Incentives to (Mis-)Report for the Euribor

A Theoretical and Empirical Analysis

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ABSTRACT

The Euro Interbank Offered Rate (Euribor) is a reference rate that is widely used in wholesale and retail financial transactions, such as for mortgage and leasing contracts. Just as its "sister rate", the LIBOR, it has been the subject of distortions, before and in the financial crisis, which is why the authorities planned to overhaul or replace it. With this background, I first construct a theoretical model to assess banks' potential incentives to misreport, as a function of its perceived market risk as well as specific funding conditions. My theoretical findings suggest that there might be systematic underquoting from banks who have a higher perceived market risk or rely more on wholesale funding in order to affect markets perception about their risk. I proceed to test these findings empirically using daily quotes of 27 Euribor panel banks from 2004 to 2014. Results do not support the model's predictions as, at least over a longer time-horizon and within the framework of the analysis, banks do not seem to have a systematic bias to use their reported Euribor quotes to signal to the market.

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I. Introduction

The Euro Interbank Offered Rate (Euribor) is a reference rate, also known as fixing, published on every working day by the European Money Markets Institute (EMMI).[2] It is supposed to reflect the interest rate at which so called "prime banks" can borrow funds in the interbank market on unsecured term deposits.[3] At the time the data for this paper was sampled the fixing was based on quotes submitted from a panel of large European banks.[4] It is calculated as a tranched mean: The highest and lowest 15% of submitted quotes are eliminated before calculating the mean.[5] There are five different maturities, ranging from one week to one year.[6]

Since many years IBORs have been an established component in financial markets. Therefore, an enormous volume of global financial transactions condition on the Euribor. Precisely, the notional volume of outstanding financial contracts indexed on the Euribor is around €181 trillion.[7] Hence, the Euribor can be considered as one of the most important reference rates. Its perceived importance for systemic risk and global financial stability is also the reason why it has come under scrutiny since the financial crisis, as discussed below.

It is important to understand that at the time the data for this paper was sampled, Euribor quotes only reflected panel banks' individual beliefs: They were asked to report at which rate a prime bank could borrow money, according to their own estimate. Hence, the quotes are not based on a bank´s actual costs of borrowing in the interbank market, other than, for instance, the Libor. This is one reason why the Euribor has received attention from policymakers and academics in recent years, criticizing the lack

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[2] Historically, the Euribor replaced the pre-existing domestic European reference rates such as the Frankfurt Interbank Offered Rate (FIBOR), Paris Interbank Offered Rate (PIBOR) and Helsinki Interbank Offered Rate (HELIBOR) in 1999. Other important and still existing IBORs are the London Interbank Offered Rate (LIBOR) and the Tokyo Interbank Offered Rate (TIBOR). Depending on the IBOR the calculating methodology may differ. However, their purpose remains the same.

[3] The definition of a prime bank was renewed in 2013 by EMMI after a recommendation of ESMA and EBA (2013) and can be found in European Money Markets Institute (2013, p.2). As discussed by Taboga (2014), especially prior to 2013 the definition was vague, which caused diverging perceptions between panel banks of what a prime bank actually is.

[4] As of 2020 the panel decreased to 18 banks. During the period of the analysis the number of banks decreased from 49 in 2004 to 25 in 2014. Banks submit their quotes simultaneously. They are obliged to submit their quotes by 10:45 a. m. (CET). The calculating agent then calculates and publishes the Euribor fixing and the individual quotes by 11:00 a. m. (CET).

[5] More information about the Euribor calculation process can be found in European Money Markets Institute (2019).

[6] Until November 2013 there used to be 15 different maturities.

[7] EMMI (2019). Contracts indexing the Euribor include interest rate swaps, interest rate futures, saving accounts, mortgages, leasing contracts etc.

of transparency of the quotes. Since banks do not have to back their submission with actual transactions data but are free to enter any quote, there is an ongoing debate in the literature about the integrity of the submitted quotes (e.g., Eisl et al., (2019), Wheatley (2012)).

Regarding the lack of transparency of Euribor quotes, according to the extant literature verified transactions data of panel banks could instead solve the issue of possible distortion. However, the implementation of such a fundamental change seems to cause difficulties for the ECB and panel banks. One commonly mentioned concern is the lack of liquidity for certain maturities (Eisl et al., (2017)). It seems that only a few banks have the required transaction volumes in the different maturities in order to participate in a transactions based Euribor panel. In sum, as matters stand today, panel banks seem not to be able to provide enough data for a purely transactions based reference rate. With the recent reforms, introducing a hybrid calculating methodology, the European Central Bank uses a variety of transactional data in order to determine the Euribor rate.

However, it is important to understand potential shortcomings of the previous system, backing up potential fears with a rigorous analysis, based on formally derived hypotheses. More generally, it is important to understand and analyse what determined the quotes of a bank. Eisl et al., (2013) argue, especially for the Libor but also for the Euribor, that to a certain degree a bank´s own credit risk and liquidity position are built into the quotes they submit. Meaning, although, the Euribor panel banks are supposed to submit their beliefs about what interest rates a prime bank offers to lend unsecured funds to another prime bank, to a certain degree the banks´ own funding conditions probably still influence their submitted quote. However, as Eisl et al., (2013) also mention, the influence of both factors are difficult to measure without detailed internal data from the banks.

Also the last decade of attempted and partially realized Euribor reforms shows that there is a need to understand what determines the quoting behaviour of individual banks, as long as the quotes are not purely transactions based, so that their validity can be verified. If it is unclear to what extent quotes reflect a bank's own conditions or its perception of the market, it is statistically unclear what a respective mean of these quotes would express – or even whether another way of calculating the index, possibly by including weighting factors, would perform better. Such a statistical view is however not the subject of this paper. Instead, this paper seeks to ask whether the reference rate could be vulnerable to systematic distortions that result from so-called "signal jamming", as banks realize that their quotes are observed by market participants and may then be interpreted as reflecting, to some extent, the bank's own financial conditions.

Importantly, this paper thus asks whether such a systematic bias exists. The paper does not analyse whether market participants could have other reasons to distort quotes on specific dates, e.g., given their trading positions. In fact, the European Commission has fined several banks for such behaviour, which is however outside the scope of the present analysis.[8]

For this I set up a signalling (or "signal jamming") model that captures such behaviour. The model gives rise to predictions regarding which types of banks should be more likely to distort their quotes in this way. I then identify observable variables that can be used to test these predictions. For this I construct measures of banks´ credit risk and liquidity and funding conditions.

