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The Oil Price and the Exchange Rate under Different Monetary Policy Regimes

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Preface

The Master's thesis is carried out as part of the Master's Degree Programme in Business Administration at Agder University College. Its aim is to apply scientific methods to a specific problem, which is relevant to business administration. The thesis is mandatory and awards 30 ECTS, and it is meant to be the final project of the 5-year master's degree programme. 15 ECTS have already been taken care of in "Siviløkonomoppgaven: Oljeprisenes påvirkning på norsk økonomi" that was written as a final project of the 4-year "Siviløkonom programme" spring 2005. The final 15 ECTS is provided by this thesis. Together, these two projects will fulfill the requirement of a final project constituting 30 ECTS.

The objective of the thesis is to study the relationship between the oil price and the Norwegian exchange rate under two different monetary policy regimes. Q. Farooq Akram revealed in his article "Oil prices and exchange rates: Norwegian evidence" (2004) a negative non-linear relationship between the oil price and the value of the Norwegian exchange rate. Akram's article is used as framework to study a linear relationship between the Norwegian exchange rate and the oil price.

I wish to express my gratitude to my counselor Jochen Jungeilges, for essential and helpful guidance during the process, in addition to good ideas and important feedback on my thesis. In addition, I would use the opportunity to thank Q. Farooq Akram at Norges Bank's research department, for willingness to provide the data that was needed.

Kristiansand, June 27, 2006

Hege Stålhane

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1 Introduction

1.1 Background

When I finished the "Siviløkonomprogramme" in June 2005, I wrote my "Siviløkonomoppgave - Oljeprisens påvirkning på norsk økonomi" together with a fellow student. It is regarded as the final project of the programme and is awarded 15 ECTS. The petroleum industry has made Norway one of the richest countries in the world. Ever since the discovery of oil and gas outside the coast of Norway in 1969, they have been essential assets and sources of revenue in Norway. The oil price and its fluctuations have a great impact on an oil nation like Norway. Norway's social welfare system is based upon oil revenue earned from the petroleum industry. In addition, companies are also affected by oil price fluctuations, either through their operations in the petroleum industry or through its effect on the economy.

Our approach to studying the oil price effect on the Norwegian economy was by looking at how the government and two different companies were affected by changes in the oil price. The government is affected through their ownership in large petroleum companies and their activity on oil fields, as well as by their income through taxes levied on companies operating on the Norwegian soil. The two companies that we looked at were different in the sense that they were differently affected by oil price changes. First, Borealis was directly affected since it buys an oil and gas combination that is used in production. Second, National Oilwell was indirectly affected since it sells equipment used in oil and gas production.

In order to fulfill the requirement to a Master's thesis I am complementing the "Siviløkonomoppgave" with 15 ECTS by taking a more specific look at the macroeconomic aspect of the economy in relation to the oil price. Norway's current account is dominated by oil and gas exports and its revenue is of great importance when making the government budget. It could therefore be interesting to study if there could be a relationship between macroeconomic variables such as interest rates, inflation and exchange rates and the oil price. It is a common perception of the public that a relationship between the oil price and the Norwegian exchange rate exists. For example, Erikstad (2006) wrote in a newspaper article

"Verre enn i 2002" that the only thing that can weaken the Norwegian exchange rate is a massive fall in the oil price, since the interest rate is already at a low level.

Both the Norwegian exchange rate and the oil price are variables that have a great impact on Norwegian companies, especially companies in the exposed sector. Thus, it would be interesting to investigate if any relationships between the two variables exit.

1.2 Problem statement

The focus of the thesis is to investigate the relationship between macroeconomic variables, such as the exchange rate and its relation to the price of Norway's most important asset, oil. Thus, the primary goal is to:

Study whether the oil price has a linear effect on the Norwegian exchange rate when one take into account the recent change in monetary policy regime.

Several studies have been conducted in order to study the relationship between the oil price and exchange rates, but with mixed results. There could be several reasons why different conclusions have been drawn. First, if one uses linear modeling approach in order to explain the variation in the exchange rate, one is assuming that there is a symmetric relationship between the exchange rate and the price of oil. That might not be the case, and non-linear regression models may contribute to better explain the variation in the data. Second, the choice of monetary policy regime and operative target might have an effect on how sensitive the exchange rate is to exogenous shocks, like oil price fluctuations. The tradition in Norway has been to stabilize the exchange rate. However, since 2001, the monetary policy has been inflation stabilization. Under a monetary policy regime that tries to stabilize the exchange rate, one might only discover a relationship, when the exogenous shocks are outside a certain range. When the shocks are within the range, the value of the exchange rate is defended by Norges Bank by using policy instruments to influence its value. This analogy implies a non-linear relationship between the exchange rate and the oil price. When the monetary policy is inflation stabilization, the exchange rate is not defended by Norges Bank anymore, it floats. In this case, one might discover a more linear relationship between the variables. Third, the oil price has increased a lot during the last five years and it has fluctuated more heavily than previously. Thus, when the oil price fluctuates within a lower range it might affect the relationship differently than when if fluctuates at a higher level. Fourth, various exchange rates will most likely not experience the same effect when exposed to oil price fluctuations.

In this thesis, the Stata software package is used to investigate a linear oil price effect on the exchange rate by using a well-specified error correction model (ECM) and the ordinary least squares (OLS) technique. The linear model has proven insufficient to describe the relationship between the exchange rate and the oil price in pervious research. However, it might be reasonable to use linear regression techniques, due to the new regime in monetary policy and heavy fluctuations in the level of the oil price. The linear ECM derived by Q. Farooq Akram in his article "Oil prices and exchange rates: Norwegian evidence" (2004) is used as framework. Quarterly observations of the Norwegian trade-weighted nominal exchange rate over the period from 1971:2 to 1997:4 are obtained by Norges Bank and used to replicate his original model. In addition, data from a new measurement system at Norges Bank is used in order to distinguish between the two monetary policies in place during the period from 1978:1 to 2005:4. Due to the lack of consensus on the appropriate set of variables to include in an exchange rate model, a number of variables were included in the general model. Thereafter, a general-to-specific strategy was used in order to determine the appropriate variables to be included in the model.

The thesis proceeds as follows. In the next section (section 2), quarterly observations of the exchange rate and the oil price are examined in order to learn more about their possible relationship. Basic exchange rate parity theories, such as the interest rate parity, purchasing power parity and the international Fisher effect, are presented in subsection 3.1, in order to understand what factors might contribute to determine value of the exchange rate. Various modeling/forecasting techniques for exchange rates are discussed in subsection 3.2. Their individual weaknesses to produce accurate forecasts are revealed. However, when they are combined they are able to determine the range of possible exchange rates.

Monetary policy in Norway is discussed in section 4, along with its implication for the value of the exchange rate. Section 4 provides the basis to understand how the choice of monetary policy can affect the ability to find a relationship between the exchange rate and exogenous shocks. An overview of the various monetary policies in Norway since 1816 is presented in subsection 4.1. The background for the recent change in monetary policy, from exchange rate stabilization to inflation stabilization is presented in subsection 4.2. In addition, each regimes strengths and weaknesses are discussed. An overview of the discussion that prevailed in both the public and academic sphere before the formal change in monetary policy in 2001 is given in subsection 4.3. Subsection 4.4 presents the current monetary policy regime, i.e. inflation stabilization, its rationale and how it is executed by Norges Bank.

In section 5, the concepts of cointegration and ECMs are presented. They provide a formal econometric approach to overcome the problems with non-stationarity in time series. An exchange rate model with oil price effects and the choice of explanatory variables is derived in section 6. A general ECM of the exchange rate and the possible independent variables derived by Q. Farooq Akram is presented in subsection 6.1.1.The data obtained from Norges Bank needed to be transformed in order to be applied in the Stata software package. The transformation is taken care of in subsection 6.1.2. Akram's ECM of the exchange rate with linear oil price effects is formulated and reproduced in subsection 6.1.3. Akram's linear exchange rate model shows that the oil price has insignificant effects on the variation in the exchange rate.

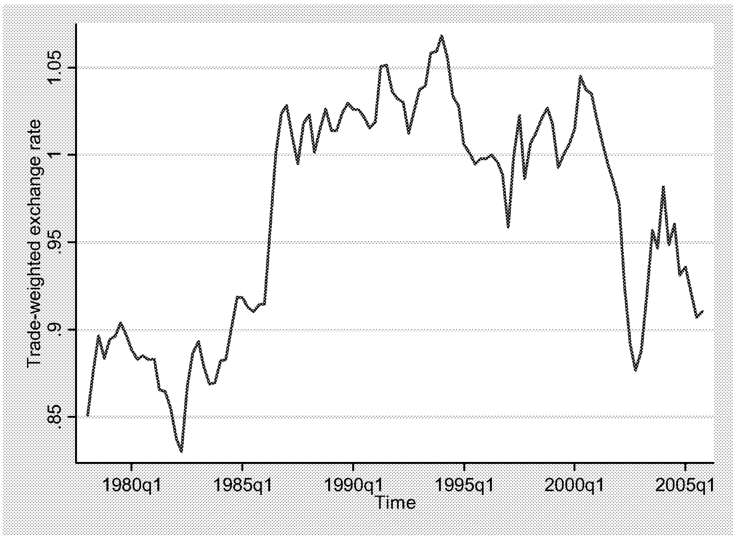
Akram's linear exchange rate model is estimated under different monetary policy regimes in section 7, using data from the new measurement system at Norges Bank. The data from the new measurement system only covers data from 1978:1 and some of the variables were missing a few observations in the beginning of the sample period. Thus, the missing values needed to be estimated by matching the old and new system. In addition, the data needed to be formatted for use in Stata. These actions are taken care of in subsection 7.1. Akram's linear model is re-estimated by using the data from the new measurement system in subsection 7.2. The resulting coefficients are a little different than Akram's original model, because it shows significant oil price effects up to one lag at the 10 percent level. In addition, two of the other independent variables, foreign inflation (cpi^f) and domestic money market rates (RSnew), were found insignificant. Subsection 7.3 will distinguish between the two different monetary policies during the sample period. The model covering the period when exchange rate stabilization is the monetary policy is estimated in subsection 7.3.1. Oil price effects up to one lag are found to be significant during this time period. In addition, the two independent variables, cpi^f and RSnew, which were found insignificant in subsection 7.2 are still insignificant. The period covering the current monetary policy of inflation stabilization is estimated in subsection 7.3.2. During this short time period, all of the independent variables were found to be insignificant, except the accelerated foreign bond rate and the oil price effect with two lags. The entire sample period is estimated in subsection 7.3.3, where another dummy is introduced in order to account for the two different monetary policies. Two of the independent variables, cpi^f and RSnew, still proved to be insignificant. However, the oil price effects are found to contribute to explain the variation in the growth in the exchange rate. In addition, the dummy variable is significant at the 10 percent level, which suggests that when inflation stabilization is the monetary policy it has a negative effect on the growth in the exchange rate. All the estimated models based on Akram's linear exchange rate model, found various oil price effects on the exchange rate when using data from the new measurement system. Thus, the significant oil prices cannot explicitly be attributed to the change in monetary policy.

2 The Norwegian exchange rate and the oil price

The Norwegian economy is characterized as a small and open economy. It is open in the sense that Norway obtains a large share of its gross domestic product (GDP) from imports and exports with foreign countries. It is small because Norway is a small part of the world market, and hence, only has minor effects on prices of internationally traded goods and services, such as the price of oil (Mankiw, 1997). The Norwegian trade balance against other countries is currently operating at a large surplus. Oil and gas is by far the largest commodities traded between Norway and other countries. About 60 percent of Norway's total exports constitutes of crude oil, natural gas and condensates (SSB, 2006). Since Norway is a net exporter, an increase in the price of oil and gas would lead to an increased demand for the Norwegian currency that might cause the currency to appreciate, cet. par. On the other hand, a decrease in the price would lead to a decreased demand for the Norwegian currency that might cause the currency to depreciate, cet. par. This analogy might contribute to explain the well known perception that changes in the oil price may cause fluctuations in the Norwegian exchange rate.

Figure 1 shows how the Norwegian exchange rate has fluctuated since the first quarter in 1978. It is based on quarterly data for the trade weighted exchange rate.

Figure 1 The Norwegian exchange rate



Source: Data obtained from Norges Bank's database (2006)

The period is characterized by large fluctuations in the value of the krone. A rise in the exchange rate indicates a decrease in the value of the krone, i.e. depreciation, while a fall in the exchange rate indicates an increase in the value of the krone, i.e. appreciation. The period covers both the previous monetary policy of a fixed/stable exchange rate and the current monetary policy of inflation stabilization, which has been in place since March 2001[1]. The krone was relatively strong compared to the trade-weighted exchange rate the beginning of the 1980s. The krone was linked to a currency basket at the time and the krone was devalued (i.e. reduced the value of the currency) in May 1986 by almost 12 percent against the currency basket. In order to link the krone more closely to the European monetary system (EMS), the monetary policy objective was to stabilize the exchange rate against the ECU and later the Euro from 1994. The period with a stable exchange rate shows a strong appreciation of the krone in 1996/1997 and later a strong depreciation in 1997/1998. The appreciation can be seen in relation to an upward trend in oil prices in 1996/1997, where it increased from 17 to 24 US dollars. The depreciation happened at a time when oil prices were falling. It started to fall after the upward trend, and it fell to 11 US dollars in 1997/1998 (see figure 2 below).

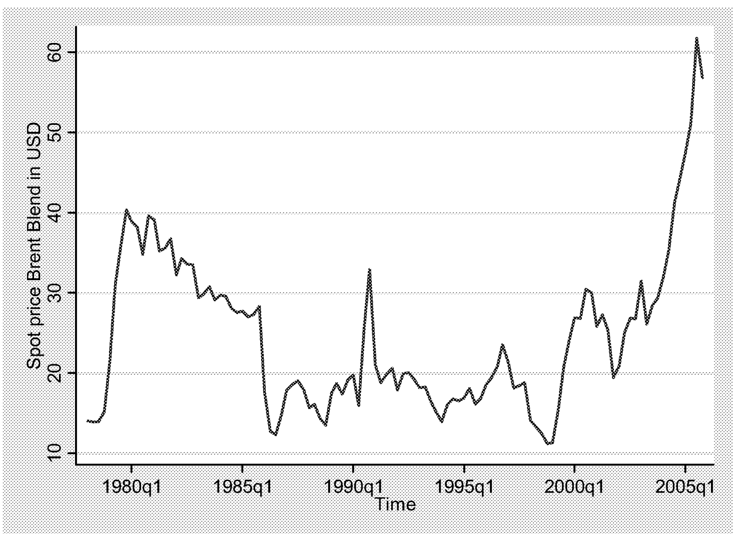
Since 2001, the monetary policy was no longer to keep a stable exchange rate, it was inflation stabilization. Thus, the value of the kone has fluctuated to a larger degree after the new regime came into place. The krone faced a strong appreciation in 2001/2002. Various reasons

[1] See section 4.1 for details on monetary policy history

are suggested to explain the strong appreciation. First, interest rates in Norway remained high, even though foreign interest rates were falling. Second, investors had become more risk averse since the burst of the Dot-com bubble. Thus, Norway served as a safe retreat due the relatively high interest rates. Third, the oil price had increased a lot since the end of 2001, (Bredesen, 2005). The Norwegian krone started to depreciate when Norges Bank began to lower the interest rate in December 2002. The interest rate fell from its highest level of 7 percent and until it reached its lowest level in March 2004, when it was set to 1.75 percent. Ever since the second quarter in 2004, the krone has strengthened against the trade-weighted exchange rate and it has remained at a strong level. One potential explanation might be an expectation of increasing interest rates, since the interest rates were at an unusual low level. Norges Bank started to increase the interest rate again in July 2005. In addition, the petroleum industry has experienced a continuous growth in oil prices, as suggested by figure 2.

The price of Brent Blend in US dollars from the first quarter in 1978 and up to the fourth quarter in 2005 is showed in figure 2. Except for in the high oil prices in 1980-1985 caused by the Iran/Iraq war and the peak in oil prices during the Gulf war in 1990/1991, the oil price has mainly fluctuated between 14 and 20 US dollars in the period up to 2000. Thus, the range between 14 and 20 USD may be characterized as the normal range for that period. However, the oil price has continued to fluctuate since then, and it has experienced a continuous increase in its value.

Figure 2 Price of Brent Blend in US dollars



Source: Data obtained from Norges Bank’s database (2006)

The organization of petroleum exporting countries (OPEC) is a group constituting of oil exporting countries that cooperates on oil related issues. OPEC is the largest producer of oil in the world and therefore has considerable influence on the price of oil. Since 2000, the member countries have adjusted their production in order to have the oil price stay within a price band of 22-28 US dollars per barrel. However, OPEC decided to temporarily suspend the current price band in January 2005, after noted that prices had fluctuated outside the price band for over a year. However, their commitment to maintain a stable market, with prices at a reasonable level remains fixed (OPEC, 2005). In addition to OPEC's price influence, politics have played a major role in determining the increasing oil prices in the last few years. The current, unstable political situation in Nigeria, the war in Iraq and the threat of nuclear weapons in Iran are examples that have contributed to cause uncertainty with the respect to the supply of oil and have made the price of oil continue to stay at a high level. Thus, instability and uncertainty in the supply countries are likely to have large and variable effect on the price of oil.

There has been much discussion in the media about the level of the oil price and whether or not it has increased to a permanent new and higher level, or if it will fall to its initial target range in the long-run. According to the report "Economic outlook" by the Organization for Economic Co-operation and Development (OECD), the oil price are likely to stay stable around 70 US dollars per barrel in the next six years (Bertelsen and Erikstad, 2006). The suggested higher level of the oil price may impose different effects on the economy compared to when the oil price was at a significantly lower level. The level of the oil price will make a big difference to the Norwegian economy, e.g. through the oil revenue available to the government when making the budget, the profitability of the large petroleum industry and the effect that oil prices may have on macroeconomic variables such as inflation, interest rates and exchange rates.

Examples of a relationship between the exchange rate and the oil price can be found during some periods in figure 1 and 2, which contribute to support the common perception of the public that such a relationship exists. The figures show periods where increasing oil prices are coinciding with an appreciation of the krone, e.g. 2002/2003, and periods where falling oil prices coincides with a depreciating krone, e.g. 1998. However, the assumed relationship between the exchange rate and the oil price has showed mixed support in empirical research. In the last five years, there has been a change in monetary policy from exchange rate stabilization to inflation stabilization, and the oil price has experienced a continuous increase in its value. The new regime in monetary policy and the higher level of oil prices may have a different effect on the Norwegian exchange rate, compared to when exchange rate stabilization was the monetary policy and when oil prices were at a significantly lower level.

