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Does the LIBOR Misdirect Monetary Policy? A Case Study on the NIBOR and Norges Bank 2007-11

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Abstract

This paper is an empirical investigation into the Norwegian Interbank Offered Rate (NIBOR) during 2007-2011. It is demonstrated that an informal rule change to the benchmark fixing mechanism, instigated by the NIBOR panel in September 2008, not only increased the susceptibility of the benchmark to deception, but fundamentally changed the decomposition of the Norwegian money market risk premium. The new NIBOR resulted in a greater dependency on the Eurozone money markets, and also came to include an additional risk premium variable: the ability of Eurozone banks to raise U.S. dollar funding. In sum, it is shown that Norway has faced both higher, and more volatile, money market risk premia since Q4 2008 – having considerable policy implications.

1. Introduction

Surging money market risk-premia during the early period of the global financial crisis forced central banks across the world to cut repo rates and to introduce a range of extraordinary measures to alleviate stress in the banking systems. The London Interbank Offered Rate (LIBOR) was widely perceived to be a reliable benchmark for the short-term interbank money market, serving its purpose as the key indicator of the first stage of the monetary transmission mechanism. Thus, the assumption that the LIBOR was based upon actual market transactions was central in attempts to decompose the LIBOR and money market risk premia such as LIBOR-OIS spreads (see, for instance, Bank of England, 2007; McAndrews, Sarkar & Wang, 2008; Poskitt, 2011; Schwartz, 2010; Soultanaeva & Strömqvist, 2009).

Recently, however, claims that the benchmark, at times, has been subject to attempts of manipulation by LIBOR panel banks, have put the integrity of the benchmark into question. LIBOR-indexed derivatives portfolios, and the stigma attached to signalling a relatively high funding cost to the rest of the market, appears to have given some banks sufficiently strong incentives to submit deceptive LIBOR quotes in order to reap monetary benefits from having the privilege to participate in the LIBOR fixing process. Collusion among LIBOR panel banks, as well as between banks and money market brokers, also appears to have been commonplace (Financial Services Agency, 2011abc; Financial Services Authority, 2012ab, 2013; U.S. Commodity Futures Trading Commission, 2012). The issue of manipulation, however, has not been confined to that of the LIBOR alone. Other equivalent benchmarks, such as TIBOR, EURIBOR and NIBOR, have also come under scrutiny from media and regulators alike.

Stenfors (2012ab) uses a game-theoretic approach to demonstrate how panel banks have the means, opportunities and incentives to submit deceptive quotes. The design of the fixing mechanism can in fact lead to systematic and long-lasting deviations of the LIBOR from the actual money market rate. The LIBOR game is a non-zero sum game, meaning that temporary deviations result in monetary transfers not only between panel banks, but also from other market participants (institutions, corporations and households alike) to the panel banks. Systematic and long-lasting deviations, however, also result in another – less quantifiable - social loss. Namely, it poses an immediate problem for central banks.

By being a proxy for the interbank money market rate, the LIBOR is the key variable in the first stage of the monetary transmission mechanism. It should not only correspond to the current and

expected future repo rates determined by the central bank, but also contain an element of credit and liquidity risk. This is important, as decisions regarding monetary policy or financial stability can be made, if not with more certainty, then at least with greater confidence if the roots and sources are better understood. Thus, an 'inaccurate' LIBOR complicates policy making. For instance, a systematically understated LIBOR might give central banks the impression that a credit squeeze is absent and therefore delay necessary rate cuts. An overstated LIBOR, on the other hand, might provide the economy with an undue monetary tightening.

Surprisingly, central banks have so far remained remarkably quiet in the LIBOR-debate. However, some of this absence can be logically explained. Due to its history in the unregulated Eurodollar market, central banks have not had any formal authority over the LIBOR fixing mechanism or the bank panel compositions. Instead, the authority has lied amongst the LIBOR panels themselves, often in conjunction with the bank lobby organisations. Smaller benchmarks in particular, such as the Swedish STIBOR and Norwegian NIBOR, have been even more informally governed.[2] The fixing mechanisms or the panel bank compositions that make up the LIBOR-equivalent benchmarks have remained remarkably untouched, despite far-reaching changes in financial markets generally - let alone recent revelations about systematic benchmark manipulation. This, coupled with lack of transparency with regards to bank-level trade data, makes any empirical investigation into the monetary policy implications of an 'incorrect' or 'skewed' LIBOR notoriously difficult. Conclusions are therefore likely to remain anecdotal or hypothetical.

An interesting exception to this is the Norwegian Interbank Offered Rate (NIBOR), which underwent a significant 'rule change' at the time of the collapse of Lehman Brothers in September 2008. As the Norwegian benchmark also lacks adequate transparency, the change is not documented as such. This, in itself, might arguably a cause for concern for the central bank. Nonetheless, this paper demonstrates that the change did indeed take place - having considerable impact on the domestic money market risk premium. As one way of studying the impact of benchmark deception on central bank policy would be to look the first stage of the monetary transmission mechanism, it provides a suitable case study where empirical evidence is obtainable.

This paper studies the NIBOR from 2007 to the end of 2011, and analyses two interlinked issues. First, given the unique fixing mechanism of the NIBOR, it investigates the susceptibility of the benchmark to manipulation during this period. It is shown that the rule change, instigated by the NIBOR panel banks in September 2008, significantly increased the scope for deception of the

[2] Although more recently governed by Bankföreningen and Finans Norge (FNO) respectively.

Norwegian benchmark. Second – and crucially - the case study measures the impact of the rule change on the Norwegian risk premium and its decomposition. As a consequence, the ramifications for central bank policy are highlighted. In doing so, this paper sheds some light on the social costs of benchmark deception.

The paper is organised as follows. The NIBOR fixing mechanism and the reasoning behind the rule change is explained in Section 2. Section 3 then empirically tests the rule change to arrive at a new expression for the 'imported' USD risk premium. Section 4 quantifies the impact on the Norwegian risk premium and considers the implications for Norges Bank's risk premium projections. Section 5 concludes.

2. The NIBOR

2.1. Institutional Background

The NIBOR fixing mechanism is unique among the LIBOR-equivalent benchmarks as it more 'purely' reflects its historical roots in the Eurocurrency market. When the NIBOR was created in the mid 1980s, the Norwegian Eurokrone market was widely regarded as too small and illiquid to serve as a calculation base for a domestic benchmark. Consequently, banks mutually agreed that the NIBOR should be based upon the covered interest parity (CIP) applying market USD/NOK FX swap rates and the USD LIBOR as the base interest rate. The stability of the CIP ensured that an *implied* Norwegian money market rate served this function well. As the markets became increasingly liquid over the years, banks found no reason to change this convention as it had been firmly anchored as the benchmark a range of financial contracts, including new NOK derivatives instruments, such as forward rate agreements (FRAs), interest rate swaps (IRSs) and cross-currency basis swaps (CRSs).

The NIBOR panel consists of six Nordic banks as of today[3]. The small panel size implies that only two submitted quotes (the highest and lowest) are omitted from the trimming procedure, and the arithmetic mean is calculated from only four remaining NIBOR quotes. Until 2011, the NIBOR was informally governed by a committee consisting of members from the 6 panel banks. Since 2011, Finans Norge (FNO) acts as the 'governing body'. According to the FNO (2011), the NIBOR

[3] Danske Bank, Den Norske Bank, Handelsbanken, Nordea, SEB and Swedbank

should reflect *'the interest rate level lenders require for unsecured money market lending in NOK'* and also *'which interest rate the bank charges on lending in NOK to a leading bank that is active in the Norwegian money and foreign exchange markets.*' Further, NIBOR submissions should be regarded as *'best possible estimates, not binding offers*'.

2.2. The NIBOR Rule Change

Through its traditional link to the CIP, NIBOR panel banks do not submit NOK money market rates directly to the NIBOR fixing, but submit USD money market rates and USD/NOK FX swaps – thereby forming an implied NOK interest rate. As with the London-based LIBOR, banks submit individual and subjective quotes, but are not required to trade at these quotes. Theoretically, the NIBOR can thus be seen as being subject to equivalent susceptibility to deception by panel banks as other benchmarks – also more lately picked up by the media and regulators alike (see, for instance, Finansdepartementet, 2012; FNO, 2013a; Langberg, Bjørnestad & Holgersen, 2013)

However, due to the unique NIBOR fixing mechanism, the ability to submit deceptive quotes is different. First, NIBOR banks are *not required* to trade at the submitted USD/NOK FX swap points, but are *expected to* be able to do so by other panel members. To be more specific, it is not backed up by a written rule, but by a gentlemen's agreement among the participating banks. Although, according to FNO (2013b), the swap points are *'traded in a market that is regarded as liquid'*, the mutually agreed FX swap bid-offer spreads used for the NIBOR fixing mechanism are significantly wider than that of the tradable interbank market, making trading at these prices less likely. This naturally increases the probability of (and the expected payoff from) deception on a daily basis to profit from underlying NIBOR-indexed portfolios. As Stenfors (2012a) shows, the trimming process, often perceived as a hindrance to single-handed manipulation, is not an effective mechanism to ensure an unbiased fixing.

Nonetheless, anecdotal evidence suggests that a submitted FX swap rate *outside* this range would normally raise complaints from other panel members, limiting the opportunity to deceive to around 2-10 basis points depending on maturity and prevailing and mutually agreed bid-offer spread[4]. Whereas this would imply a monetary transfer to one or several of the panel banks from other

[4] A tighter bid-offer spread used for the USD/NOK FX swaps in the fixing mechanism would, *ceteris paribus*, result in a lower NIBOR. Measured in terms of basis points, the bid-offer spread is wider for shorter maturities, implying greater scope for deception for these maturities.

