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The Daily Liquidity Effect in a Floor System – Empirical Evidence from the Norwegian Market

November 2012

By Olav Syrstad[1]

This paper analyses the liquidity effect in Norway by examining the relationship between a range of liquidity variables and five different measures of the short-term interbank premium. The models are estimated on data from January 2007 and up to the end of September 2011, a period in which Norges Bank implemented its liquidity policy within a so-called floor system, and prior to the new liquidity system introduced on 3 October 2011. In a floor system the key policy rate is equal to banks' deposit rate in the central bank, and as such, this analysis provides new information on the liquidity effect in a floor system. Both excess liquidity (total central bank reserves in the banking system) and structural liquidity (central bank reserves in the system before Norges Banks' market operations) have, as expected, a negative an significant effect on almost all dependent variables. Structural liquidity is the important factor driving the interbank premiums during periods characterized by low volatility, while excess liquidity gained importance during the financial crisis. This result is in line with what should be expected in a floor system. Furthermore, in periods of financial turmoil European and Norwegian banks may face higher USD rates in the interbank market either because of a general USD liquidity premium or an institution specific credit premium. My analysis provides additional insight in the division between the liquidity premium and the credit premium in a way, to my knowledge, not done in earlier literature. In line with the existing literature, the results indicate that during the financial turmoil and crisis (2007-2009), a USD liquidity premium dominated as credit conditions in USD deteriorated (USD shortage).

1. Introduction

Central banks normally manage bank reserves with a view to keep short-term interbank rates close to the key policy rate[2]. This is carried out by aiming at keeping the supply of reserves at the appropriate level, which depends on the liquidity management framework.

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[2] "Reserves" and "liquidity" will be used interchangeably. In this paper both expressions mean the outstanding amount of central bank reserves.

However, independent of the liquidity framework, transfers of funds among banks need to be settled by reserves in the central bank. This creates liquidity risk as banks are obliged to hold a non-negative amount of reserves at the end of the day. Banks holding a negative amount of reserves need to borrow reserves from other banks in the interbank market, attract alternative types of funding from non-banks or use the central bank's lending facility, the latter normally at a substantially higher cost. Then, according to theory, the cheaper are reserves, the higher is the demand to avoid the risk of being forced to use the standing lending facility at the central bank. Hence, the widespread perception is that the short-term interest rate decreases with the amount of reserves, known as the liquidity effect.

To effectively implement monetary policy it is important to understand how the supply of reserves affects interest rates. Whitesell (2006) establishes a theoretical framework for the demand for reserves, showing that the demand curve is downward sloping in line with the existence of a liquidity effect. However, he emphasizes that the slope of the demand curve may vary due to heterogeneous participants in the market, uneven distribution of reserves across banks and changes in banks' risk perception. Hamilton (1997), Thornton (2001), Carpenter and Demiralp (2006) and Thornton (2006) have all searched for empirical evidence of a liquidity effect. Carpenter and Demiralp (2006) find "clear evidence of a liquidity effect at daily frequency". Thornton (2006) also finds evidence of a liquidity effect, but states that this effect is relatively small. Thornton focuses on Fed's forecast errors and how such errors contribute to changes in the effective fed funds rate. This methodology may mix the true liquidity effect and daily changes in the demand curve, cf. Whitesell (2006).

This paper investigates the liquidity effect in Norway by analyzing the relationship between liquidity and different measures of short-term interest rates premiums (measured as the difference between the level of the interest rate and the expected policy key rate). The analysis is carried out by regressing the premiums on excess- and structural liquidity (to be defined below), in addition to several other variables which could affect the interest rate formation. The set of dependent variables contains two overnight rates and three tomorrow-next rates. The models are estimated on the period from the beginning of January 2007 up to the end of September 2011, when a new liquidity managing framework was introduced in Norway (to be discussed below). The regressions also cover three sub-samples to highlight differences prior to, under and after the financial crisis.

As the Norwegian interbank market traditionally has been tied to the fx-forward market, in particular literature by Baba and Packer (2008a,2008b, 2009) and Coffey et. al. (2009) have gained attraction. A common feature of the papers of Baba and Packer is that they use the difference between the foreign exchange swap-implied three month dollar rate and the three-month dollar Libor rate as dependent variable in their estimations.[3] They regress this variable on a set of explanatory variables, such as credit spreads between European and US financial institutions, US dollar term funding conducted by the ECB, and LIBOR-OIS spreads between the euro and the US dollar. Coffey et. al. regress the same forward exchange swap deviation on similar variables such as default risk, counterparty risk, funding liquidity risk (as measured by the three-month spread between agency mortgage backed security and Treasury repo) and term risk.

My study extends the existing literature in several ways. First, the methodology in my paper is an extension of Bernhardsen, Kloster, Syrstad and Smith (2009), and provides

[3] Liquidity risk is measured as the spread between the three-month agency mortgage backed security and the Treasury repo interest rate.

additional insight in the division between the liquidity premium and the credit premium in USD. In fact, the liquidity premium is separated from the credit premium in a way, to my knowledge, not applied in earlier literature. Second, a new dependent variable is used to isolate the impact of central bank reserves on foreign exchange(fx)-forwards. The fx-forward market is of special interest in Norway as the official Norwegian interbank rate (NIBOR) has been linked to USD rates and the corresponding fx-forward price during the period of estimation. In order to fully understand how reserves affect the tomorrow-next rate a closer look at the fx-forward market is necessary. By constructing a cross-currency forward premium based on expected policy rates (OIS rates) and compare this to the actual fx-forward premium in the market it is possible to isolate the effects of central bank reserves (the liquidity effect) on fx-forward prices. Recalculated into basis points this variable will be referred to as the *OIS-basis.*[4] This approach is similar to that of Baba and Packer (2009). Based on the regressions in this paper, it is possible to evaluate to what extent the USD-premium used by Norges Bank as a proxy for the risk premium faced by Norwegian banks has been driven by a general liquidity premium in USD or a credit premium. While the studies of Baba and Packer and Coffey et. al. do analyze how different explanatory variables affect the fx- swap deviation, this paper brings the discussion a step further, in distinguishing between the credit- and liquidity premium and explaining how the two types of premiums affect the fx-forward market. Third, new data from the settlement system and the forward market allows me to interpret how market structure affects different rates. This contributes to the evaluation of the liquidity management system and the measures taken during the financial crisis. Fourth, the paper contributes to the analysis of the short-term interest rate market in Norway, which, with a few exceptions, has not been a topic for research.

Overall, the results indicate the existence of a liquidity effect. This effect exists both for the overnight rates and the tomorrow-next rates. Moreover, uneven distribution of reserves leads to higher interest rates. Finally, the results indicate a contagion from the USD tomorrow-next rate to the corresponding Norwegian interest rate. This may be interpreted as a credit premium contagion from the USD-money market.

The paper is organized as follows. Section 2 explains how monetary policy is implemented in Norway and how NIBOR historically has been computed. Section 3 describes the econometric model and in section 4 the empirical results are discussed. Section 5 concludes.

2. Monetary policy, liquidity managing framework and money market in Norway[5]

The monetary policy in Norway is based on an inflation targeting regime, introduced in March 2001. The operational target is steering towards an annual consumer price inflation of 2.5 per cent over time. The regime is flexible, meaning that weight is given to both variability in inflation and variability in output and employment. The key policy rate is set by the Executive Board with a view to stabilising inflation close to the target in the medium term. Three times a year a Monetary Policy Report is published. In the Report, Norges Bank analyses the current economic situation and publishes its economic forecasts. Since 2005 Norges Bank has published its own interest rate forecast, on which the reference scenario for the economic outlook is based. The monetary policy decision is

[4] Similar to the OIS-basis referred to by market participants. The OIS-basis could alternatively be constructed as the difference between the actual domestic OIS-rate and the implied OIS-rate based on a foreign OIS-rate and the corresponding fx-forwards between the currencies (for T/N-maturity the key policy rate replace the OIS-rate)

[5] This section draws on Bernhardsen, Kloster, Syrstad and Smith (2009).

implemented by steering the supply of reserves available to the banking system with the aim of keeping short-term money market rates close to the key policy rate.

A range of different liquidity management frameworks exist. Broadly speaking these can be categorized as either a corridor- or a floor framework. Common for both is that they contain standing facilities, collateral schemes and in some instances reserve requirements. Within a corridor framework the central bank's standing deposit rate is below, and the standing lending rate is above the key policy rate. In a pure corridor, without any reserve requirements, the central bank normally aims to keep total reserves in the banking system at zero, or marginally higher than zero.[6] In a corridor with reserve requirements the target is normally determined by these requirements.[7] If the demand for reserves exceeds the supply, the interest rate will increase towards the corridor ceiling, represented by the central bank's standing lending rate. Similarly, if the supply of reserves exceeds the demand, the interest rate falls towards the floor of the corridor, represented by the central bank's standing deposit rate.

Up to 3 October 2011 Norges Bank implemented monetary policy within a floor system. In such a system the key policy rate is equal to the interest rate banks receive on their overnight deposits in the central bank (the central bank's standing deposit rate). The deposit rate normally forms a floor for very short-term money market rates, as banks will normally not lend money at an interest rate lower than what they achieve at the central bank. Similarly, the central bank's lending rate forms a ceiling for very short-term money market rates, as banks will normally not borrow money at a rate higher than what they have to pay the central bank. In a floor system the central bank must ensure that there is a surplus of reserves in the banking system. When banks' deposits in the central bank are sufficiently large, very short-term money market rates will be pushed down towards the deposit rate. Norges Bank carried out this strategy by providing loans, normally of short maturity, to Norwegian banks. The floor system enabled Norges Bank to keep the short-term rate close to the policy rate even in periods of extensive liquidity surplus. It made fine tuning operations unnecessary and simplified the liquidity management. The system was justified by the fact that autonomous factors in Norway fluctuate as a result of government transactions with the central bank.[8] In a floor system, liquidity forecast errors normally have only a minor impact on short-term rates because of excess supply of liquidity in the banking system.[9]

As from 3 October 2011 Norges Bank has administered the liquidity management through reserve quotas. In this system banks receive interest only on a specific portion of reserves – a quota – equivalent to the key policy rate. Deposits in excess of the quota bear lower interest – equivalent to the reserve rate. The reason for changing the system was to enhance the redistribution of liquidity in the interbank market and boost activity in the shortest segment of the money market, in addition to contain central bank reserves demand. Within this system Norges Banks steers the supply of liquidity by providing fixed rate loans and deposits, normally of short maturity, to Norwegian banks.[10] Based on some months of experience, in the new system Norges Bank has managed to keep the

[6] Examples are Canada and Sweden.
[7] Examples are UK and the euro area.
[8] Autonomous factors include, among others, developments in bank notes in circulation, transactions between banks and the government and fx-transactions conducted by Norges Bank.
[9] See Bernhardsen and Kloster (2010) for a detailed discussion about different liquidity management frameworks.
[10] See www.norges-bank.no (under "price stability"/"Liquidity management") for more details on the new system and the background for the change.

level of reserves around the announced target, and short-term rates have remained fairly stable around the key policy rate.[11]

Turning to the money market interest rates, they can be measured in terms of domestic rates reflecting rates on interbank borrowing and lending within one currency or, alternatively, on implied interest rates swapped from other currencies. Regarding the Norwegian short-term money market, only as from the beginning of October 2011 when the new liquidity system was introduced, an effective overnight interest rate has existed. The new system encouraged more overnight liquidity trading among banks, and after initiative taken by Norges Bank, Finance Norway[12] took measures to quote a new overnight rate, NOWA (Norwegian Overnight Weighted Average). Prior to the introduction of NOWA and the new liquidity system, the most prominent part of the short-term money market was in the tomorrow–next fx-forward market. Chart 1 shows the two money market rates in addition to the policy key rate and the rates on Norges Bank's standing facilities. Evidently, due to the floor system, operating until 3 October 2011, the tomorrow-next rate has been close to Norges Bank's deposit rate. As from the beginning of October 2011, the new overnight rate (NOWA) has fluctuated around the key rate.

