI experiences more apparent extremes until February 2011. Then the indexes go on to move in opposite directions.

**Figure 6: Norwegian CPI vs euro area CPI**



Source: SSB

#### 5.2.4 Nibor 3-month money market rate

Nibor (Norwegian Interbank Offered Rate) is a collective term for Norwegian money market rates with different maturities, which should reflect the interest rate that the lender requires for an unsecured loan in Norwegian kroner with delivery in two days, "spot". The calculation agent is the Oslo Stock Exchange and the monthly data is collected from SSB. Nibor with 3-month maturity is widely used as reference rate in the professional market. The 3-month Nibor rates are not based on actual trades (Finans Norge, 2016).

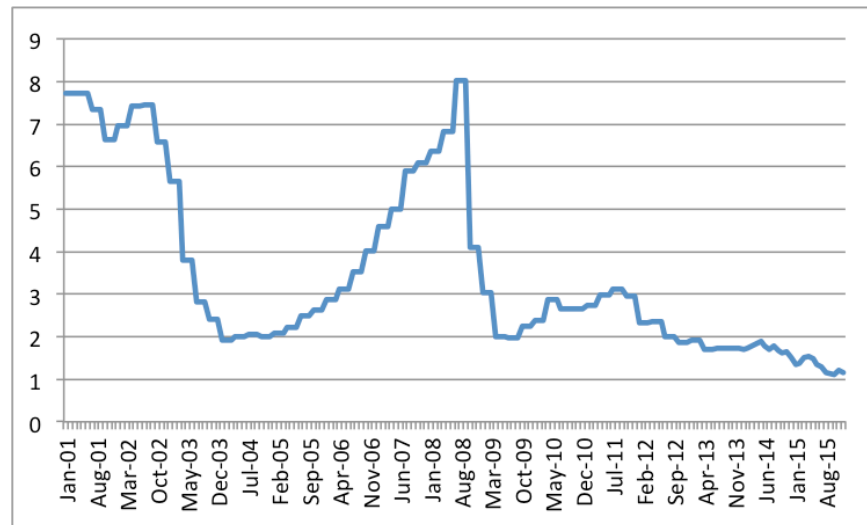
Table 5 represents the descriptive statistics of Nibor (*R*).

**Table 5: Descriptive Statistics of R**

| Variable | Observations | Min  | Max  | Average | Std. Err. |
|----------|--------------|------|------|---------|-----------|
| <b>R</b> | 180          | 1.11 | 8.03 | 3.50    | 2.06      |

The variable Nibor represents smooth amendments. As depicted in Figure 7, there are detected fluctuations that have appeared consistent. Nibor reached its highest monthly average in July 2008 at 8.03% and its lowest, within our data set, at 1.11% December 2015.

**Figure 7: Nibor 3-month money market rate 2001-2015**



Source: SSB

When interest rates are high, more people will invest and fewer will borrow in NOK. Appreciation of currency will normally be a consequence of high interest rates. With emphasis on this, we believe that if there is an increase in domestic interest rates relative the euro area, the NOK will appreciate.

### **5.2.5 Euribor 3-month money market rate**

The 3-months interest rate is a representative short-term interest rate series for the domestic money market. Euribor is the benchmark rate of the large euro money market that has emerged since 1999. It is the rate at which euro interbank term deposits are offered by one prime bank to another prime bank. The contributors to Euribor are the banks with the highest volume of business in the euro area money markets. The panel of banks consists of banks from EU countries participating in the euro from the outset, banks from EU countries not participating in the euro from the outset, and large international banks from non-EU countries but with important euro area operations (European Commission, 2016). The monthly data is calculated as averages of daily values collected from SSB.

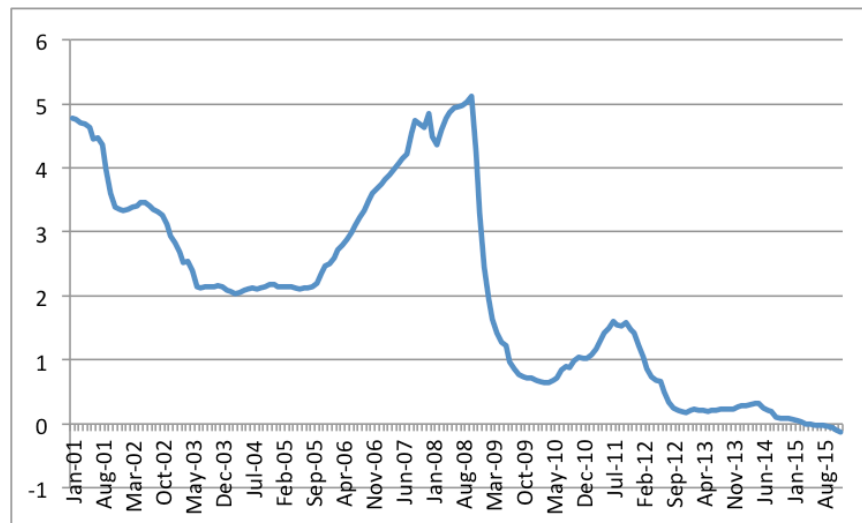
Table 6 represents the descriptive statistics of Euribor ( $R^*$ )

**Table 6: Descriptive Statistics of  $R^*$**

| Variable | Observations | Min   | Max  | Average | Std. Err. |
|----------|--------------|-------|------|---------|-----------|
| $R^*$    | 180          | -0.13 | 5.11 | 2.04    | 1.56      |

Figure 8 shows the development in Euribor. Euribor reached its peak in October 2008 at 5.11% before facing a declining trend where it hit its lowest point in December 2015 with a rate of -0.13%.

**Figure 8: Euribor 3-month money market rate 2001-2015**

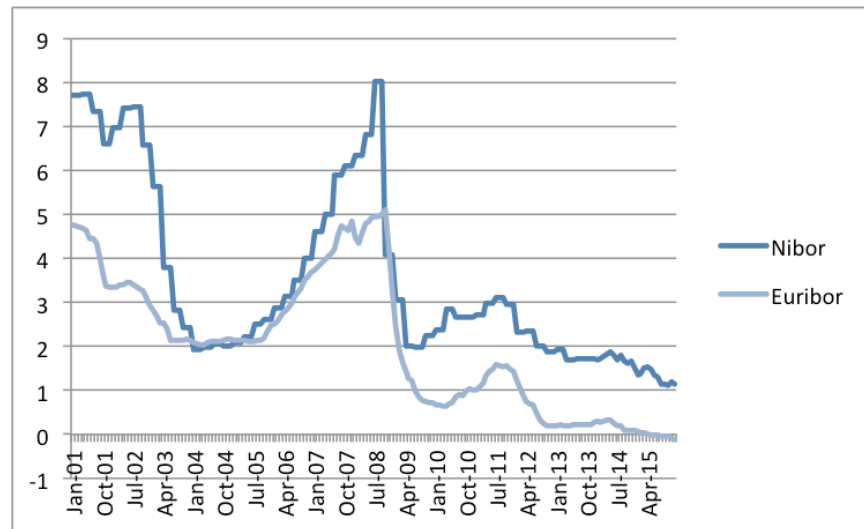


Source: SSB

We believe that if domestic Norwegian interest rates are higher than the euro area interest rates, the NOK will appreciate against the euro. Hence, there will be a negative relationship in our model.