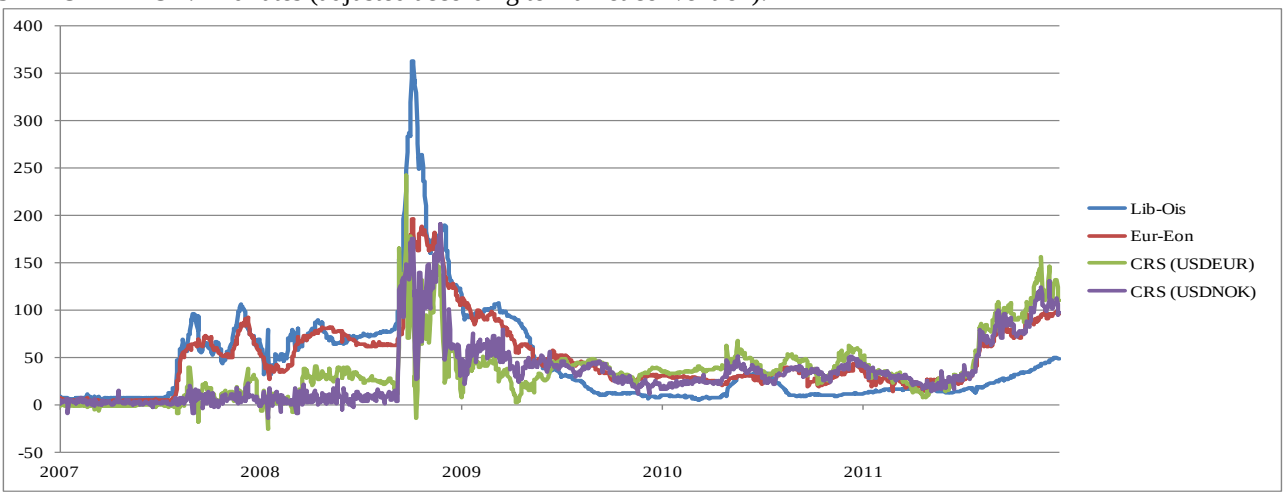
market participants each day, it could be argued that the impact on monetary policy of this kind of behaviour is limited.[5]

However, the second variable in the NIBOR fixing mechanism, namely the USD interest rate, is more liable to deception. According to FNO (2013b), this is *'the rate at which an individual bank argues it can lend unsecured U.S. dollars to the interbank market'*. However, banks are neither required to openly disclose which rate is used for the NIBOR submission, nor to trade at it. Nonetheless, using the CIP, it is a straight-forward process to derive this rate from the NIBOR and USD/NOK FX swap points, which are transparent. Prior to September 2008, this rate was indeed very close to the USD LIBOR, confirming that NIBOR panel banks used this - regardless of its accuracy - as a reference point.

The global financial crisis came to have a significant impact not only on the NIBOR level, but also on the fixing mechanism. Nordic banks, like their other European peers, faced similar difficulties in raising USD in the Eurodollar markets in 2008 - leading to a rush in demand for USD through the FX swap and cross-currency markets. When the relative demand for USD began to rise, the LIBOR began to systematically deviate from the CIP – suggesting that the benchmark significantly *understated* the actual funding cost of the banks. In financial market terms, the cross-currency basis swap (CRS), as measured against the USD LIBOR, turned negative. Figure 1 depicts this change, using an inverted scale.

[5] Historical data for individual bank USD/NOK FX swap points has not been obtained. When comparing data using end-of-day mid-market USD/NOK FX swap points with those of a money market broker (for instance Thomson Reuters page USDNOK3M= with USDNOK3M=TTKL), results show daily differences of several basis points. However, *on average* they have been close (within 1-2 bps). Nonetheless, the former includes non-NIBOR banks as well, and is simply the latest screen update. Moreover, it is the quote at mid-day, not end-of-day that matters for the NIBOR fixing.

Figure 1: 3M Lib-Ois; Eur-Eon; CRS (USDEUR); CRS (USDNOK) 2007 - 2011 (bps): Lib-Ois = 3M USD LIBOR – 3M USD OIS; Eur-Eon = 3M EURIBOR – 3M EONIA; CRS (USDEUR) = 3M USD implied from EURIBOR and EUR/USD FX swap – 3M USD LIBOR; CRS (USDNOK) = 3M USD implied from NIBOR and USD/NOK FX swap – 3M NOK NIBOR. Mid rates (adjusted according to market convention).



Sources: Thomson Reuters and author's own calculations

The CRS spread move was less severe for USD/NOK than for other currencies. As Figure 1 shows, CRS(USDNOK) was not only less volatile, but also closer to zero than, for instance, CRS(USDEUR) up until September 2008. This should, however, not be interpreted as if the Norwegian money markets were calm, or that NIBOR panel banks necessarily found it easier to raise USD funding compared to their peers. Instead, it was a direct result of the differences in the LIBOR and NIBOR fixing mechanisms. Negative CRS spreads indicated that USD term money traded at a premium to the LIBOR. As the NIBOR, *in itself*, was a function both of the LIBOR and FX swaps, the relative cost of borrowing in USD in relation to NOK through FX swaps had a *dampening* effect on NIBOR. Not only was the LIBOR possibly too low, the NIBOR became relatively even more so as 'artificially' cheap NOK could be raised through the FX swap market, on the condition that Eurodollars were available at LIBOR. The problem was that it was unlikely that any bank could raise Eurodollars at LIBOR, or even come anywhere close.

As a result of the ongoing CIP deviation (and particularly prompted by the effects of the Lehman Brothers collapse in September 2008), the NIBOR panel banks mutually agreed to switch from the LIBOR to what could be regarded as a more 'independent' USD rate for the NIBOR calculation. At the time, NIBOR panel banks claimed that the USD cash rate published by the broker Carl Kliem was seen as a more accurate and market-determined rate than the LIBOR and therefore became used as a starting point. It is important to note that since the NIBOR completely lacked regulatory oversight, this change of rule or convention was 'informal' and is undocumented *per se*.

To put this rule change into a theoretical perspective, we can refer to the Keynesian Beauty Contest framework in Stenfors (2012b). Whereas other benchmarks (such as LIBOR, EURIBOR and TIBOR) can be seen as having the short-term interbank money market rate as a logical focal point, the NIBOR is unique in the sense that the focal point was *another* benchmark: the LIBOR. The sudden the change of convention, or focal point, was triggered by the collapse of Lehman Brothers. Previously, possible NIBOR deception was limited to the submission of skewed USD/NOK FX swap points, as any potential LIBOR deception became imported 'automatically'. As will be seen in subsequent sections, the replacement of the LIBOR as a focal point with something much less conventional came to significantly increase the ability of NIBOR banks to submit deceptive NIBOR quotes.

3. A New Imported USD Risk Premium

To study the impact of the NIBOR rule change on the Norwegian money market risk premium, we need to establish the differences between the two USD rates used for the calculation, and confirm that a change actually took place at the time.

Let us first extract and decompose what we could regard as the 'imported' USD risk premium. We begin by using the standard expression for the money market risk premium (RP), the LIBOR-OIS spread:

$$RP_t^{CCY} = Libor_t^{CCY} - Ois_t^{CCY}, \quad (1)$$

where $Libor_t^{CCY}$ is the prevailing money market benchmark rate and Ois_t^{USD} the mid-market overnight index swap price for maturity *t*.

Hence, the USD LIBOR-OIS spread is expressed as:

$$LibOis_t^{USD} = Lib_t^{USD} - Ois_t^{USD}, \quad (2)$$

Consequently, we can define a different USD risk premium using the Kliem USD rate:

$$KliemOis_t^{USD} = Kliem_t^{USD} - Ois_t^{USD}, \quad (3)$$

where $Kliem_t^{USD}$ is the USD rate published by Carl Kliem.

However, as stated on the Carl Kliem Reuters page 'KLIEMMM', the published USD rate is not an observable money market rate *per se*, but an *implied* USD rate from the EUR cash market (EURIBOR) and the EUR/USD FX swap market (in other words using the CIP as well). This is analytically important in having a direct impact on the NOK risk premium.

To test whether the money market broker actually applies the CIP to arrive at the Kliem USD rate, we run the following regression (see Appendix 2 for a derivation):

$$KliemOis_t^{USD} = \alpha_t + \beta(EibOis^{USD})_t + \varepsilon_{t,} \quad (4)$$

where $KliemOis_t^{USD}$ is the USD risk premium using the USD offered rate published by Carl Kliem, and $EibOis_t^{USD}$ is the USD risk premium using the USD offered rate derived from the EURIBOR and the EUR/USD FX swap market.

The empirical results are shown in Table A1 in Appendix 3 (see also Figure 2)[6]. As we can see, $EibOis^{USD}$ is an almost perfect explanatory variable for the independent variable $KliemOis^{USD}$ for the 3, 6 and 12-month maturities ($\overline{R}^2$ of 0.983, 0.979 and 0.961 respectively). Small daily deviations are still expected to occur due the timing differences between EURIBOR (mid-day fixing) and Kliem and FX swaps (end of day quotes). On the whole, this is precisely as we should expect, as the USD rate published by Kliem is, in itself, an implied rate using the EURIBOR and the prevailing EUR/USD FX swap rates. The relationship holds firmly throughout the period studied (24 July 2009 to 30 December 2011, for which daily data has been obtained), confirming that the Kliem rate is an *implied* rate using the CIP.

