Determining the LIBOR:
A Study of Power and Deception

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Declaration for PhD thesis

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ABSTRACT

This dissertation uses an interdisciplinary approach to investigate the determination of the London Interbank Offered Rate (LIBOR). It is shown that the LIBOR is a fundamentally flawed benchmark stemming from the institutional characteristics of financial markets in general and the practices of banks in particular. As a consequence, the LIBOR is vulnerable to deception. It also gives rise to the misleading perception that it is the outcome of a market-determined process.

Specifically, a game-theoretic approach is adopted to analyse the LIBOR fixing mechanism. Several non-zero-sum 'LIBOR Games' are modelled and solved using a Bayes Nash solution, demonstrating that the banks determining the LIBOR have the means, opportunities, and incentives to submit deceptive quotes, resulting in LIBOR values that deviate from the actual average bank funding cost. Particularly important in this context are LIBOR-indexed derivatives portfolios and the stigma attached to signalling a relatively high funding cost by banks. By deploying the framework of a Keynesian Beauty Contest it then shown that deviations of the LIBOR from what could be regarded as its fundamental value could be long-lasting and systematic. Deception is thus generated endogenously, i.e., though the fixing process itself.

Further, a structural approach to the concept of power is developed within a political economy framework showing that the interests of the LIBOR banks have been served historically, through changes ranging from financial innovation to deregulation. LIBOR-determining banks can thus be conceived as 'LIBOR Clubs' with the structural power to promote their interests through the LIBOR fixing process. In the same vein, the LIBOR is a lens through which to examine significant features of the power relationship between the central bank and other banks. The power of the LIBOR-determining banks is illustrated through the empirical examination of a recent rule change impacting on the Norwegian NIBOR.

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ACI	Association Cambiste Internationale
AUD	Australian dollar
BBA	British Bankers Association
BBAIRS	BBA Interest Rate Settlement
BIS	Bank for International Settlements
bp	basis point
CAD	Canadian dollar
CD	Certificate of Deposit
CDS	Credit Default Swap
CIBOR	Copenhagen Interbank Offered Rate
CIP	covered interest rate parity
CITA	Copenhagen Interest Tomnext Average
CHF	Swiss franc
CME	Chicago Mercantile Exchange
COMCO	Competition Commission (Switzerland)
CP	Commercial Paper
CRS	Cross-currency basis swap
CTFC	U.S. Commodity Futures Trading Commission
DBA	Danish Bankers Association
DKK	Danish krone
EBF	European Banking Federation
EONIA	Euro Overnight Index Average
EUR	euro
EURIBOR	Euro Interbank Offered Rate
FAS	Financial Accounting Standards
FDIC	Federal Deposit Insurance Corporation
Fed	Federal Reserve
Fed Funds	federal funds rate

FX&MM Committee	Foreign Exchange and Money Markets Committee
FIBOR	Frankfurt Interbank Offered Rate
FNO	Finansnæringens Fellesorganisasjon (Finance Norway)
FRA	Forward Rate Agreement
FSA (Japan)	Financial Services Agency
FSA (U.K.)	Financial Services Authority
FX	foreign exchange
GBP	pound sterling
GDP	Gross Domestic Product
HELIBOR	Helsinki Interbank Offered Rate
ICMA	International Capital Market Association
IPE	International Political Economy
IRS	Interest Rate Swap
ISDA	International Swaps and Derivatives Association
ISMA	International Securities Market Association
JBA	Japanese Banking Association
JPY	Japanese yen
LIBOR	London Interbank Offered Rate
LIFFE	London International Financial Futures and Options Exchange
KrW	Kreditanstalt für Wiederaufbau
LOLR	Lender of Last Resort
MIBOR	Madrid Interbank Offered Rate
MMOLR	Market Maker of Last Resort
MNC	multinational corporation
MPC	Monetary Policy Committee
MPR	Monetary Policy Report
NB	Norges Bank
NIBOR	Norwegian Interbank Offered Rate
NOK	Norwegian krone
NPV	Net Present Value
NZD	New Zeeland dollar
OIS	Overnight Index Swap
OPEC	Organization of the Petroleum Exporting Countries
OTC	over-the-counter

PDFC	Primary Dealers Credit Facility
PIBOR	Paris Interbank Offered Rate
REIBOR	Reykjavík Interbank Offered Rate
SEC	Securities and Exchange Commission
SEK	Swedish krona
SNB	Swiss National Bank
SONIA	Sterling Overnight Interbank Average Rate
STIBOR	Stockholm Inter Bank Offered Rate
STINA	Stockholm Tomnext Interbank Average
TAF	Term Auction Facility
T-bill	Treasury Bill
TIBOR	Tokyo Interbank Offered Rate
TIFFE	Tokyo International Financial Futures Exchange / Tokyo Financial Exchange
TOIS	Tomnext Indexed Swap
TONAR	Tokyo Overnight Average Rate
TSLF	Term Securities Lending Facility
USD	U.S. dollar
WGBI	World Government Bond Index

CHAPTER 1

Introduction

1.1. Motivation, Purpose and Outline of the Dissertation

Perhaps I should be excused of the somewhat personal tone in the beginning of this dissertation. However, the motivation behind choosing the London Interbank Offered Rate (LIBOR[1]) as the topic for a PhD very much stems from my personal experience of the benchmark.

My first encounter with the LIBOR came already in Frankfurt in 1992. Working as a derivatives back-office intern for a large bank, I was not only fascinated by the 'buzz' on the trading floor, but also intrigued by the large numbers written on the trade tickets for interest rate swaps and forward rate agreements - next to 'LIBOR', 'FIBOR' or 'PIBOR'. It could be ten, fifty or one hundred million U.S. dollars (or deutschmarks, francs or whichever currency the contract was denoted in). Becoming a short-term interest rate trader myself in Stockholm a year later, I got acquainted to the Scandinavian benchmarks: STIBOR, NIBOR, CIBOR and HELIBOR. Then, moving to London and Tokyo meant having had to grasp the peculiarities of TIBOR as well as the newly created EURIBOR. Later, and to my own surprise, the keen interest by banks and hedge funds to speculate in the Icelandic króna before the global financial crisis, forced me to form an opinion not only about the outlook for

[1] Although the term 'LIBOR' refers to the London Interbank Offered Rate, it is used more generally in this dissertation to also capture other benchmarks (such as CIBOR, EURIBOR, NIBOR, STIBOR and TIBOR) that have been designed using the LIBOR as a template.

the Icelandic economy, but on probable policy decisions by the central bank, and the behaviour of the relatively new REIBOR.

Like for most other short-term interest rate traders, understanding and trying to accurately predict the LIBOR and its equivalents elsewhere, was a central part of the job, as it was the key benchmark for hedging and speculating in the short-term money market. Clients and Treasury desks occasionally had 'real' hedging requirements that were met by LIBOR-derivatives. However, along with a growing risk appetite, the speculative part gradually took over as banks became more hostile to assets (in other words: 'old-fashioned' borrowing and lending) and increased the use of financial derivatives in the daily trading routines. The close link between the LIBOR and the market it was supposed to reflect gradually began to dissolve. At the same time, the importance of the benchmark increased, as it was used in the derivatives market that constantly grew, with trade amounts now often in billions, not millions, of dollars.

For a trader not working for a LIBOR bank, or being particularly close to the fixing process, the benchmark also became a daily source of 'nuisance'. The LIBOR fixing did not always seem to be 'correct'. It sometimes appeared to be deliberately skewed in one direction or the other. However, as the ability to ultimately determine the outcome was set in stone by a club of LIBOR banks, raised eyebrows or complaints rarely resulted in more than the simple and inevitable conclusion that some banks had more 'power' than others.

From a personal perspective, the global financial crisis acted as a trigger point in revealing some of the wider implications of the LIBOR. Like many other market participants, I was confused by what then seemed to be unreasonably low LIBOR quotes by some banks that quite obviously could not raise funding in the interbank market. The benchmark was, after all, supposed to reflect not only current and expected future interest rates, but also liquidity and credit risk. The latter two variables had surged, but were they actually fully reflected in the LIBOR? Up until the crisis, my occasional meetings and conversations with central banks had related to topics on the technicalities of new derivatives, market conventions and the arrival (or departure) of new banks and clients in the market. Now, central banks became

interested in the 'basics' again: the LIBOR. In a way, this sudden change was not surprising, as the LIBOR hitherto more or less had appeared to work as intended, namely as a largely harmonious outcome of the central bank on one hand, and market participants on the other. Changes, or expected changes, in the official central bank rates had filtered through relatively smoothly to money market rates – lending support to the assumption that a repo rate change would lead to a proportional change in money market rates.

The global financial crisis radically changed this. However, it was the phrasing of the questions I got from the central banks that surprised me. It struck me how little they seemed to know about the benchmark rate they now wanted to get under control.

This anecdotal experience has helped me to shape the research questions in this dissertation. However, it does not mean that the research has been conducted in order to understand, or to be able to explain, single – albeit interesting - events in the past. I firmly believe that the LIBOR is important, and becomes even more so when the perspective is shifted from that of an individual trader, to that of the financial system as a whole. Increasingly, the LIBOR has come to act as a key symbol for a wide range of significant cornerstones within economics and finance. It is now an important benchmark for a range of financial contracts, from derivatives and corporate loans to mortgages, credit cards and student loans. It has also gradually come to act as a symbol for the first stage of the monetary transmission mechanism in central banking. As such, the impact of the LIBOR can be felt wide beyond the dealing rooms of banks.

Traditional approaches to conceptualise the LIBOR have, explicitly or implicitly, treated the benchmark as an outcome of the financial market. However, the LIBOR is a paradox. Despite representing the international money market, the LIBOR is not, and never was, a market *per se*. Therefore, this dissertation begins by questioning this assumption, whereby the first research question is posed: Can the LIBOR be seen as a market-determined outcome, or is there a more appropriate method for understanding it theoretically? If so, which method should be used and how should this be conducted?

This dissertation argues that the LIBOR should not be understood as a 'passive' outcome of the market. Instead, the susceptibility of the benchmark to 'manipulation' or 'deception', coupled with the 'perception' that it can be regarded as a market-determined outcome, suggests that the benchmark is more suitable for an inquiry addressing a more 'active' involvement of certain actors. This involvement can be analysed using a multidimensional approach to the concept of power, whereby the LIBOR is applied as a lens through which different layers of a power relationship are studied.

The second research question is therefore derived automatically from the methodology used: When using the LIBOR as a lens, what are the implications for the power relationship between central banks and LIBOR banks?

Consequently, this dissertation not only deals the various techniques that are based upon the perception that the benchmark is market-determined. It also serves as a critique of the perception of the LIBOR itself. The originality stems from the approach taken to study the benchmark, which has arguably become one of the most important 'prices' in economics and finance, as well as the implications that can be drawn from the conclusions of the study. Moreover, by revisiting the 'concept of power', a largely overlooked area within economics, the dissertation can also be read as a reinterpretation of the concept applied to a contemporary and highly relevant field.

The starting point of this dissertation is the central bank and the monetary transmission mechanism. Chapter 2 describes how the global financial crisis affected the LIBOR, and the various risk premia measured against the benchmark. It is shown that traditional methods to decompose the LIBOR into current and expected future central bank repo rates, credit and liquidity risk and using market-based measures as independent variables, treat the LIBOR as a market-determined variable. This approach has often been aimed at assessing the effectiveness of measures introduced by central banks to deal with the financial crisis, namely to reduce the elevated money market risk premia hindering the monetary transmission mechanism from working as intended.

This dissertation claims that there are serious flaws in this approach, and that a 'second autopsy' of the LIBOR is required. However, questions should not only be asked with regards to the technicalities of the previous empirical studies, or as a reaction to recent allegations that the LIBOR might have at times been 'manipulated'. Despite its appearance as a market-determined 'price', it is characterised by some fundamental issues warranting a different methodology altogether - based upon the concept of 'power'.

Moving away from the assumption that the LIBOR is simply a price of the market, or an outcome of a process of voluntary exchange, and adopting the concept of power to account for the LIBOR, requires a journey beyond neoclassical economics. A literature survey on the concept of power is conducted in Chapter 3, not in order to find a conclusive definition within a contested subject, but to form a theoretical framework for how the inquiry into LIBOR should be carried out. As any power relationship can be seen in terms of its different 'layers', an interdisciplinary approach to power is applied. Hereby, the 'lens' through which the LIBOR is analysed can be adjusted to capture different dimensions of the actors in terms of power. The three approaches used in this dissertation (a 'game-theoretic', an 'institutional' and a 'structural') broadly reflect the three main fundamental issues of the benchmark.

By using the LIBOR as a lens, the power relationship between central banks and the LIBOR panel banks automatically takes form. The first actor, the central bank, is discussed in Chapter 4. However, simply stating that the central bank, at the outset, can be regarded as 'powerful' does not result in any greater insight into this power relationship. Instead, using a method employed by Dahl (1957), the historical patterns of the power relationship are analysed from the perspective of the central bank, along with its key powers over monetary policy and financial stability. This narrative highlights the changing role of the central bank, acting in a dynamic relationship with the government, the self-regulating market and the banks. However, the approach by Dahl also provides a basis for critique and discussion on how to capture different aspects of a power relationship.

Chapter 5 studies the LIBOR from a theoretical and political economy perspective, applying a structural dimension of power. Particular emphasis is put on the historical roots of the benchmark in the Eurodollar market, and its importance for a later invention by banks: the financial derivatives market. At the core lies an attempt to portray how the LIBOR has gained the character of an 'illusion', drawing upon the concept of 'money illusion' by Fisher (1928). By illuminating different dimensions of the 'LIBOR Illusion', we can see the role of the LIBOR banks systematically within the broader structural power shift from states to markets. First, it is demonstrated that the LIBOR can be regarded as the 'missing link' between two central innovations by banks: the Eurodollar and financial derivatives markets. Second, it is shown that the LIBOR features a particular kind of information asymmetry giving LIBOR panel banks a specific competitive advantage. Third, this advantage is given a further monetary impetus as a result of the deregulation (and re-regulation) process. Finally, the process towards the increasing significance of the LIBOR has been in tandem with a weakening link to its original purpose: to serve as an 'objective' benchmark for the short-term money market. In sum, this transformation has served the interests of the LIBOR banks, which can be seen as having gained structural power by 'being able to gain by rewriting the rules of the game'.

Chapter 6 applies a game-theoretic approach to analyse the LIBOR fixing mechanism in detail. Various non-zero-sum 'LIBOR Games' are modelled and then solved using a standard Bayes Nash solution. It is shown that collusive behaviour between LIBOR panel banks, or between banks and money market brokers, can lead to LIBOR fixings that deviate from what could be regarded as the 'actual' funding costs of the banks. However, whereas these outcomes are possible, collusive behaviour is not a prerequisite. Instead, assuming banks are rational and act out of self-interest, LIBOR-indexed derivatives portfolios, or the stigma attached to signalling a relatively high funding cost, can provide LIBOR panel banks with sufficient incentives to submit 'deceptive' LIBOR quotes. The trimming process, widely regarded as a hurdle for outright and single-handed manipulation, is shown to be overwhelmingly ineffective, as are rules and constraints introduced in order to enhance transparency. It is argued that the LIBOR games are characterised by an inherent structure whereby banks have the means, opportunities and incentives to

submit deceptive quotes, leading to outcomes (LIBOR fixings) that deviate from the 'actual 'average of the banks' funding cost. From a perspective of power, banks are given the chance to influence the LIBOR in a direction that is beneficial to them. This stems from 'having the exclusive privilege to be able to play this game', in other words to participate in the LIBOR fixing process.

Chapter 7 extends the concept of 'LIBOR Games', but applies a different theoretical framework: the Keynesian Beauty Contest. By treating the LIBOR fixing as the outcome of a particular and unusual kind of *p*-beauty contest game, it is demonstrated that deviations of the LIBOR from what could be regarded as its fundamental value (the underlying money market), can be long-lasting and systematic. As the behaviour of the players are guided by the anticipation of what others will do and what they in turn anticipate others will do, a process is created whereby they are not solely dependent on their own incentives and constraints. Instead, potential deception can be seen as being generated endogenously though the fixing process itself. Simply the 'fear' of possible attempts by others to submit deceptive LIBOR quotes, will prompt seemingly 'honest' players to play 'rough'.

Chapter 8 builds upon the institutional dimension of power and focuses on the unique social practises, networks and conventions that form the rules of the LIBOR game. According to Goodhart (1995), central banks act as natural 'managers of the club of banks'. Using this statement as a point of reference, LIBOR panel banks seen as a collective can be treated as special 'LIBOR clubs'. However, the main difference between LIBOR clubs and clubs of other types of banks or financial market actors is the lack of outside regulation and authoritative oversight. The regulation, or 'institutionalisation of power', with regards to the LIBOR, is characterised by self-regulation, outside the jurisdiction of the central bank and instead closely linked to the lobby organisations promoting the interests of its members. 'The ability to (re)write the rules of the game' constitutes power, and is exemplified through a case study on the Norwegian benchmark, the NIBOR. An empirical study is conducted to show how a rule change instigated by the NIBOR Club, not only manifested its institutional power, but also came to have direct implications on central bank policy. In addition to higher domestic money market risk premia, it also led to a significantly

greater dependence on financial stress in the Eurozone and the power (or lack thereof) of the European Central Bank.

Chapter 9 summarises the outcomes from the different approaches to the concept of power to study the implications upon the central bank. Using the LIBOR as a lens, and drawing upon frameworks by Harsanyi (1962ab) as well as Lukes (1974), it is demonstrated how central bank power is affected. The dissertation concludes by putting the benchmark into a broader context of market conventions, and reflects upon recent suggestions of reforming the LIBOR.

CHAPTER 2

The Anatomy of the LIBOR

'Since the credit crunch began, it has become clearer to all of us that LIBOR, not the Bank of England base rate, is what really governs saving and borrowing rates in the high street. It has always been relied on by the market as a reliable benchmark which is also the most transparent. It is appropriate in this global downturn to ensure the continued robustness of this pillar of our financial architecture.' **(**BBA Chief Executive Angela Knight on 18 December 2008) [2]

2.1. Introduction

The aim of this chapter is to provide the platform from where we can begin to investigate in detail what the LIBOR is, how it is constructed and how various components interact to make it such an important benchmark.

The LIBOR is determined daily. Therefore, if we treat the LIBOR, at the outset, as a 'rate' or a 'price', we could see the logic in attempting to do an 'autopsy' or 'post-mortem' to identify the drivers and components that have caused a specific numerical outcome in the past. The first part of this chapter aims to do precisely that, namely to discuss the traditional approaches to decompose the LIBOR into current and expected future repo rates, credit and liquidity risk. This, as shall be seen, has been done out of necessity following the market developments since the beginning of the global financial crisis.

[2] British Bankers Association (2008)

If we, however, challenge the notion that the LIBOR is a market-determined price, it ought to be the 'outcome' or 'number' of some other process. This dissertation can be viewed in terms of a 'second autopsy' to study the determinants of this outcome in order to gain a greater understanding of the benchmark. The second part of this chapter argues why and how this should be conducted.

2.2. The First 'Autopsy'

2.2.1. LIBOR and the Monetary Transmission Mechanism

The central bank is the logical starting point for an inquiry into any money market rate. Regardless of which type of instrument is referred to, we inevitably return the institution that has the authority to issue the currency in question:

'A central bank derives the power to determine a specific interest rate in the wholesale money market from the fact that it is the monopoly supplier of 'high-powered' money, which is also known as 'base money'. […] A change in the official rate is immediately transmitted to other short-term sterling wholesale money-market rates, both to the money-market instruments of different maturity […] and to other short-term rates, such as interbank deposits. But these rates may not always move by the exact amount of the official rate change. Soon after the official rate change […], banks adjust their standard lending rates (base rates), usually by the exact amount of the policy change. This quickly affects the interest rates that bank charge their customers for variable-rate loans, including overdrafts. Rates on standard mortgages may also be changed, though this is not automatic and may be delayed. Rates offered to savers also change […].' (Bank of England, 1999)

The monetary transmission mechanism can be seen as the key channel through which a money market rate is generated. It is an outcome of the decision by the central bank, as well as actors in the financial markets. As stated by the Bank of England above, the short-term interbank money market rate is central in the first stage of the monetary transmission mechanism. This rate, in turn, affects other interest rates, and through various channels also the economy as a whole (Mishkin, 1996; Hopkins, Lindé & Söderström, 2009). The LIBOR, being the by far most frequently used benchmark for this 'short-term interbank money market', is therefore central not only in central banking, but also for the wider economy.

The short-term interbank money market is the rate at which banks borrow and lend to each other. The LIBOR, as a reflection of this rate, dates back to 1984 when the British Bankers Association (BBA) was assigned to construct agreeable trading terms and a benchmark for the growing market in syndicated loans that had sprung out the Eurocurrency market. The term LIBOR was supposed to represent where a bank was prepared to lend funds to another bank in a specified currency for a specified maturity. A benchmark was also needed for the increasing array of financial derivative instruments that became frequent tools for hedging and speculation. The LIBOR became official in 1986 for U.S. dollars, pounds sterling and Japanese yen and soon thereafter for a range of other liquid currencies for maturities ranging from one day to one year. LIBOR-equivalent benchmarks based upon the same methodology appeared in other financial centres in rapid pace, such as the TIBOR (Tokyo Interbank Offered Rate) for Japanese yen, the CIBOR (Copenhagen Interbank Offered Rate) for Danish kroner, the STIBOR (Stockholm Interbank Offered Rate) for Swedish kronor, the NIBOR (Norwegian Interbank Offered Rate) for Norwegian kroner and the EURIBOR (Euro Interbank Offered Rate) for euros.

The actual fixing mechanism of the LIBOR, and other similar benchmarks, is simple. A designated calculation agent collects the submitted quotes from the individual panel banks before noon. The trader or other bank person at the cash desk or treasury submits his or her quote from the bank terminal, and the other banks do the same without being able to see each others' quotes. During a short period, the calculation agent audits and checks the quotes for obvious errors and then conducts the 'trimming' – the omission of the highest and lowest quotes (the number which depends on the sample size). Thereafter, the arithmetic mean is calculated, rounded to the specified number of decimals and published at a certain time mid-day depending on the benchmark. As a result, the LIBOR fixing can be viewed as the average short-term bank funding cost in a particular currency.

It is important to note that, from a technical perspective, the LIBOR is not directly an outcome of market-determined process. Instead, the LIBOR can be seen as a benchmark for where the selected panel banks *argue* the money market is. More specifically, each individually submitted quote is supposed to represent where the

bank claims to be able to borrow funds, prepared to lend funds, or where they estimate others to be able to do so. For the LIBOR, banks are asked *'at what rate could you borrow funds, were you to do so by asking for and then accepting inter-bank offers in a reasonable market size just prior to 11 am?'* The EURIBOR should be *'the rate at which Euro interbank term deposits are offered by one prime bank to another prime bank within the EMU zone'*. The CIBOR is defined as *'the interest rate at which a bank is prepared to lend Danish kroner (DKK) to a prime bank on an uncollateralised basis'* The NIBOR is intended to reflect *'the interest rate level lenders require for unsecured money market lending in NOK'* and the STIBOR *'the interest rate that banks claim they can offer to offer unsecured Swedish Krona for various maturities to each other'.* TIBOR banks should quote *'what they deem to be prevailing market rates, assuming transactions between prime banks on the Japan unsecured call market'.* A more detailed summary of the benchmarks covered in this dissertation can be found in Appendix 1.

The LIBOR, being a benchmark for the interbank money market, is supposed to represent unsecured, or uncollateralised, transactions, meaning that it does not necessarily correspond to the current and expected future interest rates determined by the central bank. It should also contain an element of credit and liquidity risk. Assuming the risk-free interest rate for a specific maturity is known and observable, the LIBOR for the same maturity could therefore theoretically be decomposed into current and future interest rate expectations and a risk premium. This is important for central banks, 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. A rise in the LIBOR might reflect an intended and well-communicated repo rate hike. However, if the LIBOR rises due to poor market liquidity, some policy actions aimed at, for instance, lowering the bid-offer spreads might be appropriate. On the other hand, should the LIBOR rise as a result of poor funding liquidity of the panel banks, policy interventions such as liquidity injections or deposit insurance schemes might be justified. If the LIBOR rises due to higher perceived credit risk, i.e. a higher risk of default, some kind of action to improve bank solvency might be needed. Consequently, an incorrect signal transmitted through the LIBOR could cause the central bank to make a wrong, delayed or hastened decision.

However, the LIBOR is not only important to the central bank. It is also of relevance for the wider public, as borrowers and lenders can make more accurate portfolio allocations and risk assessments if yield, perceived default risk and liquidity can be quantified.

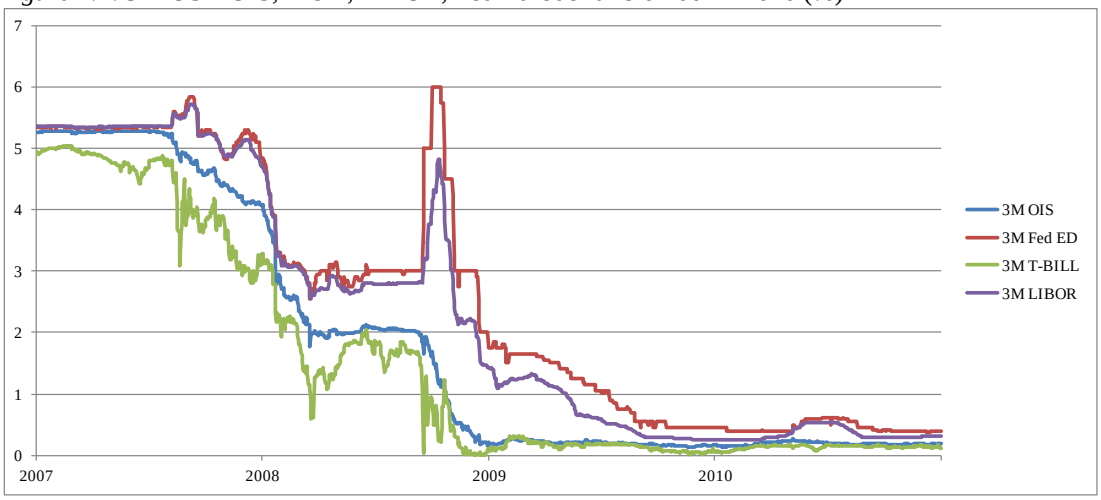
2.2.2. LIBOR and the Risk Premium

The first step in attempting to decompose the LIBOR into current and expected future interest rates, credit and liquidity risk requires us to estimate the risk-free interest rate for the relevant maturity. This can be problematic as the central bank rate is generally an overnight rate, whereas the LIBOR represents a range of maturities up to one year.

A traditional starting point to analyse the LIBOR, in terms of uncollateralised lending, has been to look at the 'TED-spread'[3], in other words the yield difference between the LIBOR and a government issued Treasury Bill (T-bill) with the same maturity. As the former should reflect unsecured borrowing between banks, and the latter secured borrowing by the government, an indication of the risk premium could be obtained simply by looking at the difference between the two. This assumes that bills and bonds issued by the government correspond to a risk-free rate. However, even though sovereign defaults are rare, government securities are neither theoretically completely risk-free, nor perceived as such by the market (as indicated by, for instance, the credit default swap (CDS) market). In addition, T-bill prices can be highly dependent on specific supply and demand factors, such as issuance and flight to safety. As a result, a rise in the LIBOR due to increased perceived credit risk among banks might work to push down T-bill yields despite an unchanged, or more pessimistic, view on the government finances. In fact, this has been prevalent throughout the global financial crisis, as T-bill yields for a number of issuers have remained low even though CDS spreads have indicated a worsening credit outlook for the same issuers. Consequently, T-bill yields can trade significantly below Overnight Index Swap (OIS) yields (see Figure 2.1).

[3] 'T' referring to T-bill and 'ED' to Eurodollars (LIBOR).

Figure 2.1: 3M USD OIS; T-bill; LIBOR; Fed Eurodollar bid 2007 – 2010 (%)



Sources: Thomson Reuters and Federal Reserve

The growth in the OIS market during the last decade has gradually come to provide a more 'suitable' measure of the risk-free interest rate – by reflecting the current and expected future repo rates set by the central bank. An U.S. dollar OIS is defined as follows (ISDA, 2003):

$$OIS = [\prod_{i=1}^{d0}\left(1 + \frac{FEDFUND_i * n_i}{360}\right) - 1] * \frac{360}{d}, \qquad (2.1)$$

where d_0 is the number of days until maturity, i represents the relevant New York banking days in chronological order, $FEDFUND_i$, for any day i is the Federal funds (effective) rate in respect of the first preceding banking day; n_i is the number of calendar days in the calculation period on which the rate is $FEDFUND_i$; and d is the number of calendar days in the calculation period.

Through an OIS, a near-perfect interest rate hedge can be obtained against an outstanding short-term loan or deposit, with minimal credit usage as notionals are not exchanged and payments are netted. An OIS can therefore be defined as the market-determined price for the current and expected future repo rate for a specific currency and maturity, without incorporating credit and liquidity risk, and a more suitable reflection of a risk-free interest rate.[4]

[4] The term 'OIS' will, unless specified, be used throughout this dissertation to represent instruments designed this way. The central bank reference rate naturally differs between currencies, but always refers to an overnight or tomnext rate. The names also differ: EONIA (EUR), SONIA (GBP), TONAR (JPY), TOIS (CHF), CITA (DKK) and STINA (SEK).

For a currency with a tradable OIS market, and a LIBOR-equivalent benchmark reflecting the money market rate, the money market risk premium can be defined in terms of the 'LIBOR-OIS spread':

$$RiskPremium_t = LIBOR_t - OIS_t, \quad (2.2)$$

where OIS_t is the observable OIS rate on day *t* for a given maturity, and $LIBOR_t$ the LIBOR fixing on day *t* for the same maturity and currency.

Seen from this perspective, the LIBOR-OIS spread could be seen as a 'barometer of fears of bank insolvency'[5], reflecting the risk that the borrower defaults (credit risk) and the ease with which the bank can raise funding (liquidity risk):

$$LIBOR_t = OIS_t + CRED_t + LIQ_t, \quad (2.3)$$

where $CRED_t$ the credit premium associated with the LIBOR panel on day *t*, and LIQ_t the liquidity premium faced by the LIBOR panel banks in the money market on day *t* (Poskitt, 2011).

However, another variable could also be incorporated into this equation, taking into account specific 'market frictions'. Hence, by adding a specific component for market liquidity, we could redefine the LIBOR as follows:

$$LIBOR_t = OIS_t + CRED_t + FLIQ_t + MLIQ_t, \quad (2.4)$$

where $FLIQ_t$ now represents the *funding* liquidity of the LIBOR panel banks on day *t*, and $MLIQ_t$ the *market* liquidity on day *t*.

Fundamentally, market liquidity is crucial for the LIBOR to exist as benchmark in the first place. Without a liquid Eurocurrency market, LIBOR would never have established itself as the key benchmark for the short end yield curve. Instead, other benchmarks might have emerged. As Gyntelberg & Woodridge (2008) point out, a simple indicator of what the market perceives as the best benchmark can be gained

[5] A term used by former Fed Chairman Alan Greenspan (Thornton, 2009).

by looking at the derivatives market, as it requires a reliable underlying benchmark. For most large currencies it tends to be the LIBOR (or its equivalent). For medium-sized currencies outside the European time-zone (such as Australian, Canadian and New Zeeland dollars), bank bills are often used. A number of emerging market currencies lack liquid interbank money markets but have properly functioning foreign exchange swap markets. Here it is common to use a benchmark derived from the implied interest rate using the foreign exchange swaps instead. Indeed, as will be explained more in detail in Chapter 8, this method is still in use to calculate the NIBOR for Norwegian kroner.

According to Kyle (1985) market risk can take three forms: the bid-ask spread (measuring how much traders lose if they sell one unit of an asset and then buy it back right away); market depth (showing how many units traders can sell or buy at the current bid or ask spread without moving the price); and market resiliency (telling us how long it will take for prices that have temporarily fallen to bounce back). Funding liquidity risk represents something different, as the ease with which a bank can obtain funding from others will depend on several other factors, such as the margin/haircut risk; the rollover risk (the risk that it will be more costly or impossible to roll over short-term borrowing); and the redemption risk (the risk that demand depositors of banks, or even equity holders of hedge funds for example withdraw funds). Thus, funding liquidity risk reflects investors' or institutions' demand for precautionary reserves. As Brunnermeier (2009) notes, all three forms of funding risk are only detrimental when the assets can be sold at fire-sale prices, i.e. when market liquidity is low.

Even though it might be useful to distinguish funding liquidity risk from market liquidity risk, it can be very difficult to separate them as they can be highly interconnected. If there are problems with funding liquidity, often there are also issues with market liquidity, while the reverse does not need to be the case. If the market dries up, for instance ahead of the release of an important and anticipated economic data release or a central bank policy announcement, bid-offer spreads can widen temporarily, but without having any real impact on funding liquidity. Market liquidity can also remain low for longer periods (for instance during holiday seasons)

in otherwise liquid markets without suggesting that any concerns should be raised regarding the health of the financial system.

Funding liquidity issues, however, do tend to automatically affect market liquidity. Reoccurring year-end cash squeezes occurred regularly before the global financial crisis in liquid currencies such as the U.S. dollar and the Swiss franc. This type of rollover risk can happen regularly - even quarterly or monthly - and need not be serious for the financial system as a whole. Apart from the liquidity squeeze ahead of new millennium, which caused fairly substantial central bank intervention, central banks have generally met demands by simply injecting ample amounts of liquidity to maintain financial stability.

Importantly, both market and liquidity risk can change without having any impact on the perceived credit risk of the banks. However, liquidity issues can of course also be closely related to credit. If the perceived credit risk of a bank is high, it should find it more difficult to raise term funding - and thereby have to pay a higher rate to compensate for this and thus expected to submit a higher LIBOR quote. Therefore, as a precautionary measure, the bank might find itself actively seeking to raise cash, and at the same to reduce lending.

In sum, although it would be useful to be able to distinguish each component that makes up the risk premium connected to the LIBOR, it is both theoretically and practically challenging.

2.2.3. LIBOR and the Global Financial Crisis

High, volatile or systematic deviations of the LIBOR from the risk-free interest rate are symptomatic of the disturbance or breakdown of the first stage of the monetary transmission mechanism. Up until 2007, the LIBOR and its equivalent benchmarks appear to have worked as intended, and reflected the first stage of the monetary transmission mechanism as described by the Bank of England back in 1999. Changes, or expected changes, in the official central bank rates filtered through

relatively smoothly to money market rates – lending support to the assumption that a repo rate change will lead to a proportional change in money market rates. Economic models, frequently based upon the Taylor Rule, could rely upon the LIBOR.

One major exception to this was the Japanese banking crisis in the 1990s. Up until August 1995, when Hyogo Bank defaulted, Japanese authorities had intervened by arranging the merger of an insolvent bank with a solvent acquiring bank. The first commercial bank failure in Japan resulted in the so called 'Japan Premium' which highlighted the increasing inability of Japanese banks to access unsecured funds in foreign currencies. The TIBOR-LIBOR spread for Japanese yen widened sharply during this period. As the TIBOR panel largely consisted of Japanese banks (and the LIBOR panel mainly of European and American banks), the higher TIBOR was a reflection of the increased funding cost of Japanese banks compared to that of their foreign peers. The quotes by the few large Japanese banks that were part of the panel in London were consistently higher and thus mostly omitted from the calculation of the LIBOR average – thereby leaving the Japanese yen LIBOR fixing largely in the hands of non-Japanese banks *without* funding issues. Hence, the TIBOR-LIBOR spread move could be said to have originated in higher perceived credit risk directly leading to funding liquidity risk that the benchmarks were supposed to express. However, the overall market liquidity in Japanese yen was not affected in the same way. Transactions in yen between non-Japanese banks continued normally and despite becoming considerably more volatile, market illiquidity did not force foreign banks to liquidate yen-denominated assets on a large scale. As such, this was not a 'Japanese yen crisis', but a 'Japanese banking crisis'.

The Japan Premium was also noticed in the foreign exchange and cross currency swap markets. Although Japanese banks were offered ample liquidity in yen from domestic sources – particularly the Bank of Japan – they needed foreign currency funding as a result of large-scale investments made abroad during previous boom years. As the Bank of Japan could not print U.S. dollars, and as the Eurocurrency markets dried up for Japanese banks (by being perceived as less creditworthy), they had to turn to the foreign exchange swap and cross currency swap markets. Hereby, they could use their yen liquidity to swap them into U.S. dollars, which they required. When Japanese banks headed for this last funding avenue, both cross

currency swap prices and foreign exchange swaps became more negative, indicating that for those holding Japanese yen, swapping them to U.S. dollars (or other foreign currencies through dollars) would be much more expensive than indicated in the Eurodollar market. As Spiegel (2001) notes, this additional risk premium was directly affected by the financial strength of the borrowing Japanese banks. However, it was also affected by the policy of the Bank of Japan (or ultimately the Finance Ministry) through its ability or desire to act as Lender of Last Resort, and also its willingness (and ability) to shield unsecured creditors from losses.

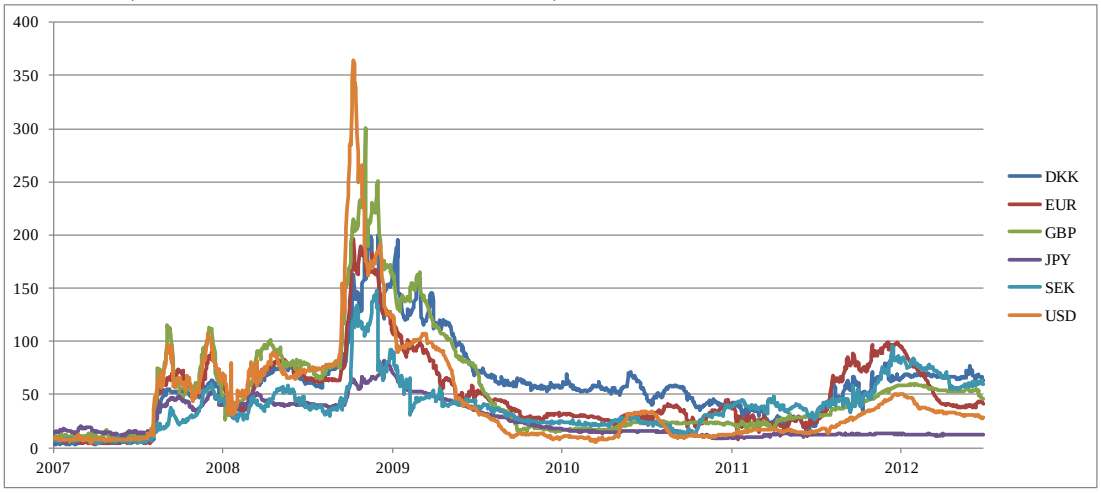
Thus, market participants not active in the Japanese yen market - or having no memory of it - had, until 2007, become used to very small deviations of the LIBOR from the official, and expected, central bank rate. Due to low volatility, and perceived risk, banks had become able and used to combining money market instruments together to create a extensive pool of market liquidity. Hedges between instruments and currencies enabled traders to 'buy time'. Access to liquidity was easy and central banks became increasingly transparent and predictable. Reoccurring year-end liquidity issues could easily be dismissed as temporary, and were smoothed out by sufficient central bank liquidity measures.