The asserted, and formally derived, signalling behaviour of banks has also been conjected by Mollencamp and Whitehouse (2008), albeit for the Libor, where panel banks are indeed asked to quote their own funding conditions, other than for the Euribor. The authors argue that banks have indeed submitted systematically lower Libor rates during the financial crises 2007/2008 in order to avoid informing the market their own deteriorating credit quality. Mollencamp and Whitehouse use the banks´ CDS spreads to build a benchmark that moves in tandem with the Libor fixing. During the crisis the CDS spreads of the Libor panel banks increased, but submitted Libor quotes did not seem to mirror market´s perception. Hence, beginning with the crisis the two measures started to diverge and showed that the Libor was not efficiently "reflecting rising default-insurance costs" anymore. Other than, starting from a formal model, analysing instead the Euribor, I also intend to cover not only the financial crisis but a much longer time span. In fact, I ask whether even outside such exceptional circumstances, individual quotes could be distorted by such a signalling motive. Sirak (2017) uses a comparable approach to Mollencamp and Whitehouse (2008), but for the Euribor. He shows that up until the financial crisis 2007/2008 his developed proxy, which is also based on banks´ CDS, could track the submitted fixing quite well, but not afterwards.

There is also another strand in the literature that comes to different conclusions, arguing that panel banks might have an interest in reporting a quote that is as close as possible to the true "underlying state". A reason for such behaviour could be reputational and liability concerns. In existing literature on herding, such as Effinger and Polborn (2001), it is argued that reputation may be in fact the main incentive for a "forecaster" to submit a preferably correct quote. Reputational cheap talk theory, as surveyed by Ottaviani and Sørensen (2006), comes to more nuanced conclusions. There, the market assesses the "forecasting skills", and thus the forecaster will try to convince the market that she is indeed well informed. In the case of the Euribor, the comparison would thus be between a reported quote, which then reflects the best guess of market funding conditions, and the final fixing. While such models also derive incentives for distortions, they do not result in systematic biases, and there should be no relationship to the variables that I will use in my analysis, such as risk and sources of funding.

[8] European Commission – Statement (2016).

The way Euribor quotes are generated and how they are then used for the final fixing, rather than relying on transaction data, for instance, may thus give rise to distortions for different reasons, and potentially also to systematic biases. To my knowledge, this is the first paper to start from a theoretical model to then assess empirically whether, in case of the Euribor, such biases can be detected in the data, both in normal times and in times of worsening credit risk and liquidity position. My model both includes the possibility that banks may have an interest in reporting a quote that is as close as possible to the true underlying state, e.g., due to reputational concerns. But they have also an interest in affecting market perceptions. For my empirical analysis, I use CDS spreads as a proxy for credit risk and build a variable reflecting wholesale funding share as a proxy for a bank´s liquidity position.[9] When I then test my model through an empirical analysis using available data on funding and risk conditions, results are not supportive of such signalling motives, though.

The remainder of this paper is structured as follows. In section II, I describe in more detail the process of Euribor rate setting and the institutional setting. I dedicate section III to the theoretical model. Section IV describes my data. Section V presents my empirical strategy and estimation results. Finally, section VI concludes my results. Additional descriptive statistics and further explanations of my regressions are provided in Appendix A.

II. Institutional Background

In this section, I extend on the description of the Euribor rate setting process. To avoid confusion, I first present details for how this was undertaken just before the financial crisis. Then, I add some description on which changes took place since then.

As already noted in the Introduction, the Euribor is an important reference rate, also known as fixing, for many retail and financial instruments. It is published on every working day by the EMMI. In the time period of the analysis the fixing is based on quotes submitted from a panel of large European banks. In 2007, just before the financial crisis, typically 47 panel banks participated.[10] I provide a full list of participants at this point of time in table 3 (Appendix A). At the time the data for this paper was sampled, each financial institute in the panel has to provide, for different maturities, an answer to the following precise definition: "Contributing panel banks must quote the required euro rates to the best of their knowledge; these rates are defined as the rates at which euro interbank term deposits are being

[9] A more detailed overview of all used variables and the rationale for them is provided in section IV and V.

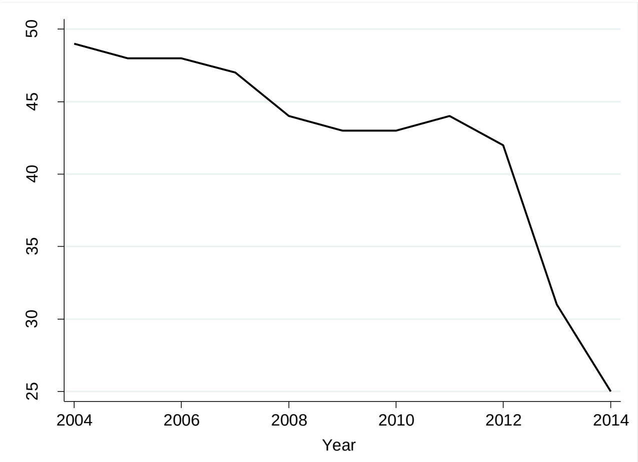
[10] In order to calculate the Euribor at least 50% of the panel banks must submit their quotes.

offered within the EMU zone by one prime bank[11] to another at 11.00 am Brussels time".[12] The panel banks must submit their quotes to GRSS before 10:45 a.m. CET. From these responses, the fixing is then calculated as follows. First, the highest and lowest 15% of submitted quotes are eliminated. Then, the unweighted mean is calculated for the remaining quotes. GRSS calculates and announces the Euribor rates at 11:00 a.m. CET once a day.

Until 2013 individual quotes were reported publicly under the following regime. The calculating agent of the Euribor was Thomson Reuters and it was administered by Euribor-EBF, which was the precursor organization of EMMI. The transition of the administrator body and the change of the calculating agent came as a response to the Euribor manipulation scandal.

I now turn to the changes that occurred since the onset of the financial crisis in 2008. First, as shown in the following graph 1 the number of panellists drastically reduced. I show the remaining panel banks in 2014 in table 3 (Appendix A).

Graph 1: Decline of number of Euribor panel banks from 2004-2014



The number of banks declined for many reasons. In general, the banking sector consolidated in the years after the crises. Further several mergers between banks took place. However, according to Vainikainen (2019) a significant reason for the decline is that panel banks have become increasingly reluctant to participate due to potential litigation risks. Therefor in the absence of underlying transactions, banks seem to fear to submit based on their expert judgement.

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[11] A "prime bank" should be understood as a credit institution of high creditworthiness for short-term liabilities, which lends at competitive market related interest rates and is recognised as active in euro-denominated money market instruments while having access to the Eurosystem's market operations.

[12] European Banking Federation (2012).

A second change relates to the publication of individual quotes. Up to March 2014, quotes were reported publicly in real time. Due to policy changes based on liability concerns Euribor rates are since only available to the general public with a 24-hour delay on the EMMI homepage. However real time Euribor rates are distributed to EMMI's Authorised Vendors and available to their subscribers. Since market participants still have the possibility to obtain real time data this policy change does not seem relevant for the analysis.