Now, having established that the Kliem USD rate is an implied rate using the EURIBOR and the EUR/USD FX swap rates enables us to compare the USD rate used in the NIBOR fixing mechanism before and after the rule change. As will be highlighted in subsequent sections, the decomposition of the Kliem rate into these two components clarifies the impact on the Norwegian risk premium.

Let us use Equation 1 to express a USD risk premium facing NIBOR panel banks:

[6] For notes on data, see Appendix 1.

$$NibOis_t^{USD} = Nib_t^{USD} - Ois_t^{USD}, \quad (5)$$

where Nib_t^{USD} is the USD rate implied from the NIBOR fixing and Ois_t^{USD} is the mid-market USD OIS price for maturity *t*.

As we know that the NIBOR fixing mechanism is based upon the CIP, it is a straightforward process to derive the implied USD rate directly from the NIBOR fixing and the FX swap market (see Appendix 4 for a derivation).

Consequently, we have now derived four different expressions for the USD risk premium using the same market-determined OIS rate: *LibOis*, *KliemOis*, *EibOis* and *NibOis*. If the NIBOR panel banks used the USD LIBOR for the NIBOR fixing prior to the rule change, NibOis and LibOis ought to have been very closely correlated. Likewise, after the rule change, NibOis should be more closely correlated with EibOis, as EibOis ≈ KliemOis. This can be tested by running two regressions for 3-month maturities[7]:

$$NibOis_t^{USD} = \alpha_t + \beta(LibOis^{USD})_t + \varepsilon_t \quad (6)$$

$$NibOis_t^{USD} = \alpha_t + \beta(EibOis^{USD})_t + \varepsilon_t \quad (7)$$

The independent variable is $NibOis_t^{USD}$ for both regressions (the USD risk premium derived from the NIBOR and the USD/NOK FX swap market). For the first regression, the explanatory variable is $LibOis_t^{USD}$, the standard USD LIBOR-OIS spread, whereas the second regression uses $EibOis_t^{USD}$, the USD rate derived from the EURIBOR and the EUR/USD FX swap points, in other words, the risk premium approximation from the Kliem screen.

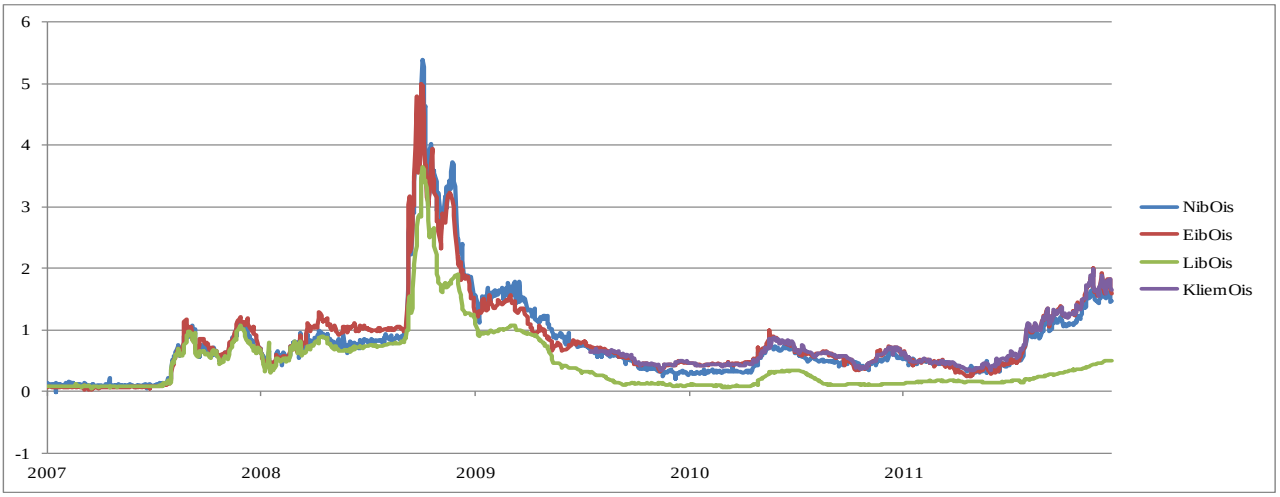
Four periods are studied (two prior to, and two after the rule change). Period I (9 January 2007 to 14 March 2008) covers 7 months before, and after, the financial crisis that started in August 2007. Period II (17 March 2008 to 12 September 2008) is the period after the Bear Sterns collapse up until the Lehman Brothers bankruptcy. Period III (15 September 2008 to 3 February 2009) covers the volatile aftermath of the Lehman collapse and the introduction – as well as the extension - of FX swap arrangements between the Federal Reserve and a number of central banks (including Norges Bank). Even though this episode is fairly short, it is sensible to isolate it due to the extremely

[7] The logic behind choosing 3 months, rather than 6 or 12 months, is two-fold. First, the market liquidity is higher. Second, it corresponds to the maturities of the risk premium projections by Norges Bank.

volatile market conditions that prevailed. Period IV (4 February 2009 to 31 December 2011) covers the period thereafter.

The empirical results are summarised in Tables A2 - A5 in Appendix 5, and can also be se seen in Figure 2.

Figure 2: 3M NibOis; EibOis, LibOis; KliemOis 2007 – 2011 (%): NibOis = 3M NibOis; EibOis = 3M EibOis; LibOis = 3M USD LIBOR – 3M USD OIS; KliemOis = 3M KliemOis.



Sources: Thomson Reuters and author's own calculations

During Period I (Table A2) both $LibOis^{USD}$ *and* $EibOis^{USD}$ performed very well as explanatory variables ($\overline{R}^2$ of 0.982 and 0.970 respectively). This is not surprising, as the CIP for most currency pairs not only held (almost) perfectly prior to the crisis, but even so up until the collapse of Bear Sterns. Prior to August 2007, all spreads were close to zero. $LibOis^{USD}$ and $EibOis^{USD}$ increased significantly thereafter, whereas both the EUR/USD and USD/NOK CRS (albeit showing increased volatility) remained close to zero (see also Figure 1). Thus, during the early part of the financial crisis, money market risk premia were fairly well reflected in the cross-currency swaps (or vice versa). The USD LIBOR was clearly used for the NIBOR fixing mechanism.

The EUR/USD CRS begins to deviate after the collapse of Bear Sterns (Period II). This marks the beginning of not only the 'Dollar Premium' as such, but the breakdown of the CIP. To put it differently, the LIBOR no longer reflected the USD rate as expressed in the FX swap markets. Cross currency swaps (quoted against the USD) in other currencies also began to deviate from the CIP, but interestingly the USD/NOK CRS remained close to zero - in effect indicating the non-existence of a Dollar Premium among NIBOR panel banks. However, from the perspective of the NIBOR fixing mechanism, it was working properly as it was supposed to imply a CRS close to

zero[8]. Instead, the 'LIBOR error' was directly imported to the NIBOR - meaning that for every basis point the USD LIBOR understated the 'actual' funding cost (as expressed in the CRS market), the NIBOR decreased by the same magnitude. Empirically (see Table A3), the relationship to $EibOis^{USD}$ breaks down during this period (the intercept having increased from 0.049 to 0.364 and $\overline{R}^2$ decreased to 0.245). The explanatory power of the $LibOis^{USD}$ is still fairly strong ($\overline{R}^2 = 0.591$), although weakened from the previous period, probably due to a combination of factors: first, this was a volatile period in the markets, and the timing differences mattered more, and second: NIBOR panel banks began to become uncertain with regards to the accuracy and reliability of the LIBOR, and possibly began taking steps in adjusting the rates to reflect this. The intercept increased from 0.019 to 0.137 (1.9 and 13.7 basis points respectively).

The empirical results for the aftermath of the collapse of Lehman Brothers (Period III) need to be analysed with a high degree of caution. The period was remarkably volatile, and the implied interest rates showed movements of several hundred basis points during a number of trading days. Despite this, the results (in Table A4) show that $NibOis^{USD}$ is now more correlated with $EibOis^{USD}$ ($\overline{R}^2 = 0.926$) than with $LibOis^{USD}$ ($\overline{R}^2 = 0.849$). It confirms that a rule change indeed took place at the time of the collapse of Lehman Brothers, or that a few banks started it whereas other banks quickly followed suit.

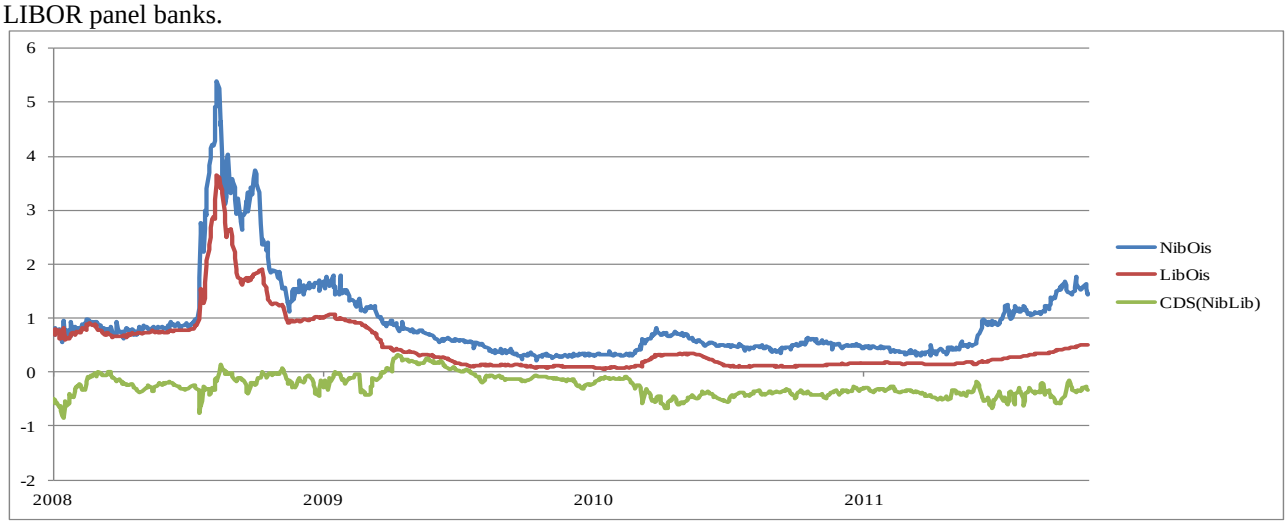
Finally, Period IV (see Table A5) demonstrates that, as the markets recovered somewhat, $EibOis^{USD}$, having replaced $LibOis^{USD}$, continued to be a good indicator for the USD risk premium used by NIBOR panel banks ($\overline{R}^2 = 0.909$). Importantly, $EibOis^{USD}$ (and therefore $NibOis^{USD}$) is consistently higher than $LibOis^{USD}$ throughout this period, and especially so during the times of uncertainly with regards to the Eurozone crisis (around May 2010 and from mid-2011 onwards).