Depicted in Figure 9 we can clearly see that Nibor and Euribor have similar trend, while Euribor near consistently has a lower rate than Nibor.

**Figure 9: Nibor vs Euribor**



### 5.2.6 Norwegian balance of trade

Balance of trade (BOT) is the difference between goods and services exported out of the country, and the goods and services imported into the country. If the amounts of a country's imports are higher than its amount of exports, the country has a trade deficit. Opposite, if the export is greater than the import, the country has a trade surplus (Library of Economics and Liberty , 2016). The monthly data is collected from SSB and calculated as the sum of the trading relationship between Norway and the nineteen countries using the euro.

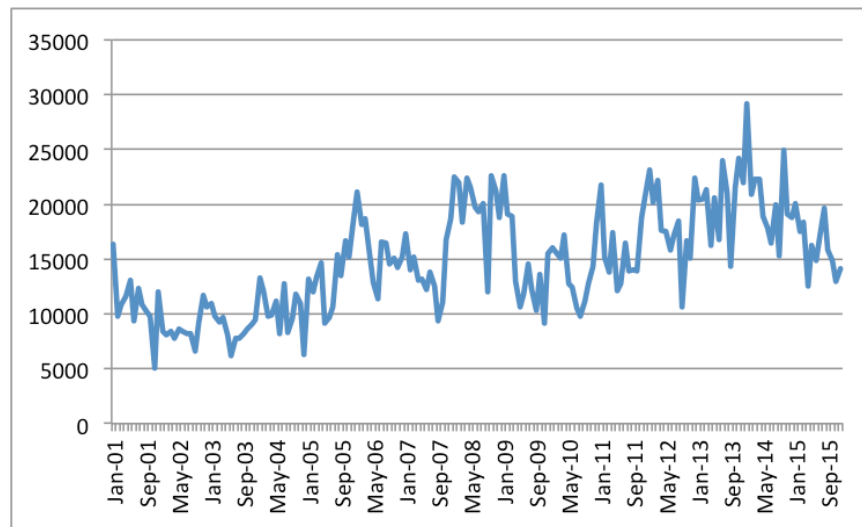
Table 7 represents the descriptive statistics of the Norwegian balance of trade with euro using countries ( $X$ ).

**Table 7: Descriptive Statistics of X**

| Variable | Observations | Min  | Max   | Average | Std. Err. |
|----------|--------------|------|-------|---------|-----------|
| X        | 180          | 5064 | 29228 | 14743   | 4696      |

The graph in Figure 10 brings forth an even increase in Norway's balance of trade with euro using countries. The increase reached its top level with a balance of 22 599 Norwegian kroner in October 2008, followed by a weak decline the later years.

**Figure 10: Norwegian balance of trade 2001-2015**



Source: SSB

Norway has a positive balance of a trade, which means that Norway exports more than it imports and that there is high demand for Norwegian goods. When demand is high, prices rise and we would imagine the NOK to appreciate with an increase in BOT.

### 5.2.7 Norwegian unemployment rate

Unemployment is the total labor force that is unemployed but are willing to work and actively seeking jobs. The unemployment rate is one of the most watched statistics because it is considered related to the economic state of a country. If the unemployment rate is rising it indicates a sign of weakening economy. Opposite, a falling rate might indicate a growing economy (Business Dictionary, 2016). The rate is retrieved from Eurostat and is represented as monthly averages from period 2001-2015.

Table 8 represents the descriptive statistics of the Norwegian unemployment rate ( $U$ ).

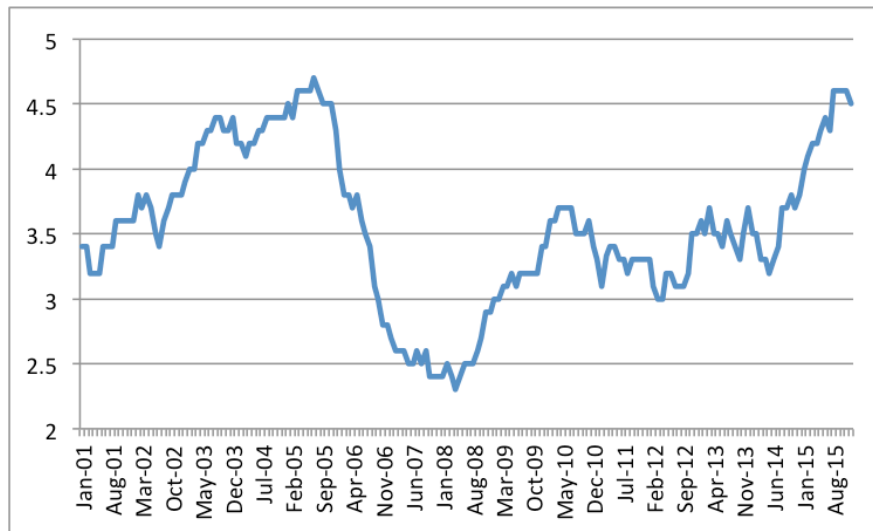


**Table 8: Descriptive statistics of U**

| Variable | Observations | Min | Max | Average | Std. Err. |
|----------|--------------|-----|-----|---------|-----------|
| U        | 180          | 2.3 | 4.7 | 3.6     | 0.6       |

The movements in the unemployment rate are depicted in Figure 11. It shows that Norway has had an overall stable unemployment rate with economic positive drop from 4.75 in July 2005 to 2.4% in October 2007. Since then there has been an increasing trend until our last observation.

**Figure 11: Norwegian unemployment rate 2001-2015**



Source: Eurostat

We chose to include this variable to investigate if productivity and stability measure would affect the NOK/euro exchange rate. A rise in the unemployment is a sign of weakening economy and can lead to cuts in interest rates. Lowering the interest rates will increase demand and thus increase prices. Low interest rates will normally result in a depreciation of currency. We believe that there should be a positive relationship between the unemployment rate and the exchange rate.

## 6. Empirical Theory

This chapter presents the research design and the strategic focus selected to answer the research questions efficiently. We will present tests to check the robustness of the models, in order to eliminate the chance of obtaining less efficient, biased and misleading estimates. Finally, we will present the Engle-Granger two-step approach and the steps included to build our model.