Over the years, also changes in Euribor rate tenors occurred. Until September 2013 Individual panel banks had to provide 15 different maturities. The reduction to seven tenors aimed on eliminating tenors that had proven to be less used in order to simplify the submission process. In December 2018 the number of tenors was further reduced to five.

As already discussed in the Introduction, the European Central Bank originally planned to replace the whole procedure, relying instead on transactional data. EMMI is seeking to reform the Euribor rate for because the EU BMR and the guidelines of international organisations on the administration of benchmarks require that benchmarks are based on transactions to the extent possible.[13] Under the requirements set by EU BMR, the Euribor could not be used by certain EU supervised entities after 31st December 2019.[14]

Emmi tested a purely transactional based system between September 2016 and February 2017 with 31 banks as a so called Pre-Live Verification Programme.[15] The outcome of the programme concluded that a fully transactions based methodology would, due to the limited number of transactions by the participating banks, not be robust.[16] However, in order to meet the EU Benchmarks Regulation requirements, EMMI has developed and transitioned to a hybrid methodology for the Euribor.[17] The hybrid methodology was tested with 16 banks from May till July 2018. According to EMMI the testing phase indicated that the new methodology provided adequate robustness and representativeness. EMMI also changed the underlying statement to: "The rate at which wholesale funds in euro could be obtained by credit institutions in the EU and EFTA countries in the unsecured money market."[18]

Currently, the calculations are based, whenever possible, in actual euro money market transactions. In absence of actual transactions, Euribor follows an approach consisting of three levels. The first level

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[13] EU BMR (2016).

[14] According to ISDA (2019) the date has been shifted to 31.12.2021.

[15] European Money Markets Institute (2017).

[16] European Money Markets Institute (2017).

[17] European Money Markets Institute 2 (2019).

[18] European Money Markets Institute 3 (2019).

simply uses transactions from the prior day using a formulaic approach provided by EMMI. Level two uses transactions across the money market maturity spectrum and from recent days, again using formulaic calculations provided by EMMI. The third level uses transactions in the underlying interest or data from a range of markets, which are related to the unsecured euro money market.

III. Model

In this Section I set up a model to derive the main hypotheses of the empirical analysis. The model seeks to capture the different, potentially conflicting forces that may drive banks' quoting behaviour. The basic model generates a simple downwards quoting bias for banks with higher perceived market risks or relying more on wholesale funding. This is the case because each bank will want to suggest that their own financing conditions are better than they are.

i. Information structure

For the purpose of the formal model only, I denote with the variable x the "object" that the quoting system for the Euribor seeks to measure: the (unknown) funding conditions of "the" prime bank. Recall now that, in contrast for instance to Libor, for the Euribor banks are not asked to quote their own funding conditions but to provide estimates of such funding conditions of a "prime bank". The variable x clearly changes over time, but for the subsequent model I can suppress such dependency. Only so as to obtain closed solutions for the subsequent model, I assume that x has some known mean $\overline{x}$ and that it is normally distributed with also known variance σ^2.

Each bank does not observe x but only a private signal of it, which depends crucially also on its own information, such as its own funding conditions. This will be important to generate potential distortions in the individual quoting behaviour. Precisely, bank n observes from its own funding condition a signal $s_n = x + z_n$. Again, for tractability z_n is normally distributed (and independent from x). I assume that the respective mean is known to all in the market and given by $\overline{z}_n$. Also, the variance σ_n^2 is known.

ii. Game

The following game determines banks' quoting behaviour. In each period, the following sequence is played out. At $t = 1$ each bank observes its signal z_n. At $t = 2$ banks submit a quote ("report") q_n. I consider in what follows only pure strategies $q_n = q(z_n)$. The bank's report is directly observed by the market. For this reason, the whole process of how q_n enters into the final fixing is irrelevant in what follows: The market can directly condition its learning on the observed quote q_n.

In solve in what follows for a Perfect Bayesian Equilibrium, that is: i) Strategies are sequentially optimal (which in my case involves however simply the optimality of the bank's strategy) and ii) Beliefs are rationally updated (in a Bayesian fashion). To formulate the respective conditions, I need to introduce the bank's preference structure, which follows next.

iii. Preferences

I only need to introduce preferences for a representative bank n. All banks are described by the same preference structure. The key assumption is that the bank has an interest in affecting the market's beliefs about its own "state", which I capture simply by its own funding conditions, z_n. That is, the market uses q_n to infer z_n.

To formulate the bank's beliefs, I introduce the market's (posterior) beliefs as a function of the observed quote q_n: $\hat{s}_n(q) = E[\hat{s}_n \mid q_n]$. The bank cares about these beliefs. In addition, the bank has an interest also in reporting a quote that is as close as possible to the true underlying state x. Reputational concerns as well as liability could be reasons for this, as discussed in the Introduction. I combine these two potentially conflicting interests in a standard way by stipulating the following linear-quadratic utility function for the bank, depending on its own report as well as the market's (induced) beliefs:

$$U_n(q_n, \hat{s}_n) = -y(q_n - x)^2 - \tau_n \hat{s}_n. \quad (1)$$

I now provide some additional comments on this utility function.

That this is always (weakly) negative is of course irrelevant. Applied to my setting, the relevant practical question is clearly what motivates a bank to participate in the Euribor panel in the first place. Answering this question is beyond my model, albeit, of course, reputational ("signalling") questions could arise if a bank suddenly decides to leave the panel. This may explain why a "window of opportunity" such as the post-crisis situation and lawsuits against banks that had, for various reasons, tried to rig notably the LIBOR then lead to a serious reduction in the number of participating banks, as I showed before.

The first term $-y(q_n - x)^2$ captures the preference for that the quote be close the real "funding cost of a prime bank", x. Deviations are punished according to the quadratic term, where y captures the respective (bank-independent) preferences. The second term $\tau_n \hat{s}_n$ captures a bank's preference *not* to be perceived to have own high funding costs. The respective strength of these preferences, τ_n, is bank dependent. I comment on this below. Intuitively, the respective preference should depend on how important the market's perception is to the bank, which in turn depends on potentially observable bank characteristics.

i. Equilibrium Characterization

The model's tractability depends on the assumption of normal distributions. In particular, I can use the well-known result that a linear combination of normal variables is itself normally distributed and that, with linear-quadratic preferences, the objective function (in expectation) depends only on the mean and the variance. This is now exploited as follows:

The bank's own conditional expectation about x, which thus is conditional on the observed signal s_n, is given by

$$\hat{x}_n(s_n) = E[x_n \mid s_n] = \frac{\sigma_n^2 \overline{x} + \sigma^2 (s_n - \overline{z}_n)}{\sigma_n^2 + \sigma^2} \tag{2}$$

and has (ex-ante) variance

$$\sigma_{x,n}^2 = \frac{\sigma_n^2 \sigma^2}{\sigma_n^2 + \sigma^2}. \tag{3}$$

This represents the intuitive insight that the bank's expectation is a mixture of the known mean of the state $\overline{x}$ and the part of the signal that is informative about it, the difference $s_n - \overline{z}_n$.

ii. Benchmark of Unbiased Reporting

I now suppose first that $\tau_n = 0$. It is immediate that in this case, the bank's report is equal to the conditional expected value, so that $q_n = \hat{x}_n$ represents the optimal strategy. I derive this formally. I do this in several steps, which will be useful to subsequently also derive the biased equilibrium outcome.