As my study covers the period from the beginning of 2007 up to the end of September 2011, the tomorrow-next rate is the most important rate to base the analysis on. Notice that during my period of estimation the tomorrow-next rate was linked to the USD-dollar rate and the fx-forward swap market, it was basically a swap interest rate (implied interest rate from USD). This means that the tomorrow-next rate could be written as

(1) $i_{NIBOR} = i_{\$} + (f\text{-}e)$

where $i_{\$}$ is the dollar funding rate, e is the (log of) the exchange rate (the amount of NOK per unit of dollar, hence an increase indicates a depreciation of NOK), f is the (log of) the forward exchange rate and i_{NIBOR} is the swap rate on NOK. The term (f-e) is referred to as the forward exchange premium.

In countries, where domestic money market rates exist alongside with swap rates, covered interest rate parity can be tested by comparing the domestic rate with the swap rate. In Norway, however, during my period of estimation, the Norwegian money market rate was merely defined by equation (1). It means that NIBOR was supposed to reflect the dollar funding rate of banks in the NIBOR-panel plus the forward premium traded in the market.[13, 14]

[11] Since the introduction of the new system in October 2011, Norges Bank's target for total reserves in the banking system has been NOK 35 billion.

[12] Finance Norway (FNO) is the trade organisation for banks, insurance companies and other financial institutions in Norway.

[13] Until mid-2011 formal rules for calculating and publishing NIBOR did not exist. After initiative taken by Norges Bank, Finance Norway (Finansnæringenes Hovedorganisasjon), took measures to formalise and publish rules for quoting NIBOR. According to the new rules, ...NIBOR is intended to reflect the interest rate level lenders require for unsecured money market lending in NOK with delivery in two days after trade. The rules adopted by FNO apply to NIBOR with maturities of one week, two weeks, one month, two months, three months, four months, five months, six months, nine months and twelve months...For more information on NOWA and the rules for quoting NIBOR, see http://www.fno.no/en/main/markets/

[14] The actual dollar funding rate available to and used by banks in the NIBOR-panel as a basis for the NIBOR fixing is unknown. Moreover, at the micro level, the rates on NOK offered by individual banks in the NIBOR-panel may differ slightly as banks may face different rates for unsecured borrowing in dollars. Moreover, the low number of active banks (only six NIBOR banks) in the Norwegian money market makes the market structure rather unique. In addition, with a market share of approximately 40 per cent, the commercial bank DNB has a dominant position. It is also worth noting that international players are active in the forward market, but less so in the Overnight-market. As such, competition in the two market-segments differs.

In the analysis below, based on data prior to the publication of the new definition of NIBOR, three measures of the money market risk premium will be based on the tomorrow-next rate, while two measures will be based on less liquid overnight rates, that also existed prior to the introduction of NOWA.

3. The Econometric Model

To analyze how liquidity and the distribution of liquidity across banks affect the short-term interest rate premium the following model is estimated:

$$(2) \quad i = \alpha + B_{ex.liq}\, ex.liq + B_{str.liq}\, str.liq + B_{err}\, err + B_{dist}\, dist + B_{sprd}\, sprd + B_{usd}\, usd$$

where *ex.liq* and *str.liq* are respectively excess and structural liquidity (reserves), to be defined below, *err* is Norges Banks liquidity forecast error, *dist* is the distribution of reserves across banks, *sprd* is the fx-forward bid-ask-spread and *usd* is the dollar money market premium. In the model *i* represent five different measures of the short-term interest rate premium (dependent variable), all of them being regressed on the set of six explanatory variables. We first discuss the dependent variables, then the explanatory ones.

3.1 Dependent variables

The dependent variables are *NONIA (O/N), NIDR (O/N), T/N-NIBOR, T/N-Norges Bank* in addition to a variable, which will be referred to as the *OIS-basis* and explained in more details in section 3.3. All the dependent variables are measured as the difference between the interest rate level and the expected policy rate.

NONIA (O/N) is the Norwegian Overnight Index Average, an overnight rate inferred from overnight transactions settled in the real-time gross settlement system. Akram and Christoffersen (2010) discuss the details and show that NONIA has stayed historically very close to the key policy rate. NONIA is not published on a regular basis.

NIDR (O/N) is the Norwegian Interbank Deposit Rate. Only three banks are quoting NIDR, which is not traded in the market.[15] It is an equal weighted average of the three individual banks` quotes, published by Reuters. Despite the low number of contributing banks, this rate is considered as a good representation of the overnight rate.

The shortest maturity quoted in NIBOR is *NIBOR-Tomorrow/Next (T/N)*. It is published by Reuters and based on a USD rate and the forward premium (cf. equation 1). The underlying forwards associated with this rate is quoted with large bid/ask spreads. Being a NIBOR bank requires an obligation to quote tradable forward prices up to an amount of 50 million NOK. Due to precautionary reasons this may contribute to larger bid/ask spreads.

Tomorrow/Next-Norges Bank: In order to adjust for high bid/ask spreads in NIBOR, Norges Bank computes an internal T/N-rate, based on actual forward trades done through Reuter Dealing and a USD-rate equal to the average of the USD T/N-rates quoted by Tullett Prebon and Carl Kliem (brokers)[16]. This rate gives Norges Bank a good indication of the actual interest rate level.

[15] The banks are DNB, Danske Bank and Nordea.
[16] This is the same usd-rate used as explanatory variable in the regressions.

3.2 Explanatory variables

Structural liquidity (str.liq) and excess liquidity (ex.liq). In particular transactions between the banks and the Government change the supply of reserves in the banking system. Structural liquidity is the level of reserves in the banking system that would prevail in the absence of any interference (liquidity provision or draining operations) by the central bank. Structural liquidity may be positive or negative dependent on the development of autonomous factors. By supplying reserves to or draining reserves from the system Norges Bank keeps the total level of reserves at the appropriate level. Both structural and excess liquidity are expected to have a separate negative effect on the money market premium (the liquidity effect). Structural liquidity may have a separate effect (given excess liquidity) because lower structural liquidity may increase the uncertainty about banks own future liquidity position. Low structural liquidity also increases bank`s borrowing in the central bank (for a given level of excess reserves), which may increase the concentration of the reserves intraday and unwillingness among banks to lend reserves. Anecdotic information indicates that especially foreign banks are worried about the concentration of reserves, hence this effect may be particularly pronounced in the fx-forward market.[17] Hence $B_{ex.liq}$ and $B_{str.liq}$ are both expected to be negative.

Norges Bank's liquidity forecast errors (err). Norges Bank publishes forecasts for structural liquidity, defined as actual outcome minus the forecast. If structural liquidity comes out higher than forecasted, the money market premium may fall. Hence B_{err} is expected to be negative.[18]

The distribution (dist) of reserves across banks may be important for short-term interest rates. When liquidity is concentrated amongst few banks, other participants may need to raise their bids in order to borrow reserves. The variable is constructed as follows: in the settlement system in the central bank one bank will, at the end of each day, have the largest amount of reserves. This amount is divided by total amount of reserves. The coefficient B_{dist} is expected to be positive.[19]

The bid/ask spread in the forward market (sprd) indicates lower liquidity and higher volatility in the forward market. This may lead to higher T/N-rates as they are directly calculated on the basis of the forwards (cf. equation (1)), but may also be a proxy for increased financial volatility in general, which may be associated with higher overnight rates. Hence B_{sprd} is expected to be positive.

The USD-premium (usd) is the difference between the USD T/N and the expected policy rate, the former being the average of USD T/N-rates from two interbank brokers, Carl Kliem and Tullett Prebon. Depending on the cause of a higher USD-premium the Norwegian money market premium will be differently affected. In fact, the effect on the Norwegian premium depends on whether a higher USD-premium stems from a dollar liquidity premium faced by all banks or a credit premium which can differ across institutions. To understand this we have to make a side-step and explain the *OIS-basis* in details, as the dependent *OIS-basis* and the two dependent variables *T/N-NIBOR* and *T/N-*

[17] Foreign banks are more active in the tomorrow-next market, closely linked to the fx-forward market.

[18] Thornton (2006) uses the central bank forecast error to measure the liquidity effect in the US. During his sample period Federal Reserve operated within a corridor framework, paying no interests on excess reserves. One of the advantages of a floor framework is considered to be the ability to absorb forecast errors without significantly increasing interest rate volatility. Forecast errors are included to examine this feature.

[19] This effect is probably greater in a floor system, where the cost of depositing excess reserves at the central bank is lower, than within a corridor system.

NB are connected, but oppositely affected by the USD-premium. As will turn out to be the case, when the *OIS-basis* is the dependent variable, the coefficient B_{usd} is expected to be negative. On the other hand, when either of the tomorrow/next-variables or the overnight-variables are dependent variables, the coefficient B_{usd} is expected to be positive. This will be the topic for the section below.

3.3 The OIS-basis, the USD liquidity premium and the credit premium

Contrary to the four dependent variables discussed in 3.1, which are straight forward to interpret, the *OIS-basis* needs considerably more explanation. As will turn out to be the case, the variable can be interpreted as an indicator of the major dislocation in the foreign exchange forward market witnessed during the financial crisis. The variable is constructed as the difference between the forward premium and the expected policy rate differential. A simple model for the money market risk premium based on the fx-forward market helps to illustrate the *OIS-basis.*[20] The model can be written as

(3) $i_N = i_{N,\$} + (f\text{-}e)$
(4) $i_{N,\$} = OIS_\$ + rp_\$ + rp_{N,\$}$
(5) $rp_\$ = i_\$ - OIS_\$$
(6) $rp_N = i_N - OIS_N$

where equation (3) is equal to equation (1). Equation (4) defines the dollar rate foreign banks (and thereby Norwegian banks) have to pay for unsecured dollar in the money market. It consists of the expected overnight rate in the market as measured by the OIS-rate[21] plus an additional money market premium faced by all banks ($rp_\$$), including both a liquidity premium and a credit premium in addition to a credit premium faced by foreign banks only ($rp_{N,\$}$). The latter can be positive or negative andif foreign banks do not face an additional credit premium, $rp_{N,\$} = 0$. Moreover, equation (5) and (6) define the money market risk premium for NOK and USD, respectively. By substituting (3), (4) and (5) into (6), we obtain

(7) $rp_N = rp_\$ + rp_{N,\$} + (f\text{-}e) - (OIS_N - OIS_\$)$

Disregarding the credit premium $rp_{N,\$}$ for a moment, we see that the NOK money market premium (rp_N) is equal to the US premium adjusted for the difference between the forward premium in the market and the difference between the OIS-differential, the latter being referred to as the "theoretical" forward premium. Our dependent variable *OIS-basis* is defined as

(8) *OIS-basis* $= (f\text{-}e) - (OIS_N - OIS_\$)$

To understand the basic intuition behind the *OIS-basis*, we proceed as follows: First, we argue that under normal circumstances, the *OIS-basis* is zero. Second, we explain that an increase in the overall dollar liquidity premium affects the OIS-basis negatively. Third, we argue that a credit premium faced by individual institutions, or groups of financial institutions (not attached to a specific currency) will theoretically leave the OIS-basis unchanged.