### 6.1 Hypothesis testing

Hypothesis testing is used to investigate whether the theory is supported by a sample of real world observations. It is almost impossible to prove if the given hypothesis is “correct”, but we can state that a particular sample conforms to a particular hypothesis. Even if we cannot prove that a given theory is “correct” by using hypothesis testing, we can reject a hypothesis with a certain level of significance. By hypothesis testing two hypothesis are derived, the null hypothesis  $H_0$  and the alternative hypothesis  $H_A$ . The null hypothesis is typically what the investigator does not expect in his research. The alternative hypothesis is the opposite, what the researcher typically expects.

(Studenmund, 2006)

To test if our variables from the dataset are affecting the development in the krone, we need to test them against the NOK/euro exchange rate, to check if there is a relationship. Here the null hypothesis will be that there is no relationship between the variables and the exchange rate. Based on earlier research we set our alternate hypothesis to be that there is a relationship between one or more of variables and the NOK/euro exchange rate.

(Studenmund, 2006)

### 6.2 Time series data

A times series data set consist of observations on a variable or several variables over time. Examples of time series data include stock prices, consumer prices index and gross domestic product. An important aspect of time series data is that past events can

influence future events and lags in behavior are prevalent in the social sciences. Opposed to cross-sectional data, the chronological ordering of observations in a time series conveys potentially important information. Economical observations can rarely, if ever, be assumed to be independent across time. Another feature of time series data that can require special attention is the data frequency at which the data are collected. The most common frequencies in economics are monthly, quarterly, and annually (Wooldridge, 2014).

### 6.3 Multiple regression analysis

A regression analysis is a tool that is well suited to analyze different economic phenomena. A simple regression model is used to study the relationship between two variables  $X$  and  $Y$ , where  $Y$  is the dependent variable, and  $X$  is the independent variable. The regression analysis illustrates how  $X$  can explain  $Y$ , or how  $Y$  varies with changes in  $X$ . A multivariate linear regression is an extended model that takes into account multiple  $X$  variables and is therefore more suitable for *ceteris paribus* analyses, where all other factors are kept constant. By using multiple  $X$  variables, a larger part of the variation in  $Y$  explained, and the model will thus receive a stronger explanatory power.

A multiple regression can be written as stated in equation 6.1

$$Y_t = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_k X_k + u_t \quad (6.1)$$

Where  $t = 1, 2, \dots, n$

$Y$  is the dependent variable,  $x$  is the independent variables which are believed to influence  $Y$ ,  $\beta_0$  is the intersection,  $\beta_{1,2,\dots,k}$  measuring changes in  $Y$  with respect to the corresponding  $X$  value, all other factors held constant and  $u$  is the error term (Wooldridge, 2014).

## 6.4 Regression Analysis with Time Series Data

### 6.4.1 Static models

Suppose that we have time series data available for two variables  $Y$  and  $Z$ , where  $Y_t$  and  $Z_t$  are dated contemporaneously. A static model will look as followed in equation 6.2.

$$Y_t = \beta_0 + \beta_1 Z_t + u_t, \quad t = 1, 2, \dots, n \quad (6.2)$$

A static model illustrates a continuous relationship between  $Y$  and  $Z$ . Typically a static model is postulated when a change in  $Z$  in period  $t$  is expected to have an immediate effect on  $Y$ . A static model is also used when we are interested in knowing if there is a trade-off between  $Y$  and  $Z$  (Wooldridge, 2014).

### 6.4.2 Ordinary least square with times series data

For the OLS estimates to be optimal, best linear unbiased estimates (BLUE), there are several conditions that need to be satisfied. In time series there are especially three conditions that should be held, these are no perfect multicollinearity, homoskedasticity and no serial correlation (Studenmund, 2006). An additional condition is Normal distribution of the error term (Wooldridge, 2014).

### 6.4.3 No perfect multicollinearity

Multicollinearity occurs whenever two or more of the independent variables in a multiple regression are moderately or highly correlated. Perfect multicollinearity implies a perfect linear relationship between the variables. This means that if there is a movement in one of the variables, the movement in the other variable will be identical. When this problem occurs, OLS will not be able to separate a variable from another, and thereby will not manage to estimate for the regression coefficients. The major consequences of multicollinearity are that estimates will remain unbiased, the variance and standard errors of the estimates will increase, the computed t-scores will fall, estimates will become very

sensitive to changes in specification, and the overall fit of the equation and the estimation of the coefficients of non-multicollinear variables will be largely unaffected (Studenmund, 2006). A way to assess the multicollinearity problem is to compute the variance inflation factor (VIF). VIF tells us to which extent the standard error of the coefficient of interest has been inflated upwards. A rule of thumb is that VIF exceeding 4 warrants further investigation, while VIFs exceeding 10 are signs of serious multicollinearity requiring correction (Penn State Eberly College of Science ). The simplest way to resolve a multicollinearity problem is to reduce the number of collinear variables until there is only one of them remaining in the set. It might be possible to identify one of the variables to be extraneous (Wooldridge, 2014).

#### **6.4.4 Homoskedasticity**

The homoskedasticity assumption states that the variance in the error term, conditional on the explanatory variables, is constant over time. If this does not hold, then the model exhibits heteroskedasticity, and OLS will not give the estimators with the lowest variance. OLS will then generate mismatched estimates of the standard deviations of the coefficients. There are several ways to test for heteroskedasticity. One test is a Breusch-Pagan test. The null hypothesis for such a test is that the error term has a constant variance, i.e. homoskedasticity. While alternative hypothesis is that the error term does not have constant variance, implying heteroskedasticity. We therefore wish to accept the null hypothesis, so we operate with homoskedasticity (Wooldridge, 2014).

#### **6.4.5 No autocorrelation**

When the errors are correlated across time we can say that the errors suffer from autocorrelation. This means that the expected value of correlation between two observations of the error term is not equal to zero. This causes the estimated coefficients to no longer be best linear unbiased estimators (BLUE). The standard error and variance thus becomes invalid. To test if the time series contains autocorrelation, a Durbin-Watson test can be performed. The Durbin Watson statistic will always be between the value of 0

and 4. The rule of thumb says the number is desired to be close to 2, a value of 2 is optimal and means that there is no autocorrelation in the sample. Values toward 0 and 4 would indicate positive autocorrelation and negative autocorrelation which both are undesirable for the sample (Wooldridge, 2014).

#### **6.4.6 Normality**

The assumption of normality states that the errors  $u_t$  are independent of  $X$  and are independently and identically distributed as Normal  $(0, \sigma^2)$ . To test for normality in the error terms a Skewness/Kurtosis test can be used. If the assumptions above hold, we can claim consistency of OLS. We can use the usual confidence intervals, t-statistics, and  $F$ -statistics as being approximately valid in large sample time series samples. Usual for large-sample time series analysis, we can dispense with the normality assumption entirely (Wooldridge, 2014). The normality assumption does not contribute to bias or inefficiency in regression assumption, there are few consequences associated with a violation of this assumption. It is only a consideration when the sample size is very small, that it is important for the calculation of  $p$ -values for significance testing (Statistics Solutions, 2013). When large samples are used, such as  $(n > 30)$  this assumption turns out to be relatively uncontroversial (Mordkoff, 2000).