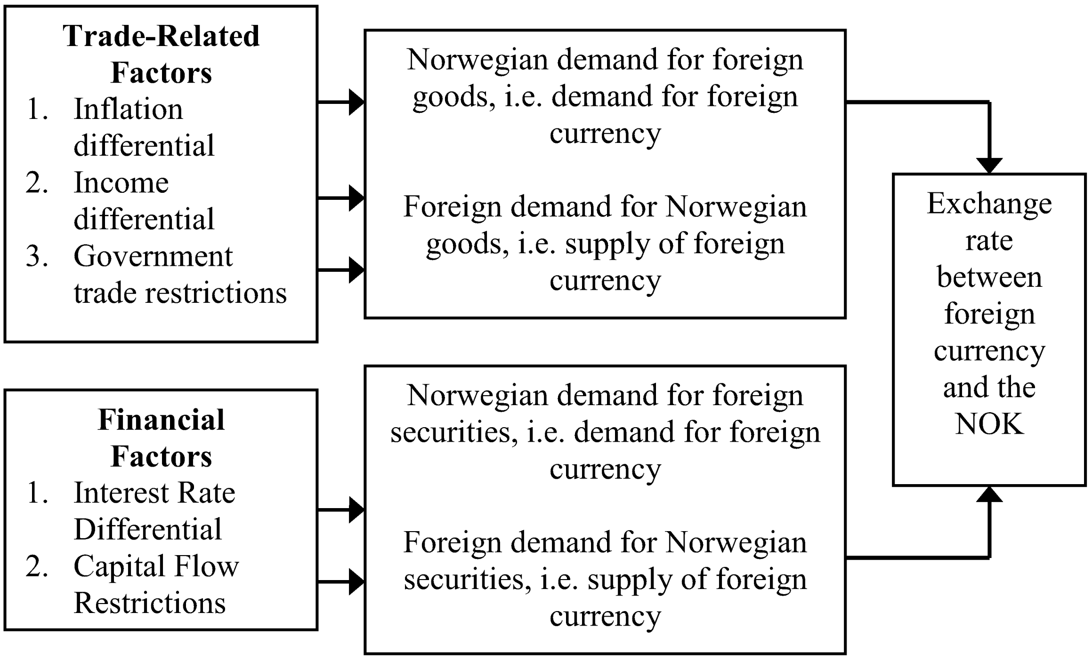
In addition to the possible relationship between the oil prices and the exchange rate, other variables may have an impact on the exchange rate. Thus, basic exchange rate theory is presented in section 3, in order to get a better understanding of what factors contribute to determine the exchange rate.

3 Exchange rate determination[2]

The foreign exchange market facilitates international trade and financial transactions between open economies by allowing currencies to be exchanged. Like any other products sold in markets, the price of a currency will be determined by its supply and demand. The exchange rate measures the value of one currency in terms of another, i.e. the price of one unit of foreign currency in terms of domestic currency, E = Norwegian currency/foreign currency. The equilibrium exchange rate is the price at which demand for that currency is equal to supply. A floating exchange rate regime is when the exchange rate is left to fluctuate and its price will be determined by market forces. If the currency declines in value it is said to depreciate and it is appreciating if it increases in value. The equilibrium exchange rate will change over time if there are changes in the supply and demand functions. Any factors that affect supply and demand for exchange rates also affect the price of currencies. Examples of these factors can be divided into factors that affect trade and factors that affect capital flows between countries.

[2] Based on Madura (2003)

Figure 3 Factors affecting the exchange rate



Source: Madura, J.: *International Financial Markets.* South-Western College Pub, 2003, p.117.

Trade-related factors constitute of the inflation differential, income differential and government trade restrictions. Changes in the inflation differential will affect international trade activity. When a country experiences a relatively higher inflation rate than other countries, it will experience less demand for its goods because it appears more expensive, and therefore less demand for its currency. In addition, its inhabitants will increase their demand for foreign goods since they have become relatively cheaper. Thus, demand for foreign currency will increase (i.e. supply of own currency). The income differential affects the volume of imports demanded. If the income level in a country increases, people will generally demand more goods and services. Thus, demand for imports will also increase, and hence demand for foreign currency. Government trade restrictions can influence the exchange rate by imposing foreign trade barriers such as tariffs and quotas.

Financial factors that affect supply and demand for domestic and foreign currency are the interest rate differential and capital flow restrictions. Changes in the interest rate differential affect investment in foreign securities. A relatively high interest rate may attract foreign inflows of capital that seeks profit opportunities, and hence increased demand for domestic currency. However, the relatively high interest rate may only reflect expectations of relatively high inflation, which may cause a downward pressure on the domestic currency. A solution is to consider the real interest rate when assessing exchange rate movements. Capital flow restrictions can influence the exchange rate through foreign exchange barriers and intervention in order to influence macroeconomic variables such as interest rates, inflation and income levels.

In addition to the trade related factors and the financial factors, expectations are likely to have an effect on the supply and demand for currencies. Foreign exchange markets react to any news that may have a future effect. Expected changes in the future will force the exchange rate to move today and may therefore contribute to enhance any speculation made about future events.

All of these factors may be interacting over a particular time period and the sensitivity of an exchange rate will depend on the volume of international transactions in trade- or capital flows between countries. Financial transactions are generally more responsive to news than trade-related factors, since it takes longer time to change and adjust trade patterns. In addition, capital flows have become increasingly larger over time and can easily overwhelm trade flows. Thus, the relationship between the factors that affect trade and the exchange rate is not always as strong as one would expect.

3.1 Exchange rate parity theories

The parity theories try to explain the relationship between the exchange rate, interest rates and inflation. The most known parity theories include; interest rate parity (IRP), purchasing power parity (PPP) and the international Fisher effect (IFE).

3.1.1 Interest rate parity (IRP)

Interest rate parity is a process of capitalizing on an interest rate differential between two countries. It is an arbitrage condition, since the process continues when there is riskless profit to be made. Uncovered interest rate parity is reached when investors earn an equal return by holding foreign assets compared to holding domestic assets. If there is profit to be made from interest rate differentials, investors will invest in the assets providing the largest expected return until equilibrium is restored, i.e. arbitrage. The country with the higher interest rate needs to face an expected depreciation in order to yield an expected return equal to the country with the lower interest rate. This interest rate parity condition may be expressed as follows;

$$i_h = i_f + \frac{E^e_{t+1} - E_t}{E_t}$$

i_h: The interest rate in the home country
i_f: The interest rate in the foreign country
E^e_{t+1}: Expected exchange rate at time t + 1
E_t: The exchange rate at time t

The interest rate parity implies that arbitrage cause the domestic interest rate to be equal to the foreign interest rate plus the expected depreciation rate of the domestic currency (Blanchard, 2006).

Covered interest rate arbitrage is the process of capitalizing on the interest rate discrepancy, while covering your exchange rate risk by selling the currency with the relatively high interest rate forward. Equilibrium is reached when the forward rate differs from the spot rate by a sufficient amount to offset the interest rate differential between two currencies.

$$F_t = E_0 \times \frac{(1+i_h)^t}{(1+i_f)^t}$$

E_0: The spot rate, which is the price of the foreign currency prevailing in the market today
F_t: The forward rate, which is a predetermined price of a foreign currency to be exchanged at a specified date in the future

In equilibrium, investors cannot use covered interest rate arbitrage to achieve higher returns than those achievable in their respective home countries, because any interest rate advantage in the foreign country will be offset by a discount in the forward rate (forward rate < spot rate). IRP generally holds because of the realignment process caused by arbitrage. Where it does not hold, (un)covered interest rate arbitrage may still not be worthwhile due to transaction cost, currency restrictions, political risk and different tax laws.

3.1.2 Purchasing power parity (PPP)

If a country's inflation increases, its exports are likely to decline and its imports tend to increase, both effects will have a negative effect on the high-inflation country's currency. The purchasing power parity tries to quantify the relationship between the exchange rate and inflation. There are two versions of the PPP theory (1) absolute form of PPP and (2) the relative form of PPP.

The absolute form of PPP is called the "law of one price" and it suggests that prices of similar products of two different countries should be equally priced when measured in one currency. Thus, the real exchange rate can be stated as follows:

$$R_t = E_t \times \frac{p_f}{p_h}$$

R_t : the real exchange rate
E_t : the nominal exchange rate
p_f : the foreign price level
p_h : the domestic price level

Thus, if PPP holds, the real exchange is fixed and all changes in the nominal exchange rate are a result from changes in price levels. The BigMac index is a popular application of the absolute form of PPP. It determines the exchange rate that would make sure that a McDonald's hamburger will cost the same around the world as in the US. However, the absolute version of PPP is unlikely to prevail in a completely accurate manner, due to transportation costs, tariffs and quotas.

The relative form of PPP takes market imperfections like transportation costs, tariffs and quotas into account and acknowledges that prices of similar products in different countries may vary. However, it states that the rate of change in the prices of products should be similar when measured in a common currency. According to PPP theory, demand for similar products will adjust when inflation rates differ in order to maintain the parity in purchasing power. The spot rate today, E_0 will adjust to the inflation differential;

$$E_t = E_0 \times \frac{(1+I_h)^t}{(1+I_f)^t}$$

I_h: Inflation in the home country
I_f: Inflation in the foreign country

The change in the value of the foreign currency, e_f can be represented as;

$$e_f = \frac{(1+I_h)}{(1+I_f)} - 1$$

e_f will be positive when inflation in the home country is larger than the inflation in the foreign country, $I_h > I_f$. A positive e_f implies that the domestic currency will depreciate. If $I_h < I_f$, e_f will be negative and the domestic currency will appreciate.

According to research, the relationship between inflation and exchange rates are not perfect even in the long run. The percentage change in exchange rates are much more volatile than the inflation differential and the lag-time between inflation differentials and exchange rates are not certain. However, the use of inflation differentials to forecast long-run movement in exchange rates is supported. Reasons why PPP does not consistently hold may be due to confounding effects. Exchange rates are also affected by interest rate differentials, income levels and risk, as well as government controls. In addition, lack of substitutes of traded goods when prices differ may contribute in explaining why PPP does not consistently hold. However, in Akram's article "PPP despite real shocks: An empirical analysis of the Norwegian real exchange rate" (2000) evidence was found to support the hypothesis that PPP hold for Norwegian data in the long-run.

3.1.3 International Fisher effect (IFE)

The Fisher effect (FE) states that the nominal risk-free interest rate is equal to the real interest rate plus inflation. It is named after Irving Fisher who first stated and interpreted it (Fisher, 1906). The international Fisher effect states that the real interest returns are similar across countries. Thus, if interest rates are high it is because inflation is high and the currency with the higher interest rates will depreciate. Investors trying to capitalize on a relatively higher interest rate will on average receive a yield similar to those who invest at home. The spot rate today, E_0 will adjust to the interest rate differential;

$$E_t = E_0 \times \frac{(1+i_h)^t}{(1+i_f)^t}$$

i_h: Interest rates in the home country
i_f: Interest rates in the foreign country

The change in the value of the foreign currency, e_f can be represented as;

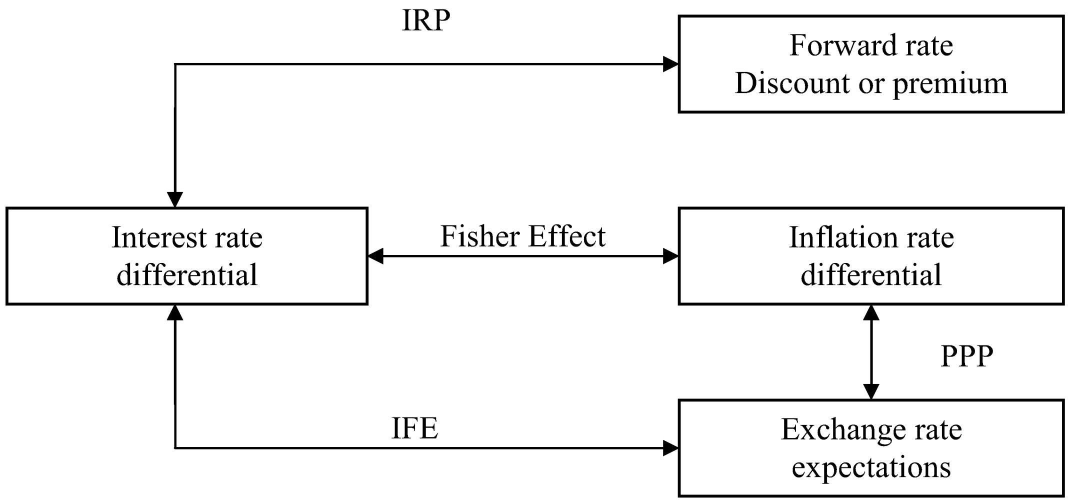
$$e_f = \frac{(1+i_h)}{(1+i_f)} - 1$$

e_f will be positive if the interest rate in the home country is larger than the interest rates in the foreign country, $i_h > i_f$. The higher interest rate indicate relatively high inflationary expectations in the domestic country, thus the domestic currency will depreciate. If $i_h < i_f$, then e_f will be negative and the domestic currency will appreciate due to decreasing inflationary expectations domestically.

Empirical studies indicate that IFE theory holds over certain periods. However, there is also evidence that it does not consistently hold. IFE states that real interest rates are similar across countries; however that is not the case. Real interest rates vary due to differences in monetary policy. PPP is related to IFE because inflation differentials influence the nominal interest rate differentials. Thus, given that IFE is based on PPP, IFE will not hold when PPP does not hold.

3.1.4 Comparison of IRP, PPP and IFE theories

Figure 4 Relationship between IRP, PPP and IFE parity theories



Source: Madura, J.: *International Financial Markets.* South-Western College Pub, 2003, p. 256.

All three theories are used to explain exchange rate determination; however, they have different implications. The covered IRP theory focuses on how the forward rate differs from the spot rate at a specific point in time. PPP and IFE focus on how the spot rate will change over time. PPP suggests how the spot rate will change over time according to inflation differentials and IFE suggests that the spot rate will change according to interest rate differentials. PPP is connected to IFE since inflation differentials influence the nominal interest rate differentials.

3.2 Exchange rate forecasting

Firms operating in an international environment are influenced by exchange rate fluctuations and conduct various activities that require exchange rate forecasting, such as hedging decisions regarding payables and receivables in foreign currencies, short-term financing and investment decisions and capital budgeting decisions.

According to the Efficient market hypothesis (EMH), markets are efficient if prices reflect "all" available and relevant information. The degree of efficiency can be categorized into weak-form, semi-strong and strong-form efficiency. Weak form efficiency implies that exchange rates today reflect all historical price movements. Semi-strong efficiency implies that all relevant public information is already reflected in today's exchange rates. Strong-form efficiency implies that all public and private information is reflected in the exchange rate. Research suggests that the market is at least semi-strong efficient. However, there is evidence of inefficiency for some currencies in specific periods. The EMH and its degree of efficiency will influence the usefulness of exchange rate forecasting. The exchange rate will only move when new information arrives. New information is random by definition, which implies one cannot forecast that exchange rates unless you have superior information.

There are four general groups of forecasting methods; (1) technical, (2) fundamental, (3) market-based and (4) mixed.

3.2.1 Technical forecasting

Technical forecasting use historical exchange rate data to predict future values by searching for patterns. Analysts using technical forecasting believe that history will repeat itself. It focuses on the near future, thus is widely used by speculators who attempts to capitalize on day-to-day exchange rate movements. This forecasting method might not be useful for various reasons. First, if one believes in EMH historic prices are already reflected in the exchange rates. Second, if patterns appear to be random over time. Third, if enough people start trading based on the patterns it will push the currency to a new level immediately and speculative profits are no longer possible. Fourth, monitoring is time consuming and there are large transaction costs involved, which might make the possible gain vanish.

3.2.2 Fundamental forecasting

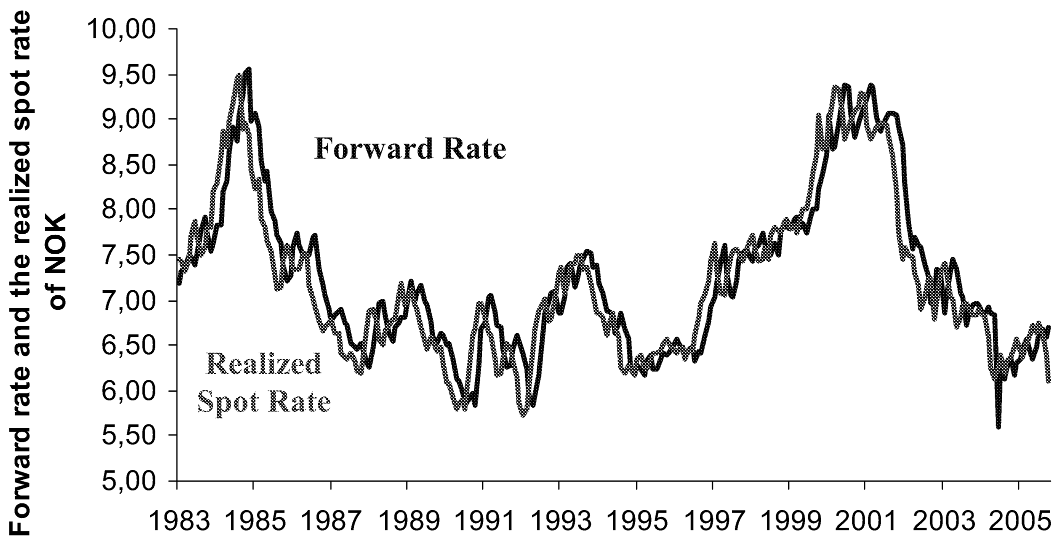
Fundamental forecasting is based on fundamental relationships between economic variables and exchange rates. Econometrics may be used to develop models that use a variety of explanatory variables. Variables that may be used as independent variables in order to explain the variation in exchange rates are; inflation, real interest rates, income, balance of payments and economic conditions. However, research show that it does not work any better than the forward rate model or the random walk model. A random walk indicates that movements in a variable cannot be predicted, it is random. Thus, the variable is just as likely to fall as to rise from today's value (Mishkin, 2001). Reasons why fundamental forecasting might face limitations may be that the precise timing of the impact of some factors on a currency's value is uncertain. Second, other factors that are not included in the estimated model might be relevant. Third, the exchange rate sensitivity to the different variables might change over time. Thus, even the most sophisticated techniques cannot provide consistently accurate forecasts.

3.2.3 Market-based forecasting

Developing forecasts from market indicators are usually based on either the spot rate or the forward rate. The use of the spot rate implies that the spot rate will be used as a forecast of the spot rate on a future date, $E_t = E[E_{t+1}]$ (where E[.] is the expectations operator). If depreciation is expected against a foreign currency, speculators will sell the currency today hoping to purchase it back at lower price. However, such actions will cause the exchange rate to depreciate immediately. Thus, the current value of the domestic currency should reflect the expectations of its value in the near future. Given that today's spot rate is the best estimate for the future spot rate, it is assumed that the exchange rate follows a random walk path. Research shows that the random walk hypothesis is proved to be useful in the short-run.