Central bankers, having grown accustomed to a seemingly liquid, transparent and well-functioning money market more or less without credit and liquidity issues during decades, could rely on the first stage of the monetary transmission mechanism. Focus could therefore be put on its channels affecting output and inflation and on methods how to increase transparency and minimise monetary policy surprises.

For market participants, central bankers and the public alike, this symmetry came to an abrupt end with the advent of the global financial crisis. The demise of the U.S. subprime mortgage market during the first half of 2007 and resulting defaults led to a spiral of surging CDS spreads referencing asset-backed securities – first containing those with the lowest credit-ratings, and then rapidly spreading to medium- and even top-rated credit quality. Severe losses were faced by, amongst others, the UBS hedge fund Dillon Read, two hedge funds run by Bear Sterns and the U.S. home loan lender Countrywide. As a result, the market for asset-backed commercial paper (CP) began

to dry up quickly. The crisis then spread outside the U.S., with the German bank IKB being the first European institution reporting rollover problems. During the first week of August 2007, a range of quantitative hedge funds suffered large losses - triggering margin calls and fire sales. On 9 August 2007, the French bank BNP Paribas froze redemptions for three investment funds, citing its inability to value structured products. Thus, the asset-backed mortgage credit risk associated with subprime lending had fairly quickly come to affect the global uncollateralised money market (Brunnermeier, 2009; Khandani & Lo, 2007). Consequently, credit, market and liquidity risk rose significantly and became reflected the in the LIBOR-OIS spreads and its equivalents in other financial centres (see Figure 2.2). These indicated that the difference between the funding costs of large banks and the risk-free rate had increased significantly.

Figure 2.2: 3M LIBOR-OIS Q1 2007 – Q2 2012 (bps): DKK = 3M CIBOR – 3M CITA bid; EUR = 3M EURIBOR – 3M EONIA bid; GBP = 3M LIBOR – 3M SONIA bid; JPY = 3M LIBOR – 3M TONAR bid; SEK = 3M STIBOR – 3M STINA bid; USD = 3M LIBOR – 3M OIS bid.



Source: Thomson Reuters

Central banks acted swiftly, with the European Central Bank injecting 95 billion euros and the Federal Reserve (Fed) 24 billion U.S. dollars overnight. On 17 August, the Federal Reserve broadened the type of collateral accepted, increased the lending horizon to 30 days and lowered the discount window by 0.5% to 5.75%. However, the measure was not deemed a success as the 7,000 or so banks that could borrow at the discount window were historically reluctant to do so because of the stigma associated with it. Using the discount window would signal desperation and hence a lack of creditworthiness towards the market. October and November 2007 saw a

series of write-downs and the total loss in the mortgage market was revised upwards. When the Federal Reserve realised that rate cuts announced during the autumn did not filter through the monetary transmission mechanism, it introduced the Tem Auction Facility (TAF) where banks could borrow from the Federal Reserve without using the discount window. As the LIBOR-OIS spreads narrowed between December 2007 and February 2008 after the TAF was introduced, the measure was judged to be working. However, spreads started to widen again and in March the Federal Reserve took new measures by expanding the TAF, and by introducing the new Term Securities Lending Facility (TSLF). A loan package to Bear Sterns through JP Morgan, and a new Primary Dealers Credit Facility (PDCF), was also announced.

Similar market movements were observed in other currencies, with central banks across the developed countries resorting to similar measures, amplified by the collapse of Lehman Brothers. Central banks found themselves in a difficult position as the symmetry in the monetary transmission mechanism had broken down. Price stability through inflation targeting had gradually become more important than financial stability as a central bank goal. This no longer applied. Having become more transparent themselves, central banks now had to rely on information and signals provided by the banks and the markets. The key indicators, the LIBOR-OIS spreads, gave evidence of severe stress in a range of currencies and markets. The Japan Premium (the TIBOR-LIBOR spread) now became negative - suggesting that non-Japanese banks found it more difficult to fund themselves than their Japanese counterparts. Counterparty risk increased as banks became reluctant to lend to each other.

Not only was the economy slowing down at a very rapid pace, and the housing market coming to a complete standstill following the sub-prime crisis, the speed of write-downs by banks were alarming and the uncertainty to each others', or indeed your own, exposure. Liquidity risk increased as banks were holding on to the cash they had as a precaution and the balance sheet traders could use. Market liquidity also deteriorated, not least as the market makers of the various money market instruments tended to be banks already in trouble.

Another LIBOR-based measure of stress in the international money markets, the cross currency swap spread, also widened significantly. This later resulted in unprecedented central bank co-operation.

A cross currency swap can be seen as the deviation from the interest rate parity (CIP) of a currency pair for a specific maturity. If the base currency LIBOR premium is set at zero, the deviation, or spread, is expressed as a basis point premium or discount on the target currency LIBOR.

According to the covered interest rate parity (CIP), interest rate differentials between two currencies should be perfectly reflected in the foreign exchange swap price, otherwise arbitrage would be possible:

$$(1 + i_{USDt}) = \frac{F_t}{S}(1 + i_{CCY2t}), \tag{2.5}$$

where i_{USDt} is the interest rate for the base currency (typically the U.S. dollar), and i_{CCY2t} the interest rate for the target currency for maturity *t*. *S* and F_t represent the foreign exchange spot and forward rates between the currencies respectively. This particular kind of arbitrage has generally ensured that the CIP has held. Otherwise, a bank could make a risk-free profit by borrowing in one currency (U.S. dollars) for maturity *t*, sell U.S. dollars and buy, say, Swiss francs at spot rate *S* and simultaneously buy U.S. dollars and sell Swiss francs forward at the forward rate F_t, and lend Swiss francs for the same maturity.

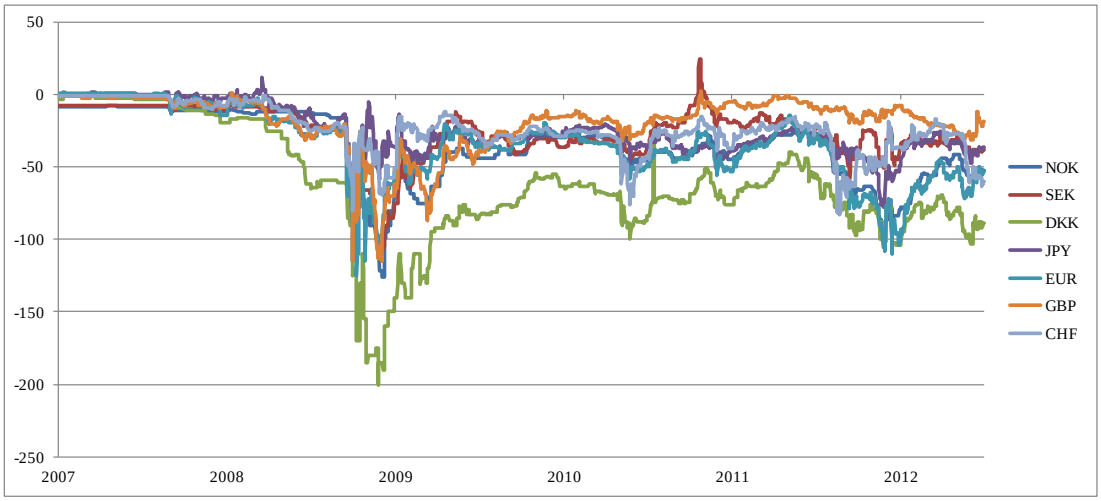
Due to historical reasons, interbank foreign exchange swaps are generally quoted against U.S. dollars. Deviations from the CIP are therefore normally measured as the difference between the implied target currency interest rate using the U.S. dollar interest rate and the foreign exchange transactions, and the interest rate for the target currency. Whereas the foreign exchange spot and swap points (the difference between the forward rate and the spot rate) are market rates, the interest rates used are generally LIBORs. As the floating index for a cross currency swap typically is 3 months, whereas the maturity of the contract can be up to 10 years or longer, the instrument can be viewed as a market price for a string of 3 months CIP deviations

for a specific maturity. Thus, the cross currency swap market provides us with a yield curve for expected future deviations from the CIP.

Small temporary deviations from the CIP can occur as a result of various degrees of market liquidity. The average interbank funding cost in one currency might not perfectly reflect that of the foreign exchange market as a whole. Moreover, as Eurocurrency deposits are unsecured, they can carry an additional risk premium, for instance if they are offered to foreign banks where they are not backed by explicit guarantees of payment in case of bank failure. However, the global financial crisis led to very large, lasting and volatile deviations in the CIP that had hitherto normally held. In fact, the markets pointed towards a specific 'Dollar Premium' indicating that the relative demand for U.S. dollars rose compared to other currencies. As such, they were showing that the problems in the money markets were not only *bank-specific* (such as with the 'Japan Premium'), but also *currency-specific* (affecting the U.S. dollar more than other currencies).

As Figure 2.3 shows, the 1-year cross currency swap spread as measured against the U.S. dollar started to deviate from the CIP as soon as the crisis broke out:

Figure 2.3: 1Y CRS Q1 2007 – Q2 2012 (bps): 3M USD LIBOR flat versus 3M NOK NIBOR; 3M SEK STIBOR; 3M DKK CIBOR; 3M JPY LIBOR; 3M EUR EURIBOR; 3M GBP LIBOR; 3M CHF LIBOR. Bid sides.



Sources: Thomson Reuters; ICAP for NOK and SEK, Tullet Prebon for DKK, JPY, EUR, GBP and CHF

The differences were generally largest for shorter maturities, up to and including 3 months, and exceptionally so in the aftermath of the Lehman bankruptcy. Domestic liquidity injections during the early days of the global financial crisis, or like those of the Bank of Japan during the Japanese banking crisis, were not sufficient to dampen demand, as only the Federal Reserve could print U.S. dollars. As the demand for dollars was particularly severe for banks outside the U.S., an international response involving the Federal Reserve was necessary to provide U.S. dollar liquidity - in technical terms to reduce the CIP deviation. This systematic deviation from the CIP therefore led to co-ordinated international central bank action, with the Federal Reserve at the helm. Temporary reciprocal currency arrangements in the form of foreign exchange swap lines were established with the Federal Reserve in order to channel dollars to banks in other jurisdictions (Baba & Packer, 2009; McGuire & von Peter, 2009). In December 2007, swap lines were set up with the European Central Bank and the Swiss National Bank. The market reaction was relatively muted. After the collapse of Lehman Brothers and a sharp move in the cross currency swap and foreign exchange swap markets, the sizes of the swap lines were increased considerably. Bank of Canada, Bank of England and Bank of Japan were added to the list of central banks with which foreign exchange swap lines were established. Soon thereafter, a range of other central banks were included into the network.

The dollar liquidity swap lines were designed to improve liquidity conditions in dollar and foreign financial markets by providing foreign central banks with the capacity to deliver U.S. dollar funding to institutions in their jurisdictions during times of market stress. The response was positive in the sense that spreads fairly quickly returned levels prior to the Lehman bankruptcy. However, as the euro sovereign debt crisis gained momentum during the spring of 2010, the global financial crisis entered into a new phase. Government bond and CDS spreads for Eurozone sovereigns began to deviate sharply, reaching levels not seen since the introduction of the common currency. Money markets faced renewed pressures, as banks became reluctant to lend to each other, fuelled by the uncertainty about each other's exposures to peripheral European countries and what the effects of the fall in prices of sovereign bonds might have on their balance sheets when marked-to-market. LIBOR-OIS and EURIBOR-EONIA spreads started to widen again, after a long period of narrowing that followed the central banks' injections of vast amounts

of liquidity into the banking systems in the aftermath of the Lehman Brothers collapse. In addition, both the foreign exchange swap and the cross-currency swap markets started to indicate serious strains in the interbank lending market for dollars again. As European banks had significantly increased their activities in the U.S. since the launch of the euro, these strains reflected difficulties the banks faced in funding them. With the European Central Bank unable to offer dollars, and the Federal Reserve unable to lend dollars directly to European banks, dollar swap lines were re-introduced on 9 May 2010 (Kaltenbrunner et al., 2010).

2.2.4. LIBOR and Central Bank Policy

Widening money market risk premia since 2007, as expressed in both LIBOR-OIS spreads and cross currency swap spreads, resulted in unprecedented and now well documented action from a range of central banks. As the first stage of the monetary transmission mechanism broke down, central bank powers were put to the test. Consequently, decomposing the LIBOR in the recent literature has almost become synonymous with assessing the effectiveness of central bank policy in dealing with the current financial crisis.

The standard technique has been to somehow quantify each of the components that make up the LIBOR-OIS spread. By assuming that the LIBOR is a reflection of the offshore money market, and taking the OIS market prices as given and representing the risk-free interest rate for a given maturity, it simply becomes a task of allocating the difference between the two variables into the appropriate credit and/or liquidity components making up the spread.

In fact, if a measure for credit risk can be agreed upon, the remaining component could be regarded as ‘non-credit’, or liquidity risk. This is the approach taken by the Bank of England (2007) in an indicative decomposition of LIBOR. In principle, CDS prices should reflect the probability of default of the reference entity, the loss given default and some compensation for uncertainty about these factors. By assuming that investors recover 40% of their deposits in the event of default, and by ignoring any

liquidity effects in the CDS market itself, an implied (risk-neutral) probability of default for the underlying security is derived. Then, using the OIS as a measure for the risk-free interest rate and adding the credit risk they arrive at an interest rate that includes credit. The residual premium from the LIBOR-OIS spread is the 'non-credit premium', or simply speaking the 'liquidity premium'. The results show that during the beginning of the market turbulence, liquidity issues played the key role. Credit issues were less significant, but increased to explaining around 10-30 basis points (bps) of the 1-year U.S. dollar LIBOR-OIS[6] spread during the last quarter of 2007. Initially, the LIBOR-OIS spread did not react to CDS prices, suggesting that credit was not a key determinant.

Soultanaeva & Strömqvist (2009) of Sveriges Riksbank conduct a similar study using the same framework to analyse the extent to which the Swedish money market risk premium (the 'STIBOR-STINA' spread) was affected by the financial turmoil. Their findings also reveal that the main driver of the money market risk premium during the first part of the crisis was liquidity risk, particularly around the collapse of Lehman Brothers. However, during the latter part of the empirical study in the first half of 2009, the relative importance of credit risk increased, more or less wiping out liquidity risk factors altogether.

Indeed, the main argument behind the extensive array of central bank liquidity injections during the early periods of the crisis was to reduce strains in the interbank money markets - in technical terms to reduce the LIBOR-OIS spreads - as rate cuts were ineffective. This spread reduction takes place through several channels. First, the central bank serves as an additional funding source for the banks and thereby lowers the funding cost of banks. Second, as the new measures reduce the incentive or pressure on the banks in reducing their exposure to risky assets, they have a positive impact on the money market conditions, which in turn could lower the perceived counterparty credit risk and hence decrease risk premia. Third, improved market confidence overall due to these measures might reduce the risk premia. Finally, with the central bank acting as Lender of Last Resort, excessive hoarding out of precautionary concerns will also be reduced (Wu, 2008).

[6] An important note is that the Bank of England uses the 1-year LIBOR. Whereas the 3-month money market became very illiquid during the crisis, the 1-year market virtually ceased to exist.

However, as Taylor & Williams (2008) argue, since the TAF does not increase the amount of total liquidity in the system[7], it should not affect the LIBOR-OIS spread. Neither does the TAF have an impact on expectations of future overnight rates or credit. By examining the early period of the crisis (2 January 2007 to 20 March 2008) and using the LIBOR-OIS spread as the dependent variable, the TAF as a dummy and various indicators of credit risk as the independent variables[8], the authors find no empirical evidence that the TAF reduced LIBOR-OIS spreads. Arguing that liquidity can be disregarded both theoretically and empirically in the case of the TAF; they draw the conclusion that counterparty credit risk is the key factor in explaining the LIBOR-OIS spread.

McAndews, Sarkar & Wang (2008), however, reach a different conclusion when investigating the effects of the TAF on the LIBOR, by examining whether the announcements and operations of the TAF program causes *shifts* or *jumps* in the LIBOR-OIS spread. According to their study, a significant reduction of the LIBOR-OIS spread can be attributed to the TAF. The authors argue that the likely reasons for the contrasting results compared to Taylor & Williams is that they use changes, not levels, of the LIBOR-OIS spread as the dependent variable in their regressions.

Even though total liquidity in the system is not affected by the TAF, it might still have an impact on the money markets. As Wu (2008) notes, under these special circumstances the effectiveness of the liquidity measures depend on whether they can resolve the misallocation of liquidity in the market. The total supply of reserves in the system might be of lesser importance, as the unwillingness of banks to lend to each other stems from *both* credit and liquidity concerns. In effect, the Federal Reserve is not only acting as Lender of Last Resort, but also as a kind of intermediary in the money markets. The author finds that the TAF had a strong effect in reducing LIBOR-OIS spreads[9], primarily though relieving financial institutions' liquidity concerns. Importantly, the study treats the establishment of the TAF as signalling a new 'regime' in the money market, and therefore differs from other

[7] Any increase in liquidity that comes from banks borrowing from the Federal Reserve using the TAF would be offset by open market sales of securities to keep the total supply of reserves from falling rapidly.
[8] Asset backed CP spreads, the TIBOR-LIBOR spread, CDS spreads for Bank of America and Citibank as well as the LIBOR-repo spread
[9] Period studied: 1 January 2007 – 24 April 2008.

studies that look at the TAF and its effect on LIBOR-OIS spreads on specific trading days.

Christensen, Lopez & Rudebusch (2009), studying the LIBOR-T-bill spread using a six-factor term structure model, also find that the liquidity measures managed to lower the liquidity premium. Thornton (2010), on the other hand, builds upon their model and reaches a different interpretation - suggesting that the TAF had little effect on the LIBOR-T-bill spread. Instead, the TAF should be seen as having increased the credit risk premium as market participants interpreted announcements of extraordinary central bank measures as a drastically worsening of the crisis.

Michaud & Upper (2008) try to decompose the LIBOR-OIS spread using the following equation:

$$RISK\ PREMIUM\ _t = TPREM_t + CREDIT_t + BLIQ_t + MLIQ_t + MICRO_t \quad (2.6)$$

The authors acknowledge that the bank specific funding liquidity ($BLIQ_t$), and the micro structure effects ($MICRO_t$) are difficult to measure, and therefore treat them as unobservable variables whose effect will appear as residuals. The default risk ($CREDIT_t$) is measured using bank CDS spreads and the spread between unsecured and secured interbank rates. Market liquidity ($MLIQ_t$) is reflected by the liquidity in the overnight cash market from the e-Mid platform. They find that both indicators of credit risk tracked the LIBOR-OIS spread well during the second half of 2007, suggesting that during this period credit concerns might have been the driving force behind the wider spread. However, the relationship with the CDS spreads broke down in January 2008, which could be explained by either the large maturity mismatch (5-year CDS spreads compared to 3-month LIBOR), or more likely that liquidity factors might have been more important. The low degree of dispersion of LIBOR quotes compared to their respective CDS premiums also suggests that the quoting behaviour was little affected by the default risk perceived by the market. In addition, an event analysis using price reaction to bank losses and central bank liquidity injections did seem to have impacted LIBOR-OIS spreads, but not CDS-spreads, pointing towards the importance of bank specific funding needs in explaining the LIBOR-OIS spread.

Schwarz (2010) uses a different approach in decomposing the euro LIBOR-OIS spread up to mid-2008, by not only constructing an own credit measure, but by disregarding funding liquidity and focusing on the impact of market liquidity risk. At the outset, she compares two bonds with the same maturity, same legal status - and hence same credit status - but with different market liquidity. The logic is built upon Longstaff (2004) who argues that Treasury market liquidity was a function of the spread between Refcorp and the U.S. Treasury bonds. Schwarz denominates the highly liquid German Bund as the euro risk-free rate and the other risk-free rate as the KrW (Kreditanstalt für Wiederaufbau) bonds. KrW bonds are German agency bonds that are less liquid than their federal government counterparts, but also fully guaranteed against default by the German federal government (and therefore ought to have an identical risk profile). Schwarz finds that approximately two-thirds of the spread move could be explained by increased *market illiquidity*.

In sum, the empirical studies have given mixed results with a somewhat bias towards liquidity risk being the key driver of the LIBOR-OIS spread. This is consistent with the vast liquidity injections by central banks particularly in the aftermath of the collapse of Lehman Brothers. Credit risk seems to have played a lesser role, with the study by the Bank of England (2007) even showing a temporary *negative* credit premium.

2.3. The Second 'Autopsy'

2.3.1. A Technical Critique

Traditional approaches to decompose the LIBOR have assumed that various market-determined measures for credit and liquidity risk ought to be able to explain the LIBOR-OIS spread. In fact, the LIBOR itself is assumed to be not only an observable variable, but also somehow market-determined or a reflection of a market. This might be intuitively correct, as the LIBOR is a benchmark that *should* represent the average funding cost of the panel banks.

However, it is questionable if and how the market-based variables used as measures actually capture market liquidity risk and credit risk as expressed in the specific LIBOR-OIS spreads. The CDS is a useful instrument to capture perceived creditworthiness of a particular bank. However, leaving aside the issue of normally comparing the long-term perceived creditworthiness (CDS are normally 5 years) with the short-term LIBOR (generally 3 or 6 months), there is also a fundamental difference between the structure of the CDS market and that of the money market. If the CDS (as determined by the market) were to perfectly reflect the creditworthiness of a particular LIBOR panel bank, the LIBOR quote by the same bank should be directly dependent on the market's *perception* of its creditworthiness. In other words, LIBOR panel banks would not only be tiered according to their CDS spreads among their LIBOR panel peers, but the banks themselves would rate each other LIBOR panel bank in accordance to its CDS spread, and adjust their money market rates accordingly. Problematically, this is not the market convention. The rating, or tiering system, is internal and not market-based - although naturally influenced by it. Ultimately, a LIBOR panel bank can also refuse to lend to another bank. This, however, does not imply that the bank in question has defaulted. Put differently, the CDS-method implies the existence of continuously changing, and market-determined, individual money market quotes that do not exist.

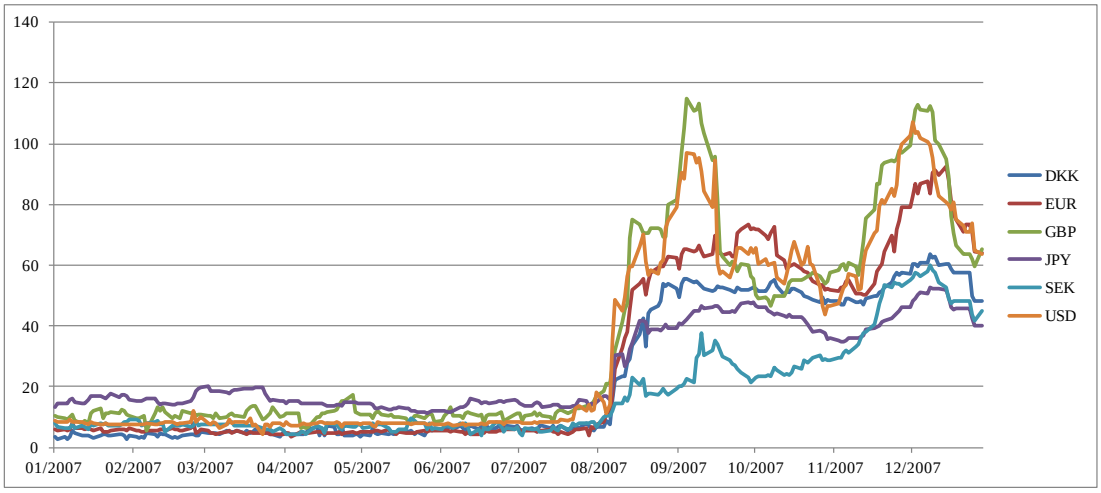
With regards to estimating market liquidity, Michaud & Upper, as well as Schwarz, use volumes traded at the e-Mid platform as a variable. The problem is that not only does e-Mid report just a fraction of trades actually taken place, it is mostly used for overnight, tomnext[10] or 1-week maturities – and not for term lending (such as 3-month or 1-year maturities) which is precisely what LIBOR reflects. The market for shorter maturities did not dry up the same way during the financial crisis, as all financial institutions still had to square their balances. Moreover, traders tend to be more reluctant to use electronic platforms during periods of stress and volatility.

Nonetheless, it is obvious that all three indicators of market liquidity as defined by Kyle were heavily affected by the financial crisis. The question is how this should, technically, affect the LIBOR-OIS *spread*? Importantly, the LIBOR-OIS spread is

[10] Whereas overnight refers to a loan or deposit from today until the next business day, 'tomnext' refers to a contract from the next business to the following business day.

measured using the LIBOR-rate (which is an offered rate) and the OIS-rate (which is a mid-market rate). The bid-offer spreads of OIS prices have remained tight throughout the crisis, so using an offer rate would not change the picture. However, if market liquidity worsened with the advent of the crisis, bid-offer spreads on 'real cash' (expressed in the LIBOR) should have widened. Thus, for market liquidity to have an impact on the LIBOR-OIS spread, less liquid currencies should observe wider spreads at the outset.

Figure 2.4: 3M LIBOR-OIS 2007 (bps): DKK = 3M CIBOR – 3M CITA bid; EUR = 3M EURIBOR – 3M EONIA bid; GBP = 3M LIBOR – 3M SONIA bid; JPY = 3M LIBOR – 3M TONAR bid; SEK = 3M STIBOR – 3M STINA bid; USD = 3M LIBOR – 3M OIS bid.



Source: Thomson Reuters

Figure 2.4 depicts the LIBOR-OIS spreads for different currencies during 2007. We should expect currencies in the most liquid money markets (such as U.S. dollars, euros and Japanese yen) to observe narrower spreads than sterling, and significantly narrower spreads than the Scandinavian currencies due to the differences in market size and liquidity. However, prior to 9 August 2007, the differences are negligible, suggesting that market liquidity was not an important driver of the spread. In fact, the Danish krone (the smallest currency) has the narrowest spread (5.1 bps) followed by the euro (5.4 bps) and the Swedish krona (6.9 bps). The widest spreads prior to the crisis were observed in the Japanese yen (15.0 bps), the pound sterling (11.0 bps) and U.S. dollar (8.3 bps). This should, however, be interpreted within the context that *all* major currencies were fairly liquid prior to the global financial crisis and that the differences related to the unique market microstructures. The crisis caused market liquidity to collapse, and we should thus expect already less liquid currencies to

become even less so. However, these seem not to have been particularly affected. Instead, the largest widening took place in the U.S. dollar, the euro and the pound sterling, suggesting that market illiquidity can be a poor predictor of the LIBOR-OIS spread.

More importantly, if the LIBOR benchmarks actually reflected the Eurocurrency market, the large deviations in the CIP need to be explained. LIBOR panel banks should not be able make significant profits by borrowing term money in, say, pounds sterling (at LIBOR) and simultaneously switching them into U.S. dollars (through foreign exchange swaps) and lending them in dollars (again at LIBOR).

Theoretically, credit and liquidity factors could explain deviations from the CIP *per se*, or why arbitrage might be possible. Increased default risk leads to higher exchange rate risk, as the foreign exchange rate might move before the maturity of the contract. The bank also faces rollover risk, as the credit situation might have changed. More importantly though, if the arbitrage is secured it is highly dependent on the conditions in the money markets. However, even an unsecured arbitrage has to be funded (generally day-to-day) and might be affected by the credit conditions in the overnight money markets. With regards to liquidity risk, margin and haircut constraints might make it more difficult to engage in lucrative arbitrage trades. The banks may also try to hoard cash to build up a liquidity pool. Furthermore, market liquidity in terms depth, resiliency and bid-offer spreads might prevent banks from actively exploit opportunities (see Griffoli & Ranaldo, 2010).

The strains, however, mostly appeared in currency pairs involving the U.S. dollar, whereas others were less affected. It is therefore difficult to argue that the deviations from the CIP were caused by ‘general market conditions’ as arbitrage activity could be conducted in any possible currency pair. The specific demand for dollar must therefore have stemmed from the fact that banks indeed had a specific shortage of the currency, or preferred the U.S. dollar as a source and pool of liquidity for precautionary measures. Baba & Packer (2008, 2009) argue that dollar funding shortages of non-U.S. financial institutions were largely responsible for the deviations from the CIP from 2007 onwards. Basing the hypothesis on the observation that European financial institutions were largely on the dollar borrowing

side of the foreign exchange swap market for euros against dollars, an asymmetry of counterparty risk between European and U.S. financial institutions could potentially show up in deviations from the CIP. Their empirical study supports the hypothesis that an asymmetry of counterparty risk between U.S. and European financial institutions was reflected in the CIP deviation.[11]

In fact, that the 'LIBOR equation' could not be solved was already observed by Hanajiri (1999) when using the CIP to analyse why the Japanese Premium differed between the markets during 1997 and 1998. In theory, the Japanese Premium in the U.S. dollar interest rate market should equal the Japanese Premium in the yen market plus the Japanese premium in the dollar-yen swap market. This was not the case, or put differently, the CIP did not hold. Importantly, already here the LIBOR was regarded as the underlying liquid money market, from which foreign exchange swaps and other instruments were derived. The author also compared the U.S. dollar LIBOR and the Eurodollar interest rates in Japan's off-shore market finding a higher rate for the latter (showing the Japan Premium). When, on the other hand, the dollar LIBOR and the implied dollar interest rate from the TIBOR and the dollar-yen foreign exchange swaps were compared, the difference was more significant. In other words, the Japan Premium appeared to be greater in the 'tradable' money market than in the LIBORs. Thus, it could be argued that a proportion of the deviations from the CIP stems from the fact that the LIBOR benchmarks consist of a few large banks, whereas the foreign exchange market is a reflection of the market as a whole. It is plausible that smaller banks or other institutions might find it more difficult than global banks to access funding during times of stress. Problematically, though, large universal banks have been far from immune during this crisis.

[11] European credit risk is measured by the senior CDS spread index for European financial institutions with investment grade ratings included in the iTraxx Europe series, and U.S. credit risk by the CDS sectoral spread index for brokers/dealers and other U.S. financial institutions with investment grade ratings. Instead of using the U.S. dollar LIBOR, the authors use the Eurodollar rate published by the Federal Reserve which should reflect a broader range of financial institutions. Hereby, they aim to reduce the noise stemming from the fact that LIBOR is set by few banks, whereas the foreign exchange swap market is open to a large number of financial institutions.

2.3.2. A Critique of the 'Perception'

The fundamental problem with the traditional approach to decompose the LIBOR does not lie as much in the technicalities, as in the basic assumption, or false perception, that the LIBOR is a rate determined by a market process. Thus, when independent traders and observers found it remarkable that large panel banks that were practically shut out of funding (such as UBS) consistently submitted LIBOR quotes at levels well below rates actually traded in the market, questions were raised with regards to the perception that the benchmark could be relied upon as a reflection of the funding cost of the panel banks. Mollenkamp & Whitehouse (2008) picked up on this, and floated the issue of possible 'LIBOR manipulation' in the Wall Street Journal on 16 April and 29 May 2008. The authors argued that some LIBOR panel banks deliberately had quoted too low LIBORs that could be justified by their credit standing as reflected in the credit default swap market. Although the article did not claim direct manipulation, it argued that banks *'may have been low-balling their borrowing rates to avoid looking desperate for cash'*. This fit with the anecdotal evidence from active traders and brokers for LIBOR-based instruments in the markets, and highlighted that some banks actually might have an incentive to under-quote LIBORs.

According to the BBA statues and the fixing mechanics, this should not take place. Erroneous or skewed quotes are omitted automatically (if they are few). The reputational damage caused by misquotes is thought to ensure this will not happen systematically. Banks can (in theory) be expelled from the LIBOR panel, and new banks can in theory apply to become members of it. This, however, is rare. When it has occurred, it has merely served as evidence of the robustness of the system. However, the BBA still felt compelled to conduct an 'investigation' as a result of the allegations of manipulation.

No evidence of manipulation was found when examining the process and the banks, but more governance and scrutiny was to take place according to the British Bankers Association (2008), which also stated:

'[...] it has been suggested that LIBOR contributions could be compared with the indicative rates from brokers shown on Thomson Reuters and Bloomberg screens. However, this is unlikely to provide any useful insights as it is a comparison of a bank's perceived cost of funding against a broker's perception of where a bank could access funds, and neither of these needs to be tied to an actual dealt rate.'

The BBA, being a lobby organisation for the banks and not for the market as a whole, would naturally argue that the banks themselves are more objective, insightful and trustworthy than the money market brokers. The issue of transparency appeared to have reached a dead end with the comment:

'[...] it is not possible to receive the details of individual dealt rates as the confidentiality agreements between brokers and their clients preclude these from being disclosed.'

It again showed the difficulty in establishing the LIBOR as an 'objective' reflection of the 'actual' money market, as it is rooted in secrecy.

However, several academics began to pick up the story of possible LIBOR manipulation, seeking to find evidence for, or against, such claims. Gyntelberg & Woodbridge (2008) acknowledged that LIBOR panel banks, in theory, could act strategically in their fixing, but that the trimming process acts as a hindering factor. The authors concluded by stating that '*interbank rates diverged to an unusual extent in the second half of 2007. This divergence was not caused by shortcomings in the design of the fixing mechanism. Rather, it reflected the dislocation in the underlying interbank markets.'* (p. 71)

Another empirical study (Abrantes-Metz et al., 2012) looking into structural breaks in LIBOR series and comparing them to other benchmarks and indicators, shows that some anomalies existed during the early part of the financial crisis, but finds the evidence inconsistent with effective manipulation. Kuo, Skeie & Vickery (2010), on the other hand, compare the LIBOR with a dataset of term loans for bank wholesale borrowing based on Fedwire (the large-value payments system operated by the Federal Reserve) and find that the LIBOR is an approximate reflection of the average wholesale borrowing rate. However, during the peak of the crisis, the LIBOR appears to have been significantly understated. Hartheiser & Speiser (2009), on the other hand, estimate a theoretical LIBOR based upon CDS spreads and average volatility

of at-the-money put options on panel banks, suggesting a cartel-like behaviour among a group of LIBOR panel banks.

Snider & Youle (2009, 2010) use a different approach altogether by basing a theory of misreporting incentives upon the individual banks' portfolio exposure to the LIBOR that gives them an incentive to push the benchmark in a particular direction.

The simplest way to illustrate this logic is through a forward rate agreement (FRA) entered into by two counterparties in order to hedge their opposite exposures to the LIBOR. The settlement amount from the derivatives contract depends on the notional amount (*N*), the contract rate, the maturity (*d*), the day count convention (*DC*) and the actual LIBOR fixing:

$$Payment_{FRA} = \frac{(LIBOR - Contract\ Rate) * d * N}{DC} \tag{2.7}$$

The counterparties would naturally have opposite interests with regards to the level of the LIBOR on the fixing day. However, if one of the counterparties were to be a LIBOR panel bank, it would automatically have an incentive to attempt to influence the LIBOR on the fixing day by submitting a rate that would maximise the payment (or minimise the loss) of the contract.

Snider & Youle study three LIBOR panel banks that are American bank holding companies and thereby required to provide interest rate derivatives and net interest revenue figures in the quarterly Reports on Conditions and Income (Call Reports) to the Federal Deposit Insurance Corporation (FDIC). By using the exposure to outstanding interest rate swaps as an approximation for LIBOR-exposure, the authors find that during the period there was a clear incentive for the banks to keep a low LIBOR, thereby suggesting that panel banks may have acted strategically when submitting their LIBOR quotes.

In 2011, regulators and financial supervisors in several countries began investigating alleged LIBOR manipulation by traders and money market brokers directly or very closely linked to the fixing process. Although the investigations are still ongoing and only some conclusions have been made, initial reports pointed to several, but

interlinked, angles in the investigation process. One relates to possible collusion between two or more banks in the LIBOR rate setting process aimed at influencing the fixing in their favour, as collusion amongst a group of banks might enable them to surpass the hurdle of the so-called trimming process. Another strand relates to the possible pressure put by banks on money market brokers to influence the LIBOR fixing, as banks might have the incentive to try to influence what the voice broker signals to the rest of the market. Thus, voice brokers have also been under scrutiny – having possibly conspired with banks, or groups of banks, to influence the LIBOR submissions (COMCO, 2012; Mackenzie, 2012).

At the time of writing three (Citibank, UBS and Barclays) have been penalised by financial regulators for attempting to manipulate the LIBOR.[12] As stated by the FSA regarding the financial penalty imposed upon Barclays, the bank had made '*submissions which formed part of the LIBOR and EURIBOR setting process that took into account requests from Barclays' interest rate derivatives traders. These trades were motivated by profit and sought to benefit Barclays' trading positions'*. The regulator also stated that the bank had '*seek to influence the EURIBOR submissions of other banks contributing to the rate setting process*' and '*reduced its LIBOR submissions during the financial crisis as a result of senior management's concerns over the negative media comment.'*

2.3.3. Identifying the Fundamental Issues

The allegations of attempted manipulation of the LIBOR highlight an important characteristic of the benchmark as a reflection of the short-term money market rate: it does not need to correspond to the first stage of the monetary transmission mechanism at all times. Seen from different perspective, the actions by the central bank on one hand, and the market on the other, need not result in a 'fair' LIBOR outcome. Rather, the decision making process and the power to ultimately determine

[12] Financial Services Agency (2011abc); Financial Services Authority (2012); U.S. Commodity Futures Trading Commission (2012)

the level of the LIBOR rests with the banks belonging to the LIBOR panel. This brings forward three fundamental issues with the benchmark.

The first fundamental issue relates to features inherent in banking itself: commercial banks are profit-maximising and wish to be perceived as ‘good’ and ‘sound’ at all times. These features have, theoretically, an impact on the LIBOR fixing mechanism in two ways.

First, according to the LIBOR rules, rates should be submitted by members of staff at a bank with primary responsibility for management of a bank’s cash, rather than a bank’s derivative book. The banks’ quotes should be ‘independent’ in the sense that the banks should not have the incentive to distort the quote in one direction or the other. However, as the LIBOR is used in a wide range of financial contracts (from mortgages, credit card and student loans to a vast and increasing range of financial derivatives), the financial impacts could be significant should the benchmark be systematically ‘manipulated’. Therefore, from the perspective of an individual LIBOR bank, it might be rational to use the privilege of being part of the LIBOR fixing process by attempting to influence the LIBOR in a direction that is beneficial for LIBOR-based contracts already held.