#### **6.5 Stationarity**

The notion of stationary processes has played an important historical role in time series analysis. A stationary time series process has a probability distribution that is stable over time, this means that it does not follow any pattern and the variance and the mean do not change over time.

It is common that macroeconomic variables increase over time. Increasing variables are typically non-stationary variables (Mahadeva & Robinson, 2004). This type of non-stationarity is typically taking the form of the variable acting as though it were a “random walk”. The variable in a random walk is non-stationary because it has the ability to wander up and down without an inherent equilibrium, and without approaching a long

term mean (Studenmund, 2006). Series that may not increase over time but the effects of innovations do not die out with time are also examples of non-stationary variables.

A major problem with regressions that involve non-stationary variables is that the standard errors produced are biased. The bias means that it is not reliable to use conventional criteria to judge whether there is a casual relationship between the variables. In many cases you can see regressions that seem to give good fit and predicts a statistically significant relationship between variables where there actually doesn't exist any. This is called a spurious regression problem.

Using Unit root testing, for example an Augmented Dickey-Fuller helps minimizing the spurious regression problem. A frequent treatment to the problem of unit roots is to ensure that all of the variables are stationary, this by differencing or detrending of the variables, and then use resulting stationary process to estimate the equation of interest (Mahadeva & Robinson, 2004).

## **6.6 Transforming non-stationary time series**

Standard regression techniques, typically ordinary least squares (OLS), demand the variables to be covariance stationary. For a variable to be covariance stationary, its mean and all its autocovariances are finite and will not change over time (Stata).

Testing for cointegration is an essential step to check if the model contains empirical meaningful relationships. Cointegration is a necessary criterion for stationarity among non-stationary variables. The variables cannot stay in fixed long-run relation to each other if they have different trends implying no possibility to model the long run, and usually there is no valid base for inference based on standard distributions. If a model does not contain proof of cointegration a solution would be to work with variables in differences. Many economic time series tend to be “first difference stationary” instead of being covariance stationary. Being first difference stationary means that the level of a time series is not stationary but its first difference is if it has a unit root (Sjö, 2008).

### 6.6.1 Testing for cointegration

The natural first step in the formal analysis of cointegration is to test if the concept of cointegration is a characteristic of the data. The Engle-Granger approach is a two-step model where testing for cointegration is part of the first step. The notion of cointegration, which was given a formal treatment in Engle & Granger (1987), makes regressions involving I(1) variables potentially meaningful. I(1) denotes the non-stationary time series while I(0) denotes stationary time series.

### 6.6.2 Engle-Granger approach

The Engle-Granger approach has the assumption that if two variables are integrated of order one, I(1), they might be cointegrated, and the unknown cointegration coefficient  $\beta_1$  has to be inferred from the data.

Running an OLS regression like shown in equation (6.3) is first step in the Engle-Granger approach.

$$y_{1,t} = \beta_1 y_{2,t} + e_t \quad (6.3)$$

From equation (6.3)  $\hat{e} = y_{1,t} - \hat{\beta}_1 y_{2,t}$  is the error term that would be stationary if  $y_{1,t}$  and  $y_{2,t}$  are cointegrated. Estimating the equation (6.3) using OLS achieves a consistent estimate for the long-run relationship between  $y_{1,t}$  and  $y_{2,t}$ , and all the dynamics and endogeneity issues can be ignored asymptotically. This occurs because of what is called the “super consistency” property of the OLS estimator when the series are cointegrated. If two variables are independent and non-stationary, running an OLS regression would give us a spurious result, as explained in section 6.5. If two variables are non-stationary, but cointegrated, the regression will not be spurious.

The Engle-Granger approach proceeds by testing whether or not the estimated residual  $\hat{e}_t$  is stationary. Employing a unit root test on the estimated residuals tests this. A standard test for this is the Augmented Dickey Fuller test (ADF) shown in equation (6.4) where a constant is added to ensure that the residual has a mean of zero. If  $\mu = 0$  then



$\Delta \hat{e}_t = \eta_t$  which implies that  $\hat{e}_t = \hat{e}_{t-1} + \eta_t$ , which is a random walk and thereby non-stationary. The following hypothesis is thereby  $H_0: \mu = 0$  versus  $H_A: \mu < 0$ . The null hypothesis is no cointegration, and a rejection of the null hypothesis is evidence in favor of cointegration.

$$\Delta \hat{e}_t = \alpha + \sum_{p=1}^p \theta_p \Delta \hat{e}_{t-p} + \mu \hat{e}_{t-1} + \eta_t \quad (6.4)$$

The first step in the Engle-Granger approach establishes if there is evidence of cointegration. If the I(1) variables are cointegrated one can proceed to the second step and use the estimated cointegrated relationship as an observable variable in an error correction model (Bjørnland & Thorsrud, 2014).

### 6.6.3 Error correction model

When cointegration exists, it is common to think about equation (6.3) as describing a long-run equilibrium relationship. This relationship describes how two variables drift upwards together. Under the maintained assumption of cointegration,  $e_t$  is stationary. In the short term the variables may deviate temporarily from the long-run equilibrium relationship. A natural question would be how is the long-run equilibrium maintained? Turning to Granger representation theorem is a common approach. The Granger representation theorem states that two variables cointegrate if and only if there exists an error correction form model for either of the variables, or all. A simplified representation of the error correction model is shown in equation (6.5). The error correction term is defined by  $ECM_{t-1} = (y_{1,t-1} - \beta_1 y_{2,t-1})$ .

$$\Delta y_{1,t} = \beta_1 \Delta y_{2,t} - (1 - \theta_1)(y_{1,t-1} - \beta_1 y_{2,t-1}) + \varepsilon_t \quad (6.5)$$

The error correction term can be stated in a more general form as represented in (6.6)

$$a(L)\Delta y_{1,t} = b(L)\Delta y_{2,t} - \gamma(y_{1,t-1} - \beta_1 y_{2,t-1}) + \varepsilon_t \quad (6.6)$$

Where the model allows for the general dynamic structure (in the lag polynomials  $a(L)$  and  $b(L)$ ) to be determined by the data. If  $y_{1,t}$  and  $y_{2,t}$  are  $I(1)$  and cointegration between them exists, then all terms in equation (6.6) are  $I(0)$  and statistical inference using standard  $t$ - and  $F$ -test are applicable (Bjørnland & Thorsrud, 2014).

## 7 Empirical Results

In this part of the thesis, we will present the results of the regressions that have been performed in STATA. We conduct an Engle-Granger two-step procedure to achieve an understanding of the independent variables long and short-run effects on the NOK/euro exchange rate. We also test our model to see if it passes typical specification tests for time series analysis.

