The Direct Effect of Oil Price Fluctuations on the Norwegian Krone

Lisa Johanna Renno

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Bachelor of International Economics and Business Economics

Student number: 386172

1. Introduction

Natural resources and commodities are, ever since they and their potential have been discovered, one of the most important goods in the economy. As such, fluctuations in their prices have ample effects on the world economy and the individual macro economics of the individual countries that trade with these commodities, which is nearly every country in the world regardless whether they are net importers or exporters of such commodities. The importance of these price fluctuations can be seen in the exchange rates of the different importers or exporters of oil. In this paper the effect of oil price fluctuations on the Norwegian Krone will be analysed and evaluated. The reason specifically why Norway and the fluctuations in oil prices are chosen for the analysis will be explained in the literature section of the paper.

The paper's main goal is to find significant evidence of the effect of oil price fluctuations on the exchange rate of the Norwegian Krone vis-à-vis the US Dollar. According to the economic theory, oil price increase lead to a strengthening, i.e. appreciation of the exchange rate, the exact mechanisms of this theory will be discussed later in the paper in the section about literature on the theroy. The data is taken from the year 1990 until 13/5/2016 on a daily basis in order to receive evidence on the short-term effect of oil price fluctuations on the Norwegian Krone. The data is then manipulated and calculated into percentage changes to receive a normal distribution of the data points. Next three different models are formed in order to check for statistical significance of oil price fluctuations on the Norwegian Krone. The models are all Least Square Regression models, but differ in variables and are checked for heteroskedasticity. All three models show that the parameter of the oil price has a significant effect of 1% confidence level on the Norwegian Krone. Concluded from the theory; the effect has to be negative, i.e. significantly lower from zero in order to support the theory. In all three models the null-hypothesis of the beta being equal to zero can be rejected and hence supports the alternative of beta being smaller than zero. Further detailed explanation of the results can be found in the result section.

Throughout the reading of the paper, the reader should keep in mind that the effect of oil prices on the Norwegian Krone that is analysed is only on a very

short-term basis, which includes the direct, i.e. on the same day or the day before, effect of the oil price change on the exchange rate. The scope of the paper does not include long-term effects or other macroeconomic fundamentals, such as government spending or GDP.

The paper is divided into four sections, section two will elaborate on the literature regarding the topic of the effect of oil price changes on the exchange rate, both in the empirical and theoretical sense. The literature on Previous Analysis explains what other previous papers have discovered and concluded and especially why the question of the potential effect of oil price fluctuations is so important in the Norwegian case. The literature on the theory concentrates on the already established theories that have been formed around the question of exchange rate movements. The third section is the empirical analysis of this paper. This section firstly explains what data is used and how it is manipulated for the statistical analysis. Secondly the methodology of the paper is explained, regarding which models and mathematical hypothesis are formed. Thirdly and lastly the results are elaborated and explained. The fourth and last section of the paper is the conclusion, where the concluding remarks are given and the reader is made attentive towards the limitations that the paper includes and what further research is possible with regards to oil fluctuations and exchange rates.

2. Literature on Previous Empirical Analysis and Theory

2.1 Literature on Previous Analysis

The reason why oil price fluctuations and the Norwegian Krone are chosen for the statistical analysis of this paper is because both variables have strong social and academic relevance and they are both subject of high volatility and are observed on a daily basis.

The fluctuation of oil prices is a very delicate topic as such. Oil is used everyday, everywhere around the globe and has provided humanity with some great technological development and advantages (Society of Petroleum Engineers, 2003), but has on the other hand also made it dependent on it, which can result in some difficulties both in the economical and political world. Because oil is so commonly

used and actually has become to be a necessity for a normal modern lifestyle, the demand for oil is very price-inelastic (Krichene, 2002), meaning that a change in oil prices will proportionally have a smaller effect on the quantity demanded than the initial change in the prices (Krichene, 2002). This emphasizes the social relevance of changes in oil prices. The paper will focus on the economic and financial strength and importance of changes in the oil prices with regards to changes on the exchange rate of the Norwegian Krone. However one should not forget the political power of the 'black gold', where sanctions, tariffs and political risks of oil exporters have great significance when it comes to determine fluctuations in the price and the effect of such changes.

In the past months and years the price of oil has been decreasing tremendously, some would argue due to price wars between the oil exporting countries (Kirk, 2015). Others would state that Saudi Arabia, which is the most powerful oil exporter, is partially to blame as they are not willing to cut down on the production of oil due to fear of losing too much of their market share once prices go up again (Kirk, 2015) and therefore cause tremendous oil price deterioration. Additional to this, also non-political influences such as new technological discoveries to extract oil, i.e Fracking (Gobry, 2014) have driven down prices.

Economists and risk analysts are particularly interested in the effect of such fluctuations in the oil prices on the economy and financial markets. Oil prices, financial markets and exchange rates often find themselves exposed to great volatility and lack of stability (Sadorsky, 1999). Economical and political movements and fluctuations have a great effect on financial markers (Aggarwal, Inclan, & Leal, 1999), which are additionally also highly driven by investors expectations (Arthur, 1995). The exchange rate is also exposed to these expectation driven decisions of investors, which can then later cause a phenomenon called over-shooting of the currency, which will be explained in the theoretical section. Previous written empirical papers demonstrate and find evidence for the potential effect of oil price fluctuations on the exchange rate. A vast of these papers focus on the Norwegian case, as Norway is a very big and influential exporter of oil and they are dependent on their right to that oil in order

to keep their economy growing (Ferraro, Rogoff, & Rossi). To increase the reader's understanding of why particularly Norway was chosen to analyse the effect of change in oil prices on the domestic currency, the market position with regards to oil exports, the current political situation with regards to the outside world, i.e. trading agreements and some historical background regarding the management of the Norwegian Krone should be taken into consideration. Furthermore the management of the ample revenues gained from the oil sales will be analysed briefly in the following section.

