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Risk premiums in NIBOR and other countries' interbank lending rates

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Interbank interest rates such as three- and six-month LIBOR, EURIBOR, STIBOR and NIBOR play an important role as benchmark rates for a number of loan contracts and various types of derivatives. Interbank rates are intended to express the cost of unsecured lending by one bank to another. During the financial crisis in autumn 2008, both NIBOR and other countries' interbank rates rose markedly in relation to central bank key rates. An extra risk premium in interbank rates reflected higher counterparty risk among banks and reduced willingness to provide liquidity. Since the financial crisis, these risk premiums in interbank rates have fluctuated more and have been considerably higher than prior to the crisis. The risk premium in NIBOR has for long periods been higher than premiums in other countries' rates. NIBOR has traditionally been derived from the interbank rate for USD and the interest rate differential between NOK and USD from the forward exchange market (forward premium). A characteristic of benchmark rates such as LIBOR, EURIBOR and NIBOR, and the USD rate on which NIBOR quoting is based, is that they are indicative. In the three-month segment of the unsecured interbank market, which is the most important point of reference, there are very few transactions, not only between Norwegian banks, but also internationally. This raises the question of whether these benchmark rates possess the characteristics a benchmark rate should have, not only with regard to NIBOR, but also to other countries' benchmark rates. The recent development with Libor manipulation (the Barclays scandal) confirms this. This Staff Memo presents an analysis of developments in NIBOR over the past few years. We show how NIBOR is influenced by developments in the NOK-USD forward exchange market. A key aspect is how the forward exchange market can dampen the impact of the USD premium on the NOK premium. Equally important is how NIBOR will depend on which USD rate banks apply in their NIBOR quoting. This dollar rate appears to be high compared to the rate the most solid Nordic banks actually pay for short-term dollar funding.

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1. Introduction

The most important instrument Norges Bank has to influence economic developments is the key policy rate. The key policy rate is the rate of interest on banks' overnight deposits in Norges Bank (up to a specified quota).[2] The key policy rate influences economic developments primarily through its impact on other interest rates set in private loan markets. These more long-term rates are influenced by the current key policy rate and expectations as to the key policy rate ahead. Three times a year, Norges Bank publishes projections for the key policy rate for the coming three to four years, providing an indication to market participants of Norges Bank's assessment of the most probable path for the key policy rate ahead. This provides a better basis for market expectations and the interest rates set by market participants in their own loan contracts.

Before the onset of the financial crisis in 2007-2008, market rates with different maturities provided a good indication of market participants' expectations with regard to the key policy rate over the following couple of years. Through the financial crisis, risk premiums in private loan markets rose sharply. Such premiums are an addition to market rates on top of the effect of the expected key policy rate. When risk premiums rise, market rates can increase even if Norges Bank has not changed the key policy rate or given any signals indicating a change in monetary policy ahead. In recent years, risk premiums have in periods been unusually high, both in money markets and in long-term private bond markets. This *Staff Memo* focuses on the money market and discusses how risk premiums in money market rates are determined, in theory and in practice.

Section 2 deals with the money market in general, while Section 3 focuses on interest rates in the interbank market. Section 4 examines the Norwegian benchmark interest rate NIBOR and Section 5 discusses a model for the interest rate premium in NIBOR and the so-called forward premium. We show how NIBOR is determined by the USD rate banks apply in their NIBOR quoting and the forward premium in the forward exchange market. Section 6 examines how the forward premium, or the so-called OIS basis, has developed for different countries after the financial turbulence intensified in the second half of 2007. Changes in forward premiums had considerable influence on the effect of the interest rate premium in USD on the interest rate premium in NOK. Section 7 examines the USD rate NIBOR banks apply in their NIBOR quoting. We refer to some possible alternative USD rates that could be applied and present some arguments for and against these alternatives. Section 8 concludes, followed by appendices containing a mathematical presentation of parts of the analysis.

[2] For a more detailed description of how quotas are calculated and Norges Bank's liquidity management system in general, see www.norges-bank.no, under the tab "Price stability" / "Liquidity management".

2. What is the money market?

The money market is a generic term for markets where market participants can invest and raise loans with a maturity of up to one year. The money market consists of a number of different loan markets. The commercial paper market is one of the most active segments of the money market, where both banks and non-financial corporations can raise short-term loans. The commercial paper market in the US is particularly large and important for US and non-US banks alike. Most large banks, including the largest Nordic banks, regularly issue commercial papers in the US market through established programs. Buyers include both banks and institutional/private investors. A Norwegian bank borrows USD in the US commercial paper market either to fund its USD lending or investment or to fund its NOK lending or investment. In the latter case, the bank swaps USD for NOK in a currency swap with the same maturity as the USD loan. The implied interest rate in NOK the bank has to pay for its funding is derived from the interest rate on the loan in USD plus the interest rate differential between the two currencies in the swap. Non-US banks use the US commercial paper market to obtain short-term funding because they can borrow on a larger scale and/or at lower rates than in domestic markets. Activity in this money market segment is high.

Another segment of the money market is the interbank market. Interbank loans are either unsecured or secured. Secured interbank loans are often in the form of repurchase agreements (repos), where the lender receives collateral in the form of securities. The borrower continues to receive interest as it accrues, but in the event of default, ownership of the securities passes to the lender. The lender can then cover the loss incurred by selling the securities in the market.

A currency swap between two banks can also be regarded as a secured interbank loan. It differs from a repo in that the lender receives collateral in the form of another currency, not in the form of securities. The parties in a currency swap exchange currencies at current spot rates in the foreign exchange market and agree to return the currencies at a future date at a rate agreed on at the start. This future rate is called the forward rate. The difference between the spot rate and the forward rate, the forward premium, corresponds to the interest rate differential between the two currencies during the contract term.

The best known segment of the money market is the unsecured interbank market, where banks can borrow from and lend to other banks. It is in this segment of the money market we find benchmark interest rates such as LIBOR, EURIBOR and NIBOR, which are indicative rates for unsecured interbank loans with maturities of up to one year. Except for the shortest maturities, activity in the unsecured interbank market is low. Turnover statistics are limited, but surveys

and anecdotal information clearly suggest that activity in the unsecured interbank market for maturities of more than a few days is very limited.[3]

While banks use the commercial paper market to obtain short-term funding, the interbank market is primarily used for day-to-day liquidity management purposes. A bank with large net payouts one day, for example, can meet its liquidity needs on a short-term basis in the interbank market. However, if the liquidity shortage proves to be more permanent, the bank will normally replace its interbank funding with other, more long-term funding from sources outside the banking system. This use of the interbank market explains why turnover is strongly concentrated on the shortest maturities. The main function of the interbank market is to be a kind of safety valve for banks, providing cover at short notice for an unexpected or short-term liquidity shortage.

The source of funding in the banking system is financial savings outside the banking sector. Banks intermediate these savings to borrowers and the interbank market has no role in this context. The interbank market can distribute liquidity among banks, but it cannot be a source of funding for the banking sector as a whole.

Chart 1. Banks' credit intermediation

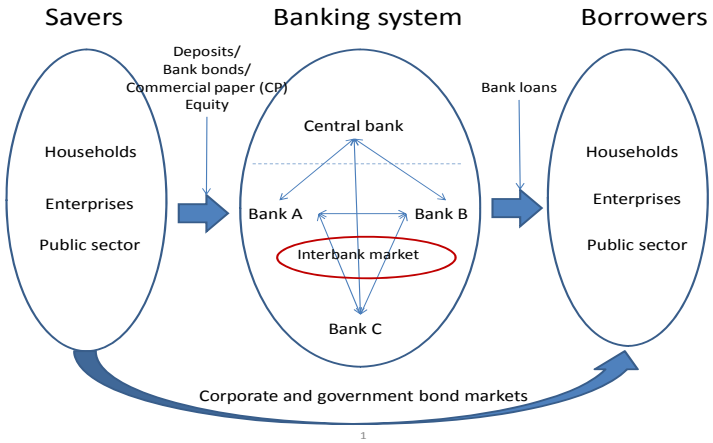


Chart 1 provides an illustration of the relationships discussed above. Households, enterprises and public authorities offer their financial savings to banks through deposits, commercial paper or bonds (directly or via funds), or by buying equities issued by banks. Banks intermediate these savings through lending to households, enterprises and public authorities. The role of the interbank market is to redistribute short-term liquidity among banks.

[3] For statistics for the euro area, see Hartmann and Valla (2008) and ECB (2011). For Denmark, see Danmarks Nationalbank (2011).

3. Interest rates in the interbank market

In Norway and many other countries, indicative interest rates on unsecured interbank loans play an important role as benchmarks for other financial prices. Some bank lending rates, for example, are referenced against NIBOR. When banks and other non-financial enterprises issue floating-rate bonds, the interest rate may be equal to NIBOR plus a premium determined by the issuer's credit risk and maturity premiums. Interbank rates are also used in the valuation of financial derivatives such as interest rate swaps, interest futures and forward rate agreements (FRAs). Through these markets, market participants can reduce their vulnerability to interest rate changes or use the instruments for speculation. Daily turnover volume in these derivative markets is very high. At the same time, we know that there are very few transactions behind the most important benchmark rates such as three-month LIBOR, EURIBOR and NIBOR. It may seem a paradox that there are very few actual trades behind the most important benchmark rates in the economy.

Interbank rates such as LIBOR and EURIBOR are calculated based on interest rates on unsecured interbank loans with varying maturities submitted by banks on a bank panel. In the absence of actual lending activity, these rates must be regarded as banks' *estimates* of the rates in such transactions, had they taken place. LIBOR is calculated for 10 currencies based on the panel banks'[4] responses to a daily questionnaire, recorded daily by the British Bankers' Association (BBA). The banks submit the rate at which they think they could borrow funds from another bank.[5] Banks are under no obligation to actually lend or borrow at the rates reported in the questionnaire.[6]

[4] A panel of banks reports its rates for each currency to the BBA (British Bankers' Association) each business day. The number of banks on the panel varies from 18 for USD to 7 for AUD and NZD and for DKK and SEK. The 25 percent highest and the 25 percent lowest rates reported in each currency are discarded and LIBOR is calculated as the average of the remaining reported rates. LIBOR is not calculated for NOK. For more details, see www.bbalibor.com.

[5] The question put to the banks is: *"At what rate could you borrow funds, were you to do so by asking for and then accepting inter-bank offers in a reasonable market size just prior to 11 am?"* Each panel bank gives an answer to this question for different maturities ranging from one day to one year.

[6] In June this year, FSA (Financial Services Authority) fined the British bank Barclays due to interest rate manipulation, in particular dollar Libor, but also Euribor. The manipulation took form in reporting (as answers to the survey) rates, which were artificially low or high, depending on Barclay's financial positions. When a bank, on a given day, has net outflows referenced to Libor, it will be an advantage for the bank with a low Libor rate (and vice versa). Such manipulation would have been by far more difficult had the reference rate been actually traded in an effective market. The press statement from FSA is http://www.fsa.gov.uk/library/communication/pr/2012/070.shtml
The report from FSA is http://www.fsa.gov.uk/static/pubs/final/barclays-jun12.pdf
See also The Economist 7-13 July 2012, "The rotten heart of finance". Financial Times has a general web site on the topic, see http://www.ft.com/intl/indepth/libor-scandal.

In principle, banks' estimates of interbank rates consist of two factors – central bank key rate expectations and a risk premium. In normal times, without market turbulence, key rate expectations are the most important factor. For a three-month interbank rate, the relevant factor is the expected average level of the key rate over the next three months, as the key rate normally determines the level of the overnight rate in the interbank market. The difference between the two is generally small and stable. A bank seeking to borrow money for three months can in principle choose between raising a three-month loan today and rolling over an overnight loan every day for three months. Theoretically, the absence of arbitrage implies that borrowing costs must be the same in both alternatives, provided risk premiums are disregarded. This creates a relationship between interbank rates and the expected overnight rate, which in turn is closely linked to the expected central bank key rate.

In practice, risk premiums in interbank rates are not zero. Risk premiums in interbank rates can vary over time, both as a result of changes in banks' credit risk and because banks' willingness to provide liquidity for a longer period can vary. Risk-weighting of interbank loans and accompanying capital requirements also play a role in this context. Chart 2 shows risk premiums in three-month money market rates for selected countries: Norway (NIBOR), Sweden (STIBOR), the UK (LIBOR), the euro area (EURIBOR) and the US (measured alternatively by LIBOR and Kliem, the latter reflecting the rate European banks must pay for unsecured three-month USD loans, see discussion below). In the pre-crisis years, risk premiums in interbank rates were generally low and stable. Interbank rates were largely determined by expectations concerning central bank key rates. During the financial crisis in autumn 2008, risk premiums rose sharply, both internationally and in Norway. Premiums were particularly high in many countries in the first few months after the Lehman Brothers collapse in September 2008. In some cases, three-month interbank rates were several percentage points higher than the expected central bank key rate.[7] Premiums have generally been higher in Norway than in other countries. Only the premium in the Kliem USD rate has been higher throughout. This is discussed in more detail below.

Premiums in interbank rates can pose challenges to the conduct of monetary policy. *Stable* premiums do not necessarily present a problem, since they can in principle be counteracted by a lower key rate.[8] Stable high premiums only create difficulties in a situation where a short-term interest rate level close to zero is required to stimulate the economy. When premiums are

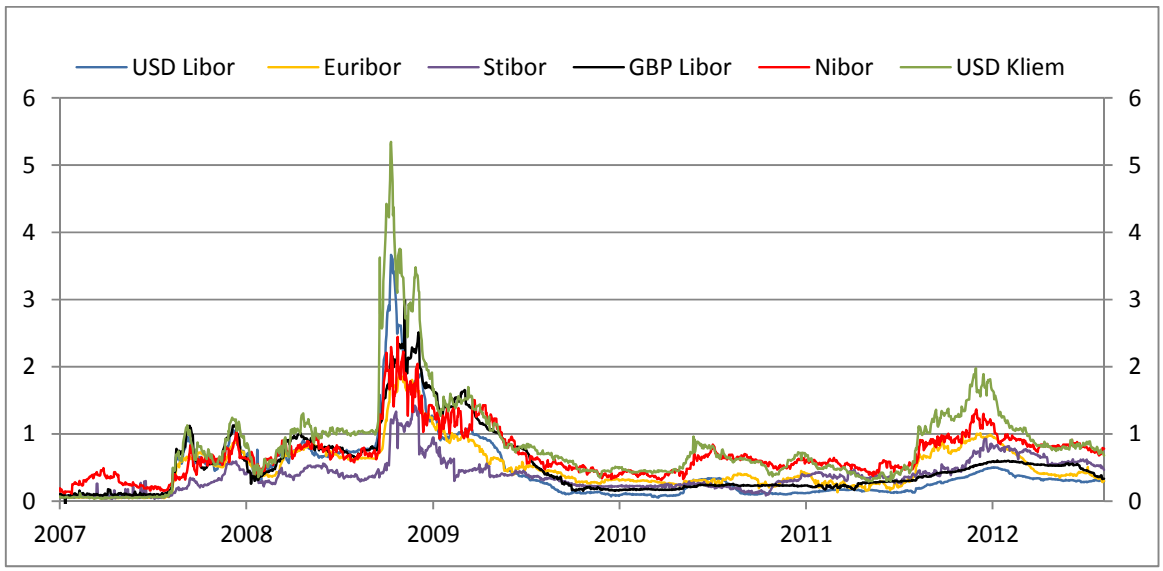
[7] The premium is measured as the difference between the interbank rate and the expected overnight rate, as expressed in OIS contracts. These contracts are discussed in more detail in Section 5.

