Does Norges Bank's trading in the foreign exchange market on behalf of the government affect the NOK exchange rate?

An empirical analysis

Oddbjørn Larsen Løberg

15.06.2018

Universitetet
i Stavanger

FACULTY OF SOCIAL SCIENCES,
UIS BUSINESS SCHOOL

MASTER'S THESIS

STUDY PROGRAM:	THESIS IS WRITTEN IN THE FOLLOWING SPECIALIZATION/SUBJECT:
Master in Business Administration	**Applied Finance**
	IS THE ASSIGNMENT CONFIDENTIAL? **NO** (**NB**! Use the red form for confidential theses)

TITLE:

Does Norges Bank's trading in the foreign exchange market on behalf of the government affect the NOK exchange rate?

An empirical analysis

AUTHOR		SUPERVISOR:
Oddbjørn Larsen Løberg		**Siri Valseth**
Candidate number: 5004 …………………	Name: Oddbjørn Larsen Løberg ………………………………………	

Abstract

This thesis attempts to find a connection between the Central Bank of Norway's trading in the foreign exchange market and the NOK-EUR exchange rate. The central bank is designated to handle currency transactions related to the non-oil government budget deficit. Theory says these transactions should not affect the long-term exchange rate (Aamodt, 2014). In investigating this, relatively newly collected foreign exchange transactions data is applied using a multivariate regression model (Rime & Sojli, 2006). The data is thoroughly analyzed, sourced from credible sources, and variations of the original model are run as a means of investigating from a different point of view. When using the data on a level form the results are mixed; one model produces no significant results, and another provides some evidence for a short-term effect. By analyzing the data after looking at the weekly changes, one model finds strong statistical significance, and another finds evidence for a long-term effect. The latter findings contradict theory, and as a result are of interest for further research.

1 Table of contents

Acknowledgements

This master's thesis is the culmination of five years of study at the University of Stavanger Business School. It has been some very educational years, and my acceptance into the master's program in Applied Finance truly expanded my knowledge of finance. The work on this thesis has continued to challenge and awe me. Given I had no previous experience in the subject matter, I feel very grateful to be able to infuse my mind with more knowledge.

A special thanks to my supervisor Siri Valseth for making me aware of the thesis topic, for very helpful comments along the way, and for having a genuine interest in the subject, it really helped motivating me.

The results and statements made in this thesis are solely those of the writer, and I take responsibility for any conclusions drawn.

2 Introduction

In the long-term, the Central Bank of Norway's ("Norges Bank") buying and selling of foreign exchange on behalf of the government should not affect the NOK-EUR exchange rate (Aamodt, 2014). I question this statement, and aim to provide empirical evidence in support of, or against, it. One of the most fundamental concepts in economics is the supply and demand relationship. If one were to examine this relationship in relation to the foreign exchange market, theoretically, an increase in demand of any given currency would cause it to appreciate, all else equal. Now, I know the daily/weekly trades from the central bank varies, but I also know the bank went from selling NOK to buying NOK around 2014. This means there were varying amount of NOK being sold at one point in time, and this supply of NOK should in theory depreciate the NOK. The switch from selling to buying NOK is said to not affect the exchange rate as well (Aamodt, 2014), but this switch causes an increased demand for NOK, which should, ceteris paribus, cause an appreciation. The foreign exchange market is a free market however, and all agents are free to purchase and sell Norwegian kroner as they please, which means their actions could potentially offset the increases in supply/demand caused by the central bank. Norges Bank is a fairly small player (evidenced by graphs B1 and B2 in the appendix), so a theoretical supply/demand relationship may be counteracted by all the other agents who are also trading. A note, since it is the central bank that does the trading, there is a possibility of signaling, even though it is stated in Aamodt (2014) that it is the non-oil budget deficit that should be the only influencer of the exchange rate. Meyer and Skjelvik (2006) notes the signaling effects of different agents as well. In addition, Aamodt (2014) says "The breakdown of the government's net cash flow from the petroleum sector into NOK and foreign currency has no bearing [on the krone exchange rate]" (p. 1). The composition of the net cash flow is divided into oil taxes, dividends and direct oil income. Therefore, should the oil companies perform poorly, or the oil price be on the decline, there would be less purchase of NOK by oil companies. Oil companies have to pay taxes in NOK, but a large amount of their revenues is in foreign exchange, thus if they have to pay less taxes, they also purchase less NOK. This is however balanced by larger purchases of NOK by Norges Bank, to be able to cover the government's deficit, so the total NOK purchase is not changing a lot. As the central bank trades in the market, I am interested in investigating whether it can affect the market enough to cause a significant change on a weekly basis in the foreign exchange rate.

In my analysis I will not use a traditional method of exchange rate determination[1]. I am using a microstructure approach. The application of microstructure theory to the foreign exchange market is relatively new (1990s), but the results so far has been promising. I will perform an econometric analysis, and I am using a multivariate regression model of the type used in Rime & Sojli (2006). The one used in this paper is a multivariate illustrative model, but it is a good jumping off point for further research. I will expand the model to include additional foreign exchange transaction and the oil price, in addition to the macro-focused interest differential. Since I include a macro-variable, this can be considered a hybrid model along the lines of the one introduced in Lyons (2002). I will be using publicly available data, which I retrieve from trusted sources, such as Statistics Norway.

2.1 Research question

"Does the Central Bank of Norway's sale/purchase of foreign exchange affect the NOK-EUR exchange rate?"

Norway has regulations that levy large taxes on oil companies, up to 78% (Finansdepartementet, 2017), and in combination with the income from the State's Direct Financial Interest (SDFI), i.e. the State company Petoro, this money is used to balance the government budget. The budget is first balanced with an intentional deficit, explicitly excluding the use of oil money, and this deficit is later balanced by the petroleum cash flows generated by the mentioned income areas. The deficit on the government budget cannot be more than 2,9%[2] of the value of the Government Pension Fund Global (GPFG). Since oil companies sell a lot of their oil in USD, EUR or another foreign currency, their revenues and profits are in a foreign currency, which means they will have to buy NOK in the FX market to pay their taxes. The income from oil taxes is the first money to be spent on the deficit balance[3]. The central bank does not have anything to do with these transactions, however, if this is not enough to cover it, then the income from SDFI will have to be converted to NOK. The SDFI income is mainly in USD, EUR and GBP, and the central bank is given the task of exchanging

---

[1] A traditional model for exchange rate determination is $P_t = \frac{E[P_{t+1}(F_{t+1})|\Im_t]}{1+r_t+\rho_t}$. Where P is the exchange rate, E = expectation operator, F = future macro-fundamentals, $\Im$ = information set, r = interest rate, ρ = risk premium (Rime & Sojli, 2006).

[2] The use of oil income over the government budget shall over time follow the expected real return of the GPFG. This used to be 4%, but were downgraded to 3% in 2017, while the estimated real return in 2018 was 2,9%.

[3] If oil taxes are higher than the deficit, then the central bank will sell NOK and buy EUR to be saved in the GPFG.

this money from a foreign currency to NOK. If the combined income of SDFI and taxes are not able to cover the budget deficit, then a third source of income must be used. The central bank has control over the government pension fund, colloquially "Oljefondet", which is valued at over 8000 billion NOK[4]. The returns from the invested capital can be used to cover the remaining budget deficit. This fund is solely invested in foreign stocks, bonds and property, and any returns will be in a foreign currency. This means that Norges Bank must buy NOK to cover the remaining deficit.

[4] Last updated 30.05.2018; the value is 8430 billion NOK.

3 Background and relevant literature

This section presents the way Norway handles its oil money, in addition to a review of theoretical and empirical works on order flow theory. Norway has transitioned from selling NOK prior to 2013, to buying NOK after 2016. The mechanics of this process is described by the "Petroleum Mechanism". Since I am exploring my research question in light of order flow analysis, I have included an overview of some of the research in this field. A more extensive literature review of relevant papers is found in appendix D.

3.1 Petroleum mechanism

Norway has a system where a large portion of the revenue earned from petroleum activities are funneled into the government. By having regulations which dictate how Norway's oil money should be spent, it benefits the entire country, not just a few companies. The money coming from these operations are being used to balance the national budget, and there are four separate income areas; taxes paid by oil companies and dividends from Statoil, both of which are in NOK; State's Direct Financial Interest (SDFI) and interest and dividends from the Government Pension Fund Global (GPFG), both of which are in foreign currencies (Lund & Stiansen, 2017). The cash from taxes, Statoil and SDFI are referred to as the government's net cash flow from the petroleum industry, and they are used to finance the "non-oil budget deficit". However, should these three income areas not be enough to finance the entire deficit, then it is possible to use returns made on the GPFG. The deficit is planned according to a fiscal rule ("Budgetary rule" or "Handlingsregelen") which stipulates how large a percentage of the GPFG may be spent on balancing the budget over time.

Until recently the income from the petroleum industry has covered the non-oil budget deficit, and the extra cash has been transferred *to* the GPFG. However, in 2016, "The government's net cash flow from petroleum activities is no longer sufficient to finance the entire non-oil deficit…" (Lund & Stiansen, 2017, p. 4). To cover the remaining deficit, portions of the return on the GPFG are therefore transferred from the GPFG to be spent via the central government budget.

Figure 1.1 portrays the petroleum fund mechanism, which shows how domestic and foreign currency move from their respective origins to balance the government budget. This figure shows the current state[5], where withdrawals from the GPFG is needed to cover the government deficit. The non-oil budget deficit can be represented by equation (1.1).

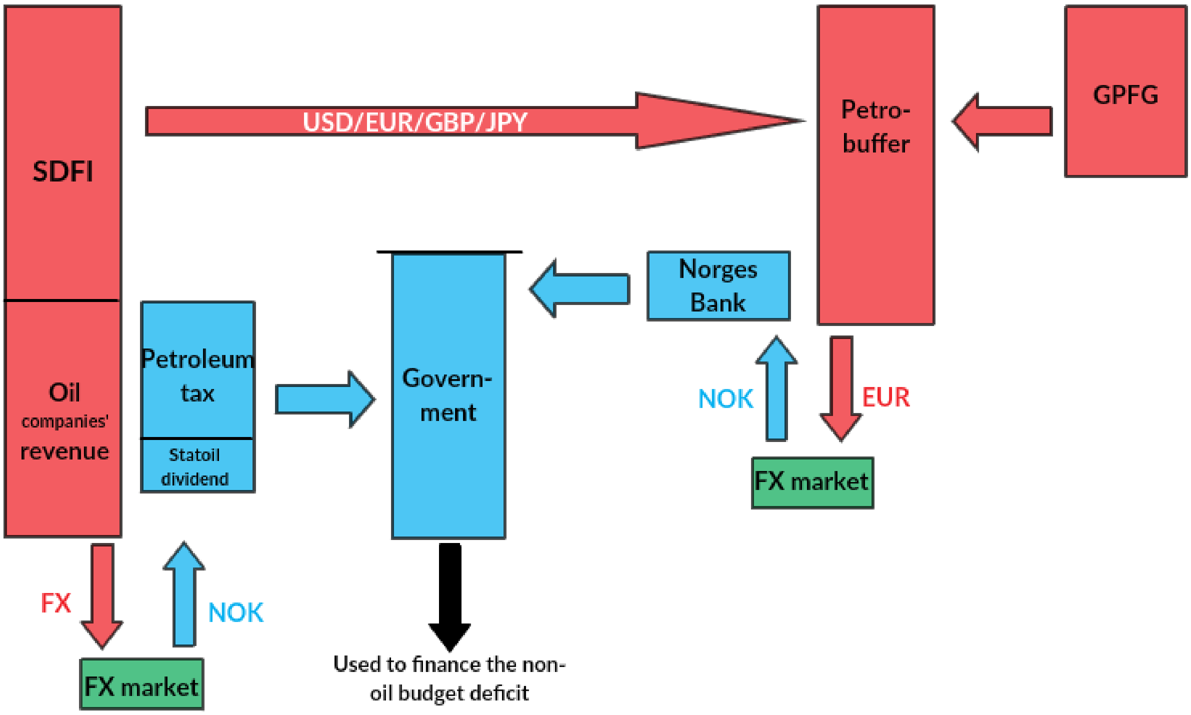


FIGURE 1.1 THE PETROLEUM MECHANISM AS IT IS NOW. TRANSFERS FROM THE GPFG ARE NEEDED TO COVER THE NON-OIL BUDGET DEFICIT. ADAPTED FROM AAMODT (2014).

Non-oil budget deficit = Oil taxes + Revenues from SDFI – SDFI expenses + Dividend from Statoil + Transfers from the GPFG (1.1)

The equation contains both domestic and foreign currency income areas, yet it is only domestic currency which can be used to balance the budget. This means some of it has to be converted, which is the job of Norges Bank. The petroleum industry (oil taxes and dividends) must convert their own revenues, but it is the central bank's mission to exchange the foreign currency coming from SDFI and GPFG.

Before and including 2013 the income from taxes and dividends were enough to cover the deficit, and the remaining were transferred to GPFG. In 2014 the income from these two areas were roughly the same as the deficit, and Norge Bank did not purchase any foreign currency

[5] Figures showing the petroleum mechanism during 2015 and for the period prior to 2013 are shown in figures A1 and A2 in the appendix.

on behalf of the government. In 2015 they were too low, and part of the income from SDFI had to be converted to NOK, with the rest being transferred to GPFG. Since 2016, all three previous income areas are not enough to cover the non-oil deficit, and thus there is a transfer from GPFG (Lund & Stiansen, 2017)

3.2 Order flow theory

Aamodt (2014) acknowledge possible short-term exchange rate fluctuations due to the central banks trading, however, the long-term effect on the NOK exchange rate is due to the size of the non-oil budget deficit. To test this theory, I will be using microstructure finance theory to investigate the research question. Meyer and Skjelvik (2006) provides a detailed introduction to a relatively newly collected dataset based on a theoretical model called order flow analysis. The model is focused on net purchase, rather than total volume, and the results so far have shown great promise. Rime & Sojli (2006) presents an illustrative model, and I use an expansion of this to analyze the order flow data. A great introduction to microstructure finance and order flow theory is the book "*The Microstructure Approach to Exchange Rates"* by Lyons (2001).

Microstructure finance can be defined as "... the study of the process and outcomes of exchanging assets under explicit trading rules" (O'Hara, 1995, p. 1). Relating this theory to the foreign exchange market is relatively new, with researchers starting to apply microstructure tools to this market in the 1990s (Lyons, 2001). The field has grown from its early days, and more research are now focused on different aspects of price determination in capital markets. The traditional theories of exchange rate determination rely heavily on prospective conditions such as fiscal policy, tariffs, and other restrictions on trade, levels of prices, wage rates and other costs in the different countries (Young, 1947). This way of determining exchange rates is well-known to have weaknesses (Young, 1947), and there are disappointing results regarding empirical research into knowing fundamentals such as GDP, inflation, discount rate and more ((Rime & Sojli, 2006), (Cerrato, Sarantis, & Saunders, 2011)). This lack of explanatory power of traditional models gave rise to the use of microstructure models in foreign exchange rate determination. Many of these models operate with order flow analysis as a key input to explain price fluctuations. The use of order flow as a predictor has shown great promise for (single) exchange rate movements (Evans & Lyons, 2002), partly due to the broad public expectations about economic fundamentals contained within order flow information (Rime, Sarno, & Sojli, 2010). Order flow can be explained as "…signed trading volume, or the net of buyer- and seller-initiated transactions" (Kleinbrod & Li, 2017). The data I use is described as both order flow data and foreign exchange transaction data (Meyer & Skjelvik, 2006). For the data to be "true" order flow data, one would need to know who initiated each transaction, and since this is not included, it is technically incorrect to call it order flow data. Intuitively though, the data on the central bank can be considered "true", since it is improbable that a bank or broker calls up the central bank to trade, it is most likely the other way around. Going further, for simplicity I am going to use order flow when referring to the data regarding transactions in the foreign exchange market, as this is also done in Rime & Sojli (2006).

Several papers use order flow as a means of measuring price differentials, and it is not just in the FX market. Thomassen & Rasmussen (2011) uses order flow to examine the stock market, and the results here are mixed. Order flow is, however, widely used in studies on the FX-market, due to its strong explanatory power and the available, rich, accurate and high-frequency data (Kleinbrod & Li, 2017). Danielsson, Luo & Payne (2012) explores exchange rate determination and inter-market order flow effects. The results are compelling and suggest that order flow is indeed a strong predictor for exchange rates. These results corroborate previous paper on the topic by Evans & Lyons (2002) , Payne (2003) and Berger, Chaboud, Chernenko, Howorka & Wright (2008). The latter also find that the order flow of GBP/USD and EUR/GBP are strongly affected by the EUR/USD order flow. Lyons (1995) test microstructure hypothesis in the foreign exchange market, and the results support two microstructure theory approaches; inventory-control and asymmetric-information. Further, Evans & Lyons (2008) compares order flow and macro news with promising results. Kleinbrod & Li (2017) extends the order flow/exchange rate theory to a multivariate framework and examine co-movements in large currencies. They find that "… effect of order flow on exchange rate comovements is significantly negative during the tranquil period but can become positive during the turbulent period ['07 global financial crisis]". Further, they find that correlations between exchange rates are stronger when there is a joint appreciation.

4 Methodology and data

This section presents the model I am going to use in my analysis, as well as a detailed breakdown of the data used. The model is an expansion on the one used in Rime & Sojli (2006), and I'm using time series data in an attempt to uncover a ceteris paribus relationship between the central bank's trading and the foreign exchange rate. The data is collected from highly credible sources, and given that it comes in different formats, I've had to manipulate it to make it usable. Appendix E "*Data collection*" shows extracts of the initial raw data and the finished summary, in addition to two "tear-off pages" containing all regression outputs and descriptive statistics.

4.1 Order flow data

The order flow data I have from Statistics Norway[6] is in a weekly format, and it contains data on the spot-, forward- and swap market. The swap market doesn't have any direct effect on the FX price (Lyons, 2001), therefore I will be focusing my research on the spot- and forward market. Further, the data is split into multiple counterparty categories, with the main categories being "Foreign banks" and "Central Bank of Norway". In addition to the two previous, there is a category for reporting banks. I've chosen to exclude this from my model because the order flows are measured from the point of view of the reporting banks. To avoid corrupting the data possibly due to double counting or initiation errors, I've decided to leave this category out. For a deeper explanation of how order flow data is collected, see appendix E. The remaining categories are either focused on Norwegian/foreign clients, or financial/non-financial clients. The last two categories contain the same data; thus, one can only pick one of the pairs to use in an analysis. I have chosen to use the "Norwegian clients" and "Foreign clients" categories[7]. "Norwegian clients" consists of other Norwegian banks, other Norwegian financial clients, and Norwegian non-financial clients, including oil companies. "Foreign clients" consists of other foreign financial clients and foreign non-financial clients.