A forward rate quoted for a specific time in the future is used as the forecasted spot rate on that future date, $F_t = E[E_{t+1}]$. Speculation will help to push the forward rate to the level that reflects the general expectation of the future spot rate. Interest rates can be used to determine the right forward rate according to IRP. Figure 5 shows the forward rate and the realized spot rate for the Norwegian krone per US dollar. They are moving quite closely in tandem over the period studied. However, the forward rate is higher than the spot rate in many of the periods, which means that the forward rate is underestimating the value of the krone. For example, in the period 1985-1988, the forward rate is always higher than the realized spot rate. When there are periods where the forward rate is constantly overestimating the realized exchange rate, it indicates a bias in relying on the forward rate as an estimator for the future spot rate.

Figure 5 Using the forward rate as a forecast for the Norwegian krone per US dollar



Source: Norges Bank. ("no date"a). *Exchange rates.* [Online]. Available: http://www.norges-bank.no/english/statistics/exchange/ [2006, June 4.]

3.2.4 Mixed forecasting

Since no single forecasting method has been found to be consistently superior, a combination of the various techniques may be preferred. The actual forecast may be a weighted average of the various forecasts developed, where the more reliable methods are assigned higher weights. However, what techniques that are regarded more reliable will change over time and between different currencies.

Even though no forecasting technique is consistently superior to any other, and according to the EMH forecasting will be useless, forecasting may still be worthwhile to companies trying to implement policies. Their goal is normally not to earn speculative profits, but rather help them determine the range of possible exchange rates in order to assess the degree their operating performance could be affected by exchange rate fluctuations.

4 Monetary policy and the exchange rate

Monetary policy is the government's control of interest rates and liquidity in the Norwegian krone (NOK) market. The history of Norwegian monetary policy has been to keep a stable exchange rate. In order to reach the exchange rate target the government used policy instruments to influence the value of the exchange rate. The current monetary policy is to maintain a low and stable inflation. However, permanent changes in the exchange rate that affect inflation, production and employment, are also considered when determining use of policy instruments. Thus, together with the explanatory variables discussed in section 3, the choice of monetary policy is likely have an effect on the value of the exchange rate. The history of monetary policy, along with discussions on previous and current monetary policies will provide a basis to better understand the relationship between the exchange rate and the choice of monetary policy.

4.1 Monetary policy regimes in Norway since 1816[3]

The system has evolved from the silver and gold standards, to agreements on a fixed or stable exchange rate, to a floating exchange rate system, see figure 6. There has been a tradition to keep a stable value of the NOK in Norway. However, there have been periods with a floating exchange rate, but that has only been due to collapses of the various fixed exchange rate regimes.

Norges Bank was founded in 1816 and the specidaler was introduced as the Norwegian monetary unit. The currency was floating in the beginning, but from 1823 it was meant to have a fixed value measured in silver. Norway went from the silver standard to the gold standard in 1874. The gold standard made each currency convertible into gold at a specified rate. Thus, the exchange rate between two currencies was determined by their relative convertibility rates per ounce of gold. Norges Bank kept gold reserves to stabilize the gold price measured in the Norwegian currency, by actively buying and selling gold in the market. The year after, Norway joined the Scandinavian monetary union, where krone was the monetary unit. The gold standard was suspended when World War I began in 1914. Some

[3] Based on Norges Bank ("no date"b)

countries reverted to the gold standard in the 1920s, but abandoned it again due to the banking panic during the Great Depression in 1931. The NOK was left to float for two years, until it was linked to pounds sterling up to 1939 and the US dollar up to World War II.

After the war an international agreement, the Bretton Woods agreement, established fixed exchange rates between currencies and lasted until 1971. A number of currencies were linked to the US dollar, which was again linked to gold. The American monetary policy served as a nominal anchor and basically controlled international interest rates and inflation developments. In order to prevent exchange rates from moving more than 1 percent above or below their initially established levels, governments would intervene (i.e. buying and selling foreign currency) in the foreign exchange market. After a while the US found it difficult to maintain the value of the US dollar fixed against gold, due to high inflation and large current account deficits after the Vietnam War. The US dollar appeared to be overvalued since foreign demand after the US dollar was substantially less than the supply of dollars. A solution to the dilemma became known as the Smithsonian agreement. New parities were established among the member currencies and new fluctuation margins were defined at 2.25 percent. The gold standard no longer served as a nominal anchor. The Smithsonian agreement is regarded as the first step in letting market forces determine the appropriate price of a currency. The fluctuation margins were widened and the currencies could move more freely toward their appropriate levels.

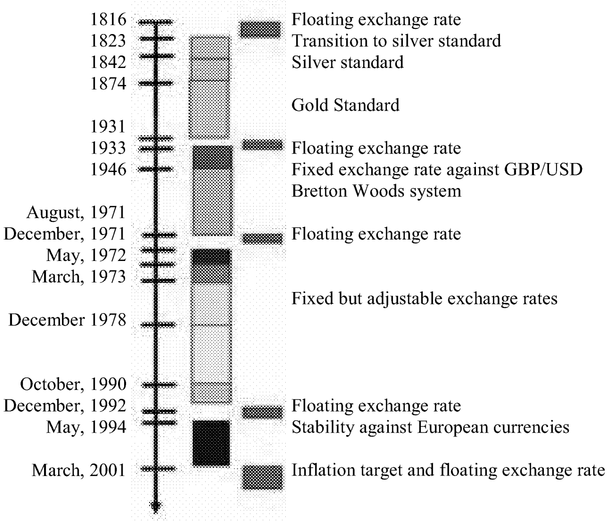
Norway participated in the European “snake” from 1972. The Smithsonian agreement and the “snake” were combined during the first year. This combination was called “the snake in the tunnel”, since the fluctuation margins between the European currencies were narrower than the margins against the dollar (one-half of the margin fluctuation in the Smithsonian agreement). The Smithsonian system collapsed the following year, due to difficulties maintaining the parities. The US dollar, the Japanese Yen and the German Mark floated after the collapse. However, the other European countries continued the “snake”, but with wider margins and without any reference to the dollar. This meant that the NOK floated against the dollar and other currencies outside the “snake”. The NOK was later devalued a number of times, and ended up leaving the system in 1978.

In 1978 a unilateral currency basket was established, where proportions of trade are used as weights, i.e. the trade-weighted currency basket. The Norwegian currency was linked to this currency basket. The purpose was to of reduce the vulnerability to devaluations in other countries. No fluctuation margins were announced, but in practice the exchange rate was maintained within margins of +/− 2-3 percent. The NOK was later devalued several times by adjusting the weights in the currency index.

The government wanted to link the krone more closely to the European Monetary System (EMS), thus the NOK was linked to the European Currency Unit (ECU) in 1990. However, several European currencies had to be floated after persistent pressure on several European currencies in autumn 1992. The krone also experienced so much pressure that the fixed exchange rate could no longer be defended. Thus, the krone floated until 1994. From 1994 to 2001 the aim was to maintain a stable exchange rate of the krone against European currencies, in practice the ECU and later the Euro. However, no fluctuation margins were established. Explicit guidelines for monetary policy was formed and made public in May 1994 and stated that in case of significant changes in the exchange rate; monetary policy instruments like intervention and interest rates were to be used in order to return the exchange rate to its initial range over time.

Since the 1990s, a number of countries have introduced an inflation target, in contrast to an exchange rate target. New guidelines for the Norwegian monetary policy were established by the government in March 2001, with a monetary policy objective to maintain a stable inflation. Thus, the Norwegian exchange rate has been considered to float after the new regime in monetary policy had been adopted.

Figure 6 Monetary policy regimes in Norway since 1816



Source: Norges Bank. ("no date"c). *Monetary policy regimes in Norway since 1816.* [Online]. Available: http://www.norges-bank.no/english/publications/occasional/34/ch7.html#box73 [2006, May 8.]

4.2 The recent change in monetary policy regime[4]

The goal for the total economic policy in Norway is: highest possible welfare for its inhabitants. A number of other objectives need to be fulfilled in order to achieve the primary goal; (1) stable economic growth, (2) effective resource allocation, (3) income distribution and (4) price stability.

The monetary policy's long-term task is to provide a nominal anchor for the economy. Monetary policy can only influence nominal variables, such as prices, directly. However, by securing price stability the other objectives can be influenced indirectly by monetary policy. Price stability is therefore the best contribution monetary policy can give in order to reach the primary goal. However, monetary policy can contribute to smooth fluctuation in production and employment more directly in the short-run. Given inflation expectations, changes in the nominal interest rate will affect the real interest rate directly, which will affect the level of economic activity.

[4] Based on Christiansen and Qvigstad, 1997

Under the previous regime of exchange rate stabilization, responsibility for economic stability was shared by fiscal, monetary and income policy, also called the “solidarity alternative”. Fiscal policy was oriented towards stabilizing the economy, monetary policy towards stabilizing the exchange rate, and income policy towards moderate wage growth, which would contribute to low inflation. Income policy is connected to a stable exchange rate such that wages are set to maintain competitiveness in exposed sectors, and that sheltered sectors will follow the trends in exposed sectors out of solidarity among workers. Together they will try to accomplish external competitiveness. In the previous framework price stability was an indirect result. Economic policy generates price stability by first securing the social bargain to keep wage growth low and second by linking the NOK to a low inflation currency basket, the ECU.

In the mid 1990s, the monetary objective of stable exchange rates got harder to maintain. The value of the NOK strengthened, i.e. appreciated, by almost 10 percent against the German Mark and the ECU from 1996 to 1997. Norges Bank tried to resist the appreciation by heavy intervention (buying foreign currency), and several reductions in the interest rate. At the time, the Norwegian economy operated near or even above full capacity and lowering the interest rate could therefore stimulate the economy further and cause the economy to overheat. However, the actions were considered necessary from a monetary policy point of view in order to weaken the exchange rate. Conflicting goals, like this example, could happen with the division of responsibilities among fiscal, income and monetary policy.

In addition to the conflict between the economic policies, free capital movements and increasingly integrated financial markets had made it more difficult to maintain a stable exchange rate. Interest rates in Norway are affected by international trends, especially by those in Germany. In 1997 the economic situation in Norway and Germany was quite different. In contrast to the idle capacity in Germany, there was a cyclical upturn in Norway. Germany reduced the interest rate in order to stimulate the economy; however the opposite was needed in Norway at the time to cool off the economy. Monetary policy contributed to amplify the cyclical trend, since the imported low interest rates were not compatible with the situation in Norway. Instead, a lot of pressure was put on maintaining a tight fiscal policy to both compensate for the low interest rates and to moderate the cyclical upturn in the Norwegian economy. Imported interest rates from a country that does not have the same business cycle could therefore result in inflationary pressure in economic upturn and deflationary pressure in downturns. Income policy also faced challenges through the pressure on the NOK from increased petroleum revenues and large current account surpluses. Increased petroleum revenues and current account surpluses would put an upward pressure on the exchange rate. An appreciation may only happen through inflation, since the nominal exchange rate is constant. In order to reverse the appreciation pressure a deflation is needed. A deflation is much harder for the income policy to accomplish than inflation.

A discussion of the current policy regime emerged in the academic and public sphere, due to challenges faced by the Norwegian "solidarity alternative", different trends in monetary and fiscal policy internationally and plans on forming a monetary union in Europe. The discussion revolved around keeping the system of stabilizing the exchange rate, adjusting the previous system or adopting a new system, based on an inflation target. A stable exchange rate means that the nominal exchange rate is the intermediate target. An explicit inflation target means a quantified inflation target is the intermediate target. Both the current regime of stabilizing the inflation rate and the previous regime of stabilizing the exchange rate constitutes strengths and weaknesses, some are addressed below.

4.2.1 Strengths and weaknesses in the previous monetary policy regime

The previous monetary policy framework had a great record to show to, thus the framework was thought to have great credibility in the market. Under this system, economic performance had been characterized by strong output and employment growth, low inflation and large external and fiscal surpluses. The growing performance in Norway stood in contrast to most other European countries, since the competitive position of the Norwegian economy had been maintained and strengthened.

The "solidarity alternative" adjusted monetary policy instruments towards the goal of maintaining a stable value of the NOK against an anchor country, and possesses several strengths. First, the nominal anchor ties inflation for internationally traded goods to the inflation found in the anchor country. This is achieved since foreign prices are determined in the market and the domestic price is fixed through the exchange rate target. In addition, a credible exchange rate target will anchor inflation expectations to the inflation rate in the anchor country (Mishkin, 2001). At the time, European countries provided the Norwegian economy with an anchor through linkage to the ECU and later the Euro. Second, it provides a clear rule for implementation of monetary policy. A tighter monetary policy is required, i.e. increasing the interest rate, when the currency is experiencing depreciation pressure and a decrease in the interest rate is needed in the face of appreciation pressure. Intervention is another policy instrument that may also be used. If intervention is used without changing the interest rate it is called sterilized intervention. However, it does not result in permanent changes in the exchange rate, since the cause of the initial pressure is not eliminated. In addition to buying and selling foreign currency, interest rates need to be changed in order to obtain persistent effects, i.e. unsterilized intervention. Third, an exchange rate target is easily understood by the public. It is observable and it is relatively easy to determine whether the target is reached or not. Fourth, the Norwegian case where the fluctuation margins are not explicitly announced is thought to be less vulnerable to speculative attacks, since it can allow exchange rate movements in the short-run.

The previous framework also possesses a lot of weaknesses. First, the target country loses its ability to use monetary policy to respond to domestic shocks that are independent to the shocks in the anchor country. In addition, shocks in the anchor country are directly transmitted to the target country through changes in the interest rates (Mishkin, 2001). This was the case in Norway when low interest rates were imported from Germany in late 1990s, although the domestic situation in Norway called for an increasing interest rate. Thus, the monetary policy contributed to actually amplify the business cycle. The pro-cyclical monetary policy places a heavy burden on fiscal policy to stabilize the economy. Too tight fiscal policy may result in under-provision of otherwise desirable services (e.g. medical care and physical structure) and there are limits in the speed of adjustment of fiscal policy when needed. Second, exchange rate targets may generate speculative pressure. If the underlying economic conditions in the target country and the anchor country differ, it might create speculation with regard to how long the target country can handle the adverse effect on the economy just to keep the exchange rate stable. Third, it lacks strong correlation with the long-term goal of low and stable inflation. Low and stable inflation in this framework requires low and stable international inflation and a stable real exchange rate. It is not that likely that the inflation in Norway's trading partners will suddenly become high and unstable. However, it is likely that the real exchange rate will vary due to lack of synchronized business cycles and structural differences in export and production. Thus, there is an inherent conflict between a stable exchange rate and low and stable inflation. Fourth, this framework implicitly assumes that the real exchange rate will remain constant over time. A shock to the real exchange rate would result in a change in inflation, since the nominal exchange rate would be held constant. If it was only temporary a deflation is needed to reverse the effect on the real exchange rate from the shock. This would be less problematic if the adjustment could take place through the nominal exchange rate.

4.2.2 Strengths and weaknesses in the current monetary policy regime

By explicitly recognize price stability as the medium-term objective would imply several strengths. First, inflation targeting enables monetary policy to focus on domestic considerations and monetary policy would be oriented towards handling shocks to the domestic cycle. Thus, cyclical alignment with other economies loses its importance. An inflation target is automatically counter-cyclically stabilizing, because it adjusts monetary policy to offset demand shocks of domestic origin, thus put less pressure on fiscal policy to stabilize the economy. Second, it is easily understood by the public. Third, in order to affect expectations, much effort is made by the central bank to make the policy transparent and credible. Transparency reduces uncertainty regarding monetary policy, interest rates and inflation and thus, improves the ability for economic planning. Communication with the public allows for a public debate on monetary policy and helps clarify the responsibility of the central bank. Thus, an inflation target tends to make the central bank highly accountable to the public and the government (Mishkin, 2001). Fourth, shocks that shift the real exchange rate can also work through changes in the nominal exchange rate, rather than just price changes alone. It will not be as disruptive and will allow for a more managed adjustment. In addition, a change in the real exchange rate through the nominal rate is easier to reverse if the initial shock is only temporary. Fifth, without any permanent shifts in the real exchange rate and provided that the target adopted is consistent with partner countries, inflation targeting will result in a stable nominal exchange rate over time. Sixth, the Norwegian government considered to start spending more revenue from petroleum activities than previously. However, increasing government expenditure would reduce the capability of fiscal policy to be the only economic policy to stabilize the economy. Thus, an inflation target would make it possible to spend more petroleum revenue, and still have the possibility to stabilize the economy.

Pursuing an inflation target could also indicate several weaknesses. First, Norges Bank's control over inflation is not perfect. Inflation reacts to changes in the policy instrument with a considerable lag, thus inflation outcomes are only revealed after a substantial lag. In addition, inflation is also influenced by other factors beyond monetary policy control. Second, the most apparent weakness is that inflation targeting could imply greater variability in the nominal exchange rate. Large exchange rate fluctuations would be damaging to the exposed sector and lead to long-run problems with the external balance. Third, a flexible exchange rate implies that there is no longer a clear link between wages and competitiveness, which was the basis for the "solidarity alternative".

4.2.3 Summary exchange rate vs. inflation stabilization

A summery over the various strengths and weaknesses in the two monetary policies considered, exchange rate and inflation stabilization, is provided in the table below.

Table 1 Summary exchange rate vs. inflation stabilization

	Strengths	**Weaknesses**
Exchange rate Stabilization	1. Inflation is tied to inflation in anchor country 2. Provides a clear rule for monetary policy implementation 3. Easily understood and observed by the public 4. Less vulnerable to speculative attacks with no announced fluctuation margins	1. Pro-cyclical monetary policy 2. Heavy burden on fiscal policy to stabilize the economy 3. Announced fluctuation margins may generate speculative pressure 4. Lacks strong-correlation with long-term goal of low and stable inflation 5. Assumes constant real exchange rate - not the case 6. Shocks in the exchange rate can only happen through inflation
Inflation Stabilization	1. Focus on the domestic business cycle 2. Easily understood by the public and much emphasis is made on transparency 3. Makes the central bank more accountable to the public and the government 4. Shocks in the exchange rate can also work through the nominal exchange rate 5. Will result in a stable nominal exchange rate over time 6. Place less pressure on fiscal policy to stabilize the economy	1. Norges Bank's control over the inflation rate is not perfect 2. Could imply greater variability in the nominal exchange rate 3. No clear link between wages and competitiveness

4.3 Discussion on a monetary policy framework

The formal change in monetary policy happened on March 29, 2001. However, the discussion of monetary policy emerged both in the academic and public sphere, as a result of the problems experienced in carrying out the previous monetary framework in the mid 1990s. The discussions in the public and academic sphere were concerned with many of the same aspects with regard to an inflation target versus an exchange rate target.