[8] Bernhardsen and Wolden-Bache (2009) and Bernhardsen (2012) show that the key policy rate has generally had a broad impact on the NIBOR money market rate. Thus, the key policy rate cannot be used to influence the size of the premiums, only the level of money market rates.

high, a key rate at zero results in market rates considerably higher than zero. The central bank must then resort to unconventional measures sooner than when premiums are low.

When the key policy rate is at a more normal level, it is *volatility* in premiums that create difficulties in the conduct of monetary policy. Volatile premiums will result in fluctuations in interbank rates even if the expected central bank key rate is constant. Counteracting volatility in premiums by changing the key rate will be demanding in practice and might result in changes in market rates other than those intended by the central bank.[9]

Chart 2. Premiums in three-month money market rates for selected countries. Daily data. 1 January 2007 – 8 August 2012. Percentage points



4. The Norwegian InterBank Offered Rate, NIBOR

The Norwegian interbank rate NIBOR differs somewhat from corresponding interbank rates in other countries. There is no daily questionnaire in Norway, as is the case for LIBOR or EURIBOR. For many years, standard practice in Norway has been for banks to base their NIBOR quoting on foreign interest rates. More specifically, NIBOR has been a currency swap rate derived from the rate on a similar loan in the USD market plus the interest rate differential between NOK and USD from the forward exchange market. In contrast to other countries, the Norwegian interbank rate was not defined in any publicly available regulation, which contributed to a lack of clarity as to what the benchmark rate actually expressed. Turbulence through the financial crisis amplified this lack of clarity. This forms part of the background for the initiative taken by Norges Bank towards the establishment and publication of a regulation for NIBOR in its letter to Finance Norway (FNO), the trade organisation for banks, in autumn 2010.

[9] See Hellum and Kårvik (2012) for a discussion of how Norges Bank calculates premiums in Norway.

The Norwegian interbank rate NIBOR is now defined in a regulation adopted by the banks in FNO and in force as from 1 August 2011. On the FNO website, NIBOR is defined as follows:

"NIBOR shall reflect the interest rate level lenders require for unsecured money market lending in NOK, based on interest rates banks charge on lending to leading banks active in the Norwegian money and foreign exchange markets."[10]

Thus, NIBOR shows the average interest rate required by NIBOR panel banks[11] to lend NOK to other leading banks active in the Norwegian money and foreign exchange markets.

Even though NIBOR is defined as a NOK rate, it must still be consistent with the interest rate on similar loans in other currencies and the forward points between NOK and other currencies in the foreign exchange market. Forward points show the interest rate differential on which currency swaps are based in the foreign exchange market. Inconsistency between the interest rates required for different currencies and forward points implies a deviation from the condition for so-called covered interest parity and an opportunity for risk-free gains (arbitrage). Such arbitrage opportunities cannot exist over time in an efficient market.[12]

Prior to the financial crisis, the NIBOR panel banks used the USD LIBOR rate as a basis for calculating NIBOR. Even though LIBOR rose sharply after the Lehman collapse in September 2008, many market participants claimed that the actual rate at which it was possible to borrow USD in the interbank market had increased even more. In September 2008, the NIBOR panel banks therefore decided to abandon LIBOR as a basis for NIBOR and to apply an interest rate they considered to be more realistic. Interbank rates are also reported by various brokerage houses in Europe and the US. After the Lehman collapse, NIBOR banks decided to base their quoting on the USD rate published by the brokerage house Carl Kliem in Frankfurt. This rate is said to express the cost for European banks of borrowing USD through the interbank market (for further discussion, see Sections 5 and 6 below).

5. A model for the interest rate premium in NIBOR and the forward premium[13]

Even though NIBOR (and rates such as STIBOR and EURIBOR) are defined as interest rates in local currency, they can also be written as a function of a USD rate and forward points traded in the forward exchange market. This form of writing interest rates is the most useful in order to understand how changes in interest rate premiums spread across countries. NIBOR must then be consistent with

[10] For further detail, see www.fno.no/en under "Markets".
[11] The NIBOR panel banks are: DNB, Nordea, Danske Bank, Handelsbanken, SEB and Swedbank.
[12] See footnote in Appendix A for a more detailed description of covered interest parity.
[13] The model is an expansion of the model in Bernhardsen, Kloster, Smith and Syrstad (2009) and follows Syrstad (2012).

(1) $i_N = i_{N,\$} + (f-e)$

where i_N is three-month NIBOR, $i_{N,\$}$ is the three-month USD rate the NIBOR panel banks use as the basis for their NIBOR quoting, f is the forward exchange rate and e is the spot rate (NOK per USD, both in logarithmic form).[14] The forward premium is the difference between the forward exchange rate and the spot rate (f-e) and expresses the price of swapping currencies today and at the same time reversing the swap in the same amount in the future, in our example in three months.[15] The swap takes place in the market and is regarded as liquid.[16] The USD rate is in principle intended to reflect the marginal cost for banks of a three-month USD loan in the unsecured interbank market. The implied NOK interest rate follows from this USD rate and the forward premium.

A change in the expected key rate in Norway or in the US will normally have a direct effect on the forward premium, "cancelling out" the change in the expected key rate. To understand this, suppose that the expected US key rate increases. A higher expected key rate increases the three-month USD rate.[17] If the forward premium did not change, market participants could borrow NOK and swap them for USD in a currency swap, resulting in a lower implied USD rate than if they had borrowed directly in the USD market. Then, the participants buy USD spot (and sell NOK) at the same time as they sell USD forward (and buy NOK). Forward purchases of NOK strengthen the forward rate ($\Delta f<0$), causing the forward premium to fall and cancelling out the increase in the USD rate. Conversely, assume that domestic interest rate increases because the domestic key rate is expected to rise. When the costs of borrowing NOK increase, banks will seek to obtain NOK via the forward exchange market, buying NOK spot (and selling USD). At the same time, they sell NOK forward (and buy USD), weakening the forward rate ($\Delta f>0$). The increase in the forward premium corresponds to the increase in domestic interest rates. Thus, changes in the expected key rate normally effect a proportional change in the forward rate and hence the forward premium.[18]

[14] Equation (1) is so-called covered interest parity (see footnote in Appendix A for details).
[15] Forward premiums are quoted in information systems in so-called PIPS. In this article, they have been converted into basis points.
[16] This means that a client can sell USD to a bank and buy NOK today and at the same time agree to reverse the transaction at a future date. Alternatively, the client can sell NOK to the bank and buy USD and agree to reverse the transaction at a future date. The price of such a swap is the forward premium.
[17] According to the expectations hypothesis for interest rate formation, "long" interest rates are determined by current "short" rates and expected future "short" rates. Thus, the current three-month rate is determined by the current overnight rate and expected overnight rates for the next three months. The overnight rate is in turn closely linked to the key rate. See Bernhardsen (2011) for details.
[18] In practice, an unexpected change in the key rate will have an instant effect on the forward rate before any trades have taken place. The price, i.e. the forward premium, is immediately adjusted to the new information. However, the instant change in the forward rate is driven by the arbitrage argument above.

The interest rate premium is defined as the money market rate minus the expected overnight rate (over the horizon for the money market rate). This can be expressed by

(2) $rp_N = i_N - OIS_N$

where rp_N is the premium in three-month NIBOR, OIS_N is the three-month OIS rate, a rate that reflects the average expected overnight rate. There is no OIS market in Norway, but the rate is estimated by Norges Bank based on judgement.[19] Similarly, the interest rate premium in USD can be expressed by

(3) $rp_{L,\$} = i_{L,\$} - OIS_\$$

where $i_{L,\$}$ is three-month LIBOR, $OIS_\$$ is the three-month OIS rate for USD and $rp_{L,\$}$ is the risk premium in three-month LIBOR. In periods, NIBOR banks may have to pay an additional credit risk premium on top of that reflected in LIBOR. First, a credit risk premium may be required from European banks in general and, in addition, Norwegian banks may have to pay a credit risk premium that may deviate from the premium for European banks. Thus, NIBOR banks' USD rate in the interbank market may be written as follows:

(4) $i_{N,\$} = OIS_\$ + rp_{L,\$} + erp_{K,\$} + erp_{N,\$}$

where $erp_{K,\$}$ is the extra premium European banks are required to pay beyond the LIBOR premium. As shown below, the USD rate for European banks is close to the Kliem rate quoted by the broker Carl Kliem in Frankfurt. We assume here that Kliem represents the cost for European banks of borrowing in USD, so that $erp_{K,\$}$ is the extra premium in the Kliem rate beyond the LIBOR premium.[20] Moreover, $erp_{N,\$}$ is the extra premium applied by NIBOR banks beyond the rate European banks are required to pay. If the credit risk premium for NIBOR banks is lower than for European banks, $erp_{N,\$}$ can be negative.[21]

[19] OIS stands for "Overnight Index Swap". The OIS rate is the fixed rate in an interest rate swap where a floating overnight rate is swapped for a fixed rate for a given period. The OIS rate expresses the expected overnight rate over a certain period, depending on the term of the swap agreement. For example, the three-month OIS expresses the expected average overnight rate for the next three months. Since the overnight rate is normally close to the key rate (the objective of liquidity policy), the OIS rate normally expresses the expected key rate. In contrast to the current level of the key rate, the OIS rate also reflects expected changes in the key rate.

[20] The notation implies that $i_{K,\$} = i_{L,\$} + erp_{K,\$}$, where $i_{K,\$}$ is the Kliem rate and $i_{L,\$}$ is LIBOR. An increase in LIBOR will then result in a similar increase in Kliem if the extra premium European banks are required to pay for USD remains unchanged.

[21] This means that $i_{N,\$} = i_{L,\$} + erp_{K,\$} + erp_{N,\$}$, i.e. NIBOR banks are required to pay LIBOR plus the extra premium required from European banks (assumed to be the extra premium in Kliem on top of the LIBOR premium) plus the extra premium NIBOR banks are required to pay in addition to the extra premium in Kliem. This equation is equivalent to equation (4) if the definition of the LIBOR premium in equation (3) is taken into account.

Inserting (4) into (1) results in

(5) $i_N = OIS_\$ + rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + (f\text{-}e)$

Inserting equation (5) into (2) results in

(6) $rp_N = rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + (f\text{-}e) – (OIS_N – OIS_\$)$

The premium in NIBOR is equal to the premium in LIBOR plus the extra premium European banks are required to pay in addition to the LIBOR premium, plus the extra premium applied by NIBOR banks, plus the difference between the forward premium and the OIS spread.

If neither European nor NIBOR banks are required to pay an additional credit risk premium, then $erp_{K,\$} = erp_{N,\$} = 0$, and $i_{N,\$} = i_{L,\$}$. This means that NIBOR banks use Libor as the basis for their NIBOR quoting. Equation (6) is then reduced to

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

The difference between OIS rates will be referred to as the *theoretical forward premium*, showing the forward premium (in basis points) required for covered interest parity to hold between OIS rates. A key variable is the difference between the actual and theoretical forward premium, referred to as the OIS basis, given by

(8) $OISB = (f\text{-}e) - (OIS_N – OIS_\$)$

where OISB is the OIS basis.[22] Equations (7) and (8) show that the premium in NOK is determined by the premium in USD and the OIS basis, i.e. that

(9) $rp_N = rp_{L,\$} + OISB$

This decomposition shows that the OIS basis gives rise to differences in premiums across countries. If the OIS basis between NOK and USD is zero, the premium in NIBOR will be the same as the premium in the USD rate applied for the Nibor quoting.

[22] The OIS basis is quoted in information systems such as Bloomberg. When the OIS basis is zero, equation (8) can be written as $OIS_N=OIS_\$+(f\text{-}e)$, which means that covered interest parity holds for OIS rates.

The following section examines developments in risk premiums since the beginning of 2007, particularly the USD rate NIBOR banks have selected as a basis for their NIBOR quoting and how the OIS basis has developed.[23]

Chart 3. USD interest rates as quoted by LIBOR and Kliem. Three-month maturity. Daily data. 1 January 2007 – 8 August 2012. Percent

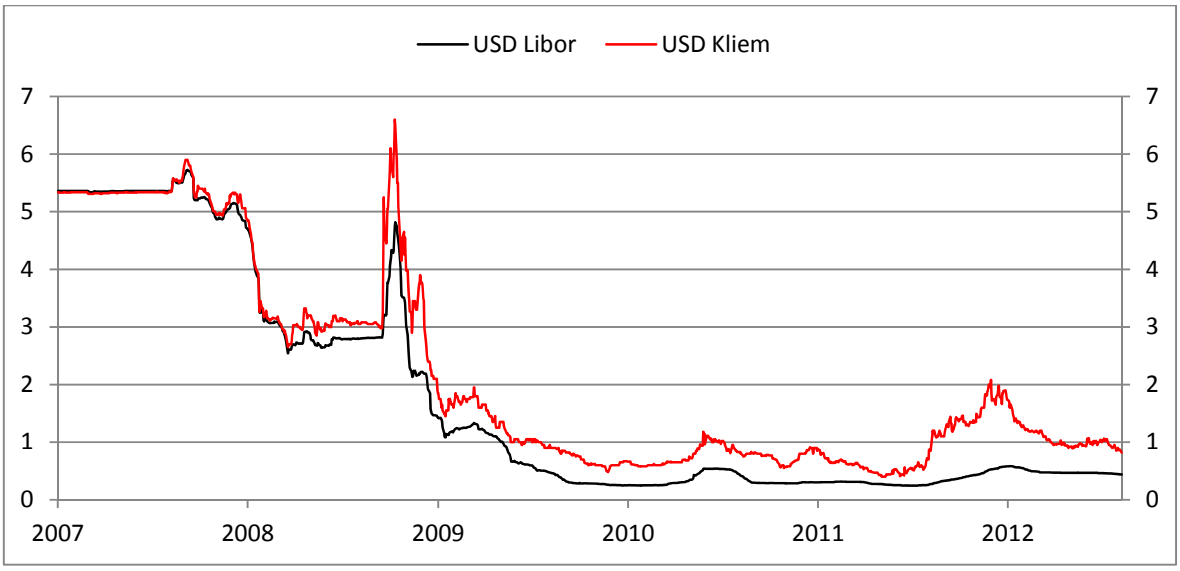


Chart 3 shows two three-month USD interest rates, LIBOR and Kliem. In the period up to 2008 Q1, the USD LIBOR and Kliem rates were approximately the same, indicating that they both reflected the actual cost to banks of a three-month USD loan in the unsecured interbank market. From the second quarter of 2008, and particularly through the crisis in autumn 2008, Kliem was higher than LIBOR. There was a shortage of USD in this period and it is widely believed that LIBOR underestimated banks' real borrowing costs, particularly for European banks. Since then, from the beginning of 2009, Kliem has remained higher than LIBOR, particularly from mid-2011 when Kliem rose to a far higher level. From about 0.5 percent in mid-2011, only marginally higher than LIBOR, Kliem rose to around 2 percent towards the end of the year. The increase reflects the crisis in the European government bond market and the uncertainty this generated in the European banking sector. Through the first quarter of 2012, Kliem fell to close to 1 percent, but was still considerably higher than LIBOR. The most recent decrease probably reflects reduced uncertainty attached to European banks after the ECB in late 2011 introduced long-term loans to the banks with three years maturity.