[20] Below I extend the model presented in Bernardsen, Kloster, Syrstad and Smith (2009).The model holds for all currency crosses, but the USD/NOK is used throughout the paper.
[21] Overnight Indexed Swap

Turning to the first issue, why is the OIS-basis normally zero? The theoretical forward premium is by definition given by the difference between the OIS-rates which are determined by the expected path of policy rates in the respective currencies. Let us illustrate this by an example.[22] Assume that the domestic three-month OIS-rate is lower than the three-month dollar OIS-rate plus the actual forward premium, i.e. $OIS_N < OIS_\$ + (f-e)$. Then, borrow domestic currency in the domestic overnight market, roll over the debt daily for three months and enter into an OIS-contract to change the floating overnight rate on the debt for a fixed rate. The borrower then disposes a given amount of domestic currency for three months at the cost given by the three-month domestic OIS-rate. Change the domestic currency for dollar spot, invest the resulting amount of dollar in the overnight dollar market, roll over the dollar investment daily for three months and enter into an overnight swap contract to change the floating overnight dollar rate on the investment for a fixed rate. The investor then knows the interest rate he or she will obtain over the three months and the corresponding amount in dollar. Sell this amount of dollar in the forward foreign exchange market and obtain domestic currency in three months, the amount being determined by the forward rate traded in the market today. If the actual forward premium equals the difference between the OIS-rates, the gain from borrowing overnight in the domestic market and lending in the overnight dollar market will be zero. If the domestic OIS-rate is lower than the dollar OIS-rate plus the actual forward premium, the gain will be positive. Due to arbitrage the actual forward premium will adjust to equal the difference between the OIS-rates, and hence the theoretical forward premium and the forward premium will be equal.[23]

Chart 2 shows the OIS-basis (the difference between the three-month actual forward premium and the theoretical forward premium) for NOK, SEK, GBP and EUR, all relative to USD. Until the financial turmoil started in August 2007 the difference was around zero for all currencies (“normal” situation). Thereafter, and in particular after the failure of Lehman Brothers in mid-September 2008, they have been negative. This reflects dollar shortage: as credit in dollar became scarce, it was more difficult to obtain dollar funding and the dollar money market premium increased. Hence financial institutions tried to obtain dollar through the foreign exchange market. They sold local currency and bought USD spot, and sold USD and bought local currency forward. This implied that the forward exchange rate and hence the forward premium fell ($\Delta f<0$) and took values substantially below the theoretical forward premium.[24] Later on, the Fed took several measures to increase the supply of dollar[25], which reduced financial institutions’ need for obtaining dollar through the fx-swap market. Hence both the need for buying dollar spot and the need for selling dollar forward declined, leading to an increase in the forward premium. In terms of our model, the difference between the forward premium and the theoretical forward premium approached the normal level of zero.

[22] The following example is based on three-month maturity. However, identical reasoning applies for all maturities, including the T/N. The difference between the T/N and longer maturities is that an OIS-contract is superflous. For shorter maturities the ”arbitrage” argument is stronger as (i)the central bank normally supply short term liquidity and, (ii) the roll over risk associated with this kind of arbitrage is lower.

[23] Strictly speaking, these transactions do not represent pure arbitrage. The agent must face the risk of not being able to roll over the loan in the domestic currency on a daily basis for three months. This risk may be assessed as significant in times of heightened market stress. However, most central banks have supplied large amounts of liquidity during the crisis, which in turn have led to ample supply of *overnight* funds in the money markets.

[24] Baba, McCauley and Ramaswamy (2009) discuss in more detail how in particular non-US banks turned to foreign exchange swap markets to obtain dollar against European currencies. Baba and Packer (2008) argue that sharp and persistent deviations from the CIP condition are related to differences in counterparty risk between European and US financial institutions.

[25] See Bernanke (2009) for more details on measures taken by Fed.

As the second issue, we now turn to the effect of a dollar liquidity premium on the *OIS-basis*. Essentially, a liquidity premium hits all financial institutions simultaneously[26]. Hence, banks will try to acquire dollar through the forward exchange market when access to other currencies are plentiful. They buy USD and sell local currency spot and sell USD and buy local currency forward, implying a stronger forward rate ($\Delta f<0$) and a lower forward premium. This process will go on as long as financial institutions can acquire dollar through the forward market cheaper as directly in the USD money market. Put differently, the process continues until the forward rate has fallen as much as the dollar premium has risen, i.e. until $\Delta f=-\Delta i_{N,\$}=-\Delta rp_{\$}$. The implication is that the forward premium falls and encounters the effect of the dollar liquidity premium on the local money market premium, hence $\Delta rp_N=0$. In the case of a liquidity premium the dislocation may remain because the currency is relatively scarce creating an excessive demand for this currency in the fx-swap market.[27] This line of arguments can easily be transferred to the T/N-maturity as well. For T/N-maturity it is, however, not necessary to enter an OIS contract since the maturity is only one day. The dislocations in very short term fx-forwards are limited compared to longer terms as central banks very fast increase the supply of short term liquidity and the roll over risk connected to exploiting the dislocation is lower, illustrated by comparing Chart 2 and the *OIS-basis* in Chart 3.

Turning to the third issue, a credit premium is transferred into the local money market premium (in contrast to the liquidity premium) via the fx-forward market. Normally, investors require the same institution-specific credit premium independently of the currency of issuance. Indeed, at the outset, if some banks face higher credit premium in USD than in NOK they may try to acquire dollar through the fx-forward market. They buy USD and sell local currency spot and sell USD and buy local currency forward, analogously to the liquidity premium situation. This will in itself put downward pressure on the forward rate. Let f* denote this new and lower rate. Banks not facing a higher credit premium can now engage in arbitrage and obtain an expected gain because $OIS_N>OIS_\$+(f^*-e)$. This can easily happen because there is no scarcity in US dollar and the credit is readily available. They can borrow USD overnight, roll over the debt daily in three months, enter into a three-month OIS-contract and fix the interest rate of the debt. Initially, they change the dollar for local currency spot, invest the local currency overnight, roll over the investment daily for three months and enter into an OIS contract to fix the interest rate of the investment. Also initially, they can sell forward the amount in local currency resulting from the investment and buy USD at the price f*. At the price f* the gain will be positive. This arbitrage activity will at the same time put an upward pressure on the forward rate ($\Delta f>0$), since local currency is sold forward. This upward pressure on the forward rate will encounter the downward pressure stemming from higher-credit-premium-banks trying to acquire dollar through the forward market. In particular, when the banks with the lower credit premium dominate the market (in size and trading activities), the higher-credit-premium-banks will not manage to influence the forward premium. Hence, banks facing a higher credit premium in USD will continue to use local currencies as funding until investors require identical credit premium in all currencies. Absence of liquidity constraints in both currencies will trigger "arbitrage"

[26] During the financial crisis, banks who did not have access to central bank facilities in Federal Reserve may have been more affected than other banks.
[27] Volume and line constraints between banks may be another source of dislocations. During the financial crisis deleveraging and balance sheet restrictions in the banking sector contributed to the persistence of the dislocation in the foreign exchange forward market even after dollar availability improved and the dislocation in the T/N-swap market disappeared.

activity. This illustrates that the *OIS-basis* expresses the relative liquidity premium between currencies, and is not influenced by the credit premium.[28] [29]

We can now turn to the regression where we focus on the two T/N-variables and the *OIS-basis* as dependent variables. Starting with the *OIS-basis*, a higher usd-premium stemming from a USD liquidity shortage (liquidity premium) will have a negative effect. However, a higher usd-premium stemming from foreign banks (including Norwegian ones) facing a higher credit premium will have no effect on the *OIS-basis*. Hence the estimated coefficient of the usd-premium will reflect to what extent the usd-premium has been a liquidity premium or a credit premium. For example, assume that the coefficient (B_{usd}) is estimated to be -0.7. This means that on average 70 per cent of the usd-premium has been a liquidity premium (which transfers one-to-one to the *OIS-basis*) and 30 per cent a credit premium, which does not transfer to the *OIS-basis* at all.[30] Notice that this interpretation is only possible because the regressions include specific variables supposed to capture the liquidity condition in NOK. If not, it would not be possible to distinguish between the credit premium and the liquidity premium, since the *OIS-basis* represent the relative liquidity premium between the two currencies.

In the regression with the T/N-rates as dependent variables the effect is opposite. A higher usd-premium caused by a USD-liquidity premium does not affect the T/N-premiums at all, the reason being that the forward premium (as reflected in the *OIS-basis*) adjusts one-to-one. Moreover, a higher credit premium affects the T/N-rates in order one-to-one. For example, assume that the coefficient (B_{usd}) is estimated to be 0.3. This means that on average, 30 percent of the usd-premium has been a credit premium, while 70 per cent has been a liquidity premium.[31]

We see that the different regressions provide different ways to measure to what extent a USD-premium will be transferred into the Norwegian money market premium. A priori (at least within our model) a credit premium will be transferred into the Norwegian money market premium in order one-to-one, while a liquidity premium will not affect it at all. A posteriori (averaged over the sample) the estimated coefficient of the USD-premium gives us a share; the share reflects to what extent the USD-premium hit by Norwegian banks has been a liquidity premium faced by all banks or a credit premium faced by Norwegian banks only. With the tomorrow/next-rates as dependent variable the coefficient is the share of the credit premium. With *OIS-basis* as dependent variable, the coefficient is the share of the liquidity premium. Theoretically, the absolute value of the coefficient B_{usd} in the regression with OIS-basis as dependent variable ($|B_{usd,OIS\text{-}basis}|$) plus the coefficient B_{usd} in the regression with the tomorrow/next-variables as dependent variable ($B_{usd,T/N}$) should be unity, i.e. $|B_{usd,OIS\text{-}basis}| + B_{usd,T/N} = 1$.

In sum, both T/N-rates are expected to increase in the *usd*-premium (hence B_{usd} is positive) and the *OIS-basis* is expected to decrease in the *usd*-premium (hence B_{usd} is negative). In the regressions with the overnight rates as dependent variables, the usd-variable may interpreted as a financial volatility variable and the coefficient B_{usd} is expected to be positive.

[28] In practice, the separation between the liquidity and credit premium is less clear than presented here. However, the main point to be made is that the credit premium is not currency specific while the liquidity premium is. The fx-forward market adjusts for the relative liquidity premium between two currencies.

[29] It is possible that counterparty risk could influence the *OIS-basis* through higher market risk (the risk of foreign exchange rate movements in case of a counterparty default) and increased settlement risk.

[30] To be sure, it does not mean that 70 per cent of all changes in the USD-premium transfers to the *OIS-basis*, the USD-premium affects the *OIS-basis* either one-to one (liquidity premium), or not at all (credit premium).

[31] Again, to be sure, it does not mean that 30 per cent of all changes in the USD premium transfers into the Norwegian money market premium. The USD-premium affects the Norwegian money market premium either one-to one (credit premium), or not at all (liquidity premium).

3.4 Data

The dataset used in the regressions starts in January 2007 and ends in September 2011.[32] Holydays and missing data are omitted. In total there are between 1099 and 1129 observations depending on the choice of dependent variable. The variables are precisely defined in Table 1a, while Table 1b shows some standard descriptive statistics of all variables. Figure 2 shows all variables, while table 2 shows the correlation matrix of the variables. Moreover, all variables are stationary, with low p-values of the Dickey-Fuller null hypothesis.