Second, as the LIBOR should not only reflect the risk-free interest rate, but also a risk premium, a contributing bank might have the incentive to conceal its own potential funding troubles publicly through the LIBOR signalling process. The funding cost of the bank, its capital and reputation are closely linked (Ederington, Yawitz & Roberts, 1987). Downgrades by rating agencies are rare events, as are financial statements. The LIBOR, by contrast, is published daily. Given the peculiar fixing mechanism of the LIBOR, whereby quotes are subjectively submitted by banks, whereas details of actual trades between banks remain confidential, the LIBOR is based upon trust. Banks should not have means, opportunities and incentives to submit quotes that do not correspond to the question asked. Whereas there might be important linguistic distinctions between ‘where you could borrow’, ‘where you would lend’ and ‘where do you view others lending to each other’, none of the LIBOR-benchmarks refer to actual ‘binding’ quotes.

The second fundamental issue of the LIBOR relates to its form of governance, which can be described as a kind of 'self-governance'. The LIBOR panel compositions have changed over time, mainly as a result of bank mergers. However, a common feature for all the panels is that they mainly include large universal banks that are highly active (and normally market-makers) in the money, foreign exchange and derivatives markets. They are typical too-big-to-fail banks. The LIBOR panels (or 'LIBOR clubs' as they will be referred to in this dissertation) generally have steering committees deciding upon the rules and structure of the benchmark. The steering committees then tend to have some kind of governing body supervising the process. This is usually the prevailing bank lobby organisation. For the LIBOR, the governing body is the British Bankers Association (BBA). Likewise, the other benchmarks refer back to the European, Japanese or Danish Banking Associations respectively. In addition, the ACI Forex plays a role in conjunction with the European Banking Federation (EBF) with regards to the EURIBOR. The Swedish and Norwegian benchmarks are more informally governed, normally through committee meetings between the panel banks themselves, although the NIBOR lately has come under the umbrella of Finance Norway (FNO). Thus, the LIBOR is not governed by the central bank, or the market, but by the banks belonging to the panels in conjunction with their lobby organisations. Among financial benchmarks, this setup is unique.

The third fundamental issue is more structural. Namely, the issue with regards to the traditional approach to decompose the LIBOR does not lie in the technicalities of how the benchmark should be decomposed, but in the *perception* that it can be decomposed with the assumption that it is a market-determined benchmark in the first place. As highlighted before, the LIBOR is not a market *per se*, but an average of where the chosen panel banks argue the market is. Designed using the tradable Eurocurrency market as a template, the LIBOR bears a close resemblance of a market. However, there are several differences: the Eurocurrency market is the international interbank money market, whereas the LIBOR is a benchmark using a fairly homogenous group of large, too-big-to-fail banks known as the LIBOR panel banks; the money market is by definition a tradable market (whether it is liquid or illiquid), whereas the LIBOR is, at the outset, non-tradable. The money market is non-transparent (trades are not reported), whereas individual LIBOR-quotes are observable on a daily basis. Finally, the 'actual' or 'traded' money market rates do

not serve as a benchmark for financial contracts (such as mortgages and derivatives), whereas the LIBOR does. Despite these differences, the LIBOR has – at least until very recently - managed to maintain its status as a term for the competitive money market colloquially, professionally as well as in the academic literature.

With its history in the Eurocurrency market, the LIBOR should be an ideal candidate as a benchmark for a liquid and efficient international money market. The LIBOR panel banks are in effect a list of the largest banks in the world that are competing fiercely against each other. If a benchmark fails to live up to its requirements, it should be replaced by a better benchmark. However, benchmark-competition has been weak, or non-existent. New indices or benchmarks are virtually impossible to emerge automatically given the large amount of outstanding derivatives contracts that would need to be re-negotiated, not to mention the possible resistance the current LIBOR clubs would show towards such a development. Another feature of any benchmark is the requirement of liquidity; and that movements in benchmark yields should not be driven by order imbalances, but rather should exclusively reflect new information about fundamentals (Wooldridge, 2001). At the outset, the LIBOR should be able to perform this function. However, it requires that the underlying money market is liquid at all times (even during crises) and that panel banks ensure that their 'actual' funding cost is revealed. Put differently, despite weak credentials, the LIBOR seems to have gained almost a monopoly status as a benchmark reflecting the short-term money market.

In sum, even though the LIBOR might appear as if it is a market-determined benchmark, some of its fundamental characteristics point towards other reference points. This is an issue that will be addressed throughout this dissertation.

2.3.4. A New Methodology

The central bank is fundamental in the determination of the short-term interbank money market rate, through its role as the monopoly supplier of high-powered money and as the institution setting the base interest rate. The imperative nature of

the central bank, by being annexed to the state, inevitably links the short-term interbank money market rate to the concept of 'power'. However, the rate is also determined by market participants, some which might be regarded as more 'powerful' than others through the ability to influence the rate at a given moment in time.

The traditional approach to decompose the LIBOR into current and expected future interest rates, liquidity and credit risk has tended to use market-based measures as independent variables. Liquidity risk, instead of credit risk has been shown to be the main driver behind widening LIBOR-OIS spreads since the beginning of the global financial crisis. Central bank action, aimed at reducing this spread through extensive liquidity injections, has in large been seen to confirm this.

This dissertation claims that there are fundamental flaws in this method – stemming from the fact that the LIBOR is not a market *per se*. It argues that a greater insight into the LIBOR can be achieved by not relying upon the element of 'voluntary exchange' a market implies, but instead incorporating a broader approach based upon the 'concept of power'.

The LIBOR is a benchmark that should reflect the short-term interbank money market rate, but ultimately the outcome is dependent on the submissions by the LIBOR panel banks. However, to understand the implications of this we need to go beyond taking into account aspects of asymmetric information or the existence of 'market power' of certain financial market actors. Since power relationships are complex, not least within banking, each 'layer' of the relationship can be seen as having its distinct aspects in terms of power. Focusing on the power relationship between LIBOR banks and the central bank would therefore require us to define these layers, and to find a methodology for how these should be investigated. For instance, an approach to study governance would naturally differ from one aimed at incentive structures derived profit-maximisation or perceived creditworthiness. Understanding 'perceptions' and 'structures' requires yet another approach.

By using the concept of a 'game' as a metaphor for the LIBOR fixing mechanism, the processes, institutions and structures surrounding the fundamental issues of the

LIBOR can be viewed in terms of different layers of a power relationship. The first fundamental issue of the LIBOR, or layer of the power relationship, relates to the nature of commercial banking itself, namely to the profit-maximising objective of banks and their inherent desire to be perceived as creditworthy. The actual LIBOR outcome, at any given time, is ultimately not determined by the market as a whole, but a specified group of LIBOR banks.

Assuming banks are rational and act out of self-interest, this process can be modelled as a non-zero-sum game: a 'LIBOR game'. Hereby, we can study not only the means and opportunities, but also the incentive structures, of the banks. Moreover, the game-theoretic approach allows us to investigate the LIBOR fixing mechanism in detail, and circumstances where the outcome (the LIBOR fixing) can reach equilibria incorporating 'deceptive' LIBOR quotes.

This game-theoretic approach can be extended to discuss a more complex type of LIBOR game, where the game has become a convention and is assumed to be played repeatedly until infinity. Using a Keynesian Beauty Contest framework in general, and that of a *p*-beauty contest game in particular, allows us to study more permanent deviations of the LIBOR from the 'actual' short-term money market rate. Hereby, we can question whether deception needs be specific to a unique bank or situation, or if it can become more systematic and 'endogenous' to the LIBOR fixing mechanism itself – thereby having a reinforcing effect upon the power of the LIBOR banks. In sum, the game-theoretic approach treats power in terms of specific actors having 'the exclusive privilege to be able to play the game'.

The second fundamental issue with regards to the LIBOR, namely that of the unique governance, is addressed from a broader perspective. The various groups of LIBOR panel banks are analysed using the concept of 'institutional power', whereby power extends beyond the collective aggregate of the individual decisions by each LIBOR bank. The governance of the benchmark, and 'the ability to (re)write the rules of the game', rests with these panels, or 'LIBOR clubs', in conjunction with their lobby organisations. Despite wide-scale changes in financial markets over the last decades, there is a remarkable lack of transparency and resistance to change with regards to the LIBOR. This makes research into the layers of institutional power of the LIBOR

clubs difficult. However, one important rule change with regards to the NIBOR took place in September 2008. Hence, a case study using an empirical technique is conducted to analyse the institutional rule change both from the perspective of the NIBOR Club as well as the Norges Bank.

The third fundamental issue, dealing with structures and the perception of the LIBOR, is arguably more complex. The LIBOR as a benchmark and an invention can be better understood when put in a political economy context discussing the structural power of markets and states. Here, the approach is to investigate the power of LIBOR banks as 'being able to gain from (re)writing the rules of the game'.

However, these fundamental issues and layers of power cannot be fully analysed without also reflecting upon the impact upon the other actor in this relationship: the central bank. Therefore, the power, or lack of power, of the central bank in the LIBOR process is addressed throughout this dissertation. The next chapter lays the theoretical framework for how this shall be done. It argues that relationships can be regarded as multidimensional, which makes an interdisciplinary approach to power both necessary and desirable. This, as will be demonstrated, is the case even (or especially) for a topic such as the LIBOR that might, on the surface, appear outside the sphere of power. One of the advantages of the concept of power is that it can be applied as a way to interpret a wide range of relationships resulting in outcomes that that are neither determined by a process of voluntary exchange, neither through acts of coercion or violence.

CHAPTER 3

The Concept of Power

3.1. Power versus Voluntary Exchange

As shown in the previous chapter, the LIBOR occupies a central role in the monetary transmission mechanism. The power of the central bank, backed by the state and manifested through its ability to decide upon and implement measures with regards to monetary policy and financial stability, *should* have an effect on the money market and hence the LIBOR.

The 'market', in this context, is not perceived as a powerful actor, or a collective of such actors. Rather, the forces of the market involve a kind of process of voluntary exchange of one good versus another, often involving some kind of monetary element. Through this market process, an outcome - a price - is established. This process might include actors with disproportional market power having the ability to temporarily influence the outcome. However, with the exception of 'market forces' (depicting the invisible hand), or 'market power' (referring to some sort of asymmetric distribution of market takers), economic studies on markets tend to avoid a wider incorporation of the concept of power.

On the surface, the LIBOR bears many resemblances of a market-determined price. The outcome (the LIBOR fixing) coupled with the institutions and the processes through which it is established gives the impression that it is a 'price' and a 'market' respectively. The rate is set by a panel of competitive banks and used in a range of financial contracts, which are also subject to a market-determined process. Still, as

shown in the previous chapter, the LIBOR lacks some of the fundamental characteristics giving it the shape of a market in its own right.

This dissertation argues that the concept of power is highly applicable when studying the LIBOR fixing mechanism and the actors involved in this process. However, a process that is *not* based upon voluntary exchange does not automatically qualify for being driven by power. Neither does an asymmetrical power relationship need to involve conflict or violence (Harsanyi, 1962ab; Schelling, 1980).

The concept of power is contested terrain. Despite being central to the understanding of social relationships, there is no real consensus view on how to define power from a philosophical and sociological standpoint. In general, economists have been more comfortable dealing with symmetry and markets, than with asymmetric relationships that the notion of power almost per definition suggests. As a result, economic theory has more been about voluntary exchange, and power studies left to other social sciences (Eckstein 1973; Baldwin 1978). Nonetheless, there are areas in economics where the term is frequently used, such as in 'monopoly power', 'bargaining power' (in game theory), 'economic power' (in international trade) or 'class power' (in Marxian political economy). Game theory within microeconomics studies problems emerging in voluntary exchanges - such as credibility, agency problems, asymmetric information, moral hazard, collective action and public goods. Power, thus, is not a game-theoretic concept in itself. It is only when the 'game' is put into a wider context when its power implications begin to emerge.

As any social relationship involves 'actors', we are inevitably required to study the actors involved in the process. Likewise, like any social relationships, those within banking can be analysed from different dimensions, or layers, depending which 'lens' is applied. There are individual relationships between bankers, between a banker and a client or a banker and a money market broker. There are relationships between competing banks, or between a bank and the central bank. There are also relationships across these layers: between the central bank and the government, between a bank and its employees and so on. Banking relationships are therefore complex to analyse, but so is the concept of power. By using the LIBOR as lens, a

specific power relationship emerges: not that between the central banks and the market, but that between the central bank and the LIBOR panel banks.

The aim with this chapter is to establish a road map for how power should be applied to study the power relationship between central banks and banks using the LIBOR as a lens. Depending on the lens used to study the particular relationship, different aspects of the power relationship can emerge. Due to both the complexity of the relationship, and the nature of the concept of power, the study inevitably becomes interdisciplinary as different layers of the power relationship require different approaches to power. Therefore, the absence of consensus with regards to the definition of power should not be seen as a liability, but an asset in providing an interdisciplinary methodology to put both the LIBOR as a focal point, and the actors having power to influence it, into a logical and systematic context. In sum, by using different approaches to power - or lenses through which the LIBOR is analysed - different aspects of the benchmark can emerge. At the same time, by regarding the LIBOR as a *lens in itself*, the power relationship between central banks and banks is illustrated though different dimensions.

This chapter begins with some basic definitions of power within social sciences, and then gradually broadens the scope - without losing sight of the relevant context. The aim is to tread carefully beyond standard economic analysis in trying to source a concept (or concepts) of power within a structure where the LIBOR is the focal point surrounded by central banks, banks and other financial markets actors. The ambition is not to source a conclusive definition of 'power'. Rather, a suitable framework is sought, that can work as a theoretical platform for the inquiry into the meaning of LIBOR as a whole.

3.2. Power, Rationality and Self-interest

Russell (1938: p. 25) argued that '*power may be defined as the production of intended effects*'. This is a strict definition and two initial questions should be asked. First, are we talking about the production, or the capacity to produce? Second, is it

necessary and/or sufficient that the effect is intended? Weber's definition is 'softer' in treating power as: '*the probability that an actor within a social relationship will be in a position to carry out his own will despite resistance, regardless of the basis on which this probability rests'* (Weber, 1978a: p. 53); and *'the chance of a man or a number of men to realize their own will even against the resistance of others who are participating in the action'* (Weber, 1978b: p. 926). Weber adds the notion of 'probability' implying that the greater the capacity to impose such will, the greater the power. After all, the degree of power needs somehow to be measurable.

However, neither of these definitions clearly refers to actual or hypothetical power. Another perspective is given by Dahl (1968: pp. 407-408) in highlighting the concepts of control and agency: '*Power terms in modern social science refer to subsets of relations among social units such that the behaviours of one or more units (the responsive units, R) depend in some circumstances on the behaviour of other units (the controlling units C)'.* In essence, we are dealing with someone getting someone else to do something he would not otherwise have done. According to Dahl (1957), a power relationship can be understood according to a set of five constituents: the 'base', 'means', 'scope', 'amount' and 'extension' of power.

Hobbes (1651: p. 56) saw power as the ability to secure well-being or personal advantage '*to obtain some future apparent good'*, and noted that power only was related to the power of others. Arendt (1958) reflects upon this in 'The Origins of Totalitarism':

'Power, according to Hobbes, is the accumulated control that permits the individual to fix prices and regulate supply and demand in such a way that they contribute to his own advantage. The individual will consider his advantage in complete isolation, from the point of view of an absolute minority, so to speak; he will then realize that he can pursue and achieve his interest only with the help of some kind of majority. Therefore, if man is actually driven by nothing but his individual interests, desire for power must be the fundamental passion of man. It regulates the relations between individual and society, and all other ambitions as well, for riches, knowledge, and honor follow from it.' (p. 139)

The definitions so far imply a significant degree of self-interest with regards to the concept of power. A basic assumption of methodological individualism is that '*the elementary unit of social life is the individual human action. To explain social*

institution and social change is to show how they arise as the result of the action and interaction of individuals' (Elster, 1989: p. 13).

Rational Choice Theory aims to logically describe a process that predicts outcomes in certain social situations where individuals act out of self-interest and are guided by rationality. Importantly, decisions are seen as individual and outcomes as collective aggregates of these decisions. Norms and structures are put aside, as the process is independent of social structures (Joseph, 1988: pp. 19-40). This theory fits with neo-classical economics as the market and society hereby become self-adjusting systems. As exchange is done voluntarily, power can be seen as playing a minor role. In any case, any 'residual' power is widely and thinly distributed, and can therefore be neglected (Rothschild, 1971: p. 9). Power, when it exists in concentrated form (such as in monopoly power) becomes a problematic concept. Consequently, as seen from an economic policy perspective, the state (having monopoly power) should not therefore only be kept small, but should act by promoting self-regulation of markets and anti-trust legislation.

Attempts to link power with Rational Choice Theory have generally been done within the study of politics, rather than economics. This is not surprising, given that the concept of power largely has been 'squeezed out' from economics textbooks. However, Rational Choice Theory does not only study social and political processes, but also the logic of 'games'. Game Theory, with its foundations in the Rational Choice Theory, has sometimes been used in various disciplines in attempting to help analyse power relationships. Here, individuals, or groups of individuals, are modelled as 'actors'[13] with a utility or objective function. Each actor is then facing a set of alternative choices. For any pair of alternatives ('a' and 'b'), the actor either prefers 'a' to 'b', 'b' to 'a', or is indifferent between 'a' and 'b'. The presence of constraints makes choice necessary, and the actor chooses a strategy to achieve the desired outcome, or to maximise his utility. The actor's incentive structure thus contains the costs associated with the different strategies, and the beliefs that these will occur - weighing up the expected utility of each possible outcome (Dowding, 1991; Hargreaves Heap et al., 1992). Given the assumptions in Rational Choice

[13] Henceforth, the term 'actor' (frequently used in economics and game theory) is used instead of 'agent', which is generally preferred within other social sciences.

Theory, and Game Theory, a framework is established within which the relative bargaining strengths, or powers, of the actors can be analysed. This framework can be used to model a wide range of social interactions where actors have the ability to exert power over others. For example, a 'powerful' actor can take options away from another's choice set; can change the relative costs of actions; can change the likelihood that a given action will lead to a given outcome; or might simply change the other's beliefs about its incentive structure. This framework can be used to model a wide range of social interactions where actors have the ability to exert power over others.

Harsanyi (1962ab) explains the strengths of power holder A over B in terms of four different influence techniques available to A. One influence technique available to power holder A is to supply information (or misinformation) on (allegedly) already existing advantages and/or disadvantages connected with various alternative policies open to B. Another influence technique of power holder A may be to set up rewards and punishments, i.e. new advantages and disadvantages subject to certain conditions as to B's future behaviour. Power holder A may also provide certain new advantages or disadvantages for B, subject to no condition. Finally, power holder A may be to rely on his legitimate authority over B - or on B's personal affection for A - which leads B to attach direct disutility to the very act of disobeying A.

Consequently, the combination of Rational Choice Theory, Game Theory and power presents a kind of platform, from where systematic work can be done to model agents, utility functions, preferences and so forth. As with other models of power, this framework is neutral as to the use of coercion. A threat of violence, for instance, can change the likely costs and benefits of different actions. So can a financial penalty in a voluntarily agreed contract, or indeed a friendly offer.

Studying the dynamic relationship between a bank on one side, and a central bank on the other, forces us to define the various actors that are playing the game. The utility function of the bank could, for instance, include profit-maximisation. The 'non-profit-maximising' central bank, on the other hand, would operate according to some kind of objective function or a social welfare function designed and/or implemented together with the elected representatives of the state (such as targeting inflation).

However, the ‘market’ or the ‘state’ is more than just a collective of actors; it is also a system or a structure. Therefore, game-theoretic models within the rational choice framework tend to become interesting, but also complex, when they are applied to the real social situations. For instance, bankers or traders might have sets of interests that go beyond a simple preference ordering of ‘a’ to ‘z’. Many games are played simultaneously and people make mistakes and learn. Some games might be played ‘unconsciously’ or ‘unintentionally’. In fact, merging Rational Choice Theory with power appears to have more been an attempt to make social and political studies appear more ‘scientific’ (by incorporating mathematical models), rather than to broaden the horizon within the field of economics to encompass the concept of power. Importantly, the framework tends to overlook collective norms and structures, and to ignore questions as to *why* a specific actors has power.

3.3. Power, Agency and Institutions

Parsons and Giddens add an important dimension to the concept of power relating to structure and agency. Parsons (1967) does not see individuals simply as self-interested utility maximisers, but socialised actors oriented to a normative context within which social action takes place. Power becomes associated with collective goals and a kind of normative consensus. The exercise of power, or the process, is not destructive but reproductive. Significantly, power is not seen as a zero-sum game, but expandable. To explain this, Parsons (1969: pp. 251-285) uses an analogy between the concept of money and the concept of power. In the economic system, money is the medium and mechanism through which actors achieve their preferred outcomes. In the political sphere, power acts in the same manner:

‘Power then is the generalised capacity to secure the performance of binding obligations by units in a system of collective organisation when the obligations are legitimised with reference to their bearing on collective goals, and where in case of recalcitrance there is a presumption of enforcement by negative situational sanctions – whatever the actual agency of that enforcement.’ (Parsons, 1967: p. 308)

Giddens’ (1984: pp. 257-8) criticism of Parsons was his entry to the sociological discussion on power – by arguing that power is always exercised over someone, and

by claiming that Parsons ignores the hierarchical character of power and the division of interest which are frequently consequent upon it. Power, according to Giddens, is generated in and through the reproduction of domination and is a capacity to achieve outcomes. Whether or not these are connected to sectional interests is not relevant to the definition itself. Power is defined in terms of agency, which is defined in terms of action, which in turn is defined as power:

'[…] to be an agent is to be able to deploy (chronically, in the flow of daily life) a range of casual powers, including that of influencing those deployed by others. Action depends upon the capability of the individual to 'make a difference' to a pre-existing state of affairs or course of events. An agent ceases to be such if he or she loses the capability to 'make a difference', that is to exercise some sort of power.' (Giddens, 1984: p. 14)

As Clegg (1989: p. 143) claims, actors, ignorant or not, are at the centre stage for Giddens' theory, and structure and system illusions sustained by their productive powers:

'Power is an integral element of all social life as are meaning and norms; this is the significance of the claim that structure can be analysed as rules and resources, resources being drawn upon in the constitution of power relations. All social interaction involves use of power, as a necessary implication of the logical connection between human action and transformative capacity. Power within social systems can be analysed as relations of autonomy and dependence between actors in which these actors draw upon and reproduce structural properties of domination.' (Giddens 1981: pp. 28-29)

The most deeply embedded structural properties implicated in the reproduction of societal totalities Giddens (ibid: p. 17) call 'structural principles', and those structural practices which have the greatest time-space extension within such totalities he refers to as 'institutions'.

The concept of power has used extensively within the field of institutional economics, such as the public choice school. Here, the term 'interest' tends to be used more frequently than 'power', yet with a comparable meaning. A typical political process could have the following structure. First, the decisions maker chooses the policy that maximises some objective, subject to the constraint that those who implement the policy, as well as the private actors affected, also maximise their

utility. Second, given the policy, the 'implementators' maximise their utility subject to the utility maximisation of the private actors. Third, the private actors maximise their utility subjective to the policy and those who implement it – and so on. Following this schema, if a regulator (the decision maker in this case) has the capacity to affect the welfare of actors, these will have an incentive to influence the decision of the regulator – and the regulator will do so if it is better off than by maximising its 'original' social welfare function (Przeworski, 2003: p. 96). Thereby, 'regulatory capture' occurs when interest groups (such a particular industry) use their powers to shape the constraints (regimes, regulation, laws etc) that are favourable to them (Stigler, 1971: pp. 3-21).

Several studies have been conducted attempting to highlight the importance of powerful interest groups in shaping monetary policy regimes. Inflation targeting and independent central banks have become a sort of 'best practise' to achieve the objective of low and stable inflation. As with any regime choice, this involves some kind of trade-off between goals. One such trade-off might be between an independent central bank pursuing inflation targeting (power delegation from the government to the central bank) and a fixed-exchange rate regime (power delegation from the central bank to a foreign central bank). Broz (2002) makes the distinction between central bank independence and fixed exchange rate regimes as alternative monetary commitments in terms of differences in transparency, where central bank independency is opaque and difficult to monitor and a commitment to fixed exchange rates being easily observed. Using empirical data the author finds that autocracies labelled as opaque political systems are more likely to adopt exchange-rate pegs than democracies, and that central bank independence is effective in limiting inflation in nations with high levels of political transparency. Bernhard & Leblang (2002) claim that politicians can use monetary commitments to help manage conflicts resulting from increased levels of economic openness in developed countries - and thereby improve cabinet durability. Frieden (2002) argues that the sectoral impact of regional exchange-rate arrangements, in particular their expected real effects on European trade and investment, exerted a powerful influence on the course of European monetary integration, and of private interests concerned about these factors in determining national currency policies. Further, Maxfield (1997) argues that politicians use central bank independence to try to signal their nation's

creditworthiness to potential investors. The more global financial markets become, the more politicians must concern themselves with signalling investors.

In sum, the outcome of a power relationship does not only depend on the decision maker or individual actors, but the power of the interest groups. Whereas then, in economic theory, 'market power' refers to the ability of a firm to directly influence a market price, and 'monopoly power' to an actor that has significant influence to determine the market terms, regulatory capture deals with constraints faced by agents and the way they can affect them. 'Government failures' as well as 'market failures' can therefore been seen as dimensions of institutional power.

3.4. Power, State and Class

Economics, as previously mentioned, touches more upon voluntary exchange. Therefore, the enabling nature of power in a social or structural setting ought to be considered. However, introducing a complex structure within which power is exercised inevitably changes the wording of the definitions. Arendt (1970) for instance, puts power into a more social context:

'*Power corresponds to the human ability not just to act but to act in concert. Power is never the property of an individual; it belongs to a group and remains in existence only so long as the group keeps together.'* (p. 44)

This social context ultimately leads us to approaching power from an imperative perspective: the state. Miliband's (1973a: p. 46) analysis of the state begins with a notion that 'the state' does not exist, but instead that the state system is made up by the sum of its institutions. As such, the state cannot, Miliband argues, claim anything. Instead, the government, or its empowered actors can – which not necessarily implies a strong, or powerful, government automatically leading to a strong state. The 'state power' lies in the institutions and it is through these that the power is exercised; or rather more specifically by the people who occupy the leading positions in each of these institutions. These people constitute what he calls the 'state elite'.

Miliband acknowledges the existence of people or actors outside the state system whose power greatly affects it. However, these are not actually part of the state power, and are to be treated as a separate entity. Miliband's approach to power stems from an analysis of the relation between the ruling class and the state, and from the attempt to shed light on the political significance of concentration of private economic power. He sees a strong relationship between these not only covering the involvement of businessmen in governmental positions, but also the powerful role played by media, the education system, various social classes, personal ties and so on. Miliband sees business and finance acting as pressure or lobbying groups towards the state institutions and consensus resulting through 'a process of massive indoctrination' (ibid: p. 164).

A closer look at not only the state, but also the structure is necessary, and Poulantzas (1969) fills some of this void in his response to (and counter-responses by) Miliband arguing that the relation between the bourgeois class and the state is an objective relation.[14] This means that if the function of the state in a determinate social formation and the interests of the dominant class in this formation coincide, it is by reason of the system itself: the direct participation of members of the ruling class in the state apparatus is not the cause but the effect, and moreover a chance and contingent one, of this objective coincidence. Hence, Poulantzas criticises Miliband for trying to reduce the role of the state to the conduct and behaviour of the members of the state apparatus. Whereas they largely agree with regards to the difference between state and institution, Poulantzas maintains that the state apparatus forms an objective system of special 'branches' whose relation presents a specific internal unity and obeys, to a large extent, its own logic.

Poulantzas (1973: p. 104) links power with classes and class interest stating that: '*by power, we shall designate the capacity of a social class to realize its specific objective interests*.' His point of reference is class struggle and conflict, and strongly distances himself from individualistic approaches to power, interest, and voluntarist conceptions of the decision-making process. He also assumes the existence of other classes towards which the power is exercised. This organisation of a class is a necessary condition of its power, but not sufficient in itself. Poulantzas continues

[14] This so-called 'Poulantzas-Miliband Debate' was published in the New Left Review 1969-70.

attempting to analyse 'state power' (ibid: p. 115) arguing that '*the various social institutions, in particular the institutions of the state, do not, strictly speaking, have any power. Institutions, considered from the view of power, can only be related to social classes which hold power*.' Thus, he sees the structure as an organising matrix of institutions – where the institutions become power centres, and not mere instruments of power, and the state henceforth the centre of the exercise of political power. Power, to Poulantzas, is not a zero-sum game:

'The State is neither the instrumental depository (object) of a power-essence held by the dominant class, nor a subject possessing of power equal to the quantity it takes from the classes which face it: the State is rather the strategic site of organization of the dominant class in the relationship to the dominant classes.' (Poulantzas, 2000: p. 148)

Miliband (1970) distances himself from what he regards as Poulantzas' abstract 'structural super-determinism' and argues that he goes too far in dismissing the role of the state elite, in over-emphasising the objective relations, and in viewing institutions as being part of the state system. Poulantzas (1973), on the other hand, replies by stressing that state power only can refer to the power of certain classes to whose interest the state corresponds. He wants to break from structuralism ideologically by not attributing specific power to the state. Moreover, he breaks with what he calls 'certain naturalist/positivist' and 'psycho-sociological' conceptions of power - such as Dahl and Foucault respectively - by arguing that the relative autonomy of the state stems from the contradictory relations of power between social classes. Foucault, namely, treats power as a social relation, which has no privileged origin and no *a priori* essence and where *'relations of power are not in a position of exteriority with respect to other types of relationships'[…]'but are immanent in the latter'* and *'both intentional and nonsubjective'* (Foucault, 1976: p. 94). On how power is exercised, Foucault (1982a) writes:

'Power exists only as exercised by some on others, only when it is put into action, even though, of course, it is inscribed in a field of sparse available possibilities underpinned by permanent structures. […] what defines a relationship of power is that is a mode of action that does not act directly and immediately on others. Instead, it acts upon their actions: an action upon an action, on possible or actual future or present actions. […] the exercise of power is a 'conduct of conducts' and a management of possibilities.' (p. 220)

Foucault summarised power as a '*general matrix of force relations at a given time, in given society'* (Foucault, 1982b: p. 186*).* Hence, both Foucault's and Poulantzas' approaches treat power not as a principle of explanation external to specific social relations but as a basic feature of all social relations whose dynamic is itself in need of explanation. However, Poulantzas disagrees with Foucault mainly on two fronts. First, he criticises him on what he sees as an attempt to individualise the social and political body. The second criticism relates to Poulantzas' (1980) view that power has precise bases in economic exploitation and therefore goes strictly against Foucault's rejection of both liberal and Marxist accounts on power which assimilated it to the commodity and/or which suggested it is always subordinated to economic imperatives. (Jessop, 1990: pp. 221-45)

3.5. Power and Structures

The Miliband-Poulantzas debate ultimately raises the question as to how, at what stage and to what degree the structure plays a role on the 'arena' where power is being exercised. In contrast to Poulantzas' structuralist approach, Cox uses a historical approach to structural power. He, like Poulantzas, sees structures in one sense as being prior to individuals – but not the latter merely as bearers of structures. Hence, structures are not regarded as given constraints, but (transformable) results of collective human action. This historical changeable character of structures is what distinguishes his approach from structuralism (Cox, 1987: p. 395).

Cox does not focus on individual action and events – rather at evidence of changes in the frameworks and structures that set limits for how actors think and behave - and the conditions that favour the maintenance or transformation of existing social orders. His starting point is the mode of production, which he argues not only takes place through a power relationship, but also creates resources that can be transformed into other forms of power (ibid: pp. 5-15). The social and political power context of production determines the 'what' and the 'how' of production. Production takes place in a pre-existing context of social power, but has a circular character as the production process itself generates new class distinctions, as well as privileges and

advantages for the dominant class. This process generates the social power of the dominant and subordinate groups of society. The power is thus produced historically and collectively through human action. The political power, in turn, is directly linked to the state and relates to those who possess control of the machinery of the state or directly can influence the government. Thereby, new modes of social relations of production arise through the exercise of state power, which in turn determine the organisation of production (ibid: p. 105). Importantly though, the actions of the state, and hence also the production, are also conditioned by what Cox refers to as 'the world order'.

According to Cox, the structure of production in any society forms the basis for the class structure. The nature of the state is also defined by its class structure upon which the state rests. His approach is therefore less instrumentalist than Miliband's insofar as the importance of manipulation or indoctrination by certain actors is subordinated. Instead, he points to certain common understandings of tasks and limits of the state. The structure defining these tasks and limits is what Gramsci (1971) earlier defined as the 'historic bloc':

'Structures and superstructures form a 'historic bloc'. That is to say the complex, contradictory and discordant ensemble of the superstructures is the reflection of the ensemble of the social relations of production' (p. 366)

Gramsci (ibid: pp. 181-182, 366) used the concept of 'hegemony' to analyse power relationships in society. The hegemonic order was more based upon consent than coercion, and the power of the dominant class over others was partly exercised through the state, not only by force, but through intellectual and moral leadership. Production relations, classes and historic blocs are not seen as isolated - but linked to a world order that is a core foundation as well as an influence through the national states. What Cox does - is that he applies Gramsci's ideas on the international level arguing that it is possible to apply hegemony and the formation of historic blocs on a global scale. Such blocs, according to Cox (1987), play a role in the transformation from one social structure of accumulation to another, such as to the liberal era in the 19th century and the 'Pax Americana' of the 20th century. Gill & Law (1989) build upon Gramsci as well as Cox to look at the 'structural power of capital', and more specifically that of 'internationally mobile financial capital'.

Both Gramsci and Cox argue that the historic blocs whereupon states are founded are connected through mutual interests and ideology. A dominant state creates an order on broad consent and principles ensuring continuing power of leading classes and some sort of prospect of satisfaction of the less powerful. One condition for its success is what Gramsci (1971: p. 6) called the 'organic intellectuals', that every new class creates alongside itself. Similarly, Cox uses the example of the *enarques* or the alumni from the g*randes écoles* and their influence in French society across sectors and Gill & Cox various links between industry and trade unions. The media and English as a *lingua franca* could also play a powerful role.

One step further away from the assumptions of rational self-interest is taken by Polanyi (1944):

'The true criticism of market society is not that it was based on economics – in a sense, every and any society must be based on it – but that its economy was based on self-interest. Such an organization of economic life is entirely unnatural, in the strict empirical sense of exceptional.' (p. 249)

Polanyi stressed the organisation of economic exchange and argued that the 19th century civilisation rested upon four institutions: the balance of power system, the international gold standard which symbolised a unique organisation of the world economy, the liberal state and the self-regulating market. According to Polanyi, the 'fount and matrix' of the system was the self-regulating market which created this specific civilisation and served as a common matrix. The Gold Standard was a way to extend the market system to an international level. The balance of power relationship between nation states was a superstructure and the liberal state a creation of the self-regulating market. Those benefitting from the system, *haute finance*, were profit-maximisers and saw it necessary to be at terms with the governments in power. International finance benefitted from trade, and international trade depended on peace. Trade, in turn, was dependent on an international monetary system (the Gold Standard) that could not function in war. Hence, the balance of power system could not in itself maintain peace - this was done by international finance, and the balance of power system was made to serve it. But even a capitalist system needed protection from itself and modern central banking was such a creation. Currencies became

managed and monetary policy was drawn into the fields of politics. Politically, the nation's identity vested in the government, economically in the central bank.

Scholars in International Relations and International Political Economy (IPE) also recognise the seemingly increasing structural power of the market, although their starting point tends to be the *state*. Kirshner (2006) argues that states will always attempt to manipulate monetary relations to advance their political objectives, and that the power of the state is increased by a world of globalised finance, as it is relatively speaking less vulnerable and has the best prospects for practicing strategic disruption – manipulating the risk of crisis and the nature of agreements to contain them.

Cohen (1977: pp. 54-56) defines structural power as *'the ability to gain by rewriting the rules of the game'*, and process power as *'the ability to gain under the prevailing rules of the game'*. States are seen to be hierarchically positioned, normally with the U.S. at the top. This theory of hegemonic stability, often referring back to Kindleberger (1973: p. 28), is also to be found in the writings of Keohane (1984) and Gilpin (1987).

Strange (1986: p. 26), a critic of this focus on U.S. hegemony, distances herself from the study of power exercises merely between states - and moves towards power as control of structures. Strange (1994) defines structural power as:

'*the power to decide how things shall be done, the power to shape frameworks within which states relate to each other, relate to people, or relate to corporate enterprises. The relative power of each party in a relationship is more, or less, if one party is also determining the surrounding structure of the relationship.'* (pp. 24-25).

Strange argues that the dynamic interplay between markets on the one hand (which have become global), and governments on the other (remaining *national* governments), has resulted in a shift of power to the former.

According to Underhill (2000), the interests of the market can be seen as integrated into the state, asymmetrically in accordance with the structural power and organisational capacity, through their close relationship to state institutions in the

policy decision-making process and in the ongoing pattern of regulatory governance of market society. Underhill agrees with Strange (and Polanyi) in regarding political authority and the market as inseparable. However, he does not see a retreat of the state (in favour the market), but changing forms of the state. As such, states and markets are not separate things as such, but part of the same integrated ensemble of governance, 'a state-market condominium'.

3.6. A Multidimensional Approach to Power

As this literature survey on the concept of power has illustrated, attempting to reach a consensus view on the definition and treatment of power in a social setting is a challenging task. Power is everywhere, achieved through birth, social class, indoctrination or structure - and can be exercised through self-interest, consent or class conflict. However, what scholars at least seem to agree upon is the multifaceted nature of the concept of power. *Embracing* some of these different dimensions of power can therefore serve to illuminate, rather than to diffuse, our understanding of complex power relationships.

Such an attempt is done by Barnett & Duvall (2005) in aiming to create a 'matrix' from where power can be studied. Power, the authors claim, is *'the production, in and through social relations, of effects that shape the capacities of actors to determine their circumstances and fate'* (ibid: p. 42). This is a broad definition and only meaningful when analysing how power can be expressed through several different dimensions, which is precisely the approach they take in attempting to create a multidimensional system for how power can be classified. The first dimension described by Barnett & Duvall is whether power works in interactions or social constitution. The second dimension concerns how specific (direct or diffuse) the social relations are through which power works. By applying these dimensions, they then study power using four categories or concepts of power.