[23] In normal times, without financial market turbulence, the OIS basis is around zero (see Appendix A for details). As shown below, in times of crisis, with high demand for USD, the OIS basis can be negative and affect the size of the interest rate premium in NOK.

Chart 4 shows three three-month NOK rates. The black line is three-month NIBOR as it has actually been quoted by banks on Reuters. The green line shows the estimated NOK rate based on the USD LIBOR rate swapped into NOK. The red line shows the corresponding implied NOK rate based on the Kliem rate instead of LIBOR.[24]

Chart 4. NOK interest rates: NIBOR, swapped from Kliem and swapped from LIBOR. Three-month maturity. Daily data. 1 January 2007 – 8 August 2012. Percent

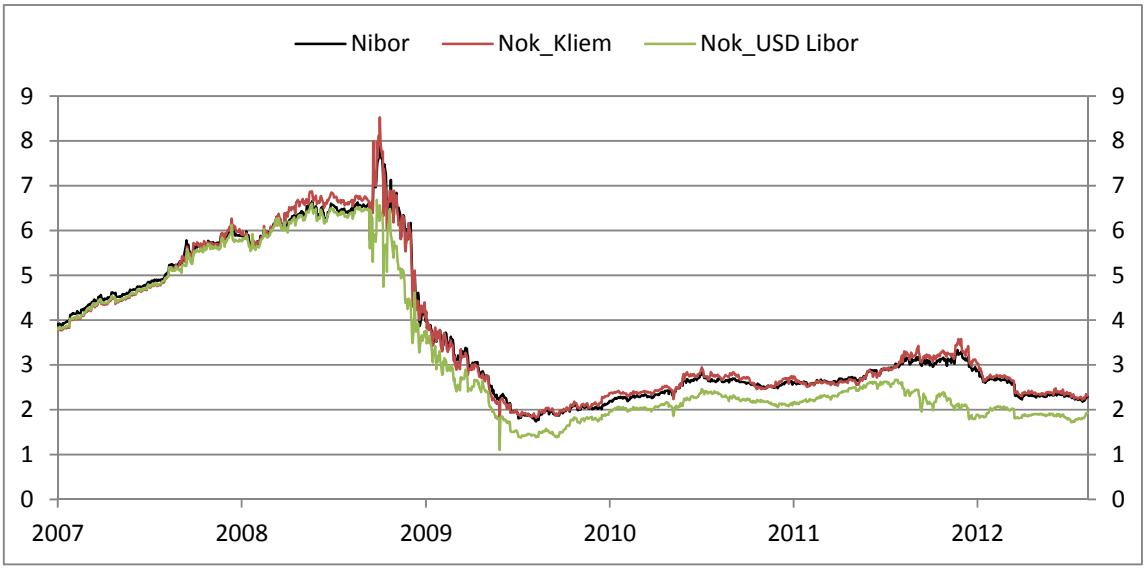


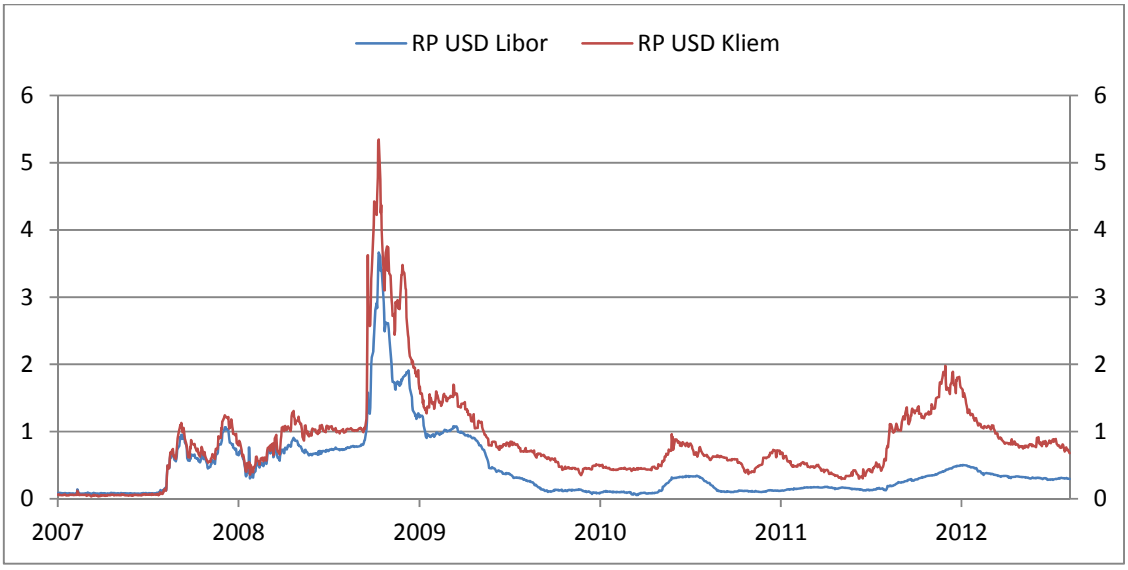
Chart 4 shows that actual NIBOR, the interest rate swapped from LIBOR and the interest rate swapped from Kliem were approximately the same up to the first quarter of 2008. This indicates that NIBOR banks based their NIBOR quoting on LIBOR (which in turn was the same as Kliem). Through spring and summer 2008, the interest rate swapped from Kliem was somewhat higher than NIBOR, indicating that NIBOR banks were still applying a USD rate close to LIBOR, even though increasing strains in the USD market were already evident. Since autumn 2008, NIBOR and the NOK rate swapped from Kliem have tended to be approximately the same and higher than the NOK rate swapped from LIBOR, indicating that NIBOR quoting has been based on a USD rate approximately equal to Kliem.

Chart 5 shows interest rate premiums in USD (three-month maturity) in LIBOR and Kliem, both minus the expected overnight rate for the next three months (OIS), cf. equation 3. The two premiums reflect developments in Kliem and LIBOR respectively (cf. Chart 3). Since the second

[24]NIBOR is the NOK interest rate quoted by NIBOR panel banks on Reuters. The NOK rate swapped from the USD Kliem rate is calculated based on the USD Kliem rate and the forward premium, cf equation (1) where $i_{N,\$}$ is set equal to Kliem and where observed forward premiums in the market are used (similarly for the implied NOK rate swapped from the USD LIBOR rate). The implied NOK rates swapped from Kliem and LIBOR will differ from NIBOR if NIBOR quoting is based on USD rates other than LIBOR and Kliem.

quarter of 2008, Kliem has been higher than LIBOR and the premiums have increased accordingly. The Kliem premium rose in particular from mid-2011 and was considerably higher than the LIBOR premium in the second half of the year.

Chart 5. Interest rate premiums in USD: LIBOR and Kliem. Three-month maturity. Daily data. 1 January 2007 – 8 August 2012. Percentage points



In the following, we decompose the interest rate premium in NIBOR. Chart 6 shows the interest rate premium in NIBOR (black), the interest rate premium in Kliem (green), the OIS basis (blue) and the USD premium implied from NIBOR (red), all with three-month maturity. The USD premium implied from NIBOR (red) is calculated based on equation (6), i.e. $rp_N = rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + (f\text{-}e) – (OIS_N – OIS_\$)$. If we let $rp_{N,\$}$ be the total USD premium applied by NIBOR banks, i.e. $rp_{N,\$} = rp_{L,\$} + erp_{K,\$} + erp_{N,\$}$, while recalling the definition of the OIS basis (cf. equation 8), equation (6) can be written as follows

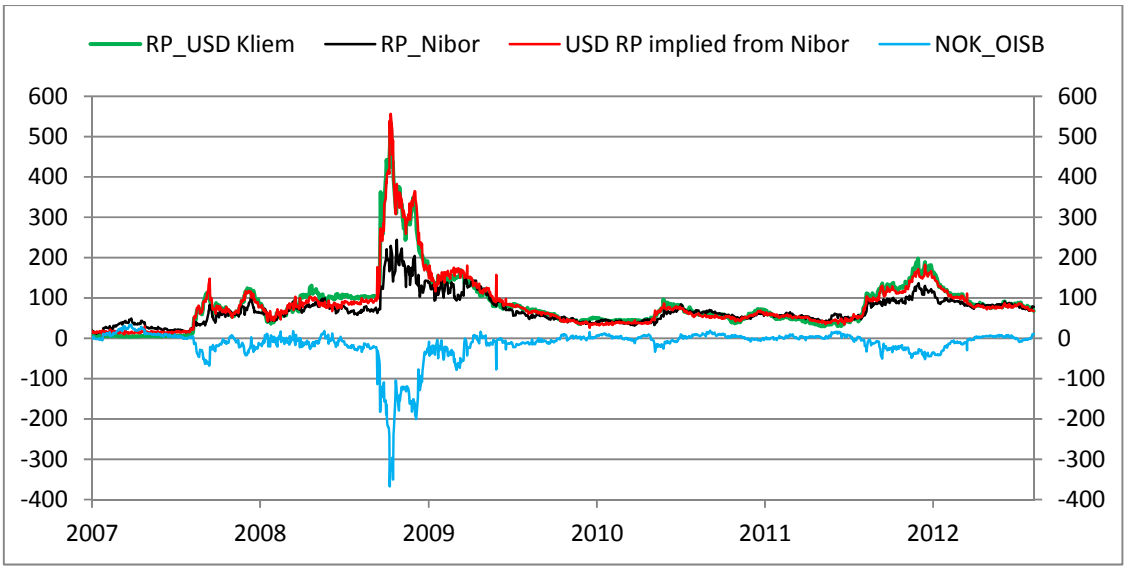
(10) $rp_N=rp_{N,\$}+OISB$

We can calculate the premium in NIBOR and the OIS basis. The difference between these two is equal to the USD premium applied by NIBOR banks, i.e. $rp_{N,\$}= rp_N-OISB$.[25] This USD premium in turn consists of two parts, the nominal USD rate (level) applied by NIBOR banks in their NIBOR quoting minus the USD OIS rate. The red line in Chart 6 thus reflects the USD rate applied by

[25] There are two possible sources of error in this calculation: First, OIS must be estimated for Norway as this market does not exist. Second, historical data are not available for forward points quoted by NIBOR banks. We apply the forward points as listed in the Bloomberg information system. These figures reflect forward points for all participants in the forward market, not only NIBOR banks. However, since this market is active and liquid, the potential for error is limited.

NIBOR banks in their NIBOR quoting. If the red line is higher than the Kliem premium (green), NIBOR banks apply a USD rate that is higher than Kliem. If the red line is below the green, NIBOR banks apply a USD rate that is lower than Kliem. With a few exceptions, the two are approximately the same, which in turn indicates that NIBOR banks have for long periods based their quoting on a USD rate approximately equivalent to Kliem (consistent with Chart 4, where NIBOR and the NOK rate swapped from Kliem are about the same).

Chart 6. The OIS basis, interest rate premium in NIBOR, interest rate premium in Kliem and the USD premium implied from NIBOR. Three-month maturity. Daily data.
1 January 2007 – 8 August 2012. Basis points



In autumn 2008, the NIBOR premium was considerably lower than the Kliem premium and the implied USD premium from NIBOR, at the same time as the OIS basis was very low. On 10 October 2008 (the peak of the red line in the chart), the NIBOR premium was 229 basis points, the OIS basis was -327 basis points, and the USD premium implied from NIBOR (red) was 556 basis points.[26] This is interpreted as follows: on this date, NIBOR banks applied a USD premium of 556 basis points. If the OIS basis had been zero, the NIBOR premium would have been the same. However, the forward market dampened the effect of the USD premium on the NIBOR premium. The mechanism is as follows: When there is a USD shortage, banks will seek to obtain USD via the forward exchange market, buying USD spot (and selling NOK) and selling USD forward (and buying NOK) at the same time. This strengthens the forward rate for NOK ($\Delta f<0$ in

[26] In the chart, the lowest level for the OIS basis is -350 basis points, but this is a couple of days later than the day used as an example here, at the peak of the red curve.

our model).[27] Forward premiums fall and dampen the effect of the USD premium on the NOK premium. Because of the stronger forward rate, the OIS basis fell to -327 basis points and dampened the effect of the USD premium on the NOK premium, reducing it from 556 basis points to 229 basis points. At the same time, the Kliem premium was 534 basis points, i.e. higher than the NIBOR premium, but somewhat lower than the USD premium implied from NIBOR. This means that on this date NIBOR banks applied a USD rate in their NIBOR quoting that was somewhat higher than Kliem.