4.3.1 Discussion in the academic sphere[5]

In 1997 Norges Bank invited a selected number of Norwegian and foreign economists to analyze the existing monetary policy regime and to assess possible alternatives to the present regime. Their contributions are to be found in "Choosing a monetary policy target" by Christiansen and Qvigstad (1997). The discussion revolved around whether the current regime should be maintained, adjusted or changed to the international trend, inflation target. There is a broad consensus among the contributors that monetary policy should provide the economy with a nominal anchor and that low and stable inflation should be the medium- and long-term objective of monetary policy. A nominal anchor is believed to provide a basis for expectations. However, no consensus was reached with regard to what monetary policy that should be used on order to reach the objective. Some were in favor of keeping the previous regime of an exchange rate target and some supported a change in monetary policy towards an inflation target.

Those in favor of an inflation target emphasized the difference in business cycles in Norway and other European countries. By linking the Norwegian currency to the Euro will cause monetary policy to be pro-cyclical and place too much responsibility on fiscal policy to secure economic stability. They found it advantageous to have a domestic nominal anchor, which will in their opinion dampen the economic fluctuation. Contributors supporting the previous regime emphasized that an inflation target could result in large fluctuations in the nominal exchange rate, which would harm the exposed sector.

[5] Based on Christiansen and Qvigstad, 1997

The major difference between the contributors were whether the inflation target would lead to excess exchange rate fluctuation, and whether it would cause a problem for the exposed sector. In addition, none of the contributors expressed a clear opinion on how a change in monetary policy would affect wage determination. Wage determination was clearer under the "solidarity alternative". However, those in favor of an inflation target believe that the "solidarity alternative" is not needed for that matter, because demand and supply in the labor market will by itself determine wage growth. The relationship between oil and gas revenue and the exchange rate is another aspect where the contributors differed in opinions. Some argue that it will lead to a real appreciation in the NOK, either through an appreciation in the nominal exchange rate or through inflation. One of the contributors argues, however, that oil and gas revenues only represent a change in assets from oil to financial claims. Thus, oil revenue will not cause a change in wealth and should therefore have no effect on the real exchange rate.

It should be noted that the theories and paradigms that provide the basis for the opinions of the contributors, are not explicitly expressed in their arguments. Thus, questioning the reasoning will be more difficult. Using different schools of thought will most likely produce different results and might be one of the reasons why the contributors differ in their main arguments.

4.3.2 Discussion in the public sphere

Many newspaper articles were written in the period from when the monetary policy started to experience problems to control the value of the NOK, and up to the formal change in monetary policy. They addressed many of the problems with the previous framework in the same way as in the academic sphere. The fact that the long-term goal for monetary policy is to secure stable prices and a high employment rate seemed to be agreed upon, however, how to reach the goal was subject to discussion. Main themes were; (1) problems with the previous system like the pro-cyclical character of the monetary policy, (2) whether or not an inflation target would cause serious problems for the exposed sector, due to large and variable exchange rate fluctuations, (3) whether or not the monetary policy had changed when Gjedrem came in to office as Governor of Norges Bank, even though there had been no formal change in the regulation of monetary policy. Alternatives to these problems revolved around giving Norges Bank more freedom to let the exchange rate fluctuate more in the short run or adopt an inflation target.

The number of advocates of a change in monetary policy seemed to be growing through the period. Aftenposten did an informal survey, by asking a panel of experts about their opinions on exchange rate targeting versus inflation targeting. The panel consisted of 67 Norwegian top economists. Fifty percent of the experts were in favor of exchange rate targeting and fifty percent were in favor of inflation targeting when they were asked in October 1998. However, in April 1999 far more preferred an inflation target, and in addition the group believing that an inflation target and an exchange rate target were equally important, were growing (Hellestøl and Aspaas, 1999). The same kind of survey was conducted in January 2000, and only 1/5 believed that a stable exchange rate should be the most important goal for monetary policy (Aftenposten, 2000).

The formal change did not happen until March 2001. However, many economists believed the change happened already when Sven Gjedrem came into office as Governor of Norges Bank in January 1999. In an article in Aftenposten in April 1999, Ola Storeng states that Gjedrem had clearly reinterpreted the monetary policy. The operative goal was no longer exchange rate stabilization, but to bring inflation and the growth in production costs down to the level in the euro zone, which would also provide the basis for exchange rate stabilization. Gjedrem emphasized that the Norwegian currency is influenced by a number of factors outside the control of Norges Bank. He would therefore take stability in the economy into consideration when setting the interest rate, and not consider short run fluctuations in the exchange rate. Storeng believed that Gjedrem removed all doubt whether Norges Bank pursued low inflation or stabile exchange rate as the operative goal for the monetary policy (Storeng, 1999). Gjedrem's solution to the prevailing problems in the previous monetary policy was therefore to have a transition phase, without any changes in the regulation of monetary policy. However, Norges Bank and the government shared the responsibility regarding inflation, and hence the business cycle.

4.4 Current Monetary Policy[6]

Even though there was a discussion going on in both the academic and public sphere regarding the policy framework, the government did not signal any possible changes in the monetary policy. In December 1998, the government stated that the exchange rate policy is still maintained, and that the recent pressure on the exchange rate does not alter their support of the monetary policy. Norges Bank asked for a larger fluctuation margin for the exchange rate, but the Government signaled no willingness to revise the monetary policy regulation. Norway's Minister of Finance, Gudmund Restad stated that the old regulation gave enough slack to cope with the fluctuations in the exchange rate (Salvesen, 1998).

However, after a century of a more or less fixed exchange rate in Norway (with only short periods where the exchange rate was considered to float) the government established new guidelines for the monetary policy in "Regulation on Monetary Policy" of 29 March 2001. Thus, the NOK has been considered to float since then. An excerpt from the regulation is given below:

§ 1.

"Monetary policy shall be aimed at stability in the Norwegian krone's national and international value, contributing to stable expectations concerning exchange rate developments. At the same time, monetary policy shall underpin fiscal policy by contributing to stable developments in output and employment.

Norges Bank is responsible for the implementation of monetary policy.

Norges Bank's implementation of monetary policy shall, in accordance with the first paragraph, be oriented towards low and stable inflation. The operational target of monetary policy shall be annual consumer price inflation of approximately 2.5 per cent over time.

In general, the direct effects on consumer prices resulting from changes in interest rates, taxes, excise duties and extraordinary temporary disturbances shall not be taken into account."

(Norges Bank, 2001)

[6] Based on Norges Bank ("no date"b)

The first paragraph in the new regulation defines the goal and the responsibilities of monetary policy. It further delegates the responsibility of the enforcement of the policy on behalf of the government to Norges Bank. The last part states what is regarded as the operational target and that monetary policy instruments should be used in order to achieve that target. Policy instruments that are available to Norges Bank in order to obtain low and stable inflation are the interest rate and intervention.

Inflation targets are found in countries comparable to Norway, e.g. Sweden, the UK, Canada, New Zealand, Australia and the EU. Low and stable inflation with low and stable inflation expectations are the best contribution monetary policy can give, in order to achieve the goal of a stable development in production and employment. It is also a necessary assumption in order to accomplish stable expectations of the exchange rate, and it is therefore an anchor for the exchange rate of the krone.

4.4.1 Why low and stable inflation?

Inflation is lasting growth in the general price level, or put differently, a fall in the value of money. Inflation is normally measured as the growth in consumer prices. Inflation possesses both benefits and costs to the economy. The costs of inflation are subtle and many economists disagree on the size of the cost.

First, a higher inflation rate leads to a higher nominal interest rate, which is a measure of the opportunity cost of holding money. Thus, when it is more expensive to hold money, people would decrease money holdings and make more trips to the bank instead. The time people spend on going to the bank could be used differently by working more or enjoying leisure. This inconvenience is called shoe-leather cost of inflation. A second cost of inflation is called menu costs, because high inflation induces firms to change their stated prices more frequently. Changing prices can be costly in the sense that it requires printing and distributing price catalogs. Third, inflation causes increased variability in relative prices when firms are changing prices frequently. The market relies on relative prices in order to allocate resources efficiently. A larger fluctuation in relative prices will therefore make it more difficult to make optimal decisions and resources might not be allocated efficiently (Mankiw, 1997). Fourth, people find it difficult when they compare their income from one year to another, choosing between various assets or deciding on how much to consume or save, because they are failing to distinguish between real and nominal values. Thus, inflation leads people to make incorrect decisions. A fifth cost of inflation arises from the interaction between the tax system and inflation. For example, the problem arises when capital gains from selling an asset need to be taxed. The tax system levies tax on nominal income, rather than the real capital gain. Thus, inflation distorts the way taxes are levied. The sixth cost of inflation is that inflation variability will cause financial assets such as bonds to be riskier. A bond pays fixed nominal payments in the future. A variable inflation will cause the real value to be uncertain. High inflation is variable inflation, and variable inflation will create uncertainty for both creditors and debtors where contracts are written in nominal terms, by subjecting them to potentially large distributions of wealth (Blanchard, 2006).

There are also benefits of having some inflation in the economy. The first benefit of inflation can be assigned to seignorage, which is the revenue to the government from printing money. Money creation is one of the options that the government has in order to finance government expenditures. The seignorage allows the government to borrow less from the public by selling bonds and makes it possible to lower taxes. However, its importance in well developed countries is limited. The seignorage argument is more relevant in countries experiencing hyperinflation, where printing money may be the government's main source of revenue (Mankiw, 1997). Second, inflation makes it possible to have negative real interest rates in order to fight a recession. If an economy has a very low inflation rate and if nominal interest rates are already at a low level, it might find it difficult to use monetary policy to avoid a decline in output after an adverse shock to aggregate demand. When nominal interest rates are equal to zero, expansionary monetary policy, i.e. increase money supply, does not have an effect on output (Blanchard, 2006). The situation when people does not believe that the interest rate can fall any further, and therefore prefer to be as liquid as possible, is known as the liquidity trap. It was first introduced by Keynes as a reaction to the classical school of thought. The liquidity trap scenario was presented in order to prove that fiscal policy will have a positive effect on the real sphere. The third benefit of inflation relates to the situation where people find it difficult to distinguish between real and nominal values, as mentioned above. However, it also possesses a benefit by allowing a decrease in real wages, without having to change the nominal wage. People would be more inclined to accept a downward adjustment in wages through inflation than lowering the nominal wage.

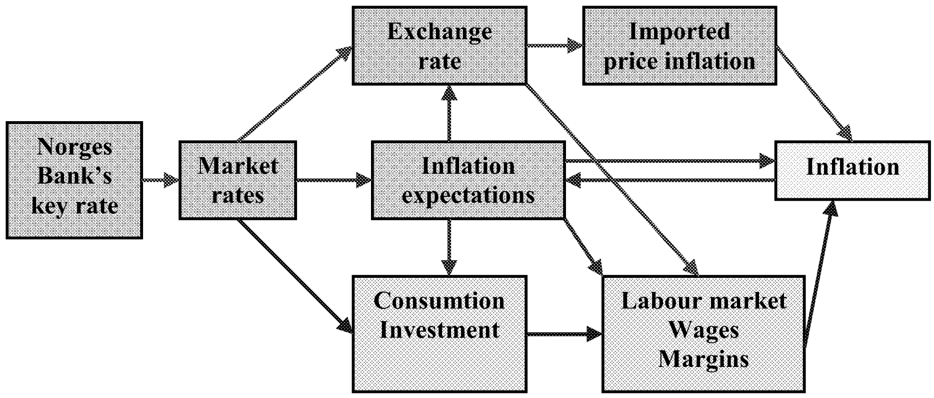
Through the discussion above it shows that inflation encompasses both costs and benefits to the economy. It is therefore equally important to avoid too low as too high inflation. However, a low and stable inflation is a prerequisite in order to allocate resources effectively in a market economy.

4.4.2 Implementation of monetary policy

Norges Bank is granted responsibility of the enforcement of monetary policy on behalf of the government. Whether to change the interest rate in order to influence inflation is discussed every 6th week. Monetary policy will have a variable and lagged effect on inflation. Norges Bank will therefore need to be forward looking in its interest rate setting. In addition, Norges Bank tries to avoid unnecessary fluctuations in production and employment when determining the interest rate level. Thus, changes in the interest rate will be set with a view that the consumer price index (an index used as a measure of the country's inflation) will gradually return to its target within a reasonable time horizon, normally 1-3 years.

Monetary policy affects the economy through several channels; the demand channel, the exchange rate channel and the expectation channel. This is called the transmission mechanism and is showed in the figure 7 below. A decrease in the interest rate will affect the channels differently. A decrease in the interest rate will affect the demand channel through households' consumption and investment in the industry. Households' consumption will most likely increase due to the fact that their disposable income increases because it is cheaper to borrow. The firm's economy strengthens from a lower interest rate and will therefore be more inclined to invest and more projects will have a positive net present value. The increased demand from consumers and firms will lead to higher production and employment. Wage growth might increase and may together with better margins result in inflation. The exchange rate channel will be affected by a decrease in the interest rate through people's financial decisions. More people will borrow and less people will invest in the Norwegian currency if the interest rate is decreased. A lower interest rate will therefore most likely lead to a weaker currency. A weaker currency makes imported goods more expensive and inflation increases. In addition, a weaker currency will result in increased demand for Norwegian exports. The expectations channel plays an important role when determining prices and wages, especially in the exchange rate market. Faith in the inflation target can provide an anchor for expectations and enhance the effect of monetary policy. Thus, much effort is made in order to make sure that households, firms and investors have faith in a low and stable inflation.

Figure 7 How a change in the interest rate affects the economy



Source: Norges Bank. ("no date"d). *Monetary policy instruments and the transmission mechanism.* [Online]. Available: http://www.norges-bank.no/english/publications/occasional/34/ch7.html#75 [2006, May 12.]

Norges Bank operates a flexible inflation targeting regime, in the sense that both the stability in inflation and stability in the real sphere, production and employment, needs to be considered. The balance between price and production stability is often thought of as to minimize a loss function. An example of a loss function is:

$$L= (\pi - \pi^*)^2 + \lambda(y - y^*)^2$$

Where π is the inflation rate, π^* is the inflation target, $y - y^*$ is the production gap. The quadratic form indicates that large differences are considered to be worse than small differences. λ is the weight given to stabilize production in proportion to the inflation target. A $\lambda>0$ indicates that both the stability in prices and production is considered when setting the interest rate (Lønning and Olsen, 2000). The loss function can also be related to the so-called "Taylor-rule", which is s a simple monetary decision rule that was meant to capture the way central banks, especially the Federal Reserve, reasoned when setting the interest rate in practice (Taylor, 1993). The interest rate should be set equal to the inflation rate plus an "equilibrium" real interest rate plus a weighted average between the inflation gap and the output gap. The main idea was that the interest rate needs to be increased when current inflation is larger than the target inflation, $\pi > \pi^*$ and reduced if the opposite is the case. In addition to consider the inflation differential, the production gap, $y - y^*$ indicates that is also important to minimize business cycle fluctuations of output around potential output. The loss function and the "Taylor-rule" indicate that both fiscal policy and monetary policy need to work together in order to secure a stabile development in the economy. However, fiscal policy will continue to have the main responsibility to stabilize the development in the Norwegian economy.

One of the differences between the contributors in "Choosing a monetary policy target" (1997) was their opinion on how movement in the price of oil would affect the exchange rate. Norway's special position as a large oil and gas producer will naturally have a large and variable affect on the Norwegian economy, and therefore needs to be considered when deciding on what economic policies that needs to be carried out. In Norges Bank's letter to the Ministry of Finance on 27 March 2001 it comments on the new regulation of monetary policy and addresses the issue regarding Norway's oil revenue.

"If budget spending is allowed to vary in step with oil prices, the Norwegian economy may experience abrupt shifts and instability. Changes in oil prices could then quickly influence wage and price expectations, the exchange rate and long-term interest rates. In that case it would be very demanding to achieve nominal stability. Short-term interest rates would then have to be changed frequently and sharply and will generally reflect an increased risk premium on the NOK, which over time would result in a generally higher interest rate level. Norges Bank would therefore emphasize the importance of establishing broad consensus concerning a credible long-term anchor for fiscal policy which takes into account that oil prices may fluctuate from one year to the next." (Gjedrem and Qvigstad, 2001).

Even though, the exchange rate floats and the operational target no longer is exchange rate stabilization, monetary policy needs to take the exchange rate into consideration when setting the interest rate. Norges Bank's reaction to a change in the exchange rate will depend on how this change will affect inflation, production and employment. Only permanent changes in the exchange rate are likely to make a difference. However, it is relatively difficult to distinguish between permanent and transient changes.[7]

Monetary policy instruments, like intervention and the interest rate, are used to reach the operation target. In many cases, a change in the interest rate will contribute to influence inflation and total demand in the right direction. An unexpected fall in total demand for goods and services will result in a decrease in inflation, production and employment. Lowering the interest rate will make sure that both demand and inflation will increase again. However, other shocks might cause a conflict between price stability and stability in the real sphere in the short-run. A large increase in wages may both increase inflation and reduce employment. A tighter monetary policy (i.e. to increase the interest rate) will contribute to decrease inflation, but will also contribute to reduce production and employment further. A number of different shocks can happen at the same time, the central bank therefore needs to consider the different effects on inflation, production and employment together in order to achieve the long-term goal.

4.4.3 Monetary policy discussion today

The current monetary policy has been in place for five years and it seems that most economists have been more or less satisfied with the enforcement of the monetary policy. However, 20002/2003 was an exception, when most economists believed that the monetary policy was tighter than it needed to be, i.e. the interest rates were kept at a high level too long.

The Norwegian economy is currently operating at full speed and has been experiencing an economic upturn since 2003, with an increasing production and decreasing unemployment rates. Both the reduction in the interest rates and a depreciation of the NOK contributed to get the economy going. However, the extremely low interest rates, high accumulation of debt and rising asset prices, but with low inflation, have resulted in a discussion of the monetary policy in the public sphere.

[7] The error correction model described in section 5 provides a solution to overcome the difficulty to distinguish between long-run and short-run effects.

The strength of the Norwegian currency, even though the interest rates are low, has also been subject to discussion. A very strong currency is a major disadvantage for the exposed sector. With a danger for the Norwegian economy to overheat, an increase in the interest rate is needed. However, it cannot be increased too fast such that the NOK is strengthening even further. According to Erikstad (2006), the only thing that can "save" the NOK in the short-run is a significant fall in oil prices. However, that may not be good for the country as a whole. He also thinks it is more likely that the oil price will increase further, rather than a sudden fall. Thus, the NOK can stay strong for a longer time than what it did in 2002, i.e. the last time Norway experienced a continuous appreciation of the NOK.