Excess- and structural liquidity, forecast errors, the distribution variable and NONIA are computed and collected from internal sources in Norges Bank.[33] NIDR and T/N-NIBOR are available at Reuters. T/N-Norges Bank and the OIS-basis are computed by Norges Bank, based on fx-forward prices from Reuter Dealing and exchange rate data and broker T/N-rates from Reuters.

4. Results

The models are estimated on the whole sample (1 January 2007 to 30 September 2011) and on three subsample periods. Subsample 1 starts on January 1 2007 and ends on August 1 2008 and covers the period prior to the height of the crisis. The second subsample starts on August 2 2008 and ends on June 1 2009, covering the financial crisis at its height. The last subsample covers the period from June 2 2009 until September 30 2010, i.e., the aftermath of the crisis.

All models are estimated with OLS and reported in Tables 3a-3e, with t-statistics based on Newey-West standard errors. Each table covers the full sample and the three subsamples. We first concentrate on the estimated liquidity effect.

4.1 The liquidity effect

In general, looking at all models over the whole sample and the different subsamples, the data indicates the existence of a liquidity effect, meaning that higher structural and/or excess liquidity reduces the money market premium measured by the five dependent variables. Out of 40 coefficients, only two of them are significant with the wrong (positive) sign, 28 are significant with the expected (negative) sign, while the rest is not significantly different from zero. However, as will be explained below, it is not surprising that some of the coefficients in some of the sub sample periods are not significantly different from zero. Moreover, the whole-period estimates reflect (and disguise) the results of the different sub samples, and to understand the relationship between the money risk premiums and liquidity, we need to go into the subsample results in some detail.

The following results are fairly robust:

- For the full sample regressions, both structural and excess liquidity have a significant effect with the expected negative sign on all dependent variables (except for NIBOR-tomorrow next, on which excess liquidity has no significant effect).

[32] However, chart 1, 2, 3, 4 and 5 are based on data until 18 November 2011.

[33] Excess- and structural liquidity are published at Norges banks webpage www.norges-bank.no. NONIA and the distribution variable are not publicly available.

- In the subsample prior to the crisis (subsample 1), the so to say "normal period" of the three subsamples, structural liquidity is the important liquidity factor driving the money market premiums. While structural liquidity has a significant effect with the expected sign in all of the models, excess liquidity is not significant in any of them (except for the *OIS-basis*, where the estimated effect of excess liquidity is significant, with the expected negative sign).
- In the subsample covering the height of the crisis (subsample 2) total liquidity becomes more important than structural liquidity (except for *T/N-NIBOR*), though structural liquidity still has some explanatory power on the risk premiums.
- In the subsample after the crisis the results are less clear. For *NONIA* structural liquidity seems to be more important than excess liquidity, while for *NIDR* it is opposite. For tomorrow-next calculated by Norges Bank and the *OIS-basis* excess liquidity is important, while structural liquidity is not. Finally, for *NIBOR* tomorrow-next, only structural liquidity is significant.

The estimated effect of excess and structural liquidity on the risk premiums must be interpreted in light of Norges Bank's system for managing reserves during the estimation period. During the whole estimation period, Norges Bank operated within a so-called floor system for managing reserves. As discussed in the introduction, within such a system banks can deposit any amount of reserves at the central bank, all of them being remunerated at the key rate. In a floor system the liquidity policy of the central bank is to supply a sufficient amount of liquidity to the banking system to ensure that the short-term money market rate remains close to the key policy rate. The key policy rate then acts as a floor for the short-term rate, as no banks will lend reserves in the market at a rate lower than the deposit rate at the central bank. In brief, in such a system there are plenty of reserves – or liquidity.

In normal times – within a floor-system – an increase in total reserves does not necessarily have a strong impact on money market premiums. Short-term interest rates are initially close to the key policy rate, and adding reserves to the banking system does not induce banks to lend more reserves in the market, a condition normally seen as necessary to reduce short-term interest rate and hence premiums. Banks simply accept the supply of reserves and want to keep them as overnight deposit at the central bank.[34] The reason is that the cost of holding reserves at the central bank is low, as the reserves are remunerated at the key rate, which again is close to the money market rate of shortest maturity. Hence, the floor-system may explain why excess reserves seem to have only a minor effect on risk premiums in normal times (subsample 1). In contrast, structural liquidity seems to have a larger effect during low volatility periods than during the crisis. One possible explanation is that when structural liquidity is low, banks become more uncertain regarding their own future liquidity position (i.e. their future deposits at the central bank). They therefore try to acquire more reserves in the market, pushing the short-term rate and hence the premium up. Furthermore, lending from the central bank increases when structural liquidity decreases, which in turn may affect the concentration of liquidity intraday. Higher short term interest rates could be the outcome. Liquidity outflow connected to lower structural liquidity may also surprise some banks, which in

[34] Of course, if the banks would try to lend the reserves in the market, the reserves would still end up as overnight deposits at the central bank at the end of the day. The crucial point here, is that banks in a floor system normally do not even have an incentive to try to lend the reserves in the market.

turn may bid up the interest rate. This effect is especially related to the floor-framework, which implies a low alternative cost of hoarding reserves. However, in periods of crisis (subsample 2), total liquidity gains importance in explaining the risk premiums. In periods characterized by high volatility and uncertainty the demand for liquidity increases and substantially more liquidity may be needed to be supplied to prevent short-term rates from rising. Hence, more liquidity may dampen upward pressure on the short-term rate and premiums.

Turning to the more specific results, Tables 3a and 3b report the estimation results for the two overnight rates, NONIA and NIDR. Focusing on the full sample, both rates show the existence of a significant liquidity effect (with the expected negative sign). The estimated coefficients indicate that a one billion increase in excess liquidity and structural liquidity reduces the NONIA-spread by 0.074 and 0.068 basis points, respectively. The liquidity effect in NIDR is somewhat smaller. As mentioned above, there are differences between the sub-samples, with structural liquidity more important in the pre-crisis period and total liquidity more important during the crisis. During the crisis demand for liquidity increased substantially. Norges Bank responded by increasing the supply of liquidity. In addition, maturity of liquidity was extended. This probably reduced the uncertainty related to changes in structural liquidity. Moreover, the effect of the liquidity variables on the premiums, as measured by the estimated coefficients, is larger during the period of crisis. This is no surprise, as liquidity demand is higher in such times.

Table 3c presents the results from the estimations using NIBOR tomorrow-next as the dependent variable. A striking result is that excess liquidity is not significant in the full sample estimation, neither in any of the subsamples. This can be explained by the wide bid/ask forward spreads in the T/N NIBOR-rate, meaning that the spreads are large enough to capture the variation caused by the liquidity effect connected to excess liquidity. The quoted bid/ask spreads in NIBOR widened substantially when the financial crisis hit. The effect of structural liquidity is still negative and significant over the full sample, though a closer look at the subsample periods shows, not surprisingly, that structural liquidity has a significant effect only in sub sample 1, the "normal" pre-crisis period (as NONIA and NIDR).

Tables 3d and 3e show the results from the estimations using respectively the tomorrow-next variable calculated by Norges Bank and the OIS-basis. For both variables a liquidity effect exists. As discussed above, in the normal pre-crisis period (sub sample 1), structural liquidity is important. During the crisis however, excess liquidity gained importance and both structural and excess liquidity have a significant effect. During the crisis (sub sample 2) the coefficients are considerably higher than in the period of normality (sub sample 1). As for the other variables, this indicates that the riskiness connected to large drops in structural liquidity is high. The uncertainty may be related to the fear of Norges Bank not providing sufficient amount of liquidity, uneven distribution of reserves from the liquidity providing operations and insufficient knowledge by foreign banks about the Norwegian framework. As for the third subsample, even if the demand for liquidity decreased, it was far from normalized. This is reflected in both the coefficients and the significance levels in the last subsample.

4.2 The effect of the remaining explanatory variables on the risk premiums

Turning to the other explanatory variables, we first look at the USD-premium. In general, for the whole sample, the USD-premium has a significant effect with the expected sign in all models. However, the full-sample results disguise differences across the sub-samples.

We start with the tomorrow-next variable calculated by Norges Bank (T/N-Norges Bank) and the OIS-basis, respectively Tables 3d and 3e. We should keep in mind the discussion above: If the USD premium reflects a credit premium faced by Norwegian banks, it will be transferred into the tomorrow-next rate premium, but not into the *OIS-basis*. If the higher USD premium is caused by a general liquidity premium, however, it will have a negative effect on the *OIS-basis*, but no effect on the tomorrow-next rate premium. Though this is a strict theoretic result, to be modified in practice as it may be difficult to distinguish a credit premium from a liquidity premium, the estimation results for the T/N-Norges Bank variable and the *OIS-basis* should be interpreted in light of this.

Data indicates that the USD-premium has a significant effect on the *OIS-basis* in sub sample 1 and 2, respectively the period prior to the crisis (but with some turbulence as from the mid of 2007) and the period covering the height of the crisis. The estimated coefficient is around 0.9 in both sub samples. With reference to equation (7) the interpretation is as follows: Assuming the USD premium increases by 100 basis points ($\Delta rp_{\$}=100$), the *OIS-basis* declines by 90 basis points (Δ (f-e) - (OIS_N -$OIS_{\$}$) = -90 bp.), implying that the domestic money market premium increases by 10 basis points ($\Delta rp_N=10$ bp.). This means that on average, the forward exchange market dampened the effect of the USD-premium on the domestic premium by around 90 per cent.[35] Furthermore, it implies that around 90 per cent of the increase in the USD-premium in subsamples 1 and 2 has been due to a USD liquidity premium and 10 per cent due to a credit premium faced by Norwegian banks.[36] This result, which indicates that a liquidity premium is the main source of the USD premium, is consistent with the view that in the period from mid 2007, and in particular during the autumn of 2008, a dollar shortage led to an excessive demand for dollar through the forward exchange market.

At the same time, we see that the estimated effect of the USD-premium on the tomorrow-next rate premium calculated by Norges Bank (Table 3d) is around 0.1 in both subsample 2 and 3. The coefficients are only borderline significant, but for the moment, concentrate on the size of them. The interpretation is that around 10 per cent of the USD-premium has been due to a credit premium and around 90 per cent due to a liquidity premium.

Hence, both regressions suggests that 90 per cent of the USD-premium has been due to a liquidity premium and 10 per cent due to a risk premium. These coefficients are in line with the theoretical discussion above: The absolute value of the coefficient B_{usd} in the regression with *OIS-basis* as dependent variable ($|B_{usd}$,*OIS-basis*$|$) plus the coefficient B_{usd} in the regression with T/N-Norges Bank as dependent variable (B_{usd},*T/N*) should be unity, i.e. $|B_{usd}$,*OIS-basis*$|$ + B_{usd},*T/N* = 1.

For subsamples 1 and 2 a USD liquidity premium (and not a credit premium) was dominant from around mid 2007 and during the height of the crisis. This changes in subsample 3, the period after the height of the crisis. In this period the USD-premium coefficient is considerably lower for the *OIS-basis* and correspondingly larger for the T/N-premium. By the same kind of argument as above, the interpretation is that the USD-

[35] The mechanism is as described in section 3.3: when a liquidity premium hits all financial institutions simultaneously, they will all try to acquire dollar through the forward exchange market. They buy USD and sell local currency spot and sell USD and buy local currency forward, implying a stronger forward rate ($\Delta f<0$) and a lower forward premium.