For this I consider first some random variable Y and the objective to minimize $E[Y]^2$. For this note first that for a random variable Y, it generally holds that $E[Y] = Var(Y) + [E[Y]]^2$. I now make use of this for the random variable $Y = q_n - x$ (for some given q_n). With this definition of Y, I have first again, given the assumed normal distributions, that

$$E[Y \mid s_n] = \frac{\sigma_n^2 (q_n - \overline{x}) + \sigma^2 (q_n - s_n + \overline{z}_n)}{\sigma_n^2 + \sigma^2}. \tag{4}$$

Note now that, for given s_n, q_n is deterministic, so that $Var(Y)$ does not depend on q_n. Thus, together with $E[Y] = Var(Y) + [E[Y]]^2$, this implies that the objective to minimize $E[Y]^2$ corresponds to that of minimizing $[E[Y]]^2$.

I now use a first-order approach to solve this minimization problem. Using the definition $Y = q_n - x$, the derivative with respect to q_n is given by

$$\frac{d[E[Y]]^2}{dq_n} = \frac{2}{\sigma_n^2 + \sigma^2}[\sigma_n^2(q_n - \overline{x}) + \sigma^2(q_n - s_n + \overline{z}_n)]. \tag{5}$$

From this it follows immediately that the first-order condition, with $\frac{d[E[Y]]^2}{dq_n} = 0$, is satisfied indeed when the bank chooses the report such that

$$\sigma_n^2(q_n - \overline{x}) + \sigma^2(q_n - s_n + \overline{z}_n) = 0, \tag{6}$$

which can be solved to obtain

$$\begin{aligned} q_n &= \frac{\sigma_n^2\overline{x} + \sigma^2(s_n - \overline{z}_n)}{\sigma_n^2 + \sigma^2} \\ &= E[x_n \mid s_n]. \end{aligned} \tag{7}$$

This is indeed the unique minimizer as the objective function is strictly convex with

$$\frac{d^2[E[Y]]^2}{dq_n^2} = \frac{2}{\sigma_n^2 + \sigma^2}(\sigma_n^2 + \sigma^2) = 2 > 0. \tag{8}$$

To summarize, when $\tau_n = 0$ the bank chooses to report $q_n = \hat{x}_n(s_n) = E[x_n \mid s_n]$.

iii. Biased Reporting

I now solve for the equilibrium with general τ_n. As is standard in the literature, I impose a particular functional form for the equilibrium strategy and then verify that, after its characterization, the bank has indeed no incentive to deviate. Specifically, I suppose that the bank follows an affine strategy of the following structure: $q_n = a_n + b_n(s_n - \overline{z}_n)$.[19]

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[19] It should be noted that I do not check whether other equilibria exist.

With such an equilibrium strategy, the market perfectly unravels the bank's quote, with the following rule for the posterior beliefs:

$$\hat{s}_n = \overline{z}_n + \frac{q_n - a_n}{b_n}. \tag{9}$$

It is now helpful to rewrite this slightly as follows, with some new parameters:

$$\hat{s}_n = \overline{z}_n + A_n + B_n q_n. \tag{10}$$

With this I now turn to the bank's optimization problem, from which the strategy must be derived. Recall that, by the preceding arguments and the bank's preferences, the bank minimizes

$$\begin{aligned} \Omega_n &= [E[Y]]^2 + \tau_n \hat{s}_n \\ &= [E[Y]]^2 + \tau_n(\overline{z}_n + A_n + B_n q_n). \end{aligned} \tag{11}$$

Note that I have only introduced the notation Ω_n for convenience (replacing the maximization problem for U_n).

Again, I differentiate with respect to q_n, obtaining

$$\frac{d\Omega_n}{q_n} = \frac{2}{\sigma_n^2 + \sigma^2}[\sigma_n^2(q_n - \overline{x}) + \sigma^2(q_n - s_n + \overline{z}_n)] + \tau_n B_n. \tag{12}$$

The first-order condition thus requires now that

$$\frac{2}{\sigma_n^2 + \sigma^2}[\sigma_n^2(q_n - \overline{x}) + \sigma^2(q_n - s_n + \overline{z}_n)] + \tau_n B_n = 0, \tag{13}$$

which can be solved to obtain

$$q_n = \frac{\sigma_n^2\overline{x} + \sigma^2(s_n - \overline{z}_n)}{\sigma_n^2 + \sigma^2} - \tau_n B_n. \tag{14}$$

It is now convenient to rewrite this to bring it in line with the presumption on the affine optimal strategy: $q_n = a_n + b_n(s_n - \overline{z}_n)$. That is, I rewrite the derived equation for q_n as

$$q_n = \left[\frac{\sigma_n^2 \overline{x}}{\sigma_n^2 + \sigma^2} - \tau_n B_n\right] + \frac{\sigma^2}{\sigma_n^2 + \sigma^2}(s_n - \overline{z}_n). \tag{15}$$

To determine the parameters, I use that, in equilibrium, the market's beliefs must be consistent with the bank's behaviour, which is required for a Perfect Bayesian Equilibrium.[20] Hence, the derived optimal strategy must be consistent with the beliefs $\hat{s}_n = \overline{z}_n + A_n + B_n q_n$ from (10) which in turn can be rewritten as

$$q_n = -\frac{A_n}{B_n} + \frac{1}{B_n}(\hat{s}_n - \overline{z}_n). \tag{16}$$

In equilibrium, both (15) and (16) must hold, with $\hat{s}_n = s_n$. This gives rise to two linear equations with two unknown parameters, A_n and B_n. In fact, by comparing the different terms in the two equations, I can make the following conclusions:

$$\frac{1}{B_n} = \frac{\sigma^2}{\sigma_n^2 + \sigma^2}, \tag{17}$$

so that

$$B_n = \frac{\sigma_n^2 + \sigma^2}{\sigma^2}; \tag{18}$$

and

$$-\frac{A_n}{B_n} = \frac{\sigma_n^2 \overline{x}}{\sigma_n^2 + \sigma^2} - \tau_n B_n, \tag{19}$$

so that

$$-A_n = \frac{\sigma_n^2 \overline{x}}{\sigma_n^2 + \sigma^2} B_n - \tau_n B_n^2. \tag{20}$$

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[20] Note that there are no out-of-equilibrium beliefs given the distributional assumptions and the stipulated strategy.