The complete dataset is comprised of two separate files, one ranging from 03.10.2005 to 03.01.2010 and the other from 04.01.2010 to 22.04.2018. The complete dataset consists of 655 weekly observations. Each observation is either a positive or a negative number, and these

[6] Statistics Norway collects foreign exchange transactions on behalf of the central bank. The statistics can be accessed from https://www.norges-bank.no/en/Statistics/Foreign-exchange-transactions/

[7] This should not affect the outcome of the analysis since the same data is used in both cases, it is just categorized differently.

are representative of the net foreign purchases. A positive number, seen from the *reporting banks'* view, indicate a net purchase of foreign exchange (sell NOK) by the reporting banks and net sales of foreign exchange (purchase NOK) by the counterparty[8]. The numbers reported are is in millions of NOK. To prevent double-counting, the reporting banks has to follow certain rules when reporting their transactions. Depending on the currency pair (EUR-NOK, USD-NOK, Other-NOK), the transaction distributions are measured in euro, dollars and Norwegian kroner. Table 1.1 shows a few examples on how the reporting works. As one can see, any transaction involving EUR will be reported as either a sale or a purchase of euro. The NOK amount in this transaction is not counted. NOK is only used as a metric when other currencies than EUR and USD are traded. These other currencies are then combined and expressed as a sale or purchase in NOK.

Bank A	EUR	USD	Other	Report
Purchase NOK 16	Sell EUR 2			Sale EUR 2
Sell NOK 16	Purchase EUR 2			Purchase EUR 2
Sell NOK 70		Purchase USD 10		Purchase USD 10
Purchase NOK 6			Sell JPY 100	Sale NOK 6
Sell NOK 120			Purchase 10 GBP	Purchase NOK 120

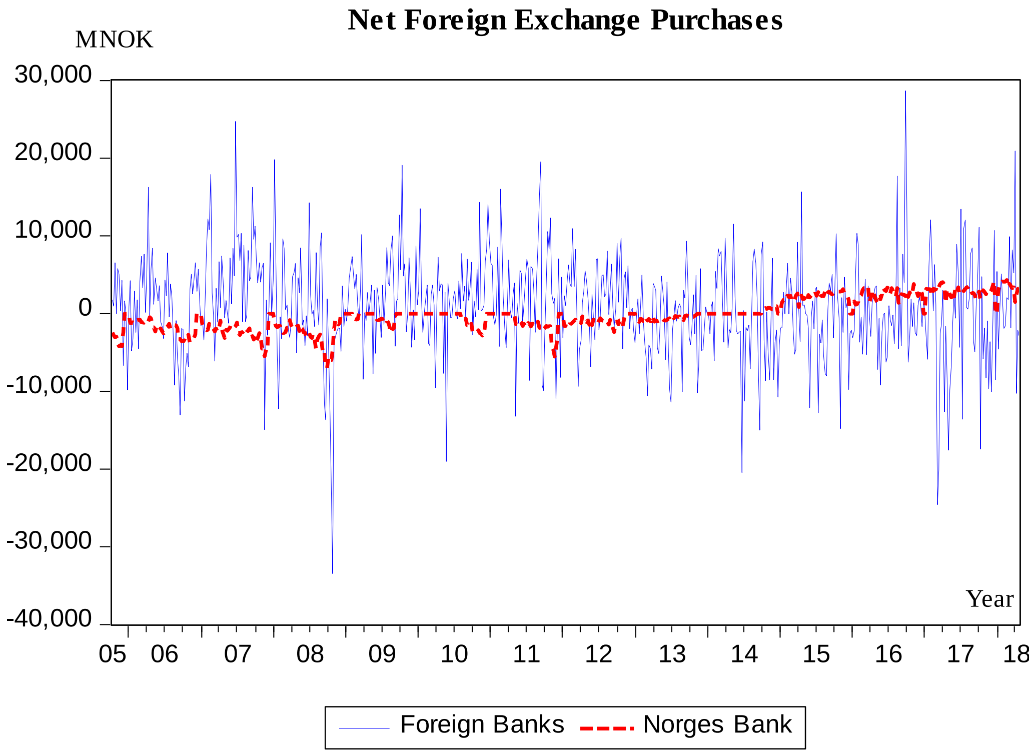
TABLE 1.1 **EXAMPLE OF HOW CURRENCY TURNOVERS ARE TO BE REPORTED BY THE REPORTING BANKS. SOURCE: (SSB, 2016).**

I have created a new file in Excel (appendix E) which will aggregate all the relevant information pertaining to my analysis. The first thing I did was to create a list of dates, ranging from October 9th, 2005 to 22nd of April 2018. I start with the 9th of October because that is the end date in the first week in the series. As such, each date in the file is the end date of each observation. Next, I copied the order flow data from the two original files and pasted them into my new file. The raw order flow data is presented in graph 1.1 and B3 (appendix), and one can see that foreign banks are a major player in the NOK-EUR market.

Graph 1.1 is *net* foreign exchange purchases among the bank categories, and one can see that most of the directional trade comes from foreign banks. A negative amount on the graph indicates a sale of NOK (purchase of foreign exchange). Graphs B1 and B2 in the appendix shows the volume of purchase and sale of foreign exchange. They present a clear

[8] One knows that in 2010 the central bank sold NOK (Bank, 2010), and in 2017 it bought NOK (Bank, 2017). This is indicated by a negative order flow in 2010 and a positive order flow in 2017.

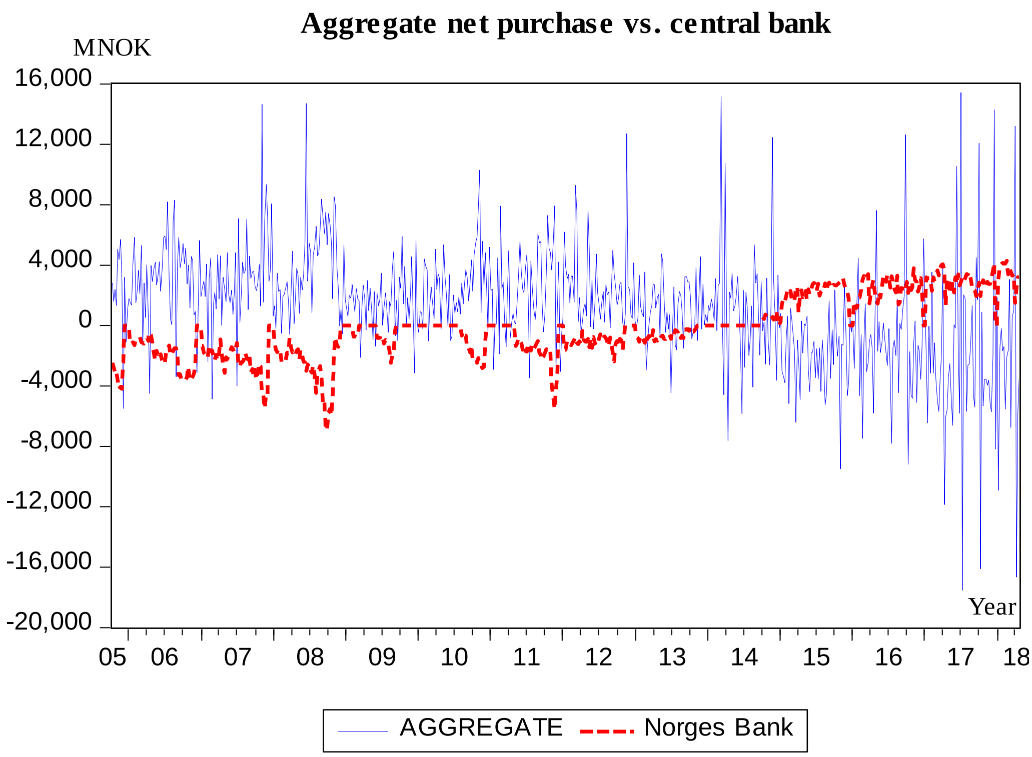
picture of foreign banks as the overall biggest player by having the most sales and purchases, and the central bank as the smallest player.



GRAPH 1.1 **RAW ORDER FLOW DATA ON LEVEL FORM FOR FOREIGN BANKS AND THE CENTRAL BANK. THE DATA IS NET FX PURCHASES, WITH A POSITIVE AMOUNT INDICATING A SALE OF FOREIGN EXCHANGE (PURCHASE OF NOK).**

Graph B3 compares the *net* foreign exchange purchases among the different clients. The Norwegian clients appear to trade more than the foreign clients from this graph, and conferring with graphs B1 and B2, this is indeed the case.

If one expects, or assumes, that net foreign exchange purchases have any influence on the foreign exchange rate, it is reasonable to also expect that the largest players has the most influence. The central bank is by far the overall smallest player, but when looking at graph 1.2, the net purchases are relatively large, which is because the bank only trades in one direction at the time (switch from selling NOK to buying NOK around 2015). Graph 1.2 compares the aggregated net purchase of all the categories (excluding the central bank) and the central bank. Graph 1.2 seems to show that the central bank is not following the trend in the rest of the market. One can see that while the market has mostly positive net purchases, the central bank has negative net purchases. This trend is evident thru the entire sample, with the central bank starting to have positive net purchases when the market is aggregating towards negative net purchases. This is due to the central bank's mission to only use "oil-income" to buy or sell foreign exchange as directed by the government.



***GRAPH 1.2* COMPARISON OF THE THREE CATEGORIES; FOREIGN BANKS + FOREIGN CLIENTS + NORWEGIAN CLIENTS, AND THE CENTRAL BANK'S NET PURCHASE.**

Now, my research question is attempting to find a connection between the central bank's purchase and sale of foreign exchange and how this might affect the NOK-EUR rate. By quickly visualizing and comparing the data on the players in the FX market (graph 1.1, 1.2, B1, B2 and B3), it is possible that the activities of the central bank affect the rate of the NOK-EUR pair. I will do a more thorough mathematical analysis later.

Table 1.2 contains descriptive statistics of the order flow data on all the categories. An interesting piece of information here is the zero median in the central bank column. The reason this is quite different from the mean is that the Central Bank of Norway has long periods of zero trade activity; usually there is no trading at the end of a given year. Further, the skewness, kurtosis and Jarque-Bera statistic shows the distributions of the data. One can see that the data for the central bank has a skewness close to zero and a kurtosis close to three. Corroborated by a Jarque-Bera statistic of 0,149, this means that the data is normally distributed.

	Foreign banks	*Central Bank of Norway*	*Δ Central bank of Norway*	*Norwegian clients*	*Foreign clients*
Mean	931	-174	8,727	364	-32,6
Median	1 013	0	0	15	-92,8
Maximum	28 667	4 299	4713	36 699	11 221
Minimum	-33 451	-6 975	-4153	-18 751	-6 682
Std. Dev.	6 469	2 038	628	5 580	1 627
Skewness	-0,290	0,017	0.633	0,847	0,645
Kurtosis	5,67	2,93	15,2	7,40	8,03
Jarque-Bera	204	0,149	4088	608	735
Probability	0,000	0,928	0,000	0,000	0,000
Aug. Dickey-Fuller	-13,9	-3,89	-20,3	-17,1	-21,9
Probability	0,0000	0,0022	0,0000	0,0000	0,0000
Observations	655	655	654	655	655

***TABLE 1.2* DESCRIPTIVE STATISTICS FOR ALL THE DIFFERENT ORDER FLOW CATEGORIES. THE CENTRAL BANK OF NORWAY HAS SIGNS OF A UNIT ROOT; THEREFORE, I HAVE ALSO LOOKED AT THE CHANGE IN THE CENTRAL BANKS DATA.**

Table 1.2 also shows the augmented Dickey-Fuller test statistic, which is test for a unit root. The null hypothesis is that the variable has a unit root, and in all cases the hypothesis is rejected. This is a test for stationarity, and a larger absolute value indicates stronger rejection of the null hypothesis. A stationary time series is one whose statistical properties are constant over time; stationarity is assumed in most statistical forecasting methods (Nau, 2018). The data in the table shows no signs of a unit root for any of the variables, except for the "Central Bank of Norway" category. I noticed this statistic was different from the others, therefore I ran two tests[9] on it, and concluded that the variable has a unit root. To deal with this, I found the first difference of it, and those statistics are presented as "Δ Central bank of Norway". When looking

[9] When running the Dickey-Fuller test, the lag length can be chosen as many different criterions, with the standard one being Schwarz Info Criterion. The second criterion I used was Akaike Info Criterion, and this one had a p-value of 0,55, which is strongly indicative of a unit root.

into the central bank category I also noticed that the data suffer from large degrees of autocorrelation. In appendix C, “Tables”, I have included the correlograms for each of the order flow variables, and one can see that the central bank has substantially more serial correlation than the others. One also sees that the first difference of the central bank variable is drastically less affected by autocorrelation. Due to the latter variable being stationary and less affected by autocorrelation, I am using this version of the variable in certain models later in my analysis.

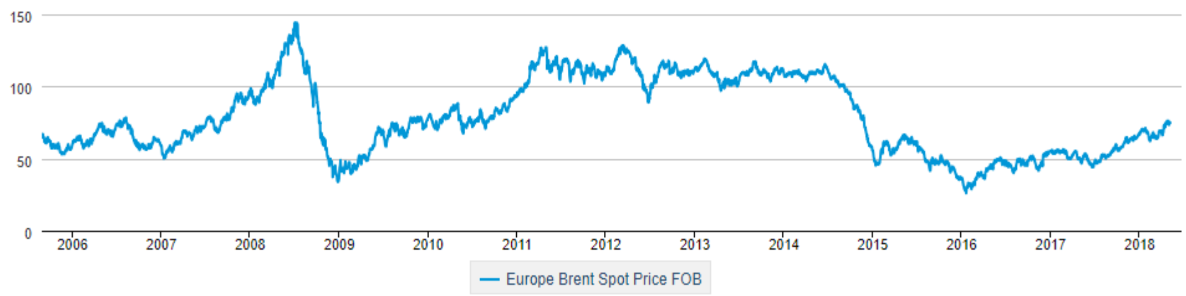
4.2 Oil price

A natural variable to include in the regression is the price of oil. Norway is a major producer of oil, and the funding for the government pension fund, as well as the SDFI income, comes from oil activities. Further, several studies have provided evidence for the long-term relationship between oil prices and exchange rates; Akram (2004), Amano & Norden (1998a, 1998b), Jawadi, Louhichi, Ameur & Cheffou (2016), Reboredo (2012), Turhan, Sensoy & Hacihasanoglu (2014).

Oil can be separated into three main benchmarks: WTI, Brent and Dubai. The prices between the three benchmarks are highly correlated, as shown in graph B4. With the high correlation it is not necessary to include all three variables in a regression. Norway produces Brent oil; therefore, I will be using this in the regression estimation.

The oil price data is taken from the U.S Energy Information Administration (EIA). This is a government agency which provides independent statistics and analysis. The data is found by going to their website[10] and clicking on “Sources & Uses” followed by “Petroleum & Other Liquids”. Next, one goes to the “Data” drop-down menu and chooses “Prices”. From here one clicks on “spot prices” and a table containing various types of oil and oil products appear. By choosing to view the history of “Brent – Europe” one will be presented with historical oil prices, ranging from 1987-2018. The data may be downloaded in a daily, weekly, monthly or annual format. I use the weekly format since all my other data is weekly. After I have the data, it is a simple copy and paste job in Excel to align it with the rest of the data.

Graph 1.3 shows the price of oil from 2005 to 2018. As one can see, the price has fallen quite a lot since its peak in 2008.



***Graph 1.3* Brent spot oil price, 2005-2018. Source: (EIA, 2018)**

[10] https://www.eia.gov/dnav/pet/hist/RBRTED.htm

Oil prices are on the rise again though and given the theoretical relationship between an increase in oil price and an oil-exporting country's currency appreciation, one could assume that the Norwegian krone will be appreciating[11].

Table 1.3 provides descriptive statistics of the raw oil price data. As one can see, the augmented Dickey-Fuller test on "Oil price" has a p-value of 0,355. This means that one fails to reject the null hypothesis about it having a unit root. Thus, it would be unwise to use this form of the oil price as an explanatory variable in a regression model. To get the variable to be more cooperative, and stationary, one option is to use the weekly, percentage change. The stats for this is presented in "ΔOil price (%)".

	Oil price	*ΔOil price (%)*
Mean	78,96	0,001156
Median	73,35	0,001010
Maximum	141,1	0,221652
Minimum	27,76	-0,151762
Std. Dev.	26,30	0,040575
Skewness	0,202	0,174920
Kurtosis	1,759	5,570601
Jarque-Bera	46,46	183,4
Probability	0,000	0,000
Aug. Dickey-Fuller test	-1,852	-20,57
Probability	0,355	0,000
Observations	655	654

TABLE 1.3 **DESCRIPTIVE STATISTICS FOR THE OIL PRICE AND THE PERCENTAGE CHANGE IN OIL PRICE.**

[11] Golub (1983), De Grauwe (1996), and Corden (1984).

4.3 Interest rates

A known relation of determining interest rates is with the use of an interest rate parity formula[12]. Speculators and arbitragers have used such a formula to find forward foreign exchange rates on many occasions. The formula relates interest rates in different countries to the spot and forward exchange rates in the same countries. The theory is derived from the law of one price, and it attempts to create a link where there is no possibility of arbitrage. The formula can be written:

$$\frac{F-S}{S}=r_d-r_f$$

Where F = forward exchange rate, S = spot exchange rate, r_d = domestic interest rate and r_f = foreign interest rate. Graph B5 shows a simplified supply-demand relationship between the NOK and the domestic interest rate. If the interest rates in Norway were to increase ceteris paribus, one would expect more people to invest there, which will create a shift in the demand curve. A higher demand will lead to increased prices, a stronger NOK, which will in turn alter the exchange rate.

The interest differential on the right-hand side of the equation attempts to predict the future exchange rate. Since I am investigating whether the order flow of the Central Bank of Norway has any explanatory power over the exchange rates, I believe that it is reasonable to include this differential as a variable in the regression. The parity is used extensively in practice, which means that it should have a statistically significant value in any regression estimation involving foreign exchange rates.

Since I am looking at the NOK-EUR exchange rate, I believe the most appropriate measures of interest rates is the NIBOR and LIBOR. These rates are the foundation for how other rates are calculated, and any changes will impact the larger economy in significant ways. They come in different maturities, with the NIBOR rate being offered on 1 week, 1-3 months and 6 months maturities. LIBOR serves different maturities, seven to be exact; overnight, one week, 1-3 months, 6 months and 12 months. This provides me with five different maturities to choose from. Rather arbitrarily I am going to use the three-month rates. This is a common rate to use, and it should not affect the results since all three rates are highly correlated, as pictured in graph B6 and B7.