[36] Since a liquidity premium transfers to the *OIS-basis* in order one-to-one, and the T/N-Norges Bank premium not at all, while a credit premium transfers to the T/N-Norges Bank premium in order one-to-one, and to the *OIS-basis* not at all.

premium in this period was stemming from a credit premium and not a liquidity premium. During this period, central banks, in particular Fed, supplied a substantial amount of USD to market participants. This reduced the USD liquidity premium. A higher credit premium faced by the NIBOR-banks may be the result of the European sovereign crisis, where European and Norwegian banks, at least to some extent, may have been considered as belonging to the same group of banks with higher credit risk. However, though the effect of the USD premium on the T/N-rate premium is significant, the size of the coefficient is low, meaning that the credit premium faced by NIBOR-banks is not very high.

Turning to the results for the tomorrow-next rate quoted by the NIBOR banks (T/N-NIBOR, Table 3c), it is striking that the USD premium has a significant effect in sub sample 2, the height of the crisis, while the effect is less (with at most borderline significance) on the tomorrow-next rate calculated by Norges Bank (T/N-Norges Bank, Table 3d). This may be due to wide bid/ask spreads in T/N-NIBOR. During subsample 2 bid/ask spreads in the fx-forward market widened substantially as a response to higher liquidity risk. Norges Banks own fx-forward sample consists of trades within the quoted spread on Reuters. Fluctuations in the USD-premium, which mostly consisted of a liquidity premium, was then offset by fx-forwards in real forward trades, while wide bid/ask spreads made it unnecessary to adjust quoted forward prices. The USD-premium also has a significant effect on the two overnight rates NONIA and NIDR, respectively Tables 3a and 3b, notably in subsample 2, the height of the crisis. The overnight rates are not directly affected by the usd-rate like the T/N-rates, but this variable may be interpreted as a measure of general risk.

Turning to the distribution variable, it has no significant effect on NONIA, but has a significant effect on NIDR in subsample 1. NONIA is measured as actual trades observed in the settlement system. Anecdotal information suggests a "gentlemen agreement" among banks in the overnight-market, meaning that a supplier of liquidity, anticipating that he or she can be on the other side of the market another day, accepts rates close to the key rate. This reduces the interest rate variability and may explain why the distribution-variable has no significant effect on NONIA. In contrast, NIDR is a quoted rate in which the participating banks are committed to quote binding prices for 250 mill NOK at the fixing (14pm for the O/N-rate). The three contributing banks, Danske Bank, DNB and Nordea are the main market participants in the O/N-market. When reserves are unevenly distributed one or more of the panel banks may have to raise their contributions to signal liquidity constraints. Finally, the distribution variable also affects the fx-forward market. Again, the distribution variable is only significant in the subsample 1. When excess reserves are limited, the distribution of these reserves matter. This effect may be pronounced by the floor system and the market structure in Norway.

Forecast errors are not significant for any of the dependent variables, except for NONIA. This result supports the hypothesis that a floor system simplifies the liquidity management by reducing the impact of forecast errors.[37]

The forward bid/ask spread variable (sprd) is significant only for NIDR (Table 3b) and TN-NIBOR (Table 3c). The reason may once again be related to the fact that they are quoted, while the other variables are traded. The bid/ask spread may be seen as a volatility indicator. Quoted rates, where the banks commit to a volume at the quoted price, normally means higher bid/ask spreads and the interest rate increase. Actually

[37] It is somewhat difficult to explain the NONIA result as the sign is opposite of what we expected a priori.

trades may not be affected of this increase in volatility. The dummy variable for end of quarter effects is included to control for window dressing. Banks have to pay fees related to deposit guarantee. This fee is related to the size of the balance sheet and banks may want to trim down their balance sheets as much as possible. This effect is especially pronounced for NIDR (Table 3b)

4.3 Rolling window regressions

Figure 2 presents the t-statistics from a 100 day window rolling regressions using the OIS-basis as the dependent variable. This supplements the picture from the subsample results presented in Table 3e. First, as discussed above, the distribution variable is only significant pre-crisis. It is reasonable to believe that the effect of the distribution of reserves decrease when excess reserves increases. Like in the subsample results (Table 3e) this is also confirmed by the rolling regressions. Furthermore, excess liquidity is not significant in a large part of the pre crisis period. Remember that the amount of excess liquidity has to be evaluated in relation to the demand. The results may indicate that the supply of reserves were plentiful relative to the demand in the pre crisis period. After Lehman, however, the demand curve shifted outwards, collateral constraints became a binding factor and banks hoarded reserves. This indicates that the amount of reserves was closer to the buckling point of the demand curve after Lehman. In contrast, structural liquidity were significant pre Lehman, but less so after. This reconfirms our subsample regressions and is related to uncertainty about the effect on individual banks outflow of reserves. This effect became less important when the banks were flooded with reserves after Lehman and the maturity of the loans from the central bank was extended.

The results from the rolling regressions for the forecast error variable supports that this variable is not significant. The forward spread-variable varies across the sample, and this may be related to large variations in the risk-aversion. The USD-spread variable is negative and significant until the liquidity condition in USD improved substantially. The first Quantitative Easing (QE1) program contributed to considerable excess liquidity in USD. In 2011 the USD- premium (usd) again became significant as signs of dollar shortage appeared connected with the rise of the European debt crisis.

4.4 Robustness

Tables 4, 5 and 6 provide the results from robustness tests, all based on estimations using the *OIS-basis*. Table 4 (regression 2) indicates that the results are robust including the change in the liquidity variables and they do not alter the results. One may argue that the T/N-rate is influenced by the expected liquidity tomorrow rather than the liquidity today. However, by including one lead for the liquidity variables (table 4, regression 3), the results remain almost unaffected. Table 4 (regression 4) includes the lead variables for the liquidity measures but excludes the original liquidity variables. The lead variables then become significant but with a bit lower coefficient for excess liquidity.

Table 5 presents the result including excess liquidity in logarithmic form. This is to capture an eventual non-linaer effect when excess liquidity increases way above its normal level. The results from Table 5 indicates that this does not improve the model. Excess liquidity is still negative and significant over the sample period. The subsample development is also similar to the base model.

Table 6 present the results from table 3e replacing the *OIS-basis* with the first differences of the *OIS-basis*. Over the full sample period, only the end of quarter dummy is significant, indicating that my model explains the level rather than the changes in the forward market. The results change remarkable when the USD-spread is eliminated. This variable is a highly significant variable and should be included in the estimations.

5. Conclusion

This paper investigates the liquidity effect in Norway by analyzing the relationship between different measures of the short-term interest rate premium, the amount of reserves and several other variables that potential could affect the money market premiums. The models have been estimated on the period from the beginning of January 2007 up to the end of September 2011 and also on subsamples covering the period prior to, under and after the financial crisis. The study provides additional insight in the division between the liquidity premium and the credit premium in USD. The liquidity premium is separated from the credit premium in a way, to my knowledge, not done in earlier literature.

A new dependent variable is used to isolate the impact of central bank reserves on forward exchange (fx) forwards. By constructing a cross currency forward premium based on expected policy rates (OIS rates) and compare this to the actual fx-forward premium in the market I have isolated the effect of central bank reserves on fx-forward prices. By using this new dependent variable and the tomorrow-next variables in the regressions, I have separated the effect of a liquidity premium from that of a credit premium. Hence it is possible to say to what extent a USD-premium hit by Norwegian banks has been a liquidity premium faced by all banks or a credit premium faced by Norwegian banks only.

For the whole period covering all subsamples, both structural and excess liquidity have a significant effect with the expected negative sign on almost all dependent variables. In the sub-sample prior to the crisis structural liquidity is the important liquidity factor driving the money market premiums. While structural liquidity has a significant effect with the expected sign in all of the models, excess liquidity has no significant effect in almost none of them. In the sub-sample covering the height of the crisis excess liquidity becomes more important than structural liquidity, though structural liquidity still has some explanatory power on the risk premiums.

Moreover, when excess liquidity is at normal levels, the results indicates that the distribution of the liquidity is important. The analysis also shows contagion effects of the USD interbank premium on the Norwegian interbank premiums. However, during the financial crisis the liquidity premium was the main contributor to the increase in the USD premium. This is confirmed by my results which show that around 85 per cent of the premium increase in USD was eliminated through the fx-forward market during the height of the financial crisis.

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Table 1a : Variables

Explanatory Variables	A priori sign	Explanation
Ex.liq	-	Excess liquidity (reserves) in the banking system. Equal to the sum of each indivdual banks deposits in Norges Bank
Str.liq	-	The therotical sum of banks deposits before Norges Banks market operations.
Err	-	Norges Banks forecast errors. Actual outcome minus forecast.
Dist	+	A measure of how equal distributed the reserves are. Higher value indicates less equal distribution of reserves.
Sprd	+	Bid/Ask spread in the forward market, measured by trades from Reuters Dealing
Usd	- (+)	A proxy for the risk premium in USD. Measured as a weigthed average between Kliemm and Tullett Prebon T/N rate minus Fed Funds target. Expected to be negative for the OIS-basis, and positive for the rest of the dependent variables.
eoq Dummy	+	End of quarter dummy. Because of window dressing expected to be positive

Dependent Variables	
NONIA	NONIA, O/N rate calculated by Norges Bank based on transactions from the settlement system.
NIDR	Offical Norwegian deposit rate (O/N-rate). Only three panel banks.
NIBOR	Tomorrow Next NIBOR quoted on Reuters. Six panel banks and quoted with large bid/ask spread
Norges-Bank T/N	Tomorrow Next rate calculated by Norges Bank with our own estimate of the USD rate and forwardpoints from Reuter Dealing
OIS-basis	Difference between theoretical forward points and actual forward points from Reuter dealing

Table 1b: Descriptive statistics

Explanatory variables

	Excess Liqudiity	Structural liquidity	Forecast Errors	Liquidity distribution	Forward Spread	USD spread
Mean	47485.19	-17109.56	-125.9738	0.283896	0.141362	0.18456
Median	42488.5	-15474	-92	0.270249	0.05	0.085
Maximum	129453	69358.13	16004	0.687214	9.4	6.5
Minimum	8985	-110215	-18417	0.061599	-7	-0.49
Std. Dev.	24477.27	34892.08	2967.29	0.11029	0.540662	0.503028
Skewness	0.935927	-0.183072	-0.239722	0.624744	6.10927	8.152779
Kurtosis	3.429748	2.606797	10.11831	3.050665	141.4705	85.72251
Jarque-Bera	169.3647	13.25479	2337.168	71.80384	887264.2	326416.3
Probability	0	0.001324	0	0	0	0
Sum	52328676	-18854735	-138823.1	312.8534	155.7806	203.385
Sum Sq. Dev.	6.60E+11	1.34E+12	9.69E+09	13.39239	321.8396	278.594
Observations	1102	1102	1102	1102	1102	1102

Dependent variables

	OIS-basis	NIBOR T/N	NIDR	NONIA	Norges Bank T/N
Mean	-4.206105	0.358126	0.134881	0.114229	0.177404
Median	2.927969	0.32	0.1167	0.09399	0.162023
Maximum	98.8393	2.56	1.1	0.924077	1.854167
Minimum	-659.4298	-0.75	0.0467	-0.036272	-1.196719
Std. Dev.	43.33792	0.242165	0.095732	0.092403	0.203564
Skewness	-8.499528	3.899445	6.613199	3.171238	0.707496
Kurtosis	103.4747	28.66546	56.93601	18.93353	15.96691
Jarque-Bera	447815.4	31030.1	132998.8	12683.25	7337.412
Probability	0	0	0	0	0
Sum	-4353.318	370.66	139.6023	118.227	183.6133
Sum Sq. Dev.	1942033	60.63776	9.476114	8.828698	42.84734
Observations	1035	1035	1035	1035	1035