2.1.1. Market Position and Political Ties

The focus of this paper will be on the price fluctuations of crude oil and the effect of those respective changes on the exchange rate of the Norwegian Krone.
Norway is a rather small Scandinavian country, but has made their oil exports one of the most powerful economical weapon in the world. They have risen to become the global top 5 oil exporter (Commission, 2016). The oil industry in Norway is enormous and reckons to be the most important industry for the country, as they seem to be reliable on the ample sales revenues to foster the growth of the other parts of the domestic economy. The revenues gained from the exports take up a big percentage (up to 22%) (Commission, 2016) of their total GDP, which shows the importance and reliance on the oil export for the Norwegian economy as a whole.

Changes in oil prices are expected to have a great effect on the Norwegian economy, because they rely so heavily upon them, but their trading partners are also exposed to volatility in the prices. The European Union is the biggest and therefore most important trading partner of Norway. Even though Norway is not in the European Union, they have close ties to the Union. They joined the European Economic Area (EEA) in 1994, which includes the Schengen Agreement, eliminating essential border controls between Norway and other countries in the Schengen area (EuropeanUnion). Furthermore allowing for a single market regarding all relevant laws, except for the once regarding agriculture and fisheries (EuropeanUnion). Norway also contributes financially to the EU and has regular political dialogue on foreign policy issues (EuropeanUnion). In general Norway is

considered to be '3/4' in the European Union (EuropeanUnion). The strong relation between Norway and the European Union explains their great trade flow, which captures 74.3% of Norway's total trade (Commission, 2016), of goods and services

2.1.2. Historical Background of Norwegian Krone (NOK-Norwegian Krone)

The Norwegian Krone has a history of different management of their Domestic Krone. The Norwegian Krone was introduced in 1875, by entering the so called Scandinavian Monetary Union, and so replacing their previous currency the Speciedaler. The Scandinavian Monetary Union included Denmark, Sweden and Norway and the currency was managed under the Gold Standard. After the breakup of the Scandinavian Monetary Union in 1914 the countries kept their currency and Norway would now move on and off of the Gold Standard, on in the periods 1916-1920 and 1928-1931. In the year 1931 the Krone was pegged to the pound, 1939 changed to being pegged to the US Dollar and during the Second World War was pegged to the German Reichsmarkt. After the defeat of Nazi Germany the Krone was pegged back to the British Pound and in 1971 introduced a free-floating exchange rate until 1978 where it was linked to a basket of currencies only to become completely free-floating again in 1992. For the statistical analysis of this paper it is highly essential that the currency is under a free-floating exchange rate to evaluate changes in oil prices on changes of the Norwegian Krone. The Krone is free-floating under a so called managed float.

2.1.3. Management of Oil Revenues

Norway relies heavily on their oil trade and has established a unique system to sustain their growing economy. The Government Petroleum Fund was established in 1990, with the purpose of the fund to support government's long-term management of the revenues gained by the petroleum. In 1998 the management of the fund was changed and given to the Ministry of Finance of Norway. The fund is now called the Government Pension Fund Global, but is more commonly called the Norwegian Oil Fund (NorgesBank). The main goal of the fund is to support the Norwegian economy as a whole and is considered to have a very long-term investment perspective, according to the Finance Minister of Norway, Sir Jensen

(Matthews, 2016). It is considered the largest sovereign fund in the world (Reid, 2016) and was established as a tool to defend the Norwegian economy against decreases of petroleum revenue, as oil is a natural resource it is scarce and will eventually at one point be used up (NorgesBank). Furthermore the fund is also a tool to challenge financial difficulties that arise from an ageing population (NorgesBank). Even though the fund was meant to support the Norwegian economy as a whole and foster other sectors, there has until now only been one withdrawal of the fund. The first and only time that the government had to withdraw money from the fund was in January 2016 to support and help the Norwegian economy (Reid, 2016).

2.1.4. Literature on Previous Empirical Analysis

Economist, market analysts and empirical paper authors focus highly on the causal effects between two phenomena and try to explain the correlation between two variables by finding some sort of causation. This paper will try to find a causal effect of changes in oil prices on changes of the exchange rate of the Norwegian Krone. The topic is academically relevant as a lot of financial trade models, such as the monetary model or Dornbusch model, which will be explained more in detail later on, try to explain causes of changes in the exchange rate. With regards to the effect of changes in the exchange rate the results given by the empirical papers do not always state the same predictability or causation.

Some say that in the Norwegian case there is evidence of significant predictability of both contemporaneous and lagged oil prices (Ferraro, Rogoff, & Rossi). Other papers however find a numerically weak and moreover a statistically insignificant relationship between oil prices and the value of the domestic Norwegian Krone (Bjørvik, Mork, & Uppstad, 1998). Furthermore others show that there is a negative relationship between oil prices and the exchange rate in Norway when the statistics are based on a non-linear model. The negative relationship implies that and increase in oil prices has negative effect on the exchange rate, meaning an appreciation of the domestic currency, however only when oil prices are particular low or high (Akram, 2004). The reason for most of these empirical papers to decide to choose Norway and the Norwegian Krone as a country and

exchange rate are to sum up because of two specific reasons. Firstly Norway is one of the biggest oil exporters, i.e. highly influential on the oil market but also dependent on the revenues gained from oil sale. Secondly the Norwegian Krone is under a free-float exchange rate, which is essential for the empirical analysis of the data. The mentioned papers are all focused on the case of Norway but if expanding the research to other countries other results can be found.

In case of Canada for example, which it a rather small oil exporter and does not have a leading market position in the industry, the effects of oil price changes on the domestic Canadian Dollar is different. One paper for example explains that changes in oil prices can depict changes in the currency exchange rate of the Canadian Dollar however only when the data is gathered on a daily bases, when trying to expand it to a monthly bases they become less significant and on a quarterly bases the effects become completely insignificant, when using an out-of sample forecast (Ferraro, Rogoff, & Rossi). The difference in both countries are too great however and widely ranged that the effect of changes in the oil prices on one countries' domestic currency should not be directly compared to the effects on another countries' currency. A comparison of this kind is not in the scope of this paper. This paper will only focus on the effect of the Norwegian Krone, keeping in mind that an effect of oil prices on the exchange rate in the Norwegian case is not to be generalized to any other case or country.

2.2 Literature on the Theory

There are several international economic models that try to predict and analyse the causes of changes in the exchange rate. The following section will describe the theory behind some of the models that are relevant for the topic on exchange rate and changes in the price of oil. If not told otherwise, all the models described below, will for simplicity reasons and for the sake of a better understanding assume that an increase in prices of oil for an oil exporting country result in an increase in the income of that country.