After substitution of B_n, this becomes

$$-A_n = \frac{\sigma_n^2}{\sigma^2}\overline{x} - \tau_n\left(\frac{\sigma_n^2 + \sigma^2}{\sigma^2}\right)^2. \quad (21)$$

Ultimately, I can thus fully write out the bank's strategy (noting that this is always conditional on the observed signal s_n):

$$\begin{aligned} q_n &= a_n + b_n(s_n - \overline{z}_n) \\ &= -\frac{A_n}{B_n} + \frac{1}{B_n}(\hat{s}_n - \overline{z}_n) \\ &= \frac{\sigma_n^2}{\sigma^2}\overline{x} - \tau_n\left(\frac{\sigma_n^2 + \sigma^2}{\sigma^2}\right) \end{aligned} \quad (22)$$

and finally, after rearranging terms,

$$q_n = \frac{1}{\sigma_n^2 + \sigma^2}\left[\sigma_n^2\overline{x} + \sigma^2(s_n - \overline{z}_n)\right] - \tau_n\left(\frac{\sigma_n^2 + \sigma^2}{\sigma^2}\right). \quad (23)$$

Here, the first term corresponds to the "unbiased outcome". The second term now introduces, when $\tau_n > 0$, a downward bias. The size is independent of the observed signal. In expectation it is given by

$$-\tau_n\left(\frac{\sigma_n^2 + \sigma^2}{\sigma^2}\right). \quad (24)$$

iv. Implications

For the purpose of the following empirical analysis, I make only use of an immediate implication of this model, namely the following: When $\tau_n > 0$, there is a downward bias in the quote, and this is stronger the higher is τ_n. This is the immediate implication of the derived bias (24).

Later I will relate τ_n to observable characteristics that should tilt the bank's preferences more towards catering to the market's beliefs.

Note on the side that the bank does not quote on average higher or lower if the known mean of its own funding costs is higher or lower: The mean $\overline{z}_n$ drops out when taken the expectation.

IV. Data Description

I employ twelve-month Euribor fixings as well as bank-specific twelve-month quotes of 27 banks, covering the period between January 2004 and December 2014. Raw data on Euribor quotes as well as the fixings are publicly available at the EMMI[21] website. The number of analysed banks is reduced to 27 because of the availability of data. The number of panel banks has been continuously declining over the examined time period. Further, many banks resigned from the panel over the years and were replaced by others. Hence, many banks only have a very limited number of examinable quotes. Also, data relating to CDSs and wholesale funding are not available for all panel banks.

There is no unique ID for each reporting institution, but panel banks are identified via abbreviations of their names. As some of the panel banks change their name during the sampling period and because of occasional typos, the data contains multiple abbreviations for the same reporting entity. Therefore, in the first step, I harmonize the names and assign a unique ID. Prior to analysing the data, I impose the following restrictions on the data. As already documented in ESMA and EBA (2013), the quotes are subject to outliers due to occasional manual mistyping.[22] These outliers are thus eliminated using the following procedures. I calculate the differences between a bank's current quote to its prior quote as well as to its subsequent quote and the current Euribor fixing. If all three differences exceed 50 bps, the quote is labelled as a typo and is replaced by a missing value. Thereby, twelve quotes are set to missing.

Upon cleaning the data, I retain 71,215 quotes.[23] I consider the daily range of quotes to assess cross-sectional variation. Overall, the average daily range of quotes is 0,155 percentage points over the period of 2004 to 2014. Up to 2008 the quotes are very concentrated at the daily level with a range of 0.084 percentage points. The range increases after the 2007/2008 crisis with 0.217 percentage points. Die standard deviation is 1.416. Further descriptive statistics are provided in table 5 (Appendix B).

Over the course of the sampling period the Euribor fixing gradually rises from around 2% to more than 5.5% in 2008 and drops to lower than 0.33% in 2014. Figure 1 visualizes this development of the Euribor fixing over the sampling period. The initial increase is driven by an initially tightening of monetary policy. Central banks were then obviously completely surprised by the crisis, and Figure 1

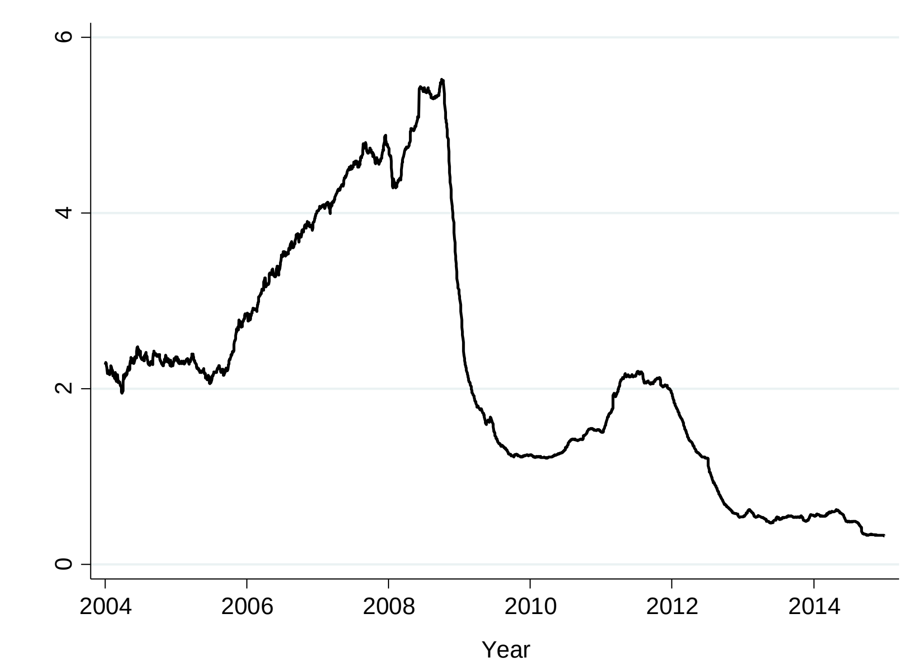
[21] The European Money Markets Institute (EMMI) is responsible for administering the reference rates Euribor and Eonia. The EMMI was formerly known as Euribor-EBF. https://www.emmi-benchmarks.eu/euribor-org/euribor-rates.html (accessed 12.11.2019).

[22] ESMA and EBA (2013, p.13) for the 5M tenor bank 7 reports a series of 1.87%, 2.87%, and 1.85% on three consecutive days. It is very likely that the submitter intended to report 1.87% on the second instance but mistyped the leading digit on the keyboard.