### 7.1 Choice of variables

After careful consideration through studying previous research and economic theory, we find it appropriate to include six different variables, which we believe can have an affect on the NOK/euro exchange rate. The number of observations is 180, using monthly data from January 2001 until December 2015.

Our variables are as presented in the discussion of the data set:  $(e)$ ,  $(o)$ ,  $(P)$ ,  $(P^*)$ ,  $(R)$ ,  $(R^*)$ ,  $(x)$  and  $(U)$ . In our estimation we have chosen to represent the  $(R)$  and  $(R^*)$  as the spread of these two variables. The dependent variable is  $e = \log$  of the exchange rate, and the independent variables are  $o = \log$  of oil price,  $P =$  Norwegian CPI 12-month change,  $P^* =$  euro harmonized CPI 12-month change,  $(R - R^*) =$  Nibor - Euribor,  $x = \log$  of Norwegian balance of trade and  $U =$  Norwegian unemployment rate. We have represented level terms as natural logarithms in our estimation.

### 7.2 Stationarity

By conducting an Augmented Dickey-Fuller test, we examine if the data is stationary. The variables are typical macroeconomic figures and thereby commonly have a natural trend, which will determine them non-stationary. If the  $p$ -value is low (typically  $P < 0.05$ ) we can reject the null hypothesis.

$H_0 =$  Stationary

$H_A =$  Non-stationary

From the results in Table 9 we observe that for variable ( $e$ ), ( $o$ ), ( $P$ ), ( $P^*$ ) and ( $U$ ), the null hypothesis for the dataset cannot be rejected, and thereby we determine the data to be non-stationary. Variable ( $x$ ) is significant, stating that there is proof for stationarity. We know that the variables are sensitive, employing a stricter stationarity test we find it to be non-stationary, we choose to move forward in our analysis with the assumption of balance of trade ( $x$ ) being a non-stationary variable when testing the level data.

**Table 9: Stationarity test on level data**

| Variable    | t-stat | DF critical test p-value | Result         |
|-------------|--------|--------------------------|----------------|
| <b>e</b>    | -0.997 | 0.754                    | non-stationary |
| <b>o</b>    | -1.443 | 0.561                    | non-stationary |
| <b>P</b>    | -3.562 | 0.007                    | non-stationary |
| <b>P*</b>   | -1.272 | 0.642                    | non-stationary |
| <b>R-R*</b> | -2.840 | 0.053                    | non-stationary |
| <b>x</b>    | -5.021 | 0.000                    | stationary     |
| <b>U</b>    | -0.814 | 0.815                    | non-stationary |

By using the first difference on each variable and testing for stationarity, we are able to prove all of them to be significant, hence rejecting the null hypothesis claiming them to be non-stationary. The stationarity feature is proved at their first differences in Table 10. This leads us to claim all of our variables to be integrated at order one (I(1)).

**Table 10: Stationarity test on first differences**

| Variable                         | t-stat | DF critical test p-value | Result     |
|----------------------------------|--------|--------------------------|------------|
| <b><math>\Delta e</math></b>     | -10.21 | 0.00                     | stationary |
| <b><math>\Delta o</math></b>     | -9.35  | 0.00                     | stationary |
| <b><math>\Delta P</math></b>     | -10.21 | 0.00                     | stationary |
| <b><math>\Delta P^*</math></b>   | -11.23 | 0.00                     | stationary |
| <b><math>\Delta R-R^*</math></b> | -15.76 | 0.00                     | stationary |
| <b><math>\Delta x</math></b>     | -21.39 | 0.00                     | stationary |
| <b><math>\Delta U</math></b>     | -12.82 | 0.00                     | stationary |

### 7.3 First step of Engle-Granger two-step approach

The Engle-Granger procedure consists of two steps. Although other lags are possible, we choose one lag and the Engle-Granger two-step approach includes this in Stata. The first step establishes if there is evidence of cointegration. If the I(1) variables are cointegrated we can interpret the long-run relationship and proceed to the second step using the estimated cointegrated relationship as an observable variable in an error correction term.

The first step of the two-step Engle-Granger approach is as followed in equation (7.1):

$$e_t = \beta_0 + \beta_1(o_t) + \beta_2(P_t) + \beta_3(P_t^*) + \beta_4(R_t - R_t^*) + \beta_5(x_t) + \beta_6(U_t) + \varepsilon_t \quad (7.1)$$

The dependent variable ( $e$ ) is regressed on a constant, ( $o$ ), ( $P$ ), ( $P^*$ ), ( $R-R^*$ ), ( $x$ ) and ( $U$ ). We achieve an explanatory power  $R^2$  of 0.668. Meaning that the independent variables explain nearly 67% of the monthly movements in the exchange rate. The output from regressing (7.1) can be interpreted as the long-run relationship is represented in Table 11. Interpretation of the long-run relationship is valid if we find proof of cointegration

**Table 11: Regression output on equation 7.1**

| Variable    | $\beta$ | Std. Err. | t      | P> t |
|-------------|---------|-----------|--------|------|
| <b>o</b>    | -0.052  | 0.008     | -6.74  | 0.00 |
| <b>P</b>    | 0.013   | 0.002     | 5.50   | 0.00 |
| <b>P*</b>   | -0.033  | 0.003     | -12.65 | 0.00 |
| <b>R-R*</b> | -0.030  | 0.003     | -10.84 | 0.00 |
| <b>x</b>    | 0.021   | 0.011     | 1.96   | 0.05 |
| <b>U</b>    | -0.022  | 0.091     | -4.30  | 0.00 |

After regressing (7.1), we store the residuals and further check for cointegration by testing the stored residuals for stationarity. If we find the stored residuals to be stationary, there is proof in favor of cointegration among the variables. An Augmented Dickey-Fuller test is used.

$H_0$  = No cointegration

$H_A$  = Cointegration

**Table 12: Stationarity test on residuals**

| Variable   | t-stat | DF critical test - P value | Result     |
|------------|--------|----------------------------|------------|
| $\epsilon$ | -4.262 | 0.001                      | Stationary |

In Table 12 we observe the  $p$ -value to be 0.001. This claims the residuals to be significant, and we succeed in rejecting  $H_0$ . By rejecting  $H_0$  we have evidence in favor of cointegration

### 7.3.1 Validation of model (7.1)

In this section we execute different model specification tests. The model is examined for the assumptions of no perfect multicollinearity, homoscedasticity, no autocorrelation and normally distributed error terms.

#### 7.3.1.1 No perfect multicollinearity

To investigate the problem of multicollinearity we estimate the variance inflation factor (VIF) in Stata

**Table 13: Variance inflation factor**

| Variable        | VIF  | 1/VIF |
|-----------------|------|-------|
| <b>O</b>        | 2.42 | 0.41  |
| <b>P</b>        | 1.15 | 0.87  |
| <b>P*</b>       | 1.15 | 0.87  |
| <b>R-R*</b>     | 1.39 | 0.72  |
| <b>X</b>        | 2.19 | 0.46  |
| <b>U</b>        | 1.68 | 0.60  |
| <b>Mean VIF</b> | 1.66 |       |

As previously stated in section 6.4.3, the “rule of thumb” for when to be concerned with multicollinearity is when the VIF is 4 and above. The output in Table 13 asserts no sign of a problem with multicollinearity in the model. This makes OLS able to separate the variables from one another and manage to estimate the regression coefficients.