The first concept is 'compulsory power', which focuses on the direct control of one actor of the conditions and actions of another. The second is 'institutional power' and

relates to actors' control over others in indirect ways, and specifically through the formal and informal institutions that mediate between A and B. The main difference between compulsory power and institutional is that in the latter A does not necessarily possess the institution that constrains and shapes B. But since A stands in a particular relation to the relevant institutional arrangements, its actions exercise power over B. The third concept is 'structural power' and concerns structures that define what kinds of social beings actors are. Therefore, structural power is about the determination of social capacities and interests, and not the constraints on action (as in institutional power). A therefore only exists because of its structural position, B. The social relational capacities, subjectivities, and interests of actors are directly shaped by the social positions that they occupy. The fourth concept is 'productive power' and is the production of subjects through diffuse social relations. Conceptually, we then move from structures to systems of signification and meaning (which are structures, but not themselves structures).

An important sociological debate during the latter part of the 20th century encompassed the distinction between 'power to' and 'power over', and the implications of the usage of the two different approaches. In short, if the notion of 'power to' or 'ability to' is used as a starting point, the power relation is captured by reference to the dispositional sense. If, on the other hand, 'power over' is seen as the base, power immediately becomes defined in terms of a specific relationship (see Hargreaves Heap et al., 1992; Lukes, 1974; Morriss, 1987). As Barry (1989: p. 308) notes: *"whereas all power is ability, not all ability is power"*. Simply acknowledging that 'the market determines the money market rate', 'LIBOR banks fix the LIBOR', or that 'central banks decide the repo rate', does not lead to any meaningful insights into power. It clearly describes an ability of an actor (or group of actors), but crucially lacks any relational references. By the same token, expressions such as 'central banks have power over banks' or 'financial markets have power over states' disregard any reference to the dispositional sense. To understand the LIBOR in terms of power, and a power relationship through the lens of the LIBOR, we therefore need to bring the concept of 'power to' together with that of 'power over'.

An influential contribution to the debate on the multifaceted nature of power can be found in Lukes' 'Power: A Radical View' (1974), where the author discusses the

'three dimensions of power'. The one-dimensional view, according to Lukes, focuses on behaviour, decision-making, issues, observable conflict and subjective interests in terms of policy preferences. This approach (represented by Dahl and also referred to as the 'pluralist' view) fails to capture elements of power where interests might be unarticulated or unobservable, or situations where people even are unaware of their own interests. The two-dimensional view focuses on decision-making and non-decision-making, issues and potential issues, observable (overt or covert) conflict and subjective interests in terms of policy preferences or grievances. It represents a critique of the behavioural focus of the one-dimensional view, and allows for consideration of how potential issues are kept out of politics. Bachrach and Baratz (1970) add the notion of 'mobilisation of bias' where *'a set of predominant values, beliefs, rituals, and institutional procedures ('rules of the game') that operate systematically and consistently to benefit of certain persons or groups at the expense of others'* (pp. 43-44).

Lukes criticises what he regards as the one-dimensional and two-dimensional views of power, insofar as they fail to account for the shaping of perceptions and preferences that ensure the acceptance of a certain order. Importantly, he stresses the importance of potential issues that are kept out of politics, regardless of whether they are rooted in social forces or institutional practises, or driven by individual decisions. 'Latent conflicts' can exist, where there is a contradiction between those exercising power (A) and the *real* interests of those they exclude (B). It is latent, in the sense that should B be made aware of their interests, there would be a conflict.

Power is a complex subject matter and the LIBOR is a unique lens. A multidimensional approach is therefore desirable to avoid both vagueness and false precision. We could argue that the market determines the money market rate, but some power in this process still has to be attributed to the central bank that determines the base or repo rate. The LIBOR, on the other hand, intended as a reflection of this money market rate, is determined by LIBOR banks. This 'active' conflict, regardless of whether it is 'visible', 'hidden' or 'invisible', is important as it sets the ground for the study of the power relationship between central banks and LIBOR banks in this dissertation.

The LIBOR as a benchmark occupies the focal point. It would therefore be natural to return to the three fundamental issues with the LIBOR as discussed in Chapter 2, and then seek to put them into the relevant context in terms of power. Reinterpreting the analogy of a 'game' by Cohen (1977), we could regard these three issues to capture different aspects of a power relationship seen from the perspective of the LIBOR panel banks.

The first fundamental issue relates to banking itself, namely that banks are profit-maximising and have an inherent desire to appear good and sound. At the outset, we could see how LIBOR panel banks have power simply by having the exclusive privilege to be able to play the game, namely by being allowed to submit quotes to the LIBOR process. Moreover, LIBOR banks might have incentives to attempt to influence the LIBOR in a direction that is beneficial to them. Game-theory can be used to illustrate how this takes place. However, the ability to, or power to (as indeed the inability or lack of power to) set the LIBOR constitutes some kind of power only if it can put into the relevant context of whom this power can be exercised *over*. The outcome of the game (the LIBOR fixing mechanism) has direct implications for central banks, thereby immediately referencing a specific power relationship.

The second fundamental issue relates to the governance, networks and institutions of the LIBOR panel banks, which in turn have an impact upon the LIBOR fixing process and the central bank. Here, the approach would be to focus on the institutions that make up the rules of the LIBOR game, and the power to be able to (re)write the rules of the game. Whereas the outcome of the LIBOR games depends on the decisions by individual players and collective aggregates of these, by predicting outcomes in certain situations, collective goals and norms are put aside. The institutional approach is broader, by accounting for actors' control over others in indirect ways, and specifically through the formal and informal institutions that mediate between A and B. Most importantly here, since A (the LIBOR banks) stands in a particular relation to the relevant institutional arrangements, its actions exercise power over B (the central bank). This approach can thus be seen as meeting point of the 'power to' and the 'power over'.

The third fundamental issue relates to the perception that the LIBOR represents a market, and to the sources and implications of this perception upon the power relationship. This, inevitably, is a more structural question as it deals with the market in a broader sense. Cohen defines structural power to the 'ability to gain by (re)writing the rules of the game'. Therefore, the structural power with regards to the LIBOR has to be considered from a historical standpoint, taking into account how it has been shaped and constrained within a political economy context.

It is important to note that these approaches to power are neither mutually exclusive, nor arranged in some kind of order of significance. Instead, they should be seen in the context of forming different, but coherent challenges to the notion that the LIBOR is either simply market-determined, or an outcome influenced between the money markets as a whole on the one hand, and the central bank on the other.

CHAPTER 4

The Power of Central Banks

4.1. Introduction

'[...] a central bank of issue causes the credit institutions to agree on uniform terms of credit and in this way tries, by virtue of its position of power, to secure to itself a continuous control and supervision of the relationships between the credit institutions and their customers. It may then utilize its control for ends of currency management or for the purpose of influencing the business cycle or for political ends such as, for instance, the preparation of financial readiness for war. The latter kind of use will be made in particular where the central bank itself is exposed to influence from the political power. Theoretically, it is conceivable that such controls can actually be established, that the ends for and the ways of its exercise become articulated in reglementations, that special agencies are created for its exercise and special appellate agencies for the resolution of questions of doubt, and that, finally, the controls are constantly made more strict. In such case this kind of domination might become quite like the authoritative domination of a bureaucratic state agency over its subordinates, and the subordination would assume the character of a relationship of obedience to authority.' (Max Weber, 1978b: p. 944)

As shown in Chapter 2, traditional decompositions of the LIBOR (into current and expected future repo rates, liquidity and credit risk) have tended to assume that the LIBOR is an outcome of voluntary exchange, rather than a process of power. Actions by the central bank to affect the level of the LIBOR have included a range of monetary policy and extraordinary financial stability measures, as well as the establishment of international swap networks among central banks. Without explicitly stating it, studies on the LIBOR and central bank policy effectiveness can be seen as having dealt with central bank power 'indirectly'. In effect, it has been demonstrated how we could regard the central bank as a 'powerful' institution – as reflected sociologically in the passage above by Weber.

Even though central banks might appear powerful at the outset, the word ‘power’ is rarely used in central bank theory and policy. Instead, terms such as ‘mandates’, ‘functions’, ‘tools’, ‘aims’ and ‘targets’ are commonplace – in effect implying different forms of power and instruments to exercise this power. Regardless of the term used to express central bank power, it is important to note that the relationship between central banks and banks is complicated by the changing objectives and powers of central banks both geographically and over time. Power has, historically, been shared with the Treasury (or Debt Office) or finance ministry, as well as with various regulatory and supervisory bodies. Increasingly, central banks have tended to become more independent from governments. This combination of independent central banks with more strict monetary policy commitments has enhanced the impression of powerful central banks.

Generally speaking, central bank powers can be said to fall into three categories. The first category is what refers to the monopoly of currency and note issuance. The second is its position as a ‘conductor’ to orchestrate monetary policy – including the determination of interest rates and money supply, as well as the management of the foreign exchange and gold reserves of the country. The third power covers financial stability and the central bank as a regulator and supervisor of the banking (or financial) industry, and ultimately as the Lender of Last Resort.

Power is inherent within central banks through their links to a particular nation state. However, this has not always been the case. Rather, the power of central banks can be seen as having evolved and gradually transformed as the role of state, on the one hand, and the markets, on the other, have changed. The purpose of this chapter is to highlight the key historical transformations that have had broader implications upon the power of central banks – and in particular those relating to the monetary transmission mechanism and the LIBOR.

4.2. Financial Stability and Power

Analysing a two-actor relationship is not a straight-forward process, as the concept of power is contested terrain in itself. How do we begin to classify the power of central banks over banks in general, and over LIBOR banks in particular?

A useful starting point is to refer to Dahl's (1957) analogy of the power relationship between the U.S. President and the Congress. Simply stating that the President has (some) power over the Congress is obvious. However, it does not lead to any greater insight into the relations between the two. Likewise, central banks can surely be regarded as powerful, but how does this power affect LIBOR banks – and vice versa? According to Dahl, a power relationship can be understood according to a set of five constituents: the 'base', 'means', 'scope', 'amount' and 'extension' of power.

In order to understand the 'base' (understood in terms of the source or the domain) of power, as well as the objective functions, of central banks we need to return to the 'cradle' of central banking, when the first central banks (such as Sveriges Riksbank, the Bank of England and Banque de France) looked very different (Goodhart, 1995: pp. 205-15). Their base of power fundamentally changed when they ceased to act within the self-regulating market and became state-run managers of the 'club of banks'. The early central banks thereby gradually transformed from profit-maximising commercial banks to what they are today, namely 'non-profit-maximising' central banks with objective functions targeting some notion of *social good*.

Initially, central banks were given the monopoly of note issue in their respective countries in return for government financial support (to finance wars etc). Governments that created a central bank by force gave powers directly to a newly created (or transformed) institution. Importantly though, this automatically implied that power was taken away from those remaining banks that were not granted the privilege. The early stages of central banking can thus be seen as a power transfer from the self-regulated market to the state, with the central bank acting and exercising power directly on behalf of the government, which in turn (using some

social welfare function) defined the objective function and powers of the central bank. The early central banks not only become the government's bank, they also stood prepared to converts their liabilities to gold, and through their comparative advantage became the natural reserve banks for smaller (and also competing) banks. Consequently, central banks entered into a power relationship with the government, as well as with *other* banks – by now having become 'the banks' bank'.

This potential conflict of interest led to the transformation towards 'non-profit-maximising' central banks using their new powers as Lender of Last Resort. The government intervention since the gradual abolishment of free banking makes the banking sector unique and central banks 'special'. The free banking debate offers a path to a deeper understanding of the ideological and theoretical grounds on which it occurred.

Vera Smith offers a definition of free banking in 'The Rationale of Central Banking' (1936):

''Free banking' denotes a regime where note-issuing banks are allowed to set up in the same way as any other type of business enterprise, so long as they comply with the general company law. The requirement for their establishment is not special conditional authorisation from a government authority, but an ability to raise sufficient capital, and public confidence, to gain acceptance for their notes and ensure their profitability of the undertaking. Under such a system all banks would not only be allowed the same rights, but would also be subjected to the same responsibilities as other business enterprises.' (p. 169)

Thus, free banking is a system of competitive note issue and other liabilities by private commercial banks with minimal regulation. A completely free banking system has no central banks, no Lender of Last Resort, no reserve requirements, and no legal restriction of banks portfolios, interest rates, or branch banking (Hanke, 2008).

The theoretical arguments put forward by free banking proponents are drawn from the Austrian school (see for instance Hayek, 1976, 1984; von Mises, 1912, 1949). First, if free trade and free competition within industries is good for overall economic activity, why should banking in general, and the market for money in particular, be

constrained by heavy regulation, controls, supervision and central bank monopoly? Bagehot (1873) early on argued that a centralised system was entirely 'unnatural'. The second argument relates to 'moral hazard' and the inherent inflationary tendencies of a central bank (Goodhart, 1988: p. 19). The incentive structure of a non-profit-maximising bank such as the central bank, coupled with ultimate backing by the state, leads it to become (over)expansionary. The moral hazard problem, the logic goes, is less prominent in privately run banks that are 'governed by profit and loss' (Dowd, 1993; White 1982, 1985, 2008ab).

Consequently, a fundamental issue is whether the banking system is sufficiently 'different' from other industries to justify the monopolisation of the currency supply and the regulatory framework implied by central banking. Whereas free banking advocates argue that banking ought to be treated equally to other sectors, Fama (1980), in contrast, highlights the special role of banks in simultaneously providing transaction and accounting systems, as well as portfolio management. Goodhart (1989: pp. 176-193) builds on this argument of the 'joint role' of banks and argues that this special case requires special treatment through the presence of central banking. Due to the information asymmetries inherent in banking, coupled with the difficulty in marking-to-market the assets of the banks, the central bank is required to go further than supervisors and regulators in other sectors of the economy. Hence, according to Goodhart, the central bank automatically emerges as a kind of manager of the club of banks by performing a dual role. The first is macroeconomic through its monetary policy mandate. The second role is microeconomic by providing support (Lender of Last Resort), and regulatory and supervisory services to maintain the health of the banking system.

As a result, the free banking debate could be seen as a question about whether central banks should exist. From a power perspective it is about which powers, if any, should be transferred from the market to an institution run by the state - and ultimately whether the self-regulating market or the state is better equipped to exercise this power.

The base power of the central bank does not, however, lead to much insight unless we understand the central bank's actual use of it, namely the means and instruments

of power. This goes beyond its fundamental power as monopoly issuer of currency. A key role of central banks, although often stated less explicitly, is maintaining financial stability, which started as soon as they were given this monopoly and became the bankers' bank. As commercial bank money progressively developed into a large share of the total money stock, the creditworthiness of banks became more important. In Europe, the formal mandate to conduct prudential supervision and acting as Lender of Last Resort evolved gradually during the 19th and early 20th century, whereas the Federal Reserve Act of 1913 explicitly gave the Federal Reserve a financial stability objective from the start**.** After the Great Depression and crises in the 1930s, banking regulation was considerably tightened on both sides of the Atlantic, and came to include strict constraints on the composition of banks' assets and liabilities, the rationing of licenses, limits on maturity transformation, separation of commercial and investment banking and a geographical segmentation of activities (Kindleberger, 2000: pp. 161-178).

Later, during the late 1970s, many of these restrictions were relaxed in conjunction with the deregulation process in other sectors of the economy and the structural development of finance, as will be discussed in the next chapter. Despite the deregulation trend in finance, however, some regulation of the financial system did occur - although the focus was put less on the markets or instruments than on the banks. This new regulatory agenda was a direct result of the failures of two internationally active banks, Franklin National Bank and Herstatt Bank, in 1974. Policy decisions culminating the in Basel Accord 1998 were not aimed at curbing the growing foreign exchange market wherefrom the majority of the bank losses had stemmed, but to try to regulate participating institutions to avoid the contagious effects of a potential bank failure - that itself had become an increasing risk as a result of deregulation. Developing countries had namely been spared of major banking crises from the late 1930s until the mid 1970s. As banking instability returned, however, the reaction by central banks became to bail out the 'too-big-to-fail' banks.

It could be argued that the means of power, as well as the scope of power (interpreted as the specific actions that influences bank behaviour and performance) of central banks with regards to financial stability had been altered in this process. Compared

to the banking crises around the turn of the century, it had now become harder for central banks to persuade other banks to help which had often been the case previously. The domestic banking systems had become more difficult to define. Using Goodhart's terminology, it had become harder to define the membership requirements of the 'club of banks' as the financial sector had grown significantly both within and beyond the jurisdiction of the central banks.

The path chosen in many countries was to create stand-alone supervisory and regulatory authorities outside the central banks. This other body tended to be more directly under political control, whereas the central bank drifted towards more independence focusing on monetary policy. The increasingly diffuse definition of the financial sector - and its instruments - was a key argument for proponents of the creation of a single regulator outside the central bank. Moreover, as central banks were granted more independent status, there was a fear of concentration of power. The logic of inflation targeting and independent central banks equally supported a separation, as to avoid a conflict of interest between monetary policy and other objectives, such as financial stability.

In sum, the interest to maintain financial stability has always been inherent in central banking, and it has been a natural to include some kind of financial stability objective in the charters. However, the degree of its importance, and to what extent the responsibility should be shared with other institutions, or indeed with commercial banks previously, has largely depended on the strictness of the monetary policy objectives, the development of the financial markets and the structure of the financial systems.

For instance, the Federal Reserve (2005) conducts monetary policy by influencing the monetary and credit conditions in pursuit of maximum employment, stable prices, and moderate long-term interest rates. However, the Federal Reserve also has a goal to maintain financial stability and to contain systemic risk that might arise in the financial markets. Bank of Japan (2012) has two main objectives: maintaining financial system stability and price stability. The primary objective of the European Central Bank (2012) is to maintain price stability, but it should also contribute to the smooth conduct of policies pursued by the authorities in charge related to the

prudential supervision of credit institutions and the stability of the financial system. The monetary policy objective of the Bank of England's (2012) is to deliver price stability (low inflation) and, subject to that, to support the Government's economic objectives including those for growth and employment. However, it also has a statutory objective to contribute to protecting and enhancing the stability of the financial systems of the U.K. The primary goal of the Swiss National Bank (2012) is to ensure price stability. However, the central bank also has the task to contribute to the stability of the financial system. The objectives of the core activities of Norges Bank (2012) are price stability, financial stability and added value in investment management. The objective of Sveriges Riksbank's (2012a) monetary policy is to maintain price stability, but it also has the task of promoting a safe and efficient payment system. Danmarks Nationalbank (2012a) has three main objectives: maintaining price stability (done by pursuing a fixed-exchange-rate policy against the euro); promoting safe settlement of cash and electronic payments; and maintaining the stability of the financial system.

The central bank's powers to maintain and ensure financial stability fall into several, although not mutually exclusive, categories. Some financial stability powers can be seen as structural in the first instance. Through the oversight of clearing and settlement systems for example, the central bank is trying to avoid contagious effects from the failure of one institution. Some sets of financial stability powers have a more direct and compulsory impact on banks, such as with the conduct of business regulation. This can be problematic with regards to financial innovation, as transparency might go against the interest of the inventor and the producer (the bank). It can also be difficult to enforce, as banks might possess a comparative advantage over regulators in the field of financial innovation. Moreover, a number of these powers can be shared with or delegated to other supervisory and regulatory institutions outside the central bank. Powers relating to (macro)prudential regulation can also be regarded also compulsory in being directed at institutions - through regulating capital and liquidity. However, the scope of the regulation is also important, namely with regards to which kind of institutions in the financial sector should be covered. The ultimate financial stability power of the central bank is its status as Lender of Last Resort - and the resolution tools linked to that status. This

power can act as a *negative* constraint upon the banks (Financial Services Authority, 2009; Haldane, 2009ab; Nier, 2009).

Problematically though, not only is the term 'financial stability' difficult to define, developments in financial stability (in contrast to signals relating to monetary policy) cannot be summarised in a single quantitative indicator and are inherently difficult to forecast and control. As a consequence, there is normally a slight, but important, difference in the wording of the financial stability objective. Whereas price stability objectives tend to use terms such as 'to ensure', financial stability is ought to be 'maintained', 'promoted' or 'contributed to' – implying a greater degree of discretion rather than rules with regards to how the objective should be achieved (Shinasi, 2004).

4.3. Monetary Policy and Power

The power of central banks to conduct monetary policy evolved from central banks being able to discount paper of other financial institutions and charge interest based on the collateral held, having become monopoly issuers of national currency and the source of the monetary base. The key power derived from the ability to choose the price at which they would lend high-powered money to the commercial banks. Through the monetary transmission mechanism, and the alteration of the 'Bank rate', 'discount rate' or 'repo rate', central banks were able to influence credit conditions domestically, but also to attract, or distract, foreign short-term funds.

A period of high inflation in developed countries after the collapse of Bretton Woods was followed by a rise in monetarism with scepticism towards the long-run trade-off between unemployment and inflation (Friedman, 1968; Phelps, 1968). The consensus view became that central banks had been heavily influenced by their respective governments to conduct monetary policy that was too accommodative, resulting in inflation. The policy response was therefore to reduce state activism and re-design the central bank objectives and the institutions to fit with these objectives – all leading to a change in the central bank powers.

The changes that followed were profound, and were supported by developments in economic theory. One of these was the 'time inconsistency problem' and the analysis of the conflict between rules and discretion in policy decisions. According to Kydland & Prescott (1977), the rational public will realise that policy makers are unable to make binding commitments regarding the future, as governments will generally change its policy if it has an opportunity and incentive to do so. Therefore, economic planning should not be seen as a game against nature, but a game against rational actors. It is not about asymmetric information or conflicting objectives between policy makers and other actors, but a problematic logical implication of rational dynamic policymaking when actors' expectations place restrictions on the policy decisions. Policy makers, therefore, face a credibility problem as they are unable to make binding commitments regarding future policies. Unless the plan already encompasses the incentives for future policy change, the public will realise that future government policy will not necessarily coincide with the announced policy. The outcome in this rational-expectations equilibrium with a policy maker exercising power at its discretion - rather than according to a set of rules - results in lower welfare. For monetary policy, it reflects the inability of policymakers to make a commitment.

Barro & Gordon (1983) argued that a discretionary policymaker can create surprise inflation to boost government revenue or reduce unemployment, thereby helping it extend its term in office. But as the rational public anticipates this, it cannot occur systematically. Therefore, inflation bias is inherent in discretionary monetary policy if the central bank's objective for unemployment is below the economy's natural equilibrium level or if policy makers simply prefer lower unemployment levels. The model thus stresses the importance of monetary institutions based on 'rules' rather than 'discretion'.

Further, studies by amongst others Bade & Parkin (1984) and Grilli, Masciandaro & Tabellini (1991) showed a negative correlation between inflation and central bank independence. Drawing upon Rational Expectations Theory, it is argued that the public anticipates the central bank attempting to expand the economy - and as a consequence, real output is not systematically affected and average inflation is left inefficiently high. The 'moral hazard' problem can thus be solved through more

independent central banks - leading to lower inflation. This view was given support from empirical studies suggesting a positive relationship between low inflation, central bank independence and macroeconomic performance. At least, evidence was found showing correlation between the first two variables - thereby giving independent central banking its status as a 'free option' (Alesina & Summers, 1993).

Central bank independence became represented in theoretical models by the weight placed on inflation objectives, and the monetary policy strategy of best practise became that of 'inflation targeting' defined by Bernanke et al. (1999) as:

'[a] framework for monetary policy characterized by the public announcement of official quantitative targets (or target ranges) for the inflation rate over one or more time horizons, and by explicit acknowledgement that low, stable inflation is monetary policy's primary long-run goal.' (p. 4)

Hence, price stability is prioritised ahead of other goals such as a fixed exchange rate, real growth, low unemployment and financial stability. Central bank independence came to be a defined as a central bank that was not influenced by the government on how to conduct its policy, although the symmetry with inflation targeting, credibility and transparency is very clear (Faust & Svensson, 2001; Svensson, 1997, 1999ab, 2000). It could be argued that the term 'central bank independence' indicated having fewer goals (normally one or two) in the central bank objective function, but more freedom (from the government) to reach these objectives.

Debelle and Fischer (1994) separate 'goal' and 'instrument' independence, where goal independence refers to the central bank's ability to determine the goals of policy without the direct influence of the fiscal authority, and instrument independence to its ability to freely adjust its policy tools in pursuit of the goals of monetary policy. For instance, the Bank of England lacks goal independence since the inflation target is set by the government, but does have instrument independence. The Federal Reserve's goals are set in its legal charter, but these goals are described in vague terms (e.g. maximum employment), leaving it to the Federal Reserve to be more flexible and thus having a high level of goal independence. Price stability is the goal of the European Central Bank, but it can choose how to interpret this goal in terms of

its indexation and definition. Thus, both Federal Reserve and European Central Bank could be regarded as having instrument independence.[15]

Consequently, economic theory gave very clear indications of what kind of monetary institution was supposed to be introduced. With low and stable inflation being the main objective, the central bank should become more independent from the state and exercise its powers in order to achieve this. However, it is important to note that this independency from the perspective of the central bank is put into the context of a relationship with the *government*, and not with profit-maximising actors such as LIBOR panel banks.

4.4. A Dynamic Power Relationship

Using the constituents by Dahl enables us to clearly identify the historical patterns of power relationships from the perspective of the central bank. In essence, the central bank has power over the banks as it can get banks to do something that they would not otherwise do. This is an uncontroversial statement, yet also reveals very little about the specific power relationship and how it has evolved over time. Therefore, it needs to be put into the context of both the evolving powers of the central bank within the state apparatus, as well as the changing structural power of the markets. Moreover, the somewhat static power classification fails to fully capture the dynamism and reciprocality that can be inherent in power relationships.

Here, Harsanyi (1962ab) adds two dimensions of social power in response to Dahl. The first relates to the opportunity costs to A of attempting to influence B's behaviour, which Harsanyi refers to as the *costs* of A's power over B. These costs can be regarded as *objective* in the sense that they describe the objective policy

[15] An index of measuring central bank independence was developed by Cukierman, Webb & Neyapti (1992) describing four legal characteristics as described in a central bank's charter. First, a bank is viewed as more independent if the governor is appointed by the central bank board, rather than by the prime minister or minister of finance, is not subject to dismissal, and has a long term of office. These aspects help insulate the central bank from political pressures. Second, independence is higher the greater the extent to which policy decisions are made independently of government involvement. Third, a central bank is more independent if its charter states that price stability is the sole or primary goal of monetary policy. Fourth, independence is greater if there are limitations on the government's ability to borrow from the central bank.

possibilities open to A. Naturally; central bank power involves some costs. These costs, like the power of central banks, can change from time to time and also depend on the policy regime. The costs of power can also become 'prohibitive'. For instance, a central bank trying to defend a certain monetary policy regime might find itself in a position where foreign exchange reserves run out, the required repo rate is too high or the capital outflow (or inflow) too large. Even though central bankers might, at times, argue that a certain policy can be defended with 'whatever it takes', it is of course not true in the strict sense, as not even central banks have unlimited funds.

The costs can also differ between central banks. Simply stating that the Federal Reserve has jurisdiction over the U.S. dollar and therefore power, and Bank of Canada over the Canadian dollar, does not give much insight into the relative powers of the two central banks. In Dahl's sense, the extension of power of the Federal Reserve is greater, as the U.S. is a larger economy and has a larger population than Canada. It could perhaps also be argued that the Federal Reserve has greater base of power by being the issuer of the world's reserve currency. However, the two central banks also face different costs - as a surprise monetary stimulus supplied by the Federal Reserve would have greater influence on the Canadian economy, than the equivalent by the Bank of Canada would have on the U.S. economy.

As Harsanyi argues, measuring power only with regards to its scope, amount and extension also gives counterintuitive results when no opportunity is given to actually use this power. For instance, measuring the ability and power to act as Lender of Last Resort is only really tested at times of crisis. Extraordinary policy measures confirming central bank power are only used if and when needed and also involve some costs. Surging risk premia, for instance, in Australia and Norway during the early days of the global financial crisis were not immediately met by central bank action, partly as the negative impact of the increasing risk premia were counter-balanced by other positive domestic economic indicators. Other central banks acted earlier, weighing in the costs and benefits of such action.

The second dimension introduced by Harsanyi relates to the opportunity costs to B of refusing to do what A wants him to do – the *strength* of A's power over B. The strength, in contrast to the costs of power, can be seen as *subjective* as it explains B's

subjective motivation in complying with A. As the next chapters will demonstrate, the fundamental issues of the LIBOR can not only be understood in terms of different approaches to power from the perspective of the banks, they can also be analysed in the form of different influence techniques available to banks to influence the central bank. The exercise of power, however, can also take a less visible route.

CHAPTER 5

The LIBOR Illusion and the Structural Power of Markets

5.1. Introduction

One of the fundamental issues with the LIBOR is the discrepancy between what the LIBOR has been perceived to be, and what it *is*. The LIBOR, being used as a benchmark, might well perform its role as an approximation of the short-term money market rate. However, this fundamental issue lies not as much in the mathematical technicalities, as in the perception that the benchmark 'objectively' *should* reflect this rate. The core contribution of this chapter is to demonstrate that the LIBOR, shown here to have the qualities of an 'illusion', illustrates important aspects of the power relationship between central banks and banks. As will be shown, this can be clarified by shifting the focal point from being the central bank, as in the previous chapter, towards a broader discussion about 'states versus markets'.

The term 'Casino Capitalism' (Strange, 1986) has often been used as an analogy to depict the increasing powers of the self-regulated international financial market during the recent decades. Empirical evidence demonstrating the growth of this 'casino' is usually found in the seemingly liquid and efficient foreign exchange, money and derivatives markets. In this context, states are seen to have given up power (willingly or unwillingly) to the speculative activity of the players in this global casino. The 'market' has tended to become regarded as a kind of courtroom in

itself, where policy decisions by governments or central banks receive an instant - supposedly objective – verdict by the participants.

Any gambling activity, whether involving skill or pure luck, has its share of winners and losers. By the same token, it could be stated that this shift of structural power from states to markets has impacted or benefitted some more than others. A financial crisis, for instance, almost per definition involves a crisis in, or as a result of, this casino. Consequently, the market has become a natural, yet often blurry, focal point around which reasons and answers are sought – be they powerful institutions such as banks and hedge funds; opaque financial instruments in the shape of derivative acronyms (even likened to 'weapons of mass destruction'); weak regulation; or powerful central banks and market-friendly ideologies. Yet when it comes to a 'real' casino, it is also claimed that 'the house always wins' – the word casino having derived from the Italian word *casa* (house). Labelling the international financial market as a casino would consequently require us not only to define the players, location or the stakes in these games, but also to investigate the nature of the house writing the rules and keeping control of the markers – namely the banks.

This chapter is theoretical and uses a political economy framework to investigate the role of banks in the transformation towards this kind of casino capitalism. Specifically, it highlights what could be regarded as the structural power shift from states to markets. Throughout, the LIBOR acts as the lens through which the key historical developments are studied.

Cohen (1977: pp. 54-56) defines structural power as '*the ability to gain by rewriting the rules of the game*'. Thus, before we move on to trying to illustrate and explain that, and how, power can be exercised through the LIBOR rate setting mechanism, the LIBOR is put into a broader historical, normative and structural context. Specifically, we need to understand why the LIBOR has become – and remained – such an important benchmark, yet been kept free from outside regulation. Interestingly, the LIBOR has tended to become regarded as an 'objective' reflection of the international money market, in several ways disguising the importance of the house of the casino we are examining here: the banks.

The chapter is organised as follows. First, the history of the LIBOR with its roots in the Eurodollar market is outlined, showing that the LIBOR can be seen as a 'missing link' to a later innovation: the derivatives market. Some of the main theoretical issues with regards to these markets are then highlighted, with emphasis on their importance in the context of structural power. The main contribution of this chapter is to show how the LIBOR, through different dimensions, can be seen as having the qualities of an illusion – suggesting an element of structural power belonging not to markets generally, but to LIBOR banks specifically. The first dimension of the LIBOR Illusion is the impression that the Eurodollar and financial derivatives markets are two separate innovations within the general increase of power of the markets. This chapter shows how the LIBOR can be seen as the missing link between the two. The second dimension is the tendency to (over)emphasise the vast gross notional amounts involved in the money markets, and the economic and social effects of these, rather the sources and incentives. Here, it is argued that the LIBOR features a special kind of information asymmetry that gives some bank particular advantage that are not generally found in other areas in finance. The third dimension of the LIBOR Illusion can be seen as a critique of the academic literature which tends to overlook analysis of the different power relationships among the actors within the financial markets. The LIBOR can be regarded as a striking example of how some actors have reaped more benefits than others as a result of both deregulation and re-regulation. The fourth dimension is the general tendency to regard the LIBOR as an 'objective' reflection of the international money market, or simply as the 'money market'. This chapter portrays how the LIBOR never was a market *per se*. Despite this, however, its significance has increased over time through a peculiar kind of transformation from reflecting 'real' to 'fictitious' cash. In sum, when the structural power transformation along the state-market axis is viewed from these dimensions, it becomes clear that LIBOR banks have 'been able to gain by rewriting the rules of the game'.

5.2. The History of the LIBOR

The history of the LIBOR begins with the Eurodollar market around half a century ago, which often is being noted for having played a central role for the forthcoming transformation and deregulation of finance (Lapavitsas, 2009). The actual birth of the Eurodollar market is normally set around 1957, when banks created a market in Europe where U.S. dollar deposits were re-lent to European institutions instead of re-invested in the United States. Eurodollars hereby came to be defined as deposits denominated in U.S. dollars at banks outside the U.S. As these kinds of deposits later came to be denominated in other currencies, these Eurocurrencies in general (Eurodeutschmarks, Euroyen, Eurosterling and so on) came to be defined as deposits outside of the jurisdiction of the central bank issuing the denominated currency.

As such, Eurodollars as an innovation in itself might not have been that revolutionary, as transactions in a currency outside of the jurisdiction of a central bank had taken place before, albeit on a limited scale[16]. However, the Eurodollar market proved to be of a special character; it became systematic; had a clear purpose; and also, after some resistance, became approved by the authorities. Fundamentally, it resulted in a growing and lasting organised international money market.

The size of the Eurocurrency market developed and grew consistently, mirroring increasing globalisation in general[17]. International trade and investment grew fast post-WWII, and U.S. multinational corporations (MNCs) in Europe in particular sought cheaper, alternative ways to fund their foreign expansion. There was demand for new funding alternatives, and compared to the U.S. domestic interest rate markets, Eurodollars offered tighter bid-offer spreads and generally lower rates as a result of less regulation, lower administrative costs, larger economies of scale and less credit risk. The process was further enabled by specific pre-existing structural economic factors - such as the U.S. balance of payments deficit after the Marshall Plan and the growing pool of U.S. dollars abroad as central banks had began accumulating large currency reserves during and after the Bretton Woods framework.

[16] For instance, sterling loans were signed in Berlin and Vienna in the 1920s, and the early 1950s saw borrowing from French banks by Italian banks (Higonnet, 1985: p. 28).
[17] From around USD 14 billion in 1964 to over USD 2,500 billion in 1988 (Sarver, 1990: p. 11).

The first Eurodollar trade, however, seems to have been triggered by fears of sovereign and political risk as the international political climate that existed as the cold war began to intensify during the late 1950s. The mounting supply of dollars on the other side of the Iron Curtain needed to be invested, but preferably not in the U.S. The first to rationally exploit this 'market opportunity' was, perhaps paradoxically, the Soviet Union when transferring deposits to its bank in Paris, the Banque pour L'Europe du Nord (more commonly known by their telex address 'Eurobank'). U.S. dollars deposited at Eurobank hence became known as Eurodollars (Higonnet, 1985: p. 28). Investors in the Middle East also began to place dollars in Europe, quite possibly influenced by the resulting instability after the outbreak of the Suez War in 1956, when the U.S. reacted by freezing some U.S. assets. Later, with the oil shocks of 1973 and 1979, OPEC countries began accumulating large U.S. dollar surpluses that they preferred to invest in Eurodollars in countries with large funding requirements. However, the main driver of the Eurodollar market was regulation, or the banks' determination to avoid it. Money markets were heavily regulated at the time, particularly in the U.S., making up a strong case for setting up a U.S. dollar money market outside the jurisdiction and scrutiny of the Federal Reserve (Sarver, 1990). This coincided with the end of the foreign exchange controls that had existed in Western Europe.

Hereby, a platform for engaging in regulatory arbitrage had been laid, and European banks jumped at the opportunity. With the Eurocurrency market, a free, competitive and global money market was beginning to take shape for the first time. Through regulatory arbitrage came the realisation by policy makers that this market could not be curbed, but instead had to be embraced and encouraged.

This process did not, however, start immediately or completely without friction. Opponents to deregulation raised concerns surrounding the possible inflationary effects caused by excessive credit creation, the weakening role of the central bank in controlling the monetary system (Einzig, 1970: pp. 113-114), the difficulties for smaller banks to compete with the new universal banks and the Eurocurrency market's impact as a destabilising factor on exchange rates due to the short-term nature of the capital flows. The new market also came to play a fundamental role in

having an impact on defining the central banks' role in promoting financial stability and acting as Lender of Last Resort.

By revisiting the debate in the early years of the Eurodollar market, Clendenning (1970) argued that, from a monetary policy perspective, the market had created a set of semi-independent international interest rates over which no single country or institution had control. From a financial stability perspective, questions were asked about the vulnerability of the domestic banks as a result of the 'opaqueness' of the new products and whether and how they should be regulated. He also saw dangers in the link between the creation of a new set of interest rates beyond the jurisdiction of the central bank, its ability to control credit, and remaining an institution to which participants automatically could turn to as Lender of Last Resort should a country's foreign exchange reserves fall below the Eurocurrency exposure by its domestic banks. Hence, early voices were raised regarding the uncertainty the growing Eurodollar market upon the autonomy of the central bank's monetary policy, its ability to maintain financial stability and the greater need for international co-operation.

This marked the beginning of a decade of competitive deregulation on both sides of the Atlantic and in tune with the general rise in neoliberal thought. Seen from a different perspective; if the Eurocurrency market was banks' response to regulation, the deregulation phase thereafter was individual states' response to other the regulation of other states.

The Eurocurrency market had, by definition, an international component and therefore a natural link to foreign exchange through the covered interest rate parity. From the banks' perspective, foreign exchange was of course necessary for active participation in the Eurodollar market. However, the Eurodollar market was not a pre-requisite for active foreign exchange trading. As the foreign exchange swap markets became more liquid, implied or synthetic Eurodollars could be constructed through the CIP. In addition, as a foreign exchange swap involved the simultaneous lending of one currency versus the borrowing of another with the same counterparty, it had the added benefit of reducing credit risk. The Eurodollar market thus also

paved the way for an increase in foreign exchange trading by banks that rapidly outgrew the requirements put forward by increasing international trade.