[23] Due to missing data my regression sample uses 65,289 observations.

shows how monetary policy started to loosen in the second half-year of 2008. The ECB deposit facility, which operates as a lower bound in the Euro-denominated unsecured overnight money market, was, over the same time span, raised from 1% to 3% and then lowered below 0% during 2014.

Figure 1 – Euribor Fixing from January 2004 to December 2014



Additionally, I also collect price data on credit default swaps from Markit. More precisely, I employ daily prices quoted for CDS that meet the following selection criteria: i) The issuer of the underlying debt security is a European credit institution and belongs to the Euribor panel; ii) The time to maturity of the CDS is one year; iii) The underlying seniority tier is senior unsecured debt; iv) The CDS is denominated in EUR; v) The type of restructuring event that triggers the default swap contract is "modified modified restructuring" (MM).[24] The price data is collected for the sampling period between January 2, 2004 and December 31, 2014. Using one-year price data allows for a perfect maturity match with the quoted twelve-month Euribor rates.

For every analysed bank I also calculate a wholesale funding rate based on their annual reports. All annual reports are obtained through Thomson Reuters Datastream. I use the following calculation to

[24] Initially, any restructuring qualified as a credit event and any bond of maturity up to 30 years was deliverable. In 2001 modified restructuring (MR) was introduced to limit the scope of opportunistic behaviour by sellers in the event of restructuring agreements. It limited the deliverable obligations to those with a maturity of 30 months or less after the termination date of the CDS contract. Modified-modified restructuring was introduced in 2003 after European market participants had raised concerns that MR had been too severe in its limitation of deliverable obligations. Hence, under MM, bonds with a remaining term of up to 60 months are considered, when a credit event occurs. MM is common for CDS on European underlyings.

determine the wholesale funding rate: $WF = 1 - (\frac{Deposits}{Liabilities})$, where the deposits as well as the liabilities are observable by the market.

Further, I use Eonia[25] rates covering the period between January 2004 and December 2014. Raw data on the Eonia are publicly available at the EMMI website.[26] Over the course of the sampling period the Eonia fixing gradually rises from just above 2% to more than 4%.[27]

V. Empirical Analysis

i. Empirical Strategy

In this section I am interested in whether banks try to affect market perception by submitting distorted (lower) Euribor quotes. Thus, I consider the following two hypotheses. First, an increase in the CDS would mean that the market already perceives bank i to be riskier. I conjecture that then a negative signal has a larger implication, and that consequently the model's τ_n is higher. Second, an increase in the wholesale funding share means that a bank relies more on wholesale funding, for which market perceptions are more important, so that again the model's τ_n should increase. I summarize the two hypotheses:

Hypothesis I. Banks with higher perceived market risk have a tendency to systematically underquote.

Hypothesis II. Banks relying more on wholesale funding have a tendency to systematically underquote.

In order to analyse my hypotheses, I employ three variations of a linear model, each with bank fixed-effects, next to other explanatory variables, which I estimate by means of Ordinary Least Squares (OLS).

My key regression equation is the following:

(1) $$b_{i,t} = \beta_0 + \alpha_i + \beta_1 WF_{i,Y} + \beta_2 CDS_{i,t} + \beta_3 Eonia_t + \varepsilon_{i,t}.$$

[25] The Eonia is a daily reference rate that expresses the weighted average of unsecured overnight interbank lending in the European Union (EU) and the European Free Trade Association (EFTA).

[26] https://www.emmi-benchmarks.eu/euribor-eonia-org/eonia-rates.html (accessed: 12.11.2019).

[27] This increase is just like that for the Euribor driven by a tightening monetary policy of the deposit facility, as mentioned above.

The dependent variable $b_{i,t}$ is a bank´s twelve-month Euribor quote minus the Euribor fixing, thus reflecting a bank's tendency to over- or underquote. In this equation, bank fixed effects are denoted as α_i. Bank fixed effects capture time invariant bank specific factors, which are outside my model. Further, credit default swaps are denoted as $CDS_{i,t}$ and capture the role of perceived market risks of bank i on day t. Wholesale funding of a bank is denoted as $WF_{i,Y}$ and is used to capture the role of bank i specific funding conditions in year Y – precisely, its dependence on wholesale funding, for which market perceptions matter (more). Finally, the Eonia rate is denoted as $Eonia_t$ and included as a control variable in order to account for market interest rate conditions on day t. As the dependent variable is in differences, there is no clear presumption on the sign of the coefficient.

Hypotheses I and II predict a negative association between $b_{i,t}$ and $CDS_{i,t}$ and $WF_{i,Y}$.

In order to test whether the results of my analysis might differ for different subsamples or time periods, I additionally estimate two variations of my initial model. In my first variation (2), I use a subsample of only systematically important banks (SIB).[28] This variation allows me to test whether banks, which are presumably more under the market spotlight have an higher interest in affecting the market's beliefs about their own "state". For this estimation, I can keep 32,866 observations.

My second variation (3) restricts the analysed period to the years of the financial crises 2007/2008. This variation allows to see whether there any differences in the results for crisis and non-crisis periods. My second variation includes 13,649 observations.

ii. Estimation Results

In this subsection, I present the regression results shown in table 1. All results can be interpreted in percentage points and show the effect on the difference between a banks Euribor quote and the Euribor fixing, $b_{i,t}$.[29]

[28] SIBs are systematically important banks due to the scale and degree of impact they have on global and regional markets. The list is published by the Financial Stability Board (FSB).

[29] Hence, a negative coefficient 0.003 would mean that the difference between a banks Euribor quotes and the Euribor fixing decreases by 0.003 percentage points or 0,3 bps.

Table 1: Regression Model (OLS) Estimate of the Determinants of $b_{i,t}$.

	(1)	(2)	(3)
CDS	0.003	-0.001	0.004
	(0.00)	(0.00)	(0.01)
Wholesale Funding Share	-0.077	-0.068	-0.110
	(0.06)	(0.08)	(0.16)
Eonia	0.000	-0.002	0.023**
	(0.00)	(0.00)	(0.01)
Constant	Yes	Yes	Yes
Bank Fixed Effects	Yes	Yes	Yes
Observations	65,289	30,421	13,649
R^2	0.112	0.048	0.118
Adjusted R^2	0.112	0.048	0.117

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table reports estimates of a baseline regression, including bank fixed effects and a constant (column 1). In the specified column the dependent variable is $b_{i,t}$. Standard errors are reported in parentheses.

None of the variables of interest have a significant effect on the quoting behaviour of banks. Further, the moderate magnitude of the CDS coefficients does not imply any economically relevant impact either. With the restrictions of the used empirical model and data, results thus suggest that, at least on average, banks with higher perceived market risks or relying more on wholesale funding do not tend to have higher incentives to signal and thus misreport (higher τ_n).