Since the end of 2008, the USD premium implied from NIBOR (red) and the Kliem premium (green) have been about the same, reflecting NIBOR banks' use of a rate close to Kliem in their NIBOR quoting. Up to summer 2011, the OIS basis was close to zero, so that the NIBOR premium was also approximately the same as the Kliem premium. From summer 2011, all the premiums increased. The USD premium implied from NIBOR and the Kliem premium increased by about the same extent, while the increase in the NIBOR premium was somewhat smaller as turbulence in the euro area led to higher demand for USD relative to NOK in the forward market. The forward premium thereby became more negative, dampening the effect of the Kliem premium on the NIBOR premium (the OIS basis became negative). This shows that even though NIBOR banks apply the Kliem rate in their NIBOR quoting, a negative forward premium (negative OIS basis) can result in a NIBOR premium that is lower than the Kliem premium.

6. Forward premiums in other countries

In this section, we take a closer look at the OIS basis in other countries in comparison with Norway. During the financial turbulence that arose in late summer 2007, and the financial crisis in autumn 2008, there was a shortage of USD credit. First, credit risk premiums (counterparty risk) increased because banks' creditworthiness became less transparent. Second, liquidity premiums rose, as banks hoarded liquidity.[28]

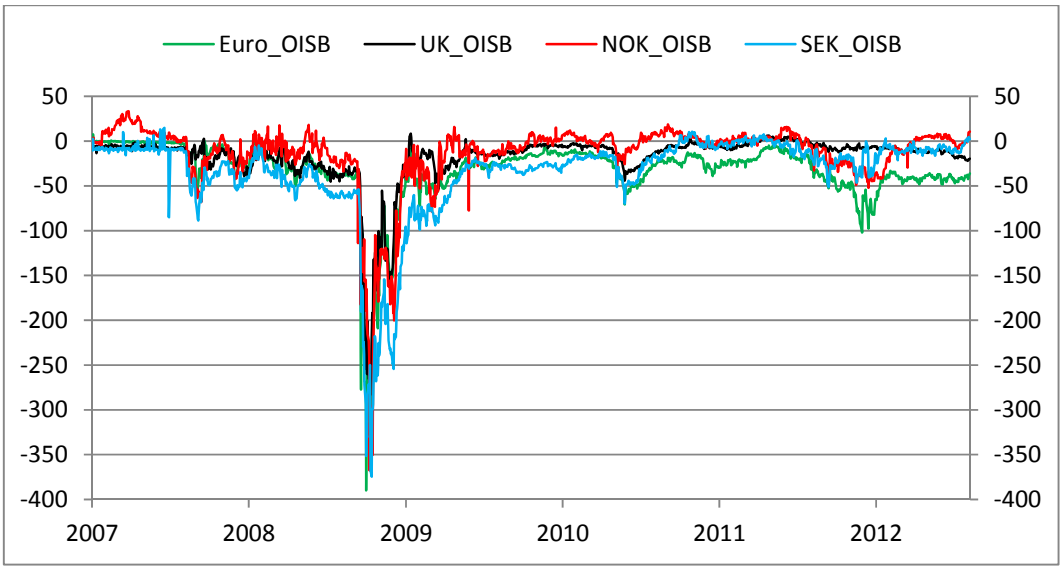
The USD shortage affected forward premiums and thereby the OIS basis. Chart 7 shows the OIS basis since the beginning of 2007 for NOK, SEK, EUR and GBP, all measured against USD (three-month maturity).[29]

[27] The OIS basis is thus determined by developments in the forward premium, which, when adjusted for changes in the expected key rate, reflects a shortage of USD. If the forward rate is changed only as a result of a change in the expected key rate, and not as a result of a USD shortage, OIS spreads will change, keeping the OIS basis unchanged.

[28] For a more detailed discussion of the USD shortage in this period, see Baba, Packer and Nagano (2008), Baba, McCauley and Ramaswamy (2009), Coffey, Hrung, Nguyen and Sarkar (2009) and McGuire and von Peter (2009a, b).

[29] Cf. equation (8) OISB = (f-e) - (OIS-OIS_{USD}), where forward and spot rates are defined as the number of units of local currency per USD and OIS indicates the OIS rate for the local currency.

Chart 7. The OIS basis (difference between actual and theoretical forward premiums) for different countries. Three-month maturity. Daily data. 1 January 2007 – 8 August 2012. Basis points



In general, the OIS basis reflects the relative surplus of USD credit, given by

(11) $R = (USD^S - USD^D) - (L^S - L^D)$,

where *R* is the relative surplus of USD credit, *L* indicates the local currency and the superscripts S and D refer to supply and demand respectively. To explain this relationship, it is helpful to divide the period after 2008 into phases:

6.1 After the Lehman bankruptcy in autumn 2008

After the Lehman bankruptcy in autumn 2008, the OIS basis (the difference between actual and theoretical forward premiums) fell by 300-400 basis points for all currencies. A USD shortage arose, with greater differentiation across banks as regards opportunities for borrowing USD directly in the USD market. For many banks, depending on their credit rating, USD borrowing costs increased. This applied to banks in general, and perhaps to European banks as much, if not more than US banks. Many banks attempted therefore to obtain USD via the forward exchange market by buying USD spot (and selling local currency), while at the same time selling USD forward (and buying local currency). This strengthened the forward rate for the local currency ($\Delta f<0$), causing the forward premium to fall.[30] This occurred in a situation where counterparty and liquidity risk were high. Many banks were therefore willing to borrow USD via

[30] All currencies are defined here as the number of units of local currency per USD, so that a lower f indicates a stronger local currency and a weaker USD.

the forward exchange market at a higher interest rate than the USD rate banks with a higher credit rating had to pay directly in the USD market.[31]

6.2 Measures taken by the Federal Reserve and other central banks in autumn 2008

After the Lehman bankruptcy and up to the beginning of 2009, the Federal Reserve and other central banks implemented measures to increase the supply of USD.[32] As a result, it became more profitable to obtain USD directly in the USD market and less profitable to obtain USD in the forward market. This reduced purchases of USD (and sales of local currency) spot and sales of USD (and purchases of local currency) forward. Reduced purchases of local currency forward weakened the forward exchange rate ($\Delta f>0$), so that the OIS basis rose to close to its pre-Lehman level.

6.3 The period from the beginning of 2009

Since the beginning of 2009, developments in the OIS basis have differed somewhat across countries as a result of differences in the liquidity measures implemented (in a situation with a shortage of USD). When the supply of local currency increases relative to USD, financial institutions may seek to obtain USD via the forward exchange market, selling local currency (and buying USD) spot and selling USD (and buying local currency) forward. Buying local currency forward strengthens the forward exchange rate ($\Delta f<0$), so that the forward premium falls, reducing the OIS basis. The more the supply of local currency increases, the more the forward premium and the OIS basis are pulled down into negative territory.[33] In general, an increase in the supply of local currency will have the same effect as an increase in the demand for USD, cf. the importance of the relative USD surplus (equation 11). Developments in the OIS basis have differed somewhat across the different countries since the beginning of 2009 because some countries supplied more local currency with longer maturities than other countries. The countries supplying most local currency tended to push down the OIS basis into more negative territory. Chart 7, for example, shows that the OIS basis for Sweden was the most negative through 2009. This may be related to the large volume of SEK liquidity supplied by the Swedish central bank, Riksbanken, in the form of long-term loans to banks. As these loans matured, the OIS basis rose towards zero again.

[31] The OIS basis had already moved into negative territory in August 2007, one year before the Lehman bankruptcy as demand for and a shortage of USD was already evident in late summer 2007 when the first signals of the impending financial crisis surfaced. Credit and liquidity premiums were already on the increase and banks facing less favourable loan terms in the USD market attempted to obtain USD via the forward exchange market. This exerted downward pressure on forward premiums and thereby on the OIS basis.

[32] See Moessner and Allen (2010).

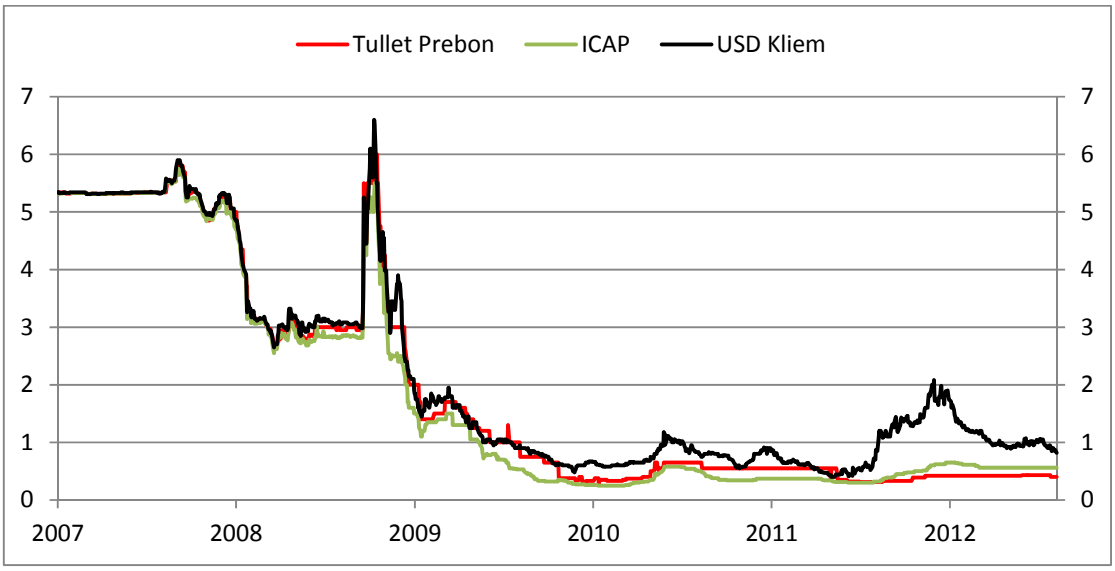
[33] The difference between the actual and the theoretical forward premium (the OIS basis) is largely negative for all the currencies in Chart 7. It can also be positive. When demand for local currency rises, participants will tend to buy local currency spot and sell local currency forward ($\Delta f>0$). The forward premium and the difference will increase. The same will occur if the supply of USD rises and banks have a surplus of USD.

Chart 7 also shows that, over the past year, the ECB has offered unlimited EUR loans in operations with maturities as long as three years. In isolation, a large supply of EUR makes credit in EUR cheap relative to credit in USD. This exerts pressure on forward points and thereby on the OIS basis between EUR and USD, pushing it below zero. This is clearly evident in Chart 7, which shows that EUR has had the most negative forward premium against USD in 2011 and 2012, as measured using the OIS basis. The negative forward premium between EUR and USD reflects banks' use of loans in EUR to seek USD in the forward market. The large supply of liquidity from the ECB and the fall in the forward premium contributes to dampening the risk premium in EURIBOR by reducing the EUR liquidity premium.

7. The implied USD rate in NIBOR

This section presents a closer examination of the other important component in NIBOR quoting, i.e. the USD rate applied by NIBOR banks. As illustrated in Chart 4 and 6, the implied USD rate in NIBOR has largely remained fairly close to the USD rate quoted by the brokerage house Carl Kliem in Frankfurt since the end of 2008. Since the OIS basis was close to zero for most of this period, the NIBOR premium has also been close to the Kliem premium.

Chart 8: Brokers' USD rates: Kliem, ICAP and Tullett Prebon. Three-month maturity. Percent. Daily data. 1 January 2007 - 8 August 2012

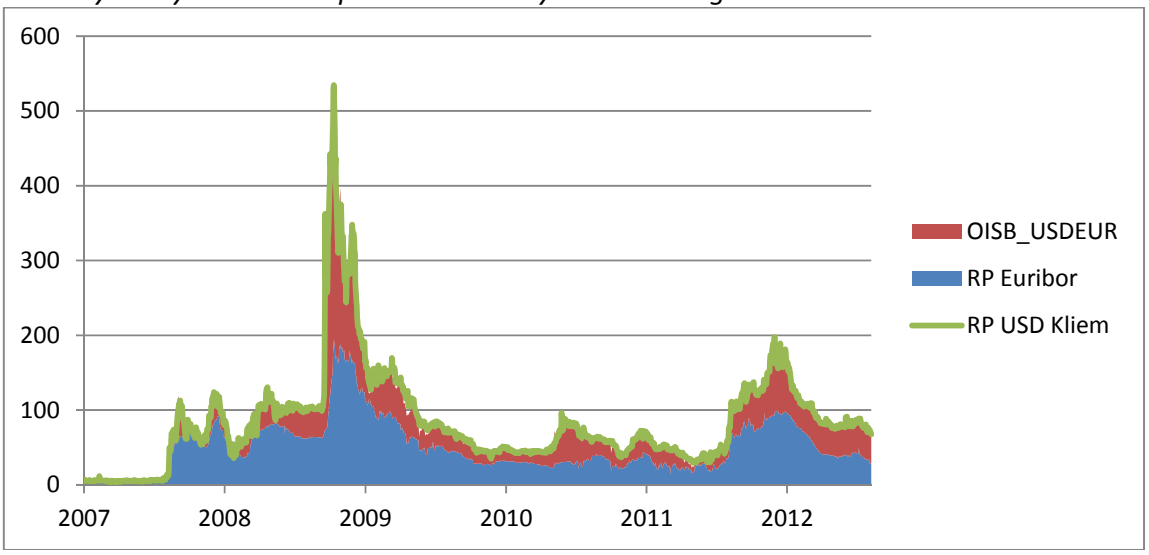


When the financial crisis began in earnest in autumn 2008, NIBOR banks abandoned LIBOR as a basis for NIBOR in favour of the Kliem rate. However, the Kliem rate was only one of several USD interest rates that could have been chosen as a basis for NIBOR. Other brokerage houses also quote interest rates intended to reflect the cost of borrowing USD in the interbank market. Chart 8 shows two of these rates, as quoted by Tullett Prebon and ICAP, both based in London. Quotes are based on information from clients and money market transactions in USD carried

out through the brokerage house. While LIBOR is clearly defined, there is no publicly available definition of these broker rates. Anecdotal information suggests that the ICAP rate (called the New York Funding Rate, NYFR) represents both interbank rates and rates on certificates of deposit and that the Tullett Prebon rate represents the most solid banks among Tullett Prebon's clients. While Kliem is based in Frankfurt with many European banks on its list of clients, both ICAP and Tullett Prebon are based in London with many of the large international banks as clients. When the Nibor-banks in the autumn of 2008 started to quote Nibor on the basis of Kliem, these three rates were roughly equal. This is consistent with a view that Kliem reflected actual costs of borrowing dollar unsecured. The same is true for the period up to the financial crisis. For much of the period since 2008, however, the Kliem rate has been considerably higher than the Tullett Prebon and ICAP rates.