[12] Cumby & Obstfeld (1981), Engel & Frankel (1984), Frankel (1979) and Taylor (1987)

The NIBOR rates can be found in two separate places[13]; the websites of the Central Bank of Norway and Oslo stock exchange. Daily data gathering was done by the central bank until the 8th of December 2013, and from then the Oslo stock exchange assumed responsibility. Given that this data is in a daily format, and I need it weekly, I will have to transform it. The first thing I do is sort the data, so that the first row is in 2005. Next, I have to get the daily data to a weekly format. Since there are more than three thousand daily observations, I will use a pivot table in Excel to organize it. This is done by first marking all the daily data and corresponding dates, then selecting "Pivot table" on the "Insert" tab. Next, one chooses an output space for the table. From here, one will be prompted with a field containing two tables. By placing the table containing the daily interest rates in the box labeled "values", and the dates in the "rows" box, one will create an interactive table consisting of all the daily data in a yearly and quarterly format. The daily interest rate data is summarized in this table; however, I want the data to be averaged. I also want it to be displayed in weeks, not quarters or years. To fix this, I first go to the table which I placed in the "values" box and click on it. This gives me the option to change the settings, and it is here that I choose "average" under the table summary header. To get the weekly date format, I simply right-click on the dates in the pivot table and choose "group". From here I deselect the "months", "quarters" and "year", and select "days". This will give me daily observations, and to get weekly, I have to change the number of days from one to seven. If one presses OK now, the data is shown in a weekly format, with a five-day average for each week. This is what I need, so I copy and paste it into the aggregate data file I created for the other variables.

The LIBOR data is found on the websites of the Federal Reserve Bank of St. Louis, in the FRED database. When on the website, choose to browse the data by "Category", then, under "Money, Banking & Finance" click on "Interest Rates" followed by "LIBOR Rates". A new page appears, and here one selects the "3-Month London Interbank Offered Rate (LIBOR), based on Euro". This presents a page where one may choose the desired date range and then download the data at a daily frequency. The same procedure is applied to this as was done above, which gives one enough data to create an interest parity column.

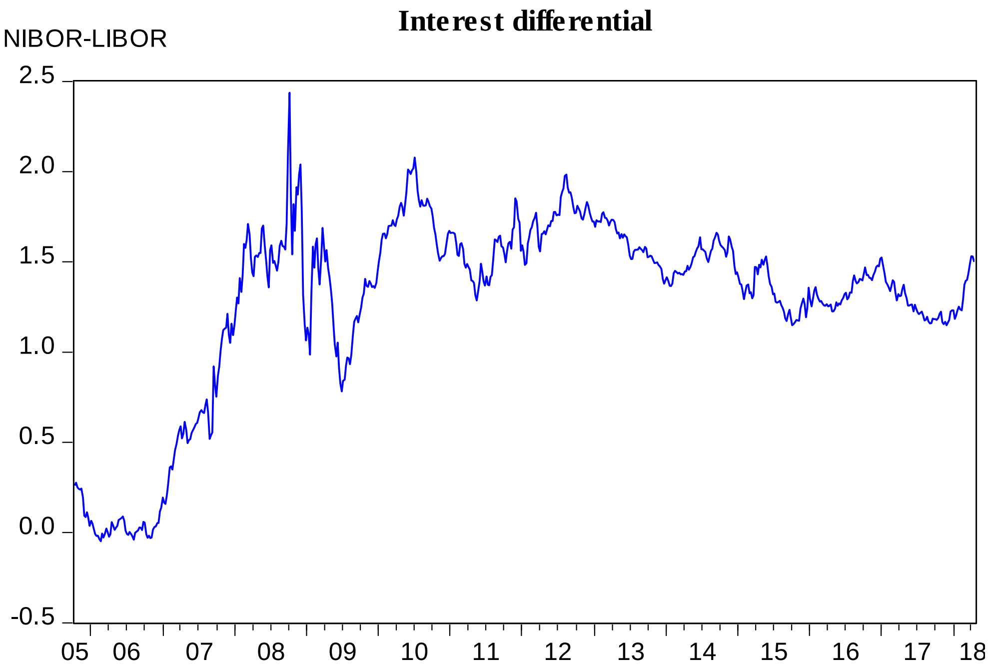
Graph 1.4 shows the interest differentials from 2005-2018, with the Norwegian krone being the domestic rates. The interest rates in Norway has been much higher than continental Europe since around 2008. These are nominal interest rates, and the NIBOR rate is creeping

[13]https://www.norges-bank.no/en/Statistics/Historical-monetary-statistics/Short-term-interest-rates/
https://www.oslobors.no/markedsaktivitet/#/list/nibor/quotelist

below one percent in recent time. Since the interest differential is upwards of one and a half percent at the same time, this means that the LIBOR rate is negative. A negative interest rate should not cause any problems in the estimation, however, something that will cause problems is the Dickey-Fuller test statistic shown in table 1.4. The interest differential variable fails to reject the null hypothesis about a unit root, which means that this is not a stationary process. It is quite important to have a stationary variable, and one way to achieve this is to difference the data. This is easily done in EViews, and the descriptive statistics of the transformed data is presented in table 1.4. The first difference is found, and it is simply calculated as $\Delta ID_t = ID_t - ID_{t-1}$.

	Interest differential	*Δ Interest differential*
Mean	1,279	0,001915
Median	1,418	0,000758
Maximum	2,437	0,386876
Minimum	-0,048	-0,569250
Std. Dev.	0,513	0,066739
Skewness	-1,335	-0,495659
Kurtosis	3,987	20,39111
Jarque-Bera	221,1	8269
Probability	0,000	0,000
Aug. Dickey-Fuller test	-2,199	-20,47
Probability	0,2068	0,0000
Observations	655	654

***TABLE 1.4* DESCRIPTIVE STATISTICS FOR INTEREST DIFFERENTIAL AND DIFFERENCED INTEREST DIFFERENTIAL DATA.**



Graph 1.4 **Interest rate differential. NIBOR is the domestic rates and LIBOR is the foreign rates.**

4.4 Foreign exchange rates

The dependent variable in the regression equation is the NOK-EUR exchange rate. There is a plethora of websites with historical foreign exchange rates, however, most of them are focused on the largest currency pairs. To find the data I needed, I used a subscription-based platform which let me download weekly data ranging from 09.10.2005-22.04.2018. The data is taken from OANDA[14], a U.S-based fintech company, with trusted high-profile clients such as Tesla, Google and KPMG. To access the data, one first goes to their website and signs in with a subscribed account to the "Historical Converter" page. When signed in, one may choose a currency pair, the frequency, the range, and the price. I chose the "NOK-EUR" pair from October 2005 to April 2018, with a "weekly" frequency and "mid" price[15]. Next, it is a simple download and copy paste into the relevant excel file.

	FX	*ΔNOK-EUR (%)*
Mean	8,36	0,000336
Median	8,14	-0,000422
Maximum	9,94	0,046003
Minimum	7,30	-0,031431
Std. Dev.	0,66	0,008370
Skewness	0,54	0,541851
Kurtosis	2,15	5,830706
Jarque-Bera	51,3	250
Probability	0,000	0,000
Aug. Dickey-Fuller test	-1,23	-17,3
Probability	0,6619	0,0000
Observations	655	654

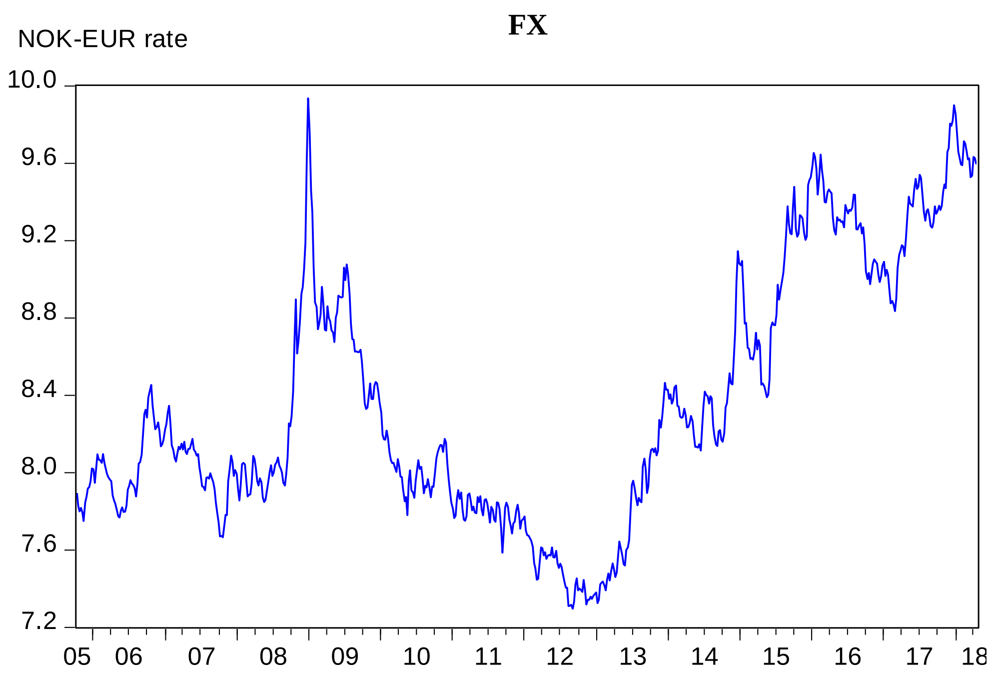
TABLE 1.5 DESCRIPTIVE STATISTICS OF THE FOREIGN EXCHANGE DATA.

14 https://www.oanda.com/fx-for-business/historical-rates

15 The "mid" price is the average between the "ask" and "bid" rates. Also, since it is a weekly frequency, the FX rate obtained is the average rate for the week.

From the raw data in table 1.5, the FX variable seems to have a unit root, which makes it a non-stationary variable. This would cause the estimation the be erroneous, so, to fix it I am going to use the weekly percentage change in price as the dependent variable. This transformation of the data doesn't change the underlying relationship among the foreign exchange rate and the explanatory variables.

Graph 1.5 displays the NOK-EUR relationship, and one can see how the global financial crisis (GFC) affected the exchange rate around 2008. The NOK was weakening quite rapidly leading up to the crisis, however, in the aftermath the Norwegian krone strengthened in relation to the euro. From a peak close to 10 NOK per EUR, to a trough a few years later at 7,30, the NOK experienced strong appreciation during this time. The exchange rate is negatively correlated with the interest rates[16], which is what one would expect when looking at the interest rate and foreign exchange graphs[17]. Graph 1.4 also shows how the interest differential may help explain the large appreciation of the NOK before and during the GFC. Higher interest rates create more demand for NOK, although, this does not explain how the interest rate differentials are quite steady post GFC, while the NOK is depreciating to pre-GFC levels.



***GRAPH 1.5* NOK-EUR RATE OVER TIME.**

---

[16] $\rho_{FX,NIBOR} = -0.432$, $\rho_{FX,LIBOR} = -0.374$, $\rho_{FX,Interest\ differential} = -0.0700$

[17] Graphs B6 and B7 in the appendix and graphs 1.4 and 1.5 in the text.

4.5 Empirical model

To investigate a causal relationship between the buying and selling of foreign exchange by the Central Bank of Norway and the NOK-EUR exchange rate, I will be using a multivariate regression model. I will be using time series data on seven explanatory variables as well as the dependent variable. My dependent variable will be the average, weekly mid-price of the NOK-EUR exchange rate. The model to be estimated is on the form:

$$\Delta FX_t = \beta_0 + \beta_1 NB_t + \beta_2 FB_t + \beta_3 NC_t + \beta_4 FC_t + \beta_5 \Delta OP_t + \beta_6 \Delta ID_t + \beta_7 \Delta FX_{t-1} + \mu_t \quad \textbf{(1.2)}$$

Where,

- ΔFX_t = The weekly, percentage change in the NOK-EUR exchange rate at time t.
- β_0 = Intercept
- NB_t = The order flow coming from the Central Bank of Norway.
- FB_t = The order flow coming from foreign banks.
- NC_t = The order flow coming from Norwegian clients.
- FC_t = The order flow coming from foreign clients.
- ΔOP_t = The percentage change in oil price.
- ΔID_t = The change in the NOK-EUR interest differential.
- ΔFX_{t-1} = First lag of the FX variable.
- μ_t = The error term.

EVeiws10 is the software used to estimate the equation, and it is estimated using ordinary least squares. I have 655 observations, however, due to some of the variables being differenced, or a percentage change, only 652 observations will be included.

5 Analysis

The model defined in the section four is estimated using ordinary least squares. The following table displays equation (1.2) estimated as "*Original model*". The dependent variable (*here:* FX_t) is inferred from the model name and the independent variables are listed in the first column, with the "*C*" variable being the intercept. The estimated beta coefficients are presented as the numbers not in parenthesis. The numbers in parenthesis are the corresponding standard errors.

Variables	*Original model*
C	0,000448* (0,00273)
NB_t	0,0150 (0,01360)
FB_t	-0,0289*** (0,00942)
NC_t	0,0568*** (0,01050)
FC_t	-0,0184 (0,01490)
ΔOP_t	-0,0072 (0,0086)
ΔID_t	-0,0200*** (0,00792)
ΔFX_{t-1}	0,1263*** (0,05400)
n	652
Adjusted R^2	0,457
F-statistic	79,3

TABLE 1.6 *P<0,1, **P<0,05, ***P<0,01. REGRESSION OUTPUT FOR THE MODEL IN EQUATION 1.2. ESTIMATION IS DONE WITH HAC STANDARD ERRORS. ORDER FLOW COEFFICIENTS AND STANDARD ERRORS ARE MULTIPLIED BY 100 000. STANDARD ERRORS ARE IN PARENTHESIS.

The adjusted R-squared indicates that about 45% of the variation in the exchange rate can be explained by the included explanatory variables. The F-statistic is quite a bit higher than the critical value for any significance level, which means the equation is overall significant. The asterisks next to a given number indicates significance at various significance levels. A side note, I chose to multiply the coefficients, and the standard errors, of the order flow variables by 100 000. I did this because the regression output has them on a scientific notation, which I think looks messy in this setup. By multiplying them I get a cleaner output, and it does not change the meaning of any variable, nor their inference capabilities.

As I estimate the equation I am careful to not read too much into it at first. Given that I know the data for the central bank is non-stationary and suffering from a large degree of autocorrelation, I want to run a few tests on the first regression output. EViews allows one to perform a host of residual and coefficient tests, and I will start by testing for heteroskedasticity and autocorrelation.

The test for heteroskedasticity I use is called a Breusch-Pagan-Godfrey test. It recognizes the null hypothesis; H_0: $Homoskedasticity$. When I perform this test on the regression I receive a p-value of 0,0141. This indicates significance at the 1% level, and I reject the null hypothesis. By rejecting the assumption of homoskedasticity, one implicitly assumes heteroskedasticity[18].

The test for autocorrelation is a Breusch-Godfrey serial correlation test, and it checks the null hypothesis H_0: $No\ serial\ correlation\ at\ up\ to\ n\ lags$. I have chosen one lag, and the resulting p-value is 0,000. This is significant at all levels, which means I reject the null and assumes some form of autocorrelation. Setting the lag level to 50 does not change the result in any significant way.

Following these tests, I estimate the model again, however, this time I will be estimating it with robust standard errors. To do this I follow the previous procedure, except that I choose a "HAC (Newey-West)" covariance method in EViews. By doing this I will estimate the equation again, this time with an attempt to overcome heteroskedasticity and autocorrelation. The estimated regression equation has the same coefficients; however, the standard errors and p-values have changed. Table 1.6 displays the final regression output.

With robust standard errors, I am able to investigate the relationship between the NB_t variable and the dependent variable, using the normal hypothesis testing methods. The following hypothesis can be checked with a t-test:

$$H_0: \beta_1 = 0 \tag{1.3}$$

$$H_1: \beta_1 \neq 0$$

The null hypothesis attempts to prove that the NB_t variable has no effect on the expected value of the FX_t variable, after controlling for all other independent variables. It checks to see whether

[18] A model suffering from heteroskedasticity doesn't cause bias or inconsistency in estimators, however, it does create a different problem. Heteroskedasticity targets the variances of one's sample and creates biased estimates of the variances, which is then used to calculate erroneous standard errors. This means that one cannot make reliable hypothesis testing statistics, such as t-tests, F-tests and LM-tests, because one's standard errors are biased, and the distributions underlying the tests are no longer properly distributed (Wooldridge, 2015)

the Central Bank of Norway's order flow has a ceteris paribus effect on the NOK-EUR exchange rate.

The standard error, for "*Original model*", in table 1.6 can be used to calculate the t-statistic for the NB_t variable; $t = \frac{\hat{\beta}_{NB}}{se(\hat{\beta}_{NB})} = \frac{0,015}{0,0136} = 1,103$. This is for a two-sided test, which is the most appropriate here, since I am testing whether beta one is equal to zero, not just smaller or larger than zero. The critical value for a sample with 652 observations at the 5% significance level is 1,96. To reject the null, $|t_{\beta 1}| > c$, which is not the case here, 1,103 < 1,96. The p-value presented in table 1.6 gives the lowest level at which the variable NB_t is significant. One can see that it is above the 10% significance level (it actually is at the 27% level), which basically means the variable is insignificant at any reasonable level.

The original model in equation (1.2) does not show any significant effect on the exchange rate when one looks at trading performed by the central bank. I don't want to make any conclusions yet though, as the model can be estimated in different variations. Other variations of the model will explore the same relationship between the foreign exchange rate and order flows, using the same data, but vary the explanatory variables or dependent variable.

I am going to run five variations of the original regression model, where[19]:

- Model 1: DV: weekly average. IV: original *plus* lags;

$$\Delta FX_t = \beta_0 + \beta_1 NB_t + \beta_2 FB_t + \beta_3 NC_t + \beta_4 FC_t + \beta_5 \Delta OP_t + \beta_6 \Delta ID_t + \beta_7 \Delta FX_{t-1} + \beta_8 NB_{t-1} + \beta_9 FB_{t-1} + \beta_{10} NC_{t-1} + \beta_{11} FC_{t-1} + \beta_{12} \Delta OP_{t-1} + \beta_{13} \Delta ID_{t-1} + \mu_t$$

- Model 2: DV: weekly average. IV: original, but with first differenced order flow for NB;

$$\Delta FX_t = \beta_0 + \beta_1 \Delta NB_t + \beta_2 FB_t + \beta_3 NC_t + \beta_4 FC_t + \beta_5 \Delta OP_t + \beta_6 \Delta ID_t + \beta_7 \Delta FX_{t-1} + \mu_t$$

[19] DV = dependent variable. IV = independent variable.