Even though the interest rates have been extremely low for a while, inflation has not seemed to be increasing significantly. One of the solutions that have been discussed in media is to reduce the inflation target to 2 percent. The reason might be that it is viewed to be easier to prevent a stronger NOK if the inflation target is closer to our neighboring countries, e.g. the inflation target of the European Central Bank (ECB) is 2 percent. Some economists have also argued to include energy prices in the inflation measure, because high energy prices is a consequence of globalization like low import prices and it is expected to last. Another solution has been to include the development in debt accumulation and asset markets when determining the interest rate. ECB assess the development in debt accumulation and asset markets in addition to inflation when determining the interest rate. This dual consideration seems to be gaining acceptance internationally, e.g. Japan is adopting the model. This thinking has not been supported by Norges Bank that argues that there is great uncertainty with regard to bubbles in asset markets. Norges Bank should therefore not include these developments when setting the interest rate, but rather help to recover if a bubble bursts.

The large emphasis made on transparency by Norges Bank, may influence expectations and provide the economy with a more credible operational target. In addition, transparency will make sure that the monetary policy and Norges Bank's actions will be subject to scrutiny and public discussion. Jullum (2006) argues that continuous suggestions about changes in the Norwegian monetary policy signals that the current one-sided focus on inflation may be too risky.

5 Error correction models and cointegration

5.1 Error correction models

Econometrics provides formal methods that can contribute to study possible relationship between the exchange rate and a set of explanatory variables. If the data gathered for an econometric analysis constitutes series of years or months, they are called time-series. Time-series may cause problems in a regression model, which do not occur with cross-sectional data, where all the observations are associated with the same point in time. The independent variables (the variables trying to explain the variation in the exchange rate, i.e. the dependent variable) from a time-series data may seem more significant in the model than they actually are, if they have the same underlying trend as the dependent variable. If any of the variables are found to have a strong relationship between each other and it is not due to any underlying causal relationships, it may cause spurious correlation. A spurious correlation will cause a spurious regression, which overstates the t-values and the overall fit of the estimated regression model.

In time-series, one major cause of spurious regression is non-stationarity. Non-stationary time-series constitute variables that have some sort of an upward or downward trend.
A stationary time series is where the major properties of the series do not change over time, a time-series variable, X_t, is stationary if: (1) the mean of X_t is constant over time, (2) the variance of X_t is constant over time, and (3) the simple correlation coefficient between X_t and X_{t-k} depends on the lag (k) but on no other variable (for all k) (Studenmund, 2001, p. 425). If any of these properties are not met, then X_t is non-stationary.

Error Correction Models (ECMs) is a formal estimation technique that provides a solution to the problems with non-stationarity in time-series models and spurious correlation. This concept started with a paper about wages and prices in the UK written by Sargan in 1964, but got more popular with the general-to-specific approach developed during the last twenty years by Professor D. F. Hendry at the London School of Economics.

5.1.1 A second- order ECM with three variables

A long run or equilibrium relationship between a dependent variable, E and two independent variables, ε and z can be expressed as:

$$E_t = \bar{E}^* - \varphi_1\varepsilon_t + \varphi_2 z_t$$

E is the trade weighted nominal value of the Norwegian krone, $\bar{E}$ is the target exchange rate, ε is the demand shock, e.g. oil price fluctuations and z may represent any other independent variable that may contribute to explain the variation in the exchange rate. The disequilibrium error measures the difference between E, ε and z, if E is different from its equilibrium value, $E_t - \bar{E}^* + \varphi_1\varepsilon_t - \varphi_2 z_t = u_{t.}$ In equilibrium, the disequilibrium error will be equal to zero. Since E takes time to adjust fully after variations in the independent variables, one can observe a short-run or disequilibrium relationship involving lagged values of ε, z and E;

$$E_t = b_0 - b_1\varepsilon_t - b_2\varepsilon_{t-1} - b_3\varepsilon_{t-2} + c_1 z_t + c_2 z_{t-1} + c_3 z_{t-2} + \mu_1 E_{t-1} + \mu_2 E_{t-2} + \omega_t \quad 0<\mu_{1,2}<1$$

By reparameterizing such that $\lambda = (1-\mu_1-\mu_2)$, $\varphi_1 = (b_1 + b_2 + b_3)/\lambda$, $\varphi_2 = (c_1 + c_2 + c_3)/\lambda$ and $\bar{E} = b_0/\lambda$ one is able to obtain a second-order error correction model after some manipulation;

$$\Delta E_t = -\mu_2\Delta E_{t-1} - b_1\Delta\varepsilon_t + c_1\Delta z_t + b_3\Delta\varepsilon_{t-1} - c_3\Delta z_{t-1} - \lambda(E_{t-1} - \bar{E} + \varphi_1\varepsilon_{t-1} - \varphi_2 z_{t-1}) + \omega_t$$

λ: is an adjustment parameter ϵ (0,1)
ω_t: is a random error term at time t
φ_1: is the long-run response of the expected change in E_t w.r.t. a marginal change in ε_{t-1}
φ_2: is the long-run response of the expected change in E_t, w.r.t. a marginal change in z_{t-1}
b_1: is the immediate response of the expected change in E_t, w.r.t. a marginal change in $\Delta\varepsilon_t$
c_1: is the immediate response of the expected change in E_t, w.r.t. a marginal change in Δz_t
b_3: is the immediate response of the expected change in E_t, w.r.t. a marginal change in $\Delta\varepsilon_{t-1}$
c_3: is the immediate response of the expected change in E_t, w.r.t. a marginal change in Δz_{t-1}
μ_2: is the immediate response of the expected change in E_t, w.r.t. a marginal change in ΔE_{t-1}

The current change in E depends on the lagged change in itself, E_{t-1}, current and lagged changes in ε, the current and lagged changes in z and on the extent of the disequilibrium error in the previous period. Only part of the error from the previous period is accounted for in the current value of E. In order to estimate the ECM the parentheses need to be multiplied out to obtain;

$$\Delta E_t = \lambda\bar{E} - \mu_2\Delta E_{t-1} - b_1\Delta\varepsilon_t + c_1\Delta z_t + b_3\Delta\varepsilon_{t-1} - c_3\Delta z_{t-1} - \lambda E_{t-1} - \lambda\varphi_1\varepsilon_{t-1} + \lambda\varphi_2 z_{t-1} + \omega_t$$

Estimates of all short- and long-run parameters can now be obtained by using standard regression analysis on ΔE_t, ε_{t-1}, z_{t-1}, E_{t-1}, $\Delta\varepsilon_t$, Δz_t, $\Delta\varepsilon_{t-1}$, Δz_{t-1} and ΔE_{t-1}.

$\bar{E}^*$ in the long-run equilibrium relationship depends on the long-run growth rates in ε, z and E. The long-run trend growth rate in ε is θ_1; $\Delta\varepsilon_t = \theta_1$ or $\varepsilon_t = \varepsilon_{t-1} + \theta_1$, and the long-run trend growth rate in z is θ_2; $\Delta z_t = \theta_2$ or $z_t = z_{t-1} + \theta_2$.

$$E_t = \bar{E}^* - \varphi_1\varepsilon_t + \varphi_2 z_t$$
$$E_t = \bar{E}^* - \varphi_1(\varepsilon_{t-1} + \theta_1) + \varphi_2(z_{t-1} + \theta_2)$$
$$E_t = \bar{E}^* - \varphi_1\varepsilon_{t-1} - \varphi_1\theta_1 + \varphi_2 z_{t-1} + \varphi_2\theta_2$$
$$E_t = E_{t-1} - \varphi_1\theta_1 + \varphi_2\theta_2$$
$$\Delta E_t = E_t - E_{t-1} = - \varphi_1\theta_1 + \varphi_2\theta_2$$

If ε grows at a long-run rate θ_1 and z grows at a long-run rate θ_2, then E must grow at a long-run rate $- \varphi_1\theta_1 + \varphi_2\theta_2$. By using the long-run growth rates for ε, z and E, a long-run equilibrium of the ECM may be obtained; −

$$\Delta E_t = \mu_2\Delta E_{t-1} - b_1\Delta\varepsilon_t + c_1\Delta z_t + b_3\Delta\varepsilon_{t-1} - c_3\Delta z_{t-1} - \lambda(E_{t-1} - \bar{E} + \varphi_1\varepsilon_{t-1} - \varphi_2 z_{t-1}) + \omega_t$$
$$- \varphi_1\theta_1 + \varphi_2\theta_2 = - \mu_2(- \varphi_1\theta_1 + \varphi_2\theta_2) - b_1\theta_1 + c_1\theta_2 + b_3\theta_1 - c_3\theta_2 - \lambda(E_t + \varphi_1\theta_1 - \varphi_2\theta_2 - \bar{E} + \varphi_1\varepsilon_t - \varphi_1\theta_1 - \varphi_2 z_t + \varphi_2\theta_2)$$
$$- \varphi_1\theta_1 + \varphi_2\theta_2 = \mu_2(\varphi_1\theta_1 - \varphi_2\theta_2) - b_1\theta_1 + c_1\theta_2 + b_3\theta_1 - c_3\theta_2 - \lambda E_t - \lambda\varphi_1\theta_1 + \lambda\varphi_2\theta_2 + \lambda\bar{E} - \lambda\varphi_1\varepsilon_t + \lambda\varphi_1\theta_1 + \lambda\varphi_2 z_t - \lambda\varphi_2\theta_2$$
$$- \varphi_1\theta_1 + \varphi_2\theta_2 = \mu_2(\varphi_1\theta_1 - \varphi_2\theta_2) - b_1\theta_1 + c_1\theta_2 + b_3\theta_1 - c_3\theta_2 - \lambda E_t + \lambda\bar{E} - \lambda\varphi_1\varepsilon_t + \lambda\varphi_2 z_t$$
$$\lambda E_t = \mu_2(\varphi_1\theta_1 - \varphi_2\theta_2) + \theta_1(b_3 - b_1) - \theta_2(c_3 - c_1) + \lambda\bar{E} - \lambda\varphi_1\varepsilon_t + \lambda\varphi_2 z_t + \varphi_1\theta_1 - \varphi_2\theta_2$$
$$\lambda E_t = \mu_2(\varphi_1\theta_1 - \varphi_2\theta_2) + \theta_1(b_3 - b_1 + \varphi_1) - \theta_2(c_3 - c_1 + \varphi_2) + \lambda\bar{E} - \lambda\varphi_1\varepsilon_t + \lambda\varphi_2 z_t$$

$$\lambda E_t = \lambda\bar{E} + \theta_1(\varphi_1 + \mu_2\varphi_1 + b_3 - b_1) - \theta_2(\varphi_2 + \mu_2\varphi_2 + c_3 - c_1) - \lambda\varphi_1\varepsilon_t + \lambda\varphi_2 z_t$$
$$E_t = \{\lambda\bar{E} + \theta_1[\varphi_1 - (b_1 - b_3 - \mu_2\varphi_1)] - \theta_2[\varphi_2 - (c_1 - c_3 - \mu_2\varphi_2)]\}/\lambda - \varphi_1\varepsilon_t + \varphi_2 z_t$$

This result needs to be identical to $E_t = \bar{E}^* - \varphi_1\varepsilon_t + \varphi_2 z_t$ in the long run, thus;

$$\bar{E}^* = \{\lambda\bar{E} + \theta_1[\varphi_1 - (b_1 - b_3 - \mu_2\varphi_1)] - \theta_2[\varphi_2 - (c_1 - c_3 - \mu_2\varphi_2)]\}/\lambda$$

$\bar{E}^*$ depends on the long-run growth rate in ε, θ_1 and the long-run growth rate in z, θ_2. If the long-run response of E to a marginal change in ε, φ_1 is larger than the difference between the short-run responses, b_1, b_3 and μ_2, $\bar{E}^*$ will vary in the same direction as the long-run growth rate in ε. If the long-run response of E to a marginal change in z, φ_2 is larger than the difference between the short-run responses, c_1, c_3 and μ_2, $\bar{E}^*$ will vary inversely with the long-run growth rate in z. The long-run $\bar{E}^*$ is equal to the short-run, $\bar{E}$ ($\bar{E}^* = \bar{E}$), if the long-run growth rate in ε and z is equal to zero, i.e. $\theta_1 = \theta_2 = 0$ or if the long-run response of E from a marginally change in ε, φ_1 is equal to the difference between the short-run responses b_1, b_3 and μ_2, $\varphi_1 = b_1 - b_3 - \mu_2\varphi_1$ at the same time that the long-run response of E from a marginal change in z, φ_2 is equal to the difference between the short-run responses c_1, c_3 and μ_2, $\varphi_2 = c_1 - c_3 - \mu_2\varphi_2$.

A more general version of the ECM may be written as:

$$\Delta y_t = \text{lagged}\ (\Delta y_t, \Delta x_t) - \lambda(y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + \varepsilon_t$$
$$\Delta y_t = \text{lagged}\ (\Delta y_t, \Delta x_t) - \lambda u_{t-1} + \varepsilon_t$$

The idea is to relate current and lagged values of the change in the variables and to include the extent of departure from the long-run equilibrium in the previous period in order to estimate Δy_t.

The advantage of the ECM is that it is formulated in terms of first differences, which typically eliminate the trends from variables that cause spurious correlation. The disequilibrium error can also be regarded as a stationary variable, given that a long-run relationship between the variables in the model exists (discussed in subsection 5.2). When all the variables can be regarded as stationary and given that the ECM is formulated correctly, ECM may be estimated by using classical regression methods.

5.2 Cointegration

A long-run relationship between the variables involves more than just correlation between them, they need to be cointegrated. Two series that are drifting together at roughly the same rate are said to be cointegrated. If the fully specified regression model, $y_t = \beta x_t + \varepsilon_t$ is written in matrix form, the cointegrating vector is $[1, -\beta]$. If y_t and x_t are I(1), i.e. become stationary after taking the first difference, one would normally expect $y_t - \beta x_t$ to be I(1). However, there may be a β such that $y_t - \beta x_t$ is I(0), then the partial difference might be stable around a fixed mean. If this is the case; the variables are said to be cointegrated, i.e. there exists a long-run relationship between them. One can distinguish between the long-run and short-run relationships between y_t and x_t. The long-run relationship is the way the two variables drift upward together. The short-run dynamics are the relationship between deviations of y_t from its long-run trend and deviations of x_t from its long-run trend (Greene, 2003, p. 650).

If the residual in the regression model, ε_t is stationary, then differencing will be counterproductive, because differencing the variables will remove the common linear trend that shows the long-run relationship. This can be shown by substituting such that $y_t = \mu + \alpha y_{t-1}$ and $x_t = \mu^* + \gamma x_{t-1}$

$$\varepsilon_t = (1, -\beta)(y_t, x_t)' = y_t - \beta x_t$$
$$\varepsilon_t = (1, -\beta)(\mu + \alpha y_{t-1}, \mu^* + \gamma x_{t-1})'$$
$$\varepsilon_t = 1(\mu + \alpha y_{t-1}) + (-\beta)(\mu^* + \gamma x_{t-1})$$
$$\varepsilon_t = \mu + \alpha y_{t-1} - \beta\mu^* - \beta(\gamma x_{t-1})$$
$$\varepsilon_t = \mu - \beta\mu^* + \alpha y_{t-1} - \beta(\gamma x_{t-1})$$

Long-run: $\mu - \beta\mu^*$
Short-run dynamics: $\alpha y_{t-1} - \beta(\gamma x_{t-1})$

A "unit root" refers to the situation where $\beta = 1$. If that is the case, y_t can be characterized by a random walk process, where the change in y_t is assumed to be drawn from a distribution with a zero mean. If the two variables are cointegrated they will drift together at the same rate, indicating that $\mu \approx \mu^*$, $\mu - \beta\mu^* = 0$, which implies that $\beta = 1$. If that is the case, differencing would be counterproductive, since it would hide the long-run relationship between y_t and x_t.

5.2.1 Testing for cointegration[8]

Engle and Granger showed in their article from 1987 that provided two time series x_t and y_t are cointegrated, the short-term disequilibrium relationship between them can always be expressed in the error correction form. This is the so-called Granger representation theorem, and is one of the most important results in cointegration analysis (Thomas, 1996, p. 431/432).

In order to see if the disequilibrium error is stationary we need to test the residuals for cointegration. For example, test four variables, w, x, y and z.

Step 1: Estimate a cointegrating or static regression by using OLS

$$z_t = \hat{\beta}_0 + \hat{\beta}_1 w_t + \hat{\beta}_2 x_t + \hat{\beta}_3 y_t + e_t$$

Step 2: Estimate the disequilibrium error by the residuals e_t

Step 3: Test e_t for stationarity using Dickey-Fuller (DF) and Augmented Dickey Fuller tests (ADF)

The Dickey-Fuller regression is expressed as;

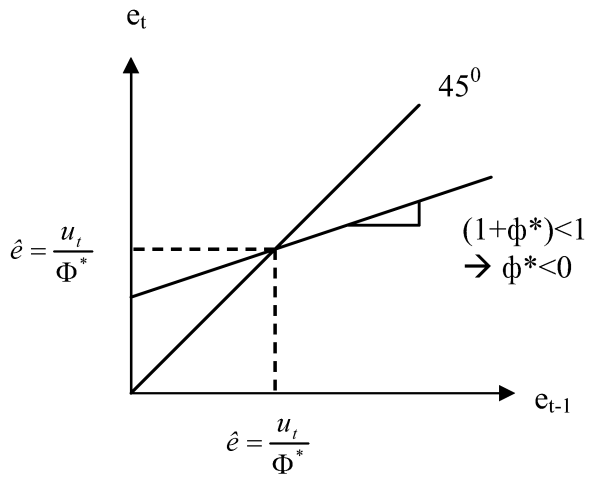
$$\Delta e_t = \phi^* e_{t-1} + \phi_1^* \Delta e_{t-1} + \phi_2^* \Delta e_{t-2} + \ldots + u_t$$

In order to determine stationarity, one can rewrite the regression with only one lag as follows;

$$\Delta e_t = \phi^* e_{t-1} + u_t$$
$$e_t - e_{t-1} = \phi^* e_{t-1} + u_t$$
$$e_t = e_{t-1} + \phi^* e_{t-1} + u_t$$
$$e_t = (1 + \phi^*) e_{t-1} + u_t$$

[8] Based on Thomas (1996)

Figure 8 Stationary residuals



The regression will be stationary when there are no changes anymore, i.e. $e_t = e_{t-1} = \hat{e}$. The 45^0-line represents all the points where $e_t = e_{t-1} = \hat{e}$. The only time the regression line possesses the property of no change in the residuals anymore, is when it intersects the 45^0-line. An intersection is only possible if the slope is less than 1, i.e. $(1+ \phi^*) < 1$, which indicates that $\phi^* < 0$.

$$\hat{e} = (1+ \phi^*)\hat{e} + u_t$$
$$\hat{e} - (1+ \phi^*)\hat{e} = u_t$$
$$\hat{e}\,[1 - (1+ \phi^*)]= u_t$$
$$-\phi^*\hat{e} = u_t$$
$$\hat{e} = u_t/ -\phi^*$$

Since $\phi^* < 0$, then $\hat{e} = u_t/ \phi^*$

To test for stationarity, the hypotheses are;

H_0: $\phi^* = 0$

H_1: $\phi^* < 0$

A rejection of H_0 implies that the residuals are stationary, i.e. y_t and x_t are cointegrated and a long-term relationship exists between them. If one fails to reject the null hypothesis, more lags of the residual may be included and tested if they are significant in explaining the current change in the residual or not. If the conclusion is not altered by adding further differenced terms, then one is unable to demonstrate cointegration between the variables.