In this context, the Eurodollar market played a starring role in the transformation of the money and credit markets and the international financial system and as whole. As the market grew, so did the foreign exchange market closely linked to it. Other spin-offs were created by banks, such as the Eurodollar CDs (Certificates of Deposit), Eurobonds and syndicated Eurocredit markets to enable the international banking community to extend credits beyond the prudential and legal lending limits of individual banks. Importantly, and from the perspective of the LIBOR, the 1980s saw the advent of derivatives based on Eurodollars.

The rate at which Eurodollars (or Eurocurrencies) were trading became known as the Eurodollar rate. This Eurodollar rate was not 'official', but for syndicated loans an average was instead taken from three reference banks at 11 a.m. two days before the rollover date. However, members of large loan syndicates became increasingly insistent that the reference bank chosen be representative in borrowing strength to the various bank syndicate members. Also, the syndicates sometimes tried to retain the right to name substitute reference banks if the requisite majority of syndicate members felt that the original reference bank had lower borrowing costs than would be representative for the syndicate as a whole (Sarver, 1990: pp. 403-04). As a result, in 1984, U.K. banks asked the British Bankers Association to develop a calculation that could be used as an impartial basis for calculating interest on syndicated loans. This led to the creation of 'BBAIRS', the BBA Interest Rate Settlement in 1985, which in 1986 became the London Interbank Offered Rate (LIBOR)[18].

The LIBOR soon not only became significant as the universally accepted benchmark for offshore currency transactions or syndicated loans, but also for financial derivatives. Although derivatives on interest rates already had begun to emerge[19], it was those benchmarked against the LIBOR that came to experience the by far highest growth rates. As the Chicago Mercantile Exchange (CME) launched the

[18] British Bankers Association (2012)
[19] Interest rate futures on U.S. Treasury bills and bonds were introduced in Chicago in the mid-1970s (Bank for International Settlements, 1986: p. 145).

world's first cash-settled futures contract, the Eurodollar future, in 1981, it quickly became the world's most actively traded short-term interest rate contract. Up until 1996, the CME used a benchmark based upon a survey where randomly selected banks were willing to lend to 'prime banks' (Mollenkamp, Ablan & Goldstein, 2012). Since January 1997, however, the contract has been fixed and settled against the LIBOR, although still bearing the name Eurodollar future reminding us of its link to the Eurodollar market.

'Perhaps no other contract exemplifies our spirit of innovation better than the CME Eurodollar contract'[…]'as the world's first cash-settled contract, CME Eurodollar futures transformed financial markets and paved the way for future contracts, such as stock indexes and weather, which cannot be physically delivered.' (CME, 2006)

According to the CME (2006), average daily volume during 1982, the first full year of trading, was 1,279 contracts – compared to 2 million contracts daily in 2006 (55% of CME average daily volume). Between 1981 and 2006, more than 2.7 trillion CME Eurodollar futures contracts had traded representing 2,700,000,000,000,000,000 U.S. dollars in notional value. The turnover is astounding and resembles the development of the foreign exchange market that had picked up earlier: the proportion linked to real underlying Eurodollar exposure is dwarfed by speculative trading, and like for foreign exchange, the most prominent users have been the banks.

The success of the LIBOR-based futures also prompted competing exchanges, such as LIFFE and TIFFE, to offer similar instruments. Euroswiss, Eurodeutschmarks, Euroyen, Short Sterling all came to be more closely referred to as no longer the Eurocurrencies, but the futures based upon their respective LIBOR. The name came to be copied in a range of other international financial centres: MIBOR in Madrid; PIBOR in Paris; TIBOR in Tokyo; STIBOR, NIBOR, CIBOR, HELIBOR and so on.

However, despite the success story of exchange-traded LIBOR-based derivatives, it was the over-the-counter (OTC) derivatives market that truly changed the market place. This was the largely unregulated market for interest rate and foreign exchange derivatives that mainly took place between banks: currency swaps, interest rate swaps (IRS), cross-currency basis swaps (CRS), caps, floors, forward rate agreements (FRA) and so on. Like the futures contracts, they started to appear in the

early 1980s and, like exchange-traded futures contracts; they too were by in large based on the LIBOR. BIS estimated the IRS market amounting to around 100-150 billion U.S. dollars in mid-1985 compared to just 3 billion in 1982. However, the growth did not appear to slow down – with *daily* turnover in 2010 reaching 1,275 billion U.S. dollars in 2010 compared to 63 billion in 1995. Indeed, much of the recent growth in the OTC derivatives market is due to the increasing appeal of LIBOR-indexed FRA market. According to the latest BIS survey, the daily turnover in the global FRA market increased from 258 billion U.S. dollars in April 2007 to 601 billion in April 2010 (Bank for International Settlements, 1986; 1999; 2010ab).

5.3. The Structural Power of the 'Market'

The Eurodollar and derivatives markets have often been used as empirical examples in illustrating the consistency and scale of globalisation and financial market integration as a result of liberalisation and deregulation since the 1980s – supported by neoliberal policies and technological advances. Neo-classical, neo-Gramscian or International Political Economy approaches all seem to agree that some kind of 'Casino Capitalism' emerged in conjunction with, or evidenced by, these two financial innovations which has led to increasing power of 'markets'.

In neo-classical economic theory, the Eurodollar market has generally been seen as an example of how well the market works when free from government regulation (Porter, 2005: pp. 12-17). As a free, global market economy seem to be more efficient than regulated one, innovations such as the Eurodollar market that competitively aims to exploit inefficiencies (through, for instance, regulatory arbitrage) are inevitable. It is also economically beneficial, and governments thus have the opportunity to speed up the process through deregulation and thereby further facilitate innovation and the globalisation of finance. Consequently, the undermining of the power of governments in favour of the market forces is both natural and welcomed. A similar, but extended, logic is applied to derivatives: being less capital intense and considerably more flexible, they are ideal instruments for

hedging and speculation, which further enhances liquidity and market efficiency in the price discovery process.

Scholars in International Relations and International Political Economy (IPE) also recognise this increasing structural power of the market, although their starting point tends to be the state. As Kirshner (2006) argues, this could take the form of outright manipulation of monetary relations by states. The power of the state is seen to have increased in tandem with the globalisation of finance.

Cohen (1977: pp. 54-56) defines structural power as *'the ability to gain by rewriting the rules of the game'*, and process power as '*the ability to gain under the prevailing rules of the game'*. Although, power can be non-intentional, the power game is all about a state versus another state – where a state can have the 'power to deflect' (the relative degree of openness and adaptability of the national economy) and/or the 'power to delay' (which can be measured as function of a country's international liquidity position relative to others in terms of foreign exchange reserves and borrowing capacity). States are thus hierarchically positioned (normally with the U.S. at the top). This theory of hegemonic stability often refers back to Kindleberger (1973: p. 28). To be regarded as a hegemon, a state must *inter alia 'hold comparative control over markets'* (Keohane 1984: p. 33), and the role of the hegemon in the process of economic growth can be seen as *'the cement that helps hold the system together'* (Gilpin, 1987: p. 76).

Strange (1996: p. 26), a critic of this focus on U.S. hegemony, distances herself from the study of power exercises merely between states - and moves towards power as control of structures. However, despite Strange's critique, she still strongly argues that the U.S. has been the main beneficiary of this transformation irrespective of where it started. Likewise, Helleiner (2006: pp. 88-89) claims that although Washington played little direct role in promoting dollarisation abroad, the country benefitted from the increasing importance of the dollar, thereby increasing its structural power indirectly.

Strange distinguishes 'relational' power (the power of A to get B to do something they would not otherwise do), from 'structural' power. Power is not only about who

holds, or can deny security, wealth and production, but who can shape the financial structure. The financial structure, according to Strange (1994: p. 90), is on the one hand the structure and power through which credit is created (shared by governments and banks); and on the other hand the structure of the international monetary system and exchange rates (determined by governments and markets). The interplay between markets, which have become global, and authorities, which are national governments, she argues, has resulted in a gain of power in favour of the former. As a result, market forces have increasingly been able to put constraints on governments.

Helleiner (1994: pp. 135-68) describes how as the Eurodollar market grew, the Federal Reserve felt increasing desire to regulate the market in order to regain its ability to control the monetary base. The Federal Reserve proposed to introduce reserve requirements on all Eurodollars, which was met by stiff opposition, both among other central banks as well as domestic U.S. banks. The latter had, in fact, in the 1970s, begun to lobby for domestic bank *de*regulation, which persuaded Congress to reject the Eurocurrency Market Control Act proposed by the Federal Reserve. According to Helleiner, as the Federal Reserve finally 'gave in' by permitting the establishment of tax-free, regulation-free international banking facilities on U.S. soil in 1981, it had not only failed to curtail the growth of the Eurodollar market, it had become totally resigned to its existence. Hence, whereas the U.S. government, with the central bank annexed to it, might not have lost against other states in the competitive deregulation race, it had lost power against the global markets.

Underhill (2000) argues that states and markets are not separate things as such, but part of the same integrated ensemble of governance, a 'state-market condominium'. Underhill agrees with Strange (and Polanyi) in regarding political authority and the market as inseparable, but does not see a retreat of the state in favour the market, but changing *forms* of the state.

In contrast to the realist IPE approaches, neo-Gramscians look at hegemony in terms of class relations. Cox (1987: pp. 5-34, 309-353) focuses on evidence of changes in the frameworks and structures that set limits for how actors think and behave, and the

conditions that favour the maintenance or transformation of existing social orders. As discussed in Chapter 3, Cox can be seen as applying Gramsci upon an international arena. Gill & Law (1989) build upon Gramsci and Cox with regards to the structural power of capital, but put particular focus on internationally mobile financial capital. Financial capital, it is argued, can react to government policies or expected policies much more rapidly than productive capital, thereby forcing governments to adopt certain policies that are suitable for finance. In their respective frameworks, capital strives for the best conditions to survive and prosper, and nation states compete to attract capital. This, they argue, is the process that was underlying the 1980s competitive deregulation of many sectors of the economy, including the financial markets. Consequently, there is a dialectic relationship between the nature and scope of markets on one hand, and the forms of state intervention and regulation on the other. The rapidly growing and globally more integrated capital markets, the birth of the Eurodollar market, along with technology and communications, led to international mobile capital gaining more structural power.

Although the Eurodollar market has figured prominently in discussions about the structural power of states and markets, the derivatives market has rarely figured more than as footnote or as convincing further evidence that the financial markets have expanded significantly, and thereby that markets (or capital) have gained increasing structural power. Power, now, seems to have become more widely diffused, both among states and between actors, leading to what Cohen (2008) refers to as a 'leaderless diffusion' involving greater ambiguity in prevailing governance structures, with the result of hegemonic theories finding less support. Underhill & Zhang (2008) recognise that recent developments often not only have been encouraged by the states themselves, but by 'powerful market players' – exemplifying with the case of international banking supervision and securities regulation.

The almost incomprehensibly large notional amounts traded in foreign exchange and derivatives (in proportion to international trade or global GDP), their opaque nature (the lack of transparency and the abundance of mathematical derivations) and their consistent appearance alongside financial crises has also spurred a sense of urgency to theorise financial derivatives. McKenzie (2011) draws upon Hilferding (1910) in

describing derivatives as involving the fictitious creation of a financial asset by the markets. The derivatives themselves have no intrinsic value as the value is derived from the value of another asset. What sets financial derivatives (which have been prominent during this era of financialisation) apart from previous historical examples (such as those based upon agricultural products), is the driving forces behind the spread of these derivatives. With cash-settled derivatives (the Eurodollar future being the first), the underlying commodity does not need to change hands (Toporowski, 2001; Saber, 1999), and is therefore significantly more prone to use by speculative capital – an activity 'expertly' undertaken by banks. Hereby lies the explanation not only to the frequent use of derivatives for speculation (instead of hedging), but also the role of financial intermediaries in the trading, sales, marketing and innovation of these financial instruments. Thus, for Post-Keynesians and Marxists alike, financial derivatives become natural ingredients in the theory of financial crises – in terms of asset inflation or rent seeking and financialisation.

5.4. The LIBOR Illusion

5.4.1. Four Dimensions of the Illusion

As we have seen, the approaches to the concept of structural power within financial markets are highly divergent in the literature. However, there are also important similarities when it comes to the nature of the Eurodollar and derivatives markets. First, the Eurodollar and derivatives markets are generally treated as significant, yet separate, innovations in a range of emerging and seemingly complex and opaque financial instruments. Second, and in particular with regards to foreign exchange and financial derivatives, regardless whether their economic and social effects are being assessed as beneficial or harmful, there is a tendency, even temptation, to emphasise the vast gross notional amounts involved in the trading of these instruments. Third, financial market actors tend to be subject to generalisations within the literature. Consequently, differences between important actors or groups of actors within the markets are often overlooked. Fourth, there is a tendency, in economics in general, to

regard the signals sent from these markets as objective, although not necessarily as democratic.

These tendencies to generalise have contributed to the impression that financial markets have become characterised in some kind of form of 'Casino Capitalism', giving the impression – or *illusion* - that the structural power belongs the 'market' as a whole, rather than to specific actors, or groups of actors, *within* the market. As an analogy, we can refer to the concept of money illusion, referring to the tendency of people to think of currency in nominal, rather than real, terms:

'Why is it that we have been so slow to take up these fundamental problems which are of vital concern to all people? It is because of the 'Money Illusion'; that is, the failure to perceive that the dollar, or any other unit of money, expands or shrinks in value.' (Fisher, 1928: p. 4)

Using this as a reference point, the LIBOR Illusion is therefore about the tendency of people to regard the LIBOR as an 'objective' reflection of the international money market.

5.4.2. The 'Missing Link' between Two Innovations

Explanations for the birth and rapid growth of the Eurodollar market can be found in a range of macroeconomic, regulatory, political or ideological factors. Nonetheless, the consistency and scale of growth points to other arguments. Importantly, the aforementioned drivers fail to explain the continuing expansion even after deregulation had taken place, the U.S. balance-of-payments had begun to reverse, and the international political arena had stabilised. Demand by MNCs also played a crucial role in justifying the market, but as the market size outgrew international trade and investment it becomes more difficult to argue for obvious causality. With hindsight, it can be even tempting to ignore or at least downplay the role of the Eurodollar market and instead focus on the transformation of finance from the end of Bretton Woods, or the early 1980s, with its process of liberalisation, deregulation, privatisation, globalisation etc.

This would, however, be the wrong approach. Instead, by returning to and re-emphasising the Eurodollar market as one of the founding stones in this process, an important 'actor' emerges that would otherwise easily be overlooked: the commercial banks. The Eurodollar market did not emerge naturally within the market. It was invented by banks for profit-maximising reasons.

Deregulation, regardless of its drivers, laid the platform for a new framework that benefitted not only the Eurodollar market itself, but in particular its by far most prominent producers and users: the banks themselves. The phenomenal growth in the international money and foreign exchange markets during the following decades was not spurred by end-users such as multinational companies, but almost exclusively by financial institutions – and large banks in particular.[20]

However, despite recognising the growing proportion of speculation instead of hedging in foreign exchange trading, questions are seldom asked *why* this process has been taking place. The Eurodollar market offers an insight into this. It gradually ceased to be primarily a source for funding or an outlet for investments, and instead turned into the prime tool to speculate on short-term interest rates in an increasing range of currencies. This was an area where banks, naturally, had a superior competitive, informational and economical advantage. As banks were able to take on more risk, the Eurodollar market was an ideal instrument for taking directional short-term interest rate risk. The growth in foreign exchange trading saw a similar pattern. The abolishment of capital controls made it possible for any bank to be involved in the Eurodollar market by constructing 'synthetic' Eurodollars through the CIP.

At the same time, central banks evolved to be become more independent from governments and got clearer and narrower mandates to fight inflation, instead of maintaining exchange rate targets. The increasing unilateral transparency of central banks in the decision making process in monetary policy increased their predictability, that in turn benefitted the banks.

As we know from the history of the LIBOR, there is a very clear link between Eurodollars and the LIBOR on the one hand, and between the LIBOR and financial

[20] See, for instance, Table 2 and Table 7 in Bank for International Settlements, 2010a.

derivatives on the other. The LIBOR Illusion is central to the perception that the Eurodollar and financial derivatives markets are two separate innovations within the general, and broader, increase of power of the markets. The LIBOR serves as a 'missing link' between these two markets.

5.4.3. Beyond Information Asymmetry

In particular with regards to foreign exchange and financial derivatives, there is a general temptation and tendency to emphasise the vast gross notional amounts traded, and the economic and social effects of these, rather than the sources and incentives for these. If we return to the theoretical explanations for the increasing structural power of the markets since the 1980s and compare them to the behaviour of the banks since the advent of the Eurodollar market, banks have appeared opportunistic with regards to innovation and regulation. Neither the Eurodollar market, nor the LIBOR-derivatives market - let alone the LIBOR invention itself - appeared spontaneously. Instead, banks have consistently been prominent.

As an illustration, let us first compare the differences between financial markets and goods markets in general. In goods markets, money is exchanged simultaneously for goods. The money market, on the other hand, represents a financial market where one lender gives money today in the hope of receiving it back at a later agreed date. The LIBOR (i.e. the money market) should reflect the bank funding cost, which not only includes current and expected future repo rates, but also perceived creditworthiness and access to liquidity. This information asymmetry in the money market is naturally central to the regulation of banks, and to why banks exist.

However, even though the LIBOR sprung out of the Eurodollar market, it was per definition never a market in itself, only a benchmark or a supposedly 'objective' reflection of where money markets were trading. The information asymmetry - or power - in the money market is further distorted as the fixing mechanism and the regulation of the LIBOR always has been in the hands of the banks themselves or

their lobby organisations. This, in itself, naturally benefits LIBOR panel banks specifically.

A LIBOR-derivative does not normally involve the exchange of principal and the credit and liquidity risk can thus be regarded as minimal. The information asymmetry (or the power of the lender or borrower) is therefore totally different, as we are dealing not only with the *ability to forecast or predict* the LIBOR, but with the *ability to determine* the future LIBOR. Thus, banks not only have a general competitive advantage in the money markets, the LIBOR banks set the LIBOR themselves, giving them significant influence and advantage.

The global markets in foreign exchange and money markets (for both cash and derivatives) are not only concentrated within a relatively small group of banks. LIBOR panel banks are dominant *within* this group of banks. According to the Euromoney FX and Rates Surveys conducted in 2012, which capture client price-taking activity only and not any interbank or interdealer broking volumes, this relationship holds consistently across asset classes. In the foreign exchange market as a whole, the top 15 banks had a total market share of 87% in 2012. 13 LIBOR-panel banks accounted for 96% of this portion. In the foreign exchange swap market, the top 10 banks had a total market share of 78%, with 8 LIBOR banks accounting for a 92% of this (Euromoney, 2012a). A similar pattern can be seen in the interest rate markets, where the top 15 banks had a total market share of 94% (for both cash and derivatives) in 2012. 11 LIBOR-panel banks accounted for 81% of this portion. In the cross-currency basis swap market, the top 10 banks had a total market share of 84%, with 8 LIBOR banks accounting for a 92% of this (Euromoney, 2012b). This serves as one explanation as to why LIBOR-instruments remain attractive for banks, and why regulation has remained in control by precisely these banks, in contrast to what is the case for other benchmarks in finance.

5.4.4. Regulatory Arbitrage Re-emerges

There has been a tendency in the literature to overlook, or even to completely disregard, different power relationships among actors within financial markets – not least with regards to regulation. The deregulation process since the 1980s has generally been regarded as having resulted in an unregulated (outside the jurisdictions of central banks and supervisory authorities) or self-regulated market (mainly governed by market conventions). With regards to the Eurodollar market, this has generally been the case. However, when it comes to the LIBOR and LIBOR-based derivatives, the truth lies elsewhere.

Whereas the LIBOR did emerge from the Eurodollar market, the power and control of the rate setting mechanism was never in hand the hands of a market, but in the hands of a few large and homogenous banks. Undoubtedly, the deregulation process from the 1980s has had a profound impact on the development of these markets. However, the LIBOR has neither been regulated by some public body, nor self-regulated by the 'market'. Instead, it has been regulated by the LIBOR clubs themselves. In fact, the supervisory and enforcement agencies have been bank lobby organisations (such as the BBA), rather than central banks, regulatory agencies (such as the FSA) or organisations representing the 'wider market' (such as ISDA or ISMA).

Further, the Eurodollar market prompted regulatory arbitrage between different jurisdictions which resulted in a competitive deregulation process among states. As such, both the Eurodollar and the financial derivatives markets managed to escape the confinements of particular regulatory jurisdictions. Some regulation of the financial system did occur though, although the focus was put less on markets or instruments than on institutions. This new regulatory agenda was a direct result of the failures of two internationally active banks, Franklin National Bank and Herstatt Bank, in 1974. The reaction by policy makers was not to curb the growing foreign exchange market wherefrom the majority of the losses had stemmed, but to try to regulate participating institutions to avoid the contagious effects of a potential bank failure.

The 1988 Basel Accord that was put in place focused on settlement and credit risk as bank assets were classified according to pre-set brackets ranging from 0% to 100%, and banks were required to hold capital equal of 8% of the risk-weighted assets. However, whereas the Basel rules put new constraints on banks, they simultaneously opened doors. Excessive on-balance sheet asset usage (such as Eurodollars) was penalised, at the same time as off-balance sheet product trading (e.g. LIBOR-derivatives) was rewarded.

Hereby, a new kind of regulatory arbitrage re-emerged. Despite being designed as a deterrent towards excess risk taking, it also had the adverse effect by acting as an incentive for increased off-balance sheet activity by banks. However, this time around the regulatory arbitrage was not aimed at policies set by individual central banks or governments, but at the international regulatory framework itself. The Basel Accord coincided not only with the recently invented LIBOR and LIBOR-based derivatives, but also another development: securitisation. Standard interbank deposits and loans not only attracted a heavy burden according to the new rules, they were also non-marketable securities in lacking the flexibility in being repackaged and resold.

Importantly, despite the Eurodollar market still growing, these institutional changes combined led to a reduction in its relative importance as a funding source or investment outlet for the banks with a number of consequences for the market microstructure.

First, the Eurodollars (as expressed in the LIBOR), as a proportion of total credit creation, began to diminish already in the 1980s (Camacho & Nieto, 2009), whereas LIBOR-derivatives, as a proportion of banks' total LIBOR exposure, increased and began to all but completely replace the Eurocurrency market as a vehicle for hedging, speculating and leveraging. Banks could choose to expose themselves to the LIBOR in large notional terms without with little real or physical exposure.

Second, maturities became, on balance, shorter, as trading in-and-out was a highly capital intense activity. Trading in very short-term maturities (1-day, 1-week, etc), however, had less to do with rate expectations and credit than with daily funding and

liquidity requirements to square up the bank balances. The LIBOR, as a reflection of the term money market, became less linked to a market that actually was trading. For example, a recent survey by the European Central Bank (2011a) shows that the vast majority of unsecured lending is overnight (around 80%), and that transactions up to 1 month account for the most of the remaining part.

Third, foreign exchange swaps became increasingly more liquid (as expressed in, for instance, implied bid-offer spreads) than the actual underlying Eurocurrencies. Through the CIP, implied or synthetic Eurocurrencies could be constructed not only more cheaply, but also less credit-intensively. Cross currency basis swaps continued to be expressed in terms of a spread price between two particular LIBOR-benchmarks despite the diminishing market activity in the underlying markets linked to the benchmark used.

Finally, the liquidity of LIBOR-derivatives such as FRAs and IRSs increased as they were more suitable for the trading 'needs' than the underlying Eurocurrencies. Superior liquidity gave them an advantage over the underlying asset (the term money market) in the price determination process. The LIBOR for longer maturities became less driven by actual Eurocurrency trading in those maturities, and more a reflection of the prevailing yield curves implied from LIBOR-derivatives. At the same time, the underlying interest rates in the pricing of foreign exchange premia gradually started to lose its link to the real and physically tradable interest rate differential, as in the case of the CRS market, and instead became increasingly a function of the derivatives of the LIBOR. In sum, the LIBOR can be seen as having gradually started to become more dependent on its own derivative.[21]

[21] A number of bank employees (both traders and IT programmers) that have been interviewed confirm that LIBOR-indexed futures, FRAs, IRSs and CRSs gradually began to replace the longer-dated LIBORs (with maturities over 3M) in the pricing and market-determination process of FX swaps during the 1990s. At the same time, money market traders increasingly began to look towards the LIBOR-indexed derivatives markets, rather than the money market itself, both in terms of risk-taking as well as for indications of the direction of the LIBOR. This trend appears to have consistently followed the growth of the LIBOR-based derivatives market. Moreover, what became a convention in the most liquid markets gradually came to be introduced also in less-liquid markets.

5.4.5. The Transformation from 'Real' to 'Fictitious' Cash

The developments discussed above lead us to the core, and the fourth dimension of the LIBOR Illusion, namely to regard the signals sent from these markets as 'market-determined'. As already discussed in Chapter 2, there has been a tendency to regard the LIBOR as an 'objective' reflection of the international short-term money market, or simply as the 'money market'. This perception is of course convenient, as according to the rules, the LIBOR – as a benchmark - *should* reflect the average funding cost of banks.

In fact, the derivatives market has served to enhance the impression that the LIBOR represents something 'liquid' and 'tradable'. The notional amount of outstanding LIBOR-based derivative contracts has been reaching astonishing levels; with the BBA estimating that loans amounting to 10 trillion U.S. dollars, and 350 trillion of interest rate swaps alone, are indexed by the LIBOR (U.S. Commodity Futures Trading Commission, 2012). According to statistics compiled by the Bank for International Settlements (2011), the notional amount of outstanding OTC interest rate derivatives contracts amounted to 554 trillion U.S dollars in the first half of 2011. The LIBOR, and its equivalents, are thus the by far most frequently used benchmarks for IRS, FRAs and OTC interest rate options. The annual turnover in the LIBOR-equivalent futures contracts is equally impressive. In 2011, the value of Eurodollar futures contracts traded on the CME reached 564 trillion U.S dollars. The turnover in options on Eurodollar futures was 193 trillion. The corresponding figures for the EURIBOR futures and options contracts traded on LIFFE were also large: 241 trillion and 126 trillion euros respectively. With regards to short sterling futures (the GBP LIBOR futures), the turnover was 58 trillion pounds sterling (Futures Industry Association, 2011).

Seen as a combined entity, and when adding other LIBOR-derivatives as well (such as TIBOR, STIBOR, NIBOR etc), it is not surprising that trading volumes in interest rates derivatives and foreign exchange swaps not only are used to illustrate the growth and power of financial markets as such, but to give a firm impression that these markets are highly liquid and efficient, and thus 'objective'. However, even

though the notional amounts of LIBOR-based derivatives have increased in the recent decades, the importance of the 'LIBOR market itself' has developed in the opposite direction.

Whereas the Eurodollar market could be seen as having achieved its aim by the mid-1980s: global market integration and deregulation, it continued to play a crucial role by having created the main benchmark (LIBOR) to which the vast majority of derivatives were been fixed and settled. Similar to the development of the foreign exchange market previously, the LIBOR derivatives markets outgrew the Eurodollar market. Whereas the more liquid (and less credit intense) foreign exchange market had managed to reduce some of the 'necessities' of the Eurocurrency market, the LIBOR derivatives market (which was even less credit intense) and new sources of funding made the term money market all but unnecessary, transforming the true interbank money market more into a platform of rather 'boring' routine bank operations - rather than into any kind of casino. In effect, the LIBOR was never a market *per se*, but its significance had increased as it gradually transformed from 'real' to truly 'fictitious' cash. Perhaps no better illustration of the 'faith' in the LIBOR-equivalent benchmarks can be found than in the EURIBOR, which was first published on 30 December 1998 - 2 days *prior* to the euro *ex nihilo* became legal tender on 1 January 1999.

5.5. Concluding Discussion

Since the beginning of the current global financial crisis, the LIBOR has been at the epicentre in being a key variable in the central bank's decision making process as the first link to the monetary transmission mechanism. A fundamental issue with the LIBOR has been its wide-reaching and increasing importance as a benchmark for a specific market, without a definite connectedness to it. As this chapter has shown, the LIBOR casts a wide web across the financial system with regards to rate expectations, credit and liquidity strains, the interconnectedness of banks and market regulation (or the absence of it).

The LIBOR has also served as an indicator for the relative funding demand in one currency versus another. The deviation from the CIP ultimately forced the Federal Reserve to step in through 'temporary' reciprocal currency arrangements in the form of foreign exchange swap lines with other central banks in order to channel U.S. dollars to banks in other jurisdictions, as domestic liquidity injections were not sufficient to dampen demand – as only the Federal Reserve can print dollars (Baba & Packer 2008, 2009; McGuire & von Peter, 2009). These networks have not only highlighted how interconnected the banking systems and money markets have become, but the importance and power of the Federal Reserve with its control over the world's reserve currency (and the failure of the euro to act as such). The Federal Reserve has had the opportunity to act opportunistically, as the swap lines have ultimately protected American banks and its own domestic financial system – having become more exposed to the Eurozone within an increasingly integrated global financial system (Kaltenbrunner et al., 2010). In effect, the Federal Reserve can be seen as having become a global Market Marker of Last Resort (MMOLR) in Eurodollars. The requirement of a Lender of Last Resort is of course inherent in banking itself, and a contradiction in the deregulation process (Harvey, 2007).

That the existence of risk premia, such as deviations from the CIP, can have direct political economy implications is not unique. The Japan Premium the late 1990s was directly affected by the financial strength of the borrowing Japanese bank, as noted by Spiegel (2001). However, it was also affected by the policy of the Bank of Japan (or ultimately the Finance Ministry) through its ability or desire to act as Lender of Last Resort, and also its willingness (and ability) to shield unsecured creditors from losses. The offshore premium faced by a borrowing Japanese bank was therefore a function of both the true economic characteristics of that bank and the expectations concerning government intervention in the event of its insolvency. Indeed, Peek & Rosengreen (1999) found empirical evidence that the Japanese Premium played a major role in the shaping of government policy towards the banking sector. Government announcements that occurred in the absence of concrete actions appeared to be ineffective; injections of funds into the banking system decreased the Japan Premium, whereas actions to strengthen supervision increased the premium.

Whereas the swap networks is an interesting example of how the Eurodollar market, and the LIBOR, continues to be prominent in issues relating to political economy and the structural power of the markets, it is necessary to recall the discussion from Chapter 4, namely that the central bank is not merely an appendix to the government, but after all also a *bank*. The central bank is, after all, a bank and it is impossible (or even desirable) for it to isolate itself from the other banks. Having evolved from 'profit maximising' banks to 'non-profit-maximising' or 'socially optimising' banks, the central banks have tended to become followers, not leaders, in financial innovation. They have generally welcomed financial innovation, but perhaps later worried about its effects. The attitude has been to (often quietly) embrace the development and, once having become established and accepted, begin to use the innovations (like indeed the Eurodollars) themselves by incorporating them into their own daily routines.

The financial structure, according to Strange (1994: p. 90), is on the one hand the structure and power through which credit is created (shared by governments and banks); and on the other hand the structure the international monetary system and exchange rates (determined by governments and markets). The LIBOR – in its different disguises - has figured prominently in this shift of structural power from states to markets. The benchmark is ultimately dependent on the powers of central banks, but also influenced by the market. However, as this chapter has demonstrated, within this state-market condominium, LIBOR panel banks have been able to exercise significant influence that stems all the way back to the birth of the Eurodollar market and the fundamental changes that followed. The historical roots of the LIBOR – and the illusion that it is a 'market' – have so far kept it free from outside regulation and oversight, and instead firmly in the hand of the 'house of the casino'. To fully understand the shift of structural power from the states to the market – we can therefore not disregard the impact of certain key actors in this 'game'. Cohen defines structural power as '*the ability to gain by rewriting the rules of the game'*. LIBOR banks have acted opportunistically when avoiding regulation set by outside parties. Some rules have been (re)written by the banks themselves and maintaining a status quo has probably been in their interest. Importantly, LIBOR banks have been central in the shaping of the false perception that the LIBOR is market-determined benchmark. Using Lukes' terminology, a 'latent conflict' of

wants and preferences between LIBOR banks and banks has gradually been created and sustained. There is a clear contradiction between the interests of the banks, on the one hand, and the central banks' *real* interests on the other.

However, locating the LIBOR solely within its relational sense, namely along the central bank versus bank axis, or state versus market axis, fails to recognise some important features of the benchmark and the power relationship. It is therefore necessary to put the LIBOR into its *dispositional* context, namely by focusing directly on the mechanism shaping those who have the power to determine the benchmark. The next two chapters apply a game-theoretic approach to show that the self-regulated and non-enforceable LIBOR fixing mechanism resembles a 'LIBOR Game', where systematic off-market equilibria can arise even in the absence of collusive behaviour among banks. This is particularly evident during a financial crisis when banks have large and homogenous LIBOR-based derivatives portfolios, and the mechanism lacks rules of transparency and enforcement. LIBOR banks not only have the means and opportunities, but also the incentives to submit deceptive quotes.

Chapter 8 then combines the concepts of 'power to' and 'power over' as it extends the logic to explain how the LIBOR panel banks - as groups - act as 'LIBOR clubs', and therefore exercise institutional power versus the central bank by being 'able to (re)write the rules of the game'. It thus focuses on the networks and institutions that make up the rules of the game. This 'institutionalisation of power' differs from that of the underlying money, or foreign exchange, markets in general, which are influenced not only by the general market practises amongst the market making banks, but also to some degree by other 'players' involved, such as central banks, regulators and end-users. The concentration of power with regards to the LIBOR seems to be concentrated among a few actors: the LIBOR panel banks, or the 'LIBOR Club'.

CHAPTER 6

LIBOR Games: Means, Opportunities and Incentives to Deceive

'The point […] of locating power is to fix responsibility for consequences held to flow from the action, or inaction, of certain specifiable agents.' (Lukes, 1974: p. 56)

6.1. LIBOR Manipulation?

The issue of possible manipulation of the LIBOR first received media attention when it was raised by Mollenkamp & Whitehouse (2008) in the Wall Street Journal in May 2008. The authors argued that some LIBOR panel banks had deliberately quoted LIBOR rates that were too low to be justified by their credit standing reflected in the CDS market. Although the article did not claim outright manipulation, it argued that banks *'may have been low-balling their borrowing rates to avoid looking desperate for cash'*.

The actual LIBOR fixing mechanism is simple. A designated calculation agent collects the submitted quotes from the individual LIBOR panel banks before noon. The trader or other bank person at the cash desk or treasury submits his or her quote from the bank terminal, and the other banks do the same without being able to see each others' quotes. During a short period, the calculation agent audits and checks the quotes for obvious errors and then conducts the 'trimming' – the omission the

highest and lowest quotes (the number which depends on the sample size). Thereafter, the arithmetic mean is calculated, rounded to the specified number of decimals and published at a certain time mid-day (British Bankers Association, 2012a).

Although the LIBOR is an observable benchmark, the individually submitted LIBOR quotes do not need to correspond to the actual funding cost faced by the panel banks. The integrity of the LIBOR fixing mechanism is thus based upon the assumption that the banks reveal the truth. The assumption that the LIBOR itself is based upon actual market transactions is in fact central to previous attempt to decompose the LIBOR into current and expected future interest rates, credit and liquidity risk. As shown in Chapter 2, decomposing money market risk premia (such as the LIBOR-OIS spread) in the recent literature has almost become synonymous with assessing the effectiveness of central bank policy in dealing with the current global financial crisis.

The contents of the Wall Street Journal article gave support to anecdotal evidence from active market participants, who had been claiming that the LIBOR systematically deviated from observable money market transactions. Already in the early days of the current global financial crisis, numerous market participants began to observe that, despite the LIBOR beginning to rise substantially; it was still significantly lower than where the money market *de facto* appeared to be trading - or at least ought to have been trading had there been enough market liquidity. For instance, traders found it inconceivable that some banks that were practically shut out of interbank funding (such as UBS and several other large European banks) submitted LIBOR quotes at levels well below where the market reportedly was trading. However, the BBA, which oversees the LIBOR fixing mechanism, took a defensive stance versus these claims and defended the integrity of the process. No evidence of manipulation was found after an internal investigation had been conducted, but the BBA nonetheless promised more governance and scrutiny (British Bankers Association, 2008).

However, in 2011, regulators and financial supervisors in several countries began investigating alleged LIBOR manipulation by traders and money market brokers directly or very closely linked to the fixing process. Although the investigations are

still ongoing and only some conclusions have been made so far, initial reports pointed two, but interlinked, angles in the investigation process. One related to possible collusion between two or more banks in the LIBOR rate setting process aimed at influencing the fixing in their favour, as this might enable them to surpass the hurdle of the so-called trimming process (COMCO, 2012). The second angle related to the possible pressure put by banks on money market brokers to influence the LIBOR fixing. Thus, third-party voice brokers, acting as middle-men, also came under scrutiny, having possibly conspired with banks, or groups of banks, to influence the LIBOR submissions. Namely, if the money market were to be volatile or illiquid, banks might have the incentive to try to influence what the voice broker signals to the rest of the market. This scenario was discussed by Mackenzie (2012), when describing the dilemma a voice broker can face in favouring one particular bank ahead of others. The relationship-based trader-broker model can be seen as system where both stand to benefit mutually: the broker by following the instructions from his or her largest and most profitable account, and the bank by gaining from the more 'independent' status the broker holds in the market by often being better informed and 'required' to adhere to anonymity rules.

Although the investigation covers a large number of banks, at the time of writing three (Citibank, UBS and Barclays) have been penalised by financial regulators for attempting to manipulate the LIBOR. As stated by the FSA regarding the financial penalty imposed upon Barclays, the bank had made *'submissions which formed part of the LIBOR and EURIBOR setting process that took into account requests from Barclays' interest rate derivatives traders. These trades were motivated by profit and sought to benefit Barclays' trading positions'*. The regulator also stated that the bank had *'seek to influence the EURIBOR submissions of other banks contributing to the rate setting process' and 'reduced its LIBOR submissions during the financial crisis as a result of senior management's concerns over the negative media comment'*. (Financial Services Agency (2011abc); Financial Services Authority (2012); U.S. Commodity Futures Trading Commission (2012))

This chapter illustrates how the LIBOR rate setting process, or fixing mechanism, can be analysed from a game-theoretic perspective.[22] It is shown how collusive behaviour between LIBOR panel banks, or between banks and brokers, can lead to LIBOR fixings that deviate from what could be regarded as the 'actual' funding costs of the banks – more widely referred to as a 'manipulated LIBOR'. However, collusive behaviour is not a prerequisite for such outcomes. Instead, LIBOR-indexed derivatives portfolios, or the stigma attached to signalling a relatively high funding cost, can provide LIBOR panel banks with sufficient incentives to submit quotes deviating from their actual funding cost. Hereby, the 'LIBOR games' highlight a fundamental flaw in the LIBOR rate setting process. It can be seen as a structure where players (LIBOR banks) have the means, opportunity and incentive to submit deceptive quotes, resulting in outcomes (LIBOR fixings) deviating from the 'actual' bank funding cost. Constraints put in place to hinder such outcomes are shown to be ineffective – having implications for central bank policy and regulation alike.