### 7.3.1.2 Homoskedasticity

To verify if the assumption of homoskedasticity holds we use a Breusch-Pagan test.

$H_0$  = Homoskedasticity

$H_A$  = Heteroskedasticity

**Table 14: Breusch-Pagan test**

|                     |        |
|---------------------|--------|
| <b>Chi2(1)</b>      | 1.00   |
| <b>Prob&gt;Chi2</b> | 0.3183 |

From the results in Table 14 we observe that the null hypothesis cannot be rejected. Rejection of  $H_0$  states the model to have constant variance in the error term and thereby avoiding the problem of heteroskedasticity. Claiming the model to be homoscedastic implies that OLS will give estimators with the lowest variance. To ensure this we also need to investigate the assumption of no autocorrelation before claiming the model to be BLUE.

### 7.3.1.3 No Autocorrelation

When testing for autocorrelation we achieve a Durbin-Watson statistic of 0,43. This value is not close to the “rule of thumb” value of 2. Our model displays signs of positive autocorrelation and cannot be claimed BLUE. Although the model shows signs of autocorrelation, this is a common problem with time series data and we choose to continue with our estimation.

### 7.3.1.4 Normality

To investigate if our data sample has normal distributed error terms we use a Skewness/Kurtosis test.

$H_0$  = Normal distribution

$H_A$  = No normal distribution

**Table 15: Skewness/Kurtosis test**

| Variables  | Pr(Skeweness) | Pr(Kurtosis) | adj<br>chi2(2) | Prob>chi2 |
|------------|---------------|--------------|----------------|-----------|
| $\epsilon$ | 0.142         | 0.021        | 7.00           | 0.031     |

We found the residuals to be significant at 95% confidence level, as stated in Table 15, thus rejecting  $H_0$ . There is no proof for normal distribution in our data sample, which is not a serious problem in a data set containing 180 observations.

### 7.4 Second step of Engle-Granger two step approach

As we discovered proof of cointegration in our data sample we could proceed to the second step in Engle-Granger's model and use the estimated cointegrated relationship as an observable variable in an error correction term.

In the second step the first difference of the dependent variable is regressed on the lagged level of the differences and on the error correction term. This is to estimate the short-term dynamic of the model, as well as the adaption toward the long-term equilibrium exchange rate. The model is as stated in equation (7.2). Where  $u_t$  is the error term and the error correction term is  $ect_{t-1}$ .

$$\Delta(e_t) = \alpha_0 + \alpha_1 \Delta(e_{t-1}) + \alpha_2 \Delta(o_{t-1}) + \alpha_3 \Delta(P_{t-1}) + \alpha_4 \Delta(P_{t-1}^*) + \alpha_5 \Delta(R_{t-1} - R_{t-1}^*) + \alpha_6 \Delta(x_{t-1}) + \alpha_7 \Delta(U_{t-1}) + \theta ect_{t-1} + u_t \quad (7.2)$$

$$ect_{t-1} = e_{t-1} - \beta_0 + \beta_1(e_{t-1}) + \beta_2(o_{t-1}) + \beta_3(P_{t-1}) + \beta_4(P_{t-1}^*) + \beta_5(R_{t-1} - R_{t-1}^*) + \beta_6(x_{t-1}) + \beta_7(U_{t-1})$$



**Table 16: Regression output on equation 7.2**

| Variables            | $\beta$ | Std. Err | t     | P> t |
|----------------------|---------|----------|-------|------|
| ect_11               | -0.073  | 0.042    | -1.75 | 0.08 |
| $\Delta o_{11}$      | -0.010  | 0.016    | -0.63 | 0.53 |
| $\Delta P_{11}$      | -0.003  | 0.002    | -1.20 | 0.23 |
| $\Delta P^*_{11}$    | -0.002  | 0.005    | -0.46 | 0.64 |
| $\Delta(R-R^*)_{11}$ | -0.002  | 0.003    | -0.73 | 0.46 |
| $\Delta x_{11}$      | -0.005  | 0.005    | -0.92 | 0.36 |
| $\Delta U_{11}$      | 0.006   | 0.011    | 0.60  | 0.55 |

A negative and statistically significant coefficient on the error term supports the hypothesis of cointegration, and gives information about the speed of correction. We would like to eliminate the insignificant variables and proceed with a preferred model including only significant variables. But as stated in Table 16 none of our step two variables are significant, so we cannot estimate a preferred equation and thereby end our analysis.

#### **7.4.1 Validation of model (7.2)**

Equivalent model specification tests for (7.1) are also conducted for model (7.2). The results are provided in this section.

##### **7.4.1.1 No perfect multicollinearity**

We investigate the problem of multicollinearity by estimation the variance inflation factor in Stata.

**Table 17: Variance inflation factor**

| Variable             | VIF  | 1/VIF |
|----------------------|------|-------|
| $\Delta o_{11}$      | 1.24 | 0.81  |
| $\Delta P_{11}$      | 1.13 | 0.89  |
| $\Delta P^*_{11}$    | 1.22 | 0.82  |
| $\Delta(R-R^*)_{11}$ | 1.14 | 0.88  |
| ect <sub>11</sub>    | 1.11 | 0.90  |
| $\Delta x_{11}$      | 1.05 | 0.96  |
| $\Delta u_{11}$      | 1.03 | 0.97  |
| <b>Mean VIF</b>      | 1.13 |       |

A mean VIF of 1.13, stated in Table 17, affirms no sign of a problem with multicollinearity.

#### 7.4.1.2 Homoskedasticity

We use a Breusch-Pagan test to inspect if the assumption of homoskedasticity holds.

$H_0$  = Homoskedasticity

$H_A$  = Heteroskedasticity

**Table 18: Breusch-Pagan test**

|                     |       |
|---------------------|-------|
| <b>Chi2(1)</b>      | 2.83  |
| <b>Prob&gt;Chi2</b> | 0.093 |

Interpreting the results in Table 18, we avoid the problem of heteroskedasticity by failing to reject  $H_0$ .

#### 7.4.1.3 No Autocorrelation

Performing a Durbin-Watson test for autocorrelation we obtain a Durbin Watson statistic of 1.53. This is not close to the optimal value of 2, therefrom we claim the model to exhibit a concern of autocorrelation. Accordingly we claim model (7.2) to not be BLUE.

Although the model indicates a problem concerning autocorrelation, this is a common problem with time series data and we choose to continue with our model.