2.2.1.Literature on the DIY model

The Do It Yourself model is the simplest model by David Henderson in predicting the effect on the exchange rate. In this model an increase in income would increase the demand for imports and thus increasing demand for foreign currency, hence decreasing the value of the domestic currency and causing depreciation (Henderson, 1985). This model however is kept far too simple and is not analytical relevant enough for this paper so the focus will lie on the next model regarding the effects on the exchange rate resulting from an increase in income, i.e. increase in oil prices.

2.2.2.Literature on the Dornbusch model

The Dornbusch model focuses on two effects of an increase in income. The first effect is the effect on the goods market, and the second is the effect of the money market. To start with the model, again some assumptions have to be made.

Other models that concentrate on the effect on exchange rates often rely on unrealistic assumption, such as the monetary model, which relies heavily on the assumption of Purchasing Power Parity (PPP) and does not take into account the role of expectations. These assumptions make the model too simple and as such non-applicable to the real world. The Dornbusch model is in that sense more realistic as the first assumption is that the aggregate demand is determine by the IS-LM mechanism. Briefly described, the IS curve is the downward sloping curve in a graph, where interest rate is on the y-axis and national income on the x-axis. The IS-curve is influenced and shifts by a change in government spending and real exchange rates. The LM-curve is upward sloping on the graph and focuses more on the money market of the economy. The LM curve symbolizes the ratio of money supply to price at a given interest rate and national income (Copeland, Sticky prices: The Dornbusch model, 2014).

The second assumption is however more important for the analysis of this paper, because it gives importance to expectations in the market. Expectations are very powerful when determining the price and value of financial market products (Kim, Mc:Kenzie, & Faff, 2003). The second assumption states that *financial markets adjust instantaneously. In particular, investors are risk neutral, so that uncovered interest parity (UIRP) holds at all times*. The assumption implies that the

financial markets react instantly on changes of any kind, while the goods market, i.e. the price of goods need time to adjust to different situations, meaning that the adjustment of prices lag behind the already made adjustments of the financial market (Dornbusch, Expectations and Exchange Rate Dynamics, 1976). The second part of the assumption covers the UIRP, which is a model made to predict changes in the expected nominal exchange rate, using the interest rate differentials of two countries. The equation below is a representation of perfect capital mobility, which is assumed to hold at all time (Dornbusch, Expectations and Exchange Rate Dynamics, 1976)

$$r = r^* + \Delta s^e \qquad 2.1$$

The domestic interest rate, i.e. the Norwegian interest rate is depicted by *r,* while the foreign interest rate is depicted by r^*. The *s* is the nominal exchange rate and the *e* shows that it is the *expected* change of the nominal exchange rate. Another method to calculate the expected change of the nominal exchange rate is by comparing the long-run equilibrium of exchange rate, which is assumed to be determined by the relative domestic money stock, national income and interest rates with regards to the foreign country (Copeland, Sticky prices: The Dornbusch model, 2014). If the exchange rate is then to deviate from the long-run equilibrium, expectations are formed that the exchange rate will go back to its long-run value through change in expectations. The formula is as follows

$$\Delta s^e = \theta\ (\ \overline{s}\ -\ s) \qquad (\theta > 0) \qquad 2.2$$

$\overline{s}$ is the long-run exchange rate and the θ determines the speed in which the exchange rate goes back to its long-run equilibrium (Dornbusch, Expectations and Exchange Rate Dynamics, 1976). Furthermore Dornbusch states, that the exchange rate is expected to converge faster towards the long-run equilibrium the further away it is from it at the initial point in time. It is however hard to find the exact value of the long-run equilibrium, therefore to make the statistical analysis easier and more comprehendible, equation 2.1 is rearranged to the following equation.

$$\Delta s^e = r - r^* \qquad 2.1.2$$

The expected change of exchange rates can be determined by the interest rate differentials of two countries. Lets say for example that the domestic country has a higher interest rate than the foreign country, i.e. $r > r^*$. For the uncovered interest parity condition to hold, the expected exchange rate change must compensate for the interest differentials. In the example where $r > r^*$ the domestic currency must depreciate and appreciate if $r < r^*$.

As mentioned before the Dornbusch model makes a distinction between the effect of the money market and the effect of the goods market. Dornbusch's main focus is to restore the markets back to an equilibrium level, always keeping in mind that the prices in the goods markets are sticky, which is assumption three. The goods market model elaborates on how an increase in wealth has an effect on the currency and on the goods market particularly the market for non-oil production. The volume of the non-oil production is kept fixed in the model and causes a rise in the value of the domestic currency, as the real exchange rate must ultimately fall, so as to reduce the relative competitiveness of the non-oil production of the country (Copeland, 2014). The appreciation of the currency crowds out the foreign demand and hence leaves room for the additional consumption of the domestic consumers (Copeland, 2014).

The second effect of an oil price increase is the one on the domestic money market. The Dornbusch model predicts, when assuming that the oil price increase has indeed no effect on wealth or permanent income, the goods market equilibrium is not changed or interfered with, the solemn effect in this scenario is on the money market (Copeland, 2014). The increased demand for money and the unchanged supply of it causes the currency to appreciate (Copeland, 2014). In the short-run however the currency overshoots, implying that the short-run appreciation is greater than the long run appreciation. Overshooting is a result of sticky prices, which is one of the assumptions in the Dornbusch model. Prices are sticky in the short run and become flexible in the long run, causing a deprecation of the currency, however keeping the overall effect on the currency to be appreciating and the price levels to decrease.

Combining the two effects, the general case predicts that the economy with increasing oil prices and domestic production of such will experience currency overshooting in the short run and real appreciation in the long run (Copeland, 2014). The exact opposite is assumed to be true when oil prices decrease, there is an overshooting depreciation of the currency in the short- run, but an overall depreciation in the long run, after price levels had the chance to adjust. The real effect in the long-run is less than the effect in the short run. However the scope of this paper is limited to only the price changes of oil and the nominal exchange rate and does not include any other exogenous shocks such as changes in the monetary or fiscal policies or other macroeconomic fundamentals.