The chapter proceeds as follows. First, three different cooperative and non-cooperative 'LIBOR games', where players have incentives in terms of endowments, are modelled and solved using a standard Bayes Nash solution. Then, a purely non-cooperative game is introduced, studying the effect of the stigma attached to submitting a relatively high LIBOR, as well as considering the impact of potential reputational constraints or requirements to trade at submitted quotes. Finally, conclusions are drawn.

[22] The LIBOR games in this chapter were carefully designed after numerous interviews and informal meetings with traders and money market brokers directly, or indirectly, involved in the LIBOR, EURBOR, TIBOR, NIBOR and STIBOR submission processes. The identities of the interviewees have been kept anonymous.

6.2. Three Single-Period LIBOR Games

6.2.1. Assumptions and Rules of the Single-Period LIBOR Games

i) Players

Consider 3 different single-period games - henceforth called the 'LIBOR Base Game', the 'LIBOR Collusion Game' and the 'LIBOR Bribe Game' respectively. In each game, there are 4 players (i.e. LIBOR panel banks), the smallest number of players in order to account for the so-called trimming mechanism:

$$P = \{P_i, P_j, P_k, P_l\} \tag{6.1}$$

ii) Endowments

Players start with an endowment (denoted 'E'):

$$E_i \in \{E^+, E^0, E^-\}, \tag{6.2}$$

where $E^+>0$, $E^0=0$ and $E^-<0$. The endowment is a derivatives portfolio benchmarked against the LIBOR. For the sake of argument, let us simply assume that players with a positive endowment (E^+) benefit from a high LIBOR, players with a negative endowment (E^-) from a low LIBOR and players with no endowment (E^0) are indifferent (see Appendix 2 for a more thorough financial interpretation of the endowment).

iii) The Money Market

All players face the same bank funding cost, denoted M (where M is a unique number > 0). At t_0, the interbank money market trades at 'M', and M is equivalent to the previous day's LIBOR fixing ($L_{F(t0)}$). In the LIBOR Base Game and the LIBOR Collusion Game, M is public knowledge. In the LIBOR Bribe Game, however, M is uncertain and can be any number within a range $[M^L, M^H]$, where $M^L \leq M \leq M^H$. Let it also be that $M^L = M - \alpha$, and $M^H = M + \alpha$.

iv) The LIBOR Fixing

The LIBOR fixing rule states that all players are supposed to submit their 'actual' funding cost to the LIBOR fixing mechanism. However, assume all players are able to submit quotes within a range $[M^L, M^H]$, where $M^L \leq M \leq M^H$. Thus, any individual LIBOR quote, L_i (where $L_i \neq M$) can be regarded as a 'deceptive' quote. Let it also be that $L^M = M$, $L^H = L + \alpha$, and $L^L = M - \alpha$, where $0 < \alpha < M$.

The actual LIBOR fixing mechanism is straight-forward. Players submit their quotes at t_1 without being able to see each others' quotes. Thereafter, a third party (a designated independent calculation agent) audits and checks the quotes for obvious errors and then conducts the 'trimming process' – the omission the highest and lowest quotes. Thereafter, the arithmetic mean is calculated and published. The LIBOR fixing (L_F) at t_2 is thus:

$$L_F = \frac{\sum_{i=1}^{4} L_i - max\{Li\} - min\{Li\}}{2} \tag{6.3}$$

Henceforth, L_F will denote the *expected* LIBOR fixing at t_1.

v) Payoffs

Let us assume that players act out of self-interest and are rational – and that this is public knowledge. In each game, players try to maximise the payoffs from their respective endowments, with the expected payoff function[23] for player P_i at t_1:

$$\pi_i = E_i(L_F - M) \tag{6.4}$$

vi) Strategy in the LIBOR Base Game

As the endowment is privative knowledge, players set equal probabilities for the other players to have either E^+, E^0 or E^- so that:

$$p(E^+_{n\neq i}) = p(E^0_{n\neq i}) = p(E^-_{n\neq i}) = 1/3 \tag{6.5}$$

[23] See Appendix 2 and 3.

Further, players can choose to submit a 'high' LIBOR quote (L^H), a 'fair' LIBOR quote (L^M) or a 'low' LIBOR quote (L^L):

$$S_i = \{L^H, L^M, L^L\} \tag{6.6}$$

Let it also be that player P_i only submits a quote ≠ M if there is a marginal benefit in doing so, with the optimal strategy being:

$$s_i^* = \begin{cases} L^H, \ \pi_i(L^H) > \pi_i(L^L) \cap \ \pi_i(L^H) > \pi_i(L^M) \\ L^M, \ \pi_i(L^M) \geq \pi_i(L^H) \cap \ \pi_i(L^M) \geq \pi_i(L^L) \\ L^L, \ \pi_i(L^L) > \pi_i(L^H) \cap \ \pi_i(L^L) > \pi_i(L^M) \end{cases} \tag{6.7}$$

Thus, player P_i sets the probability z_j^H of player P_j playing high if $s_j^* = L^H$, z_j^M if $s_j^* = L^M$ and z_j^L if $s_j^* = L^L$:

$$\begin{aligned} z_{n\neq i}^H &= Prob\{s_{n\neq i}^*, L_{n\neq i}^H\} \\ z_{n\neq i}^M &= Prob\{s_{n\neq i}^*, L_{n\neq i}^M\} \\ z_{n\neq i}^L &= Prob\{s_{n\neq i}^*, L_{n\neq i}^L\} \end{aligned} \tag{6.8}$$

Figure 6.1: Time Line of Events (LIBOR Base Game)

t_0	t_1	t_2
The endowment of each player is known. The knowledge is private.	*Each player chooses a strategy and submits a LIBOR quote to maximise his expected payoff.*	*The LIBOR fixing is calculated and revealed, as are the individual quotes. The payoffs are calculated.*

vii) Strategy in the LIBOR Collusion Game

In the LIBOR Collusion Game, let us assume that the endowment is no longer private, but 'semi-private' knowledge. To be precise, player P_i (with $E^{\neq 0}$) knows that the endowment of player P_j is $E_j = E_i \neq 0$, and they decide to collude by submitting identical quotes. Hence:

$$p(E_{n\neq i,j}^+) = p\left(E_{n\neq i,j}^0\right) = p\left(E_{n\neq i,j}^-\right) = 1/3 \tag{6.9}$$

Player P_i (with E^0) has nothing to gain by colluding, giving the following strategy options for the players:

$$S_i^C = \{L^{H(C)}, L^M, L^{L(C)}\} \tag{6.10}$$

Like in the LIBOR Base Game, let it also be that player P_i only submits a quote ≠ M if there is a marginal benefit in doing so, with the optimal strategy being:

$$s(C)_i^* = \begin{cases} L_C^H,\ \pi_i\left(L^{H(C)}\right) > \pi_i\left(L^{L(C)}\right) \cap\ \pi_i\left(L^{H(C)}\right) > \pi_i(L^M) \\ L^M,\ \pi_i(L^M) \geq \pi_i\left(L^{H(C)}\right) \cap\ \pi_i(L^M) \geq \pi_i\left(L^{L(C)}\right) \\ L_C^L,\ \pi_i\left(L^{L(C)}\right) > \pi_i\left(L^{H(C)}\right) \cap\ \pi_i\left(L^{L(C)}\right) > \pi_i(L^M) \end{cases} \tag{6.11}$$

Also, player P_i sets the probability z_j^H of player P_j playing high if $s_j^* = L^H$, z_j^M if $s_j^* = L^M$ and z_j^L if $s_j^* = L^L$:

$$\begin{aligned} z_{n\neq i}^H &= Prob\{s_{n\neq i}^*, L_{n\neq i}^H\} \\ z_{n\neq i}^M &= Prob\{s_{n\neq i}^*, L_{n\neq i}^M\} \\ z_{n\neq i}^L &= Prob\{s_{n\neq i}^*, L_{n\neq i}^L\} \end{aligned} \tag{6.12}$$

Figure 6.2: Time Line of Events (LIBOR Collusion Game)

t_0	t_1	t_2
The endowment of each player is known, and semi-private. Players Pi and Pj (with $E_j = E_i \neq 0$) know each others' endowment, but not that of the others.	*Each player chooses a strategy (with possible collusion) and submits a LIBOR quote to the calculation agent to maximise his expected payoff.*	*The LIBOR fixing is calculated and revealed, as are the individual quotes. Payoffs are calculated.*

viii) Strategy in the LIBOR Bribe Game

In the LIBOR Bribe Game, the endowment is private knowledge and collusion with another player is not possible. Let us assume that players sets equal probabilities for the other players to have either E^+, E^0 or E^- so that:

$$p(E_{n\neq i}^+) = p(E_{n\neq i}^0) = p(E_{n\neq i}^-) = 1/3 \tag{6.13}$$

However, in this game, all players know that M can be any number within a range $[M^L, M^H]$, where $M^L \leq M \leq M^H$. Further, let us assume that there is a third party (money market) broker that is better informed, from whom the precise level of M can be obtained. This third party can be bribed by player P_i to signal a deceptive level of M. In practice, the bribe by a bank could also simply be a threat to cease doing business with the broker and go to a competitor. As such, a bribe, or treat, might put

the broker in an awkward position as his revenue depends not only on his long-term reputation of being 'fair' and 'objective', but the trading volume of often just a few trading accounts. Therefore, a bribe or treat can work to cement a strong relationship. From the broker's perspective, the best source of information normally comes from the most active banks, which normally also are the most active trading banks in LIBOR-related instruments. The strategy options when bribes are allowed become:

$$S_i^B = \{L^{H(B)}, L^H, L^M, L^{L(B)}, L^L\} \tag{6.14}$$

Let it also be that player P_i only submits a quote ≠ M if there is a marginal benefit in doing so, with the optimal strategy being:

$$s(B)_i^* = \begin{cases} L^{H(B)},\ \pi_i\left(L^{H(B)}\right) > \pi_i(L^H) \cap\ \pi_i\left(L^{H(B)}\right) > \pi_i(L^M) \cap \\ \quad \pi_i\left(L^{H(B)}\right) > \pi_i\left(L^{L(B)}\right) \cap\ \pi_i\left(L^{H(B)}\right) > \pi_i(L^L) \\ L^H,\ \pi_i(L^H) > \pi_i\left(L^{H(B)}\right) \cap\ \pi_i(L^H) > \pi_i(L^M) \cap \\ \quad \pi_i(L^H) > \pi_i\left(L^{L(B)}\right) \cap\ \pi_i(L^H) > \pi_i(L^L) \\ L^M,\ \pi_i(L^M) \geq \pi_i\left(L^{H(B)}\right) \cap\ \pi_i(L^M) \geq \pi_i(L^H) \cap \\ \quad \pi_i(L^M) \geq \pi_i\left(L^{L(B)}\right) \cap\ \pi_i(L^M) \geq \pi_i(L^L) \\ L^{L(B)},\ \pi_i\left(L^{L(B)}\right) > \pi_i\left(L^{H(B)}\right) \cap\ \pi_i\left(L^{L(B)}\right) > \pi_i(L^H) \cap \\ \quad \pi_i\left(L^{L(B)}\right) > \pi_i(L^M) \cap\ \pi_i\left(L^{L(B)}\right) > \pi_i(L^L) \\ L^L,\ \pi_i(L^L) > \pi_i\left(L^{H(B)}\right) \cap\ \pi_i(L^L) > \pi_i(L^H) \cap \\ \quad \pi_i(L^L) > \pi_i(L^M) \cap\ \pi_i(L^L) > \pi_i\left(L^{L(B)}\right) \end{cases} \tag{6.15}$$

Further, player P_i sets the probability z_j^H of player P_j playing high if $s_j^* = L^H$, z_j^M if $s_j^* = L^M$ and z_j^L if $s_j^* = L^L$:

$$\begin{aligned} z_{n\neq i}^H &= Prob\{s(B)_{n\neq i}^*, L_{n\neq i}^{H(B)}\} \\ z_{n\neq i}^M &= Prob\{s(B)_{n\neq i}^*, L_{n\neq i}^H\} \\ z_{n\neq i}^L &= Prob\{s(B)_{n\neq i}^*, L_{n\neq i}^M\} \\ z_{n\neq i}^L &= Prob\{s(B)_{n\neq i}^*, L_{n\neq i}^{L(B)}\} \\ z_{n\neq i}^L &= Prob\{s(B)_{n\neq i}^*, L_{n\neq i}^L\} \end{aligned} \tag{6.16}$$

Figure 6.3: Time Line of Events (LIBOR Bribe Game)

t_0	t_1	t_2
The endowment of each player is known. The knowledge is private.	*Each player chooses a strategy (with a possible bribe) and submits a LIBOR quote to the calculation agent to maximise his expected payoff.*	*The LIBOR fixing is calculated and revealed, as are the individual quotes. The payoffs are calculated.*

6.2.2. Outcomes of the Single-Period LIBOR Games

If player P_i assumes all other players will submit quotes equal to M, the trimming process is effective, as any quote ≠ M will be omitted, and the expected LIBOR fixing will be equal to M. If, on the other hand, player P_i believes that players might have underlying incentives to deceive, the expected LIBOR fixing depends on the probabilities he sees for each possible outcome. Assuming that all players act out of self-interest and are rational, and that this is common knowledge, we can work out the best strategy given each endowment. By using a Bayes Nash solution for these games, we can see how the LIBOR fixings can differ from M, as it depends on the expected strategy of each of the four players (see Appendix 3 for more thorough explanation).

i) Outcome of the LIBOR Base Game

In all three LIBOR games, each player has the *means* and *opportunity* to submit a deceptive LIBOR quote, as a result of the fixing mechanism and by having the exclusively privilege of being allowed to play the game.

However, a deceptive quote (i.e. where $L_i \neq M$) will only be submitted if a player has the *incentive* to do so, i.e. if $E_i \neq 0$. This is intuitive, as players expect that not only themselves, but also the others, are rational and will act out of self-interest. As each player knows that, on average, one other player will choose the same strategy as himself, the trimming process does not act as a hindrance to submit a deceptive quote. It is irrelevant which one of the two players will be omitted through the trimming process, as one of them will still have an impact.

As a result, the optimal strategy for players with E≠0 is submitting deceptive quotes with the aim to skew the LIBOR fixing in their favour:

$$\begin{aligned} s_i^*(E_i^+) &= L^H \\ s_i^*(E_i^0) &= L^M \\ s_i^*(E_i^-) &= L^L \end{aligned} \tag{6.17}$$

The expected payoffs are:

$$\begin{aligned} \pi_i^*(E_i^+, L_i^H) &= \frac{1}{3}\alpha E \\ \pi_i^*(E_i^0, L_i^M) &= 0 \\ \pi_i^*(E_i^-, L_i^L) &= \frac{1}{3}\alpha E \end{aligned} \tag{6.18}$$

The expected LIBOR fixing for players with E≠0 hence deviates from M:

$$\begin{aligned} \overline{L}_F(E_i^+, L_i^H) &= M + \frac{1}{3}\alpha \\ \overline{L}_F(E_i^0, L_i^M) &= M \\ \overline{L}_F(E_i^-, L_i^L) &= M - \frac{1}{3}\alpha \end{aligned} \tag{6.19}$$

ii) Outcome of the LIBOR Collusion Game

In the LIBOR Collusion Game, player P_i (with $E^{\neq 0}$) knows that the endowment of player P_j is $E_j = E_i \neq 0$. Both players know that they are better off colluding by agreeing to play the same strategy at t_1. This alters the probability set as Player P_i now knows the strategy of player P_j with certainty.

The expected payoff increases for players with $E^{\neq 0}$. Player P_i (with E^0) has nothing to gain by colluding, and his strategy remains to submit L_i=M:

$$\begin{aligned} s_i^*(E_i^+, C) &= L^{H(C)} \\ s_i^*(E_i^0, C) &= L^M \\ s_i^*(E_i^-, C) &= L^{L(C)} \end{aligned} \tag{6.20}$$

The expected payoff increases for players involved in collusion:

$$\pi_i^*(E_i^+, C) = \frac{13}{18}\alpha E$$
$$\pi_i^*(E_i^0, C) = 0 \qquad (6.21)$$
$$\pi_i^*(E_i^-, C) = \frac{13}{18}\alpha E$$

Likewise, the expected LIBOR fixing for players with $E^{\neq 0}$ deviates more from M as the likelihood of deceptive LIBOR quotes has increased:

$$\overline{L}_F(E_i^+, C) = M + \frac{13}{18}\alpha$$
$$\overline{L}_F(E_i^0, C) = M \qquad (6.22)$$
$$\overline{L}_F(E_i^-, C) = M - \frac{13}{18}\alpha$$

iii) Outcome of the LIBOR Bribe Game

From the LIBOR Base Game, we know that player P_i knows that players with E^+ will always play 'high', players with E^- will always play 'low' and players with E^0 will always play 'fair'. However, from the assumptions we know that player P_i only submits a quote ≠ M if there is a marginal benefit in doing so. If the level of M is uncertain, players with E^0 will therefore have an incentive to get the opinion from the better informed third party broker (who in this case can be bribed).

However, player P_i thus knows that one player – on average – can be influenced by the signal sent from the broker, as players with E^0 will always play fair (M) unless he believes the rate might be at another level. This can be achieved by paying a bribe (B) to the broker for him to signal that M, in fact, is at the higher or lower end of the scale $M^L \leq M \leq M^H$. Thus, for players with $E^{\neq 0}$, bribing the broker will be rational if the cost of the bribe is sufficiently low ($B < 19\alpha E/27$), thereby ensuring that neutral players, unintentionally, will submit deceptive quotes. Thus, the optimal strategies are:

$$s_i^*(E_i^+, B) = \begin{cases} L^{H(B)}, & B < \frac{19}{27}\alpha E \\ L^H, & B \geq \frac{19}{27}\alpha E \end{cases}$$

$$s_i^*(E_i^0, B) = L^M \tag{6.23}$$

$$s_i^*(E_i^-, B) = \begin{cases} L^{L(B)}, & B < \frac{19}{27}\alpha E \\ L^L, & B \geq \frac{19}{27}\alpha E \end{cases}$$

The expected payoffs:

$$\pi_i^*(E_i^+, B) = \begin{cases} \frac{19}{27}\alpha E - B, & B < \frac{19}{27}\alpha E \\ \frac{1}{3}\alpha E, & B \geq \frac{19}{27}\alpha E \end{cases}$$

$$\pi_i^*(E_i^0, B) = 0 \tag{6.24}$$

$$\pi_i^*(E_i^-, B) = \begin{cases} \frac{19}{27}\alpha E - B, & B < \frac{19}{27}\alpha E \\ \frac{1}{3}\alpha E, & B \geq \frac{19}{27}\alpha E \end{cases}$$

As a result, the expected LIBOR fixing for players with $E^{\neq 0}$ deviates more from M compared to the LIBOR Base Game if the cost of the bribe is low:

$$\bar{L}_F(E_i^+, B) = \begin{cases} M + \frac{19}{27}\alpha, & B < \frac{19}{27}\alpha E \\ M + \frac{1}{3}\alpha, & B \geq \frac{19}{27}\alpha E \end{cases}$$

$$\bar{L}_F(E_i^0, B) = M \tag{6.25}$$

$$\bar{L}_F(E_i^-, B) = \begin{cases} M - \frac{19}{27}\alpha, & B < \frac{19}{27}\alpha E \\ M - \frac{1}{3}\alpha, & B \geq \frac{19}{27}\alpha E \end{cases}$$

6.3. A LIBOR Game with Reputational Constraint and Stigma Incentive

Let us now disregard the possibility of collusion and bribes, and return to a situation where the endowments are private knowledge and M both public knowledge and certain. However, here we introduce a new constraint and incentive involving reputation and stigma.

6.3.1. Assumptions and Rules of the LIBOR Reputation/Stigma Game

i) Assumptions

At the outset, the assumptions are identical to the LIBOR Base Game, where the 4 players start the game with an endowment that is private knowledge. The payoff from this endowment is:

$$\pi_i(E) = E_i(L_F - M) \tag{6.26}$$

ii) Reputational Constraint

However, in this game, there is a reputational constraint facing all players. This mechanism is put in place to prevent players from submitting deceptive LIBOR quotes, and thus giving them an incentive to adhere to 'fair play'. The payoff from the reputational constraint ('ρ') is written as:

$$\pi_i(\rho) = (\sum_{j \neq i} |L_j - M| - 3|L_i - M|)\rho \tag{6.27}$$

Hence, under this arrangement, a player submitting a LIBOR quote $L_i \neq M$ is subject to a payoff consisting of two parts and equalling the sum of profits from others' deception and the loss from the own deception. From a bank's perspective, the constraint could be interpreted as follows: submitting a deceptive quote might, if

discovered, result in less client business, legal costs of being under regulatory investigation or even the risk of being excluded from the panel altogether and being replaced by another bank. Likewise, if only *other* panel banks decide to deceive, the bank playing fair will receive a relative reputational boost on the expense of the others. The constraint could also be interpreted as purely affecting the trading desk or treasury, if they were required to commit to their quotes in 'reasonable market size', where a deceptive quote would be exploited monetarily by all other LIBOR panel banks (i.e. similar to a reputational loss). Likewise, there would an immediate trading gain should others decide to submit deceptive LIBOR quotes.

iii) Stigma Incentive

The second new variable is the 'stigma' (denoted as 'σ'):

$$\pi_i(\sigma) = \left(\frac{\sum_{j=1}^{4} L_j}{4} - L_i\right)\sigma, \tag{6.28}$$

According to the British Bankers Association (2012a), LIBOR quotes are supposed to reflect '*where the bank can fund itself in the interbank market'*. Therefore, an individual quote above the *average* of the panel quotes might be interpreted as a signal that the bank has funding problems relative to the others. Likewise, a lower than average quote would signal that the bank is in relatively good shape – as individually submitted LIBOR quotes are visible to the whole market, not only to the other LIBOR panel banks, after the fixing. The stigma incentive, thus, rewards players submitting a below-average quote – regardless of the actual LIBOR fixing.

iv) Payoff function

This LIBOR game involves a trade-off between the endowment and the different constraints, and the conflicting incentives this can result in. The payoff function facing each player is:

$$\pi_i(E, \rho, \sigma) = \pi_i(E) + \pi_i(\rho) + \pi_i(\sigma) \tag{6.29}$$

v) Strategy of the Game

Let us assume that players sets equal probabilities for the other players to have either E^+, E^0 or E^- so that:

$$p(E^+_{n\neq i}) = p(E^0_{n\neq i}) = p(E^-_{n\neq i}) = 1/3 \tag{6.30}$$

Further, players can choose to submit a 'high' LIBOR quote (L^H), a 'fair' LIBOR quote (L^M) or a 'low' LIBOR quote (L^L):

$$S_i = \{L^H, L^M, L^L\} \tag{6.31}$$

Let it also be that player P_i only submits a quote ≠ M if there is a marginal benefit in doing so, with the optimal strategy being:

$$s_i^*(E,\rho,\sigma) = \begin{cases} L^H,\ \pi_i(L^H) > \pi_i(L^L) \cap\ \pi_i(L^H) > \pi_i(L^M) \\ L^M,\ \pi_i(L^M) \geq \pi_i(L^H) \cap\ \pi_i(L^M) \geq \pi_i(L^L) \\ L^L,\ \pi_i(L^L) > \pi_i(L^H) \cap\ \pi_i(L^L) > \pi_i(L^M) \end{cases} \tag{6.32}$$

Thus, player P_i sets the probability z_j^H of player P_j playing high if $s_j^* = L^H$, z_j^M if $s_j^* = L^M$ and z_j^L if $s_j^* = L^L$:

$$\begin{aligned} z^H_{n\neq i} &= Prob\{s^*_{n\neq i}, L^H_{n\neq i}\} \\ z^M_{n\neq i} &= Prob\{s^*_{n\neq i}, L^M_{n\neq i}\} \\ z^L_{n\neq i} &= Prob\{s^*_{n\neq i}, L^L_{n\neq i}\} \end{aligned} \tag{6.33}$$

Figure 6.4: Time Line of Events (LIBOR Game with Reputation/Stigma)

t_0	t_1	t_2
The endowment of each player is known (but not those of the others). Constraints and incentives are announced.	*Each player chooses a strategy and submits a LIBOR quote to the calculation agent to maximise his expected payoff subject to constraints and incentives.*	*The LIBOR fixing is calculated and revealed, as are the individual quotes. The payoffs are calculated.*

6.3.2. Outcomes of the LIBOR Reputation/Stigma Game

Let us consider the two new variables in turn. At the outset, we know that the optimal strategy of players with E^0 is to play 'fair'. However, if the reputational constraint is large enough ($\rho \geq E/9$), players with $E^{\neq 0}$ will also choose to play 'fair'. Thus, the expected outcomes of the game will depend on the ratio between ρ and E.

The stigma incentive has an impact if $\sigma > 0$, as players with E^0 now also will have the incentive to submit deceptive quotes, namely low quotes. The expected payoff matrix changes, as players take into account that the optimal strategy of players with E^0 is now to play 'low'. Under this scenario, fair play is not an optimal strategy, and the expected LIBOR decreases. However, above a certain σ-ratio, even players with E^+ will opt to play 'low' as the benefit of submitting a high quote to maximise the profit of the endowment is outweighed by the stigma of being perceived as a player with funding difficulties.

For $\{\rho = 0 \cap \sigma = 0\}$, the outcomes are identical to that of the LIBOR Base Game. However, for $\{\rho > 0 \cap \sigma > 0\}$ and again using the Bayes Nash solution as in the previous 3 games, we get 6 different equilibria, as the different thresholds where players would choose to change strategy yield different 'scenarios' with altered probability distributions. Each equilibrium has a different set of optimal strategies, expected payoffs and expected LIBOR fixings:

$$s_i^*(E_i^+,\rho,\sigma)=\begin{cases}L^H, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)\\ L^H, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap\left(0<\rho<\frac{1}{9}E\right)\\ L^M, & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right)\\ L^M, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\\ L^L, & \left(\sigma\ge4\rho+\frac{4}{9}E\right)\\ L^M, & \left(\sigma<4\rho-\frac{4}{9}E\right)\end{cases}$$

$$s_i^*(E_i^0,\rho,\sigma)=\begin{cases}L^M, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)\\ L^L, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap\left(0<\rho<\frac{1}{9}E\right)\\ L^M, & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right)\\ L^L, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\\ L^L, & \left(\sigma\ge4\rho+\frac{4}{9}E\right)\\ L^M, & \left(\sigma<4\rho-\frac{4}{9}E\right)\end{cases}\tag{6.34}$$

$$s_i^*(E_i^-,\rho,\sigma)=\begin{cases}L^L, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)\\ L^L, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap\left(0<\rho<\frac{1}{9}E\right)\\ L^L, & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right)\\ L^L, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\\ L^L, & \left(\sigma\ge4\rho+\frac{4}{9}E\right)\\ L^M, & \left(\sigma<4\rho-\frac{4}{9}E\right)\end{cases}$$

$$\pi_i^*(E_i^+,\rho,\sigma)=\begin{cases}\alpha(\frac{1}{3}E-\rho-\frac{3}{4}\sigma)\,, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)\\ \alpha(-\frac{1}{27}E-\sigma)\,, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap(0<\rho<\frac{1}{9}E)\\ \alpha\left(-\frac{4}{27}E+\rho-\frac{1}{4}\sigma\right), & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right)\\ \alpha\left(-\frac{14}{27}E+2\rho-\frac{1}{2}\sigma\right), & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\\ \alpha(-E), & \left(\sigma\ge4\rho+\frac{4}{9}E\right)\\ 0, & \left(\sigma<4\rho-\frac{4}{9}E\right)\end{cases}$$

$$\pi_i^*(E_i^0,\rho,\sigma)=\begin{cases}2\alpha\rho, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)\\ \alpha(\frac{1}{2}\sigma)\ , & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap(0<\rho<\frac{1}{9}E)\\ \alpha(\rho-\frac{1}{4}\sigma), & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right)\\ \alpha(-\rho+\frac{1}{4}\sigma), & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\\ 0, & \left(\sigma\ge4\rho+\frac{4}{9}E\right)\\ 0, & \left(\sigma<4\rho-\frac{4}{9}E\right)\end{cases}\qquad(6.35)$$

$$\pi_i^*(E_i^-,\rho,\sigma)=\begin{cases}\alpha(\frac{1}{3}E-\rho+\frac{3}{4}\sigma)\,, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)\\ \alpha(\frac{19}{27}E+\frac{1}{2}\sigma)\ , & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap(0<\rho<\frac{1}{9}E)\\ \alpha(\frac{13}{27}E-2\rho+\frac{1}{2}\sigma), & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right)\\ \alpha(\frac{23}{27}E-\rho+\frac{1}{24}\sigma), & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\\ \alpha(E), & \left(\sigma\ge4\rho+\frac{4}{9}E\right)\\ 0, & \left(\sigma<4\rho-\frac{4}{9}E\right)\end{cases}$$

$$\overline{L}_F(E_i^+,\rho,\sigma)=\begin{cases} M+\frac{1}{3}\alpha, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho) \\ M-\frac{1}{27}\alpha, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap\left(0<\rho<\frac{1}{9}E\right) \\ M-\frac{4}{27}\alpha, & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right) \\ M-\frac{14}{27}\alpha, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right) \\ M-\alpha, & \left(\sigma\ge4\rho+\frac{4}{9}E\right) \\ M, & \left(\sigma<4\rho-\frac{4}{9}E\right) \end{cases}$$

$$\overline{L}_F(E_i^0,\rho,\sigma)=\begin{cases} M, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho) \\ M-\frac{19}{27}\alpha, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap\left(0<\rho<\frac{1}{9}E\right) \\ M-\frac{4}{27}\alpha, & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right) \\ M-\frac{23}{27}\alpha, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right) \\ M-\alpha, & \left(\sigma\ge4\rho+\frac{4}{9}E\right) \\ M, & \left(\sigma<4\rho-\frac{4}{9}E\right) \end{cases} \tag{6.36}$$

$$\overline{L}_F(E_i^-,\rho,\sigma)=\begin{cases} M-\frac{1}{3}\alpha, & \left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho) \\ M-\frac{19}{27}\alpha, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right)\cap\left(0<\rho<\frac{1}{9}E\right) \\ M-\frac{13}{27}\alpha, & \left(4\rho-\frac{4}{9}E\le\sigma<4\rho\right) \\ M-\frac{23}{27}\alpha, & \left(4\rho\le\sigma<4\rho+\frac{4}{9}E\right) \\ M-\alpha, & \left(\sigma\ge4\rho+\frac{4}{9}E\right) \\ M, & \left(\sigma<4\rho-\frac{4}{9}E\right) \end{cases}$$

Interpreting each outcome in turn, we can see that under Scenario I, where:

$$\left(0<\rho<\tfrac{1}{9}E\right)\cap(\sigma<4\rho), \tag{6.37}$$

the reputational constraint is not large enough to prevent players from submitting deceptive LIBOR quotes. Likewise, the stigma constraint does not tempt players with $E^{\neq0}$ to submit low quotes. The expected LIBOR is identical to that of the outcome of the LIBOR Base game.

Under Scenario II, where:

$$\left(4\rho\le\sigma<4\rho+\tfrac{4}{9}E\right)\cap\left(0<\rho<\tfrac{1}{9}E\right), \tag{6.38}$$

the reputational constraint is still fairly small, but the stigma constraint has increased – prompting players with E^0 to switch strategy, namely to play 'low' instead of 'fair'. The expected LIBOR falls as the probability of low submissions increases.

Scenario III, where:

$$\left(4\rho - \tfrac{4}{9}E \leq \sigma < 4\rho\right), \tag{6.39}$$

implies that the reputational constraint is large enough for all players to what we could regard as 'initially consider playing fair'. However, the stigma constraint is also significant enough for players with E^- to play 'low' (boosted by the payoff from the endowment), but for not enough for others to deviate from their fair quotes. The expected LIBOR equilibrium is slightly below M.

Scenario IV, where:

$$\left(4\rho \leq \sigma < 4\rho + \tfrac{4}{9}E\right), \tag{6.40}$$

also implies that the reputational constraint is large enough for players to 'initially consider playing fair'. However, the stigma constraint is now large enough for players with $E^{\leq 0}$ to play 'low', whereas players with E^+ stick to their fair quotes. The expected LIBOR equilibrium is lower than under Scenario III.

Under Scenario V, where:

$$\left(\sigma \geq 4\rho + \tfrac{4}{9}E\right), \tag{6.41}$$

the stigma incentive is considerable – inducing all players to submit low LIBOR quotes regardless of their endowments or the reputational constraint. The expected LIBOR fixing reaches its minimum, i.e. M-α.

Thus, Scenario VI where:

$$\left(\sigma < 4\rho - \frac{4}{9}E\right), \tag{6.42}$$

is the only situation where no deceptive quotes can be expected to be submitted. This is when the reputational constraint is large, whereas the stigma constraint is small enough not to give incentive for any players to deviate from the fair quotes. Here, the expected LIBOR always equals M. This could be regarded as the only scenario where the LIBOR fixing process works as 'intended', namely to reflect the banks' actual funding costs.

6.4. Conclusions

The LIBOR games presented in this chapter illustrate that if panel banks have LIBOR-based derivatives portfolios, are rational and act out of self-interest, they not only have the means and opportunities, but also the incentives to submit deceptive LIBOR quotes – resulting in a LIBOR fixing no longer reflecting the 'actual' funding cost of the panel banks. Should two or more banks collude, or have the opportunity to collude with a money-market voice broker, the likelihood of what we could regard as off-market LIBOR equilibria increases. However, whereas collusion of this kind makes this more likely, and the impact greater, it is by no means a pre-requisite. Because, at the core of the LIBOR games lies the importance of the belief each player has about what others will do and how this will affect the optimal strategy. The LIBOR games are not zero-sum games. Instead, LIBOR panel banks, by having the exclusive privilege to play these 'games', are able to influence the LIBOR that is beneficial to them. The trimming process can act as a hindrance for banks to submit deceptive quotes, but is no guarantee in itself as banks should expect others also to act out of self-interest. Deception can thus become the norm, rather than the exception, depending on the various constraints and incentives banks are presented with.

Banks, being profit-maximising and the most frequent users of instruments indexed to the LIBOR, naturally have an interest in the outcome of the LIBOR fixing. LIBOR-indexed derivatives portfolios (called 'endowments' in these games) serve as incentives to submit deceptive quotes, and these incentives can be seen as having strengthened in tandem with the growth in the derivatives markets linked to the benchmark. The notional amount of outstanding LIBOR-based derivative contracts has now reached astonishing levels; with the BBA estimating that 10 trillion U.S. dollars of loans and 350 trillion of interest rate swaps alone are indexed by the LIBOR (U.S. Commodity Futures Trading Commission, 2012). According to statistics compiled by the Bank for International Settlements (2011), the notional amount of outstanding OTC interest rate derivatives contracts amounted to 554 trillion U.S. dollars in the first half of 2011. The LIBOR, and its equivalents, are thus the by far most frequently used benchmarks for IRS, FRAs and OTC interest rate options. The annual turnover in the LIBOR-equivalent futures contracts is equally impressive.

Snider & Youle (2009, 2010) base a theory of misreporting incentives upon the individual banks' portfolio exposure to the LIBOR that gives them an incentive to push the benchmark in a particular direction. They study three LIBOR panel banks that are American bank holding companies and thereby required to provide interest rate derivatives and net interest revenue figures in the quarterly Reports on Conditions and Income (Call Reports) to the FDIC. By using the exposure to outstanding interest rate swaps as an approximation, the authors find that during the period there was a clear incentive for the banks to keep a low LIBOR, thereby supplying evidence that panel banks may have acted strategically when submitting their LIBOR quotes. The outcomes of the LIBOR games lend support to this argument.

The 'stigma' of submitting a relatively high funding costs poises another problem with the LIBOR fixing mechanism, as banks inherently have an interest in appearing sound and solid. In theory, the LIBOR should not only reflect current and future interest rate expectations, but also credit and liquidity risk. Should banks face credit and liquidity constrains, these ought to be reflected in the LIBOR submissions and *ceteris paribus* result in a higher LIBOR fixing, as the banks' funding costs increase.

As the individual LIBOR submissions are made public, they serve as snap-snot indicators of the perceived creditworthiness of the banks. This signal to the market is important as the funding cost of the bank and its capital and reputation are closely linked (see for instance Ederington, Yawitz & Roberts, 1987). Downgrades by rating agencies are rare events, as are financial statements. The LIBOR, in contrast, is submitted and published daily and can reduce the uncertainty of whether a particular bank faces immediate funding problems or not. The stigma incentive therefore results from the individual LIBOR submissions being public knowledge at the same time as the actual funding cost is private knowledge. This lack of transparency, coupled with the natural desire of banks to appear sound at all times thus works as an incentive to conceal potential funding problems publicly through the LIBOR signalling process. Put differently, it works as an incentive to 'low-ball' the LIBOR in similar fashion to the stigma of having to borrow at the discount window from central banks during the early days of the crisis. Submitting a LIBOR quote could signal that the bank is in trouble and thereby having a direct negative impact on the CDS price, bond price, share price and so on, which would yet again affect the short-term funding cost faced by the bank.

The outcomes of the LIBOR Games also highlight the conflict of interest that might exist within a LIBOR panel bank. Trading desks, for instance, could be more concerned about the payoff resulting from the LIBOR-indexed derivatives portfolios, whereas the Management might put greater emphasis on the 'stigma constraint'. This issue of loose 'Chinese Walls' between departments, where one department might increase the pressure put on the LIBOR submitting entity, has to some degree been confirmed recently in the case between the Japanese FSA against Citigroup and UBS in December 2011 (Financial Services Agency, 2011abc), and the UK and US regulators' against Barclays in July 2012 (Financial Services Authority, 2012; U.S. Commodity Futures Trading Commission, 2012).

Individually submitted LIBOR rates are not binding and LIBOR panel banks do not have to commit to their quotes in any way. Instead, the BBA LIBOR rule states that the submitted rate must be formed from that bank's perception of its cost of unsecured funds in the interbank market, i.e. the London Money Market (British Bankers Association, 2012a). Likewise, the rules for the TIBOR and the EURIBOR

do not mention any requirement to act as a market maker at the submitted rate (Japanese Bankers Association, 2012a; European Banking Federation, 2012acd). However, regardless if a binding rule exists or not, the reputational damage of some kind of manipulation should not be totally disregarded. Being seen as unfair and putting an own bank's interests ahead of those of the clients can be equally damaging. Moreover, possibly an even more important factor is the informal gentlemen's agreements about 'fair play' that exist in financial markets, and it would be unreasonable to assume that even traders are not bound by such. Problematically though, agreements such as these tend to break down in a crisis situation.