Although we know the reasons behind the deviations between the different risk premium expressions, namely the rule change, also factors could theoretically also have played a role. For instance, NIBOR panel banks might have found it more difficult to raise funding in USD compared to their peers in the LIBOR panel. However, as Figure 3 shows (depicting the average 5-year CDS spreads of the respective panels), the NIBOR panel banks were generally regarded as *more* creditworthy than the LIBOR-peers since September 2008. The only exception was a brief period in early 2009, when the exposure by Swedish banks to the Baltic mortgage market dragged down the

[8] The implied CRS basis is normally calculated using LIBOR, NIBOR and the *mid* FX swap points. Therefore, as long as the bid-offer spread for USD/NOK FX swaps is greater than zero, the basis will be negative. Prior to the crisis, the USD/NOK CRS was normally around -6 effectively implying an implied bid-offer spread in the FX swap market of 12 basis points.

average perceived creditworthiness of the NIBOR panel. In general, the Nordic countries, and its banks, were less hit by the crisis than the U.S., the U.K. or the Eurozone, as also highlighted by the sovereign CDS spreads of the countries.

Figure 3: 3M NibOis; 3M LibOis; 5Y CDS (NibLib) 2008-2011 (%): NibOis = 3M NibOis; LibOis = 3M USD LIBOR – 3M USD OIS; CDS (NibLib) = Average 5Y CDS spread for NIBOR panel banks – Average 5Y CDS spread for LIBOR panel banks.



Sources: Thomson Reuters and author's own calculations

With regards to liquidity, the Nordic central banks introduced similar extraordinary liquidity measures, as well as FX swap agreements with the Federal Reserve, as their peers, ensuring that the NIBOR-panel banks had equal access to USD funding via the central bank[9]. Neither should market liquidity have an impact on the regressions, as the data has been adjusted for the prevailing bid-offer spreads.

In sum, the empirical evidence presented here suggests that the NIBOR panel banks did replace the LIBOR with the Kliem USD rate at the time of the Lehman Brothers bankruptcy, after arguing that the LIBOR no longer reflected the actual USD interbank funding cost. However, after closer scrutiny we can conclude that this rate is not 'independent' either, as the indication ($Kliem^{USD}$) is an implied rate also, namely though the EURIBOR and the EUR/USD FX swap points – expressing the cost of Eurozone banks borrowing at EURIBOR and swapping them into USD.

[9] In fact, as Allen & Moessner (2010) point out, only two other developed countries had enough foreign exchange reserves to cover for the USD shortages during the crisis: Japan and Norway.

4. Implications for Monetary Policy

4.1. New Variables Determining the NOK Risk Premium

Having established that an informal rule change took place in September 2008, and that the new USD rate is derived using the CIP, let us now turn to the decomposition of the Norwegian risk premium. Although the reported level of the USD funding cost faced by NIBOR panel banks is of interest for Norges Bank, it is the domestic NOK risk premium that is of greater concern for monetary policy and the Norwegian economy.

The additional risk premium derived solely as a result of the rule change instigated by the NIBOR panel can be extracted. For this purpose, we use Equation 1 to express the Norwegian risk premium as:

$$RP_t^{NOK} = Nibor_t^{NOK} - Nois_t^{NOK}, \quad (8)$$

where $Nibor_t^{NOK}$ is the NOK NIBOR and $Nois_t^{NOK}$ represents the *theoretical* NOK overnight index swap rate (the daily compounded current and expected future repo rates) for maturity *t*, as no such market yet exists in the currency. Using the OIS as a risk-free rate (whether it is tradable or purely theoretical) enables to decompose the NIBOR into specific components – before and after the rule change.

Through derivation (see Appendix 6), we can see that the 'old' NOK risk premium (prior to the rule change) had two components:

$$RP(old)_t^{NOK} \approx (Libor_t^{USD} - Ois_t^{USD}) - CRS(NoisOis)_t \quad (9)$$

The first component is the USD LIBOR-OIS spread, and the second components, $CRS(NoisOis)_t$, is the cross-currency basis swap using the theoretical NOIS for NOK and OIS for USD. We could regard the latter as a quantification of the relative demand for USD against NOK (derived from the FX swap market) expressed in a basis point spread as measured against the risk-free tradable OIS market and theoretical NOIS market (rather than the LIBOR and NIBOR as is the market convention for CRS in general).

The 'new' NOK risk premium, however, looks very different:

$$RP(new)_t^{NOK} \approx (Euribor^{EUR} - Eonia^{EUR})_t + CRS(EoniaOis)_t - CRS(NoisOis)_t \quad (10)$$

where $(Euribor^{EUR} - Eonia^{EUR})_t$is the EURIBOR-EONIA spread and $CRS(EoniaOis)_t$ is the cross-currency basis swap using EONIA for EUR and OIS for USD - quantifying the relative demand for USD versus EUR (derived from the FX swap market) expressed in a basis point spread as measured against the risk-free tradable OIS and EONIA markets.

In other words, we now have two expressions for the decomposed Norwegian money market risk premium, each consisting of market-observable, and theoretical, variables. The differences are striking. We can see from Equation 9 that, prior to the rule change, there were two drivers of the NOK risk premium: the USD LIBOR-OIS spread and the CRS spread between NOIS and OIS. Hence, the risk premium as reported by LIBOR panel banks was directly 'imported' to Norway, regardless of its accuracy or appropriateness as a proxy for the USD funding cost of NIBOR panel banks. From the perspective of monetary policy, we can also see that a repo rate adjustment by the Federal Reserve or Norges Bank (or market expectations of such) has no direct effect on the risk premium. Instead, the premium is determined by the LIBOR panel bank's assessment of the USD risk premium (which, however, the Federal Reserve might be able to influence *indirectly*).

The CRS component is market-determined, but also subject to possible intervention by both central banks. A NOK liquidity injection, for instance, would reduce the risk premium, whereas relatively easier access to USD funding would increase the risk premium (as it would make NOK relatively more expensive). Consequently, unless the LIBOR fully reflects the demand for USD as expressed in the FX or cross currency swap market (i.e. if the CIP does not hold), the NOK risk premium will be under- or overstated by the same magnitude. As the empirical results show, the fixing mechanism based upon this principle worked well up until around the collapse of Bear Sterns in March 2008. This broke down with the rise of the Dollar Premium, when the LIBOR no longer fully reflected the price banks were prepared to pay as expressed in the FX swap and cross-currency swap market. This suggests that the Norwegian risk premium was somewhat *understated* during the period between the collapse of Bear Sterns to that of Lehman Brothers in 2008.

Now, as Equation 10 shows, the dynamics of the NOK risk premium changed fundamentally as a result of the rule change. The LIBOR is no longer 'relevant' and the standard expression for the USD risk premium (the LIBOR-OIS spread) has instead been replaced by the *EURIBOR-EONIA*

spread. This is important, as it could be argued that the EURIBOR is less prone to manipulation due to its larger panel size (43 banks at the time). However, the EURIBOR has not managed to escape allegations of systematic manipulation either, so this argument does not hold. Nevertheless, it could also be claimed that the EURIBOR-EONIA spread is a better measure for the NOK risk premium than the LIBOR-OIS spread due to the closer similarity of the banking systems as a whole. It could be stated that the EUR risk premium expressed by banks mainly in the Eurozone is a better proxy for Norway than is the USD risk premium states by a more international panel in London. Problematically though, as the Eurozone crisis has shown, the EURIBOR panel contains a number of banks whose funding costs hardly are representative of a typical NIBOR panel bank. Moreover, the problems faced, and measures taken, by the European Central Bank have differed significantly from those of the Norges Bank since 2010.

Finally, with regards to the CRS, the impact of the USD/NOK swap market is the same. However, whereas a domestic USD funding squeeze, or a NOK liquidity injection, previously would have a dampening effect on the risk premium, the new explanatory variable $CRS(EoniaOis)$ works the opposite way – and is completely outside the remit of Norges Bank. A USD funding squeeze among Eurozone banks (or a EUR liquidity injection by the European Central Bank) would – *ceteris paribus* - *increase* the NOK risk premium.