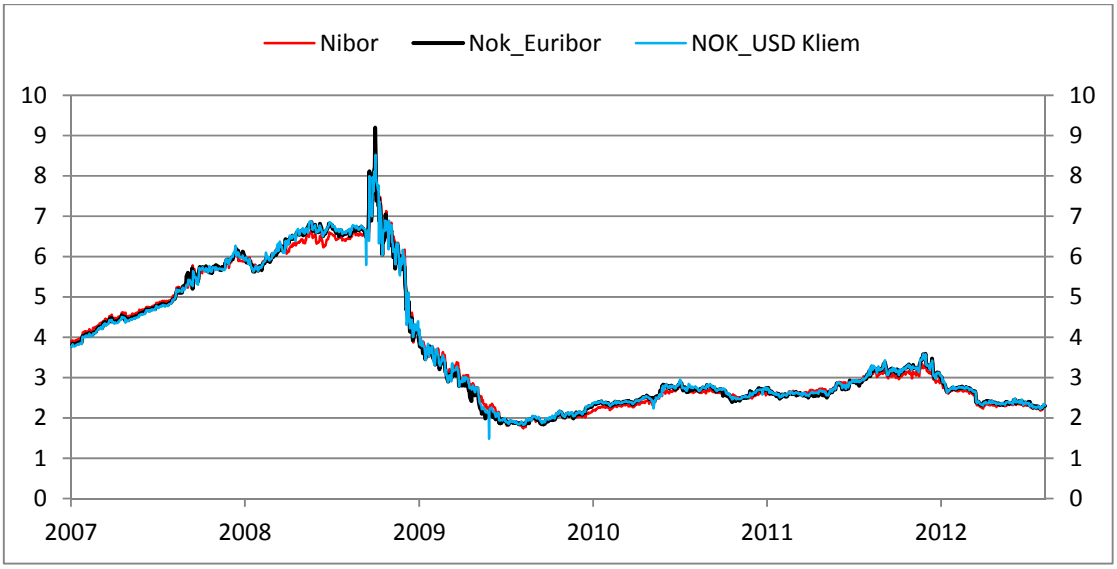
According to the Kliem brokerage house, the Kliem rate expresses the USD rate European banks are required to pay in the unsecured interbank market. Since there is very little activity in the unsecured interbank market in maturities of more than a few days, it is not clear which information the interest rate is based on. However, the Kliem rate is very close to the rate achieved by using the three-month EURIBOR and swapping to USD in the forward exchange market (see Chart 9). This means that covered interest parity holds well between EURIBOR and Kliem, while it does not hold between EURIBOR and the USD LIBOR rate. This suggests in turn that banks that borrow EUR at a rate close to EURIBOR cannot borrow USD at a rate close to LIBOR. If they had been able to do so, it would have been cheaper to obtain EUR by borrowing USD at a rate close to LIBOR and swap to EUR, than to borrow EUR at a rate close to EURIBOR.

Chart 9: EURIBOR premium, OIS basis between USD and EUR and Kliem premium. Three-month maturity. Daily data. Basis points. 1 January 2007 – 8 August 2012



Assuming that EURIBOR is a reasonable expression of the interest rate European banks have to pay for EUR, it follows that Kliem is a reasonable expression of the rate they have to pay for USD. In more general terms, if covered interest parity holds for all currency pairs, interest rates measured in a common currency must be the same. This is also illustrated in Chart 10, which shows NIBOR, the NOK interest rate swapped from Kliem and the NOK rate swapped from EURIBOR. The similarity between the NOK rate swapped from Kliem and the NOK rate swapped from EURIBOR is consistent with the similarity between EURIBOR and the EUR rate swapped from Kliem (cf. Chart 9).[34]

Chart 10. NIBOR, the NOK rate swapped from Kliem and the NOK rate swapped from EURIBOR. Three-month maturity. Daily data. Percentage points. 1 January 2007 – 8 August 2012



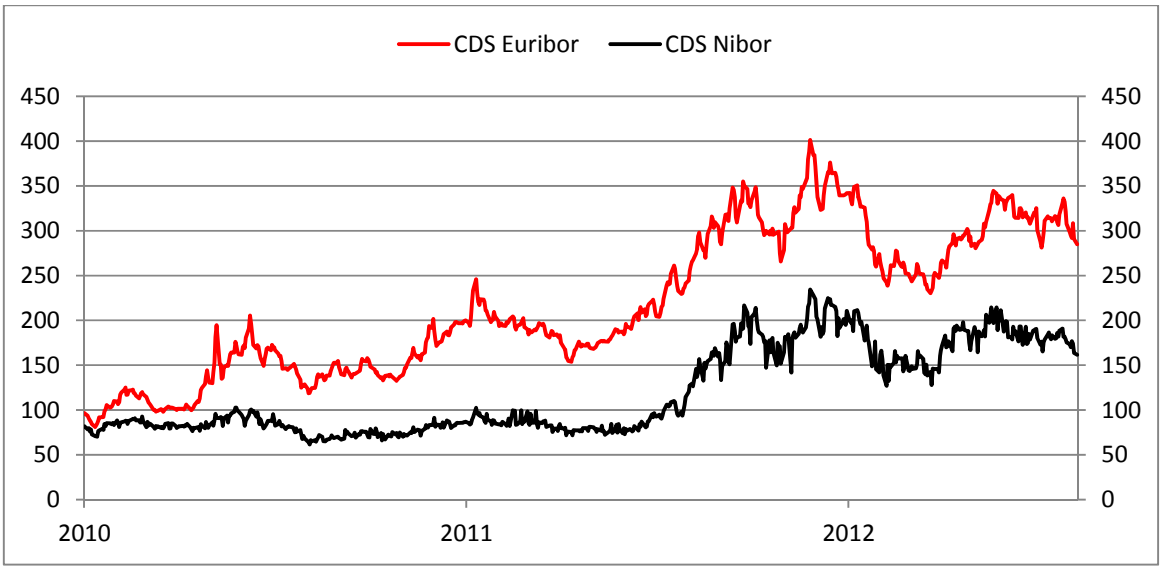
By basing their NIBOR quoting on the Kliem rate for USD, NIBOR panel banks implicitly base their quoting on the risk premium for European banks. In the credit default swap (CDS) market, however, credit risk for NIBOR panel banks is priced far lower than for banks on the EURIBOR panel (see Chart 11).[35] According to the definition, NIBOR reflects the price of lending to leading

[34] See Appendix B for the relationship between forward premiums for different currencies when covered interest parity holds.

[35] Chart 11 shows an average of 5-year CDS prices for those banks for which such data are available. The NIBOR panel includes all the NIBOR banks, while the EURIBOR panel includes 36 of a total of 44 banks. CDS prices express the cost of insuring against default in the underlying security and thus the credit risk premium due to the issuer of the security. For en bank, the CDS price expresses the credit risk premium on an unsecured senior bank bond issued by a bank. This comparison is subject to the reservation that CDS prices have a five-year horizon, while money market rates have a three-month maturity. A one-to-one relationship between CDS prices and risk

banks active in the Norwegian money and foreign exchange markets. NIBOR quoting seems to indicate that most of the 44 European banks on the EURIBOR panel are included.[36] An alternative interpretation would have to be that NIBOR banks assign to each other the same credit risk as a wide range of European banks despite lower CDS prices for NIBOR banks.

Chart 11. Average CDS prices for NIBOR banks and EURIBOR banks.
Daily data. 1 January 2010 – 8 August 2012



The implied USD rate in NIBOR can also be assessed through a comparison with the Swedish interbank rate STIBOR.[37] Chart 12 shows the implied USD rates (measured as premiums) on which NIBOR and STIBOR are based.[38] The implied USD rate in NIBOR has generally been higher than the implied USD rate in STIBOR.

The difference between the two implied USD rates was particularly wide in the periods of high unrest around the sovereign debt problems in the euro area. It would seem that because of the linkage between NIBOR and the Kliem rate, this unrest contributed to a markedly higher impact

premiums in interbank rates should not therefore be expected. Nonetheless, higher CDS prices should in isolation imply higher risk premiums in interbank markets.

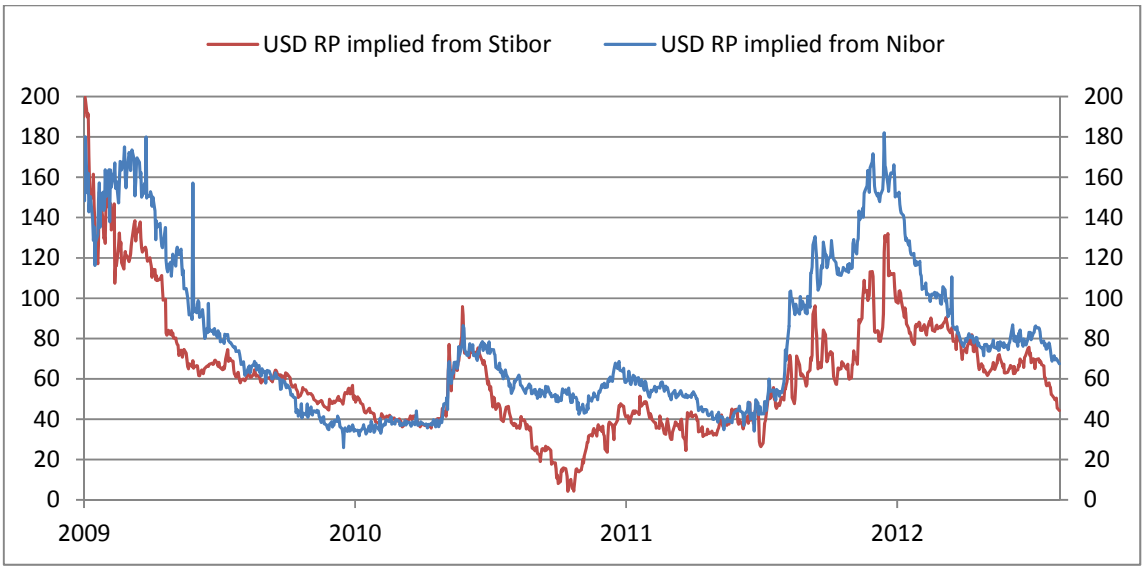
[36] The EURIBOR panel consists of banks from Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, UK, Denmark, Sweden, Japan and the US.

[37] As is the case for NIBOR, there is limited written documentation of how money market rates are fixed in Sweden. STIBOR (the Stockholm Interbank Offered Rate) is compiled and calculated by the Stockholm stock exchange (OMX Nordic Exchange). On the exchange's website, STIBOR is defined as the rate that banks are charged when borrowing money from other banks. It is an average of the rates quoted by selected banks in the exchange system after the highest and lowest quotes have been excluded. STIBOR rates are compiled and published daily at 11:05. There are STIBOR fixings on eight different maturities, from T/N (tomorrow/next) to 12 months.

[38] The implied USD rate in NIBOR is calculated as in Chart 6. The implied USD rate in STIBOR is calculated in the same way.

on the NIBOR rate than on the STIBOR rate. As shown in Chart 12, the implied USD rate has, in periods, been as much as 50 basis points higher in NIBOR than in STIBOR. It is not possible to establish on this basis whether the USD rate in NIBOR has been "too high" or the USD rate in STIBOR "too low" in this period.[39] We can only note that the USD rate in NIBOR has in periods been high relative to the USD rate in STIBOR, particularly through the second half of 2011 when financial turbulence in the euro area was high.[40]

Chart 12. Implied USD premium in STIBOR and NIBOR. Three-month maturity. Daily data. 1 January 2009 – 8 August 2012. Basis points.



The implied USD rate in NIBOR can also be compared with the interest rate on USD loans in the US commercial paper market. As discussed in Section 2, banks' short-term funding is largely obtained in commercial paper markets, not in interbank markets.[41] The use of NIBOR as a

[39] Market participants have claimed that STIBOR, particularly during the financial crisis, was not "right", that it was "artificially low" and did not reflect the interest rate banks had actually wanted to charge for unsecured lending in SEK in the interbank market. If this was the case, it may explain some of the difference between the two implied USD rates in Chart 12.

[40] When the implied USD rate in STIBOR is lower than the implied USD rate in NIBOR, a possible explanation could be that the credit risk for STIBOR panel banks is lower than for NIBOR panel banks. This is not the case. On the contrary, average CDS prices have been lower for NIBOR banks than for STIBOR panel banks. This difference, however, is due to the inclusion of the Royal Bank of Scotland (RBS) in the STIBOR panel until April 2012. To that date, the STIBOR panel consisted of Nordea, Danske Bank, SEB, Swedbank and Handelsbanken in addition to RBS. The NIBOR panel consists of the same banks minus RBS and including DNB. If RBS is disregarded, CDS prices for the two panels are about the same. The lower implied USD rate in STIBOR than in NIBOR cannot therefore be explained by lower credit risk premiums for STIBOR banks than for NIBOR banks.

[41] Banks also obtain a considerable share of funding in the European commercial paper market, but since NIBOR is based on a USD rate, we focus on the USD commercial paper market.

benchmark for bank lending rates should imply that NIBOR is determined by banks' marginal borrowing costs in the markets where they actually obtain their funding.

Chart 13 shows, for the period January 2007 – August 2012, the implied USD rate in NIBOR, the LIBOR rate, the average USD rate in the commercial paper market for banks with an AA credit rating, and the USD rates on USD loans in the commercial paper market reported by the DNB and NORDEA banks themselves. All have three-month maturities. Chart 14 shows the same, but with a shorter window, from 1 January 2010.

A starting-point could be an assumption that these rates should not deviate too far from each other. In the period to autumn 2008, there were only small deviations between the USD rate implied in NIBOR, the LIBOR rate and the USD rates solid banks had to pay in the commercial paper market. Since the second half of 2010 and particularly since the second half of 2011, however, the implied USD rate from NIBOR has been considerably higher than the average rate in the commercial paper market and the rates reported by DNB and NORDEA. This raises the question of whether NIBOR is an accurate expression of the marginal cost of banks' short-term borrowing converted into NOK.

However, it can be maintained that NIBOR is intended to reflect the marginal cost of obtaining funds at short notice and that the interbank rate in USD (Kliem) expresses this marginal cost. In the interbank market, it is, in principle, possible to borrow unsecured funds at very short notice, while borrowing in the commercial paper market to a greater extent follows an issue program that is more fixed over time. It could therefore be maintained that a NOK rate swapped from the USD rate in the commercial paper market does not reflect the cost of obtaining NOK unsecured at short notice.[42] How quickly a bank can obtain funding in the commercial paper market is nonetheless a key question: the faster this can occur, the more it can be claimed that the rate in the commercial paper market expresses the actual marginal USD cost, and the more reasonable it would be to base NIBOR quoting on the commercial paper market rate. It is in any event unclear why NIBOR is a good benchmark for banks' short-term borrowing as long as it is based on USD rate at which banks seldom or never trade, and as long as banks do not actually need to borrow USD in order to submit NIBOR quotes. Charts 13 and 14 also show that the USD rate on which NIBOR quoting is based is very sensitive to the turbulence in Europe. The rates on actual USD loans in the commercial paper market have reacted far less.