2.2.3.Hypothesis

The theoretical framework above led to the following propositions.

Proposition 1: An increase in oil prices has a negative effect i.e. appreciation on the domestic exchange rate of oil exporters.

Proposition 2: A positive interest differential has a positive effect on the domestic exchange rate.

The first proposition focuses on the effect of changes in the oil prices on the domestic currency of the Norwegian Krone. The expectations are that an increase/decrease in oil prices lead to an appreciation/depreciation of the Norwegian Krone. The second proposition focuses on the UIRP assumption to hold.

3. Empirical Analysis

3.1. Data

The main data that this paper focuses on is taken from the West Texas Intermediate Oil price and the daily exchange rate of the Norwegian Krone is provided at their central banks' website.

3.1.1. Exchange Rate

The data for the Norwegian Krone versus the US Dollar exchange rate is taken from the 11/12/1981 until the 13/5/2016, however this needs to be adjusted for

the other variables, as the data for those could not be found for that long of a time period. Therefore the data is limited form the 1/1/1990-13/5/2016. Some basic statistics are taken from this data set. The mean of the exchange rate is 6.803379 while the median is 6.562700, which implies that the exchange rate is not normally distributed and has a skewedness to the right of 0.753802. The standard deviation is 0.982032 (Appendix A.1.1). To accurately analyse the changes of oil price fluctuations on the exchange rate the percentage change has been calculate, by the following formula

$$\Delta s_t = \frac{s_t - s_{t-1}}{s_{t-1}} \qquad 3.1$$

The percentage change in exchange rate *s* in time *t* is calculated by the subtraction of the exchange rate *s* in time *t* by the exchange rate *s* in time *t-1* divided by the exchange rate *s* in time *t-1*. The result is a decimal place, for example 0.02 which can be multiplied by 100 to bring 2%. The mean of this data is 0.0000879, meaning that the mean change of the nominal exchange rate is 0.00879%, the median is 0.00. Overall the data set centres around 0.00, with a very small skewedness of 0.064874 and a standard deviation of 0.007298.The histogram can be found in the Appendix A.1.2, where it is clearly shown that the data is nearly normally distributed. A unit root test was also done to check whether the data is stationary or not. An Augmented Dickey-Fuller test was done for this analysis and the results show that when checking for a random walk for the exchange rate data, the null hypothesis, which states that the data set is non-stationary and has a unit root, could not be rejected for any of the three confidence levels, 1%, 5% or 10%. However when repeating the Augmented Dickey-Fuller test, but instead using the percentage change of the exchange rate, the null hypothesis of a unit root could be rejected, concluding that the data is now stationary. The statistical values received can be found in the Appendix A.1.3.

3.1.2.Oil Prices

The data for the oil prices is taken from The Texas Intermediate for crude oil. Data was available from the 1/1/1990 until the 13/5/2016. The procedure here is identical to that what was done with the exchange rate. The basic statistics showed that the data set was very skewed to the right with a mean of 46.5453 but

a median of 31.6100, a standard deviation of 30.93160, a minimum of 10.82000 and a maximum of 145.3100. (Appendix A.2.1.). The first primary data already shows how volatile and unstable the price of oil is. Hence for a better understanding of the data the percentage change of the oil prices was calculated in the same way that was previously done with the exchange rate.

$$\Delta P_t = \frac{P_t - P_{t-1}}{P_{t-1}} \qquad 3.2$$

The LHS shows the percentage change of the oil prices *P* in time *t*. The RHS is the same as with the exchange rate, only difference is that the exchange rate *s* was substituted by the price of oil *P*. The basic statistic from this new data set shows a much better distribution, with a mean of 0.000274, i.e. 0.0274% and a median of 0.000109, i.e. 0.0109%. The data is centred around 0.00 and has a standard deviation of 0.024746 (Appendix A.2.2). For the oil prices another Augmented Dickey-Fuller Test is constructed and the results are similar to the ones for the nominal exchange rate. The null hypothesis could not be rejected for the oil prices, but could under a 1% confidence level be rejected for the percentage change of oil prices, meaning that the data set when manipulated is stationary (Appendix A.2.3.).

3.1.3.Interest Rate Differentials

As already explained in the theory section, the interest rates are very crucial for the analysis in changes of the exchange rates, due to arbitrage opportunity that erupts when two countries have different interest rates. A country with a higher interest rate is going to have more demand for their currency, because investors see an opportunity to gain more money with the same amount of risk, if it is assumed that both countries have the same credit risk. The theory described a model called uncovered interest parity, describing that an interest differential has to be offset by a change in the respective exchange rates, due to expectations. The formula was when rearranged to the following.

$$\Delta s^e = r - r^* \qquad 2.1.2$$

In this case r is the domestic i.e. the Norwegian interest rate and r^* is the interest rate in the American market. The interest rates for Norway were taken from the Norges Bank and are the government bonds with a maturity of 10 years. The US

interest rate was taken from the website of the Federal Reserve same as for Norway the interests of the U.S. Treasury securities at a 10 year maturity were taken. The data for both countries is taken daily form the 1/1/1990 until the 13/5/2016. (Appendix A.3.1.). A summary of the basic statistics is shown in the table below.