Thus, despite having decoupled from potential issues with the accuracy of the LIBOR fixing, the NIBOR now relies upon the accuracy of the Kliem rate, which in turn depends on the EURIBOR (and the accuracy of it), and the health of the European banking system. Moreover, whereas the CRS component previously could be influenced by Norges Bank and/or the Federal Reserve, a completely new actor has entered the arena: the European Central Bank.

4.2. Risk Premium Projections in the Context of Possible Deception

Fluctuating money market risk premia do not necessarily need to be damaging if their causes are well understood and appropriate offsetting policy measures are available. Likewise, whereas temporary deceptive behaviour with regards to the LIBOR rate setting process is problematic from a distributional (or legal) perspective, is does not need to alter central bank policy. Nonetheless, decisions with regards to monetary policy and financial policy are not made on an *ad hoc* basis, but are forward-looking. Therefore, a systematic or fundamental change in the way the risk premium is

derived ought to influence the way the central bank makes its forecasts – and consequently its decisions.

Repo rate or risk premium projections by a central bank might differ from that of the market. However, they are not disconnected, as the repo rate (determined by central bank) affects the money market rate, and the expected future money market rates (as observed in the FRA and IRS markets) impact long term rates, which in turn influence domestic economic output and inflation. In Norway, the NIBOR plays a central role in this symbiosis, being the first observable step in the monetary transmission mechanism, as well as the key underlying benchmark for the majority of forward-looking interest rate derivative instruments. If the drivers of the risk premium change as a result of a rule change, this should not only influence on the observable risk premium, but also the *expected future* risk premia. Consequently, models to support policy decisions should take this into account, echoing a statement from Norges Bank Governor Olsen in 2011:

'Norges Bank operates under a formal monetary policy mandate. The Bank's objective is to stabilise inflation and provide the economy with a nominal anchor. As a minimum, an economic model to be used as support for interest rate decisions should be based on the assumption that monetary policy can steer inflation.'[...]'Economic agents can be expected to look ahead when making consumption and investment decisions. It is not only current economic policy that is likely to matter to them, but also what they expect it will be in the future. Expectations must therefore be incorporated and play a role in a monetary policy model.' (Olsen, 2011)

Norges Bank has been at the forefront with regards to transparency, and since October 2008 publishes not only its own repo rate paths, but also NOK risk premium projections. Daily historical risk premia, as well as quarterly averages of the projected risk premia are published in conjunction with every Monetary Policy Report (MPR). To cast some light on the impact of the NIBOR rule change upon monetary policy, we can investigate whether any 'unusual' patterns have arisen since 2008.

To compare risk premium assessments and projections by the Norges Bank with market data and actual outcomes, we first interpolate the quarterly averages published by the central bank in conjunction with each monetary policy report. We then calculate the forward-forward rates implied by the various market variables. We also use 5-day moving averages, and a lag, to match the data available to the central bank at the time of the report.

To analyse the projected NOK risk premia 3, 6 and 9 months forward as assessed by Norges Bank, let us first define:

$$\Delta RP_{t+1}^{NB} = RP_{t+1}^{NB} - RP_t^{NB}, \quad (11)$$

where ΔRP_{t+1}^{NB} is the difference between the projected risk premium for day t_{+1} and the actual risk premium (according to the Norges Bank's calculation method) for day *t*. For each MRP, let *t* be the 5-day moving average used by Norges Bank and t_{+1} the interpolated risk premium projections 3, 6 and 9 months forward.

Returning to Equation 10, we know that the new NOK risk premium can be decomposed into three 'drivers', namely the EURIBOR–EONIA spread, the CRS(EurOis) and the CRS(NoisOis). As the first two variables are observable, we can work out how the market priced and projected them at each moment:

$$\Delta EurEon_{t+1}^{MKT} = EurEon_{t+1}^{MKT} - EurEon_t^{MKT} \quad (12)$$

$$\Delta CRS(EonOis)_{t+1}^{MKT} = CRS(EonOis)_{t+1}^{MKT} - CRS(EonOis)_t^{MKT}, \quad (13)$$

where $\Delta EurEon_{t+1}^{MKT}$ is the difference between the market EURIBOR-EONIA spread (using FRAs and forward-forward EONIA) for day t_{-1} and the actual market EURIBOR-EONIA spread for day *t*. $\Delta CRS(EonOis)_{t+1}^{MKT}$ is the difference between the market implied CRS basis (using forward-forward OIS, EONIA and EUR/USD FX swaps) for day t_{-1} and the market implied CRS basis for day *t*.

As there is no NOK OIS market, a 'theoretical NOIS' needs to be constructed to account for the final component: the CRS (NoisOis), which measures the demand for USD relative to NOK in OIS-terms. Problematically, the central bank does not openly disclose the precise method of its estimation, but bases it upon market interest rates, interviews with market participants and 'judgement', which includes comparisons with risk premia in other currencies and FX swap rates (Hellum & Ø. Kårvik, 2012). For sake of comparison, however, let us simply assume that the remaining component *should* equal the residual of the NOK risk premium calculated by the central bank minus the two observable variables:

$$CRS(NoisOis)_{t+1}^{NB/MKT} \approx RP_{t+1}^{NB} - EurEon_{t+1}^{MKT} - CRS(EonOis)_{t+1}^{MKT} \quad (14)$$

The net impact of the NIBOR rule change on the NOK risk premium can be quantified by subtracting Equation 10 from 9. The results, which are fairly substantial, can be seen in Table 1 (and Figure 3).

Table 1: Impact of the NIBOR rule change on the NOK risk premium (%). 5-day moving averages.

	Actual	Projected Δ (Market Pricing)			Actual Δ			Difference		
MPR	*t*	3M	6M	9M	3M	6M	9M	3M	6M	9M
29.10.08	0.27	0.05	0.22	0.04	0.13	-0.22	0.17	0.09	-0.45	0.13
25.03.09	0.34	0.07	0.13	0.15	-0.05	0.11	-0.00	-0.11	-0.02	-0.15
17.06.09	0.26	-0.05	-0.11	-0.03	0.22	0.07	0.10	0.27	0.18	0.13
28.10.09	0.31	-0.10	-0.12	-0.11	0.03	0.08	-0.03	0.13	0.20	0.09
24.03.10	0.38	-0.10	-0.11	-0.10	0.10	0.08	0.18	0.21	0.19	0.29
23.06.10	0.49	0.00	-0.02	0.01	-0.03	0.08	-0.16	-0.03	0.10	-0.17
27.10.10	0.27	-0.02	0.00	-0.04	0.15	-0.12	0.04	0.17	-0.12	0.09
16.03.11	0.27	0.05	0.05	0.04	-0.09	0.64	N/A	-0.14	0.59	N/A
22.06.11	0.18	0.05	0.08	0.09	0.80	N/A	N/A	0.76	N/A	N/A
19.10.11	0.93	-0.17	-0.34	-0.40	N/A	N/A	N/A	N/A	N/A	N/A

Sources: Thomson Reuters Datastream and author's own calculations

After the rule change, the NOK risk premium was around 30 basis points higher than should the old method have been used. However, the effect on the risk premium was particularly high during times of Eurozone stress (49 bps at the time of the publication of MPR 2/2010 and almost a full percentage point (93 bps) for MPR 3/2011[10]). Considering that Norges Bank most frequently adjusts its repo rate in 25 bps increments, the effect is significant.

Table 2 shows the actual and projected risk premia as calculated by the Norges bank vis-à-vis the *actual* change in the risk premium that occurred during the same period.

Table 2: NOK Risk Premia assessed by Norges Bank in its Monetary Policy Reports (MPR) (%). 5-day moving averages.

	Estimate	Projected Δ (Norges Bank)			Actual Δ			Difference		
MPR	*t*	3M	6M	9M	3M	6M	9M	3M	6M	9M
29.10.08	1.79	-0.51	-1.04	-1.24	-0.67	-0.57	-1.16	-0.16	0.47	0.08
25.03.09	1.15	-0.19	-0.30	-0.33	-0.41	-0.63	-0.77	-0.22	-0.33	-0.44
17.06.09	0.89	-0.29	-0.31	-0.33	-0.33	-0.51	-0.52	-0.04	-0.20	-0.19
28.10.09	0.51	-0.12	-0.19	-0.22	-0.06	-0.06	0.14	0.06	0.13	0.36
24.03.10	0.35	-0.04	-0.08	-0.09	0.30	0.29	0.24	0.34	0.37	0.33
23.06.10	0.65	-0.10	-0.17	-0.23	-0.01	-0.06	-0.14	0.09	0.11	0.10
27.10.10	0.55	-0.10	-0.09	-0.12	0.05	-0.08	-0.05	0.15	0.01	0.07
16.03.11	0.55	-0.01	-0.08	-0.16	0.02	0.34	N/A	0.03	0.41	N/A
22.06.11	0.55	-0.13	-0.22	-0.27	0.32	N/A	N/A	0.46	N/A	N/A
19.10.11	0.94	-0.13	-0.25	-0.32	N/A	N/A	N/A	N/A	N/A	N/A