However, some kind of reputational constraint could, both in theory and in practise, be imposed in order to prevent banks from submitting rates that deviate from their 'actual' funding cost. In this chapter, the reputational constraint has been modelled similarly to a 'binding rule', making it clear that LIBOR panel banks not only get penalised by submitting deceptive quotes, but also reap the reward in case another bank decides to do so. As such, it resembles a realistic market making scenario where a market maker is eager to avoid quoting a misprice that will be exploited by a market taker, but at the same time hoping for another market maker to do so and thereby exploiting the market making obligation of the latter. It could also be seen as mechanism whereby individual LIBOR quotes are checked against real transaction data. This chapter, however, shows that the constraint mechanism might need to be prohibitively high to have the desired effect, namely to prevent LIBOR panel banks from only looking after their own interests.

In sum, these games show illustrate how LIBOR panel banks can have the means, opportunities and incentives to submit deceptive quotes – resulting in a LIBOR fixing that deviates from the 'actual' average bank funding cost. The LIBOR games are not zero-sum games, and the exclusive privilege to be able to play this game gives banks power to influence the LIBOR in a direction that is beneficial to them.

CHAPTER 7

LIBOR as a Keynesian Beauty Contest: A Process of Endogenous Deception

7.1. Introduction

The previous chapter introduced a game-theoretic approach to illustrate how the LIBOR fixing, at a given time, can be driven by different incentives and constraints of the individual LIBOR panel banks. Using simple game theory, it can be shown that collusion is possible, but not a pre-requisite, for a LIBOR fixing deviating from what could be regarded as the prevailing money market rate.

This chapter extends this analysis by sketching a situation that resembles a more realistic situation. First, a larger LIBOR panel is introduced, with a more robust trimming process. Second, the assumptions with regards to the derivatives portfolios are relaxed; now allowing for endowments to have any sign or size, and its ability to change from day to day as old trades mature and new trades are put on. Third, the funding cost is no longer assumed not to be identical among the banks, but diverse – and *to some degree* also observable by the market as a whole. Thus, the stigma acts as a tighter constraint on some banks more than others. Fourth, the LIBOR Game is not played once, but repeatedly until infinity. Players learn from previous rounds, and can take into account anticipated moves in future rounds. This type of game is significantly more complex, but so its degree of realism. LIBOR banks are hardly solely driven by self-interest, rationality and probability functions – but also guided

by prevailing conventions and anticipation of what others will do, and what they in turn anticipate others will do.

Up until around 2008, the LIBOR was widely perceived to be a reliable reflection of the interbank money market. Recently, however, claims that the benchmark, at times, has been subject to attempts of manipulation by LIBOR panel banks, have put this into question. This chapter extends the game-theoretic analysis from the previous chapter, but shifts the focus more towards the discrepancy between the LIBOR, and the rate it *fundamentally* should reflect, namely the interbank money market rate.

Keynesian Beauty Contests in general, and *p*-beauty contest games in particular, have often been used to illustrate why stock markets are volatile and how the price of a tradable asset systematically can deviate what objectively could be regarded as its 'fundamental value'. From this perspective, we could also consider if some kind of fundamental value exists in the money market, and if and why the money market rate at times deviates from this fundamental value. The LIBOR, in this context, should be seen as a reflection of the money market rate, and not *vice versa*.

The LIBOR rate is supposed to be an 'objective' reflection of the interbank money market rate, and more specifically the average subjectively reported funding cost of a group of banks. Using the Keynesian Beauty Contest framework, this chapter conceptualises the money market as a kind of fundamental value against which the LIBOR should be benchmarked. This 'LIBOR game', being played an infinite number of times, consists of players guided by the anticipation of what others will do and what they anticipate others will do. By regarding the LIBOR fixing as the outcome of a peculiar form of a *p*-beauty contest game, a situation is demonstrated where the LIBOR deviates from this money market rate (loosely defined as 'M' in the previous chapter). In fact, a *p*-beauty contest game is precisely how we could view the LIBOR Game.

Importantly, as players are also guided by the anticipation of what others will do and what they anticipate others will do, some LIBOR panel banks can also be seen as being driven towards a behavioural pattern that is not dependent on their own incentives and constraints in the first instance, but generated endogenously though the process itself. Deception in this case does not need to result from the self-interest of an individual LIBOR submitter, but rather from the perception that others will act

in such a manner that not submitting deceptive LIBOR quotes would be punished. This can result in long-lasting deviations of the LIBOR from the underlying money market. As the LIBOR fixing mechanism facilitates such behaviour, it is characterised by a fundamental and systematic flaw.

This chapter begins with a brief overview of the typical *p*-beauty contest games in the literature, and a discussion on how the LIBOR could conceptually fit into this context. Next, a LIBOR *p*-beauty contest game is constructed with the aim of being as realistic as possible. Given the utility function of each player (LIBOR panel bank), possible outcomes of this game are then considered. Finally, conclusions are drawn – highlighting that deception is not randomly distributed among the banks, but can have a tendency to become endogenous to the LIBOR fixing process itself. This has implications for understanding the dimensions and relations of power: LIBOR panel banks not only have power over the LIBOR by being allowed to play the game, the process reinforces this power and can induce LIBOR panel banks to exercise it in a certain and systematic way – sometimes even against their own will or 'unintentionally'.

7.2. The *p*-Beauty Contest Game: Regarding the Money Market as the 'Fundamental Value'

'Professional investment may be likened to those newspaper competitions in which the competitors have to pick out the six prettiest faces from a hundred photographs, the prize being awarded to the competitor whose choice most nearly corresponds to the average preferences of the competitors as a whole: so that each competitor has to pick, not those faces which he himself finds prettiest, but those which he thinks likeliest to catch the fancy of the other competitors, all of whom are looking at the problem from the same point of view. It is not a case of choosing those which, to the best of one's judgement, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligences to anticipating what average opinion expects the average opinion to be. And there are some, I believe, who practise the fourth, fifth and higher degrees.' (Keynes, 1936: p. 156)

The passage by Keynes above has provided the basic platform for numerous and different variants of games labelled as Keynesian Beauty Contest games. In essence, we are in dealing with the phenomenon of market participants not always simply

seeking a long-term fundamental value of an asset, but taking a more short-term view and incorporating what they believe others will do and how they believe others will do and so on.

Although some of the games modelled with this passage in mind might lack direct connotations to Keynes (Fung, 2006; Lanteri & Carabelli, 2011), we are nonetheless concerned with the observation that the price of a financial asset often deviates from the consensus view of the fundamental value of the asset in question. Moreover, the price reaction to changes in fundamentals in a beauty contest is much more sluggish than that of the consensus fundamental value (Allen, Morris & Shin, 2006). To put it differently, game-theory is used to understand and illustrate the role of higher-order beliefs in asset pricing as each market participant has the ability to affect the market price, and he knows that the others do as well.

A typical illustration of a *p*-beauty contest game is when a large number of players simultaneously shall choose a number from a closed interval [0,100]. The person who chooses the number closest to p times the mean wins a prize. In case there is a draw, the prize is divided equally amongst the winners. To explain the process in a classic *p*-beauty contest game, p is normally set at 2/3. Assuming the guesses are normally distributed between 0 and 100, the rational guess would there be two-thirds of 50, i.e. 33. But since others think the same, it would be 22 (two-thirds of 33), and so on. Hence, for $0 \leq p < 1$ there is only one Nash equilibrium, namely zero (see for instance Duffy & Nagel, 1997; Ho, Camerer & Weigelt, 1998; Nagel, 1995, 1999; Nagel et al., 2002).

There are many variants of this game in the literature. For instance, the game might consist of a group of players that are supposed to guess the average number of the group, where either $p = 1$, $0 < p < 1$ or $p > 1$. We could also have a situation where players know their own *p*s, but not that of the others (i.e. p only being private knowledge). Suppose we have a game with many players where there are 3 types of players, each simultaneously selecting a number [0,100]. Player type 1 shall guess p times the mean where $p = 2/3$, player type 2 where $p = 1$ and player type 3 where $p = 4/3$. No player knows the other's p, neither the distribution of the *p*s among the players. Furthermore, players could be obliged to pay a 'fine' whose size is determined by how far the chosen number deviates from the best guess[24]. Thus,

[24] For a *p*-beauty contest designed with 'fines', see Güth, Kocher & Sutter (2001).

whichever type of *p*-beauty contest game is modelled, within each specific game, players need to anticipate what the others will do and what they will anticipate others will do and so on.

Recalling the choice of optimal strategy (which depends on what the other players are *expected* to do) from the different LIBOR games presented in Chapter 6, we can sketch a game bearing closer resemblance to a real situation. In fact, a *p*-beauty contest game is precisely how we could view the LIBOR Game.

In chapter 2, it was shown how the LIBOR traditionally has been decomposed into current and expected future risk-free interest rates, credit and liquidity risk. This approach assumes that the LIBOR rate is 'objective' in the sense that it perfectly reflects where the panel banks are able to raise funds from each other, i.e. the money market rate. Problematically, the method is fundamentally flawed should the LIBOR for one reason or the other not equal this money market rate.

In terms of a Keynesian Beauty Contest, the LIBOR, as a benchmark, should reflect the money market – and not *vice versa*. Conceptually then, we could treat the money market rate (whether perfectly observable or not) as a kind of fundamental value, or a focal point, towards which the LIBOR rate should aim. More specifically, the LIBOR fixing mechanism can be viewed as a game with more than two players where $p = 1$ in a *p*-beauty contest game.

Let us assume that the money market rate is common knowledge and all banks face the same funding cost. Banks in such a game would be driven by a desire to guess exactly the average of all guesses. Theoretically, we have a coordination game with infinitively many equilibrium points in which all players choose the same number (see Ochs, 1995)**.** However, in a LIBOR game, we do have a natural focal point: the money market rate. Therefore, the money market rate could be regarded as the fundamental value and also $p = 1$. The trimming process (with the highest and lowest quotes being omitted from the process) is a mechanism put in place to ensure that players remain alert and aim for $p = 1$ in every round of the game.

The frequent use of fixed intervals in *p*-beauty contest games is not without controversy, as it could be argued that the price drift of a financial asset often lacks

typical boundaries. To some degree, the same could be said about the LIBOR, which has experienced some sharp moves during times of crisis. Nonetheless, the boundaries are hardly infinite, and some kind of fixed range of numbers or a 'tolerated' LIBOR range probably exists theoretically. It could, for instance, be argued that a 'zero lower bound' of nominal interest rates could be applied to the LIBOR as well (although this could change should the central bank in question decide to lower the policy rate well below zero). The upper bound might be high, as the LIBOR should reflect any liquidity and credit strains in the banking system. However, it still ought to correspond to some kind of 'worst-case-scenario' where the central bank is *perceived* to be forced to step in by intervening in the money markets. After all, at some LIBOR-level, banks become insolvent and should be removed from the fixing panel in question.

Another special feature of the LIBOR game is the fixing mechanism, where outliers are omitted through a trimming process. However, as players tends to avoid extreme endpoints (see Rubinstein, Tversky & Heller, 1997), and also learn from the LIBOR fixing of the previous day, outliers will increase their efforts not to be omitted the next day. Thus, the original design of the LIBOR fixing mechanism could be seen as a median-effort-game (see Cachon & Camerer, 1996), where it is assumed that LIBOR panel banks harmonise their behaviour following a learning process. However, players in the LIBOR game may have different incentives or constraints in the form of endowments, reputation and stigma distorting this coordination process. Moreover, players might not know the optimal strategy of the others.

In the context of a *p*-beauty contest game, we could therefore consider a new variant with the following basic setup: 16 players choose a number between [0,100] and aim to guess closest to the mean times $p = 2/3$. However, in contrast to the classic *p*-beauty contest game, in terms of calculation of the mean, only the 8 middle quotes are considered (after the 4 highest and 4 lowest are omitted).

Players in a LIBOR game could also be assigned endowments, that are either positive, zero or negative, and that are private knowledge. The endowment (denoted as 'E') could, for instance, be a LIBOR-indexed derivatives portfolio that gives players the incentive to play a certain way. We could see this as a game where player type 1 shall guess *p* times the mean (between [0,100]) where $p = 2/3$ (in other words E^-), player type 2 where $p = 1$ (E^0) and player type 3 where $p = 4/3$ (E^+). If $p \neq 1$ we

immediately get a situation where the LIBOR becomes more likely to deviate from the 'actual' money market rate, as players are allocated different focal points depending on their underlying LIBOR-indexed derivatives portfolios.

Another feature of this game could be that each player is ranked individually from 1 to 16 by an 'independent referee', according to how good they are perceived to be at this game, with their rankings being public knowledge. Furthermore, the rules in this game could also state two distinct possibilities of receiving a fine. First, a reputational fine is paid according to how far they deviate from the 'correct' guess. Players are thus given the incentive to take the game seriously. Second, players receive an additional fine if they, on average, manage to outwit higher ranked players (in other words choose a number that is lower than the average of the numbers guessed by the players ranked above him). This is to prevent the audience from distrusting the integrity of the game, as well as the judgement of the independent referee.

Using these particular features as our point of reference, let us now turn to the LIBOR *p*-beauty contest game.

7.3. The LIBOR *p*-Beauty Contest Game

7.3.1. Rules of the Game

Consider a hypothetical LIBOR game with 16 players (LIBOR panel banks). The LIBOR fixing procedure is as follows. A calculation agent collects the submitted quotes from the 16 individual panel banks before noon. The individual LIBOR submissions are done simultaneously, without the ability to see each others' quotes. Then, the calculation agent conducts the 'trimming', the omission the 4 highest and 4 lowest quotes. Thereafter, the arithmetic mean is calculated of the 8 remaining LIBOR submissions.

The game is being played from t_{-1} to infinity. Let us also assume that each player is only allowed to adjust their quotes by increments of 10 basis points (0.10%).

Furthermore, the tolerable LIBOR range is [0.00%, 2.00%]. These are not a necessary conditions, but useful for the sake of simplicity and clarity of argument.
In the first round (at t_{-1}) all 16 banks faced the same (largely known) funding cost (M), as they were perceived to be equally creditworthy and had similar access to liquidity. The banks had no endowments. Therefore, M was the clear focal point and all banks submitted LIBOR quotes at, or close to, the funding cost at the time (assumed to be, say, 1.00%). Hence, as outliers were omitted through the trimming process, the LIBOR fixing at t_{-1} was 1.00%. In effect, this can be seen as having been a *p*-beauty contest with p=1.

Now, let us assume that four significant changes takes place at t_0, without altering the fixing mechanism as such.

First, some players are given a LIBOR-indexed derivatives portfolio, or an endowment (E), which is private knowledge. The payoff from the endowment in each round depends on the sign and size of the endowment, as well as the change in the LIBOR fixing (L^F):

$$\pi^{E}_{i(t)} = E_i \Delta L^F, \qquad (7.1)$$

where $\Delta L^F = L^F_t - L^F_{t-1}$. Thus, each player has an incentive to submit a quote that maximises the expected change in value of the endowment from t_{-1} to t.

This could now be seen as a *p*-beauty contest game, where we have 3 types of players not knowing what type the others are or the distribution among them, not dissimilar from the single-period LIBOR games introduced in the previous chapter. Player type 1 shall guess p times the mean where p = 2/3 (in other words E^-), player type 2 where p = 1 (E^0) and player type 3 where p = 4/3 (E^+). The strategy of each player would simply depend on the sign of the endowment at each point of time.

The second change is the introduction of a 'stigma' attached to submitting a relatively high LIBOR. This is directly caused by a credit crisis, leading to a wider distribution of the perceived creditworthiness of the players (banks) by the market. Due to the crisis, the average bank funding cost has now increased from 1.00% to 2.00%. Let us assume that the OIS price is unchanged, implying that the increase in the funding cost is purely a reflection of increased credit and liquidity strains. As a

result, higher market volatility also allows for larger day-to-day moves (0.20% instead of 0.10%), and an increase in the tolerable LIBOR range to [0.00%, 4.00%]. Further, the wider distribution of the perceived creditworthiness at t_0 calls for the introduction of an independent an objective referee as well as an internal ranking system of the players. Let us simply say that the referee is 'the market'. The internal ranking system is market-determined in the sense that each player is allocated a place hierarchically according to how creditworthy it is perceived to be compared to its peers. The perceived creditworthiness of each individual bank is assessed by the observable 5-year CDS spreads in the market, which prior to t_0 were identical.

Let us now assume that from t_0, the CDS spreads are unequally distributed between the 16 banks {A, B, C... P}, ranging from 100 bps to 475 bps. $Bank_A$ (CDS = 100) is perceived as the most creditworthy, $Bank_B$ slightly less (CDS = 125) and so on. $Bank_P$ is regarded as the riskiest with a CDS spread of 475 bps. Let us also assume that the CDS spreads remain constant throughout the game.

As a result, the bank funding cost is now partly dependent on the long-term funding cost (the CDS price which is public knowledge) and the short-term funding cost (which is private knowledge only, but subjectively communicated through the LIBOR submission). Thus, each bank now not only wants to maximise the value of its LIBOR-indexed derivatives portfolio, but also wants to minimise the stigma (σ) attached to having a relatively high funding cost. The payoff from the stigma can be written as:

$$\pi^{\sigma}_{i(t)} = (\lambda \Delta \sigma_i^{LT} + \chi \Delta \sigma_i^{ST}), \tag{7.2}$$

where λ and χ are constants. The RHS of the equation consists of two parts: the stigma derived from the long-term funding cost, and the stigma from the short-term funding cost (the LIBOR). The long-term funding cost is exogenously determined and market-observable (measured by the CDS spread). The payoff from this stigma (σ^{LT}) cannot be influenced by the player's actions as it is market-determined:

$$\Delta \sigma_i^{LT} = \left(CDS_{i(t)} - \frac{\sum_{j=1}^{16} CDS_{j(t)}}{16} \right) - \left(CDS_{i(t-1)} - \frac{\sum_{j=1}^{16} CDS_{j(t-1)}}{16} \right) \tag{7.3}$$

However, the stigma derived from the short-term funding cost (σ^{ST}) is *endogenously* derived from the LIBOR fixing mechanism, which the player has influence over.

Here, the individual banks can (and wish to) minimise the bank funding cost as it is perceived to be by the market:

$$\Delta\sigma_i^{ST} = \left(L_{i(t)} - \frac{\sum_{j=1}^{16} L_{j(t)}}{16}\right) - \left(L_{i(t-1)} - \frac{\sum_{j=1}^{16} L_{j(t-1)}}{16}\right) \quad (7.4)$$

The third change in the game is the introduction of a reputational constraint. Namely, each player is subject to a reputational fine (expressed as 'ϕ') of how much the player's LIBOR quote deviates from the mean of the others:

$$\pi_{i(t)}^{\phi} = \left|L_{i(t)} - \frac{\sum_{j\neq i} L_{j(t)}}{15}\right| \phi \quad (7.5)$$

This is to protect third-party actors with exposure to the LIBOR from being affected by potential incentives individual banks might have to submit either too high, or too low, quotes.

Finally, the fourth change is the introduction of an integrity constraint, where each player is also subject to a integrity fine (denoted 'ω') should they signal a relatively too low funding cost, as the market (which is aware of the CDS-spreads) would not regard it as credible should a bank claim its short-term funding cost to be lower than those with lower CDS spreads:

$$\pi_{i(t)}^{\omega} = f(F_i^{LT}, F_i^{ST})\omega \quad (7.6)$$

In sum, the new payoff function for each player can be written as follows:

$$\pi_{i(t)} = E_{i(t)}\Delta L^F - \left(\left|L_{i(t)} - \frac{\sum_{j\neq i} L_{j(t)}}{15}\right| \phi + \lambda\Delta\sigma_i^{LT} + \chi\Delta\sigma_i^{ST} + f(F_i^{LT}, F_i^{ST})\omega\right) \quad (7.7)$$

Next, let us discuss the outcomes of this game.

7.3.2. Outcome: A Process towards 'Endogenous Deception'

To analyse the potential outcomes of this game, let us first recap the LIBOR fixing at t_{-1}, which was 1.00%. The credit crisis then resulted in an average increase in the short-term funding cost by 1.00%. Following the new restriction of only being

allowed to move in 0.20% increments in each round, the 'market' should expect a LIBOR fixing at 1.20% at t_0, 1.40% at t_1 and finally 2.00% at t_4, as each player gradually submits a higher LIBOR quote. Since the average short-term funding cost now is 2.00%, which could be regarded as the 'fundamental value of M', we should theoretically expect this to be reflected in the LIBOR fixing as time progresses.

However, the new game now also more closely resembles that of the 'real' LIBOR fixing mechanism, and new incentives and constraints apply. Importantly, the mechanics of this game can imply a totally different outcome.

The endowments change the dynamics of the game. As LIBOR banks are now given incentives to submit deceptive quotes (like in the single-period LIBOR games), the quotes will now be more widely dispersed. Players with small or no endowments at all ($E \approx 0$) have no incentive to submit deceptive quotes, and would therefore, on average, increase their quotes towards the expected 2.00%.

A player with E^- would choose to submit 0.80% and a player with E^+ 1.20% in the first round. Moreover, they would gradually move towards the respective extreme points of the tolerated range (0.00% or 4.00%). Many quotes would naturally be omitted through the fixing process. Nonetheless, the outcome after a number of rounds have been played would depend on the distribution of the endowments, and in this case also the learning process that follows from the signalling in each round.

However, the reputational constraint (expressed by 'ϕ'**)** works as a hindrance to submit overly deceptive quotes, as the fine takes into account the size of the deviation from the average quotes. At the outset, the LIBOR should drift towards 2.00% in a few days as the average funding cost, which is public knowledge, has increased substantially. This knowledge should make players with E^+ more comfortable in raising their quotes than players with E^- in lowering their quotes. However, the reputational constraint prevents any player from adjusting his quote by a large increment, as this could cause a reputational fine. Should the groups with E^+ and E^- be equally distributed, the LIBOR would have a tendency to move (albeit slowly) higher. Should the E/ϕ-ratio increase, players with large endowments would have the incentive to change their quote slightly more in their favour as the relatively small fine of being an outlier is outweighed by the possibility that others think and do the same.

Importantly, players with $E \approx 0$ cannot be safely assured that a 'fair' quote or even a quote in a 'fairer' direction will be left unpunished. The reputational cost occurs regardless if the player has an endowment or not, and imitating the crowd will consequently be necessary to avoid potential losses stemming from being an outlier. In fact, the mere expectation that players in a large sub-group (say with E^-) will shift their quotes in one direction will prompt players with E^0 to do the same, as they would otherwise (possibly unfairly) face a penalty from deviating from the mean. Thus, at this stage the game can be seen as a situation where incentives are balanced against the constraint of having to imitate the crowd.

Now, since t_0, the individual bank funding costs are diverse, which in itself should imply LIBOR quotes scattered around 2.00% after a few days as the market expects the LIBOR to trend toward its fundamental value. In fact, judging by the observable CDS spreads, the market should expect some kind of ordering of the LIBOR quotes from the 'best' banks' quotes well below 2% and the 'worst' banks' significantly above 2%. The trimming mechanism should ensure that the extreme outliers are omitted (those hardly affected by the crisis and those facing severe trouble and possibly even nationalisation).

From the players' perspective, however, the worsening perceived long-term, as well as the short-term, funding cost have a direct negative impact. In this game, the long-term funding cost is exogenous determined, expressed by the CDS market. However, whereas the measure for the long-term funding cost is public knowledge, the short-term funding cost lacks transparency. Instead, players are assessed according to their own assessments announced through their respective LIBOR submissions. In both instances players are rewarded (or penalised) according to how they compare against their peers. Thus, all banks now have an incentive to submit relatively low LIBOR quotes to distance themselves from the others.

Leaving the endowments aside for a moment, the integrity constraint (ω) prevents all banks apart from $Bank_A$ to submit a relatively low quote at t_0, as they would automatically face a penalty not only from deviating from the others (the reputational constraint), but also from having submitted a non-credible quote (the integrity constraint). The market or the wider public, comparing the CDS spreads between the

players, would simply not believe that the player's own assessment of its credit and liquidity standing is correct.

If the reputational cost is small, but not non-existent, and the potential stigma payoff large, $Bank_A$ would have an incentive to signal to the market that its short-term funding cost indeed is much lower than that of its peers (by submitting, say, 0.90%). At t_1, with the results from the previous round now taken into account into the respective strategy decisions, $Bank_B$ can safely quote 0.90%, whereby $Bank_A$ has the opportunity to lower its quote a step further (to 0.80%) in order to distinguish itself even further from the its less creditworthy peers . At t_2, it is $Bank_C$'s turn to quote 0.90%, whereas $Bank_A$ and $Bank_B$ yet again opt to distance themselves further from the less creditworthy banks. Seen in isolation, this process would continue until the Nash equilibrium of 0.00% is reached.

However - and here is the essence of the *p*-beauty contest game - banks *anticipate* that the others will move. $Bank_B$ can therefore safely quote, say, 0.95% already at t_0, as it *knows* that the best strategy of $Bank_A$ is to quote 0.90% (as it is also aware of the CDS spread of the other banks). Likewise, $Bank_C$ anticipates that $Bank_B$ anticipates that $Bank_A$ will quote 0.90% and can therefore also lower its quote slightly – and so on. Now, $Bank_A$, in the first place, also anticipates that others anticipate its initial move and therefore takes this into already with its first move.

The economics imply that the average funding cost is 2.00% and that the LIBOR fixing should not trend lower, but higher. This LIBOR *p*-beauty contest game, however, illustrates that even though the LIBOR 'should' trend towards 2.00%, this process can be very slow or not happen at all. In fact, the game shows that the opposite can take place. Therefore, this LIBOR game is about imitating the crowd, but at the same time trying to outsmart it slightly, with the knowledge that others will do the same. The combination of different incentives and constraints, and the anticipation of what others will do, result in a slow process towards an equilibrium not necessarily equalling the 'expected' average funding cost of the panel banks. Furthermore, quotes can be narrowly distributed which might not be justified by the distribution of perceived creditworthiness among the panel banks.

Naturally, banks with strong incentives (from endowments or stigma) to submit deceptive quotes can be better off doing so. In this game, however, even players

seemingly without such incentives get caught up in this process. For instance, players with a bank funding cost precisely equalling the average of 2% can be penalised from not only finding themselves as unexpected outliers, but being 'required' to signal a slightly better creditworthiness than actually assessed internally. Likewise, players with negligible or no endowments at all can become less focused on the fundamental money market rate, than the anticipated LIBOR-rate. In sum, even for the seemingly average and fair player, the LIBOR *p*-beauty contest game becomes a loss-making process of *not* following the crowd. Deception can be seen as a problem not specific to the behaviour of individual players, but systematic and endogenous to the LIBOR fixing process itself.

7.4. Concluding Discussion

The 4-player single-period LIBOR games in Chapter 6 showed that the trimming process, or limited reputational constraints, might not be effective in ensuring a 'fair' LIBOR fixing. An endowment in the form of a LIBOR-indexed derivatives portfolio, or the stigma attached to signalling a high funding costs relative to others, can act as incentives to submit deceptive LIBOR quotes. Different forms of collusion can be a possible – but not exclusive – reason for an off-market LIBOR if panel banks do not know each others' endowments, but rather assume that all banks always aim to opt for the best possible strategy to use its ability to influence the LIBOR fixing.

In contrast to the games using a Bayes Nash solution, the LIBOR *p*-beauty contest game is not driven by probability functions. Rather, players anticipate what others will do, and what they anticipate others will do and so on. The process is assisted by the learning process, as quotes are the individual quotes are revealed daily, and a new round is being played already the following business day. Therefore, players can form opinions how to interpret the moves of others, and thereby better judge the distribution of the incentives and constraints of others.

By regarding the LIBOR fixing as the outcome of a peculiar form of a *p*-beauty contest game, we have illustrated how the LIBOR can systematically deviate from what could be regarded as its fundamental value, namely the consensus view of

where the average money market funding cost is. The exclusive privilege to be able to influence the LIBOR rate rests with the LIBOR panel banks.

LIBOR-indexed derivatives portfolios can act as incentives to submit deceptive quotes. What is more, there is nothing preventing LIBOR banks from increasing or decreasing their own exposure to the benchmark they themselves can influence. Systematically favourable LIBOR fixings give the incentive to keep or increase the exposures, while unfavourable fixings give incentive to reduce them. In the LIBOR *p*-beauty contest game presented in this chapter, it would obviously pay for some players to collude through communication, should it be possible. For instance, a group of banks with identical endowments might want to mutually agree to opt for the same strategy to maximise the expected payoff, and consequently also share the reputational 'fine'.

However, seen in isolation, the 'stigma' works against collusion, as individual banks are judged individually compared to their peers. Therefore, another incentive to submit a deceptive quote is derived from the stigma of signalling a relatively high funding cost. This is perhaps the single most important explanation why anecdotal evidence throughout the global financial crisis has suggested that the LIBOR consistently has been too low. This view is also supported by recent investigations into the conduct of a number of LIBOR panel banks.

The LIBOR *p*-beauty contest game modelled in this chapter highlights another feature of the stigma: its relation to market indicators. For instance, the Bank of England uses the sum of LIBOR and the CDS spreads of the large U.K. banks as a credit cost measurement in the Financial Stability reports, as measures for the short-term and long-term funding cost of the banks. The LIBOR *p*-beauty contest game highlights that even though both are *observable* variables; the latter can act as a variable that influences the LIBOR panel banks to submit deceptive quotes. It is important to remember that the LIBOR is not a market *per se*, but a benchmark of where the selected panel banks *argue* the market is. However, none of the benchmarks are fully based upon observable market prices. Individually submitted LIBOR rates are not binding, but should be formed from that bank's *perception* of its cost of unsecured funds in the interbank market. The ambiguity can of course be greater, if the 'actual' money market rate is volatile or even unknown – which the

current financial crisis has shown repeatedly since the summer of 2007. This, as such, gives LIBOR panel banks more room for 'manoeuvre'.

If the long-term funding cost of a particular bank is observable through some market-determined process (such as the CDS market), whereas the short-term funding cost is a kind of self-assessment (the LIBOR), the former can act as a variable that influences the LIBOR panel banks to submit deceptive quotes. This fundamental problem is highlighted through the 'integrity constraint' in the game. It could be argued that the individual quotes by the LIBOR panel banks should be 'ranked' according to their perceived creditworthiness in the market, for instance by their respective CDS-spreads. Even though no such ranking systems exist officially, the continuous market assessment of long-term creditworthiness, and the LIBOR banks' awareness of it, induces a process whereby banks want to look good, but not 'too' good. The integrity constraint in the LIBOR *p*-beauty contest game also shows that even though players at times might be ordered correctly, the distance between them depends on the other features of the game.

In fact, the results show how the LIBOR can have a tendency to observe a certain 'stickiness'[25], and how the different LIBOR quotes among the panel banks can be more narrowly distributed than would be suggested by other financial indicators. As such, it might give the false impression that the money market is stable, and that banks have fairly similar funding costs. For instance, a Greek bank practically shut out of interbank funding is under no requirement to submit a higher EURIBOR rate than others. However, as was demonstrated already during the Japanese banking crisis and the era of the Japan Premium, some banks can be perceived to be more creditworthy than others and a higher LIBOR rate would therefore be expected. In the Japanese case, it meant that the Japanese yen TIBOR (consisting mainly of Japanese banks) fixed higher than the Japanese yen LIBOR (with relatively few Japanese banks). Similarly, it meant that Japanese LIBOR contributors consistently became outliers and subject to the trimming process. The integrity constraint shows that even though players at times might be ordered 'correctly', the distance between them depends on the other features of the game.

[25] The LIBOR has tended to react more slowly to unexpected rate moves, liquidity and credit shocks than the 'actual' money market rate.

The ‘reputational constraint’ appears as an incentive not to submit a LIBOR quote that deviates too much from the others. In essence, the goal becomes not to outsmart the market, but to imitate the crowd. A possible and striking outcome of this is the inability of fair players, with small endowments or an average funding cost level, to determine the outcome of the game, despite their natural desire to harmonise their quotes around the ‘fundamental rate’. Deception can become endogenous to the LIBOR fixing process, and *not* deceiving is punished in similar way as to paying above market for a distraught asset. Moreover, communication and signalling becomes endogenous to the LIBOR *p*-beauty contest game, as it is played 5 business days a week and more than 200 times a year. Collusion might lead to quicker and more certain outcomes. However, a non-cooperative LIBOR game such as this can lead to the same results; although their ‘conception of the solution’ is totally different (see Schelling, 1980: pp. 94-95).

The trimming process has often been regarded as an effective prevention method against systematic manipulation[26]. This assumes either that artificially low and high quotes are normally distributed, or that a LIBOR panel bank knows that a deceptive quote will be omitted from the calculation and therefore will be ineffective. However, neither the outcomes of the single-period LIBOR games in the previous chapter, nor of the *p*-beauty contest game presented here, support this argument. Moreover, a typical LIBOR panel composition is probably not heterogeneous, but fairly homogenous at the outset. Namely, a common feature of all LIBOR panels is that they largely consist of universal ‘too-big-to-fail’ banks that are highly active (and normally market-makers) in the money, foreign exchange and derivatives markets. As the recent global financial crisis has shown, the distribution of their asset and liabilities is not randomly distributed, but fairly similar.

Most importantly though, as players are also guided by the anticipation of what others will do and what they anticipate others will do, some LIBOR panel banks can also be seen as being driven towards a behavioural pattern that is not dependent on their own incentives and constraints in the first instance, but generated *endogenously* though the process itself. Deception in this case does not need to result from the self-interest of an individual LIBOR submitter, but from the perception that others will act in such a manner that *not* submitting deceptive LIBOR quotes would be

[26] Gyntelberg & Wooldbridge (2008), for instance, acknowledge that LIBOR panel banks, in theory, could act strategically in their fixing, but that the trimming process acts as a hindering factor.

penalised. As such, the LIBOR fixing mechanism is characterised by a fundamental and systematic flaw.

In sum, by regarding the LIBOR fixing as the outcome of a peculiar form of a *p*-beauty contest game, we can illustrate how the LIBOR can systematically deviate from what could be regarded as its fundamental value, namely the consensus view of where the average money market funding cost is. The privilege to be able to influence this rate rests with the LIBOR panel banks and, as already previously stated, players have power over the LIBOR by having the exclusive privilege to be allowed to play the game. Importantly though, as players are also guided by the anticipation of what others will do and what they anticipate others will do, some LIBOR panel banks can also be seen as being driven towards a behavioural pattern that is not dependent on their own incentives and constraints in the first instance, but generated *endogenously* though the process itself. Deception in this case does not immediately need to result from greed or self-interest, but rather from the perception that others will act in such a manner that *not* submitting deceptive LIBOR quotes would be punished. The power, as expressed in the LIBOR as an instrument, becomes reinforced as the 'manipulation' (whether conscious or unconscious) receives a kind of conventional status. This acts to further diffuse the distinction between the LIBOR and the money market rate it is supposed to reflect.

CHAPTER 8

LIBOR Club Power:
A Case Study on the NIBOR

8.1. LIBOR Clubs

The two previous chapters illustrated how the LIBOR rate setting process can be analysed from a game-theoretic perspective - demonstrating that collusion is a possible, but not a necessary, prerequisite for 'off-market' LIBOR equilibria – or LIBORs that deviate from what the market fundamentally could expect to see. This becomes particularly evident during a financial crisis where (homogenous) banks have large LIBOR-based derivatives portfolios, and the mechanism lacks rules of transparency and enforcement. Players (banks) can be seen as having power, simply by having the exclusive privilege of being allowed to play the LIBOR fixing game, and thus being in a position to influence the LIBOR. The fixing mechanism itself works to reinforce this power. The LIBOR can have a tendency to become 'sticky' and individual quotes to end up unduly 'bundled' together, thereby proving the false impression of not only the creditworthiness of particular banks, but also of the liquidity of the money market which the LIBOR is intended to fundamentally reflect.

However, whereas the outcome of the LIBOR games depends on the decisions by individual players and collective aggregates of these by predicting outcomes in certain situations (like Rational Choice Theory), collective goals and norms are put aside. This chapter goes beyond the game-theoretic approach. By focusing on the

institutions and networks that make up the rules of the game, it brings power in its relational sense back to the equation.

The institutional dimension of power, as outlined in Chapter 3, relates to actors' control over others in indirect ways, and specifically through the formal and informal institutions that mediate between A and B. The main difference between 'compulsory' and institutional power is that in the latter A does not necessarily possess the institution that constrains and shapes B. But since A stands in a particular relation to the relevant institutional arrangements, its actions exercise power over B. Regulatory capture can occur if interest groups, such as a particular industry, use their powers to shape the constraints (regimes, regulation, laws etc) that are favourable to them (see Stigler 1971: pp. 3-21). The outcome therefore does not only depend on the decision maker, but the power of the interest groups. By locating the LIBOR within its institutional arrangements (by treating the group of LIBOR panel banks as 'A', and the central bank as 'B'), we can begin to investigate of the institutional power of these 'LIBOR clubs' over central banks.

Naturally, central banks have an interest in participating, at least as an observer, in important matters relating to financial markets and benchmarks they are influenced and constrained by. For instance, they are founding members of the Association Cambiste Internationale (ACI)[27], or more commonly known as Forex – the leading trade organisation for dealers in foreign exchange and money markets. Central banks also participate in the International Capital Market Association (ICMA, 2012), which represents a broad range of capital market interests and is the forum for market conventions and standards within capital markets; and in the International Swaps Dealers Association (ISDA)[28], although primarily as 'subscriber members' in contrast to the banks and market makers acting as 'primary members'. Indeed, the central banks normally take the pivotal role in appointing primary dealers in foreign exchange and in governments bonds (often in collaboration with the Treasury or the Debt Office). Hereby, they act as natural 'managers of the club of banks', referring to Goodhart's terminology.

[27] ACI The Financial Markets Association (2008a)
[28] ISDA (2012)

However, due to its history in the Eurodollar market (see Chapter 5), the LIBOR has never been under the jurisdiction of the central bank. The benchmark lacks regulation, and central banks do not have authority over the LIBOR fixing mechanism or panel composition. This does not necessarily imply that the LIBOR lacks rules. Institutionalised social practises and conventions in the form of benchmarks and indices are generally governed and constituted by a shared set of rules (Porter, 2005: p. 71), which can have a high degree of autonomy from governments or central banks.