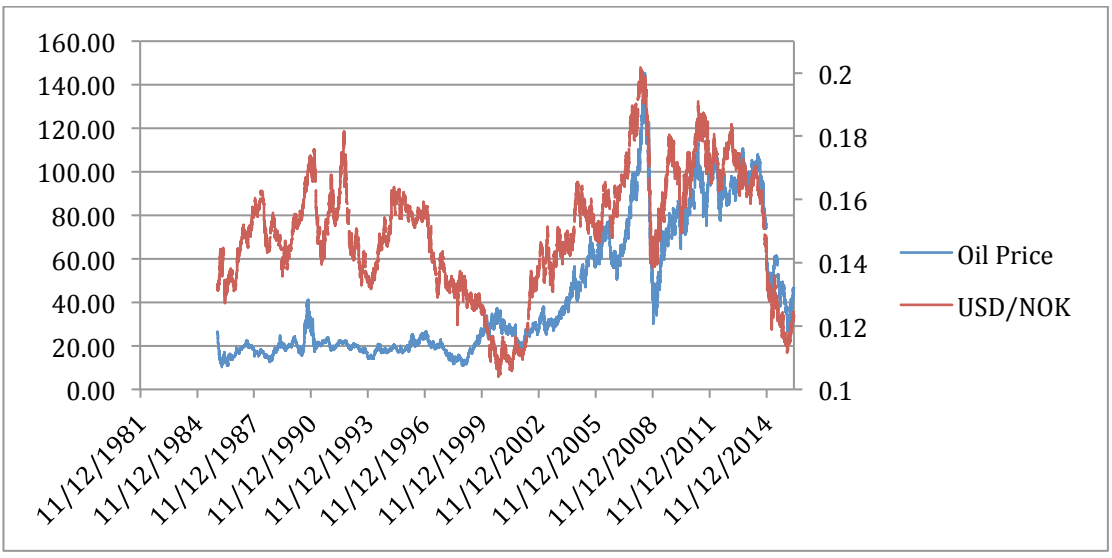
Table 1.

Variable	NOK/USD	Change NOK/USD
Mean	6.803379	8.79E-05
Median	6.562700	0.000000
Std. Dev.	0.982032	0.007298
Minimum	4.958900	-0.057776
Maximum	9.606200	0.045144
Type	continuous	percentage

Variable	Oil Price	Change Oil Price	Interest Differentials
Mean	46.65453	0.000274	0.003755
Median	31.61000	0.000109	0.003136
Std. Dev.	30.93160	0.024746	0.013217
Minimum	10.82000	-0.333953	-0.090800
Maximum	145.3100	0.20765	0.042600
Type	continuous	percentage	percentage

When combining the two main variables, the exchange rate and the oil prices a primary analysis can be done by taking a glance at the following graph.

Graph 1.



The red curve shows the exchange rate of the US Dollar versus the Norwegian Krone, which is the inverse of the Norwegian Krone versus the US Dollar. An appreciation of the Norwegian currency, i.e. a decrease of the exchange rate of the Norwegian Krone is exactly the same thing as a depreciation of the US dollar, i.e. increase of the US Dollar. Hence an increase of the USD/NOK, meaning the US Dollar(s) one would receive for one Norwegian Krone, curve shows a depreciation for the US Dollar and an appreciation for the Norwegian Krone and vice versa if the curve decreases. The graph provides the reader with a visual aid to see how the oil price and the Norwegian Krone move along each other. It becomes especially obvious that after 2001 the two curves move smoothly with one another. Before 2001 and specifically between 1999 and 2001 the two curves move in opposite directions. Before that there seems to be a correlation but not as consistent as in the years 2001-2016. The graph supports the theory, that an increase in the oil prices will lead to an appreciation of the exchange rate of the Norwegian Krone and a depreciation if there is a decrease. However the graph only shows how the graphs move along each other, which should not be interpreted as a causal effect of oil prices on the exchange rate. To analyse the causal effect of one variable on another a regression has to be formed, which will be elaborated upon later.

3.2. Methodology

The methodology of this paper concentrates on the oil price fluctuations and their respective effect on fluctuations of the Norwegian exchange rate. The data is gathered on a daily basis, which shows the short response of the exchange rate on changes on the oil price. Gathering the data on a daily basis is helpful to see the direct effect of changes of the oil price on the exchange rate, but also narrows down the scope of the paper, as other macroeconomic data of the Norwegian economy, such as the GDP per capita growth and the Norwegian export growth, can not be included in the regression. The reason why they can not be included is that the data can only be found annually or/and quarterly and when trying to average the growth rates to the specific months and days a lot of crucial information from the data is lost, hence these kind of variables are not included in the analysis of this paper.

The variables of interest are the dependent variable; the percentage change of the Norwegian Krone versus the US Dollar, the independent variables; the percentage change of oil prices and the interest differential between Norway and the US. The regressions that are formed are the following.

Model 1:

$$\Delta s_t = \alpha + \beta_1 \Delta P_t + \varepsilon_t$$

The mathematical hypothesis for model 1 is the following:

$$H_o: \beta_1 = 0$$
$$H_1: \beta_1 < 0$$

The first beta shows the effect that a percentage change of oil prices in time *t* has on the percentage change of the nominal exchange rate on the Norwegian Krone at time *t*. The alternative hypothesis states that the beta is expected to be negative. This is elaborated and concluded in the literature about the theory; an oil price increase causes a decrease of the nominal exchange rate, i.e. appreciates the currency.

Model 2:

$$\Delta s_t = \alpha + \beta_1 \Delta P_t + \beta_2 InterestDifferentials_t + \varepsilon_t$$

Again here similar to the first model a mathematical hypothesis is formed and is the following

$$H_o: \beta_2 = 0$$
$$H_1: \beta_2 > 0$$

The second model includes a second beta that shows the effect of interest rate differentials, again as explained in the literature section regarding the theory; a positive difference between the domestic and foreign the interest rates leads to an increase in the expected change of the nominal domestic exchange rate. This leads to the expectation and alternative hypothesis that the second beta should be positive.

3.3. Results

Model 1 is the simplest one and only includes the dependent variable, percentage change of the Norwegian Krone, the constant and the independent variable, the percentage change of oil prices. The model shows that the fluctuations in the oil price have scientific explanatory value of a significance level of 1% on the percentage change of the Norwegian Krone. The estimator is negative and shows as predicted in the theoretical framework, that a price augmentation in oil has a negative causal effect on the exchange rate. The estimator is -0.03083, meaning that a 1% increase in the price of oil leads to a 0.03083% decrease in the exchange rate of the Norwegian Krone. The constant is not statistically significant under any of the three confidence levels of 1%, %5 and 10$%. The mathematical first null hypothesis can hence be rejected for the first estimator. By rejecting the null hypothesis it is concluded that the estimator is statistically significantly smaller than zero.

The second model is model 1, while adding another variable, the interest differentials between Norway and the US. The statistical analysis shows again that the fluctuations of the oil prices have explanatory value under a 1% confidence level, while the constant and interest differential have no significance. The estimator of the percentage oil price change is similar to the one seen in model 1, with -0.030512. However the interesting thing to discover here, is that the interest differential has, even though not significant, a negative effect on the percentage change of the Krone. The theoretical framework predicted that the effect should be positive, but it is now shown that it is negative. Hence the second mathematical null hypothesis cannot be rejected.