[42] One could also maintain, as NIBOR is intended to reflect the marginal cost of obtaining funds at short notice, that the bank in the Nibor-panel with the lowest rating determines the level of Nibor. Even though the CP-rates DNB and Nordea report to pay imply a NOK rate lower than Nibor, the CP-rate of other Nibor-banks may imply a NOK rate closer to NIBOR.

Chart 13: USD rates, three-month maturity. Kliem, the USD rate implied in NIBOR, the average USD rate in the CP market for a bank with an AA rating and USD rates in the CP market reported by DNB and NORDEA. Percent. Daily data. 1 January 2007 – 8 August 2012

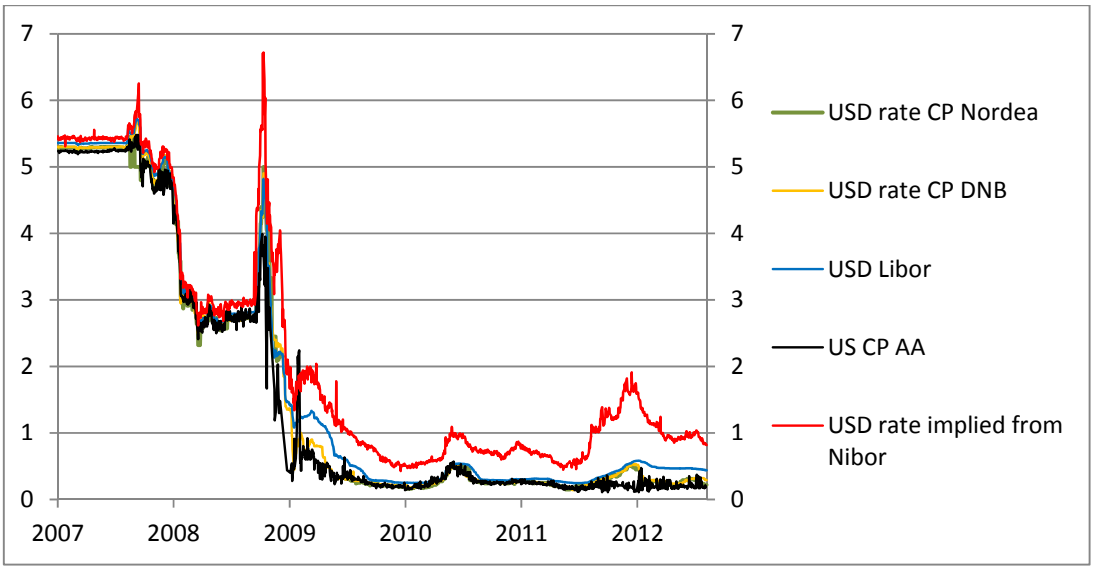
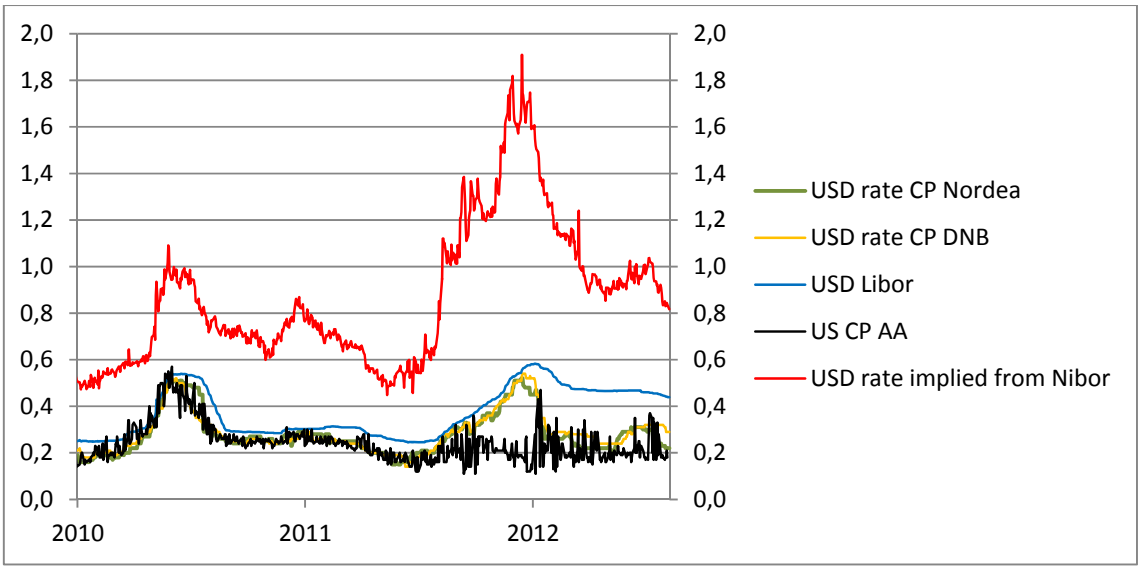


Chart 14: USD rates, three-month maturity. Kliem, USD rate implied in NIBOR, average USD rate in the CP market for a bank with an AA rating and USD rates in the CP market reported by DNB and NORDEA. Percent. Daily data. 1 January 2010 – 8 August 2012



Trading in the commercial paper market is active, an interest rate has been established in this market and this rate swapped to NOK should in principle provide a better expression of banks'

short-term *borrowing* rate measured in NOK. However, NIBOR is defined as the rate charged by a bank on unsecured *lending* to another bank. It could therefore be maintained that a NOK rate swapped from the commercial paper market rate cannot reflect a lending rate in NOK, as such a rate would not include the credit risk premium or any maturity premium the bank would charge to lend the funds to another bank.

A benchmark rate in the interbank market should in principle reflect the expected overnight rate plus the premium charged by a bank to lend the funds to another bank for a given period.[43] If the funds must first be obtained via the forward exchange market, the benchmark should be based on the rate actually paid by banks to borrow USD in transactions that take place. This USD rate swapped to NOK would reflect banks' marginal borrowing rate in NOK. The lending rate will be equal to this borrowing rate plus a risk premium. The risk premium should reflect a maturity premium plus the credit risk premium for banks active in the Norwegian market.[44]

Based on the above, the observed difference between the USD rate on which NIBOR is based and the USD rate banks actually pay in the commercial paper market can be interpreted as an expression of two factors: (i) the difference between borrowing USD at very short notice in the interbank market and borrowing USD via an issue program in the commercial paper market and (ii) the risk premium charged by NIBOR banks on lending in the Norwegian interbank market. If we take the rates banks actually pay in the commercial paper market as estimates of banks' actual borrowing costs, Charts 13 and 14 show that the implied risk premium has in periods been high. For example, solid Norwegian banks had to pay an interest rate of close to 50 basis points on a three-month loan in the US commercial paper market towards the end of 2011. The implied risk premium they charged to lend these funds to another bank via the Norwegian interbank market was well over 100 basis points, i.e. more than twice as high.

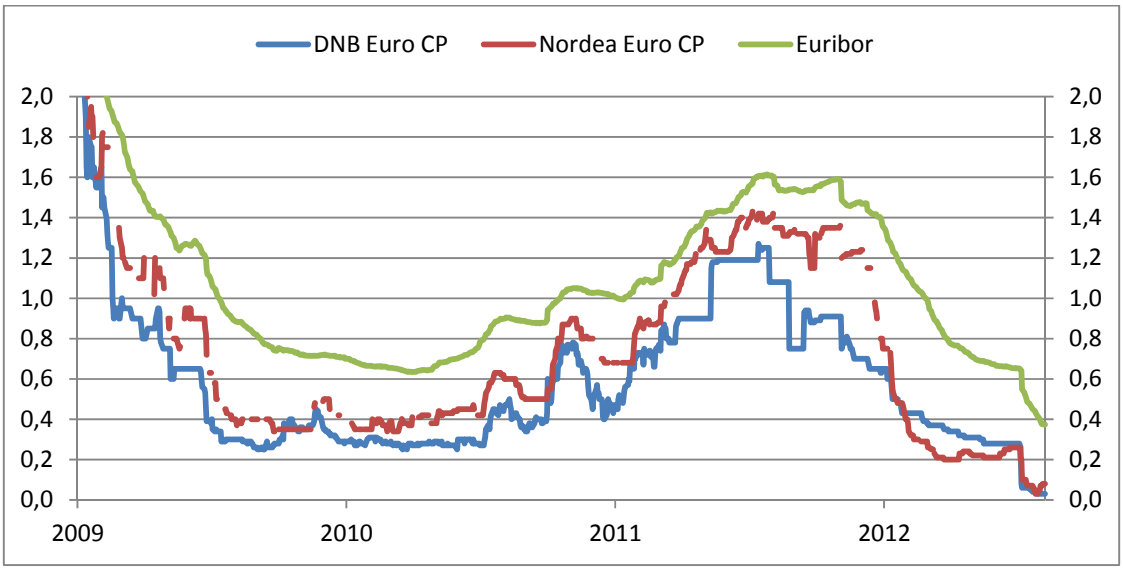
[43] As discussed in Section 5, there is no OIS market in Norway. This makes it difficult to use the expected overnight rate as a benchmark rate. Nonetheless, in principle a lending rate should, theoretically speaking, be thought of as the sum of expected overnight rates plus various premiums, and it should be assessed whether the current benchmark rate reflects these factors to a reasonable extent.

[44] In Denmark a working group (consisting of the central bank, Finansrådet, Realkreditrådet and Realkreditforeningen) has evaluated the need for a reference rate in addition to CIBOR. The group concluded that the best supplement to CIBOR is a Cita-swap, a swap rate where the tomorrow-next rate is the floating leg. Though customers have not shown an interest in such a reference rate directly, market participants welcome new reference rates, which can improve the Danish money market. The group also considered a currency swap rate as an alternative, but concluded such a rate to be less appropriate, as ...In view of market participants, FX-swaps are not appropriate as reference rates in the money market. The reason is that an FX-swap rate always depends on the other currency developments and will hence be sensitive for the liquidity situation and the situation in the money market for that currency... For details, see http://nationalbanken.dk/C1256BE200574B9C/side/Redegoerelse_om_Nationalbankens_deltagelse_i_Cibor-fastsaettelsen.

It is important to note that even if NIBOR banks had based NIBOR on a lower USD rate, so that NIBOR quotes had been lower, this does not necessarily mean that bank lending rates to households and businesses would have been lower. Bank lending rates are determined by the rates banks must pay to obtain funding, i.e. interest rates on deposits, interest rates on covered bonds and interest rates on unsecured paper, including bank bonds and commercial paper issued in local and foreign currency. It is these rates, combined with the competitive situation, that determine lending rates. To the extent a bank's lending is referenced against NIBOR, a lower NIBOR (due to the lower implied USD rate on which it is based) could then have led to a higher credit risk premium charged by banks on top of NIBOR, resulting in the same lending rate.

When Charts 13 and 14 show that USD CP rates are lower than the USD rate implied in NIBOR, one could naturally also raise the question of banks' rates in the commercial paper market for EUR compared with EURIBOR. We showed above that the Kliem rate is about equal to EURIBOR swapped to USD (cf. Chart 9). If banks' CP rate for USD is lower than Kliem, their CP rate for EUR must also be lower than EURIBOR. Assume the opposite: that banks' CP rate for EUR was equal to EURIBOR. Banks would then be able to obtain EUR by borrowing USD in the commercial paper market at a rate lower than Kliem, swap to EUR and thereby obtain EUR at a rate lower than EURIBOR. Chart 15 confirms this and shows that the CP rate for EUR that DNB and NORDEA report to pay is lower than EURIBOR.

Chart 15: EURIBOR and the EUR rates in the euro commercial paper market reported by DNB and NORDEA. Percent. Daily data. 1 January 2009 – 8 August 2012



Banks are also exposed to NIBOR in their long-term borrowing. Banks' long-term market funding is largely in the form of foreign currency bonds, which can have fixed or floating interest rates, for example referenced against USD LIBOR or EURIBOR. The bonds are mainly used to fund lending in NOK to Norwegian customers. As these loans are usually floating-rate loans in NOK, banks also seek a floating rate on their borrowing for risk management reasons. Fixed-rate loans in foreign currency can first be exchanged for floating-rate loans in foreign currency in an interest rate swap. The floating-rate loan in foreign currency can then be exchanged for a floating-rate loan in NOK in a basis swap. In a basis swap, the parties exchange both principal and floating-rate interest payments in one currency against another. The principle underlying a basis swap can be illustrated using the following example: assume that a NIBOR bank has raised a five-year USD loan at a floating rate referenced against LIBOR. The bank pays the current three-month LIBOR on this loan every three months plus a fixed premium reflecting the bank's credit risk and the general maturity premium investors demand on a five-year USD loan. However, the bank wants funding in NOK. The bank can exchange this five-year USD loan for a NOK loan in the same amount from its counterpart in a basis swap. As payment for the USD loan it has exchanged, the bank receives three-month LIBOR every three months. At the same time, the bank pays three-month NIBOR plus or minus a premium to its counterpart every three months. This premium is the price of the basis swap. The bank can use the LIBOR rate it receives in the basis swap to cover the interest payments on the USD loan.

The bank that raised the USD loan is thus exposed to NIBOR and not to USD LIBOR. Total borrowing costs for the bank are determined by the sum of the following:

- The price the bank has to pay for the long-term USD loan (LIBOR + credit risk premium and maturity premium for a five-year USD loan)
- minus LIBOR (which it receives in the basis swap)
- plus NIBOR with the price of the basis swap deducted (which it pays in the basis swap).

The bank's net funding costs consist of a credit risk premium and maturity premium for the original USD loan plus NIBOR with the price of the basis swap deducted.[45]

[45] See Appendix C for a numerical example of cash flows in a basis swap.