- Model 3: DV: weekly average. IV: same as model 2 *plus* lags;

$$\Delta FX_t = \beta_0 + \beta_1 \Delta NB_t + \beta_2 FB_t + \beta_3 NC_t + \beta_4 FC_t + \beta_5 \Delta OP_t + \beta_6 \Delta ID_t + \beta_7 \Delta FX_{t-1} + \beta_8 \Delta NB_{t-1} + \beta_9 FB_{t-1} + \beta_{10} NC_{t-1} + \beta_{11} FC_{t-1} + \beta_{12} \Delta OP_{t-1} + \beta_{13} \Delta ID_{t-1} + \mu_t$$

- Model 4: DV: Friday's[20] FX-rate. IV: original;

$$\Delta FX_f = \beta_0 + \beta_1 NB_t + \beta_2 FB_t + \beta_3 NC_t + \beta_4 FC_t + \beta_5 \Delta OP_t + \beta_6 \Delta ID_t + \beta_7 \Delta FX_{f-1} + \mu_t$$

- Model 5: DV: Friday's FX-rate. IV: original *plus* lags;

$$\Delta FX_f = \beta_0 + \beta_1 NB_t + \beta_2 FB_t + \beta_3 NC_t + \beta_4 FC_t + \beta_5 \Delta OP_t + \beta_6 \Delta ID_t + \beta_7 \Delta FX_{f-1} + \beta_8 NB_{t-1} + \beta_9 FB_{t-1} + \beta_{10} NC_{t-1} + \beta_{11} FC_{t-1} + \beta_{12} \Delta OP_{t-1} + \beta_{13} \Delta ID_{t-1} + \mu_t$$

The variation models are estimated with HAC standard errors, just as the original model. The dependent variable in model four and five is the foreign exchange rate on Friday for each week. The reason I choose to use this, instead of the average, is because I believe the Friday rate has had time to compound all the order flow information throughout the week. I'm not saying that information is compounded only at the end of a given week, but to give the model some variation, I believe that using the Friday rate, compared to using a single other weekday, proves more realistic.

The variation models, in table 1.7, generate quite different results compared to the original model. In model one, by including the lagged NB variable, the results have shifted drastically. Going from no significance to statistical significance at the 1% level for both NB variables are surprising. It is worth nothing though, the signs of the NB variables in this model are in opposite direction. I will touch more in this in the next section. Model two and three looks at the first difference of the NB variable, and the estimation produces highly significant coefficients. Model three produces same sign coefficients, which is of particular interest, and I will

[20] Data collection for the "Friday's FX-rate" variable follows the same procedure as described in the section on foreign exchange data, except I use a "daily" frequency. Further the data is processed in Excel to extract only the Friday dates for the sample period.

definitely investigate this more in the next section. Model four and five uses the single Friday rate as a dependent variable, and the results are not especially noteworthy regarding the NB variable. Comparing these last two models to their respective original models, there is one anomaly in the oil price variable. The use of oil price as a predictor for exchange rates have been researched before, but it is not of interest to me, therefore I will not be following up on this. What I will do is to test whether the variables are linear combinations of one another. Given the high significance change from the original model to model one, I suspect something are awry. If the variables are affected by large degrees of multicollinearity I would want to know and adjust my interpretation thereafter.

To investigate, I find the variance inflation factor, a ratio used to quantify multicollinearity in an OLS regression. Table 1.8 contains the VIF[21] for the original model as well as all five variation models. Multicollinearity does not reduce the overall predictive power of a model (O'Brien, 2007), however, a variable suffering from a high degree of linearity should not be used to predict in of its own. A VIF ratio above ten indicates severe form of multicollinearity, while a ratio below 2,5 shows no significant collinearity among the variables. Since there are large discrepancies in what is considered a large VIF ratio, I will assume a middle-ground of about five when deciding whether multicollinearity is a problem.

The estimations of the last two models are quite similar to the original, which is to be expected, since the only thing changing is when, or how, the exchange rate is measured. Going into the next section, I will focus my discussion on the original model and variant one, two and three.

[21] Wooldridge (2015) says that "large" correlations among the independent variables in a multivariate regression model usually invoke multicollinearity, however there is no well-defined limit for what is categorized as large. Allison (2012) prefers a VIF less than 2,5, and other researchers prefers VIF < 5 (Ringle, Wende & Becker 2015) and VIF < 10 (Hair, Anderson, Tatham & Black, 1995).

Variables[22]	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
C	0,000596*** (0,000242)	0,000515*** (0,000246)	0,000631*** (0,000231)	0,000682*** (0,000327)	0,000756*** (0,000310)
$(\Delta)NB_t$	-0,1150*** (0,03890)	-0,1280*** (0,05270)	-0,1180*** (0,03860)	-0,1890 (0,01890)	-0,134*** (0,0485)
FB_t	-0,0244*** (0,00806)	-0,0348*** (0,00822)	-0,0249*** (0,00680)	-0,0421*** (0,01290)	-0,0372*** (0,0118)
NC_t	0,0563*** (0,00903)	0,0491*** (0,00892)	0,0552*** (0,00779)	0,0698*** (0,01550)	0,0764*** (0,0141)
FC_t	0,0217 (0,01700)	0,0132 (0,01460)	0,0223 (0,01560)	0,0283 (0,02230)	0,0365 (0,0245)
ΔOP_t	-0,0037 (0,00946)	-0,0074 (0,00861)	-0,0155 (0,00947)	-0,0262*** (0,01188)	-0,0274*** (0,01282)
ΔID_t	-0,0150** (0,00767)	-0,0204*** (0,00743)	-0,0155*** (0,00752)	-0,0212*** (0,00677)	-0,0155*** (0,00602)
ΔFX_{t-1}	0,1883*** (0,04576)	0,1311*** (0,05282)	0,1800*** (0,04767)	-0,1736*** (0,05460)	-0,0866 (0,05896)
$(\Delta)NB_{t-1}$	0,1170*** (0,04080)		-0,0656*** (0,02850)		0,1410*** (0,04920)
FB_{t-1}	-0,0034 (0,00679)		-0,0051 (0,00620)		0,0046 (0,00801)
NC_{t-1}	-0,0330*** (0,00787)		-0,0341*** (0,00758)		-0,0425*** (0,01240)
FC_{t-1}	0,0235 (0,01700)		0,0223 (0,01640)		0,0383*** (0,0193)
ΔOP_{t-1}	-0,0446*** (0,00748)		-0,0448*** (0,00743)		-0,0254*** (0,00877)
ΔID_{t-1}	-0,0122* (0,00755)		-0,0125* (0,00755)		-0,0188*** (0,00873)
N	652	652	652	652	652
Adjusted R^2	0,533	0,465	0,535	0,422	0,485
F-statistic	58,1	81,9	58,6	68,9	48,1

TABLE 1.7* REGRESSION OUTPUT FOR THE VARIATION MODELS. *P<0,1, **P<0,05, P<0,01. STANDARD ERRORS IN PARENTHESIS. ORDER FLOW VARIABLES ARE MULTIPLIED BY 100 000.**

[22] The NB variables are used on a level form in model one, four and five, while the first difference is used in model two and three.

Variable	*Original*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
C	1,21**	1,77**	1,22**	1,58**	1,24**	1,70**
$(\Delta)NB_t$	1,72**	19,3	1,57**	1,45**	1,78**	16,7
FB_t	6,90	7,23	5,54	4,99*	4,85*	5,82
NC_t	5,92	5,79	4,92*	4,34*	3,93*	4,92*
FC_t	1,23**	1,84**	1,14**	1,70**	1,23**	1,65**
ΔOP_t	1,67**	2,70*	1,65**	2,75*	1,95**	2,84*
ΔID_t	2,37**	1,93**	2,63*	1,93**	1,54**	1,28**
ΔFX_{t-1}	2,96*	2,64*	2,90*	2,75*	1,77**	2,85*
$(\Delta)NB_{t-1}$		20,5		1,11**		17,0
FB_{t-1}		4,12*		3,56*		3,67*
NC_{t-1}		3,32*		3,19*		4,40*
FC_{t-1}		1,50**		1,38**		1,39**
ΔOP_{t-1}		1,61**		1,61**		1,39**
ΔID_{t-1}		3,41*		3,41*		3,09*

TABLE 1.8 VIF RATIOS FOR ALL MODELS. **VIF < 2,5; *2,5 < VIF < 5. ANYTHING ABOVE 5 IS CONSIDERED TO HAVE STRONG PRESENCE OF MULTICOLLINEARITY.

6 Results

This section interprets the work and results from the “Analysis” section. I begin by comparing my findings to current theory, followed by detailed explanations of the importance of the various models. Next, I present a breakdown of the most important coefficients, before concluding with the overall significance of the model.

The theory presented in Aamodt (2014) is unambiguous, and the writer clearly states that the long-term effect of central bank trading should not affect the NOK exchange rate. To investigate this, I have performed a multivariate regression analysis, where I use relatively newly collected order flow data. Together with some “traditional” exchange rate determinants, such as oil price and interest differentials, I have used the order flow data to search for a relationship between the foreign exchange rate and the central bank’s trading. The use of order flow as an explanatory variable falls under microstructure finance, and in contrast to traditional methods of exchange rate determination, this has proven quite successful (see section 3.2). Also, by using a microstructure approach, compared to a traditional method, it is much easier to pin down how much of the overall trading comes from each party, thus enabling more accurate research.

Table 1.6 contains the output for the model I began with in equation (1.2), and it supports the theory that the central bank’s trading does not affect the NOK exchange rate. The model uses the change in the average, weekly, mid NOK-EUR rate as the dependent variable, and takes the weekly order flows, oil price changes, interest differentials and lagged rate as independent variables. The variable explaining central bank trading is the NB_t variable, and this does not show any statistical significance at the 5% or 10% significance level. For this reason, I fail to reject the null hypothesis in (1.3) and cannot infer any significant relationship amongst the central bank’s trading and the foreign exchange rate.

As I am working with time-series data, I wonder if any of the previous periods can produce a significant ceteris paribus relationship with the FX-rate. To get a broad overview, I analyze five versions of the original (1.2) model. The output from this analysis is presented in table 1.7. These variations are all valid models to use if one wants to investigate an all-else-equal relationship between the central bank’s trading and the foreign exchange rate.

Model one and three allow for a contemporaneous, as well as a lagged, relationship among the FX-rate and the independent variables. These variations of the original model produce statistically significant beta coefficients for the *NB* variables. Both $(\Delta)NB_t$ and its lag, $(\Delta)NB_{t-1}$, are statistically significant at the 1% level for either of the two variation models. At a first glance this conflicts with theory, but a closer look at model one provides a more theory-friendly result. Since the coefficient signs are in opposite directions, and the coefficient sizes are basically the same, it is reasonable to assume that the effects are only short-term. This provides evidence in favor of the theory presented in Aamodt (2014), which states that the long-term effect of trading shouldn't affect the exchange rate. A note to model one though, the results of the multicollinearity test in table 1.8 shows large VIF ratios for the NB variables. Such a large linear dependence means that an explanatory variable cannot be used to infer a significant relationship with the dependent variable (O'Brien, 2007). Collinearity does not reduce the overall predictive power of the model, but it is not possible to look at, say, the NB_t variable while holding everything else equal. Given this information, the apparent short-term effects, which are in line with the theory, must be carefully analyzed before any conclusions are drawn. I do not provide any more analysis into the effects of multicollinearity in this paper.

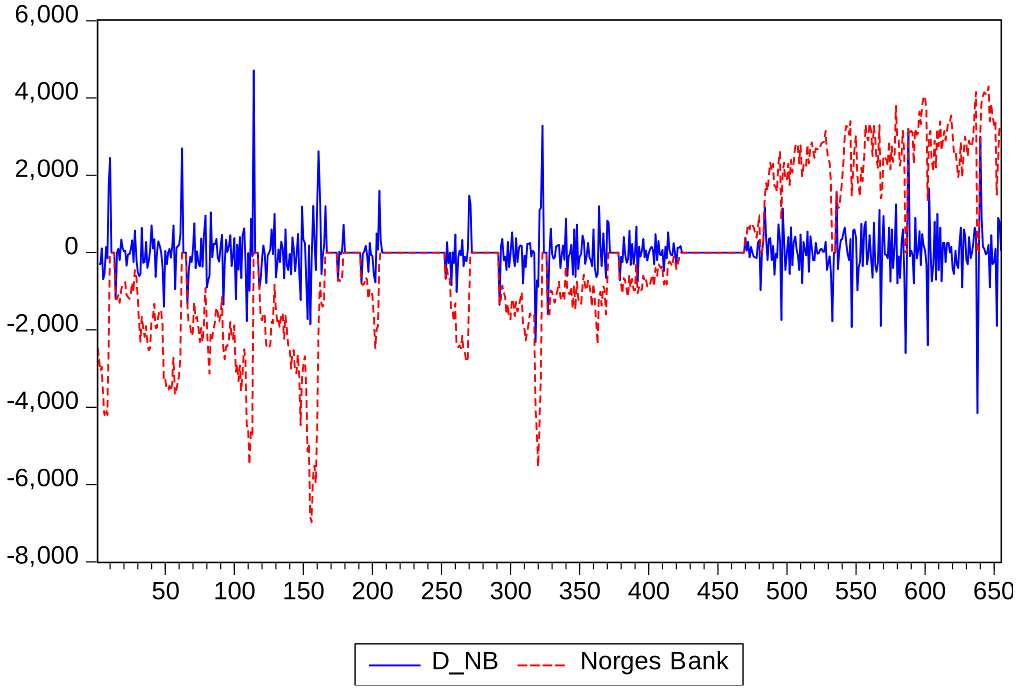
Similar to model one though, is model three. The same variables are used here, apart from the central bank's order flows. In this model I have taken the first difference of these order flows, and the results seem to contradict the theory. By using the differenced order flows, I get statistically significant coefficients, but they do not have any indication of being corrupted by multicollinearity. In addition, the signs of the coefficients are both negative, which would indicate a more long-term effect. Graph 1.6 presents the raw data for the central bank, both on level form and differenced form. The solid line represents the differenced form, and for this amount to be positive, there has to be a larger trade, in the positive direction, on day t as compared to day $t-1$[23]. This means that any point on the graph above zero is because of a larger trade, compared to the previous week. Relating this to the central bank's trading, a deviation in the weekly trading amounts seem to affect the exchange rate. Inconsistencies in the bank's trading amounts should not happen; Lund & Stiansen (2017) has this to say about the conversion of foreign exchange:

[23] Example of how a change from day to day causes positive or negative changes.

$t = 100$, $t-1 = 50$ => $\Delta t = 50$	$t = 50$, $t-1 = 100$ => $\Delta t = -50$
$t = -50$, $t-1 = -100$ => $\Delta t = 50$	$t = -100$, $t-1 = -50$ => $\Delta t = -50$

… Norges Bank purchases a fixed daily amount of NOK each month. The amounts to be converted are announced on the last trading day of the month prior to the purchases. … By accepting that the level of the PBP can fluctuate, foreign exchange transactions can be smoothed thought the year… (p. 5).

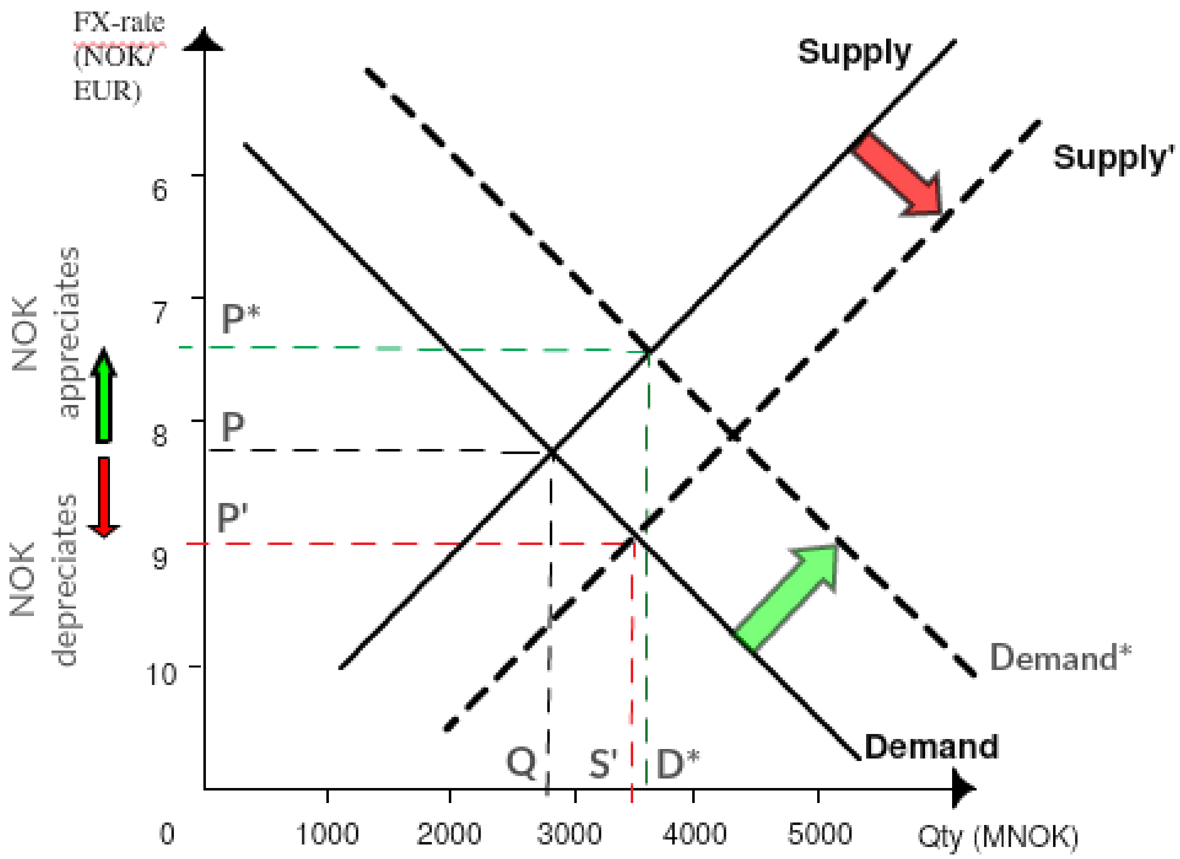
Since the foreign exchange transactions are expected by the market to stay the same throughout the month, deviations may signal different information, which in turn could create long-term effects on the NOK-EUR exchange rate. Lund & Stiansen (2017) mentions purchases of NOK here, but this logic is fairly applied to sale of NOK as well. The attempts at keeping the transactions smooth by varying the PBP (a holding portfolio) is a good idea, however, graph 1.6 paints a different picture. The reality is that there are large weekly changes in the amount traded, and model two and three in my analysis provides evidence for these changes affecting the exchange rate.