The third model includs also the first lags of the percentage change of the currency and of the percentage change of oil prices. The change of oil prices again has a significant effect of -0.030604%, meaning a 1% increase of oil prices would lead to a decrease in the currency of 0.030604%, i.e. an appreciation, therefore rejecting the first mathematical null hypothesis. The interest differential has similar to the second model no significant explanatory value; hence the second null hypothesis cannot be rejected. The lag percentage change of the currency has

a negative effect under a 10% confidence level and is negative. The interpretation of this result is, that an increase in the previous period *t-1* by 1% causes the current period *t* to have a decrease of -0.031845%. Recall the literature on theory, where Dornbusch described that the exchange rate will change in order for it to be in its equilibrium, an increase in the previous period thus leads to a decrease in the following. The lag of the oil price percentage change is significant under a 1% confidence level and the estimator is negative. From the analytical point of view the lag of the change in oil prices in time *t-1* has a very similar effect on the percentage change of the currency in time *t* as does the current change in oil prices in time *t*. The effect is a 0.036027% decrease of the currency caused by a 1% increase of the lagged oil price. In fact the lagged oil price in the third model has a slightly greater effect on the percentage change of the currency than does the oil price changes in the current period.

Table 2.

Variables	Model 1	Model 2	Model 3
Constant	6.22E-05	0.000124	0.000135
	(0.669518)	(1.214808)	(1.306855)
Change_Oilprice	***-0.03083	***-0.030512	***-0.030604
	(-5.856495)	(-5.76963)	(-5.781133)
Interest_Differentials		-0.009635	-0.00937
		(-1.000865)	(-0.952203)
Change_exchange(-1)			*-0.031845
			(-1.793189)
Change_Oilprice(-1)			***-0.036027
			(-7.851623)
Number of Observations	6185	6114	5823
Darwin-Watson Stat.	2.075038	2.076049	2.006806
Adjusted R-Squared	0.010773	0.010542	0.024654
Significance level	1% = ***	5%= **	10%= *
t-Statistic in Parentheses			

To check for robustness of the model a fourth model was build, which includes the ten lags of the change of exchange rates and the change of oil prices. The goal of the robustness check is to make sure that even if other variables are added the variables of interest, i.e. estimator of the change of oil prices and interest differentials, do not change their explanatory values. The table below only shows

the variables of interest, hence the lags are not included, but can be found in the Appendix B.

Table 3.

Variables	Model 4
Constant	9.08E-05
	(0.689959)
Change_Oilprice	***-0.035817
	(0.689959)
Interest_Differentials	-0.005687
	(-0.457129)
Change_exchange (-1)	*-0.039688
	(-1.727985)
Change_Oilprice(-1)	***-0.038374
	(-6.634957)
...	
Number of Observations	3796
Adjusted R-squared	0.030822
Durbin-Watson Stat.	2.016961
Significance level	1%=***
	5%=**
	10%=*
t-Statistic in Parentheses	

The table shows that the estimator of the change of oil price in the current times period *t* still has a significant negative explanatory value. The value of the estimator (-0.035817) is very similar, only a little greater in absolute terms, to the estimators for this variable in the previous models, hence again the first null hypothesis is rejected. The explanatory value of the interest differentials is still negative and not significantly different from zero, as such the second null hypothesis cannot be rejected. The lagged percentage change of the currency in time period *t-1* and the lagged percentage oil price change at time *t-1* are negative and significant on a 10% and 1% confidence level respectively, which show very similar results to those in model 3. The robustness check mainly shows that the effect of changes in the exchange rates when caused by a change in oil price changes are immediate and follow the same day or the day after. The effect is very short term, which explain the frequent fluctuations on the exchange rate market during high price volatility periods in the oil industry. Even though mentioned in the literature about the theory, the statistics gathered are not sufficient to check

for overshooting of the currency in the short-run simply because the data does not give insight into the long-run exchange rate. To calculate the long-run value of the exchange rate other macro economic variables are needed, which are not included in the scope of this paper. Nevertheless the analysis gives enough evidence to support the main theory of the Dornbusch model, that there is indeed an appreciation in case of an increase in income, i.e. in the oil prices in the short run.

4. Conclusion

The results given above give insight and statistical weight regarding the important effect of oil price fluctuation on the Norwegian exchange rate. An increase in oil prices lead to an appreciation of the currency, whereas vice versa a decrease leads to depreciation. The results regarding the effect of oil prices on the exchange rate support the Dornbusch theory, while the results found regarding interest differentials are non-supportive of the UIRP theorem. The lags of the exchange rate and oil price fluctuations further support the Dornbusch theory that was established, showing that exchange rates try to find some equilibrium, leading to a negative effect of the first lagged exchange rate. The first lagged oil price fluctuations have a similar effect to the effect of the current oil price changes on the exchange rate.

The statistical analysis is done on a daily basis and should not be expanded for long-run analysis. The main focus lies on the first estimator, the estimator of the percentage change in oil price at time *t*. When comparing for example the highest and lowest recorded oil price during the time interval of interest from 1990-2016 the forecast that the regression estimator gives is not in line with the real value of the change in the exchange rate. The highest oil price was in 03/7/2008 with a price of 145.31$, while the lowest was in 10/12/1998 with a price of 10.82$. This movement shows an increase of 1241%, the estimator would hence predict that the exchange rate would decrease by 38%, but in reality it actually decreases by 32.9% from and exchange rate of 7.5555 to an exchange rate of 5.0661. The estimator correctly predicts, whether the percentage change of the exchange rate is negative or positive, but the magnitude of the change is not precisely accurate.