Chart 16: Basis swaps USD/NOK and NIBOR premium. Daily data. January 2007 – August 2012

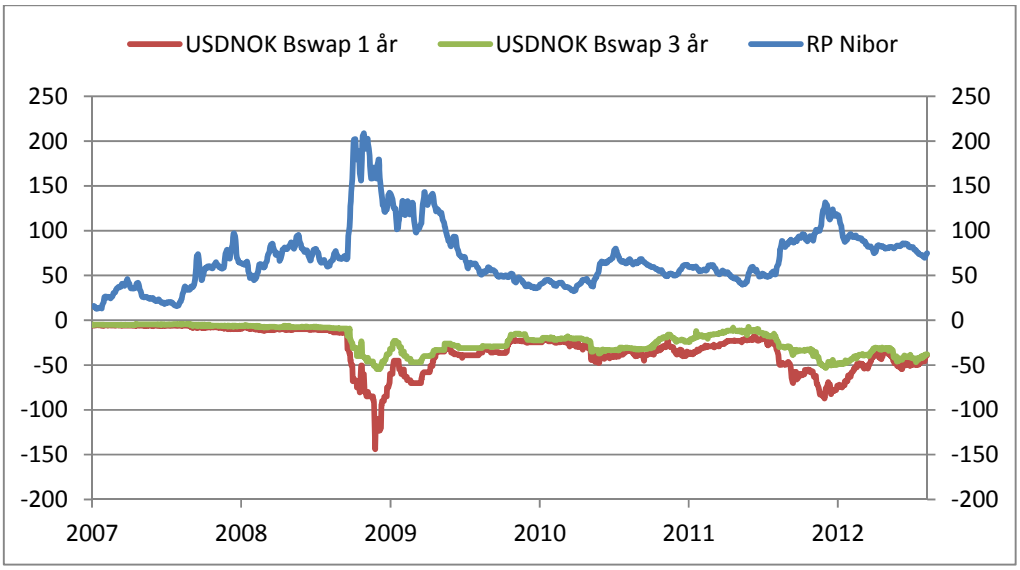


Chart 16 shows how one-year and three-year basis swaps (i.e. the price measured as a deduction from NIBOR in basis points) between USD and NOK have developed since 2007. When the financial crisis became acute in autumn 2008, basis swaps between NOK and USD fell sharply. At the lowest, one-year basis swaps fell to close to -150 basis points. This means that a bank that exchanged a USD loan for a NOK loan for one year could receive LIBOR in the swap and only have to pay NIBOR minus 150 basis points. This reflects the strong demand for USD relative to other currencies at that time.[46] Relative to LIBOR, a NOK loan had a lower price in real terms than expressed by the NIBOR rate.

Chart 16 also shows the strong negative relationship between the NIBOR risk premium and the basis swap. A high NIBOR premium accompanies a negative value for the basis swap. This means that if the NIBOR premium is high (relative to the LIBOR premium) at the time the basis swap is agreed on, the price of the basis swap will be negative. The party supplying USD and receiving NOK will not in reality pay the NIBOR rate, but the NIBOR rate minus a deduction equivalent to the price of the basis swap.[47]

The relationship between the NIBOR premium and the basis swap depends on the factors driving the NIBOR premium, especially if it is driven by a general liquidity premium in USD or a

[46] This was also reflected in the OIS basis, which became negative during the USD shortage, cf. Chart 7.

[47] Since the basis swap by structure is linked to LIBOR, it will also compensate for any underestimation of borrowing costs in LIBOR. If LIBOR is lower than the expected US key rate plus the general liquidity premium lenders in the US charge the safest borrowers, the basis swap will be affected.

credit risk premium applied by NIBOR banks. For example, assume that a general liquidity premium will at any time apply to three-month USD loans.[48] This premium reflects the compensation required by the lender to supply USD liquidity for three months, even to the safest borrowers. The premium is on top of the expected key rate. If both LIBOR and the USD NIBOR rate correctly reflect this premium, the basis swap will not be affected.[49] But if the USD NIBOR rate overestimates this premium, the price of the basis swap will be lower to compensate for a NIBOR rate that is too high. The same will occur if LIBOR for USD is artificially low in relation to the general liquidity premium for USD.

An increase in the NIBOR premium will make banks' *existing* long-term funding more expensive as they have to pay a higher current NIBOR rate in the basis swaps they have already entered into. The deduction in the basis swap (the price) is determined when the agreement is entered into and remains fixed for the term of the agreement. But for *new* funding, an increase in the NIBOR premium could fully or partly be countered by a fall in the price of the basis swap. This means that banks receive compensation for the NIBOR premium through the basis swap to the extent this premium overestimates the general liquidity premium on USD. The discussion earlier in this section shows that the USD rate in NIBOR to a great extent reflects the credit risk of a wide range of European banks, implying that it exceeds the general liquidity premium on USD.[50]

Higher maturity or credit risk premiums in bond markets will make banks' marginal long-term funding more expensive. An increase in NIBOR in excess of the general liquidity premium on USD will, however, not have this effect as the increase is neutralised when banks convert a USD loan into a NOK loan through a basis swap.

8. Summary and conclusion

NIBOR is the most important benchmark rate in Norway. A number of money market rates are referenced against NIBOR, including interest rates on bonds issued by banks and non-financial enterprises, as well as prices for many financial derivatives. A number of bank lending rates are also referenced against NIBOR.

Such a key interest rate should be well defined, so that it is clear what the rate expresses, and the rate-setting process should be transparent. New rules relating to NIBOR were published in 2011, stating that NIBOR is intended to show the average interest rate charged by NIBOR panel

[48] Before the financial crisis erupted in 2008, the general liquidity premium on USD was low.

[49] For some borrowers, there may also be an individual credit risk premium. An individual credit risk premium will not, however, be reflected in the basis swap.

[50] See Appendix D for a more detailed discussion of the relationship between the basis swap, the interest rate premium and the OIS basis. The different effects on the basis swap of a general liquidity premium in USD and an additional credit premium for Norwegian banks are discussed in particular.

banks on NOK loans to other leading banks active in the Norwegian money and foreign exchange markets. Despite this, a number of questions still remain as to which factors determine the level of NIBOR.

The NIBOR rate is in practice a foreign exchange swap rate consisting of two components: the USD rate applied by NIBOR banks in their NIBOR quoting and the interest rate differential in the forward exchange market (forward premium). In this *Memo*, we have examined NIBOR and these two components. Our goal has been to understand what drives the interest rate premium in NIBOR and why it has been generally high compared with the premium in other countries' benchmark rates. We have shown that the interest rate premium in NIBOR is driven by the USD premium applied by NIBOR banks in their NIBOR quoting plus the forward premium. A key factor is that when the general liquidity premium in USD increases, which in isolation leads to the application of a higher USD rate in NIBOR quoting, the forward premium will tend to dampen the effect of the USD premium on the NIBOR premium.

There was clear evidence of this mechanism during the financial crisis. In autumn 2008, strong demand for credit in USD led to a considerable increase in premiums in USD rates. At the same time, the forward market dampened some of the contagion from the USD premium, with the result that the premium in NIBOR and other currencies rose less sharply than the premium in USD. As the Federal Reserve increased the supply of credit in USD, forward points fell back to their equilibrium values and premiums in different countries' interbank rates tracked each other more closely. Central banks in other countries were to some extent able to influence premiums in domestic currencies relative to USD. To achieve this, however, central banks had to repeatedly provide cheap loans with longer-than-normal maturities to the respective banking systems.

A characteristic of benchmark rates such as LIBOR, EURIBOR and NIBOR, and the USD rate applied in NIBOR quoting, is that they are indicative, there are virtually no trades at these rates. The implied USD rate on which NIBOR is based is in principle intended to reflect banks' marginal cost of having to borrow unsecured USD in the interbank market at short notice. However, there is virtually no activity in the unsecured interbank market at maturities of more than a few days. In the three-month segment of the unsecured interbank market, which is the most important point of reference, there are very few transactions, not only between Norwegian banks, but also internationally. This raises the question of whether these benchmark rates possess the characteristics a good benchmark rate should have, not only with regard to NIBOR, but also to other countries' benchmark rates (c.f. the discussion of Libor manipulation, footnote 6). It is difficult to determine whether NIBOR – as it is currently quoted, but not traded –

reflects the interest rate that would have been formed if unsecured NOK loan transactions between NIBOR banks had actually taken place.

An alternative might be for banks to base their NIBOR quoting on the actual USD rates they have to pay in, for example, the US commercial paper market. We have shown that these rates are considerably lower than the implied USD rate on which NIBOR is based. An objection to this alternative might be that NIBOR is intended to reflect the marginal cost of obtaining funds at short notice. In the interbank market, it is in principle possible to borrow unsecured funds at short notice, while borrowing in, for example, the commercial paper market to a greater extent follows an issue program that is more fixed over time. It could therefore be maintained that basing NIBOR quoting on USD commercial paper market rates would not be in line with the current definition that the rate should reflect the cost of a loan that can be raised at short notice in the interbank market. How quickly a bank can obtain funding in the commercial paper market is nonetheless a key question: the faster this can occur, the more reasonable it would be to regard the rate in the commercial paper market as the actual marginal borrowing cost in USD.

It is important to note that even though the USD rate on which NIBOR is based seems high in relation to banks' actual funding costs in USD, this does not necessarily mean that bank lending rates for bank customers are higher than they would otherwise have been. Bank lending rates are determined by the actual rates banks pay for funding and the competitive situation in the market. It is nonetheless a paradox that the most important benchmark rates in the three-month segment, not only NIBOR in Norway, but also LIBOR and EURIBOR, have such an important role in financial markets given that few actual trades take place at these rates.

Appendix A: The OIS basis is normally zero

The model is given by the equations[51]

(1) $i_N = i_{N,\$} + (f-e)$

(2) $rp_N = i_N - OIS_N$

(3) $rp_{L,\$} = i_{L,\$} - OIS_\$$

(4) $i_{N,\$} = OIS_\$ + rp_{L,\$} + erp_{K,\$} + erp_{N,\$}$

It follows that (equation 6 in main text)

(6) $rp_N = rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + (f-e) - (OIS_N - OIS_\$)$

The last term is referred to as the OIS basis, i.e. (equation 8 in main text)

(8) $OISB = (f-e) - (OIS_N - OIS_\$)$

In a perfect world, i.e. in the absence of all types of risk and transaction costs, the OIS basis will be zero (the actual forward premium is equal to the theoretical), i.e. $(f-e) = (OIS_N - OIS_\$)$. The following arbitrage argument underlies this statement:

- Assume that three-month domestic OIS is lower than three-month USD OIS plus the actual forward premium, i.e. $OIS_N < OIS_\$ + (f-e)$.
- Raise an overnight NOK loan in the domestic market. Roll the loan over daily for three months (i.e. raise a new overnight loan tomorrow and repay the loan raised today, and

[51] Equation (1) is related to covered interest parity. The theoretical derivation is as follows: Let i_N be the domestic three-month interest rate, i.e. it is assumed that there is a purely domestic three-month NOK market where banks can borrow and lend funds. An investor can then invest one krone domestically and receive the return $(1+i_N)$ with certainty in three months. Alternatively, the investor can first exchange the krone for USD at the current spot rate and receive 1/E USD, where E is the spot rate for NOK (number of NOK per USD). Then he can invest the exchanged amount at the USD rate and receive $1/E\ (1+i_{N,\$})$ USD with certainty in the future, where $i_{N,\$}$ in this example is assumed to be the USD rate the investor can receive on his investment for three months. At the same time, he sells this USD amount forward at the current forward rate, F. Then he knows with certainty that he will receive $F/E\ (1+i_{N,\$})$ in NOK in three months. Since these two investment alternatives provide an assured return, they must be equal, i.e. $(1+i_N)=F/E(1+i_{N,\$})$. If not, arbitrage opportunities exist: funds are borrowed where interest rates are lowest and invested where rates are highest. By taking the logarithm of both sides, the equation $i_N=i_{N,\$}+(f-e)$ follows, where $f=\ln(F)$, $e=\ln(E)$, $i_N \approx \ln(1+i_N)$ and $i_{N,\$} \approx \ln(1+i_{N,\$})$. This arbitrage argument presupposes that a domestic three-month interest rate exists and can be used in actual trades. This is not the case in Norway. In other words, there is little point in using standard tests for covered interest parity and comparing the domestic rate (i_N) with the swap rate ($i_{N,\$}+f-e$). Equation (1) above must therefore be regarded as a relationship that NIBOR must be consistent with.

so on). The cost of borrowing using this strategy depends on the overnight rate realised over the next three months and is not assured today.

- Enter into an OIS agreement today, where you receive the floating overnight rate and pay three-month OIS (assume first for the sake of argument that a domestic OIS exists). You then have a given NOK amount for three months at a rate known today (the OIS rate), while you use the floating-rate overnight interest you receive in the swap to pay the interest on the rolling overnight loan.
- The NOK amount borrowed today (and that will be rolled over for three months ahead) is exchanged for USD today at the current spot rate, e. This USD amount is invested overnight in the USD market. The investment is rolled over daily for three months. The return using this investment strategy depends on the actual realised overnight interest over the three-month period and is unknown today.
- Enter into an OIS agreement today. Exchange the floating overnight rate you receive on the USD investment for the next three months for the fixed OIS rate. Then the return in USD of rolling over the USD investment overnight will already be known today.
- This known USD amount that you will receive in three months is sold forward today at the forward rate, f. You then know the NOK amount you will receive in three months.
- If the domestic OIS rate is equal to the foreign OIS rate plus the forward premium, the return provided by these two strategies will be the same.
- If the domestic OIS rate is lower than the foreign OIS rate plus the forward premium, as in the example above, a positive return will be achieved by borrowing NOK and rolling over the loan overnight for three months, securing the NOK rate with an OIS agreement, swapping to USD spot, investing USD overnight for three months, securing the USD return with an OIS agreement and selling the forthcoming USD amount forward at today's forward rate.
- Such a gain will trigger arbitrage. There will be a tendency to buy USD and sell NOK spot and to sell USD and buy NOK forward. Buying NOK forward will tend to strengthen the NOK forward rate ($\Delta f<0$). The forward premium will thereby be reduced, (f-e) falls, reducing the difference above.

Thus, in a "perfect world", the theoretical and actual forward premiums will be equal. Then, it follows from equation (6) that the NIBOR premium is equal to the LIBOR premium plus the extra premium for European banks on top of the LIBOR premium plus the extra premium NIBOR banks apply in addition.[52]

[52] If there is no domestic OIS, as is the case in Norway, the reasoning above must be adjusted to some extent. We argued that an investor could borrow NOK overnight for three months, secure total interest expenses with an OIS agreement and thereby know today how much it costs to borrow NOK overnight for three months. If there is no OIS, the OIS rate must be replaced by the expected overnight rate, which in turn is close to the expected key rate.