GRAPH 1.6 **DIFFERENCED AND LEVEL NET PURCHASE OF FOREIGN EXCHANGE BY THE CENTRAL BANK. WEEKLY CHANGES IN NET PURCHASES CAUSES THE SOLID LINE TO MOVE, AND IF IT'S ABOVE ZERO THERE IS AN APPRECIATION OF THE NOK.**

The coefficients are of interest, especially the sign; one may have an idea of which direction any particular variable should affect the foreign exchange rate. I will look at the coefficients of the order flow variables, the oil price and the interest differential.

Theoretically, the NOK should appreciate when there is an increase in demand for it and depreciate when there is a decrease in demand. Graph 1.7 displays this theoretical relationship.



GRAPH 1.7 THEORETICAL IMPACTS OF, AND INCREASES IN, DEMAND OR INCREASES IN SUPPLY, ON THE NOK-EUR EXCHANGE RATE. AN INCREASE IN DEMAND WOULD, ALL ELSE EQUAL, APPRECIATE THE NOK RATE.

As an initial example, the sign of the coefficient for the *NB* variable (level-form) in the original model is positive, which means that a net purchase of 1000 NOK will increase the weekly percentage change of the foreign exchange price by 0,0152%[24]. From the order flow data, one knows that a purchase of NOK (sale of FX) is represented by a positive integer. Since the central bank can both supply and demand NOK, this will shift the curves, which in turn will move the equilibrium rate up or down. Graph 1.7 shows this relationship theoretically; an increase in demand (NOK purchase) from the central bank appreciates the NOK, while a sale

[24] The coefficient is scaled up by 100 000, so to get it back to its regular level, I first divide it by 100 000. This gives 0,000000152. A purchase of 1000 MNOK is equal to 0,000000152*1000 = 0,000152. Since the regression equation is on a log-level form, one multiples 0,000152 by 100% to get 0,0152%, which is the weekly, ceteris paribus effect of the central bank's trading on the foreign exchange rate.

of NOK (increase in the supply) depreciates the NOK. The coefficient from the regression output is positive, which means that a purchase (i.e. an increase in demand) causes the NOK to depreciate[25]. This does not make sense according to the theory.

Now, the sign of the coefficient to the *NB* variable in the original model isn't very important, given that the variable is not statistically significant, I just use this to explain the theoretical supply/demand relationship for foreign exchange in graph 1.7. What is interesting though, is the negative sign I get from model two and three. The central bank variables in these models are differenced, but the negative sign on the coefficients are in line with the supply/demand theory shown in graph 1.7. Since a purchase of NOK is represented by a positive integer (1000 MNOK), this means that an increase in the positive direction (1000 MNOK → 1200 MNOK), week-over-week, increases demand of NOK. And, with an increase in demand, one expects an appreciation of the NOK. As one knows, travelling in the positive trade direction causes the weekly changes to be positive, and given the negative sign of the *NB* variables, this causes the weekly change in the foreign exchange rate to be negative. When the FX change is negative, one has an appreciation of the NOK, which is to be expected when the demand increases. This logic may also be used to explain a positive change in the order flow caused by a reduction in the supply (i.e. -1000 MNOK → -800 MNOK). Since there is now a reduction in the supply, from graph 1.7 one expects an appreciation of the NOK exchange rate, which is what one gets with a negative *NB* coefficient. Figure 1.2 presents a chart on how the changes in the central bank's order flows from week to week affects the exchange rate. Graph 1.6 can simply be interpreted as: if the solid lines are above zero, there is an appreciation of the NOK, if its below, depreciation.

The coefficient for the oil price can be interpreted in much the same way as the differenced central bank coefficient. Research on the relation between oil price and exchange rates vary, but a link between oil price increases and dollar depreciation has been made recently. My models only show significant lagged effects of the oil price, and these come with a negative coefficient. That is to be expected, if a depreciation of the dollar, in regard to oil price hikes, relative to other currencies is the assumption.

The "traditional" macro variable of interest differentials are statistically significant in all models, with the lag being "less important" than the contemporaneous variable. The original

---

[25] The only way a weekly percentage change (which the dependent variable is) can be positive is if FXt = y and $FX_{t-1} < y$. A larger FX-rate in week *t* means that the NOK depreciated week-over-week, which conflicts with the theory that an increase in demand will cause an appreciation of the NOK.

model, as well as model one, two and three has negative coefficient signs. This is evidence for the exchange rate being affected by the interest rate in the long-term. The signs are also as expected, since a greater interest differential will affect the exchange rate negatively, i.e. make it appreciate. This is what one would expect in theory as well, a larger interest rate in Norway would create more demand for investments here, which would increase the demand for NOK.

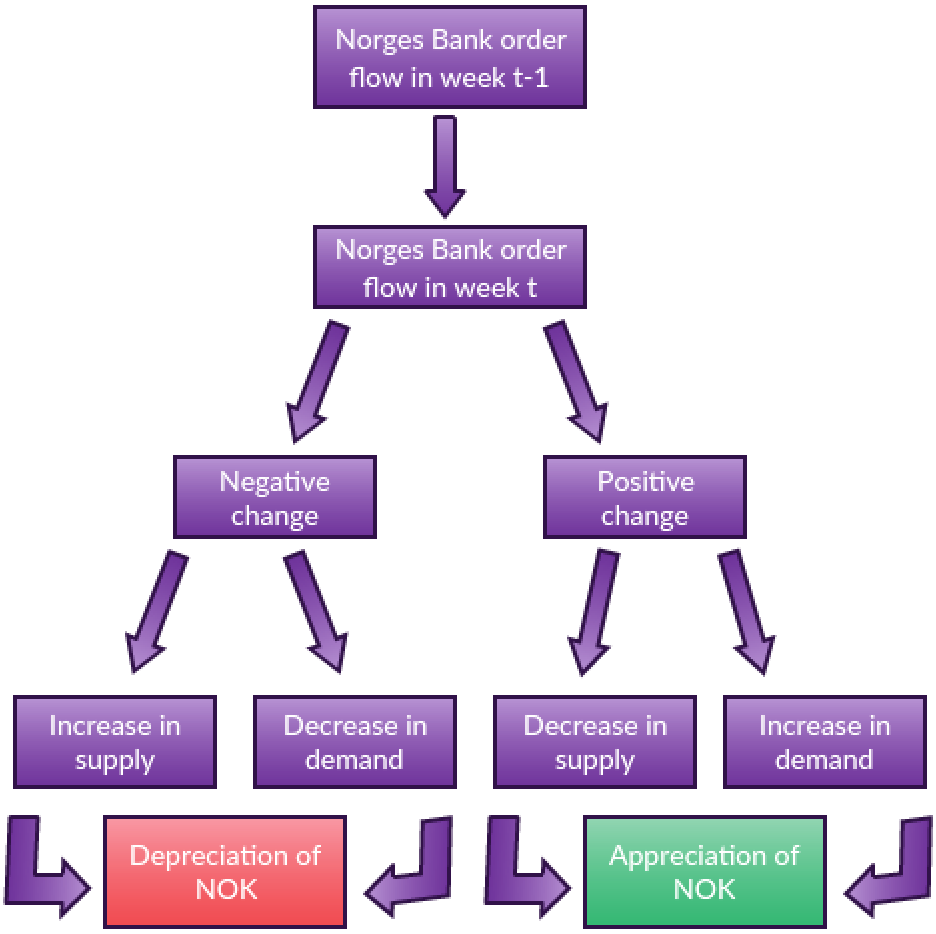


FIGURE 1.2 FLOWCHART OF HOW CHANGES IN THE CENTRAL BANK'S FOREIGN EXCHANGE TRANSACTIONS WEEK-TO-WEEK AFFECT THE NOK EXCHANGE RATE, ACCORDING TO MODEL TWO AND THREE.

If one looks at the F-statistics for the original model, as well as the three first variations, there is evidence for an overall statistical significance. This is an indication that the models are useful and could, to a degree, be used to forecast the foreign exchange rate. The F-stats are quite large though, but this is expected when the corresponding adjusted-R^2 are also relatively large.

Overall, I find mixed evidence to the theory in Aamodt (2014). When I look at the level form of the order flows (as in the original model) I find do not find anything, or weak evidence, to contradict theory. However, this change when I instead use the first difference. By examining the model under an order flow change, I find evidence in support of an opposing view. By holding all else equal, using model two, I can, with a 1% statistical significance, say that for every 1 billion NOK in weekly trading changes, the NOK exchange rate appreciates by 0,128%.

7 Conclusion

When the Norwegian central bank operates in the foreign exchange market, it is on behalf of the government. The trades are not part of any monetary policy to control the exchange rate, and for this reason it does not want the trades to affect the exchange rate. It is the size of the non-oil budget deficit that influences the NOK exchange rate (Aamodt, 2014). When the budget deficit is announced it is assumed to be rapidly incorporated into the price. Since everyone knows how large the deficit is, it is relatively easy to calculate how much, and in which direction, trading the central bank will undergo. In addition, the central bank announces each month its intent to purchase/sell a specific amount of foreign exchange (Bank (2010) & Bank (2017)) and it attempts to purchase/sell the same amount every day for that month (Lund and Stiansen, 2017). As noted in Meyer and Skjelvik (2006), economic agents provide different signals to the market, and since it is the central bank that does the trading, there is a possibility for mixed interpretations.

To investigate whether the central bank's trading has an effect on the exchange rate I use an approach developed in the 1990s. It builds on microstructure finance and uses order flows in an attempt to explain exchange rates. The regression model is derived from Rime & Sojli (2006), and it uses time-series data on four order flow variables, the lagged exchange rate as well as an oil price and interest differential variable. I go on to run six different versions of the model, and the results are pointing in a direction which contradict the theory. One model finds no link to the central bank's trading and the foreign exchange rate, another finds a link, but these results are corrupted by multicollinearity. Two versions of the model find a strongly statistically significant relationship between the central bank's trading and the foreign exchange rate, and these models use the first difference of the central bank variable. By using the difference, I manage to eliminate a large portion of the autocorrelation, and I get the variable to be stationary.

The research is limited in the sense that I have not had any formal education in microstructure theory, so I've had to learn the concepts on my own. I do have a solid background in finance, so the concepts make sense to me, but I think a deeper understanding gained through formal education would let me investigate the relationships more thoroughly. Also, the data available limits me to statistical models, as opposed to a structural model which require dealer data, which I do not have access to.

I did not find any other papers explicitly looking into the central bank's trading in the foreign exchange market. This means that any future work can use this paper as a starting point. More advanced models and a deeper knowledge could investigate the relationship at different levels and from different angles.

References

Aamodt, E. (2014). The petroleum fund mechanism and associated foreign exchange transactions by Norges Bank. *Central Bank of Norway's website*(2), 10.

Akram, Q. F. (2004). Oil prices and exchange rates: Norwegian evidence. *Econometrics Journal, 7*(2), 476-504. doi:10.1111/j.1368-423X.2004.00140.x

Allison, P. (2012). When Can You Safely Ignore Multicollinearity? Retrieved from https://statisticalhorizons.com/multicollinearity

Amano, R. A., & Norden, S. (1998a). Exchange Rates and Oil Prices. *Review of International Economics, 6*(4), 683-694. doi:10.1111/1467-9396.00136

Amano, R. A., & Norden, S. (1998b). Oil prices and the rise and fall of the US real exchange rate. *Journal of International Money and Finance, 17*(2), 299-316. doi:10.1016/S0261-5606(98)00004-7

Bank, N. (2010). Norges Banks Valutakjøp I November 2010 [Press release]. Retrieved from https://www.norges-bank.no/Publisert/Pressemeldinger/2010/Pressemelding-29-oktober-2010/

Bank, N. (2017). Valutatransaksjonar I November 2017 [Press release]. Retrieved from https://www.norges-bank.no/Publisert/Pressemeldinger/2017/2017-10-31-pressemelding/

Berger, D. W., Chaboud, A. P., Chernenko, S. V., Howorka, E., & Wright, J. H. (2008). Order flow and exchange rate dynamics in electronic brokerage system data. *Journal of international Economics, 75*(1), 93-109. doi:10.1016/j.jinteco.2007.10.004

Cerrato, M., Sarantis, N., & Saunders, A. (2011). An investigation of customer order flow in the foreign exchange market. *Journal of Banking & Finance, 35*(8), 1892-1906. doi:10.1016/j.jbankfin.2010.12.003

Corden, W. M. (1984). Booming sector and Dutch Disease economics: Survey and consolidations. *Oxford Economics Papers, 36*(3), 359-380. doi:10.1093/oxfordjournals.oep.a041643

Cumby, R. E., & Obstfeld, M. (1981). A Note on Exchange-Rate Expectations and Nominal Interest Differentials: A Test of the Fisher Hypothesis. *The Journal of Finance, 26*(3), 697-. doi:10.1111/j.1540-6261.1981.tb00654.x

Danielsson, J., Luo, J., & Payne, R. (2012). Exchange rate determination and inter-market order flow effects. *The European Journal of Finance, 18*(9), 823-840. doi:10.1080/1351847X.2011.601655

De Grauwe, P. (1996). *International money: Postwar-trends and theories*. Oxford: Oxford University Press.

EIA. (2018). Europe Brent Spot Price FOB. Retrieved from https://www.eia.gov/dnav/pet/hist/rbrteD.htm

Engel, C., & Frankel, J. (1984). Why interest rates react to money announcements: An explanation from the foreign exchange market. *Journal of Monetary Economics, 13*(1), 31-39. doi:10.1016/0304-3932(84)90006-0

Evans, M., & Lyons, R. (2002). Order Flow and Exchange Rate Dynamics. *Journal of Political Economy, 110*(1). doi:10.3386/w7317

Evans, M., & Lyons, R. (2008). How is Macro News Transmitted to Exchange Rates? *Journal of Financial Economics, 88*(1), 26-50. doi:10.3386/w9433

Finansdepartementet. (2017). *Skattesatser 2018*.

Frankel, J. (1979). One the Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials. *The American Economic Review, 69*(4), 610-622. doi:http://www.jstor.org/stable/1808707

Golub, S. (1983). Oil prices and exchange rates. *The Economic Journal, 93*, 576-593. doi:10.2307/2232396

Hair, J. F. J., Anderson, R. E., Tatham, R. L., & Black, W. C. (1995). *Multivariate Data Analysis (3rd ed)*. New York: Macmillian.

Jawadi, F., Louhichi, W., Ameur, H. B., & Cheffou, A. I. (2016). On oil-US exchange rate volatility relationships: An intraday analysis. *Economic Modelling, 59*(C), 329-334. doi:10.1016/j.econmod.2016.07.014

Kleinbrod, V. M., & Li, X. (2017). Order flow and exchange rate comovement. *Journal of International Money and Finance, 77*, 199-215. doi:10.1016/j.jimonfin.2017.07.022

Lund, K., & Stiansen, K. (2017). The petroleum fund mechanism and movements in the petroleum buffer portfolio (PBP). *Central Bank of Norway's website*(2), 11.

Lyons, R. (1995). Tests of microstructural hypotheses in the foreign exchange market. *Journal of Financial Economics, 39*, 321-351. doi:10.1016/0304-405X(95)00832-Y

Lyons, R. (2001). *The Microstructure Approach to Exchange Rates*. Cambridge, Massachusetts, England: The MIT Press.

Lyons, R. (2002). Foreign exchange: macro puzzles, micro tools. Retrieved from https://ideas.repec.org/a/fip/fedfer/y2002p51-69.html

Meyer, E., & Skjelvik, J. (2006). Valutahandelsstatistikken – ny innsikt i valutamarkedet. *Penger og Kreditt, 34*(1), 30-38.

Nau, R. (2018). Statistical forecasting: notes on regression and time series analysis. Retrieved from https://people.duke.edu/~rnau/411diff.htm

O'Brien, R. M. (2007). A Caution Regarding Rules of Thumb for Variance Inflation Factors. *Quality and Quantity, 41*(5), 673-690. doi:10.1007/s11135-006-9018-6

O'Hara, M. (1995). *Market Microstructure Theory*. Cambridge, Massachusetts, USA: Blackwell Publishers Ltd.

Payne, R. (2003). Informed trade in spot foreign exchange markets: an empirical investigation. *Journal of international Economics, 61*(2), 307-329. doi:10.1016/S0022-1996(03)00003-5

Reboredo, J. C. (2012). Modelling oil price and exchange rate co-movements. *Journal of Policy Modeling, 34*(3), 419-440. doi:10.1016/j.jpolmod.2011.10.005

Rime, D., Sarno, L., & Sojli, E. (2010). Exchange rate forecasting, order flow and macroeconomic information. *Journal of international Economics, 80*(1), 72-88. doi:10.1016/j.jinteco.2009.03.005

Rime, D., & Sojli, E. (2006). Ordrestrømanalyse av valutakurser. *Penger og Kreditt, 34*(2), 110-115.

Ringle, C. M., Wende, S., & Becker, J. (2015). SmartPLS3. Retrieved from http://www.smartpls.com

SSB. (2016). *Rapportering til valutahandelsstatistikken*. Kongsvinger: Statistics Norway.

Taylor, M. P. (1987). Covered Interest Parity: A High-Frequency, High-Quality Data Study. *Economica, 54*(216), 429-438. doi:10.2307/2554178

Thomassen, S. Y., & Rasmussen, T. (2011). *Measuring the price impact from large trades and order flow: an empirical study in market microstructure on Oslo Stock Exchange.* (Master, NHH), Retrieved from https://brage.bibsys.no/xmlui/bitstream/handle/11250/169331/Thomassen%20og%20Rasmussen%202011.pdf?sequence=1&isAllowed=y

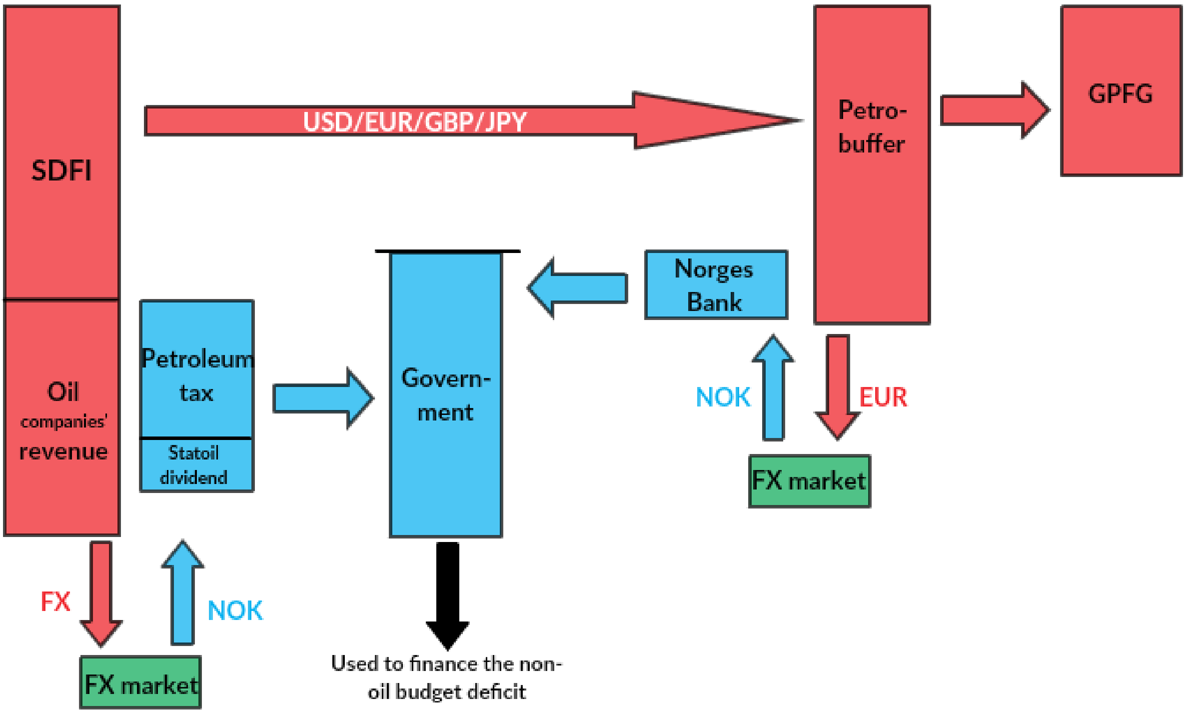
Turhan, M. I., Sensoy, A., & Hacihasanoglu, E. (2014). A comparative analysis of the dynamic relationship between oil prices and exchange rates. *Journal of International Financial Markets, Institutions and Money, 32*(C), 397-414. doi:10.1016/j.intfin.2014.07.003

Wooldridge, J. M. (2015). *Introduction to Econometrics*. Cheriton House, United Kingdom: Cengage Learning EMEA.