Furthermore the reader should keep in mind that the historical direction of the movement is important. The analysis is laid out in a way that the prediction of fluctuations in the exchange rate should only be done moving forward in time and not backward, hence an analysis moving back from 03/7/2008 to 10/12/1998 is not useful. Another point of interest is the time interval of the analysis. As mentioned before the analysis is laid out on a daily basis and the direct effects of changes in oil prices on the exchange rate of the Norwegian Krone are in the focus. The main conclusion of the paper might not be the mathematical value of the first estimator, as that can change vastly among the time horizon, due to different factors such as market volatility in general, financial crises or even political insecurities, but more so the sign of the estimator. In all four models the sign of the estimator of the percentage change of oil is significantly smaller than yero, concluding that an increase in oil prices causes a strengthening of the Norwegian Krone. Additionally the analysis also shows that the movement of the oil price change is proportionally more than the movement of the exchange rate. In average for the time interval of this paper this estimator is 0.03083, but as it is an analysis on a daily basis on historical data, no direct forecasts should be made from this analysis, except for the prediction of the direction of the exchange rate movement, which has a negative relationship to that of the price of oil.

The empirical evidence shows that changes in oil prices have a significant effect on the exchange rate of the Norwegian Krone, which is highly important for both the social and academic relevance of this topic. Norwegian domestic consumers or the European Union, which as mentioned in the beginning of the paper has strong ties with Norway are highly influenced by fluctuations of the Norwegian Krone and thus have a high interest in understanding potential causes that result in disruptions or fluctuations of the currency. From the academic perspective, the Dornbusch theory can be supported with the evidence given in this paper, both that an oil price increase causes and appreciation in the producing country's currency, but also that expectations seem to try to bring back a currency to some sort of equilibrium.

Even though the empirical analysis supports the theory there some additional limitations that have to be kept in mind. The biggest limitation that was encountered was that using only daily data limits the data set taken to make a scientific model, because variables such as GDP growth, export volumes, trade flows and such could not be included as they are only published on an annually or quarterly basis. Even if this data were to be taken and calculated to some average too much information would have been lost in the process. A solution for this problem is to maybe expand the analysis to a quarterly or annually base, meaning that all variables are taken annually or quarterly, however this was not in the scope of this paper, but might be helpful for further possible research. The further research can be extended to a more macro-economic level. Another limitation is that the interest rates are non-stationary when doing the Augmented-Dickey Fuller test, which could lead to incoherent analysis of this variable. Additional to limitations given by the variables, there appears to be a hindering with regards to the external validity of the results given. The reader has to be very careful when wanting to apply the knowledge gained from these results unto other countries or cases. Norway was particular taken for reasons explained in the beginning of the paper and so other countries will have other characteristics, which might then influence the data gained and cause other possible results.

The main conclusion that should be drawn from this paper is that oil prices have a negative causal effect on the Norwegian Krone; meaning that an increase in oil prices strengthens the Norwegian Krone. To what magnitude the currency is strengthened however should be handled with special care, as other variables that have important influences on the market play a role in determining the exact magnitude of the change.

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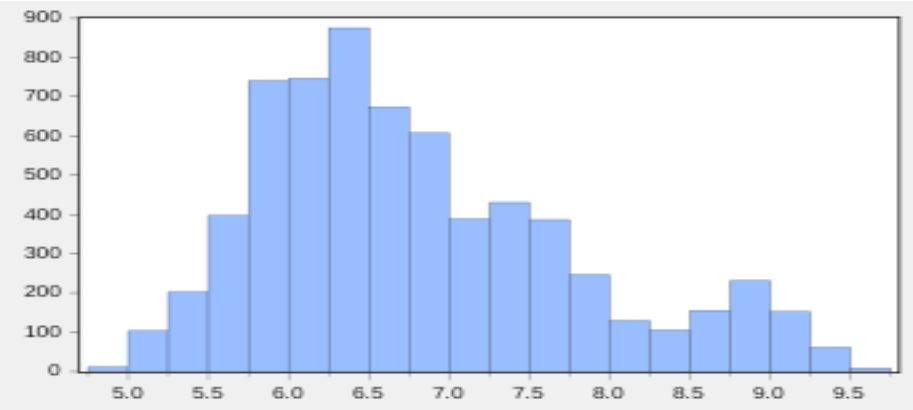
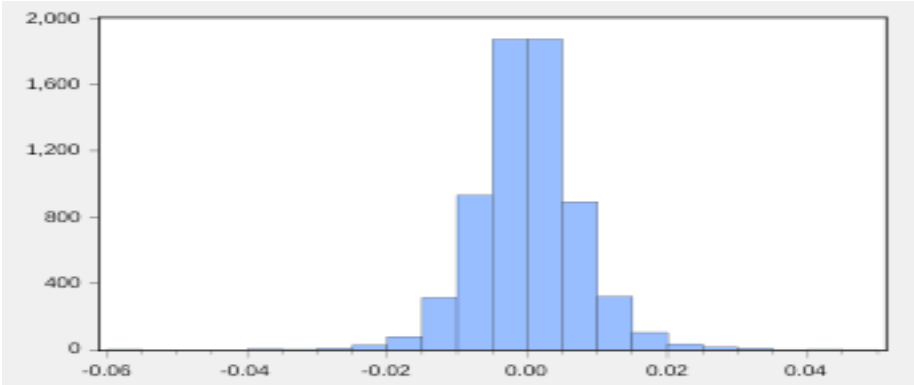
Appendix

Apendix A

A.1.1 (NOK/USD)



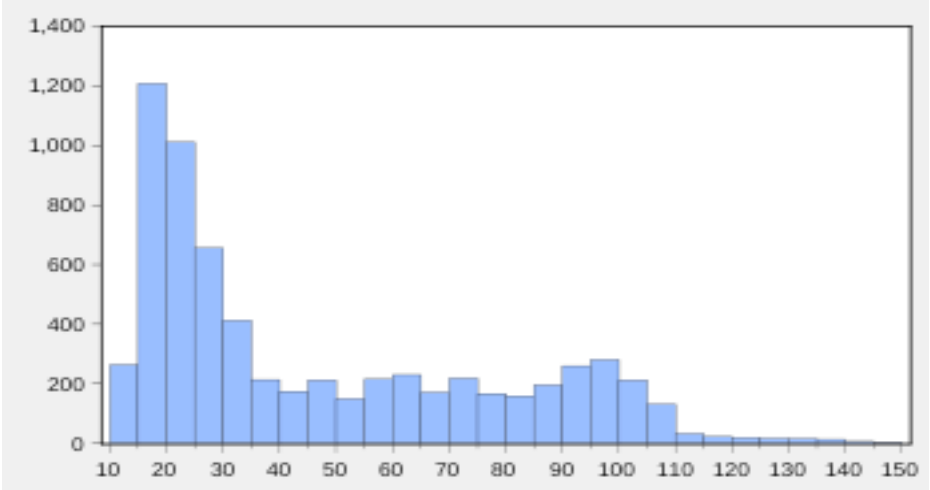
A.1.2 (Change NOK/USD)