The Dickey-Fuller tests are criticized to lack power, i.e. they may fail to reject the null hypothesis even when y_t and x_t are in fact cointegrated. This is particularly a problem when ϕ^* is close to zero. Another cause of the problem is the critical values. There is a downward bias in OLS's estimate of the ϕ^* , thus critical values need to be more negative than the critical values in a normal t-test before the null hypothesis may be rejected. Alternative critical values estimated by McKinnon in 1991 may be used. The critical values are based on simulation and are therefore only an approximation. One needs to be aware of these sources of problems when interpreting the results of cointegration.

Given that the residuals are stationary, one can use them as estimates of the true disequilibrium errors, u_t in the ECM, as suggested by the two-stage estimation procedure by Engle and Granger in their 1987 article. The other option is the general-to-specific approach as suggested by Banerjee et al., which carries out the estimation of long- and short-run parameters in a single step.

(1) The Engle-Granger two-stage procedure

Step 1: Estimate long-run parameters by estimating the cointegrating regression

$$y_t = \hat{\beta}_0 + \hat{\beta}_1 x_t + e_t$$

Step 2: The residuals from the cointegration regression, e_t, are used as estimates of the true disequilibrium errors, u_t.

$$\Delta y_t = \text{lagged } (\Delta y_t, \Delta x_t) - \lambda e_{t-1} + \varepsilon_t$$

In addition to substitute the residuals, one also needs to include the appropriate number of lags on the differenced variables. In order to determine how many lags to include in the model can be found by experimentation and then tested if they make a significant contribution to the current change in y_t or not. One can also include the first differences of other I(1) variables even though a long-run relationship is not determined. These variables will therefore only affect y_t in the short-run.

The Engle-Granger procedure is criticized for small sample bias present in the OLS estimation of the cointegration equation. This bias carries over into estimation of the disequilibrium errors and hence into the second step where estimates of the short-run parameters are obtained. One should therefore only be guided by the results given in a cointegration analysis, which may give valuable information about the long-run relationships.

(2) General-to-specific approach

In the Engle-Granger procedure the short-run responses needs to be modeled separately, but in the general-to-specific approach estimation of both short- and long-run parameters are carried out in a single step.

Step 1: The true disequilibrium errors are substituted into $\Delta y_{t;}$

$$\Delta y_t = \text{lagged } (\Delta y_{t,} \Delta x_t) - \lambda u_{t-1} + \varepsilon_t$$

$$\Delta y_t = \text{lagged } (\Delta y_{t,} \Delta x_t) - \lambda(y_{t-1} - \beta_0 - \beta_1 x_{t-1}) + \varepsilon_t$$

$$\Delta y_t = \lambda\beta_0 + \text{lagged } (\Delta y_{t,} \Delta x_t) - \lambda y_{t-1} + \lambda\beta_1 x_{t-1} + \varepsilon_t$$

Step 2: Apply OLS to the ECM regression

The structure in the lags on the differenced variables needs to be determined by experimentation. The variables that are found to be insignificant are dropped and then the model is estimated again, based on the significant variables. Even though both y_{t-1} and x_{t-1} are I(1), OLS can still be applied given an assumption on cointegration, which indicate that there is a linear combination of y_{t-1} and x_{t-1} that are I(0). This assumption can be tested for stationarity by analyzing the residuals from the equation derived in step 1in the Engle-Granger procedure, as shown above with the Dickey-Fuller test.

The advantages of the error correction model and cointegration are used in the next section to derive an exchange rate model with oil price effects.

6 An exchange rate model with oil price effects

The common perception of the public of a relationship between the oil price and the exchange rate was supported in during some periods in figure 1 and 2. However, research has shown mixed support for the proposed relationship. According to Akram (2004), the failure of empirical studies to find a significant relationship might be attributed to the fact that previous studies have only looked at a linear relationship between oil prices and exchange rates. A linear relationship assumes symmetric effects on the exchange rate by changes in the oil price and that these effects are independent of the level of oil prices.

In Q. Farooq Akram's article "Oil prices and exchange rates: Norwegian evidence" (2004) he first derives a linear relationship between the oil price and the Norwegian exchange rate, which serves as his reference model. In addition, he studies the possibility that there could be a non-linear relationship between the variables. In the non-linear model, the data supported a relatively strong negative relationship between the oil price and the Norwegian exchange rate when oil prices were below 14 US dollars and were falling. A negative relationship indicates that when the oil price increases, the Norwegian exchange rate will decrease (i.e. the Norwegian currency increases in value, it appreciates). The econometric modeled developed is also found to have strong predicative properties, compared to a similar linear model and the random walk model.

6.1 Akram's framework

Akram's model covers the post Bretton Woods period and up to the recent change in monetary policy. This period can be characterized by a stable exchange rate system (see subsection 4.1). When monetary policy is used to stabilize the exchange rate it will have implications for the ability to find a relationship between demand shocks, such as oil price fluctuations, and the Norwegian currency. However, the central bank will only use policy instruments, such as the interest rate or intervention, to resist fluctuations in the exchange rate when experiencing demand shocks that are within a predetermined range. If the shocks are outside the given range it might imply that interest rates need to be at levels that can harm the economy as a whole. By letting the exchange rate fluctuate when the demand shocks are outside of the given range, is more advantageous than keeping the exchange rate stable. Thus, one might only be able to discover a relationship between demand shocks and the exchange rate when the shocks are beyond the upper and lower limits of the range. This non-linear relationship between the exchange rate level and demand shocks may be characterized as;

$$E = \bar{E} - \varphi\varepsilon \times F(\varepsilon)$$

E is the trade weighted nominal value of the krone, $\bar{E}$ is the target exchange rate and ε is the demand shock. A non specified function, $F(\varepsilon)$ will be equal to zero, when ε is within its limits of the given range, $\varepsilon_L \leq \varepsilon \leq \varepsilon_H$. The exchange rate level will be defended and will cause the exchange rate to be equal to the target exchange rate, $E = \bar{E}$. However, $F(\varepsilon)$ will be equal to one when the shocks are below and above the given range, $\varepsilon < \varepsilon_L$ and $\varepsilon > \varepsilon_H$. Shocks outside the range will cause exchange rate fluctuation beyond the target, $\bar{E}$. Thus, a positive value of the coefficient, φ implies that shocks above the range will cause the target exchange rate to decrease, i.e. the krone will appreciate. The target exchange rate will increase if the shocks are below the range, i.e. the krone will depreciate. If the costs of resisting depreciation in the exchange rate are considered to be larger than the costs of resisting an appreciation, one might only discover a relationship when the demand shock is below the given range, since the exchange rate is defended for demand shocks above the range. An example of a demand shock is oil price fluctuations, i.e. $\varepsilon = OILP$.

$$E = \bar{E}(X) - \varphi OILP \times F(OILP)$$

Oil price shocks will cause the exchange rate to fluctuate beyond its target. The target exchange rate is determined by a vector of explanatory variables X. The normal range of oil prices were considered to be between 14 and 20 US dollars. Thus, one might find the Norwegian exchange rate depreciating when oil prices are below the lower limit of the range, 14 US dollars, while the exchange rate might appreciate when the oil price exceeds 20 US dollars. In addition, relatively low and high oil prices might increase the public's expectations of a change in the exchange rate, e.g. when there is a downward or upward trend in the oil price.

6.1.1 A general ECM of the exchange rate

An error correction model (ECM) is developed from the non-linear relationship between the oil price and the exchange rate outlined above, $E = \bar{E}(X) - \varphi OILP \times F(OILP)$ (see subsection 5.1). In addition, other relevant macroeconomic variables that might have an influence on the exchange rate are included in the ECM. Due to lack of consensus on the appropriate set of variables to be included in an exchange rate equation, a "general-to-specific" modeling strategy is used. This strategy allows for the possibility to carry out the long-run and short-run estimation at the same time. Variables that are not found to make a significant contribution in explaining the variation in the dependent variable are dropped. Thus, only the variables that were found significant were included and the model was re-estimated.

The ECM is based on a log linear specification of the trade-weighted nominal exchange rate, E for a set of explanatory variables (X), and an unspecified function $f_t[.]$ that represent long-run effects of oil prices.

$$
\begin{aligned}
\Delta e_t = {} & \alpha_0 - \varphi[e - (cpi - cpi^f)]_{t-1} + \beta_1[R - R^f]_{t-j} \\
& + \textstyle\sum^p_{j=0}[\alpha_i \Delta e_{t-1-j} + \pi_{1\,j}\Delta cpi_{t-j} - \pi_{2\,j}\Delta cpi^f_{t-j} - \beta_{2j}\Delta R_{t-j} \\
& + \beta_{3j}\Delta R^f_{t-j} + \mu_j \Delta F\ I.Y_{t-j} + \Gamma'_j \mathbf{Z}_{t-j}] \\
& + f_t[\Omega_{1j} oilp_{t-1}, \textstyle\sum^p_{j=0}\Delta\Omega_{2j} oilp_{t-j}] + \nu_t
\end{aligned}
$$

The independent variables includes domestic consumer prices (CPI), foreign consumer prices (CPI^f), domestic interest rates (R), foreign interest rates (R^f), Norwegian current account deficit relative to GDP (ΔFI_Y), a subvector Z that includes growth in domestic GDP and productivity, and growth in domestic government expenditures and the oil price (oilp)[9]. ν_t is the residual and it is assumed to be independently, identically and normally distributed with a zero mean and a constant variance σ^2. Variables in small letters are natural logs of the variables, Δ denotes a change over a quarter, and p denotes the number of lags. The number of lags is determined during the estimation.

$[e - (cpi - cpi^f)]$ represents the real exchange rate. Under the purchasing power parity (PPP), the real exchange rate is fixed and all changes in the nominal exchange rate are due to

[9] See appendix 1 for definition of variables

changes in the price levels (see subsection 3.1.2). This term represents the disequilibrium error in the ECM together with the constant term α_0. When assumed to be stationary, it sates the long-run relationship between the nominal exchange rate and the inflation differential. As mentioned in subsection 3.1.2, the use of PPP to model a perfect relationship between the exchange rate and the inflation differential are not generally supported, especially not in the short-run. Inflation differentials are one of the variables affecting trade, and trade patterns need some time to adjust. However, in Akram's working paper: "PPP despite real shocks: an empirical analysis of the Norwegian real exchange rate" (2000), the hypothesis of a PPP relationship working in the long-run is not rejected on Norwegian data.

Interest rates are one of the variables affecting capital transactions through the demand of domestic assets relative to foreign assets. Capital seeks the highest yield. Thus, if there is large capital mobility, capital transactions can change its pattern relatively fast. The interest rate differential will affect fluctuations in the exchange rate in the short-run, $R - R^f$. Due to arbitrage; the expected return on risk free assets should be equal between countries. Thus, if a country has a relatively higher interest rate, its currency is expected to depreciate to offset the advantage in the interest rate, i.e. uncovered interest rate parity (see subsection 3.1.1). In addition, according to the international Fisher equation, relatively higher interest rates only reflect an expectation of higher inflation. Thus, a relatively higher interest rate will cause the exchange rate to depreciate (see subsection 3.1.3). The Norwegian government bond rate, RB is used as a measure of the domestic interest rate and the trade-weighted government bond rate, RB^f is used as a measure of foreign interest rate. In addition, the Norwegian and European money market rates, RS and RS^f are tried out in the model.

When a country imports more than it exports, the country is running a current account deficit. In that case, the demand for the domestic currency will decrease relatively to supply and the domestic currency is likely to depreciate. The Norwegian current account deficit relative to GDP, ΔFI_Y is therefore included in the model.

The vector Z represents the possibility that relatively higher growth in domestic GDP and productivity will increase the value of the domestic currency, while increased government expenditures is believed to depreciate the domestic currency.

6.1.2 Data transformation

The first objective will be to replicate the results that Akram generated based on a linear representation of the relationship between the exchange rate and the oil price. In order for the data from Norges Bank to be applicable in Stata, the data needed to be transformed. First of all, Stata does not recognize "," as a decimal point, "." is the mathematical operator that needs to be used. Second, all the variables needed to be renamed from the abbreviations used in Norges Bank's database to the definitions used in Akram's article. Third, the data set needed to be formatted in order to handle time series variables. Fourth, the natural logs of the variables were made. In addition, the PPP variable, the "real interest rate" and the dummy variable were defined.[10]

6.1.3 An ECM of the exchange rate with linear oil price effects

In order to replicate Akram's results of a linear representation of the relationship between the exchange rate and the oil price, the oil price function in the general model is formulated such that it represents a linear relationship;

$$f_t[\Omega_{1j}oilp_{t-1}, \sum^{p}_{j=0}\Delta\Omega_{2j}oilp_{t-j}] = \Omega_{1j}oilp_{t-1} + \sum^{p}_{j=0}\Delta\Omega_{2j}oilp_{t-j}$$

The data set is based on quarterly data and covers the period from 1971:2 and up to 2000:4, where the last 12 observations were used to test for out-of-sample forecasting.

Table 2 An ECM with linear oil price effects using data from 1972:2 – 1997:4

$$\Delta\hat{e} = -\underset{(-3.32)}{0.106}[e-(cpi-cpi^f)]_{t-1} + \underset{(3.19)}{0.263}\Delta e_{t-1} - \underset{(-2.12)}{0.223}\Delta cpi^f_t - \underset{(-2.47)}{0.202}\Delta RS_t$$

$$-\underset{(-2.18)}{0.260}\Delta(RB_{t-1}-\Delta cpi_{t-2}) + \underset{(2.27)}{0.691}\Delta^2 RB^f_{t-1} + \underset{(2.63)}{0.164}\Delta_4 FI\_Y - \underset{(-4.29)}{0.037}id97q1$$

$$-\underset{(-1.04)}{0.008}\Delta oilp_t - \underset{(-1.33)}{0.010}\Delta oilp_{t-1} + \underset{(0.20)}{0.001}\Delta oilp_{t-2}$$

[10] See appendix 2 for transformation of the variables and the Stata statements needed to replicate Akram's model

F(11,92) = 8.17 Prob > F = 0.0000 R-squared = 0.494 Adj R- squared = 0.4335 n=103

The results from the estimated linear model are presented in table 2,[11] where the t-values are showed in parentheses below the coefficients. The t-value is a measure obtained when a variable follow a student t-distribution, given a null hypothesis that the value of the coefficient is equal to zero. If the coefficient has a value equal to zero, the independent variable does not contribute significantly to model. When the t-values are large it indicates that the estimated value is unlikely to happen given that the null hypothesis is true. Thus, one rejects the null hypothesis that the variable in question is equal to zero and that it is not contributing to explain the variation in the dependent variable. The level of the t-values shows that they are all significant on both the 10 and the 5 percent level, except the level effects of the oil prices. Akram included all the variables that were found to contribute significantly to explain the variation in the dependent variable, i.e. the change in the nominal exchange rate. In addition to the significant variables, the oil price, with up to two lags, were also included.

The R-squared is a measure of the total variance in the dependent variable around its mean that is explained by the model. It can obtain values between zero and one, where a value of one indicates that all the variation is captured by the estimated model. Thus, a R-squared value of 0.494 indicates that 49.4 percent of the total variance in the growth in the nominal exchange rate is explained by the estimated model. The adjusted R-squared is also a measure of how well the estimated model fits the data. However, the adjusted R-squared is adjusted for the degrees of freedom. It only increases when a meaningful independent variable is included in the model and hence, should serve a model selection criterion. An adjusted R-squared value of 0.4335 indicates that 43.35 percent of the total variance in the growth in the nominal exchange rate is explained by the estimated model.

The goodness of the model is further supported by the F-test. The F-test is a test of the significance of the entire model, i.e. to determine whether a linear relationship prevails between the dependent variable and the independent variables. The null hypothesis states that none of the independent variables contribute significantly to the model. The probability to

[11] See appendix 3 for the output provided by Stata when using the regress statement

obtain a larger value than the F-value obtained, 8.17 given that the null hypothesis is true, is estimated to be 0.000. Thus, one can reject the null hypothesis and conclude that at least one of the independent variables is contributing significantly to explain the variation in the growth in the nominal exchange rate.

According to the estimated model, the nominal exchange rate reflects the ratio between domestic and foreign prices in the long run, as postulated by PPP theory. However, level effects of oil prices proved not to contribute significantly to the model in the long-run. Positive changes in domestic money market rates, ΔRS_t, real interest rates, $\Delta(RB_{t-1} - \Delta cpi_{t-2})$ and foreign inflation, cpi^f place an appreciation pressure on the exchange rate in the short-run. Changes in the current account deficit ΔFI_Y and acceleration in foreign bond rates place a depreciation pressure on the exchange rate in the short-run. However, the short-run oil price effects proved to be insignificant on both the 10 percent and 5 percent level. Akram's findings are in line with other research done on the subject, but are still in conflict with the public perception that oil price fluctuations contribute to change the Norwegian exchange rate.

According to Akram, one possible explanation for the insignificant oil price effects may be due to misrepresentation of the oil price in the linear model. A non-linear model may contribute to explain the effect in a more appropriate way. His non-linear model supports that suggestion. He found a significant negative relationship between the exchange rate and the oil price, when oil prices were below 14 US dollars and falling. However, a change in monetary policy regimes can also contribute to alter the findings in the linear model. The hypothesis that the choice of monetary policy makes a difference when investigating a linear relationship between the oil price and the exchange rate is investigated in the next section.

7 Akram's linear model under two monetary policy regimes

This section proceeds as follows. Norges Bank uses a different measurement system now than the one that was used in Akram's article. Thus the data needs to be transformed. This obstacle is handled in subsection 7.1. Akram's linear model, based on the new measurement system from 1978:4 and up to 1997:4, is tested in subsection 7.2. In subsection 7.3, separate models of two different time periods (1978:4-1998:4 and 1999:1-2005:4) are estimated in order to distinguish between the different monetary policy regimes. In addition, the entire sample is studied in subsection 7.4, by using a dummy for the different monetary policy regimes.