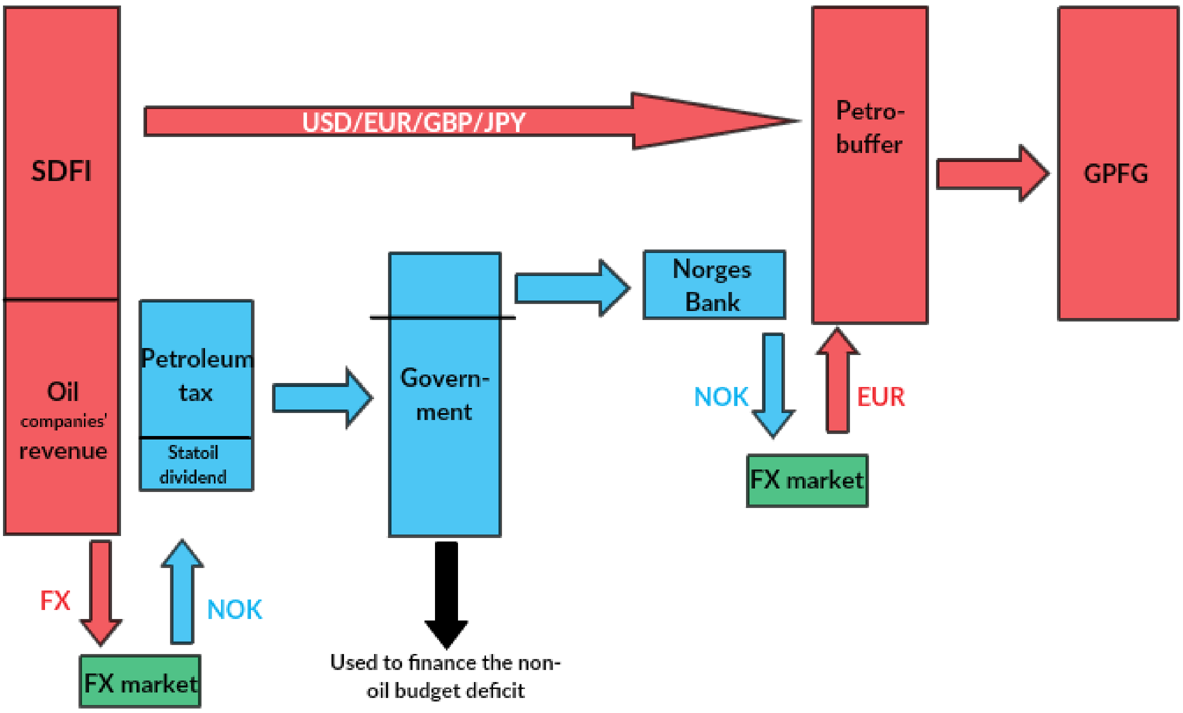
Young, J. P. (1947). Exchange Rate Determination. *The American Economic Review, 37*(4), 589-603.

Appendix

A Figures



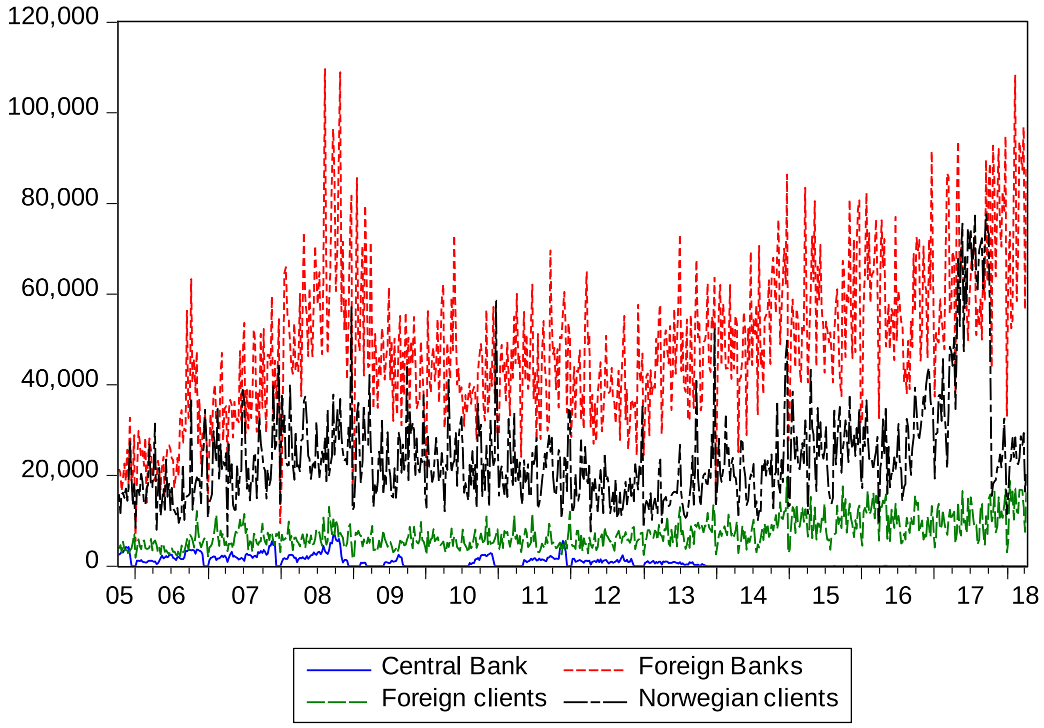
FIGUR A1 PETROLEUM MECHANISM IN 2015 REPRINTED FROM AAMODT (2014)



FIGUR A2 PETROLEUM MECHANISM PRIOR TO/DURING 2013. REPRINTED FROM AAMODT (2014)

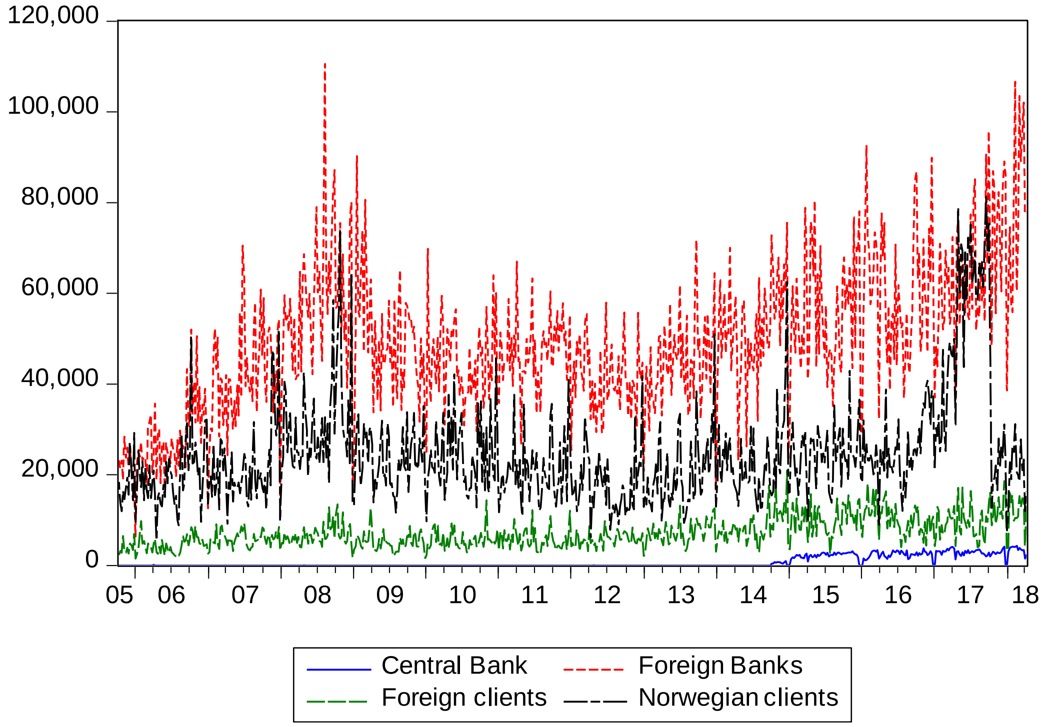
B Graphs

Foreign Exchange Sales

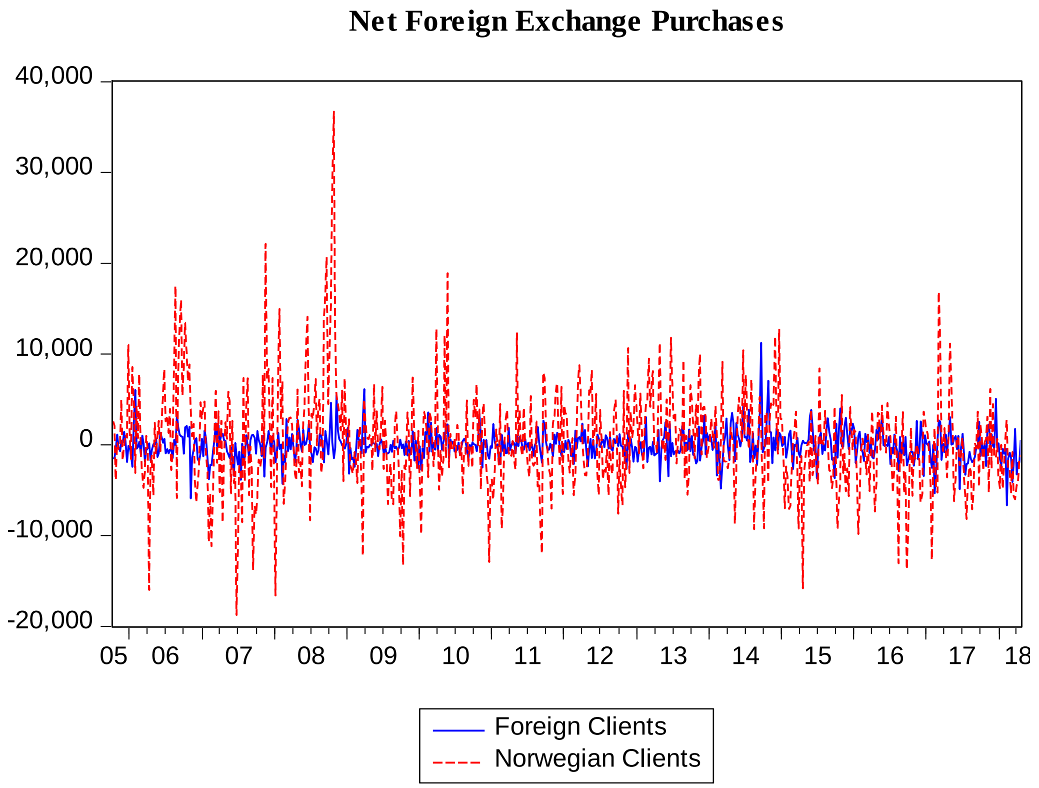


GRAPH B1 **TOTAL FOREIGN EXCHANGE *SALES*, CATEGORIZED.**

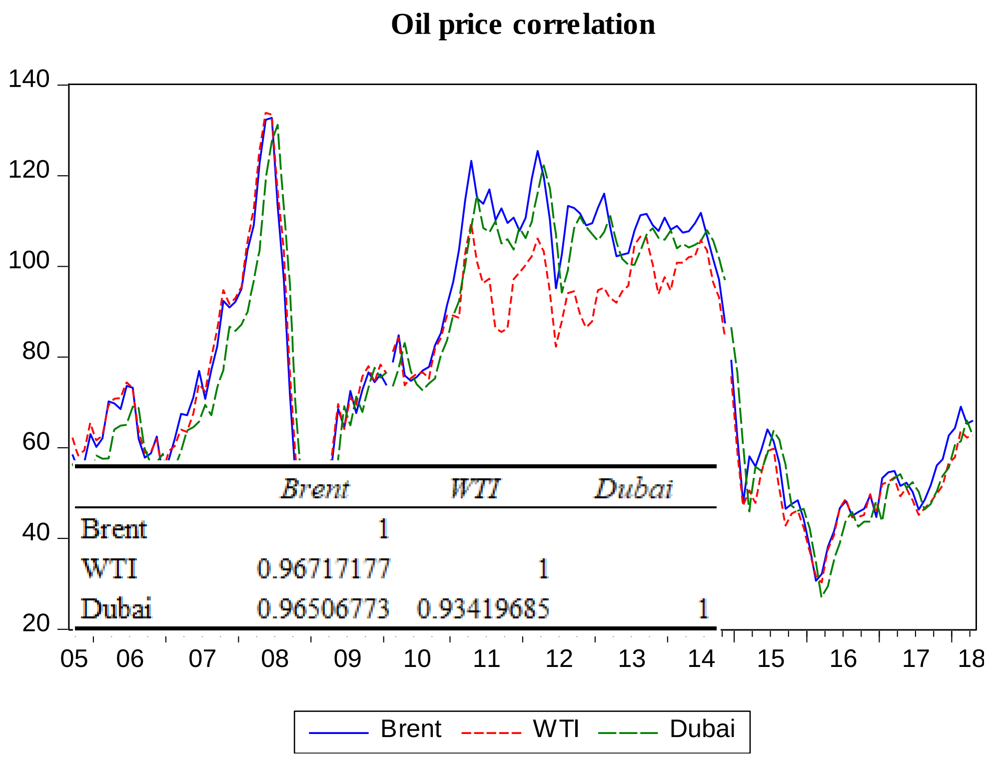
Foreign Exchange Purchases



GRAPH B2 **TOTAL FOREIGN EXCHANGE *PURCHASES*, CATEGORIZED.**

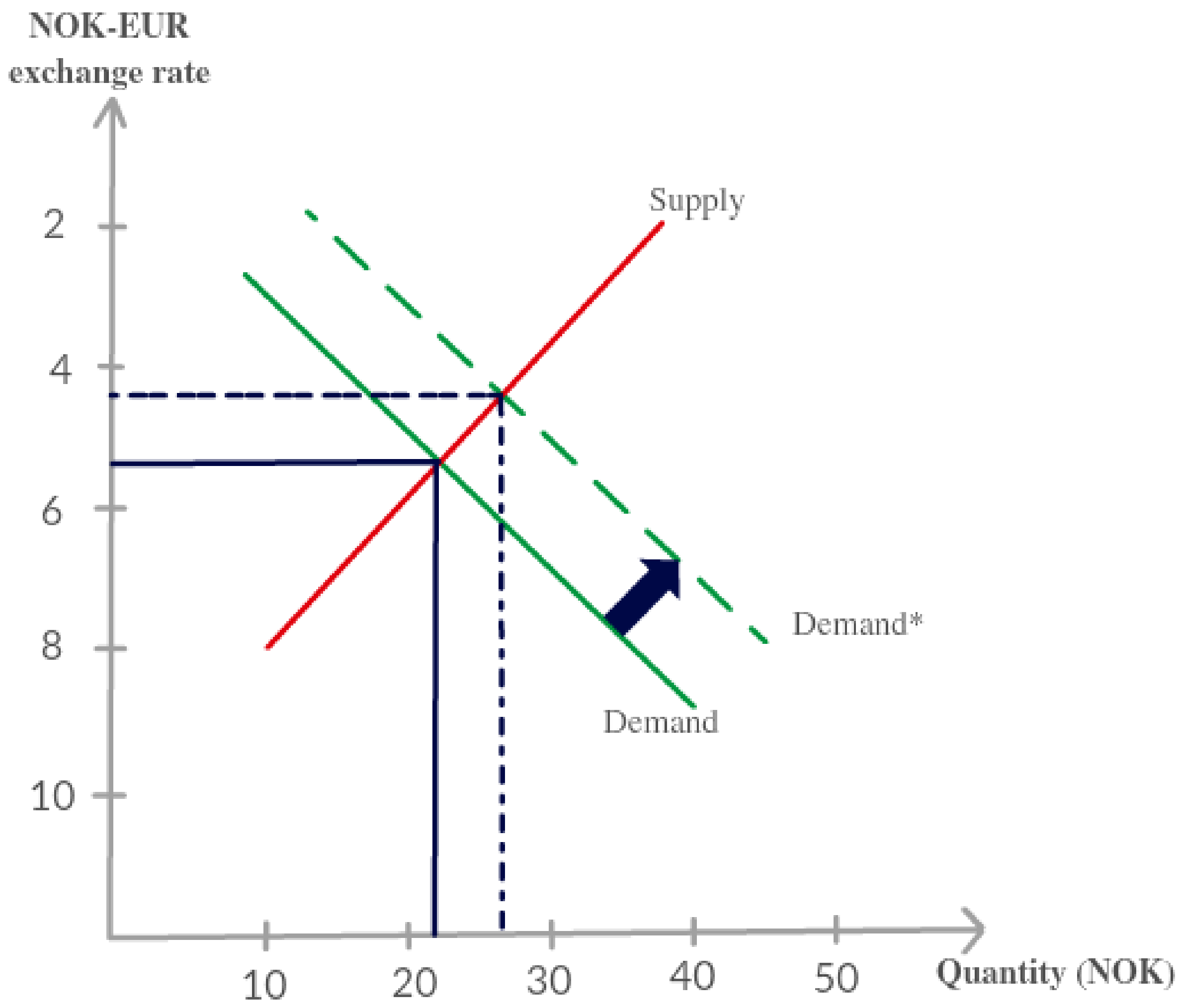


GRAPH B3 NET FOREIGN EXCHANGE PURCHASES; FOREIGN CLIENTS AND NORWEGIAN CLIENTS.