Column 2 shows the results based on a subsample consisting of SIBs. Again, there is no statistically significant relationship. The effect of CDS remains also economically irrelevant. Hence the variation does not change the findings already presented in column 1.

The third column presents the results of the model using the time period of the financial crises in 2007 and 2008. Although the effect of the variable WF is now clearly higher than in the previous variations, it remains insignificant. It appears that also the focus on the crisis alone does not alter results.

iii. Results for balanced samples

The following table 2 shows a balanced version of the models presented in section V. In order to have a balanced sample I trim the years 2004, 2013 and 2014.[30] As already stated in section V, the results clearly indicate no tendencies of (more) underquoting when perceived credit risk worsens or dependency on wholesale funding increases. Hence, the findings of the analysis do not change by using a balanced panel.

[30] In 2013 eleven banks ceased contributing to the Euribor. Further in 2004 the whole sale funding share could not be obtained for some banks. In order to have a balanced dataset the years 2004, 2013 and 2014 were excluded.

Table 2: Regression model (OLS) estimate of the determinants of $b_{i,t}$ (balanced sample).

	(1)	(2)
CDS	0.005*	-0.001
	(0.00)	(0.00)
Wholesale Funding Share	-0.073	-0.087
	(0.05)	(0.07)
Eonia	0.002	-0.002
	(0.00)	(0.00)
Constant	Yes	Yes
Bank fixed effects	Yes	Yes
Observations	54,602	24,329
R^2	0.118	0.060
Adjusted R^2	0.118	0.059

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The table reports estimates of a baseline regression, including bank fixed effects and a constant (column 1). In the specified column the dependent variable is $b_{i,t}$. Standard errors are reported in parentheses.

Column 1 shows the baseline regression (1). Now, CDS is marginally significant, albeit its sign is now positive, other than predicted. Also, the size is not of economic significance. A coefficient of 0.005 would imply that the difference between a banks Euribor quotes and the Euribor fixing increases by 0.005 percentage point. The coefficient for WF remains as in the previous models insignificant and at similar levels as the unbalanced models.

Column 2 shows the results based on a balanced subsample consisting of SIBs. Clearly, none of the variables of interest are again significant. Also, the even lower CDS coefficient indicates no economic significance. It would imply a decrease between the difference of a banks Euribor quotes and the Euribor fixing of only 0,001 percentage points.

VI. Conclusion

The relevance of Euribor makes it crucial to understand what determines the quoting behaviour of individual banks, otherwise quotes are vulnerable to distortion and do not reflect funding conditions. The purpose of this paper is to derive theoretically potential distortions and then to analyse whether banks behave accordingly, notably to use quotes to mask financial distress and to affect market´s perceptions.

While my model indicates that banks will tend to underquote in order to affect the perception of the market more when this indeed matters more, such as funding depends more on market conditions, I do not find this in the data. Precisely, publicly observable proxies of risk such as the CDS do not indicate that banks have higher incentives to "signal" when they are already perceived to be riskier, and also their wholesale funding share does not indicate higher such incentives. Results do not change when I focus on the financial crisis or focus on systemically important banks.

Of course, while I do not find evidence of such "signalling" and the resulting distortions, this may be due to the employed empirical strategy, rather than the absence of such behaviour. But it may also be the fact that the previous wording of the Euribor, which asks banks' perception of the funding condition of a hypothetical (prime) bank, was less subject to such "signalling" as the Libor, where own funding conditions are reported. As noted in the Introduction, while initially there was a strong impetus to reform also the Euribor, potentially replacing perceptions and quotes entirely with data from transactions, dearth of such data were one reason for why such a sweeping reform has not taken place earlier. Alternatively, when signalling is a major concern, there could also be the option not to publish individual quotes at all. As noted in Section I, current reforms have indeed postponed the publication of such data. However, the implementation of the new hybrid transactional data methodology will eliminate any signalling potential.

References

British Bankers' Association (2012). *BBA Libor explained: The basics.* http://www.bbalibor.com/bbalibor-explained/the-basics.

BEIßER, J. and READ, O. (2016): „Libor- und Euribor-Skandal und erste Konsequenzen". *Zeitschrift für das gesamte Kreditwesen, Heft 5-2016,* 17-22.

Duffie, D. and Jeremy, S. (2015). "Reforming LIBOR and Other Financial Market Benchmarks". *Journal of Economic Perspectives, 29(2)*: 191–212.

Duffie, D., Dworczak P., and Zhu H. (2014). "Benchmarks in Search Markets". *National Bureau of Economic Research Working Paper 20620.*

Effinger, M. R. and Polborn, M. K. (2001). "Herding and anti-herding: A model of reputational differentiation". *European Economic Review 45*. 385-403.

Eisl, A., Jankowitsch, R., Subrahmanyam, M. G. (2017). "The Manipulation Potential of Libor and Euribor". *European Financial Management, Volume 23, issue 4,* 604-647.

Eisl, A., Jankowitsch, R., Subrahmanyam, M. G. (2013). "Are Interest Rate Fixings Fixed? An Analysis of Libor and Euribor". *SSRN Electronic Journal, 10.2139/ssrn.2201013.*

European Money Markets Institute (2017). "EURIBOR PRE-LIVE VERIFICATION PROGRAMOUTCOME."

European Money Markets Institute 2 (2019). "EURIBOR Benchmark Statement".

European Money Markets Institute 3 (2019). "EURIBOR Benchmark Statement".

ESMA, and EBA (2013). "Principles for Benchmark-Setting Processes in the EU".

EU BMR (2016). "Regulations - Regulation (EU) 2016/1011 of the European Parliament and of the Council of 8 June 2016". *Official Journal of the European Union, L 171/1.*

European Banking Federation (2012). Euribor frequently asked questions. http://www.euribor-ebf.eu/assets/files/Euribor%20FAQs%20Final.pdf.

European Commission – Statement (2016). Statement by Commissioner Vestager on decision to fine Crédit Agricole, HSBC and JPMorgan Chase € 485 million for euro interest rate derivatives cartel. https://ec.europa.eu/commission/presscorner/detail/en/STATEMENT_16_4307.

European Money Markets Institute (2019). "EURIBOR Intraday Re-fixing Policy v.2". *D0356C-2015.*

European Money Markets Institute (2013). "Euribor Code of Conduct". *European Money Markets Institute.*

Financial Stability Board (2014). "Reforming Major Interest Rate Benchmarks".

ISDA (International Swaps and Derivatives Association, Inc.) (2019). "Frequently Asked Questions: EURIBOR reform".