Table 2: Correlation Matrix

Probability	OIS-basis	NIBOR	NIDR	NONIA	Norges Bank T/N	Ex.liq	Str.liq	Err	Dist	Sprd	Usd
OIS-basis	1										

NIBOR	-0.237226	1									
	0	-----									
NIDR	-0.237008	0.370650	1								
	0	*0*	-----								
NONIA	-0.287258	0.725333	0.446069	1							
	0	*0*	*0*	-----							
Norges Bank T/N	0.174038	0.509283	0.289120	0.534378	1						
	0	*0*	*0*	*0*	-----						
Ex.liq	-0.138013	-0.064944	-0.129215	-0.233940	-0.3232	1					
	0	0.066	0.0001	0	0.00E+00	-----					
Str.liq	0.017671	-0.207096	-0.139918	-0.355476	-0.329629	0.242962	1				
	0.535	*0*	*0*	*0*	*0*	*0*	-----				
Err	-0.021456	0.025173	-0.045630	0.038788	0.000761	0.048335	-0.002050	1			
	0.5176	*0.6268*	*3.43E-01*	*0.2628*	*0.8856*	*0.1534*	*0.8567*	-----			
Dist	-0.101677	0.027346	0.019134	-0.005886	0.010641	0.362020	0.029404	0.036186	1		
	0.0015	*0.2348*	*0.4786*	*0.9721*	*0.5163*	*0*	*0.4202*	*0.2624*	-----		
Sprd	-0.428737	0.338840	0.218908	0.335148	0.107689	0.136175	-0.023291	0.041075	0.07061	1	
	0	*0*	*0*	*0*	*0.0002*	*0*	*0.457*	*0.1737*	*0.0367*	-----	
Usd	-0.772394	0.586202	0.411009	0.534322	0.319211	0.008515	-0.148371	-0.001055	0.12845	0.438515	1
	0	*0*	*0*	*0*	*0*	*0.9046*	*0*	*0.7536*	*0.0008*	*0*	-----

The sample period goes from 01.01.2007 - 30.09. 2011 with 1022 observations after adjustment. P-values in italics, of the null hypothesis of no correlation.

Table 3a: Results with NONIA as dependent variable

Dependent variable: Overnight-rate (NONIA)	(1) Full Sample			(2) Sample period: 1/1/07-1/8/08			(3) Sample period: 2/8/08-1/6/09			(4) Sample period: 2/6/09-30/9/11		
	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat	
Ex.liq	-0.0741	-4.19	***	0.0340	0.75		-0.1200	-3.22	***	-0.0363	-2.23	**
Str.liq	-0.0687	-5.49	***	-0.0867	-4.56	***	0.0839	2.17	**	-0.0372	-4.91	***
Err	0.1870	2.86	***	0.0132	0.11		0.6660	2.40	**	0.0224	0.78	
Dist												
Sprd	0.01926	1.75	*	0.00026	0.05		0.01880	1.37		-0.002065	-1.76	*
Usd	0.09271	5.29	***	0.0897	2.67	***	0.08038	3.92	***	0.142721	4.52	***
eoq Dummy	0.0528	2.50	**	0.0549	1.28		0.07538	1.95	*	0.033571	1.57	
$Dist_{-1}$	0.0168	0.60		0.05624	1.70	*	-0.2162	-1.46		-0.003429	-0.17	
Adj R^2	0.44			0.36			0.44			0.36		
Num.Obs	1076			339			183			554		

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects
The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Table 3b: Results with NIDR as dependent variable

Dependent variable: Overnight-rate (NIDR)	(1) Full Sample			(2) Sample period: 1/1/07-1/8/08			(3) Sample period: 2/8/08-1/6/09			(4) Sample period: 2/6/09-30/9/11		
	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat	
Ex.liq	-0.0529	-6.34	***	-0.00328	-0.93		-0.0625	-2.54	**	-0.0461	-4.36	***
Str.liq	-0.0220	-2.87	***	-0.0454	-4.03	***	0.0164	0.64		0.00479	0.78	
Err	0.0352	0.52		-0.0864	-1.08		0.3030	1.93	*	0.0900	1.24	
Dist												
Sprd	0.01543	2.43	**	-0.0473	-1.20		0.0141	2.40	**	-0.00165	-0.28	
Usd	0.0649	13.02	***	0.06067	2.40	**	0.06605	11.1	***	0.05054	1.87	*
eoq Dummy	0.56782	5.67	***	0.32158	2.21	**	0.541036	1.99	**	0.75926	7.01	***
$Dist_1$	0.03004	1.54		0.06598	2.44	**	-0.048	-0.64		0.01902	0.78	
Adj R^2	0.65			0.42			0.68			0.84		
Num.Obs	1020			340			182			498		

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects

The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Table 3c: Results with NIBOR T/N as dependent variable

Dependent variable: NIBOR Tomorrow-Next rate (NIBOR)	(1) Full Sample			(2) Sample period: 1/1/07-1/8/08			(3) Sample period: 2/8/08-1/6/09			(4) Sample period: 2/6/09-30/9/11		
	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat	
Ex.liq	-0.0545	-1.05		-0.02905	-0.25		0.03588	0.29		-0.03551	-0.59	
Str.liq	-0.1131	-4.00	***	-0.08089	-2.24	**	-0.07917	-0.61		-0.08657	-3.26	***
Err	0.2791	1.23		-0.38253	-1.38		0.65516	0.54		0.229186	1.67	*
Dist	-0.028431	-0.34		0.14010	2.13	**	-0.9010	-1.86	*	0.01727	0.18	
Sprd	0.050746	2.08	**	0.02011	0.24		0.056707	2.77	***	-0.0157	-1.70	*
Usd	0.26013	7.00	***	0.06877	1.06		0.25900	6.03	***	0.1281	1.18	
eoq Dummy	-0.0456	-0.89		0.08327	1.41		-0.242934	-1.11		-0.02246	-0.64	
Adj R^2	0.36			0.09			0.36			0.08		
Num.Obs	1097			346			186			565		

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects

The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Table 3d: Results with T/N-Norges Bank as dependent variable

Dependent variable: Tomorrow-Next rate (Norges Bank T/N)	(1) Full Sample			(2) Sample period: 1/1/07-1/8/08			(3) Sample period: 2/8/08-1/6/09			(4) Sample period: 2/6/09-30/9/11		
	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat	
Ex.liq	-0.24748	-5.85	***	-0.13104	-1.28		-0.32700	-3.41	***	-0.2063	-3.49	**
Str.liq	-0.13803	-6.00	***	-0.14522	-3.79	***	-0.32100	-2.81	**	-0.0383	-1.24	
Err	0.14627	0.73		0.19693	0.74		0.54800	0.42		0.0646	0.56	
Dist	0.15459	2.50	**	0.112985	1.39		0.274090	0.73		-0.0085	-0.16	
Sprd	0.01180	0.88		-0.052781	-0.38		0.027142	1.04		0.00765	1.12	
Usd	0.10627	2.37	**	0.097637	1.12		0.068567	1.62		0.6074	4.55	***
eoq Dummy	0.13323	1.88	*	0.033016	0.31		0.719320	1.91	*	0.0296	0.93	
Adj R^2	0.27			0.15			0.26			0.29		
Num.Obs	1099			344			185			570		

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects

The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Table 3e: Results with the OIS-basis as dependent variable

Dependent variable: Tomorrow-Next rate (OIS-basis)	(1) Full Sample			(2) Sample period: 1/1/07-1/8/08			(3) Sample period: 2/8/08-1/6/09			(4) Sample period: 2/6/09-30/9/11		
	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat	
Ex.liq	-0.24504	-4.56	***	-0.19843	-1.96	**	-0.4300	-2.49	**	-0.20387	-3.53	***
Str.liq	-0.11939	-4.45	***	-0.13999	-3.79	***	-0.2730	-1.72	*	-0.03609	-1.17	
Err	-0.20070	-0.58		0.17292	0.70		-0.1978	-0.75		0.03729	0.30	
Dist	20.6857	2.86	***	18.6330	2.31	**	44.360	0.74		0.42289	0.07	
Sprd	7.7549	1.17		11.5885	1.17		11.789	1.31		0.84534	1.60	
Usd	-0.83881	-9.15	***	-0.9219	-10.9	***	-0.8685	-7.91	***	-0.37107	-2.85	***
eoq Dummy	13.1223	1.93	*	3.68323	0.36		65.439	1.76	*	3.81594	1.11	
Adj R^2	0.67			0.63			0.66			0.29		
Num.Obs	1102			346			186			570		

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects

The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Table 4: Results with the OIS-basis as dependent variable (full-sample estimations)

Dependent variable:	(1)			(2)			(3)			(4)		
Tomorrow-Next rate	Full Sample			Full Sample			Full Sample			Full Sample		
(OIS-basis)	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat	
Ex.liq				-0.25093	-4.68	***	-0.124	-1.01				
Str.liq				-0.11683	-4.24	***	-0.164	-2.24	**			
Err	-0.238	-0.67		-0.23922	-0.68		-0.242	-0.69		-0.3950	-1.15	
Dist	14.3461	2.12	**	20.5041	2.82	***	20.560	2.83	**	20.406	2.79	**
Sprd	7.5511	1.14		7.70786	1.17		7.7089	1.17		7.5912	1.15	
Usd	-0.83652	-9.10	***	-0.83931	-9.13	***	-0.839	-9.13	***	-0.8386	-9.06	***
eoq Dummy	10.044	1.44		12.6871	1.83	*	12.680	1.82	*	11.0349	1.68	*
ΔEx.liq				0.12532	1.05							
ΔStr.liq				-0.04844	-0.64							
Ex.liq-1							-0.127	-1.06		-0.2440	-4.71	***
Str.liq-1							0.0468	0.62		-0.1080	-3.99	***
Ex.liq+1	-0.18500	-3.74	***									
Str.liq+1	-0.13100	-7.78	***									
Adj R^2	0.67			0.68			0.68			0.67		
Num.Obs	1102			1102			1102			1102		

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects

The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Table 5: Results with the ∆OIS-basis as dependent variable

Dependent variable: Tomorrow-Next rate (∆OIS-basis)	(1) Full sample			(2) Sample period: 1/1/07-1/8/08			(3) Sample period: 2/8/08-1/6/09			(4) Sample period: 2/6/09-30/9/11	
	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat
Ex.liq	-0.09153	-1.62		0.05030	0.40		-0.56300	-1.75	*	-0.00553	-0.25
Str.liq	-0.04708	-1.25		-0.06158	-1.83	*	0.04830	0.24		0.00916	0.87
Err	0.55441	1.52		-0.22406	-0.50		3.30600	1.73	*	-0.09990	-0.68
Dist	14.5729	1.43		8.01455	0.81		44.94094	0.50		-1.03549	-0.41
Sprd	0.55441	0.09		-31.510	-1.54		-3.141885	-0.29		0.62522	1.42
Usd	-0.26568	-1.45		-0.35285	-2.14	**	-36.20123	-1.51		0.00953	0.23
eoq Dummy	34.3140	2.01	**	36.2306	2.53	**	173.1381	1.97	*	2.45990	0.57
Adj R^2	0.09			0.22			0.16			-0.05	
Num.Obs	1024			311			175			538	