Sources: Norges Bank and author's own calculations

[10] Norges Bank Monetary Policy Reports 23 June 2010 and 19 October 2011

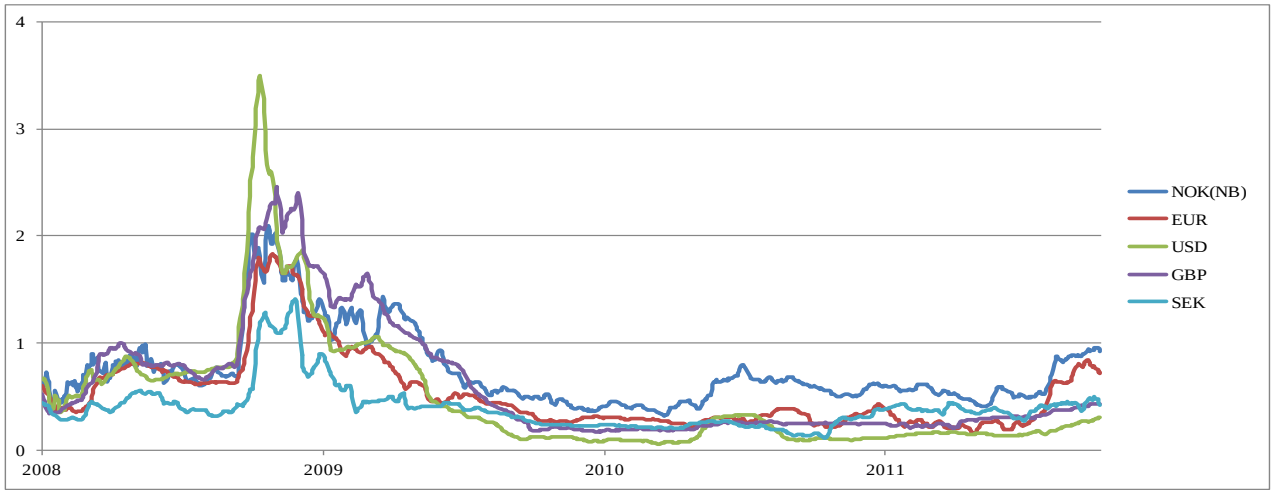
Although this paper has no intention to assess how well the projections have fared compared to the market (or any other model), three observations are notable.

First, throughout the period studied, Norges Bank regarded the NOK risk premia as higher than its peers. As Figure 4 shows, Norges Bank consistently assessed the NOK risk premium to be higher than most of its main trading partners since 2009 (apart from a brief spell in 2009 when the GBP risk premium was higher).

Second, Norges Bank projected, without exception, a narrowing of the NOK risk premium over time.

Third, since MPR 3/2009, Norges bank was, again without exception, too optimistic with regards to the development of the NOK risk premium. Importantly, these differences were largest around the time of Eurozone stress.

Figure 4: 3M Money market risk premia 2008 - 2011 (%): NOK (NB) = 3M Norges Bank's own estimate; EUR = 3M EURIBOR – 3M EONIA bid; USD = 3M LIBOR – 3M OIS bid; GBP = 3M LIBOR – 3M SONIA bid; SEK = 3M STIBOR – 3M STINA bid.



Sources: Thomson Reuters, Norges Bank and author's own calculations

Turning to market data, we can see from Table 3 that from mid-2010, the market fairly consistently predicted slightly higher EURIBOR-EONIA spreads 3, 6 and 12 months forward – the only exception being around October 2011, when spreads were already highly elevated. A similar pattern can be seen from Table 4, depicting the relative demand for USD versus EUR in OIS-terms. In other words, markets during this period painted, quite understandably, a fairly negative outlook with regards to risk premia in the Eurozone, which should *ceteris paribus* also have had an influence on the risk premium projections by the Norges Bank.

Table 3: EURIBOR-EONIA spreads (%). 5-day moving averages.

	Actual	Projected Δ (Market Pricing)			Actual Δ			Difference		
MPR	*t*	3M	6M	9M	3M	6M	9M	3M	6M	9M
29.10.08	1.66	-1.04	-1.11	-1.20	-0.61	-1.09	-1.16	0.43	0.02	0.05
25.03.09	0.89	-0.17	-0.26	-0.22	-0.42	-0.53	-0.59	-0.25	-0.27	-0.37
17.06.09	0.41	-0.01	0.01	-0.08	-0.00	-0.11	-0.13	0.01	-0.12	-0.04
28.10.09	0.27	0.00	-0.02	0.05	0.04	-0.03	0.00	0.04	-0.01	-0.04
24.03.10	0.28	-0.08	-0.05	-0.01	0.03	0.08	0.08	0.11	0.13	0.09
23.06.10	0.31	0.06	0.06	0.05	0.06	0.05	-0.04	0.00	-0.01	-0.08
27.10.10	0.22	0.08	0.04	0.03	0.08	0.00	0.09	0.01	-0.04	0.06
16.03.11	0.21	0.07	0.05	0.07	0.01	0.49	N/A	-0.06	0.43	N/A
22.06.11	0.19	0.03	0.06	0.08	0.61	N/A	N/A	0.57	N/A	N/A
19.10.11	0.72	-0.06	-0.25	-0.22	N/A	N/A	N/A	N/A	N/A	N/A

Sources: Thomson Reuters Datastream and author's own calculations

Table 4: CRS (EonOis) spreads (%). 5-day moving averages.

XCCYEUR	Actual	Projected Δ (Market Pricing)			Actual Δ			Difference		
MPR	*t*	3M	6M	9M	3M	6M	9M	3M	6M	9M
29.10.08	1.58	-0.74	-0.74	-1.06	-1.30	-1.21	-1.33	-0.56	-0.47	-0.27
25.03.09	0.51	0.21	0.27	0.18	-0.29	-0.31	-0.40	-0.51	-0.58	-0.57
17.06.09	0.25	0.04	0.08	0.10	-0.05	-0.13	-0.11	-0.09	-0.21	-0.21
28.10.09	0.15	-0.05	-0.02	-0.08	-0.03	0.07	0.18	0.03	0.08	0.16
24.03.10	0.16	0.03	0.01	0.04	0.33	0.03	0.16	0.30	0.01	0.12
23.06.10	0.50	0.07	0.07	0.07	-0.30	-0.17	-0.28	-0.37	-0.24	-0.34
27.10.10	0.16	-0.00	0.09	0.08	0.09	-0.08	0.02	0.09	-0.16	-0.06
16.03.11	0.22	0.01	0.05	0.04	-0.13	0.23	N/A	-0.14	0.17	N/A
22.06.11	0.12	0.05	0.09	0.09	0.32	N/A	N/A	0.27	N/A	N/A
19.10.11	0.51	0.01	0.09	0.02	N/A	N/A	N/A	N/A	N/A	N/A

Sources: Thomson Reuters Datastream and author's own calculations

The empirical data presented so far clearly paints a conflicting view. Norges Bank, during this period, consistently projected lower domestic risk premia, whereas the first two variables in Equation 10 show the market predicting unchanged, or higher, risk premia in the Eurozone. Thus, for the equation to hold, Norges Bank ought to have had a specific view on the third component (the USD/NOK CRS market) that not only deviated from market expectations, but also stood in stark contrast with its statements published at the MPC meetings during this period:

First, the projections by Norges Bank could have included an assessment that the NIBOR panel banks, over time, would face relatively more severe USD funding pressures than the Eurozone banks. This would, *ceteris paribus*, dampen the risk premium through the CRS component. This is unlikely, however, as even though the Eurozone crisis had spill-over effects on the Norwegian banking system, the overall effects were considerably more contained, not least evidenced by the Norges Bank itself in regarding it unnecessary to reintroduce the FX swap lines with the Federal Reserve.

Second, the optimistic risk premium projections by the central bank could have been derived from a view that more accommodative liquidity provisions in NOK would become necessary. Added NOK liquidity would namely have an impact upon FX swap market and hence the CRS. Again, this is highly improbable, as Norges Bank seemed increasingly uneasy with regards to its provisions to the domestic banks:

'[...] It would appear that banks have grown accustomed to dealing directly with the central bank instead of redistributing liquidity in the interbank market'...'It makes banks passive. The market for short-term unsecured liquidity becomes very limited or disappears. The pricing mechanism – or the rates set in the money market – contains information that will not emerge if a public actor such as the central bank takes the market's place. Consequently, we now need to set clearer boundaries between the central bank's role as lender of last resort and settlement bank and the role of the market.' (Gjedrem, 2010)

Third, Norges Bank could have regarded the USD rate used in the NIBOR fixing as too high for Norwegian banks. In other words, the central bank could have – knowingly or unknowingly of its relevance for the fixing mechanism - doubted the validity of the Kliem USD rate. However, Norges Bank appears to have put greater emphasis on specific domestic money market conditions rather than the fixing mechanism itself:

'During the financial crisis, risk premiums (money market rates less expected key policy rate over the same horizon) were generally higher in Norway than in other countries. They have also remained higher in Norway than in other countries in the post-crisis period.'...'Premiums have remained high and volatile over the past year and are above what can be assumed to be a normal level. High premiums are an indication that the money market in Norwegian kroner is functioning poorly.' (Norges Bank, 2010)

As has been shown is this paper, the higher and more fluctuating Norwegian risk premium is not a result of illiquidity in the domestic money market, but a direct result of the NIBOR fixing mechanism. Consequently, it appears as if even though the NOK risk premium projections ought to have been more influenced by risk premia in the Eurozone, Norges Bank put more emphasis on other factors in their projections: either that global markets consistently overstated the problems in the Eurozone (unlikely), or that the NIBOR banks would embark upon yet another rule change. Institutionally, however, this could only take place through a mutually agreed rule change by the NIBOR panel banks themselves, or by the same banks beginning to understate their USD funding costs relative to the money market broker page. Either way, NIBOR banks can be seen as having gained increasing scope for deception – at the expense of Norges Bank.

5. Conclusions

This paper has empirically demonstrated that an informal rule change to the NIBOR fixing mechanism in September 2008 came to have a significant impact on the decomposition of the Norwegian risk premium. Two major conclusions can be drawn from this study.