Market Participants Group on Reforming Interest Rate Benchmarks (2014). "Final Report". *Financial Stability Board.*

McDonald, O. (2019). "Reforming Benchmarks". *Holding bankers to account - A decade of market manipulation, regulatory failures and regulatory reforms, Part IV Chapter 9,* Manchester University Press.

Mollencamp, C. and Whitehouse, M. (2008). "Study casts doubt on key rate - WSJ Analysis Suggests Banks May Have Reported Flawed Interest Data for Libor". *Wall Street Journal*, May 29.

Molitor, P. (2018). "Update on quantitative mapping exercise". *ECB-PUBLIC Working Group on Euro Risk-Free Rates.* https://e-markets.nordea.com/api/research/attachment/87580

Ottaviani, M. and Sørensen, P. N. (2006). "The strategy of professional forecasting". *Journal of Financial Economics, 81(2)*: 441–466.

Sirak, A. S. (2017). "Information Transmission in the Euribor".

READ, O. (2017): „Der Weg zur Libor- und Euribor-Reform mit Transaktionsdaten". *Zeitschrift für das gesamte Kreditwesen, Heft 15-2017,* 29-34.

Taboga, M. (2014). "What Is a Prime Bank? A Euribor-OIS Spread Perspective." *International Finance, 17(1)*: 51–75.

Vainikainen, J. (2019). "Hybrid Euribor –a temporary benchmark rate?". *Nordea Bank Abp - Nordea Markets.*

Wheatley, M. (2012). "The Wheatley Review of Libor: Initial discussion paper". *HM Treasury and The Rt Hon George Osborne.*

Appendix A

Table 3: List of banks in the Euribor panel (historic)

Euribor panel banks 2007	Euribor panel banks 2014	Euribor panel banks 2020	All Euribor panel banks
ABN AMRO	Banca Monte dei Paschi di Siena S.p.A.	Banco Bilbao Vizcaya Argentaria	ABN AMRO
Allied Irish Bank	Banco Bilbao Vizcaya Argentaria	Banco Santander	Allied Irish Bank
Banca Monte dei Paschi di Siena	Banco Santander	Banque et Caisse d'Épargne de l'État	Banca Monte dei Paschi di Siena
Banca Nazionale del Lavoro (BNPP)	Banque et Caisse d'Épargne de l'État	Barclays	Banca Nazionale del Lavoro (BNPP)
Banco Bilbao Vizcaya Argentaria	Barclays	Belfius	Banco Bilbao Vizcaya Argentaria
Banco Santander	Belfius	BNP-Paribas	Banco Santander
Bank of Ireland	BNP Paribas	Caixa Geral De Depósitos (CGD)	Bank of Ireland
Banque et Caisse d'Épargne de l'État	Caixa Geral De Depósitos	CaixaBank S.A.	Banque et Caisse d'Épargne de l'État
Barclays	CaixaBank S.A.	CECABANK	Barclays
BayernLB	CECABANK	Crédit Agricole s.a.	BayernLB
Belfius	Crédit Agricole s.a.	Deutsche Bank	Belfius
BNP Paribas Fortis (BNPP)	Danske Bank	DZ Bank	BNP Paribas Fortis (BNPP)
BNP-Paribas	Deutsche Bank	HSBC France	BNP-Paribas
Caixa Geral De Depósitos (CGD)	DZ Bank	ING Bank	Caixa Geral De Depósitos (CGD)
CAPITA	HSBC France	Intesa Sanpaolo	CaixaBank S.A.
CECABANK	ING Bank	Natixis	CAPITA
CIC	Intesa Sanpaolo	Société Générale	CECABANK
Citibank	JP Morgan	UniCredit	CIC
Commerzbank	National Bank of Greece		Citibank
Crédit Agricole s.a.	Natixis		Commerzbank
Danske Bank	Nordea		Crédit Agricole s.a.
Deutsche Bank	Pohjola Bank		Danske Bank
Dresdner	Société Générale		Deka Bank
DZ Bank	The Bank of Tokyo Mitsubishi		Deutsche Bank

Erste Group	UniCredit		Dresdner
Helaba			DZ Bank
HSBC France			Erste Group
HypoVereinsbank			Helaba
ING Bank			HSBC France
JP Morgan			Hypovereinsbank
KBC			ING Bank
LandesBank Berlin			Intesa Sanpaolo
LBBW			JP Morgan
Natexis			KBC
National Bank of Greece			La Banque Postale
Natixis			LandesBank Berlin
Nordea			LBBW
NordLB			Natexis
Rabobank			National Bank of Greece
RBI			Natixis
SANP			Nordea
Société Générale			NordLB
The Bank of Tokyo Mitsubishi			Pohjola Bank
UBS			Rabobank
UniCredit			RBI
WestLB			SANP
			Société Générale
			Svenska Handelsbanken
			The Bank of Tokyo Mitsubishi
			Ubibanca
			UBS
			UniCredit
			WestLB

Table 4: List of banks in the respective regression panels (balanced and unbalanced)

(1) Baseline model	(2) SIB model	(3) Crises period model
Banca Monte dei Paschi di Siena S.p.A.	Banco Bilbao Vizcaya Argentaria	Banca Monte dei Paschi di Siena S.p.A.
Banco Bilbao Vizcaya Argentaria	Banco Santander	Banco Bilbao Vizcaya Argentaria
Banco Santander	Barclays	Banco Santander
Barclays	Belfius	Barclays
BayernLB	BNP Paribas	BayernLB
Belfius	Commerzbank	Belfius
BNP Paribas	Crédit Agricole s.a.	BNP Paribas
Caixa Geral De Depósitos	Deutsche Bank	Caixa Geral De Depósitos
Commerzbank	HSBC France	Commerzbank
Crédit Agricole s.a.	ING Bank	Crédit Agricole s.a.
Danske Bank	Nordea	Danske Bank
Deutsche Bank	Société Générale	Deutsche Bank
DZ Bank	UBS	DZ Bank
Erste Group		Erste Group
HSBC France		HSBC France
ING Bank		ING Bank
Intesa Sanpaolo		Intesa Sanpaolo
KBC		KBC
Landesbank Baden-Württemberg		Landesbank Baden-Württemberg
Natixis		Natixis
Nordea		Nordea
Rabobank		Rabobank
RBI		RBI
Société Générale		Société Générale
Svenska Handelsbanken		Svenska Handelsbanken
UBS		UBS
UniCredit		UniCredit

Appendix B

Table 5: Descriptive statistics

	Number of observations	Mean	Std. Dev.	Min.	Max.
CDS	70.578	0,753	1.267	0.01	14.76
WF	270	0.628	0.133	0.241	0.91
EONIA	71.138	1.619	1.422	-0.085	4.601
Quotes	71.215	2.298	1.416	0.24	5.65
bit	71.215	-0.001	0.045	-0.686	0.484