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects

The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Table 6: Results with the OIS-basis as dependent variable

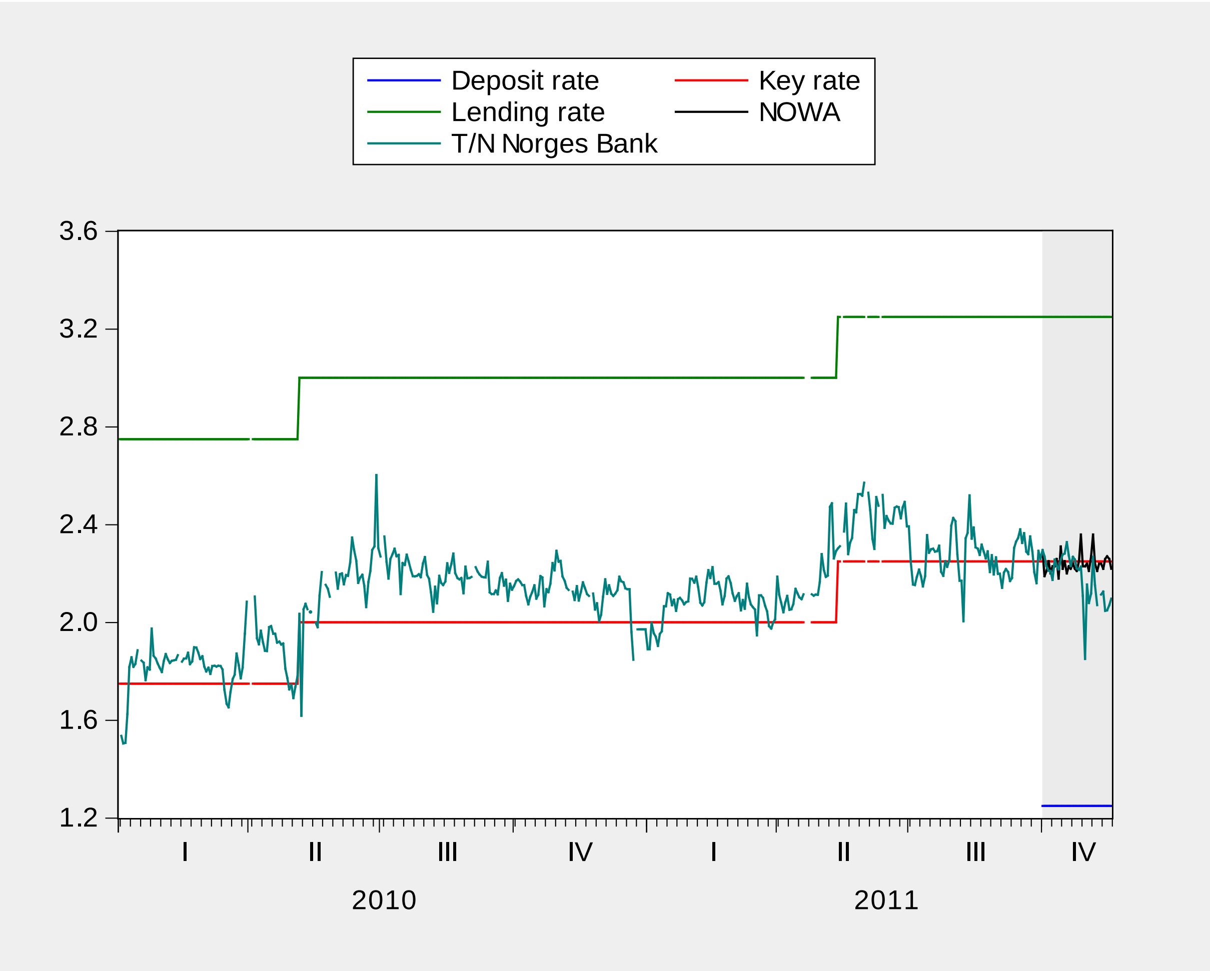
Dependent variable:	(1)			(2)			(3)		(4)	
Tomorrow-Next rate (OIS-basis)	Full sample			Full sample						
	Coeff.	t-stat		Coeff.	t-stat		Coeff.	t-stat	Coeff.	t-stat
Ex.liq (Log)	(-10.2886)	(-4.56)	***	-0.21595	-1.81	*				
Str.liq	-0.123870	-4.68	***	0.06689	1.62					
Err	-0.15898	-0.46		-0.05007	-0.14					
Dist	18.6879	2.56	**	-36.5922	-1.28					
Sprd	7.60349	1.15		-2.98224	-0.19					
Usd	-0.83854	-9.10	***							
eoq Dummy	13.7553	2.02	**	-9.54181	-0.79					
Adj R^2	0.67			0.02						
Num.Obs	1102			1102						

Ex.liq = Excess liquidity measured as available reserves for the banking system after market operations; Str.liq = Structural liquidity measured as available reserves before central bank market operations; Err = Forecast errors made by the central bank; Dist = distribution of reserves measured as the share of the bank with largest deposit in the central bank; Sprd = Bid/Ask spread in the forward market; Usd = spread between key policy rate and the T/N rate in US; eoq Dummy = Dummy for end of quarter effects

The models have been estimated using Newy-West estimator using robust standard errors. The symbols *,** and *** represent significance levels of 10 per cent, 5 per cent and 1 per cent respectively.

Chart 1

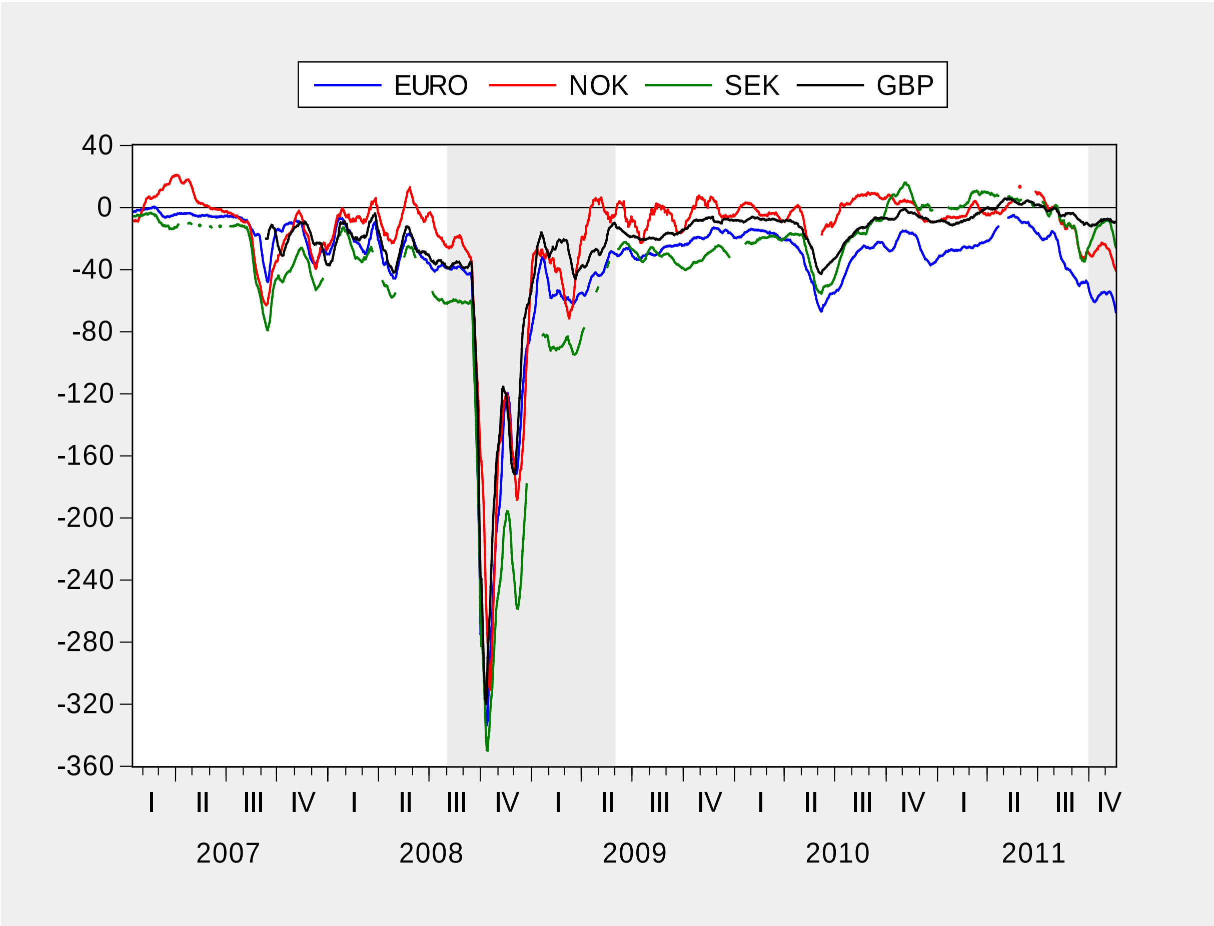
Norges Bank's key rate, the lending and the deposit rate, T/N calculated by Norges Bank and NOWA.[38] *Per cent. 1. January 2010-18. November 2011. Daily data. Source: Norges Bank*



[38] The shaded area represents the period from 3 October 2011 to 18 November 2011. The new liquidity management framework was introduced 3 October 2011. This period is not included in the results reported in table 3 to table 6.