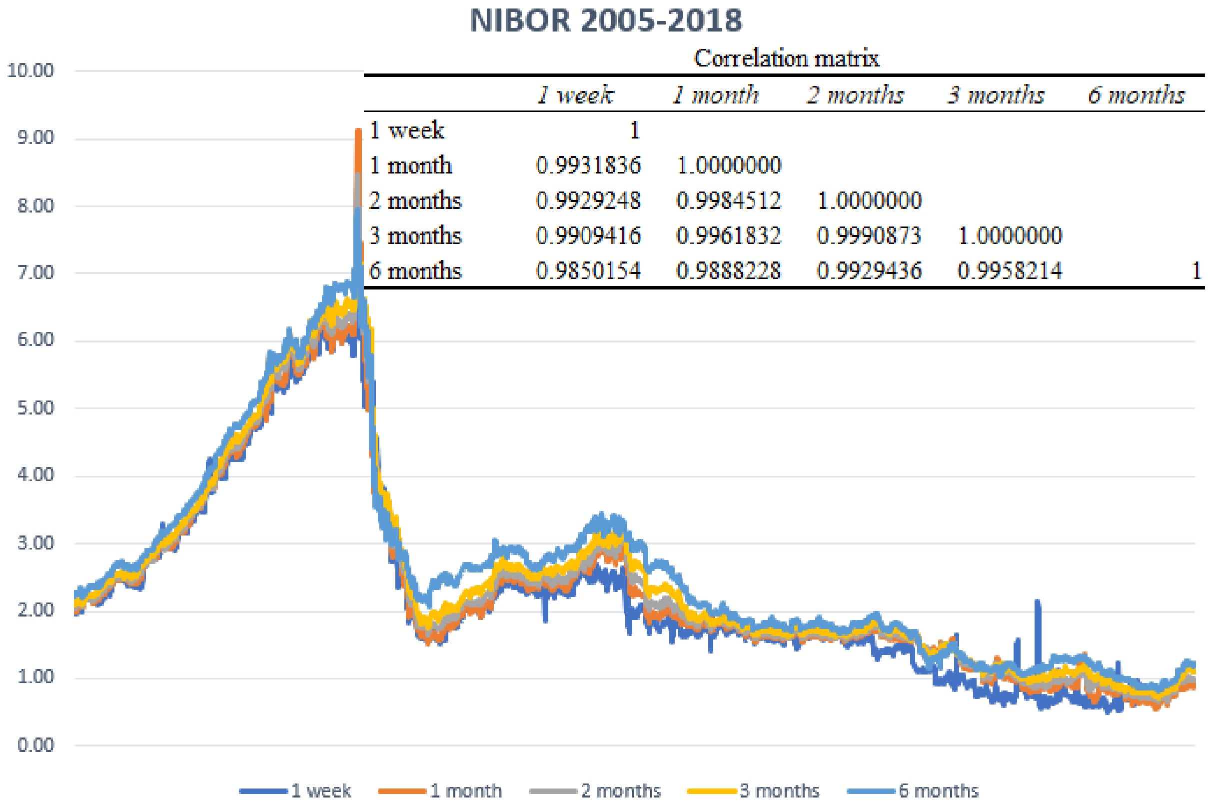


	Brent	*WTI*	*Dubai*
Brent	1		
WTI	0.96717177	1	
Dubai	0.96506773	0.93419685	1

GRAPH B4 OIL PRICE OF BRENT, WTI AND DUBAI W/ CORRELATION MATRIX.



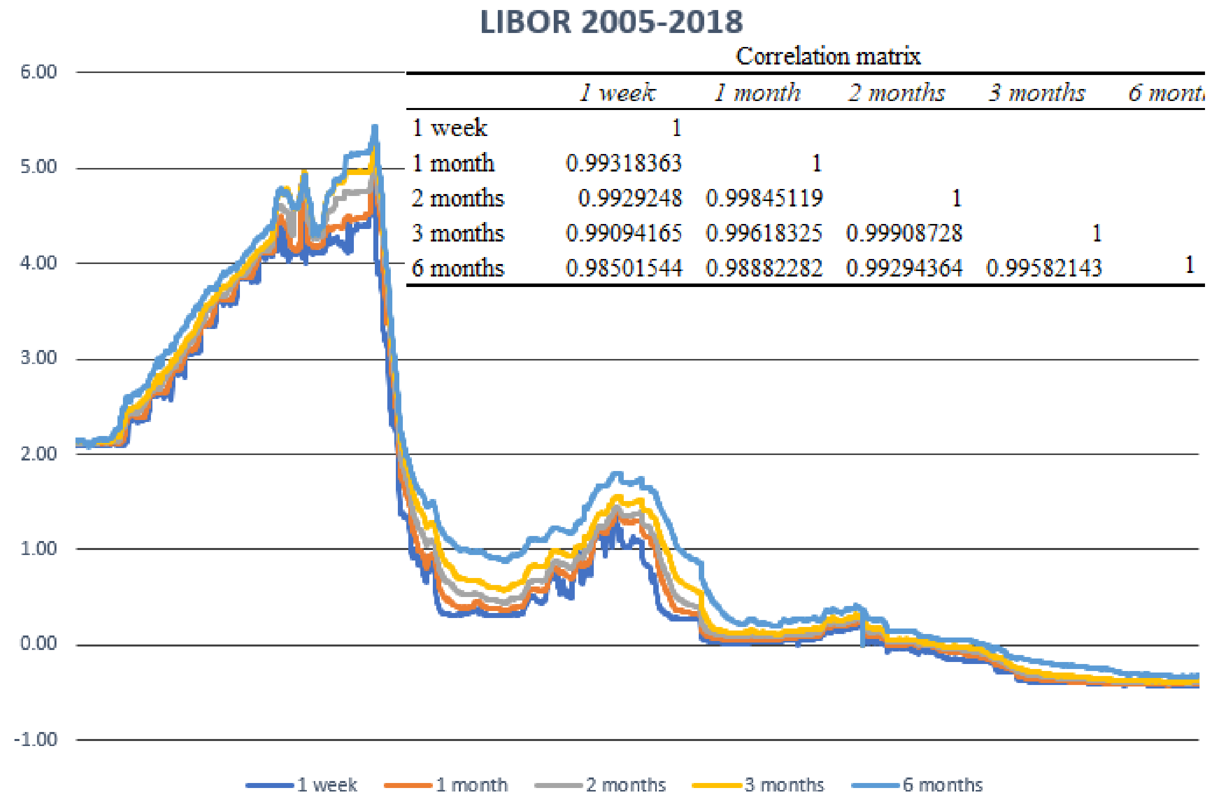
GRAPH B5 SUPPLY AND DEMAND CURVES FOR NOK. AN INCREASE IN THE DOMESTIC INTEREST RATE (R_{NOK}) CREATES AN INCREASED DEMAND, WHICH INCREASES THE NOK EXCHANGE RATE.



Correlation matrix

	1 week	*1 month*	*2 months*	*3 months*	*6 months*
1 week	1				
1 month	0.9931836	1.0000000			
2 months	0.9929248	0.9984512	1.0000000		
3 months	0.9909416	0.9961832	0.9990873	1.0000000	
6 months	0.9850154	0.9888228	0.9929436	0.9958214	1

Graph B6 **Comparison of different maturity NIBOR interest rates w/ correlation matrix.**



Correlation matrix

	1 week	*1 month*	*2 months*	*3 months*	*6 mont*
1 week	1				
1 month	0.99318363	1			
2 months	0.9929248	0.99845119	1		
3 months	0.99094165	0.99618325	0.99908728	1	
6 months	0.98501544	0.98882282	0.99294364	0.99582143	1

Graph B7 **Comparison of different maturity LIBOR interest rates w/ correlation matrix**

C Tables

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.949	0.949	593.01	0.000
		2	0.900	-0.009	1127.2	0.000
		3	0.862	0.086	1618.1	0.000
		4	0.832	0.063	2075.9	0.000
		5	0.806	0.034	2505.5	0.000
		6	0.787	0.091	2916.7	0.000
		7	0.772	0.034	3312.2	0.000
		8	0.758	0.040	3694.1	0.000
		9	0.743	0.011	4061.7	0.000
		10	0.731	0.047	4418.5	0.000
		11	0.720	0.025	4765.3	0.000
		12	0.711	0.028	5103.4	0.000
		13	0.703	0.036	5434.5	0.000
		14	0.703	0.093	5765.9	0.000
		15	0.700	0.008	6095.4	0.000
		16	0.695	0.004	6420.2	0.000
		17	0.696	0.094	6746.6	0.000
		18	0.692	-0.024	7070.3	0.000
		19	0.680	-0.052	7383.4	0.000
		20	0.670	0.022	7687.5	0.000

TABLE C1 CORRELOGRAM CENTRAL BANK.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.020	-0.020	0.2708	0.603
		2	-0.108	-0.108	7.8880	0.019
		3	-0.069	-0.075	11.067	0.011
		4	-0.069	-0.086	14.191	0.007
		5	-0.094	-0.117	19.974	0.001
		6	-0.027	-0.061	20.448	0.002
		7	-0.024	-0.069	20.839	0.004
		8	0.030	-0.010	21.438	0.006
		9	-0.023	-0.062	21.798	0.010
		10	-0.007	-0.038	21.832	0.016
		11	-0.012	-0.043	21.923	0.025
		12	-0.020	-0.049	22.190	0.035
		13	-0.088	-0.119	27.405	0.011
		14	0.024	-0.019	27.790	0.015
		15	0.045	-0.003	29.151	0.015
		16	-0.032	-0.072	29.839	0.019
		17	0.050	0.020	31.526	0.017
		18	0.036	0.000	32.389	0.020
		19	-0.009	-0.017	32.444	0.028
		20	-0.025	-0.031	32.859	0.035

TABLE C2 CORRELOGRAM FIRST DIFFERENCE CENTRAL BANK.

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.272	0.272	48.525	0.000
		2	0.168	0.102	67.204	0.000
		3	0.068	-0.001	70.213	0.000
		4	0.071	0.041	73.516	0.000
		5	0.091	0.063	78.956	0.000
		6	0.099	0.055	85.479	0.000
		7	0.057	0.002	87.674	0.000
		8	0.102	0.073	94.646	0.000
		9	0.050	-0.004	96.296	0.000
		10	0.081	0.045	100.64	0.000
		11	0.003	-0.046	100.64	0.000
		12	-0.055	-0.079	102.64	0.000
		13	0.046	0.076	104.08	0.000
		14	-0.066	-0.104	106.99	0.000
		15	-0.005	0.013	107.01	0.000
		16	0.002	0.013	107.01	0.000
		17	-0.044	-0.050	108.33	0.000
		18	0.015	0.039	108.48	0.000
		19	-0.020	-0.021	108.75	0.000
		20	-0.013	0.009	108.87	0.000

***TABLE C3* CORRELOGRAM FOREIGN BANKS.**

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.379	0.379	94.433	0.000
		2	0.211	0.079	123.80	0.000
		3	0.158	0.064	140.27	0.000
		4	0.124	0.040	150.44	0.000
		5	0.132	0.066	162.02	0.000
		6	0.104	0.020	169.21	0.000
		7	0.088	0.021	174.35	0.000
		8	0.133	0.084	186.17	0.000
		9	0.079	-0.017	190.38	0.000
		10	0.093	0.041	196.14	0.000
		11	0.041	-0.035	197.26	0.000
		12	0.016	-0.020	197.42	0.000
		13	0.050	0.033	199.10	0.000
		14	0.045	0.008	200.48	0.000
		15	-0.001	-0.044	200.48	0.000
		16	0.043	0.043	201.71	0.000
		17	-0.011	-0.049	201.79	0.000
		18	0.025	0.030	202.23	0.000
		19	0.004	-0.017	202.24	0.000
		20	-0.018	-0.020	202.47	0.000

***TABLE C4* CORRELOGRAM NORWEGIAN CLIENTS.**

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.153	0.153	15.383	0.000
		2	0.036	0.013	16.261	0.000
		3	-0.018	-0.026	16.481	0.001
		4	0.108	0.117	24.133	0.000
		5	0.088	0.057	29.233	0.000
		6	0.038	0.010	30.201	0.000
		7	-0.033	-0.038	30.903	0.000
		8	-0.005	-0.003	30.922	0.000
		9	0.008	-0.003	30.964	0.000
		10	-0.117	-0.136	40.078	0.000
		11	-0.041	-0.001	41.195	0.000
		12	0.053	0.077	43.101	0.000
		13	0.039	0.014	44.100	0.000
		14	-0.025	-0.017	44.530	0.000
		15	0.017	0.053	44.726	0.000
		16	-0.034	-0.044	45.526	0.000
		17	-0.021	-0.041	45.815	0.000
		18	-0.017	-0.011	46.000	0.000
		19	0.001	0.008	46.001	0.000
		20	0.042	0.033	47.213	0.001

TABLE C5 **CORRELOGRAM FOREIGN CLIENTS.**

D Literature review

Author/Journal	Year	Methodology	Variables	Result/Abstract
Akram; Econometrics Journal	2004	Non-linear economtric model - framework of Ozkan and Sutherland (1998), equilibrium correction model (EqCMs)	Krone/ECU exchange rate index, oil price	Strong evidence for a non-linear negative relationship between the value of the Norwegian krone and crude oil prices. Change in oil prices has a strong impact on the exchange rate when oil prices are particularly low, i.e. below 14 USD.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Amano, Norden; Review of International Economics	1998	Johansen and Juselius cointegration test, Phillips and Hansen's FMLS	Real price of oil (WTI), real exchange rate (mark, yen, dollar)	Rise in oil prices by 10% causes depreciation of Mark (0.9%) and Yen (1.7%) and an appreciation of USD (2.6%).

Author/Journal	Year	Methodology	Variables	Result/Abstract
Amano, Norden; Journal of International Money and Finance	1998	Johansen and Juselius cointegration test, Single-equation error-correction model (ECM)	Real effective value of the USD and US real price of oil	Stabil long run link between oil prices and the US real effective exchange rate. Prices of oil Granger-causes the exchange rate; higher prices lead to appreciation.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Berger, Chaboud, Chernenko, Howorka, Wright; Journal of International Economics	2008	Time-series regression, Engle-Granger (1987) and Johansen trace (1988) cointegration test	Order flow, EUR, YEN, USD	Confirmation of the presence of a strong association between exchange rate returns and interdealer order flow at horizons up to two weeks. Weaker relationship at longer horizons, and little evidence of cointegration. Strongest relationship when market liquidity is lowest.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Cerrato, Sarantis, Saunders; Journal of Banking & Finance	2011	Sticky-price monetary model (first difference), Sager and Taylor (2008), Evans and Lyons (2002)	Order flow, EUR, JPY, CHF, GBP, AUD, NZD, CAD, SEK, NOK, money supply, output, interest rate (long and short)	Nine liquid currency pairs are investigated with the use of order flow analysis, and evidence on exchange rate impacts are found on both profit-motivated- and corporate/private traders. Forecasting powers are bleak, perhaps due to weekly order flow/FX data being used and the information contained within the order flow is already impounded into the exchange rate. How quickly the market absorbs this information is an open question.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Corden; Oxford Economic Papers	1984	Core Model, Paradox Model	North Sea oil	Expectations of oil discoveries at various stages are looked at and appreciation ensues when actuals are greater than expectations.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Cumby & Obstfeld; The Journal of Finance	1981	Fisher effect	ln(USD), London Eurodollar deposits, London Euro deposits, CAD, FF, DM, Netherlands guilders, CHF, GBP	The Fisher-parity relationship does not hold. Deviations from the parity may be interpreted as evidence favoring the existence of a foreign exchange risk premium, which lends support to recent theories suggesting foreign exchange market efficiency is consistent with the existence of risk premia at equilibrium.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Danielsson, Luo, Payne; The European Journal of Finance	2012	Multivariate regression, Meese and Rogoff	EUR/USD, EUR/GBP, GBP/EUR, USD/JPY	Strong explanatory power is discovered for all sampling frequencies Discovery of cross-market order flow effects. Predictive power of order flow for exchange rate change is investigated, and it is shown that the order flow specifications reduce RMSEs relative to a random walk for all exchange rates at high-frequencies.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Engel, Frankel; Journal of Monetary Economics	1984	Generalized Dornbusch overshooting model	Monetary forecast error, Eurodollar rate, exchange rate	When the money supply grows more rapidly than had been expected, the market assumes that the Fed will reverse the error in the future, not that it has raised its money growth target. The expectation of future tightening causes the interest rate to rise and the exchange rate to fall.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Evans, Lyons; Journal of Political Economy	2002	Structural models, portfolio shifts model	USD, DM, YEN interest rate, order flow,	Instead of relying exclusively on macroeconomic determinants, the model includes a determinant from microstructure-order flow. It is strikingly successful in accounting for realized rates. The model produces significantly better short-horizons forecasts than a random walk model.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Evans, Lyons; Journal of Financial Economics	2008	Heteroskedasticity based approach/portfolio shift model	USD, DM, order flow, information content (in order flow)	This paper tests whether macroeconomic news is transmitted to exchange rates via the transactions process and if so, what share occurs via transactions versus the traditional direct channel. They identify the link between order flow and macro news, and order flow varies considerably with macro news flow. At least half of the effect of macro news on exchange rates is transmitted via order flow.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Frankel; The American Economic Review	1979	Real interest differential model, with hints of Frenkel-Bilson and Dornbusch	USD-DM, real interest differential	A monetary expansion causes a long-run depreciation because it is an increase in the supply of the currency, and an increase in expected inflation causes a long-run depreciation because it decreases the demand for the currency.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Golub; The Economic Journal	1983	Discrete-time model, stock/flow model	OPEC, America, Europe, Britain, USD, DM, GBP price of oil, quantities of oil	Th paper attempts to explain the differences in the response of the foreign exchange market to oil price increases between the first and second oil shocks of the 1970s. In 1973-4, the dollar appreciated in the wake of unexpected oil price hikes but tended to depreciate in 1979 following news about oil price rises. American dependence on OPEC oil is the main cause of the shift.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Jawadi, Louhichi, Ameur, Cheffou; Economic Modelling	2016	Continuous-time jump-diffusion model, GARCH	USD/EUR exchange rates	Negative relationship between the US dollar/euro and oil returns, indicating that a US$ appreciation decreases oil price. Further evidence for volatility spillover from the US exchange market to the oil market.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Kleinbrod, Li; Journal of International Money and Finance	2017	Multivariate framework	USD, AUD, CAD, EUR, GBP, JPY, returns, return volatility, bid-ask spreads, order flow	Extends the linkage between order flows and exchange rates from the univariate to the multivariate framework. The effect of order flow on exchange rate comovements is significantly negative during the tranquil period but can become positive during the turbulent period. This negative effect lessens as the intraday frequency lowers.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Lyons; Journal of Financial Economics	1995	Extension of Madhaven and Smidt	spot DM/USD, dealer quantity (order flow), dealer position, third-party brokers	Data in this paper support both the inventory-control and asymmetric-information approaches to microstructure theory. Strong evidence of an inventory-control effect on price is new. These results highlight the importance of inventory-control theory in understanding trading in the foreign exchange market.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Meyer, Skjelvik; Penger og Kreditt	2006	Theoretical/ Presenting order flow data	Customer groups, contract type, maturity, FX-pair	This paper explains and introduces a relatively newly collected dataset for Norges Bank, namely order flow. Order flow analysis has shown promising results so far, and this dataset will contribute to additional empirical research on foreign exchange rates. The categories make it possible to investigate the different customers.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Payne; Journal of International Economics	2003	VAR structure	order flow, USD, DM	New evidence on information asymmetries in inter-dealer FX markets. Shows that asymmetric information accounts for around 60% of average bid-ask spreads. Further, 40% of all permanent price variation is shown to be due to transaction-related information.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Reboredo; Journal of Policy Modeling	2012	Marginal distribution model: TGARCH, Copula models	EXR (USD per unit of foreign currency), Crude oil prices in USD (WTI)	Increases in oil prices is weakly associated with USD depreciation and vice versa. Copula models: tail independence between oil prices and exchange rates in the periods before and after the financial crisis.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Rime, Sarno, Sojli; Journal of International Economics	2010	Hybrid models, order flow models, carry trade strategy, random walk	USD, EUR, GBP, JPY	This paper adds to the research efforts that aim to bridge the divide between macro and micro approaches to exchange rate economics by examining the linkages between exchange rate movements, order flow and expectations of macroeconomic variables.