First, with regards to possible NIBOR manipulation, the rule change has catered for greater scope to submit deceptive NIBOR quotes by individual panel banks. Previously, such behaviour was theoretically only possible through the submission of FX swap points. Any inaccuracy linked to the signalling of the bank funding cost was directly 'imported' through the LIBOR. Although the new USD rate might be regarded as less prone to manipulation, it is dependent on the EURIBOR. Put differently, one imported benchmark lacking regulatory oversight and binding rules has been replaced by another. The higher volatility of the Kliem USD rate compared to the LIBOR has come to increase the scope for NIBOR manipulation, to some extent already existing though the submission of the USD/NOK FX swap points. Crucially, as the rule change was not formal or documented, temporary or systematic deviations from the Kliem USD rate can be more easily 'justified' considering the lack of requirement to trade at submitted quotes.

Second, with regards to the implications for central bank policy, the rule change immediately resulted in higher domestic risk premia (around 0.30%) and a significantly greater dependence on developments in the Eurozone, the health of the banking system in the area, as well as the policy action by the European Central Bank. However, as the 'new' USD rate in the NIBOR fixing mechanism is based upon the CIP *also*, the NOK risk premium has become sensitive to the ability of Eurozone banks to fund themselves in USD. Therefore, whenever the Dollar Premium has been more elevated in the Eurozone than in Norway, as it has been during times of Eurozone stress, this has been reflected in an *additional* NOK risk premium. Consequently, when Eurozone banks were seen to be under pressure (both during late spring 2010 and in the second half of 2011), the problems were not only imported to the NOK risk premium, they became *magnified*. Hence, the net impact of the rule change on the Norwegian risk premium during these periods was around 0.5% and 1%. The Norwegian monetary transmission mechanism was fundamentally impacted.

Theoretically, a rise in the NIBOR might reflect an intended and well-communicated repo rate hike. However, if the NIBOR rises due to poor market liquidity, some policy actions aimed at, for example, lowering the bid-offer spreads might be appropriate. On the other hand, should the benchmark rise as a result of funding difficulties of the panel banks, policy interventions such as

liquidity injections might be justified. If the NIBOR rises due to higher perceived credit risk, some kind of action to improve bank solvency might be needed. Consequently, any 'incorrect' signal transmitted through the NIBOR could cause the central bank to make a wrong, delayed or hastened decision – having an impact for the economy as a whole. This empirical study suggests that the NIBOR, as a result of it direct link to the LIBOR, understated the Norwegian risk premium from the early days of the global financial crisis up until September 2008. After the rule change, the risk premium has, relatively speaking, been (sometimes considerably) higher and more volatile – arguably more so than could have been justified. What is more, the fundamental change in the NIBOR fixing mechanism should also have changed the way the central bank shapes its risk premium forecasts. The results shown here suggest that this did not take place.

To conclude: as the rule change was instigated by the NIBOR panel banks, it confirms the general lack of governance and transparency with regards to the benchmark. The LIBOR appeared to have lost its reliability as an unbiased reflection of the actual funding cost of banks during 2008, and the change probably therefore made sense at the time. However, the absence of Norges Bank, regulators or other market participants in the decision making process is remarkable - considering the implications the change had on such an important benchmark for the Norwegian economy.

Appendix 1: Data

Market data in this paper is from Thomson Reuters. More specifically, USD/NOK and EUR/USD FX spot bid rates are from the Reuters multi-contributor page; whereas USD/NOK and EUR/USD FX swap bid rates for 3, 6, 9 and 12 months are from Thomson Reuters (Tullet Prebon). USD cash bid rates for 3, 6, 9 and12 months are from Thomson Reuters (Carl Kliem / KLIEMMM). EURIBOR, LIBOR and NIBOR rates for 3, 6, 9 and 12 months are from Thomson Reuters. EONIA, OIS bid rates for 3, 6, 9 and12 months are from the Reuters multi-contributor page. 5-year banks CDS spreads, as well as USD, EUR and NOK FRA bid rates from Thomson Reuters Datastream. Where necessary, market data has been adjusted to mid-rates according to the prevailing market conventions. Data from Norges Bank for estimated NOK risk premia, as well as folio rate and money market risk premium projections, are from the data files attached to the Monetary Policy Reports (MPR) of the Norges Bank published in conjunctions with the following MPC meetings: 29 October 2008 (MPR 3/2008), 25 march 2009 (MPR 1/2009), 17 June 2009 (MPR 2/2009), 28 October 2009 (MPR 3/2009), 24 March 2010 (MPR 1/2010), 23 June 2010 (MPR 2/2010), 27 October 2010 (MPR 3/2010), 16 March 2011 (MPR 1/2011), 2 June 2011 (MPR 2/2011) and 19 October 2011 (MPR 3/2011).

Appendix 2: Kliem and the CIP

To test whether Kliem is actually using the CIP, we begin by using the standard expression for the money market risk premium (RP), the LIBOR-OIS spread:

$$RP_t^{CCY} = Libor_t^{CCY} - Ois_t^{CCY}, \quad \text{(A2.1)}$$

where $Libor_t^{CCY}$ is the prevailing short-term unsecured money market benchmark rate and Ois_t^{CCY} the overnight index swap (OIS) for maturity *t*.

Thus, we can define the USD risk premium as observed from the Kliem screen as:

$$KliemOis_t^{USD} = Kliem_t^{USD} - Ois_t^{USD}, \quad \text{(A2.2)}$$

where $Kliem_t^{USD}$ is the USD offered rate published on the Carl Kliem screen and Ois_t^{USD} the mid-market USD OIS price for maturity *t*.

Using the CIP, we can also derive a risk premium from the implied USD rate (henceforth called Eib^{USD}) for banks able to borrow at EURIBOR and swapping them into USD:

$$Eib_t^{USD} = \left[\left(1 + Euribor_t^{EUR} * \frac{d_t}{360}\right)\frac{s_t^{EURUSD}}{f_t^{EURUSD}} - 1\right] * \frac{360}{d_t}, \quad \text{(A2.3)}$$

where $Euribor_t^{EUR}$ is the EUR EURIBOR fixing published by EBF-EURIBOR, s_t^{EURUSD} is the EUR/USD FX spot rate, f_t^{EURUSD} is the EUR/USD FX forward rate and d_t is the number of days for maturity *t*.

This USD risk premium can thus be written as:

$$EibOis_t^{USD} = \left[\left(1 + Euribor_t^{EUR} * \frac{d_t}{360}\right)\frac{s_t^{EUR/USD}}{f_t^{EUR/USD}} - 1\right] * \frac{360}{d_t} - Ois_t^{USD} \quad \text{(A2.4)}$$

We can then compare $KliemOis_t^{USD}$ (the USD risk premium using the USD offered rate published by Carl Kliem) with $EibOis_t^{USD}$ (the USD risk premium using the USD offered rate derived from the EURIBOR and the EUR/USD FX swap market).

Appendix 3: Empirical Results (Kliem and the CIP)

Table A1: Predicting KliemOis using EibOis (24.07.2009-30.12.2001)

$KliemOis_{3M} = \alpha_{3M} + \beta_{3M}(EibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.983252				
Adjusted R Square	0.983226				
Standard Error	0.044953				
Observations	633				
ANOVA	Df	SS	MS	F	f
Regression	1	74.86139	74.86139	37045.57	0
Residual	631	1.27512	0.002021		
Total	632	76.13651			
	Coefficient	S Error	Stat	P-value	
Intercept	-0.15479	0.003754	-41.2285	3.4E-181	
EibOis	0.964991	0.005014	192.4723	0	

$KliemOis_{6M} = \alpha_{6M} + \beta_{6M}(EibOis) + \varepsilon_{6M}$

Regression Statistics					
R Square	0.979508				
Adjusted R Square	0.979476				
Standard Error	0.053556				
Observations	633				
ANOVA	df	SS	MS	F	f
Regression	1	86.51021	86.51021	30161.65	0
Residual	631	1.809846	0.002868		
Total	632	88.32005			
	Coefficient	S Error	Stat	P-value	
Intercept	-0.17521	0.005335	-32.843	1.1E-138	
EibOis	0.974904	0.005614	173.6711	0	

$KliemOis_{12M} = \alpha_{12M} + \beta_{12M}(EibOis) + \varepsilon_{12M}$

Regression Statistics					
R Square	0.960923				
Adjusted R Square	0.960861				
Standard Error	0.088415				
Observations	633				
ANOVA	df	SS	MS	F	f
Regression	1	121.2988	121.2988	15516.72	0
Residual	631	4.932714	0.007817		
Total	632	126.2315			
	Coefficient	S Error	Stat	P-value	
Intercept	-0.10047	0.008713	-11.5311	4.76E-28	
EibOis	0.941775	0.00756	124.5661	0	

Appendix 4: Testing the Rule Change

To test whether a rule change actually took place in September, we begin by using Equation A2.1 to express a USD risk premium facing NIBOR panel banks:

$$NibOis_t^{USD} = Nib_t^{USD} - Ois_t^{USD}, \quad \text{(A4.1)}$$

where Nib_t^{USD} is the USD rate implied from the NIBOR fixing and Ois_t^{USD} is the mid-market USD OIS price for maturity *t*.

As we know that the NIBOR fixing mechanism is based upon the CIP, it is a straightforward process to derive the implied USD rate directly from the NIBOR fixing and the FX swap market:

$$Nib_t^{USD} = \left[\left(1 + Nibor_t * \frac{d_t}{360}\right)\frac{s_t^{USD/NOK}}{f_t^{USD/NOK}} - 1\right] * \frac{360}{d_t}, \quad \text{(A4.2)}$$

where $Nibor_t$ is the NOK NIBOR fixing, s_t^{USDNOK} is the USD/NOK FX spot rate, f_t^{USDNOK} is the USD/NOK FX forward rate and d_t is the number of days for maturity *t*.