Chart 2

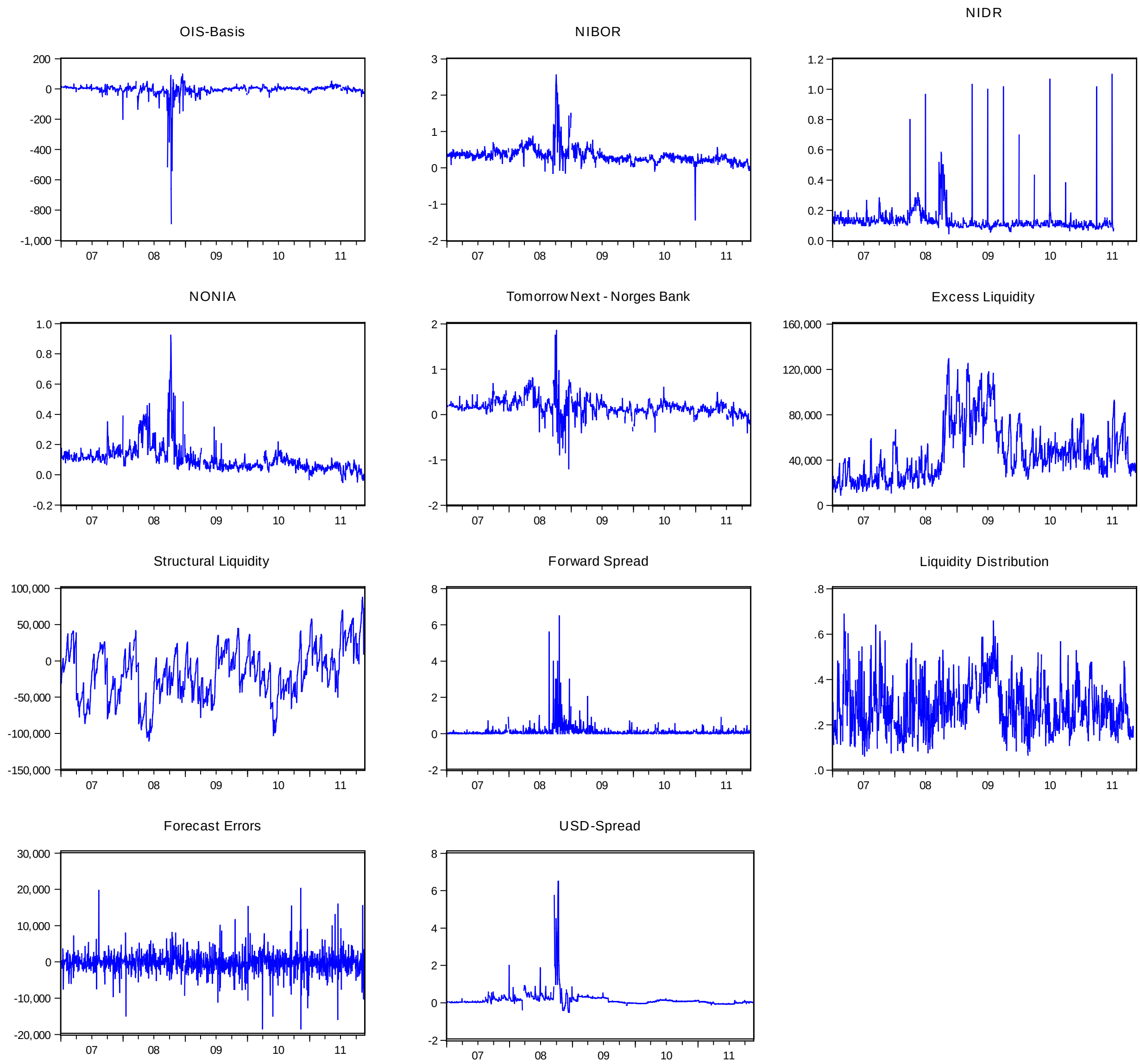
OIS-basis: the difference between the forward premium and the OIS-differential for NOK, SEK, GBP and EUR, all relative to USD.[39] *Basis points. 3 month maturity. 10-days moving average, 1 January 2007 – 18 November 2011. Source: Reuters and Norges Bank*



[39] The shaded area represents the period from 3 October 2011 to 18 November 2011. The new liquidity management framework was introduced 3 October 2011. This period is not included in the results reported in table 3 to table 7.

Chart 3

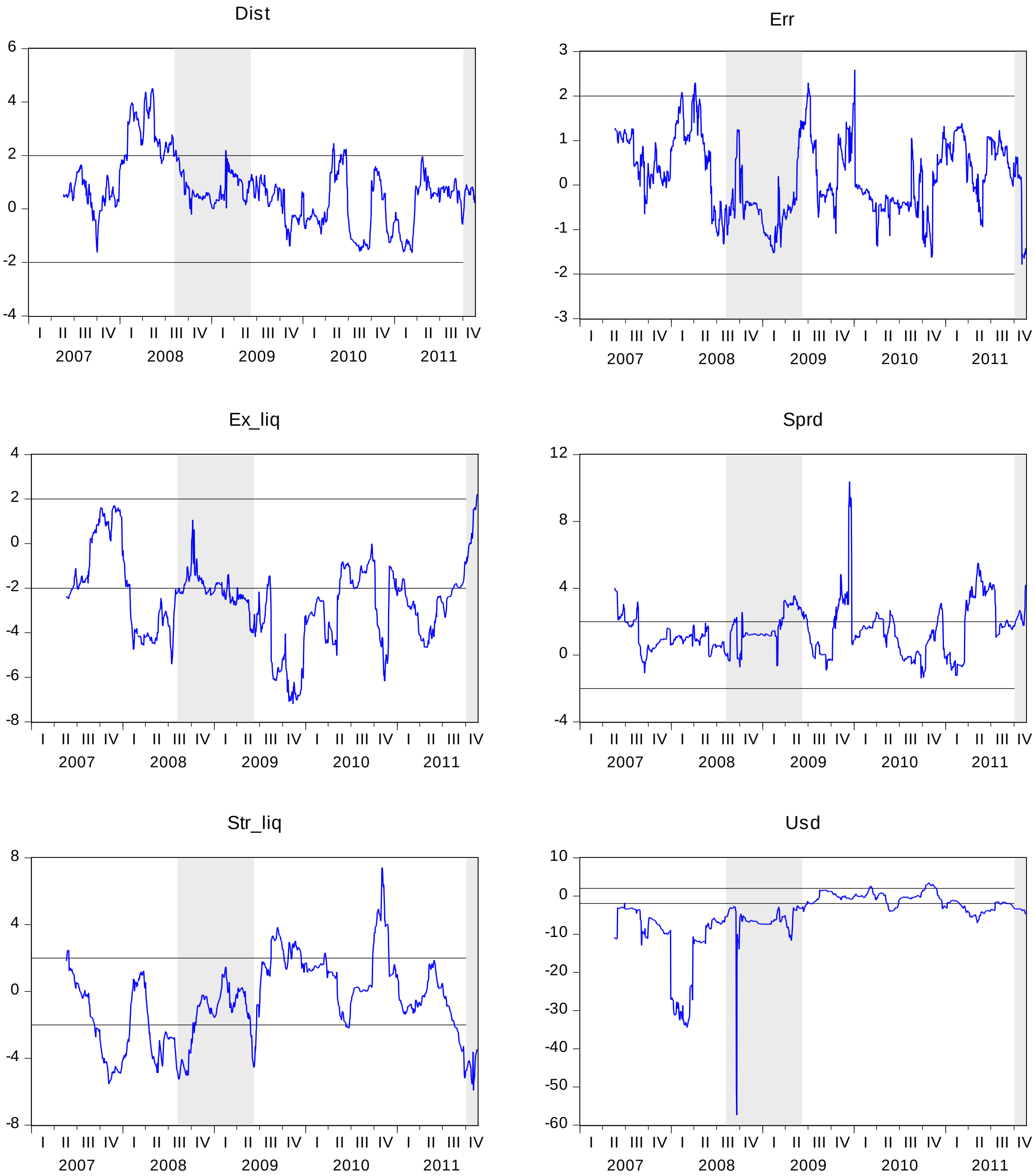
Dependent and explanatory variables variables[40]



[40] The OIS-Basis is measured in basis points, NIBOR T/N, NIDR, NONIA and Norges Bank T/N is in per cent. Structural liquidity, Excess liquidity and Forecast errors are in 1000 NOK, but coefficients are scaled in the estimations such that they represent the effect of one billion changes in basis points. The forward spread is measured in forward points, the USD-spread in per cent and the Liquidity distribution in per cent.

Chart 4

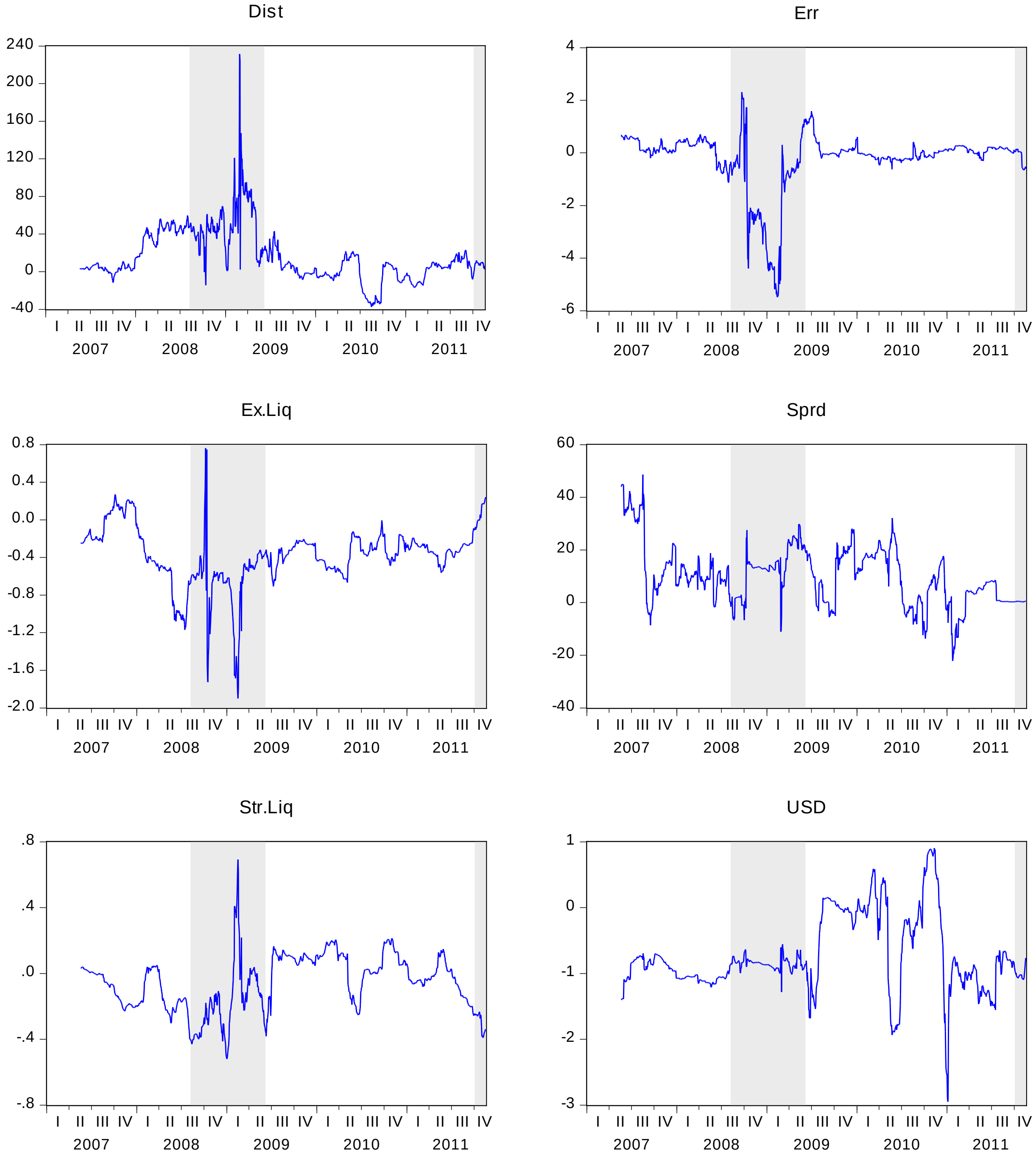
T-stats from rolling window regressions with the OIS-basis as dependent variable[41]



[41] Regressions based on 100 observations, rolling one step forward. Estimations are based on the regression model in table 3e (1). The first shaded area indicates the crisis and goes from 1.8.2008 until 1.6.2009. The second shaded area goes from 30.9.2011 to 18.11.2011, in which Norges Bank has operated in their new liquidity management system. This data period is not included in tables. The horizontal lines indicate 5 per cent significance level.

Chart 5

Coefficients from rolling window regressions with the OIS-basis as dependent variable[42]



[42] Regressions based on 100 observations, rolling one step forward. Estimations are based on the regression model in table 3e (1). The first shaded area indicates the crisis and goes from 1.8.2008 until 1.6.2009. The second shaded area goes from 30.9.2011 to 18.11.2011, in which Norges Bank has operated in their new liquidity management system. This data period is not included in tables.