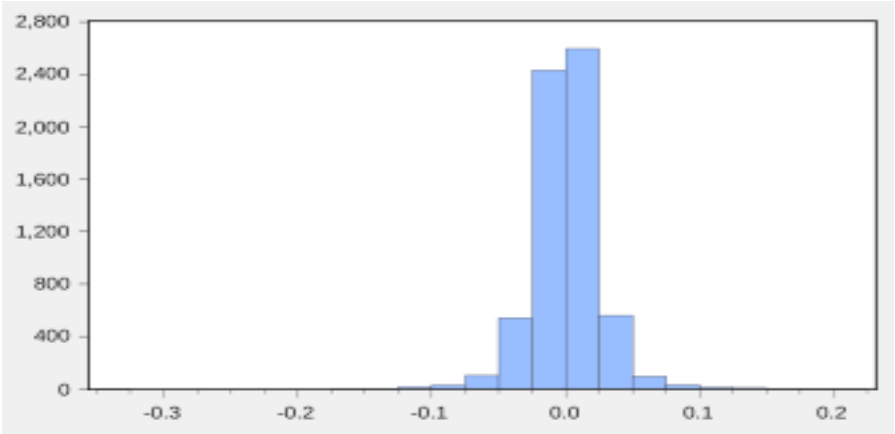
A.1.3.

Unit Root Test (Augmented Dickey-Fuller)	NOK_USD (level)	NOK_USD % Change
t-Statistic	-1.806803	-81.25089
Critical values:		
1% level	-3.431179	-3.431203
5% level	-2.861791	-2.861802
10% level	-2.566946	-2.566951
Rejected Null hypothesis	No	Yes
Stationary	No	Yes

A.2.1 (Oil Price)



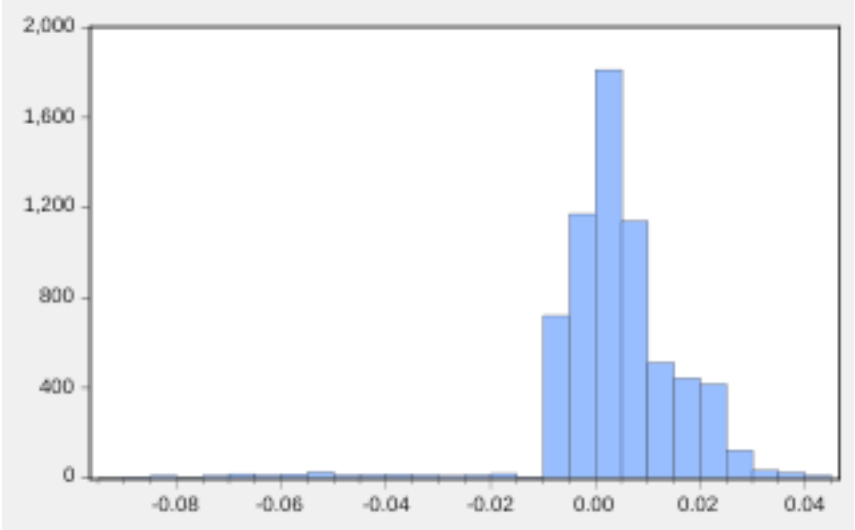
A.2.2 (Oil Price Change)



A.2.3.

Unit Root Test (Augmented Dickey-Fuller)	Oil Prices (level)	Oil Prices % Change
t-Statistic	-1.547651	-80.41758
Critical Values:		
1% level	-3.431226	-3.431226
5% level	-2.861812	-2.861812
10% level	-2.566957	-2.566957
Rejected Null Hypothesis	No	Yes
Stationary	No	Yes

A.3.1. (Interest Rates Differentials)



B.1

Variables	Modle 4
Constant	9.08E-05
	(0.689959)
Change_Oilprice	***-0.035817
	(0.689959)
Interest_Differentials	-0.005687
	(-0.457129)
Change_exchange(-1)	*-0.039688
	(-1.727985)
Change_Oilprices(-1)	***-0.038374
	(-6.634957)
CHANGE_EXCHANGE(-2)	0.014706
	(0.656671)
CHANGE_OIL_PRICES(-2)	-0.00328
	(-0.631585)
CHANGE_EXCHANGE(-3)	-0.020995
	(-0.967811)
CHANGE_OIL_PRICES(-3)	0.001141
	(0.225424)
CHANGE_EXCHANGE(-4)	-0.00057
	(-0.027627)
CHANGE_OIL_PRICES(-4)	-0.00832
	(-1.497087)
CHANGE_EXCHANGE(-5)	0.004807
	(0.242831)
CHANGE_OIL_PRICES(-5)	-0.001172
	(-0.203686)
CHANGE_EXCHANGE(-6)	-0.032399
	(-1.527536)
CHANGE_OIL_PRICES(-6)	-0.001089
	(-0.204051)
CHANGE_EXCHANGE(-7)	-0.003281
	(-0.159357)
CHANGE_OIL_PRICES(-7)	0.000234
	(0.044774)
CHANGE_EXCHANGE(-8)	-0.026475
	(-1.237769)
CHANGE_OIL_PRICES(-8)	*-0.015768
	(-2.772253)
CHANGE_EXCHANGE(-9)	-0.016722
	(-0.860204)
CHANGE_OIL_PRICES(-9)	0.000104
	(0.019267)
CHANGE_EXCHANGE(-10)	0.003033
	(0.150444)
CHANGE_OIL_PRICES(-10)	-0.002963
	(-0.565309)
Number of observations	3796
Adjusted R-squared	0.030822
Durbin-Watson Stat.	2.016961
Significance level	1%=***
	5%=**
	10%=*
t-Statistic in Parentheses	