7.1 Data transformation

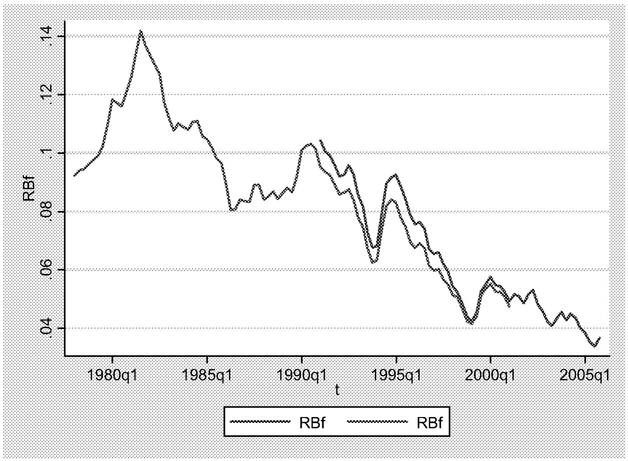
The data used in Akram's exchange rate model was obtained from a different database than the one currently in use at Norges Bank. The new database covers data from 1978:1 and the data used in Akram's model covers data from 1971:1 to 2000:4. The new database uses a different measurement system and a different aggregation level than previously. Thus, the data sets are not directly comparable.

One variable is left out from the new measurement system, compared to the old measurement system, FI_Y, i.e. the current account deficit relative to GDP. Hence, this variable is left out in the subsequent estimations of Akram's exchange rate model. In addition, some of the variables, RB^f, RB, RS and CPI^f are missing values in the beginning of the sample period under the new measurement system. The missing values in the new database need to be estimated by matching the new and old measurement system and create new datasets. The old and new measurement systems from 1978:1 are plotted against each other in Stata, to study whether they follow the same pattern. The plot of the RB variable showed that the values from the old and new database overlap each other perfectly. Thus, the old measurement system serves as a reasonable estimation of the missing values in the new measurement system. The estimated missing values together with the subsequent observations from the new measurement system are used to create a new data set, RBnew.

The plot of the RS variable showed that the values are very close to each other, at least in the beginning and the end of the sample period. There are only three missing values in the new measurement system, and the old measurement system were close to the values in new measurement system at the beginning of the sample period. Thus, the old measurement system serves as a reasonable estimate of the missing values. The estimated missing values together with subsequent observations from the new data set are used to create a new data set, RSnew.

The values of the RB^f variables do not overlap each other in the same manner, but they clearly follow the same pattern, where the new data is always higher than the old data measures (see figure 9).

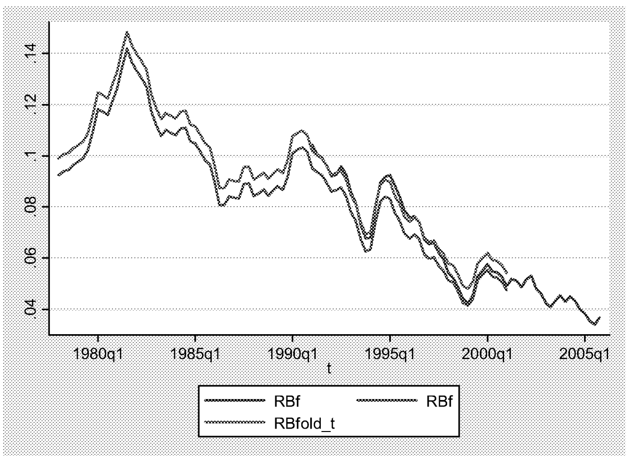
Figure 9 Time series plot of RB^f under new and old measurement system



Source: Data obtained from Norges Bank's database (2006)

In order to create a reasonable estimate of the missing values in the new measurement system, a constant is added to the old measurement system. The estimated time series, RBfold_t is plotted against observation values from the old and new measurement system in figure 10.

Figure 10 Time series plots of RB^f, included the estimated time series

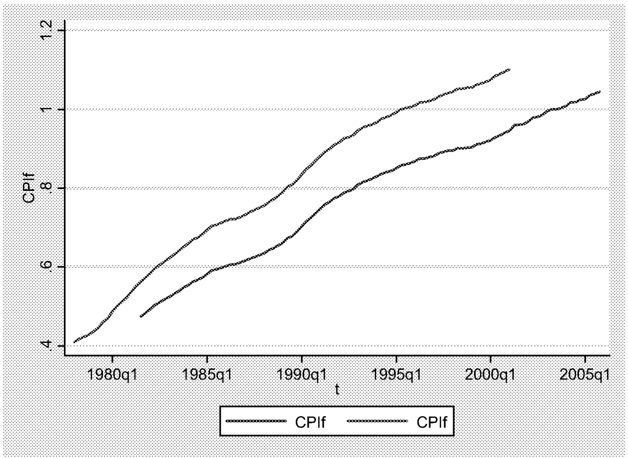


Source: Data obtained from Norges Bank's database (2006)

RBfold_t seems to be a good estimate of the missing values in the new data set. The estimated missing values together with subsequent observations from the new measurement system are used to create a new dataset, RBfnew.

The plot of the CPI^f shows that the variables do not overlap each other. However, they have the same underlying trend, where the old measurement system is always higher than the new measurement system. Although, there might be a tendency for the difference between them to increase slightly (see figure 11).

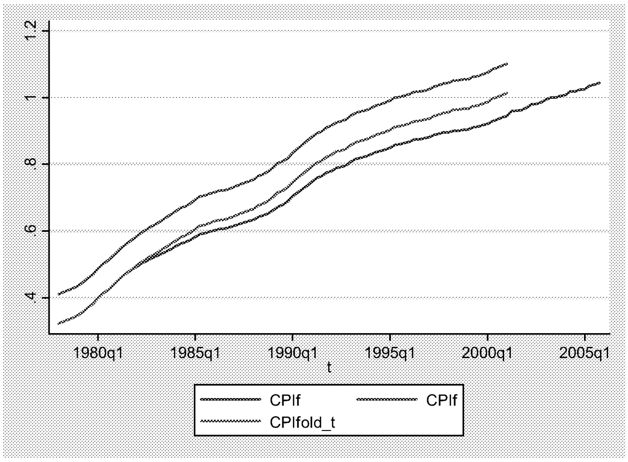
Figure 11 Time series plot of CPI^f under new and old measurement system



Source: Data obtained from Norges Bank’s database (2006)

A constant can be subtracted from the old measurement system, in order to create a reasonable estimate of the missing values in the new measurement system. The estimated time series, CPIfold_t is plotted against the observation values from the old and new measurement system in figure 12.

Figure 12 Time series plots of CPI^f, included the estimated time series



Source: Data obtained from Norges Bank's database (2006)

CPIfold_t seems to be a relatively good estimate of the missing values in the new measurement system in the beginning of the sample period. Since we are only interested in the beginning of the sample period, it does not matter that CPIfold_t deviates from the new data later in the sample period. The estimated missing values together with subsequent observations obtained from the new measurement system are used to create a new data set, CPIfnew.

In addition to estimate the missing values in the new measurement system, it was necessary to perform the same procedure as in subsection 6.1.2 in order to make the data set applicable for use in Stata.[12]

7.2 Akram's exchange rate model under the new measurement system

The new data set is based on quarterly data and consists of the estimated missing values in the new measurement system together with the subsequent observations from the new measurement system. Data from 1978:4 and up to 1997:4 are used in order to test Akram's linear model under the new measurement system.

[12] See appendix 4 for transformation of the variables and the Stata statements needed using the new measurement system

Table 3 An ECM with linear oil price effects using data from 1978:4 – 1997:4

$$\Delta\hat{e} = -\underset{(-3.73)}{0.139}\,[e - (cpi - cpi^f)]_{t-1} + \underset{(3.59)}{0.356}\Delta e_{t-1} + \underset{(0.96)}{0.090}\Delta cpi^f_t - \underset{(-0.44)}{0.053}\Delta RSnew_t$$

$$-\underset{(-3.73)}{0.536}\Delta(RBnew_{t-1} - \Delta cpi_{t-2}) + \underset{(2.48)}{0.890}\Delta^2 RBfnew_{t-1} - \underset{(-3.08)}{0.027}id97q1$$

$$-\underset{(-1.74)}{0.017}\Delta oilp_t - \underset{(-2.88)}{0.030}\Delta oilp_{t-1} + \underset{(1.08)}{0.012}\Delta oilp_{t-2}$$

F(10,66) = 7.38   Prob > F = 0.0000   R-squared = 0.5279   Adj R- squared = 0.4564   n=76

The results from the estimated linear model are presented in table 3,[13] where the t-values are showed in parentheses below the coefficients. The resulting ECM has one less variable (FI_Y)[14] than Akram's linear model and fewer observations available to estimate the model.

The F-test is a test of the significance of the whole model. There is a 0.0000 probability that the F-value obtained, 7.38 will prevail given that the null hypothesis (i.e. none of the variables contribute to explain the variation in the dependent variable any better than using its mean) is true. Thus, one can reject the null hypothesis and conclude that at least one of the independent variables is contributing significantly to explain the variation in the growth in the exchange rate.

The R-squared measure of fit has a value of 0.5279, which implies that 52.79 percent of the total variance in the growth in the nominal exchange rate is explained by the estimated model. In addition, the adjusted R-squared has a value of 0.4564 in this time period. Thus, more of the total variance in the dependent variable is explained using the new measurement system compared to using the old measurement system. This model has higher explanatory power, even though the new measurement system excludes one variable and has fewer observations available.

[13] See appendix 5 for the output provided by Stata when using the regress statement

[14] By excluding the FI_Y variable from Akram's original linear model does not alter the findings regarding the significance of the other variables

The resulting t-values are different from the t-values in Akram's original linear model. Foreign inflation, cpi^f and domestic money market rates, RSnew are neither on the 10 percent nor the 5 percent level significant anymore. In addition, cpi^f has a positive sign, compared to a negative sign in the original model. Another distinction between the models is that the short-run oil price effect with no lags is significant on the 10 percent level, and the short-run oil price effect with one lag is significant on the 5 percent level. The difference in results can be explained partially by the smaller number of observations included in the model. In addition, definition of variables and the aggregation level used will make a difference when estimating a model.

According to the estimated model, the nominal exchange rate reflects the ratio between domestic and foreign prices in the long run, as postulated by PPP theory. Positive changes in the real interest rates, $\Delta(RBnew_{t-1} - \Delta cpi_{t-2})$ together with the oil price up to one lag, place an appreciation pressure on the exchange rate in the short-run. Acceleration in foreign bond rates places a depreciation pressure on the exchange rate in the short-run. However, foreign inflation, the domestic money market rates and the short-run oil price effect with two lags proved to be insignificant. By using the new measurement system and fewer observations, the estimated model indicates that changes in the oil price have an effect on explaining the variation in the growth in the exchange rate. If the change in oil price is increased by one percent, the expected growth in the exchange rate will decrease (i.e. appreciate) by 0.017 percent, given all the other variables are in the model. If the change in the oil price with one lag is increased by one percent, the expected growth in the exchange rate will decrease (i.e. appreciate) by 0.030 percent, given all the other variables are in the model. Thus, even though the model shows that changes in the oil price have an effect on the nominal exchange rate, the effects are rather small.

7.3 An ECM of the exchange rate under two different monetary policies

A change in monetary policy regimes, from exchange rate stabilization to inflation stabilization implies that Norges Bank will not use policy instruments to stabilize the exchange rate, it floats. Thus, oil price fluctuations may have a more linear effect on the exchange rate under the new monetary policy regime, than during the previous regime where the exchange rate was defended as long as the economic shocks were within a predetermined range. Akram's model will be tested separately on the two different monetary policies, using data from the new measurement system. Subsection 7.3.1 will cover the period when the monetary policy was exchange rate stabilization by using data from 1978:4 to 1998:4. Subsection 7.3.2 will cover the period for the current monetary policy, i.e. inflation stabilization. Even though the formal change of monetary policy did not happen until March 2001, many economists believe that monetary policy took on a new path when Sven Gjedrem came into office as the Central Bank Governor in January 1999 (see section 4.3.2). Thus, data from 1999:1 will be included in the model estimated for inflation stabilization. Subsection 7.3.3 will test the entire sample period using data from 1978:4 to 2005:4, where a dummy is introduced to account for the difference in monetary policy during the period.

7.3.1 Akram's model under the period of exchange rate stabilization

Quarterly data from 1978:4 and up to 1998:4 are used in order to test Akram's linear model when exchange rate stabilization is the monetary policy.

Table 4 An ECM with linear oil price effects using data from 1978:4 – 1998:4

$$\Delta\hat{e} = \underset{(-3.46)}{-0.130}\,[e - (cpi - cpi^f)]_{t-1} + \underset{(2.98)}{0.289}\Delta e_{t-1} + \underset{(1.08)}{0.102}\Delta cpi^f_t - \underset{(-0.32)}{0.037}\Delta RSnew_t$$

$$- \underset{(-3.46)}{0.501}\Delta(RBnew_{t-1} - \Delta cpi_{t-2}) + \underset{(2.35)}{0.854}\Delta^2 RBfnew_{t-1} - \underset{(-3.00)}{0.027}id97q1$$

$$- \underset{(-2.36)}{0.023}\Delta oilp_t - \underset{(-2.74)}{0.029}\Delta oilp_{t-1} + \underset{(0.588)}{0.006}\Delta oilp_{t-2}$$

$F(10,70) = 6.82$ Prob > F = 0.0000   R-squared = 0.4936   Adj R- squared = 0.4213   n=80

The results from the estimated linear model are presented in table 4,[15] where the t-values are showed in parentheses below the coefficients. The resulting ECM is close to the previous estimated model. However, four more observations are included in the model. Compared to

[15] See appendix 6 for the output provided by Stata when using the regress statement

Akram's original linear model, this model has one less variable (FI_Y) and fewer observations available for estimation.

The F-test shows that there is a 0.0000 probability that the F-value obtained, 6.82 will prevail given that the null hypothesis (i.e. none of the variables are contributing to explain the variation in the dependent variable) is true. Since the F-value obtained is highly unlikely given the null hypothesis, one can reject the null hypothesis and conclude that at least one of the independent variables is contributing significantly to explain the variation in the growth in the exchange rate.

A R-squared value of 0.4936 indicates that 49.36 percent of the total variance in the growth in the nominal exchange rate is explained by the estimated model. Thus, the estimated model with four more quarters has lower explanatory power compared to using data up to 1997:4. In addition, the adjusted R-squared is 0.4213 for this time period, which is lower than in the previous model that has lower degrees of freedom.

The t-values are quite similar to the t-values obtained when data up to 1997:4 was used. Foreign inflation, cpi^f, domestic money market rates, RSnew and the oil price effect with two lags are still insignificant on both the 10 percent and the 5 percent level. However, the short-run oil price effects up to one lag are now significant on both the 10 percent and 5 percent level.

In line with the previous estimated model, the nominal exchange rate reflects the ratio between domestic and foreign prices in the long run, as postulated by PPP theory. Positive changes in the real interest rates, $\Delta(RBnew_{t-1} - \Delta cpi_{t-2})$ together with the oil price effects up to one lag, place an appreciation pressure on the exchange rate in the short-run. Acceleration in foreign bond rates places a depreciation pressure on the exchange rate in the short-run. However, foreign inflation, domestic money market rates and the short-run oil price effect with two lags still proved to be insignificant. By adding four more quarters of observations to the previous estimated model oil price effects with no lags were also found to be significant when explaining the variation in the growth in the exchange rate at the 5 percent level. If the change in the oil price is increased by one percent, the expected growth in the exchange rate will decrease by 0.023 percent (i.e. appreciate), given all the other variables are in the model. If the change in the oil price with one lag is increased by one percent, the expected growth in the exchange rate will decrease by 0.029 percent (i.e. appreciate), given all the other variables are in the model. The effect on the growth in the exchange rate is increased by only a small amount, compared to the previous estimated model. However, the oil price effects on the exchange rate are still rather small.

7.3.2 Akram's model under the period of inflation stabilization

Economists argued that the change in monetary policy from exchange rate stabilization to inflation stabilization started when Sven Gjedrem came into office as the Governor of Norges Bank in January 1999. Thus, quarterly data from 1999:1 and up to 2005:4 are used in order to test Akram's linear model when inflation stabilization is the monetary policy.

Table 5 An ECM with linear oil price effects using data from 1999:1 – 2005:4

$$\Delta\hat{e} = \underset{(-0.51)}{-0.044}\,[e - (cpi - cpi^{f})]_{t-1} + \underset{(1.22)}{0.202}\Delta e_{t-1} - \underset{(-2.07)}{1.338}\Delta cpi^{f}_{t} - \underset{(-1.00)}{0.776}\Delta RSnew_{t}$$

$$- \underset{(-0.93)}{0.258}\Delta(RBnew_{t-1} - \Delta cpi_{t-2}) + \underset{(2.38)}{2.919}\Delta^{2} RBfnew_{t-1}$$

$$- \underset{(-1.16)}{0.034}\Delta oilp_{t} - \underset{(0.91)}{0.029}\Delta oilp_{t-1} + \underset{(3.18)}{0.101}\Delta oilp_{t-2}$$

$F(9,19) = 2.89$ Prob > F = 0.0247   R-squared = 0.5776   Adj R- squared = 0.3775   n=28

The results from the estimated linear model are presented in table 5,[16] where the t-values are showed in parentheses below the coefficients. The resulting ECM has two variables (FI_Y and id97q1) less than Akram's original linear model and fewer observations available to estimate the model.

The F-test shows that there is a 0.0247 probability that the F-value obtained, 2.89 will prevail given that the null hypothesis is true. This F-value is lower than the ones obtained in the previous models, which can be explained by the large number of insignificant variables and

[16] See appendix 7 for the output provided by Stata when using the regress statement

the much smaller number of observations. However, the F-value obtained is still unlikely given the null hypothesis. Thus, one can reject the null hypothesis and conclude that at least one of the independent variables is contributing significantly to explain the variation in the growth in the exchange rate.

The R-squared value during this time period is 0.5776, which indicates that 57.76 percent of the total variance in the growth in the nominal exchange rate is explained by the estimated model. In addition, the adjusted R-squared is 0.3775. The lower explanatory power compared to previous models can be explained by the lower number of observation and hence, lower degrees of freedom.

The resulting t-values are quite different from the previous estimated models. Only the foreign government bond yield and the oil price effect with two lags are found to be significant in the model at the 5 percent level. In addition, foreign inflation, cpi^f was found to be significant at the 10 percent level (it is even close to be significant at the 5 percent level) and has the same sign as in the original linear model.