Inserting Equation A4.2 into A4.1 gives us an expression for the USD risk premium facing NIBOR panel banks ($NibOis_t^{USD}$):

$$NibOis_t^{USD} = \left[\left(1 + Nibor_t * \frac{d_t}{360}\right)\frac{s_t^{USD/NOK}}{f_t^{USD/NOK}} - 1\right] * \frac{360}{d_t} - Ois_t^{USD} \quad \text{(A4.3)}$$

If the NIBOR panel banks used the USD LIBOR for the NIBOR fixing prior to the rule change, NibOis and LibOis ought to have been very closely correlated. Since the rule change, NibOis is likely to be more correlated with EibOis, as EibOis ≈ KliemOis.

Appendix 5: Empirical Results (Rule Change)

Table A2: [Period I] Pre-Bear Sterns (09.01.2007-14.03.2008)

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(LibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.982413				
Adjusted R Square	0.982356				
Standard Error	0.043448				
Observations	309				
ANOVA	df	SS	MS	F	f
Regression	1	32.37322	32.37322	17149.32	2E-271
Residual	307	0.579532	0.001888		
Total	308	32.95275			
	Coefficient	S Error	Stat	P-value	
Intercept	0.018878	0.003866	4.882966	1.68E-06	
LibOis	1.052313	0.008036	130.9554	2E-271	

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(EibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.970382				
Adjusted R Square	0.970285				
Standard Error	0.056384				
Observations	309				
ANOVA	df	SS	MS	F	f
Regression	1	31.97675	31.97675	10058.27	1.1E-236
Residual	307	0.975999	0.003179		
Total	308	32.95275			
	Coefficient	S Error	Stat	P-value	
Intercept	0.049347	0.004805	10.26951	1.84E-21	
EibOis	0.872123	0.008696	100.2909	1.1E-236	

Table A3: [Period II] Pre-Lehman Brothers (17.03.2008-12.09.2008)

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(LibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.593756				
Adjusted R Square	0.590582				
Standard Error	0.048641				
Observations	130				
ANOVA	df	SS	MS	F	f
Regression	1	0.442632	0.442632	187.0815	8.33E-27
Residual	128	0.302846	0.002366		
Total	129	0.745478			
	Coefficient	S Error	Stat	P-value	
Intercept	0.137472	0.049938	2.752866	0.006767	
LibOis	0.917051	0.067047	13.67777	8.33E-27	

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(EibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.250675				
Adjusted R Square	0.244821				
Standard Error	0.066061				
Observations	130				
ANOVA	df	SS	MS	F	f
Regression	1	0.186873	0.186873	42.82042	1.31E-09
Residual	128	0.558605	0.004364		
Total	129	0.745478			
	Coefficient	S Error	Stat	P-value	
Intercept	0.363786	0.069655	5.222673	6.94E-07	
EibOis	0.445271	0.068045	6.543731	1.31E-09	

Table A4: [Period III] Post-Lehman Brothers (15.09.2008-03.02.2009)

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(LibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.850552				
Adjusted R Square	0.849057				
Standard Error	0.40413				
Observations	102				
ANOVA	df	SS	MS	F	f
Regression	1	92.95067	92.95067	569.129	4.57E-43
Residual	100	16.33209	0.163321		
Total	101	109.2828			
	Coefficient	S Error	Stat	P-value	
Intercept	0.407993	0.105649	3.861762	0.0002	
LibOis	1.307319	0.054799	23.85642	4.57E-43	

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(EibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.926405				
Adjusted R Square	0.925669				
Standard Error	0.283596				
Observations	102				
ANOVA	df	SS	MS	F	f
Regression	1	101.2401	101.2401	1258.785	1.82E-58
Residual	100	8.042684	0.080427		
Total	101	109.2828			
	Coefficient	S Error	Stat	P-value	
Intercept	0.152778	0.078158	1.954725	0.053408	
EibOis	1.011036	0.028496	35.47936	1.82E-58	

Table A5: [Period IV] Post-Euro (04.02.2009-30.12.2001)

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(LibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.729651				
Adjusted R Square	0.729292				
Standard Error	0.203712				
Observations	755				
ANOVA	df	SS	MS	F	f
Regression	1	84.337	84.337	2032.29	4.5E-216
Residual	753	31.24837	0.041499		
Total	754	115.5854			
	Coeff.	S Error	Stat	P-value	
Intercept	0.312848	0.011045	28.32576	9.9E-121	
LibOis	1.366203	0.030306	45.08093	4.5E-216	

$NibOis_{3M} = \alpha_{3M} + \beta_{3M}(EibOis) + \varepsilon_{3M}$

Regression Statistics					
R Square	0.909613				
Adjusted R Square	0.909493				
Standard Error	0.11779				
Observations	755				
ANOVA	df	SS	MS	F	f
Regression	1	105.1379	105.1379	7577.813	0
Residual	753	10.44745	0.013874		
Total	754	115.5854			
	Coefficient	S Error	Stat	P-value	
Intercept	-0.03626	0.009297	-3.90039	0.000105	
EibOis	0.997058	0.011454	87.05063	0	

Appendix 6: Decomposition of NOK Risk Premium

To decompose the NOK risk premium, we begin by using the standard expression for the money market risk premium (RP), the LIBOR-OIS spread:

$$RP_t^{CCY} = Libor_t^{CCY} - Ois_t^{CCY} \quad \text{(A6.1)}$$

For the Norwegian krone market, this would be expressed as:

$$RP_t^{NOK} = Nibor_t^{NOK} - Nois_t^{NOK}, \quad \text{(A6.2)}$$

where $Nois_t^{NOK}$ represents the *theoretical* NOK overnight index swap rate (the daily compounded current and future expected repo rates) for maturity *t*, as no such market yet exists in the currency.

Next, using the OIS (rather than the LIBOR) as benchmark rates, the deviation from the CIP (or the cross currency basis swap) can be written as:

$$CRS(Ois^{CCY2}Ois^{CCY1})_t = Ois_t^{CCY2} - \left[\left(1 + Ois_t^{CCY1} * \frac{d_t}{360}\right)\frac{f_t^{CCY1/CCY2}}{s_t^{CCY1/CCY2}} - 1\right] * \frac{360}{d_t} \quad \text{(A6.3)}$$

Hence, for NOK against USD as:

$$CRS(NoisOis)_t = Nois_t^{NOK} - \left[\left(1 + Ois_t^{USD} * \frac{d_t}{360}\right)\frac{f_t^{USD/NOK}}{s_t^{USD/NOK}} - 1\right] * \frac{360}{d_t}, \quad \text{(A6.4)}$$

where $CRS(NoisOis)_t$ is the cross-currency basis swap using the theoretical NOIS for NOK and OIS for USD.

Inserting Equation A6.4 into A4.6 gives us a close approximation of the 'old' NIBOR (which was based upon the LIBOR):

$$Nibor(old)_t^{NOK} \approx Libor_t^{USD} + (Nois_t^{NOK} - Ois_t^{USD}) - CRS(NoisOis)_t, \quad \text{(A6.5)}$$

The 'old' NOK risk premium can be written as:

$$RP(old)_t^{NOK} \approx (Libor_t^{USD} - Ois_t^{USD}) - CRS(NoisOis)_t \quad \text{(A6.6)}$$

Now, the rule change altered the composition of the NOK risk premium, as the LIBOR was replaced by the Kliem USD rate. By changing the USD rate in Equation A6.5, the 'new' NIBOR equation (after the rule change) can be written as:

$$Nibor(new)_t^{NOK} \approx Kliem_t{}^{USD} + (Nois_t^{NOK} - Ois_t^{USD}) - CRS(NoisOis)_t \quad \text{(A6.7)}$$

However, anecdotally as well as empirically demonstrated, we also know that Kliem is not a perfectly independent rate either, rather a derivation from the EURIBOR and the prevailing cross currency basis swap between EUR and USD:

$$Kliem_t^{USD} \approx \left[\left(1 + Euribor_t^{EUR} * \frac{d_t}{360}\right)\frac{s_t^{EURUSD}}{f_t^{EURUSD}} - 1\right] * \frac{360}{d_t} \quad \text{(A6.8)}$$

Next, following Equation A6.3, the cross currency basis swap for EUR against USD using OIS can be written as:

$$CRS(EoniaOis)_t = Eonia_t^{EUR} - \left[\left(1 + Ois_t^{USD} * \frac{d_t}{360}\right)\frac{f_t^{USD/EUR}}{s_t^{USD/EUR}} - 1\right] * \frac{360}{d_t} \quad \text{(A6.9)}$$

where $CRS(EoniaOis)_t$ is the cross-currency basis swap using EONIA for EUR and OIS for USD - quantifying the relative demand for USD versus EUR (derived from the FX swap market) expressed in a basis point spread as measured against the risk-free tradable OIS and EONIA markets. Equations A6.8 and A6.9 give us:

$$Kliem_t^{USD} \approx Euribor_t^{EUR} - (Eonia_t^{EUR} - Ois_t^{USD}) + CRS(EoniaOis)_t \quad \text{(A6.10)}$$

Therefore, by inserting Equation A6.10 into A6.7, we get an expression of the 'new' NOK risk premium:

$$RP(new)_t^{NOK} \approx (Euribor^{EUR} - Eonia^{EUR})_t + CRS(EoniaOis)_t - CRS(NoisOis)_t \quad \text{(A6.11)}$$

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