#### 7.4.1.4 Normality

To examine our data sample for normal distributed error terms, we use a Skewness/Kurtosis test.

$H_0$  = Normal distribution

$H_A$  = No normal distribution

**Table 19: Skewness/Kurtosis tests**

| Variables | Pr(Skeweness) | Pr(Kurtosis) | adj<br>chi2(2) | Prob>chi2 |
|-----------|---------------|--------------|----------------|-----------|
| <i>u</i>  | 0.001         | 0.002        | 16.12          | 0.001     |

Considering the results stated in Table 19, we reject  $H_0$  in favor of  $H_A$ . Our model detects no normally distributed errors, however it is not a serious problem regarding the size of the data set.

## **8. Discussion of Empirical Results**

In this part of the thesis we will discuss the outcomes from the Engle-Granger two-step approach. We will discuss each variable's significance and effect from our model output against our original expectations from economic theory and previous research. Then we will review our results in light of the purchasing power parity and uncovered interest parity theorems.

### **8.1 Discussion of Engle-Granger output as a whole and on variables**

Measured by the determination coefficient ( $R^2$ ), the Engle-Granger approach explains 67 percent of the monthly movements in the Norwegian krone exchange rate in the period 2001-2015. In the first step of the two-step Engle-Granger procedure we found proof in favor of cointegration meaning that the long-run relationship can be interpreted. We find all our explanatory variables to be significant in the long-term solution for the exchange rate. In the second step we try to determine the short-run dynamic in the model as well as how swiftly the krone exchange rate moves towards long-run equilibrium when it deviates from this. The coefficient on the error term informs us of the speed of correction. This coefficient should be negative and have a value between -1 and 0, if not, a long-term equilibrium level will never be achieved. In our model the coefficient is -0.073 which means that 7.3 percent of a deviation of 1 percent from the long-term equilibrium adjusts back each month. The error term is significant at a 90% level and we claim the adjustment to be valid. The coefficients on our explanatory variables say something about the effect of a lagged variable change on the exchange rate. However none of the explanatory variables are significant within an acceptable confidence level and we cannot proceed to optimize our model by elimination of insignificant variables.

#### **8.1.1 Oil price**

In the Engle-Granger approach we find the oil price to be a significant variable at a 95% confidence level in a long-run relation to the exchange rate. This is consistent with earlier research, both Bjørnstad & Jansen(2006) and Bernhardsen & Røysland(2000) found the oil price to play a role in the movements of the Norwegian krone. ( $o$ ) is measured as the natural logarithm of oil price, thus we can interpret the result as elasticity. Stated in Table

11, a negative coefficient on ( $o$ ) implies that a sustained increase in the oil price of 1 percent will lead to a real appreciation of the krone of 0.05 percent. Hence, having a negative relationship with the exchange rate as we pay fewer kroner per euro. Although there is uncertainty associated with the exact relationship between the oil price and NOK/euro exchange rate, the effect is consistent with what we would expect from theory.

We also find the coefficient to be negative when testing for the short-run relation, represented in Table 16. The coefficient on a lagged change in ( $o$ ), ( $\Delta o_{II}$ ) states that an effect of a 1 percent change in ( $o$ ) in the previous period provides a negative effect of 0.01 percent in a change in the exchange rate. In our estimation this is interpreted as an appreciation of the NOK. However we cannot determine ( $\Delta o_{II}$ ) to have an effect on the exchange rate in the short-run deviation from the long-run equilibrium level, as the  $p$ -value claims it to be insignificant.

### **8.1.2 Norwegian CPI**

The Norwegian CPI ( $P$ ) level can be used to measure the inflation by reflecting the Norwegian price levels. Theory predicts that if price levels increase it will cause currency depreciation. While research states that more commonly, inflation will have a significant negative effect than a significant positive effect on an exchange rate.

In the first step of the Engle-Granger approach we claim the long-run relation valid considering the  $p$ -value. Finding the variable ( $P$ ) significant and to have a positive sign. Our model states that a 1 percent permanent increase in ( $P$ ) will cause a depreciation of the krone of 1.3 percent in the long run, represented in Table 11. The estimated coefficient has the right sign in view of what we would expect from the relationship between inflation and exchange. The positive sign is also consistent with research by Bjørnstad & Jansen (2006) and Bernhardsen & Røysland(2000).

In the second step of the Engle-Granger approach we try to determine the short-term effect of a lagged change in ( $P$ ), ( $\Delta P_{II}$ ), on the exchange rate if there is a deviation from

the long-term equilibrium level. Our model predicts that a 1 percent increase in (P) the previous month affects the exchange rate with a negative relation of 0.3 percent. Considering our estimation this is understood as an appreciation of the NOK. The effect is represented in Table 16. We estimate the coefficient of ( $\Delta P_{II}$ ) to be insignificant and cannot find proof of the short-run effect. If ( $\Delta P_{II}$ ) was significant the adjustment of the Norwegian CPI to the equilibrium level exchange rate is a process that is slow and there is a great difference in the long and short-run coefficients.

### **8.1.3 Euro area harmonized CPI**

The variable euro area harmonized CPI ( $P^*$ ) can be a measure of inflation in euro currency countries. In our model this is what we try to depict. From theory we believe that a decrease in the foreign price level will cause the exchange rate to decrease in value causing the NOK to appreciate against the euro in the long run.

From the first step in the Engle-Granger approach, as stated in Table 11, we can determine the variable ( $P^*$ ) significant in a long-run relationship. This means that there is a causal relationship between ( $P^*$ ) and the exchange rate. Determining ( $P^*$ ) significant suggests that a sustained increase in ( $P^*$ ) of 1 percent will lead to a real appreciation of the Norwegian krone of 3.3 percent. This is consistent with findings in Bernhardsen & Røisland(2000). We would expect an increase in the foreign index to lead the exchange rate to decrease in value causing the NOK to appreciate against the euro.

The variable appears in Table 16, in the output on the second step in the Engle-Granger approach, to have a negative coefficient. A negative coefficient implies an appreciation of the NOK. This is also harmonized with the beliefs originating from theory. The  $p$ -value states that the variable is not significant at a 95 % confidence level, leading us to declare it insignificant. No evidence of a 1 percent change in ( $P^*$ ) in the former period having a negative effect of 0.3 percent in the short run on the exchange rate is proved.

#### **8.1.4 Interest rate differential (Nibor-Euribor spread)**

The purpose of including the Nibor-Euribor spread ( $R-R^*$ ) was to enhance the interest rate differential effect on the exchange rate. Suggested from theory, if the 3-month money market rates differ, an increase in interest rates domestically, will lead to an appreciation of the Norwegian krone.

From the first step in the Engle-Granger approach we estimate the interest rate differential to be significant in a long-run relationship. Bjørnstad & Jansen (2006) also find support of this. From the coefficient stated in Table 11, a 1 percent permanent increase in the ( $R-R^*$ ) will cause a real appreciation of the krone of 2.9 percent. This symbolizes that if there is a permanently higher increase in the domestic interest rates relative to the euro area the krone will increase its purchasing power compared to the euro. This consists with our beliefs from research by Kloster, Lokshall & Røisland (2003) about ( $R-R^*$ ) effect on the NOK/euro exchange rate.