In contrast with the previous estimated models, the nominal exchange rate does not show a relationship between domestic and foreign prices in the long run, as postulated by PPP theory. Positive changes in foreign inflation, cpi^f places an appreciation pressure on the exchange rate in the short-run. Acceleration in foreign bond rates and the oil price effect with two lags place a depreciation pressure on the exchange rate in the short-run. However, the other short-run variables proved to be insignificant. One explanation could be assigned to the low number of observations used to estimate the model. Thus, the time period is not long enough to detect a relationship between the exchange rate and the independent variables.

Even though the model covering the monetary policy with exchange rate stabilization showed that oil price effects up to one lag were significant and the oil price effect with two lags were insignificant, the opposite is suggested when inflation stabilization is the monetary policy. If the change in oil price with two lags is increased by one percent, the expected growth in the exchange rate will increase (i.e. depreciate) by 0.101 percent, given all the other variables are in the model. This effect is larger than the oil price effects found in the previous models. However, the depreciation effect is opposite of what is thought to be the common perception of the public, which suggests an appriciation pressure from an increasing oil price.

7.3.3 Akram's exchange rate model covering the entire sample period

Quarterly data from 1978:4 and up to 2005:4 are used in order to test Akram's linear model using the entire data sample. In addition, a dummy variable are introduced in order to account for the change in monetary policy. They dummy has a value of 1 when the time period t is ≥ 1999:1, i.e. during the monetary policy of inflation stabilization, and a value of zero when the monetary policy is exchange rate stabilization.

Table 6 An ECM with linear oil price effects using data from 1978:4 – 2005:4

$$\Delta\hat{e} = -\underset{(-3.32)}{0.120}\,[e - (cpi - cpi^f)]_{t-1} + \underset{(3.41)}{0.294}\Delta e_{t-1} + \underset{(0.09)}{0.010}\Delta cpi^f_t - \underset{(-1.05)}{0.142}\Delta RSnew_t$$

$$-\underset{(-2.89)}{0.396}\Delta(RBnew_{t-1} - \Delta cpi_{t-2}) + \underset{(2.38)}{1.189}\Delta^2 RBfnew_{t-1} - \underset{(-2.44)}{0.026}id97q1 - \underset{(-1.89)}{0.006}monp$$

$$-\underset{(-1.89)}{0.020}\Delta oilp_t - \underset{(-2.47)}{0.027}\Delta oilp_{t-1} + \underset{(2.26)}{0.026}\Delta oilp_{t-2}$$

$F(11,97) = 5.69$ Prob > F = 0.0000 R-squared = 0.3923 Adj R- squared = 0.3234 n=108

The results from the estimated linear model are presented in table 6,[17] where the t-values are showed in parentheses below the coefficients. The resulting ECM has the same amount of variables as in Akram's original linear model, but another dummy is included and the current account deficit is left out. In addition, there are a few more observations available to estimate this model.

According to the F-test, which test the significance of the whole model, there is a 0.000 probability that the F-value obtained, 5.69 will prevail given that the null hypothesis is true. Thus, one can reject the null hypothesis and conclude that at least one of the independent variables is contributing significantly to explain the variation in the growth in the exchange rate.

[17] See appendix 8 for the output provided by Stata when using the regress statement

The R-squared value covering the entire sample period is 0.3923, which indicates that 39.23 percent of the total variance in the growth in the nominal exchange rate is explained by the estimated model. In addition, the adjusted R-squared is 0.3234. The model estimated on the entire sample has a relatively lower explanatory power than the previous estimated models using approximately the same independent variables but covering different time periods.

The resulting t-values are similar to the t-values obtained in the previous estimated models. Foreign inflation, cpi^f and domestic money market rates, RSnew are found to be insignificant. In addition, the sign of foreign inflation is opposite of what was found in Akram's original linear model. The monetary policy dummy, monp, and the oil price effect with no lags are found to be insignificant at the 5 percent level. However, they are both significant at the 10 percent level. The other variables, including level effects of the oil price with one and two lags, were found to be significant at the 5 percent level.

As in Akram's original linear model, the nominal exchange rate shows a relationship between domestic and foreign prices in the long run, as postulated by PPP theory. Positive changes "real interest rates," and oil price effects up to one lag place an appreciation pressure on the exchange rate in the short-run. In addition, the monetary policy dummy shows that that the choice of monetary policy has an effect (but small) on the nominal exchange rate on the 10 percent level. Thus, when the monetary policy is inflation stabilization it will cause the expected growth in the Norwegian exchange rate to decrease (i.e. appreciation) by 0.006 percent. Acceleration in foreign bond rates and the oil price effect with two lags place a depreciation pressure on the exchange rate in the short-run.

Even though the model covering the entire sample period shows that the oil price has significant effects on the growth in the exchange rate, it is quite small. If the change in oil price with no lags is increased by one percent, the expected growth in the exchange rate will decrease (i.e. appreciate) by 0.020 percent, given all the other variables are in the model. If the change in oil price with one lag is increased by one percent, the expected growth in the exchange rate will decrease (i.e. appreciate) by 0.027 percent, given all the other variables are in the model. The effects from changes in the oil price up to one lag are in line with the significant effects in the previous models. If the change in the oil price with two lags are increased by one percent, the expected growth in the exchange rate will increase (i.e. depreciate) by 0.026 percent, given all the other variables are in the model. This is smaller than was found in the estimated model in subsection 7.3.2 and it is still the opposite effect of what is perceived by the public from an oil price increase.

8 Conclusions

The different estimated models using the new measurement system show various results regarding the oil price effects on the nominal Norwegian exchange rate, but they all show some type of oil price effects. However, when an oil price effect is found to be significant in explaining the variation in the exchange rate, the effect is found to be quite small compared to the other independent variables. The last estimated model covers the entire data sample and has included a dummy in order to account for the two different monetary policies during the period. The dummy suggests that an inflation stabilization regime has a small, but significant negative effect on the growth in the exchange rate at the 10 percent level. In addition, the oil price effect with up to one lag has a negative linear relationship with the exchange rate in the short-run. These findings are in line with the public's perception of such a relationship. In contrast, the oil price effect with two lags was found to have a positive effect on the exchange rate.

When using the new measurement system, various oil price effects were found in all of the estimated models. Thus, it is not possible to assign the reason for significant oil price effects to the change in monetary policy, even though the change in monetary policy was found to be significant. Explanations for failing to find a clear distinction between the oil price effects during the different monetary polices, could be the small number of observations available from the period with inflation stabilization as the monetary policy, as well as the uncertain timing of the change in monetary policy.

All the estimated models are based on Akram's linear exchange rate model from his article "Oil prices and exchange rates: Norwegian evidence" (2004). In addition, the database currently in use at Norges Bank is different than the database at Norges Bank that was used in Akram's original model. Exchange rate theories suggest that the precise timing of the impact of the independent variables is not certain and the sensitivity of the exchange rate is likely to change over time. Thus, the various results can partially be attributed to the fact that it is difficult to find one model that can perfectly explain the variation in a dependent variable, especially when variables are defined differently than in the original model and when economic conditions changes.

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Data

The data used when estimating Akram's model in section 6 and 7 is obtained from Norges Bank's database

Appendix 1 List of variables

Variable	Explanation
CPI	Consumer price index for Norway, 1991=1
CPI^f	Trade-weighted average for consumer price indices for Norway's trading partners. Measured in foreign currency, 1991=1
E	Trade-weighted nominal value of the krone based on import-shares of trading countries, 1991=1
RB	Yield on 6-year Norwegian government bonds, quarterly average
RB^f	Basket-weighted average of interest rates on long-term foreign bonds
OILP	Spot price per barrel of Brent Blend crude oil in US dollars
FI_Y	A measure of the Norwegian current account deficit relative to GDP, fixed 1991 prices, Mill. NOK
id97q1	Impulse dummy that has a value of 1 in 1997:1, -1 in 1997:2 and zero elsewere
monp	Dummy variable that has a value of 1 when t≥1999:1 and zero elsewhere

Appendix 2 Transformation of variables and Stata statements using the old measurement system

Renaming the abbreviations used in Norges Bank's database (left hand side) to the definitions used in Akram's article (right hand side):

CPI = CPI
PCKONK = CPIf
PBVAL = E
R.BS = RB
R.BKUR = RBf
OILPUSD = OILP
D.LZ_Y = FI_Y

Stata statements:

Format the data set in order to handle time series variables.

1. gen t=q(1971q1) + _n−1 (where q implies that the data set constitutes of quarterly time series)
2. format t %tq
3. tsset t, quarterly

   This statement is important, because none of the time series operators will work if the data set is not specified to constitute time series.

Create natural logs:

1. gen cpi=ln(CPI)
2. gen cpif=ln(CPIf)
3. gen e=ln(E)
4. gen oilp=ln(OILP)

Create the "Real interest rate":

gen RealR_1=L.RB − D.L2.cpi

Create the dummy variable:

1. gen id97q1 = 0
2. replace id97q1=1 if T==105 or replace id97q1=1 if t==q(1997q1)
3. replace id97q1= −1 if T==106 or replace id97q1= −1 if t==q(1997q2)

Create Δ_4FI_Y:

gen D4FI_Y=FI_Y – L4.FI_Y

Create purchasing power parity:

gen ppp=e − (cpi − cpif)

Make the regression:

regress D.e L.ppp D.L.e D.cpif D.RS D.RealR_1 D2.L.RBf D4FI_Y id97q1 D.oilp D.L.oilp D.L2.oilp if t>=q(1972q2) & t<=q(1997q4), noc

Appendix 3 An ECM with linear oil price effects using data from 1972:2 - 1997:4

Source	SS	df	MS
Model	.012395575	11	.00112687
Residual	.012696846	92	.000138009
Total	.025092421	103	.000243616

Number of obs		103
F(11, 92)	=	8.17
Prob > F	=	0.0000
R-squared	=	0.4940
Adj R-squared	=	0.4335
Root MSE	=	.01175

D.e	Coef.	Std. Err	t	P>t	[95% Conf.	Interval]
ppp						
L1	-.1062137	.0320171	-3.32	0.001	-.1698024	-.0426249
e						
LD	.2630507	.0825704	3.19	0.002	.0990588	.4270426
cpif						
D1	-.2234692	.10548	-2.12	0.037	-.4329617	-.0139768
RS						
D1	-.2021024	.0818889	-2.47	0.015	-.3647408	-.039464
RealR_1						
D1	-.2597373	.119154	-2.18	0.032	-.4963873	-.0230872
RBf						
LD2	.6906613	.3035904	2.27	0.025	.0877047	1.293618
D4FI_Y	.1641194	.0624497	2.63	0.010	.0400889	.2881499
id97q1	-.037026	.0086368	-4.29	0.000	-.0541795	-.0198725
oilp						
D1	-.007621	.0073139	-1.04	0.300	-.022147	.006905
LD	-.0100465	.0075469	-1.33	0.186	-.0250354	.0049423
L2D	.0014191	.0072335	0.20	0.845	-.0129472	.0157854

Appendix 4 Transformation of variables and Stata statements using the new measurement system

Format the data set in order to handle time series variables.

1. gen t=q(1978q1) + _n−1 (where q implies that the data set constitutes of quarterly time series)
2. format t %tq
3. tsset t, quarterly

   This statement is important, because none of the time series operators will work if the data set is not specified to constitute time series.

Create natural logs:

1. gen cpi=ln(CPI)
2. gen cpif=ln(CPIfnew)
3. gen e=ln(E)
4. gen oilp=ln(OILP)

Create the "Real interest rate":

gen RealR_1=L.RBnew − D.L2.cpi

Create the dummy variables:

1. Dummy to account for the appreciation and the subsequent depreciation in 1997:
   a) gen id97q1 = 0
   b) replace id97q1=1 if t==q(1997q1)
   c) replace id97q1=−1 if t==q(1997q2)
2. Dummy to account for the change in monetary policy
   a) gen monp = 0
   b) replace monp = 1 if t>=q(1999q1)

Create Δ_4FI_Y: This variable was not included in the new measurement system

Create the purchasing power parity variable:

gen ppp=e − (cpi − cpif)

Make the regression:

1. Replicate Akram's model using new measurement system:
   regress D.e L.ppp D.L.e D.cpif D.RSnew D.RealR_1 D2.L.RBfnew id97q1 D.oilp D.L.oilp D.L2.oilp if t>=q(1978q4) & t<=q(1997q4), noc

2. Akram's model when the monetary policy is exchange rate stabilization:
   regress D.e L.ppp D.L.e D.cpif D.RSnew D.RealR_1 D2.L.RBfnew id97q1 D.oilp D.L.oilp D.L2.oilp if t>=q(1978q4) & t<=q(1998q4), noc

3. Akram's model when the monetary policy is inflation stabilization:
   regress D.e L.ppp D.L.e D.cpif D.RSnew D.RealR_1 D2.L.RBfnew id97q1 D.oilp D.L.oilp D.L2.oilp if t>=q(1999q1) & t<=q(2005q4), noc

4. Akram's model testing the whole sample period, using a dummy to account for choice of monetary policy:
   regress D.e L.ppp D.L.e D.cpif D.RSnew D.RealR_1 D2.L.RBfnew id97q1 monp D.oilp D.L.oilp D.L2.oilp if t>=q(1978q4) & t<=q(2005q4), noc

Appendix 5 An ECM with linear oil price effects using data from the new measurement system covering 1978:4 − 1997:4

Source	SS	df	MS
Model	.010541312	10	.001054131
Residual	.009427715	66	.000142844
Total	.019969027	76	.00026275

Number of obs = 76
F(10, 66) = 7.38
Prob > F = 0.0000
R−squared = 0.5279
Adj R−squared = 0.4564
Root MSE = .01195

D.e	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
ppp						
L1	−.1391017	.0373277	−3.73	0.000	−.2136288	−.0645746
e						
LD	.3557299	.0992052	3.59	0.001	.1576603	.5537994
cpif						
D1	.0898819	.0933608	0.96	0.339	−.0965189	.2762826
RSnew						
D1	−.0528796	.12031	−0.44	0.662	−.2930863	.1873271
RealR_1						
D1	−.5356998	.1435324	−3.73	0.000	−.8222715	−.249128
RBfnew						
LD2	.8904242	.3592816	2.48	0.016	.1730953	1.607753
id97q1	−.0273127	.0088636	−3.08	0.003	−.0450094	−.009616
oilp						
D1	−.0174546	.0100164	−1.74	0.086	−.0374531	.0025438
LD	−.0301405	.0104574	−2.88	0.005	−.0510194	−.0092616
L2D	.0120091	.0111483	1.08	0.285	−.0102493	.0342674

Appendix 6 An ECM with linear oil price effects covering the period with exchange rate stabilization 1978:4 − 1998:4

Source	SS	df	MS
Model	.010121509	10	.001012151
Residual	.010381916	70	.000148313
Total	.020503425	80	.000256293

Number of obs = 80
F(10, 70) = 6.82
Prob > F = 0.0000
R−squared = 0.4936
Adj R−squared = 0.4213
Root MSE = .01218

D.e	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
ppp						
L1	−.130134	.03758	−3.46	0.001	−.2050849	−.0551832
e						
LD	.2892644	.0969638	2.98	0.004	.0958763	.4826525
cpif						
D1	.1017124	.0944218	1.08	0.285	−.086606	.2900308
RSnew						
D1	−.037384	.1180912	−0.32	0.753	−.2729094	.1981414
RealR_1						
D1	−.5012022	.1447563	−3.46	0.001	-.7899095	-.2124948
RBfnew						
LD2	.8542988	.3642435	2.35	0.022	.1278381	1.580759
id97q1	-.027039	.0090247	-3.00	0.004	-.0450382	-.0090397
oilp						
D1	-.0233747	.009904	-2.36	0.021	-.0431276	-.0036219
LD	-.0286225	.010454	-2.74	0.008	-.0494725	-.0077726
L2D	.0059289	.0108944	0.54	0.588	-.0157994	.0276572

Appendix 7 An ECM with linear oil price effects covering the period with inflation stabilization 1999:1 - 2005:4

Source	SS	df	MS
Model	.008047501	9	.000894167
Residual	.005884931	19	.000309733
Total	.013932432	28	.000497587

Number of obs = 28
F(9, 19) = 2.89
Prob > F = 0.0247
R-squared = 0.5776
Adj R-squared = 0.3775
Root MSE = .0176

D.e	Coef.	Std. Err.	t	P>t	[95% Conf. Interval]	
ppp						
L1	-.0435454	.0854073	-0.51	0.616	-.2223048	.1352141
e						
LD	.2017704	.1660075	1.22	0.239	-.1456872	.549228
cpif						
D1	-1.337998	.6459022	-2.07	0.052	-2.689887	.0138905
RSnew						
D1	-.7756899	.7747154	-1.00	0.329	-2.397188	.8458081
RealR_1						
D1	-.2582633	.2783845	-0.93	0.365	-.8409288	.3244022
RBfnew						
LD2	2.919292	1.228669	2.38	0.028	.3476585	5.490926
id97q1	(dropped)					
oilp						
D1	-.0335735	.0289159	-1.16	0.260	-.0940951	.0269481
LD	-.0289627	.0318471	-0.91	0.375	-.0956195	.0376941
L2D	.1014016	.0318841	3.18	0.005	.0346674	.1681358

Appendix 8 An ECM with linear oil price effects covering the entire sample period using data from 1978:4 - 2005:4

Source	SS	df	MS
Model	.013508537	11	.001228049
Residual	.02092732	97	.000215746
Total	.034435857	108	.000318851

Number of obs = 108
F(11, 97) = 5.69
Prob > F = 0.0000
R-squared = 0.3923
Adj R-squared = 0.3234
Root MSE = .01469

D.e	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
ppp						
L1	-.1200203	.036102	-3.32	0.001	-.1916728	-.0483678
e						
LD	.2937028	.0861293	3.41	0.001	.12276	.4646456
cpif						
D1	.0096105	.1110405	0.09	0.931	-.2107743	.2299952
RSnew						
D1	-.142208	.1352677	-1.05	0.296	-.4106768	.1262608
RealR_1						
D1	-.3958698	.136912	-2.89	0.005	-.6676023	-.1241373
RBfnew						
LD2	1.189429	.3903947	3.05	0.003	.4146038	1.964255
id98q1	-.0263291	.0107778	-2.44	0.016	-.0477201	-.0049382
monp	-.0059019	.0031203	-1.89	0.062	-.0120948	.0002909
oilp						
D1	-.0198048	.0104765	-1.89	0.062	-.0405976	.0009881
LD	-.0274149	.0110802	-2.47	0.015	-.0494061	-.0054237
L2D	.0255325	.0112751	2.26	0.026	.0031545	.0479106