Appendix B: The relationship between forward premiums when covered interest parity holds

In the main text, we showed that NIBOR, the NOK rate swapped from Kliem and the NOK rate swapped from EURIBOR are approximately the same (cf. Chart 10), and that this is consistent with the USD rate swapped from EURIBOR being equal to Kliem (cf. Chart 9). To illustrate this relationship, we use the formula for swap rates as our starting-point (analogous to covered interest parity, see footnote 1 in Appendix A), i.e.

(1) $i_{N,Kliem} = i_{Kliem} + (f\text{-}e)_{nokusd}$

(2) $i_{N,euribor} = i_{euribor} + (f\text{-}e)_{nokeur}$

(3) $i_{usd,euribor} = i_{euribor} + (f\text{-}e)_{usdeur}$

where $i_{N,Kliem}$ is the NOK rate swapped from Kliem, $i_{N,euribor}$ is the NOK rate swapped from EURIBOR and $i_{usd,euribor}$ is the USD rate swapped from EURIBOR. Moreover, the exchange rates are defined as the amount of kroner per USD, the amount of kroner per EUR and the amount of USD per EUR. Assume first that covered interest parity holds between EURIBOR and Kliem, as we suggested in Chart 9. This means that equation (3) can be written as follows

(3') $i_{Kliem} = i_{euribor} + (f\text{-}e)_{usdeur}$

Inserting (3') into (1) gives

(4) $i_{N,Kliem} = i_{euribor} + (f\text{-}e)_{usdeur} + (f\text{-}e)_{nokusd}$

Inserting (2) into (4) (by inserting for $i_{euribor}$)

(5) $i_{N,Kliem} = i_{N,euribor} - (f\text{-}e)_{nokeur} + (f\text{-}e)_{usdeur} + (f\text{-}e)_{nokusd}$

Assume that the NOK rate swapped from EURIBOR ($i_{N,euribor}$) and the NOK rate swapped from Kliem ($i_{N,Kliem}$) are the same (cf. Chart 10). The following sum must then hold:

$- (f\text{-}e)_{nokeur} + (f\text{-}e)_{usdeur} + (f\text{-}e)_{nokusd} = 0$, i.e.

In this case, the final interest cost of borrowing NOK overnight for three months is determined by the actual average overnight rate over the three-month period. There is therefore an extra uncertainty in relation to the original arbitrage argument, but in terms of expectations, the argument remains the same.

$(f\text{-}e)_{nokeur} = (f\text{-}e)_{usdeur} + (f\text{-}e)_{nokusd}$

For three currency pairs, given the construction of swap rates analogous to covered interest parity, and given that covered interest parity holds between the currencies traded, the forward premium for any of the currency pairs can be written as the sum of the other two.

Appendix C: Numerical example basis swap

As a numerical example of the cash flows in a basis swap, assume that bank A raises a five-year loan of USD 100, where the interest rate is floating three-month LIBOR plus 100 basis points. This means that the bank must pay the lender LIBOR plus 100 basis points every three months. The bank enters into a basis swap with bank B and exchanges the USD 100 for NOK today, at an assumed exchange rate of NOK 5 per USD, and thus receives NOK 500. At the same time, the banks agree to reverse the exchange in five years' time. In the meantime, bank A pays three-month NIBOR plus the price of the basis swap to bank B, while bank B pays three-month USD LIBOR to bank A. Assume that there is a shortage of USD. This means that the price of the basis swap is negative, so that bank A, which sends USD to bank B, receives a discount on its NIBOR payments to bank B. Assume that the price of the basis swap is -50 basis points.

For bank A, cash flows are as follows:

Initially:

- Bank A raises a loan of USD 100 at floating three-month LIBOR+100 basis points
- Bank A sends USD 100 to bank B and receives NOK 500 kroner from bank B

In three months:

- Bank A receives the three-month LIBOR rate applicable at that time from bank B and pays the three-month NIBOR rate applicable at that time minus 50 basis points to bank B

In six months:

- Bank A receives the three-month LIBOR rate applicable at that time from bank B and pays the three-month NIBOR rate applicable at that time minus 50 basis points to bank B

……

In four years and nine months:

- Bank A receives the three-month LIBOR rate applicable at that time from bank B and pays the three-month NIBOR rate applicable at that time minus 50 basis points to bank B

In five years

- Bank A sends NOK 500 to bank B and receives USD 100 from bank B. Bank A redeems the original loan of USD 100

Bank A's cash flows are in sum:

LIBOR + premium(100bp) – LIBOR + NIBOR + priceBS(-50bp) = NIBOR + premium(100bp) + priceBS(-50bp) = NIBOR + 100bp - 50 bp = NIBOR + 50bp.

Where the *premium(100bp)* is the extra premium bank A must pay on top of LIBOR for the five-year loan in USD and *priceBS(-50bp)* is the price of the basis swap, here -50 basis points. Bank A has thus raised a USD loan, but with all its interest exposure in NOK, in our example NIBOR plus 50 basis points. The bank must initially pay a premium of 100 basis points in order to borrow USD for five years, but because of the shortage of USD relative to NOK, the banks recoups some of this in the basis swap.

Appendix D: Relationship between interest rate premium, OIS basis and basis swap

In this appendix, we derive the relationship between the interest rate premium, the OIS basis and the basis swap based on the model in Section 5, included again below. It is given by

(1) $i_N = i_{N,\$} + (f-e)$

where f is the forward exchange rate, e is the spot rate (both in logarithmic form, number of NOK per USD, so that an increase implies a weaker krone) and where (f-e) is the forward premium in basis points. In addition,

(2) $rp_N = i_N - OIS_N$

and

(3) $rp_{L,\$} = i_{L,\$} - OIS_\$$

where OIS_N is OIS for NOK, rp_N is the risk premium in NIBOR, $OIS_\$$ is USD OIS, and $rp_{L,\$}$ is the risk premium in LIBOR. The USD rate NIBOR banks have to pay can be written as

(4) $i_{N,\$} = OIS_\$ + rp_{L,\$} + erp_{K,\$} + erp_{N,\$}$

where $erp_{K,\$}$ is the extra premium European banks have to pay on top of the LIBOR premium (assumed to be the extra premium in Kliem in addition to the LIBOR premium), and $erp_{N,\$}$ is the

extra premium NIBOR banks have to pay on top of this (can be negative if credit risk premiums for NIBOR banks are lower than for European banks). Inserting equation (4) into (1) gives

(5) $i_N = OIS_\$ + rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + (f\text{-}e)$

Inserting equation (5) into (2) gives

(6) $rp_N = rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + (f\text{-}e) - (OIS_N – OIS_\$)$

The premium in NIBOR is given by the premium in LIBOR, the extra premium European banks have to pay on top of the LIBOR premium (represented by the Kliem premium on top of the LIBOR premium), the extra premium NIBOR banks have to pay in addition to the extra premium in Kliem, the forward premium and the spread between OIS rates. If neither European banks nor NIBOR banks have to pay an additional credit risk premium, $erp_{K,\$} = erp_{N,\$} = 0$, and $i_{N,\$} = i_{L,\$}$, where $i_{L,\$}$ is USD LIBOR. Equation (6) is then reduced to

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

The difference between the forward premium and the OIS spread defines the OIS basis, given by

(8) $OISB_{USDNOK} = OIS_\$ + (f\text{-}e) – OIS_N$

Inserting equation (8) into (6) gives

(9) $rp_N = rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + OISB_{USDNOK}$

The OIS basis is normally zero, giving

(10) $OIS_N = OIS_\$ + (f\text{-}e)$

Equation (10) has the same structure as equation (1) and is covered interest parity. The OIS basis may deviate from zero in periods. In times of financial market turbulence, demand for USD will often be high. Market participants with limited access to USD in the USD market, will seek to obtain USD in the forward market, buying USD and selling NOK spot, while at the same time selling USD and buying NOK forward. This strengthens the forward rate for NOK, reducing f

($\Delta f<0$).[53] Forward premiums fall and the OIS basis becomes negative. A negative OIS basis thereby reflects high demand for USD.

Even though it may be difficult in practice to distinguish liquidity premiums from credit risk premiums, the argument can be made, within a theoretical framework, that the effect on the OIS basis of an additional credit risk premium for Norwegian banks differs from the effect of a general liquidity premium in USD. This difference influences both the OIS basis and the basis swap. If there is an increase in the general liquidity premium in USD, the forward market will dampen and counteract the increase in the USD premium for NIBOR banks, leaving the NIBOR premium unaffected. A general increase in the liquidity premium in USD is expressed by an increase in the LIBOR premium ($rp_{L,\$}$) in equation (5). Given the initial prices in the forward exchange market, it will then be cheaper to obtain USD via this market. Participants buy USD and sell NOK spot and sell USD and buy NOK forward. This strengthens the forward exchange rate ($\Delta f<0$), which pushes up the implied USD rate via the forward exchange market.[54] The strengthening of the NOK forward exchange rate continues until the cost of obtaining USD via the forward market is equal to the cost of obtaining USD directly in the USD market, i.e. until $\Delta f=-\Delta rp_{L,\$}$. The forward market thus counteracts the increase in the USD premium, leaving the NIBOR premium unaffected. On the other hand, an additional credit risk premium for NIBOR banks affects the NIBOR premium and, within the theoretical framework, in a one-to-one ratio.[55] This distinction influences the price of a basis swap, as the impact of a general liquidity premium in USD differs from the impact of an additional credit risk premium for NIBOR banks.

Equation (6) can be written as follows:

(11) $0 = erp_{K,\$} + erp_{N,\$} + \{ (f-e) - (OIS_N - OIS_\$) - rp_N + rp_{L,\$} \}$

where the last term in {}-parentheses is referred to as the basis swap between NOK and USD. It is given by

(12) $BS_{USDNOK} = (f-e) - (OIS_N - OIS_\$) - rp_N + rp_{L,\$}$

[53] The OIS basis is thus determined by developments in the forward premium, which, when adjusted for changes in the expected key rate, reflects a shortage of USD. If the forward rate is changed only as a result of a change in the expected key rate, and not as a result of a USD shortage, OIS spreads will change, keeping the OIS basis unchanged.

[54] The implied USD rate is given by $i\$=iN-(f-e)$, analogous to equation (1), but expressed as the interest rate on USD swapped from another currency, in this case NOK.

[55] Discussed in more detail in Syrstad (2012).

Inserting equation (8) into equation (12) gives

(13) $BS_{USDNOK} = OISB_{USDNOK} – rp_N + rp_{L,\$}$

Thus, the basis swap can be decomposed into the OIS basis, the NIBOR premium and the LIBOR premium.

Inserting equation (6) into equation (12) gives

(14) $BS_{USDNOK}=\{OIS_\$ + (f\text{-}e) – OIS_N\}- \{rp_{L,\$} + erp_{K,\$} + erp_{N,\$} + (f\text{-}e) - (OIS_N – OIS_\$)\} + \{rp_{L,\$}\}$

This gives

(15) $BS_{USDNOK} = - erp_{K,\$} - erp_{N,\$}$

In order to understand the factors driving the basis swap, we will discuss equations (12), (13), (14) and (15), distinguishing between an increase in the general liquidity premium on USD and an additional credit risk premium for Norwegian banks.

(iii) Increase in the general liquidity premium in USD. Assume that the liquidity premium in USD rises for all banks and results in a higher LIBOR rate. In equation (6), this means that the LIBOR premium rises, but that the Kliem premium on top of the LIBOR premium and the extra premium applied by NIBOR banks in addition to this remain unchanged.[56] It follows that the basis swap also remains unchanged since the LIBOR premium is not included in equation (15). The LIBOR premium is, however, included in equation (14), and it is useful to discuss equation (14) in the following way: When the LIBOR premium increases as a result of a general liquidity premium on USD, the forward premium and the OIS basis fall to the same extent as the rise in the LIBOR premium, so that the effect on the NIBOR premium in equation (6) is zero (cf. discussion above). In equation (14), which shows all the components in the basis swap, we see that these effects are "cancelled out": the LIBOR premium ($rp_{L,\$}$) is included with a positive and negative sign, as is the case for the forward premium (f-e). If we then turn to the basis swap as written in equation (13), we see that a fall in the OIS basis counteracts the increase in the LIBOR premium, so that the basis swap is zero. In this case, the full increase in the liquidity premium occurs in LIBOR, with the forward market and the OIS basis acting as a "shield".

[56] Kliem and NIBOR rise as much as LIBOR, but the "extra premiums" do not change, cf. footnotes 20 and 21 in the main text.

Thus: in the event of a general increase in the liquidity premium on USD ($\Delta rp_{L,\$}>0$),

- *the OIS basis falls to the same extent as the rise in the LIBOR premium*
- *the basis swap remains unchanged.*

(ii) *Higher credit risk premium for NIBOR banks*
Assume that the USD rate applied by NIBOR banks increases relative to LIBOR, and assume that this occurs because NIBOR banks' extra premiums increase as a result of higher credit risk premiums ($\Delta erp_{N,\$}>0$). In contrast to the case where a general liquidity premium is applied to all banks, the forward market will not counteract the increase in the USD rate applied by NIBOR banks, and NIBOR premiums will increase. In equation (6), thereby, $\Delta rp_N = \Delta erp_{N,\$}$. The OIS basis (equation 8) remains unchanged, while the basis swap falls (equations 13, 14 and 15).

Thus: in the event of an additional credit risk premium for Norwegian banks,

- *the OIS basis will remain unchanged, and*
- *the basis swap will fall by the same extent as the rise in the credit risk premium applied to NIBOR banks*.[57]

We see that in the event of an increase in the USD rate for NIBOR banks, a key factor is how the forward market and thus the OIS market react. The more the forward market provides a "shield" against the increase in the USD premium, the more the OIS basis changes and the less the basis swap falls.

Furthermore, the following argument may be useful to the discussion: In normal times (pre-financial turbulence), NIBOR quoting was based on LIBOR. Equation (6) is then reduced to equation (7), and since the OIS basis is normally zero (cf. equation 10),

(16) $rp_N = rp_{L,\$}$

The NIBOR premium is then determined by the LIBOR premium, and both the OIS basis and the basis swap are zero. In periods of turbulence, equations (7) and (16) do not hold, and the basis swap is determined by two factors:

[57] A situation is also possible where credit risk premiums rise for European banks, but not for NIBOR banks. In that case, $erp_{K,\$}$ will increase, while $erp_{N,\$}$ will fall by the same extent. Then, both the OIS basis between NOK and USD and the basis swap between NOK and USD will remain unchanged.

- which USD rate NIBOR banks apply and in particular to what extent this rate deviates from LIBOR (important because basis swaps are priced in terms of LIBOR)
- to what extent the forward market provides a “shield” and dampens the impact on the NIBOR premium of the USD premium applied by NIBOR banks.

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