We test the interest differentials short-run effect in the second step of the Engle-Granger approach. Here we find that a 1 percent increase in the lagged change of the interest rate differential ( $\Delta(R-R^*)_11$ ) is shown to have a negative effect on the change in the exchange rate with 0.02 percent. The negative coefficient entails and appreciation of the NOK. This is however not significant in the results from Table 16. We have no proof a short-run relation of the previous periods effect on the current exchange rate.

#### **8.1.5 Norwegian balance of trade**

Norway exports more than it imports, which means that there is a high demand for its goods and thus for its currency. When demand is high, prices rise, hence, the currency should appreciate. This is the effect that we wished to prove when including this variable.

In the first step of the Engle-Granger approach we find the explanatory variable balance of trade ( $x$ ) to be significant in a long-term relation to the exchange rate. The variable has a positive coefficient, which implies that an increase in the balance of trade will affect the

Norwegian krone value negatively. This consists with findings in Lane & Milesi-Feretti (2002), they also find evidence of the balance of trade having a negative long-term relation to the exchange rate. ( $x$ ) is measured as the natural logarithm of the Norwegian balance of trade, thus we can interpret the regression output on (7.1) as an elasticity. Stated in Table 11, a 1 percent increase in the balance of trade with euro using countries will lead to a depreciation of the NOK of 0.02 percent. The positive coefficient is not what we would expect regarding theory. We do not find the effect of high demand of export increasing the currency demanded and thereby its value.

Referring to the second step in Engle-Granger we find the balance of trade coefficient in Table 16 to be negative and confirming our beliefs in reference to theory. The effect is opposite the results in the first step. A lagged first difference of ( $x$ ), ( $\Delta x_{-1}$ ) states that an effect of a 1 percent change in ( $x$ ) in the previous period provides a negative effect of 0.05 percent change in the exchange rate. The negative coefficients suggests and appreciation of the NOK. The  $p$ -value is 0.35 and we cannot claim the effect valid. Thereby we cannot prove a short-run relation if there is a deviation from the long-run equilibrium level on the exchange rate.

### **8.1.6 Unemployment rate**

Our choice to include this variable in the model was to see if a productivity and stability measure would reflect in the Norwegian exchange rate. A rise in the unemployment rate is a sign of a weakening economy and can initiate cuts in interest rates. A cut in interest rates will increase demand and thus increase prices. Depreciation of the currency will normally be a consequence of low interest rates.

Testing for a long-run relationship in the first step of the Engle-Granger approach the variable unemployment rate appears to be significant on a 95% confidence level. A negative coefficient implies that a 1 percent increase in the unemployment rate will provide an appreciation of the krone with 2.2 percent in the long run as stated in Table 11. Our results from this model do not consist with our expectations of a depreciation of



the NOK. The negative coefficient implies Norwegians paying less per euro, and an appreciation of the NOK.

From the second step in the Engle-Granger approach, Table 16 cites that the coefficient has a positive sign and would confirm our belief about the variable in a short-run relation. Although an insignificant variable,  $(\Delta U_{II})$  states that an effect of a 1 percent change in  $(U)$  in the previous period provides a positive effect of 0.06 percent on a change in the exchange rate. The positive coefficient would signify a depreciation of the NOK. We are also critical to our choice of variable for a productivity measure and believe that this variable does not estimate a good representation of the effects we wished to prove.

## **8.2 Discussion of empirical results in light of PPP**

If trade exists and capital can move freely between two countries, it is difficult to imagine that prices of tradable goods could be substantially different in different countries over time. We find in the first step of the Engle-Granger approach that the price levels in Norway and the euro area are significant variables from equation (7.1) represented in Table 11. For absolute PPP to hold  $\beta_2 = -\beta_3$ . Interpreting the coefficients in model (7.1),  $\beta_2 = 0.01$  and  $\beta_3 = -0.03$ , thereby we do not find an indication of the theory to hold. Another way to envision this is that since a change in our other explanatory variables will change the exchange rate, we can say that the exchange rate is not in constant equilibrium such as when there is equal purchasing power for two countries. As previously mentioned in section 2.3, the theory of PPP holds better in the long run than in the short run. Our model is a time series for 14 years and we believe that if we had a wider data span the PPP relation would be more likely to hold.

## **8.3 Discussion of empirical results in light of UIP**

The theory of uncovered interest parity implies that there can be no expected gains by investing in one currency relative to another. Before the long-term level of the exchange rate can be reached, an increase in domestic interest rate relative to foreign countries'

must be matched by a corresponding depreciation in the exchange rate. When investors benefit from higher interest rates domestically, they lose in that their country's currency becomes less valuable. When one also expects that a wider interest rate differential will increase investors' demand for the country's currency, we see the two contradictory effects. While the theory of uncovered interest parity shows the change in the exchange rate over time, it assumes that investors' portfolio adjustments take place relatively quickly. Interpreting the coefficient on  $(R-R^*)$  in model (7.1) represented in Table 11, we observe it to be 0.03. For an indication of the theory of uncovered interest parity to hold this coefficient should be 0.1. The interpretation of this is that some risk premium exists and is time variant.

## 9. Conclusion

This thesis investigates the development in the Norwegian krone against the euro. By conducting an econometric analysis we have studied factors that might show causality. In order to obtain necessary results required to answer our research question and try to explain the short and long run effects we have used an Engle-Granger two-step approach. Our data set stems from the period 2001-2015 and is collected monthly.

When using the Engle-Granger approach, we find the long-run model to explain 67 percent of the monthly movements in the exchange rate in the first step. Finding proof of cointegration validates the model and gives us ground for interpretation. We find all our explanatory variables, the oil price, Norwegian CPI, euro area harmonized CPI, interest rate differential, balance of trade and the unemployment rate to reflect a long term relationship with the exchange rate.

In the attempt of determining the short-run relation in the second step as well as how swiftly the krone exchange rate moves towards long-run equilibrium when it deviates from this. We find results in validation of the coefficient of the lagged residuals to explain the speed of correction. In our model 7.3 percent of a deviation of 1 percent from the long-term equilibrium adjusts back each month. We fail to find support of the significance of the lagged variable changes in the short run while trying to understand the effect on a change in the exchange rate.

To distinguish our results in light of purchasing power parity, we do not find proof of equivalent purchasing power. The theory of purchasing power parity is more likely to hold in the long run as opposed to the short run. Expanding our data set would plausibly increase the likelihood of validating the theory. Discussing the results with regards to uncovered interest parity, we do not find support in light of the theory to hold. This can be interpreted as proof of an opportunity to make profit with exchange rate speculations.

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