Author/Journal	Year	Methodology	Variables	Result
Rime & Sojli; Penger og Kreditt	2006	Multivariate regression/VAR	Interest differential, Order flow, trend	An illustrative model with a short sample yet order flow analysis has shown great promise in explaining the foreign exchange rate. With the use of new order flow data, they hope future research can help to understand the foreign exchange market better.

Author/Journal	Year	Methodology	Variables	Result/Abstract
Turhan, Sensoy, Hacihasanoglu; Journal of International Financial Markets, Institutions and Money	2014	Consistent dynamic conditional correlation model (cDCC)	Crude oil price Brent, Exchange rates (USD/local currency)	Link between oil prices and exchange rates has intensified in the last decade; they became strongly negatively correlated (which also associates an increase in the oil prices with the US dollar depreciation against other currencies).

E Data collection

	Date	Norges Bank	Foreign Banks	Norwegian Clients	Foreign Clients	EUR-NOK	Oil price diff	Interest diff
2	09.10.2005	-2460	1,790	2571	-1,530	7.89482		0.26
3	16.10.2005	-2770	958	2064	-1413	7.82598	-0.00577	0.28
4	23.10.2005	-3060	6550	-3879	-279	7.79941	-0.00751	0.25
5	30.10.2005	-2950	-12	230	1117	7.81792	0.00602	0.24
6	06.11.2005	-3640	5788	-466	-272	7.79607	0.00410	0.24
7	13.11.2005	-4199	5060	25	-707	7.74976	-0.03320	0.24
8	20.11.2005	-4051	323	4939	443	7.84621	-0.05318	0.19
9	27.11.2005	-4200	4270	-1714	285	7.87518	-0.00372	0.09
10	04.12.2005	-2450	-6665	-251	1427	7.91737	0.00037	0.09
11	11.12.2005	0	1634	1141	429	7.92444	0.04628	0.11
12	18.12.2005	0	0	790	-1885	7.95343	0.04780	0.08
13	25.12.2005	0	-9827	11030	-144	8.02122	-0.04068	0.04
14	01.01.2006	0	870	1228	-318	8.01719	0.01810	0.07
15	08.01.2006	-1200	4251	-1566	-1150	7.94678	0.07564	0.05
16	15.01.2006	-1200	-4762	8559	-2433	8.01942	0.00745	0.02
17	22.01.2006	-1105	-3261	4500	2862	8.09409	0.02187	-0.01
18	29.01.2006	-1300	2917	-3100	6033	8.06677	0.00362	-0.02
19	05.02.2006	-960	-2398	4326	-418	8.06436	0.00361	-0.02
20	12.02.2006	-845	1785	746	-258	8.05012	-0.04328	-0.04
21	19.02.2006	-810	-4496	7806	349	8.09627	-0.05210	-0.05
22	26.02.2006	-765	4117	-891	-1115	8.05146	0.02326	-0.01
23	05.03.2006	-1105	7354	-3077	1014	8.02034	0.02812	-0.03
24	12.03.2006	-1150	3323	-4755	120	7.99287	-0.02555	-0.01
25	19.03.2006	-1190	7651	-3006	-1842	7.97582	0.04908	0.02
26	26.03.2006	-1100	151	973	-596	7.96297	-0.01298	0.00
27	02.04.2006	-781	4966	-593	-362	7.95473	0.05113	-0.02
28	09.04.2006	-1025	16249	-15989	155	7.88183	0.03351	-0.01
29	16.04.2006	-455	-216	-2535	-1750	7.85772	0.02958	0.06
30	23.04.2006	-640	5734	-1185	-577	7.83996	0.05268	0.04
31	30.04.2006	-1150	8416	-5583	77	7.80434	0.00414	0.01
32	07.05.2006	-1755	1205	2417	50	7.77466	0.00110	0.03
33	14.05.2006	-2305	4585	-1062	678	7.76743	-0.03401	0.04
34	21.05.2006	-1665	3150	868	-1324	7.80358	-0.03691	0.07
35	28.05.2006	-1930	1631	2616	-921	7.82011	0.00929	0.07
36	04.06.2006	-2180	3594	-718	1343	7.79724	0.00409	0.08
37	11.06.2006	-1905	-1021	2487	805	7.79768	-0.01251	0.09
38	18.06.2006	-2300	-1698	5332	222	7.83017	-0.02534	0.07

EXTRACT OF THE SUMMARY OF ALL THE DATA COLLECTED AND USED IN THE ANALYSIS.

	A	B		C	D	E	F	G
1								
2		**Tabell 1. Valutatransaksjoner. Spot og forward**						
3		*Table 1. Foreign exchange transactions. Spot and forward*						
4								
5		**Millioner kroner**/*Million NOK*		**2010**				
6				**Uke 1**	**Uke 2**	**Uke 3**	**Uke 4**	**Uke 5**
7				**04.01-10.01**	**11.01-17.01**	**18.01-24.01**	**25.01-31.01**	**01.02-07.02**
8	Netto valutakjøp	*Net foreign exchange purchase* [1]						
9								
10	Instrument	Spot		4,249	5,538	7,979	5,187	301
11		Forward		-2,250	-4,398	-8,962	-863	2,690
12		**Totalt**		**1,998**	**1,140**	**-983**	**4,324**	**2,991**
13								
14	Motpartinndeling med fokus på finansielle	Rapportørbanker	*Reporting banks*	1,082	293	-764	-87	-988
15	og ikke-finansielle kunder	Utenlandske banker	*Foreign banks*	13,529	1,709	-2,413	-22	1,674
16	*Counterparty category with focus on*	Finansielle kunder	*Financial clients* [2]	-2,770	-223	-299	1,229	1,054
17	*financial and non-financial clients*	Ikke-finansielle kunder	*Non-financial clients* [3]	-9,842	-638	2,493	3,204	1,250
18		Norges Bank	*Central Bank of Norway*					
19		**Totalt**		**1,998**	**1,140**	**-983**	**4,324**	**2,991**
20								
21	Motpartinndeling med fokus på norske	Rapportørbanker	*Reporting banks*	1,082	293	-764	-87	-988
22	og utenlandske kunder	Utenlandske banker	*Foreign banks*	13,529	1,709	-2,413	-22	1,674
23	*Counterparty category with focus on*	Norske kunder	*Norwegian clients* [4]	-9,853	-460	3,646	3,047	1,672
24	*Norwegian and foreign clients*	Utenlandske kunder	*Foreign clients* [5]	-2,759	-402	-1,453	1,386	633
25		Norges Bank	*Central Bank of Norway*					
26		**Totalt**		**1,998**	**1,140**	**-983**	**4,324**	**2,991**
27								
28	Valutakjøp	*Foreign exchange purchases* [6]						
29								
30	Instrument	Spot		83,927	80,714	65,091	82,672	77,245
31		Forward		40,963	21,521	26,610	36,832	44,941
32		**Totalt**		**124,890**	**102,236**	**91,700**	**119,504**	**122,186**
33								
34	Motpartinndeling med fokus på finansielle	Rapportørbanker	*Reporting banks*	31,578	33,531	25,924	44,254	42,131
35	og ikke-finansielle kunder	Utenlandske banker	*Foreign banks*	69,783	43,440	35,928	45,990	49,913
36	*Counterparty category with focus on*	Finansielle kunder	*Financial clients* [2]	7,862	9,896	11,696	11,336	9,735
37	*financial and non-financial clients*	Ikke-finansielle kunder	*Non-financial clients* [3]	15,668	15,368	18,152	17,925	20,407
38		Norges Bank	*Central Bank of Norway*					
39		**Totalt**		**124,890**	**102,236**	**91,700**	**119,504**	**122,186**
40								
41	Motpartinndeling med fokus på norske	Rapportørbanker	*Reporting banks*	31,578	33,531	25,924	44,254	42,131
42	og utenlandske kunder	Utenlandske banker	*Foreign banks*	69,783	43,440	35,928	45,990	49,913
43	*Counterparty category with focus on*	Norske kunder	*Norwegian clients* [4]	18,741	21,507	25,418	21,654	21,403
44	*Norwegian and foreign clients*	Utenlandske kunder	*Foreign clients* [5]	4,789	3,758	4,431	7,607	8,739
45		Norges Bank	*Central Bank of Norway*					
46		**Totalt**		**124,890**	**102,236**	**91,700**	**119,504**	**122,186**
47								
48	Valutasalg	*Foreign exchange sales* [7]						

Front | **Tab1** | Tab2 | Tab3 | Ark2 | Tab4 | MetadataN | MetadataE

EXTRACT OF THE ORDER FLOW DATA. ONE CAN SEE ALL THE CATEGORIES AND HOW THE DATA IS SORTED.

	A	B	C	D
1	Date	Brent	WTI	Dubai
2	01.09.2005	58.54	62.26	56.54
3	01.10.2005	55.24	58.32	53.67
4	01.11.2005	56.86	59.41	51.31
5	02.12.2005	62.99	65.49	53.13
6	02.01.2006	60.21	61.63	58.31
7	02.02.2006	62.06	62.69	57.58
8	05.03.2006	70.26	69.44	57.65
9	05.04.2006	69.78	70.84	64.06
10	06.05.2006	68.56	70.95	64.91
11	06.06.2006	73.67	74.41	65.08
12	07.07.2006	73.23	73.04	69.05
13	07.08.2006	61.96	63.8	68.78
14	07.09.2006	57.81	58.89	59.77
15	08.10.2006	58.76	59.08	56.5
16	08.11.2006	62.47	61.96	56.82
17	09.12.2006	53.68	54.51	58.67
18	09.01.2007	57.56	59.28	52.01
19	09.02.2007	62.05	60.44	55.68
20	12.03.2007	67.49	63.98	59.05
21	12.04.2007	67.21	63.46	63.84
22	13.05.2007	71.05	67.49	64.54
23	13.06.2007	76.93	74.12	65.76
24	14.07.2007	70.76	72.36	69.46
25	14.08.2007	77.17	79.92	67.21
26	14.09.2007	82.34	85.8	73.25
27	15.10.2007	92.41	94.77	77.14
28	15.11.2007	90.93	91.69	86.73
29	16.12.2007	92.18	92.97	85.75
30	16.01.2008	94.99	95.39	87.17
31	16.02.2008	103.64	105.45	89.96
32	18.03.2008	109.07	112.58	96.78
33	18.04.2008	122.8	125.4	103.47
34	19.05.2008	132.32	133.88	118.95
35	19.06.2008	132.72	133.37	127.59
36	20.07.2008	113.24	116.67	131.22
37	20.08.2008	97.23	104.11	113.21
38	20.09.2008	71.58	76.61	95.97

Ark1

EXTRACT OF THE DATA ON THE OIL PRICE.

	A	B	C
1	Date	LIBOR	NIBOR
2	09.10.2005	2.181428	2.442
3	16.10.2005	2.185626	2.462
4	23.10.2005	2.185078	2.436
5	30.10.2005	2.214978	2.458
6	06.11.2005	2.267904	2.506
7	13.11.2005	2.306628	2.55
8	20.11.2005	2.345526	2.54
9	27.11.2005	2.444628	2.538
10	04.12.2005	2.467704	2.554
11	11.12.2005	2.453054	2.566
12	18.12.2005	2.466878	2.548
13	25.12.2005	2.488178	2.526
14	01.01.2006	2.48904667	2.555
15	08.01.2006	2.489228	2.538
16	15.01.2006	2.501666	2.52
17	22.01.2006	2.512254	2.504
18	29.01.2006	2.532628	2.514
19	05.02.2006	2.556904	2.54
20	12.02.2006	2.578802	2.542
21	19.02.2006	2.600404	2.552
22	26.02.2006	2.623052	2.618
23	05.03.2006	2.670102	2.642
24	12.03.2006	2.694426	2.686
25	19.03.2006	2.703626	2.726
26	26.03.2006	2.733578	2.736
27	02.04.2006	2.789104	2.766
28	09.04.2006	2.810454	2.8
29	16.04.2006	2.7616275	2.82
30	23.04.2006	2.771845	2.8125
31	30.04.2006	2.817152	2.832
32	07.05.2006	2.8601275	2.8875
33	14.05.2006	2.876376	2.914
34	21.05.2006	2.889904	2.96
35	28.05.2006	2.907926	2.9825
36	04.06.2006	2.931554	3.012
37	11.06.2006	2.969228	3.0575
38	18.06.2006	2.964826	3.03

Ark1

EXTRACT OF THE INTEREST RATES DATA.

	Foreign banks	*Central Bank of Norway*	*Δ Central bank of Norway*	*Norwegian clients*	*Foreign clients*	*Oil price*	*ΔOil price (%)*	*Interest differential*	*Δ Interest differential*	*FX*	*ΔNOK-EUR (%)*
Mean	931	-174	8,727	364	-32,6	78,96	0,001156	1,279	0,001915	8,36	0,000336
Median	1 013	0	0	15	-92,8	73,35	0,001010	1,418	0,000758	8,14	-0,000422
Maximum	28 667	4 299	4713	36 699	11 221	141,1	0,221652	2,437	0,386876	9,94	0,046003
Minimum	-33 451	-6 975	-4153	-18 751	-6 682	27,76	-0,151762	-0,048	-0,569250	7,30	-0,031431
Std. Dev.	6 469	2 038	628	5 580	1 627	26,30	0,040575	0,513	0,066739	0,66	0,008370
Skewness	-0,290	0,017	0.633	0,847	0,645	0,202	0,174920	-1,335	-0,495659	0,54	0,541851
Kurtosis	5,67	2,93	15,2	7,40	8,03	1,759	5,570601	3,987	20,39111	2,15	5,830706
Jarque-Bera	204	0,149	4088	608	735	46,46	183,4	221,1	8269	51,3	250
Probability	0,000	0,928	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
Aug. Dickey-Fuller	-13,9	-3,89	-20,3	-17,1	-21,9	-1,852	-20,57	-2,199	-20,47	-1,23	-17,3
Probability	0,0000	0,0022	0,0000	0,0000	0,0000	0,355	0,000	0,2068	0,0000	0,6619	0,0000
Observations	655	655	654	655	655	655	654	655	654	655	654

***TEAR-OFF*. DESCRIPTIVE STATISTICS FOR ALL VARIABLES USED IN THE REGRESSION MODELS.**

Variables	*Original model*	*Model 1*	*Model 2*	*Model 3*	*Model 4*	*Model 5*
C	0,000448* (0,00273)	0,000596*** (0,000242)	0,000515*** (0,000246)	0,000631*** (0,000231)	0,000682*** (0,000327)	0,000756*** (0,000310)
(Δ)NB$_t$	0,0150 (0,01360)	-0,1150*** (0,03890)	-0,1280*** (0,05270)	-0,1180*** (0,03860)	-0,1890 (0,01890)	-0,134*** (0,0485)
FB$_t$	-0,0289*** (0,00942)	-0,0244*** (0,00806)	-0,0348*** (0,00822)	-0,0249*** (0,00680)	-0,0421*** (0,01290)	-0,0372*** (0,0118)
NC$_t$	0,0568*** (0,01050)	0,0563*** (0,00903)	0,0491*** (0,00892)	0,0552*** (0,00779)	0,0698*** (0,01550)	0,0764*** (0,0141)
FC$_t$	-0,0184 (0,01490)	0,0217 (0,01700)	0,0132 (0,01460)	0,0223 (0,01560)	0,0283 (0,02230)	0,0365 (0,0245)
ΔOP$_t$	-0,0072 (0,0086)	-0,0037 (0,00946)	-0,0074 (0,00861)	-0,0155 (0,00947)	-0,0262*** (0,01188)	-0,0274*** (0,01282)
ΔID$_t$	-0,0200*** (0,00792)	-0,0150** (0,00767)	-0,0204*** (0,00743)	-0,0155*** (0,00752)	-0,0212*** (0,00677)	-0,0155*** (0,00602)
ΔFX$_{t-1}$	0,1263*** (0,05400)	0,1883*** (0,04576)	0,1311*** (0,05282)	0,1800*** (0,04767)	-0,1736*** (0,05460)	-0,0866 (0,05896)
(Δ)NB$_{t-1}$		0,1170*** (0,04080)		-0,0656*** (0,02850)		0,1410*** (0,04920)
FB$_{t-1}$		-0,0034 (0,00679)		-0,0051 (0,00620)		0,0046 (0,00801)
NC$_{t-1}$		-0,0330*** (0,00787)		-0,0341*** (0,00758)		-0,0425*** (0,01240)
FC$_{t-1}$		0,0235 (0,01700)		0,0223 (0,01640)		0,0383*** (0,0193)
ΔOP$_{t-1}$		-0,0446*** (0,00748)		-0,0448*** (0,00743)		-0,0254*** (0,00877)
ΔID$_{t-1}$		-0,0122* (0,00755)		-0,0125* (0,00755)		-0,0188*** (0,00873)

***TEAR-OFF*. REGRESSION OUTPUTS FOR THE ORIGINAL EQUATION AND ALL THE VARIATIONS.**