What sets the LIBOR clubs apart, however, is that the authority generally lies within the LIBOR clubs, namely the committees consisting of the LIBOR fixing panel banks themselves. Moreover, in contrast to the regulation, supervision and enforcement of banks in general (conducted by central banks or regulatory bodies such as the SEC or the FSA), the 'governing body' with regards to the LIBOR clubs are usually the bank lobby organisations.

The governance of other financial benchmarks, or indeed simply market conventions, tends to be transparent and subject to influence by the needs and wants of a wider range of users and participants. Hence, the regulation - albeit often with a 'soft' touch - of money or foreign exchange markets, is influenced not only by the general market practises amongst the market making banks, but also to some degree by other 'players' involved, such as central banks, regulators and end-users. However, this regulation, or 'institutionalisation of power', with regards to the LIBOR differs markedly though the link to the lobby organisations, as the main objectives and tasks of these associations are to promote the interests of its members, not the soundness of the market convention or the integrity of the benchmark (see Appendix 1 for an overview). The BBA (which governs the LIBOR) aims to influence decision makers through '*promoting a legislative and regulatory system for banking and financial services'[…]'which takes account of our members' needs and concerns and provides an effective and competitive market place in which their businesses can prosper*. BBA also *'promote[s] and defends the [banking] industry'* by engaging *'with government, devolved administrations and Europe as well as the media and other*

key stakeholders to ensure the industry's voice is heard and to highlight the strength and importance of UK banking.'[29]

Among the guiding principles of the European Banking Federation (governing the EURIBOR in conjunction with the ACI) is *'to promote the principles of self-regulation and better regulation within the EU, so as to alleviate the burden on banks and improve their competitiveness; and work to win support for ever increasing regulatory convergence internationally, to advocate free and fair competition in EU and world markets, to lobby at EU and international level in support of the free market and to ensure that European banks face a level playing field on EU and global markets, operating free of unfair distortions of competition, to support banks' efforts to increase their efficiency and competitiveness, to support the banking industry's efforts to increase efficiency and improve customer service'[...]'Its aim is to ensure that the experience and the views of banks are taken into consideration in the shaping of relevant policies. The EBF also actively promotes the positions of the European financial services, and in particular the banking industry in international fora.'*[30] The primary task of the Danish Bankers Association (which oversees the CIBOR) is *'to create good operating conditions for the banks'* and *'closely monitor the political processes and play an active and specific role in political decision-making that is relevant for the banks' business platform. In so doing, we target our efforts and communication at, for example, the Danish Parliament, the government and the EU.'*[31]Among the Japanese Bankers Association's (governing the TIBOR) tasks is '*to support the banking business of member banks'* by amongst other things '*expressing opinions on financial system reform and other banking-related matters, researching banking-related matters and providing policy recommendations.'*[32] The Swedish and Norwegian benchmarks (NIBOR[33] and STIBOR) have been more informally governed, normally through committee meetings between the panel banks themselves.

[29] British Bankers Association (2012b)
[30] European Banking Federation (2012b)
[31] Finansraadet (2012)
[32] Japanese Bankers Association (2012b)
[33] Since recently governed by FNO

The LIBOR panel compositions have slowly changed over time, mainly as a result of bank mergers, and now generally include large universal banks that are highly active - and normally market-makers - in the money, foreign exchange and derivatives markets (see Chapter 5 and Appendix 1). Likewise, despite the differences in size (ranging from just 5 members in the STIBOR Club to 43 in the EURIBOR Club) they have also tended to increasingly include international banks that are not under the direct jurisdiction of the central bank issuing the underlying currency for that particular benchmark. In other words, they are either typical too-big-to-fail banks for the domestic banking system, or 'global systematically important banks' – with, for instance, 14 out of the 18 USD LIBOR panel members belonging to the latter group (see Appendix 1 and Financial Stability Board, 2011). However, a common and special characteristic of the LIBOR clubs is that they are self-regulated, or overseen by lobby organisations of the banks themselves, in other words interest groups that protect the institutional setting of the LIBOR.

Membership in a LIBOR club is very difficult to obtain, as the formal selection criteria per definition not only exclude non-bank financial institutions from the clubs, but implicitly also the vast majority of smaller and medium-size banks. Requirements such as branch presence, market making ability, sizeable trading activity and reputation result in disqualification for most institutions already at the application stage (British Bankers Association, 2013; European Banking Federation, 2012c; FNO, 2011; Japanese Bankers Association, 2012a). However, not only are the formal barriers to entry high as specified by the governing bodies, anecdotal evidence gathered from interviews with several non-panel institutions point towards another, arguably more crucial hurdle: 'informal' resistance among the existing panel members to broaden or diversify the panel base. A 'reputable' bank might find it difficult to enter, whereas an existing member (even under the spotlight of financial regulators) might continue to submit LIBOR quotes on a daily basis. 'Competition' is also hindered by the lack of transparency with regards to the clubs.

The ongoing integrity of the LIBOR is protected by the clubs themselves, or associations working for the clubs. It should not come as a surprise that the lobby organisations often have acted as defendants on behalf of the banks regarding the integrity of the LIBOR fixing mechanism, despite pressure from individual non-

member banks and end-users such as pension funds, corporations and hedge funds. Even the ACI has expressed their critical view with regards to recent investigations, supported by the wider market community[34].

Thus, the LIBOR panel banks are not only powerful insofar as they generally are large universal banks, and could be regarded as a strong collective formation with monetary power. If we treat them as a 'LIBOR clubs', we can see that power could become associated with collective goals and a kind of normative consensus. As they stand in a particular relation to the central bank, they can exercise institutional power over the latter. The club sets the rules, which can influence the LIBOR, which in turn has an impact on the preferences and constraints of the central bank, such as the timing and magnitude of a repo rate adjustment or the assessment of the stress in the financial system and appropriate policy measures.

No major overhaul, or rule change, with regards to the LIBOR has taken place since its inception. The institutions, such as the fixing mechanism or the panel bank composition, that make up the LIBOR-equivalent benchmarks have remained remarkably unchanged since its invention, despite far-reaching changes in financial markets generally, perhaps as the clubs have had an interest in maintaining a status quo for several decades.

In fact, this precise lack of regime or rule change, and the high degree of secrecy with regards to the process, makes an investigation into institutional power difficult. Simply claiming that LIBOR clubs consist of 'powerful banks', and are supported by 'powerful lobbying groups' is insufficient in explaining rule changes – or indeed the lack of such change.

An interesting exception to this rule of status quo is the Norwegian Interbank Offered Rate (NIBOR) that underwent a rule change at the time of the collapse of Lehman Brothers in September 2008. This chapter studies this change up until the end of 2011, considering the institutional power relationship between the NIBOR Club and Norges Bank.

[34] ACI The Financial Markets Association (2008ab)

The case study begins by briefly explaining the unique NIBOR fixing mechanism and puts it into the perspective of the central bank. The rule change, a fundamental amendment in the fixing procedure, is then tested empirically, showing the significant impact it had on the Norwegian krone risk premium. Importantly, as the rule change was instigated and executed by the NIBOR Club and the NIBOR Club only, it serves as an illustration of its power. The chapter concludes with by discussing the policy implications upon the central bank.

8.2. Notes on Data

Market data in this chapter 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).

8.3. Actor A: The NIBOR Club

8.3.1. The CIP Deviation as a Trigger Point

Norges Bank, an early adopter of inflation targeting, has gradually become more transparent in setting regular Monetary Policy Committee (MPC) meeting schedules and by publishing its own inflation, repo rate and risk premium projections. Its most important monetary policy instrument is the folio rate, which is the interest rate on banks deposits in Norges Bank. This influences short-term money market rates, in particular the NIBOR, the key benchmark affecting the wider Norwegian economy.

The global financial crisis had an impact on Norway as well. However, despite the worsening credit situation and the global liquidity concerns appearing in 2007, the inflation outlook caused Norges Bank to maintain a fairly hawkish stance with regards to monetary policy well into 2008. The collapse of Lehman Brothers, however, saw a sharp reversal in this policy, prompting large rate cuts and liquidity injections similar to those of other central banks. Norges Bank also entered into swap facilities with the Federal Reserve to address the elevated pressures in USD short-term funding markets.

By shifting the focus from the macroeconomic situation to that of the LIBOR, it is important to note that the NIBOR fixing mechanism is unique among the developed countries as it more 'purely' reflects the history of the benchmark in having derived from the Eurocurrency market. As the NIBOR will be used as the 'lens' in this chapter, a brief description of the benchmark is necessary.

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. Instead, banks mutually agreed that the NIBOR should be based upon the CIP formula applying market USD/NOK FX swap rates and the USD LIBOR as the base interest rate. As the markets became increasingly liquid over the years, banks found no reason to change this mechanism as it had been firmly anchored as the benchmark

for a range of financial contracts, including new NOK derivatives instruments, such as FRAs, IRSs and CRSs.

The NIBOR panel consists of six Nordic banks as of today[35]. The general fixing mechanism is similar to that of other benchmarks, but the small size of the panel implies that only two submitted quotes (the highest and lowest) are omitted from the trimming procedure, and the arithmetic mean thus calculated from only four remaining NIBOR quotes. However, 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. The NIBOR should, according to their trade organisation FNO '*reflect the interest rate level lenders require for unsecured money market lending in NOK'* and also *reflect 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.*'[36]

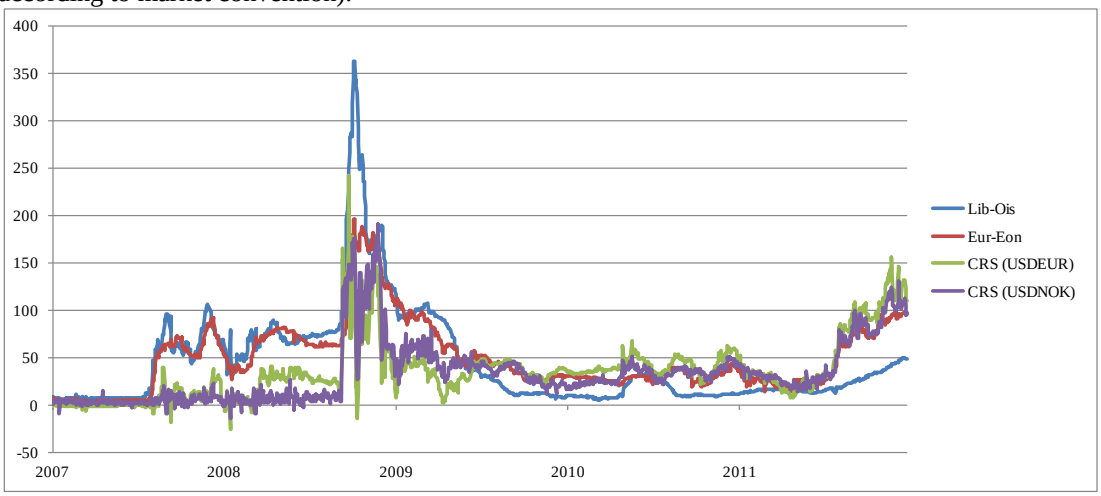
Further, NIBOR submissions should be '*regarded as best possible estimates, not binding offers*'. Thus, as with the London-based LIBOR, banks are not required to trade at these rates. More specifically, they are not *required* to trade at the USD interest rate, but *expected to be prepared* to trade at the USD/NOK FX swap points submitted. The latter is not backed up by a written rule, but by a gentlemen's agreement among the participating banks. However, the mutually agreed FX swap bid-offer spreads for the NIBOR fixing mechanism are significantly wider that of the tradable interbank market, making trading at these prices less likely in any case. Nonetheless, a submitted FX swap rate widely different from the interbank market would normally raise complaints from other panel members.

Nordic banks, like their other European peers, faced similar difficulties in raising USD in the Eurodollar markets 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 in 2008, the LIBOR began to systematically deviate from the CIP – suggesting that the benchmark significantly *understated* the real funding cost of the banks. In

[35] Danske Bank, Den Norske Bank, Handelsbanken, Nordea, SEB and Swedbank
[36] FNO (2011)

financial market terms, the cross-currency basis swap (CRS), as measured against the USD, turned negative. Figure 8.1 depicts this change, using an inverted scale.

Figure 8.1: 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. This should, however, not be interpreted as Norwegian banks necessarily found it easier to raise USD funding compared to their peers. Instead, it was a 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.

8.3.2. A Rule Change Secretly Instigated by the NIBOR Club

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 a more 'subjective' USD rate for the NIBOR calculation. At the time of the rule change, the 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. Moreover, Carl Kliem was a money broker screen, and was as such easier to 'defend' than a purely subjective quote.[37]

However, as can be read from the Carl Kliem broker screen on the Reuters page 'KLIEMMM', its 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, which will be discussed in subsequent sections.

To study the impact of the rule change on the NIBOR step-by-step, let us begin by using the standard expression for the money market risk premium (RP), the LIBOR-OIS spread:

$$RP_t^{CCY} = Libor_t^{CCY} - Ois_t^{CCY}, \tag{8.1}$$

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:

$$KliemOis_t^{USD} = Kliem_t^{USD} - Ois_t^{USD}, \tag{8.2}$$

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*.

[37] This is according to interviews with several NIBOR-panel banks. The rule change, however, was not openly disclosed to other market participants, nor has it been publicly documented since.

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:

$$Eib_t^{USD} = \left[\left(1 + Euribor_t^{EUR} * \frac{d_t}{360}\right)\frac{s_t^{EURUSD}}{f_t^{EURUSD}} - 1\right] * \frac{360}{d_t}, \quad (8.3)$$

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[38] and d_t is the number of days for maturity *t*. This USD risk premium can thus be written as:

$$EibOis_t^{USD} = \left[\left(1 + Euribor_t^{EUR} * \frac{d_t}{360}\right)\frac{s_t^{EUR/USD}}{f_t^{EUR/USD}} - 1\right] * \frac{360}{d_t} - Ois_t^{USD} \quad (8.4)$$

Carl Kliem *should* be using the CIP to arrive at the Kliem USD rate. To test whether this statement holds, let us thus run the following regression:

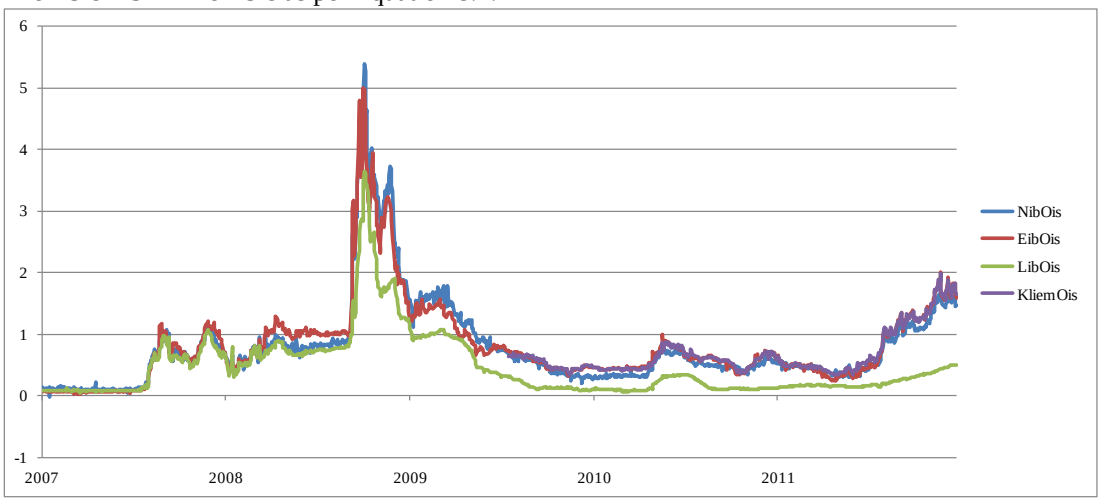
$$KliemOis_t^{USD} = \alpha_t + \beta(EibOis^{USD})_t + \varepsilon_{t,} \quad (8.5)$$

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 A5.1 (see also Figure 8.2).

[38] The differences in the equations stem from the market convention of EUR being the base currency for EUR/USD and NOK for USD/NOK.

Figure 8.2: 3M NibOis; EibOis, LibOis; KliemOis 2007 – 2011 (%): NibOis = 3M NibOis as per Equation 8.8; EibOis = 3M EibOis as per Equation 8.4; LibOis = 3M USD LIBOR – 3M USD OIS; KliemOis = 3M KliemOis as per Equation 8.2.



Sources: Thomson Reuters and author's own calculations

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 ($\bar{R}^2$ 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 not subjective, but an *implied* rate.

8.3.3. Testing the NIBOR Rule Change

The next step is to test the impact of the rule change on the *NOK risk premium*. Let us begin by using Equation 8.1 to express a USD risk premium facing NIBOR panel banks:

$$NibOis_t^{USD} = Nib_t^{USD} - Ois_t^{USD}, \qquad (8.6)$$

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:

$$Nib_t^{USD} = \left[\left(1 + Nibor_t * \frac{d_t}{360}\right)\frac{s_t^{USD/NOK}}{f_t^{USD/NOK}} - 1\right] * \frac{360}{d_t}, \quad (8.7)$$

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*. As a result, inserting Equation 8.7 into 8.6 gives us an expression for the USD risk premium facing NIBOR panel banks ($NibOis_t^{USD}$):

$$NibOis_t^{USD} = \left[\left(1 + Nibor_t * \frac{d_t}{360}\right)\frac{s_t^{USD/NOK}}{f_t^{USD/NOK}} - 1\right] * \frac{360}{d_t} - Ois_t^{USD} \quad (8.8)$$

Thus, 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. Since the rule change, NibOis is likely to be more correlated with EibOis, as EibOis ≈ KliemOis. This can be tested by running the following two regressions for 3-month maturities:

$$NibOis_t^{USD} = \alpha_t + \beta(LibOis^{USD})_t + \varepsilon_t \quad (8.9)$$

$$NibOis_t^{USD} = \alpha_t + \beta(EibOis^{USD})_t + \varepsilon_t \quad (8.10)$$

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

8.3.4. Empirical Results

During Period I (see Table A5.2) both $\text{LibOis}^{\text{USD}}$ *and* $\text{EibOis}^{\text{USD}}$ 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. $\text{LibOis}^{\text{USD}}$ and $\text{EibOis}^{\text{USD}}$ increased significantly thereafter, whereas both the EUR/USD and USD/NOK CRS (albeit showing increased volatility) remained close to zero (see also Figure 8.1). 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[39]. 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 A5.3), 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 A5.4) 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.

Finally, Period IV (see Table A5.5) 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).

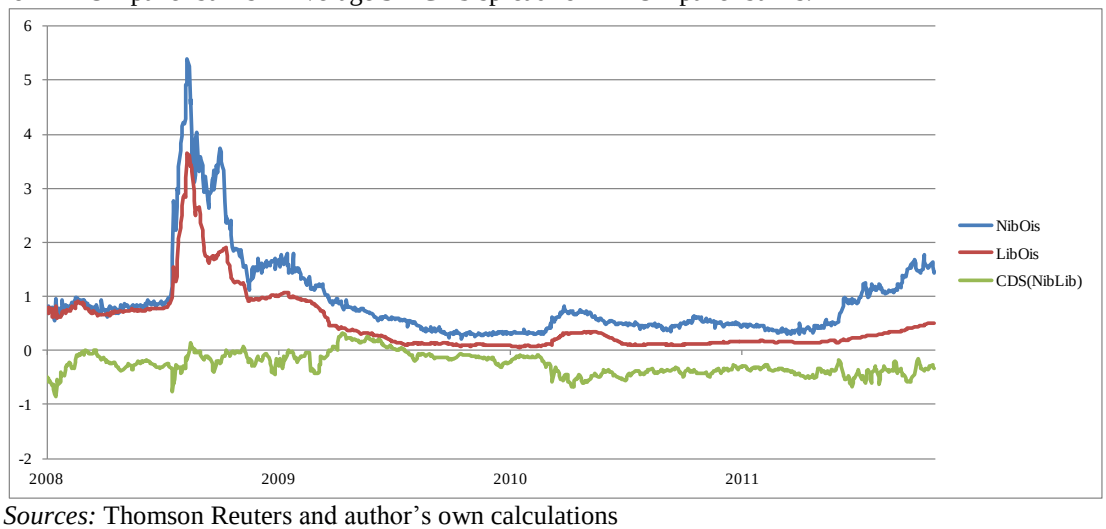
Thus, the empirical evidence presented here suggests that the NIBOR panel banks did replace the LIBOR with a more subjective USD rate at the time of the Lehman Brothers bankruptcy, after arguing that the LIBOR no longer reflected the true USD

[39] 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.

interbank funding cost. The mechanism, or the 'rules of the game', was changed by the NIBOR Club. However, after closer scrutiny we can conclude that this rate is not subjective 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.

According the logic of traditional methods to decompose the LIBOR (as discussed in Chapter 2), which assume that the LIBOR is a market-determined rate, a change in the perceived credit and/or liquidity risk should determine the level and development of the various USD risk premium expressions. Although we know the reasons behind the deviations between the different risk premium expressions (i.e. the rule change), these drivers could, theoretically, also have been important factors in increasing the imported USD premium. NIBOR panel might have found it more difficult to raise funding in USD compared to their peers in the LIBOR panel. However, as Figure 8.3 shows (depicting the average 5-year CDS spreads of the respective panels), the NIBOR panel banks have generally been regarded as *more* creditworthy than the LIBOR-peers since September 2008. The only exception is a brief period in early 2009, when the exposure to the Baltic mortgage market by Swedish banks dragged down the 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 8.3: 3M NibOis; 3M LibOis; 5Y CDS (NibLib) 2008-2011 (%): NibOis = 3M NibOis as per Equation 8.8; 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[40]. Neither should market liquidity have an impact on the regressions, as the data has been adjusted for the prevailing bid-offer spreads.

As such, this empirical study supports the claims expressed in Chapter 2, namely that the traditional decomposition of the LIBOR disregards something very fundamental: that the LIBOR is not a market.

8.4. Actor B: Norges Bank

8.4.1. The Impact on the NOK 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. The NIBOR is the central variable in the first step of the Norwegian monetary transmission mechanism. The smoothness and transparency of this mechanism, acting as a constraint on the central bank, can be affected both through central bank policy, and market forces. This section, however, extracts the impact solely resulting from rule change instigated by the NIBOR Club.

To study the direct impact of the rule change, let us first use the standard expression for the money market risk premium (RP), the LIBOR-OIS spread:

$$RP_t^{CCY} = Libor_t^{CCY} - Ois_t^{CCY} \tag{8.11}$$

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

$$RP_t^{NOK} = Nibor_t^{NOK} - Nois_t^{NOK}, \tag{8.12}$$

[40] 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.

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. Using the OIS as risk-free rate (whether it is tradable or purely theoretical) enables to decompose the NIBOR into specific components – before and after the rule change.

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:

$$CRS(Ois^{CCY2}Ois^{CCY1})_t =$$
$$Ois_t^{CCY2} - \left[\left(1 + Ois_t^{CCY1} * \frac{d_t}{360}\right)\frac{f_t^{CCY1/CCY2}}{s_t^{CCY1/CCY2}} - 1\right] * \frac{360}{d_t} \quad (8.13)$$

Hence, for NOK against USD as:

$$CRS(NoisOis)_t =$$
$$Nois_t^{NOK} - \left[\left(1 + Ois_t^{USD} * \frac{d_t}{360}\right)\frac{f_t^{USD/NOK}}{s_t^{USD/NOK}} - 1\right] * \frac{360}{d_t}, \quad (8.14)$$

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

Inserting Equation 8.14 into 8.6 gives us a close approximation of the 'old' NIBOR (which was based upon the LIBOR):

$$Nibor(old)_t^{NOK} \approx Libor_t^{USD} + (Nois_t^{NOK} - Ois_t^{USD}) - CRS(NoisOis)_t, \quad (8.15)$$

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

$$RP(old)_t^{NOK} \approx (Libor_t^{USD} - Ois_t^{USD}) - CRS(NoisOis)_t \quad (8.16)$$

We can see from Equation 8.16 that there were two drivers of the old NOK risk premium: the USD LIBOR-OIS spread and the CRS spread between NOIS and OIS. Hence, neither a repo rate adjustment by the Federal Reserve, nor by Norges Bank (or market expectations of such) has a 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, we can see that 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.

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 8.15, the 'new' NIBOR equation (after the rule change) can be written as:

$$Nibor(new)_t^{NOK} \approx Kliem_t{}^{USD} + (Nois_t^{NOK} - Ois_t^{USD}) - CRS(NoisOis)_t \qquad (8.17)$$

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

$$Kliem_t^{USD} \approx \left[\left(1 + Euribor_t^{EUR} * \frac{d_t}{360}\right)\frac{s_t^{EURUSD}}{f_t^{EURUSD}} - 1\right] * \frac{360}{d_t} \qquad (8.18)$$

Next, following Equation 8.13, the cross currency basis swap for EUR against USD using OIS can be written as:

$$CRS(EoniaOis)_t = Eonia_t^{EUR} - \left[\left(1 + Ois_t^{USD} * \frac{d_t}{360}\right)\frac{f_t^{USD/EUR}}{s_t^{USD/EUR}} - 1\right] * \frac{360}{d_t} \quad (8.19)$$

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 8.18 and 8.19 give us:

$$Kliem_t^{USD} \approx Euribor_t^{EUR} - (Eonia_t^{EUR} - Ois_t^{USD}) + CRS(EoniaOis)_t \quad (8.20)$$

Therefore, by inserting Equation 8.20 into 8.17, we get an expression of the 'new' NOK risk premium:

$$RP(new)_t^{NOK} \approx (Euribor^{EUR} - Eonia^{EUR})_t + CRS(EoniaOis)_t - CRS(NoisOis)_t \quad (8.21)$$

As Equation 8.21 shows, the dynamics of the NOK risk premium have now changed fundamentally. 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 its large panel size (43 banks). However, the EURIBOR has not managed to escape allegations of systematic manipulation either. 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. 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 that of the Norges Bank since 2010.

With regards to the CRS, the impact of the USD/NOK swap market remains 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 health of the European banking system. Moreover, whereas the CRS component previously could be influenced by Norges Bank and/or the Federal Reserve, an additional 'player' has entered this arena: the European Central Bank. The effect of this change on the NOK risk premium has been particularly notable during times of Eurozone stress.

During the spring of 2010, the European sovereign debt crisis gave rise to renewed pressures in the money markets fuelled by uncertainty over each other's debt holdings and funding ability, pushing up LIBOR-OIS as well as EURIBOR-EONIA spreads as banks became reluctant to lend to each other. Moreover, the FX swap and the cross-currency swap markets started to indicate serious strains in the interbank lending market for USD, particularly in the Eurozone. As argued by amongst others Baba & Packer (2008, 2009), non-US financial institutions were largely responsible for the deviations from the CIP from 2007 onwards[41]. These strains were a symptom of European banks being unable, or having to pay a high cost, to fund their activities in the U.S., which had surged since the launch of the euro. The drivers this time were different, however. European banks had faced funding problems from different sources: in addition to short-term funding problems reflected in LIBORs, banks had also experienced more medium-term funding problems, such as rolling over their corporate debt. Moreover, reflecting the increased internationalisation of the banking systems, European banks faced a specific funding gap for dollar assets as a result of

[41] Basing the hypothesis on the observation that European financial institutions were largely on the dollar borrowing side of the EUR/USD FX swap market, an asymmetry of counterparty risk between European and US financial institutions could potentially show up in deviations from CIP.

them taking positions in dollar denominated assets (Kaltenbrunner et al., 2010). With the European Central Bank unable to offer USD, and the Federal Reserve unable to lend directly to European banks, USD swap lines were on re-introduced on 9 May 2010. However, spreads remained elevated and very closely correlated with the prevailing uncertainty with regards to Eurozone sovereign – and consequently also – bank risk. Thus, the conditions for the swap lines were eased on 3 November 2011 to '*ease strains in financial markets and thereby mitigate the effects of such strains on the supply of credit to households and businesses and so help foster economic activity*.' (European Central Bank, 2011b). The swap networks not only highlighted how interconnected the banking systems had become, but the importance and the power of the Federal Reserve with its control over the world's reserve currency.

The net impact of the NIBOR rule change on the NOK risk premium can be quantified (by subtracting Equation 8.21 from 8.16). The results, which are fairly substantial, can be seen in Table 8.1 (and Figure 8.3).

Table 8.1: 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

Since the rule change, the NOK risk premium has been around 30 basis points higher than should the old method have been used. However, the effect on the risk premium has been 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[42]). Considering that Norges Bank most frequently adjusts its repo rate in 25 bps increments, the effect is not insignificant on monetary policy.

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

However, the relatively high risk premium is probably more due to the NIBOR rule change rather than to the specific domestic money market conditions as suggested by Norges Bank (2010a):

'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.'

8.4.2. The Impact on the NOK Risk Premium Projections

Consistently higher NOK risk premium does not necessarily need to be damaging if its causes are well understood and appropriate offsetting policy measures available. The fixing mechanism, relatively speaking, *understated* the premium previously, and now possibly *overstates* it. However, decisions with regards to monetary policy and financial policy are not made on an ad hoc basis, but are forward-looking. As such, models to support policy decisions include expectations and forecasts:

'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)

A change in a LIBOR rule, as such, need not change the objective function of a central bank. However, if the drivers of the risk premium change fundamentally as a result of a rule change, forecasts become constrained by them.

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. As there is no NOK OIS market, a 'theoretical NOIS' has to be

constructed. 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). However, 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 analyse the projected NOK risk premia by Norges Bank 3, 6 and 9 months forward, let us first define:

$$\Delta RP_{t+1}^{NB} = RP_{t+1}^{NB} - RP_{t}^{NB}, \tag{8.22}$$

where $\Delta \mathrm{RP}_{t+1}^{\mathrm{NB}}$ 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[43].

Table 8.2 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 8.2: NOK Risk Premia Assessed by Norges Bank in its Monetary Policy Reports (MPR) (%). 5-day moving averages.

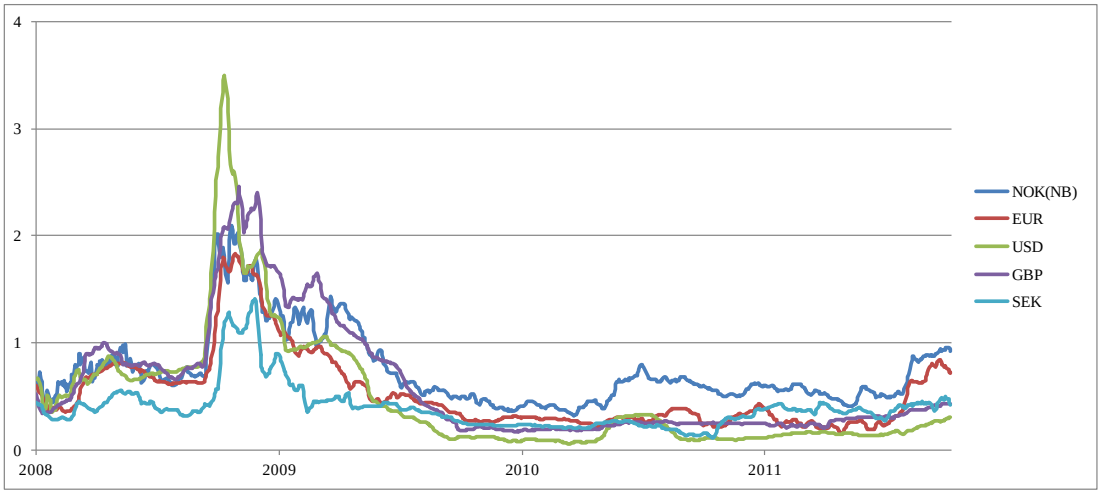
	Estimate	Projected Δ (Norges Bank)			Actual Δ			Difference		
MPR	*t*	3M	6M	9M	3M	6M	9M	3M	6M	9M
29.10.08	1.79	-0.51	-1.04	-1.24	-0.67	-0.57	-1.16	-0.16	0.47	0.08
25.03.09	1.15	-0.19	-0.30	-0.33	-0.41	-0.63	-0.77	-0.22	-0.33	-0.44
17.06.09	0.89	-0.29	-0.31	-0.33	-0.33	-0.51	-0.52	-0.04	-0.20	-0.19
28.10.09	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

[43] 5-day moving averages are used henceforth to match Norges Bank's method.

Although this chapter has no intention to assess how well the projections have fared compared to the market (or any other model), several observations are notable. First, throughout the period studied, Norges Bank has regarded the NOK risk premia as higher than its peers. As Figure 8.4 shows, Norges Bank has consistently regarded 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 has, without exception, projected a narrowing of the NOK risk premium over time. Third, since MPR 3/2009, Norges bank has, again without exception, been too optimistic with regards to the development of the NOK risk premium. Importantly, these differences have been largest around the time of Eurozone stress.

Figure 8.4: 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

Naturally, repo rate and 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 the central bank) affects the money market rate (and the LIBOR-benchmark), and the expected future money market rates (as observed in the FRA and IRS markets) impact long term rates, which in turn influence economic output and inflation. The LIBOR 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. Thus, an

institutional regime change impacting the LIBOR will not only have an influence the current observable risk premium, but on expected future risk premia as well.

Returning to Equation 8.21, 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 a comparison, let us first see how the market has priced and projected the first two drivers:

$$\Delta EurEon_{t+1}^{MKT} = EurEon_{t+1}^{MKT} - EurEon_{t}^{MKT} \quad (8.23)$$

$$\Delta CRS(EonOis)_{t+1}^{MKT} = CRS(EonOis)_{t+1}^{MKT} - CRS(EonOis)_{t}^{MKT}, \quad (8.24)$$

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.

We can see from Table 8.3 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 8.4, 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 8.3: 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

Source: Thomson Reuters Datastream

Table 8.4: CRS (EonOis) 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	1.58	-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

However, the NOK risk premium also depends on the outlook for the remaining component, namely the demand for USD relative to NOK in OIS-terms: the CRS (NoisOis). As we cannot compute the Nois precisely in the absence of a NOK OIS market, we could suggest that the remaining components equals the residual of the NOK risk premium calculated by the central bank minus the 2 observable variables:

$$CRS(NoisOis)_{t+1}^{NB/MKT} \approx RP_{t+1}^{NB} - EurEon_{t+1}^{MKT} - CRS(EonOis)_{t+1}^{MKT} \quad (8.25)$$

However, for this equation to hold, Norges Bank ought to have consistently had a specific view on the USD/NOK CRS market that not only deviated from market expectations, but also conflicted with its statements published at the MPC meetings during this period. In other words, the projections would have included an assessment that the NIBOR panel banks, over time, would face USD funding difficulties being relatively more severe than for the Eurozone banks. This is unlikely, as even though the Eurozone crisis has had spill-over effects on the

Norwegian banking system, the overall effects have been more contained, not least evidenced by the Norges Bank itself in regarding it unnecessary to reintroduce the FX swap lines with the Federal Reserve.

Theoretically, the optimistic risk premium projections could also have been derived from a view that more accommodative liquidity provisions in NOK would become necessary. However, this is unlikely, as Norges Bank since 2010 has 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)

Therefore, it appears as if even though the NOK risk premium projections ought to be more influenced by risk premia in the Eurozone, Norges Bank have considered other outcomes more likely: either that the market overstated the problems in the Eurozone, or that the NIBOR panel banks would begin to regard the Kliem USD rates as too high and embark on yet another rule change. Such a decision, however, could only be able taken by the NIBOR Club.

8.5. Concluding Remarks

The case study in this chapter has shown that a rule change initiated by the NIBOR Club has had a significant impact on the NOK risk premium, and the way the premium should be forecast. The change, itself, was not random, but resulted from the USD LIBOR having become an increasingly doubtful and biased reflection of the 'actual' funding cost of banks. However, the power to change the rule at will rested with the NIBOR Club only. This ability to fundamentally change the rules that influence the benchmark can be attributed not to the central bank, a regulator or the market as a whole, but to the club of banks that make up the panel. Using an

institutional approach to power such as this suggests that a rule change ought to have been favourable to the club members in order for them to follow it though. It could, for instance, be that NIBOR banks benefit more from higher fixings (due to large floating NIBOR mortgage portfolios) than their peers in other jurisdictions. However, evidence for this is difficult to obtain. Moreover, the NIBOR fixing mechanism is unique, the panel relatively is small and a rule change such as this is a rare event. Nonetheless, the case study should serve as an illustration of how much institutional power rests within a LIBOR Club, and how this can influence the central bank. With regards to the NIBOR change, it has resulted in higher domestic risk premia 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, the NIBOR fixing now also has another independent variable: the CRS (EonOis) spread, showing the demand by, and ability of, Eurozone banks to fund themselves in USD. The CRS (NoisOis) variable works to offset this impact. However, should the Dollar Premium be more elevated in the Eurozone than in Norway, as it has been during this crisis, this would be 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. As such, the constraints on the Norwegian monetary transmission mechanism have been altered fundamentally as a result of this change.

Norges Bank has, however, recognised some of the weaknesses with the NIBOR fixing mechanism, in its lack of regulation and transparency:

'*There are also other weaknesses in Norway's money market. When setting household and corporate interest rates, banks not only take into account movements in the key rate, but also give weight to the money market rate, i.e. the Norwegian InterBank Offered Rate (NIBOR). In our opinion, there are shortcomings in the way this rate is set. The basis for setting the rate can be made more transparent for the benefit of other participants and it is calculated using information from only six large participants. This group does not include Norway's largest saving banks or any international banks. We will take the initiative for improving the structure for setting NIBOR.*' (Norges Bank, 2010a)

Despite this, no major changes to the NIBOR have taken place as of yet - apart from the benchmark now being overseen by FNO, the trade organisation of the banks, instead of exclusively by the NIBOR panel banks themselves.

CHAPTER 9

Conclusions

'We will end up with a new regime based on actual transactions. The idea we can base it on 'my word is my LIBOR' is dead.' (Bank of England Governor Sir Mervyn King on 29 June 2012) [44]

9.1. Introduction

This dissertation has investigated the LIBOR by questioning the assumption that the LIBOR is an outcome of the market, and instead directly addressed some of its fundamental issues inherent in the benchmark. These issues can be seen in terms of separate, but interlinked, layers of the power relationship between central banks and LIBOR banks. Each issue has been given its own distinct dimension, stemming from different theoretical approaches to the concept of power.

This concluding chapter serves as a summary of the ramifications of this study. As the LIBOR has been used as lens to study a specific power relationship, the implications upon the two actors involved in this relationship will be discussed. The dissertation has revealed some issues that could be regarded as fundamental flaws in the LIBOR as benchmark. Recent proposals to reform the LIBOR will therefore also be considered.

[44] Masters & Giles (2012)

9.2. The Power of LIBOR Banks

The LIBOR fixing mechanism has been investigated in detail in this dissertation using a game-theoretic approach. Several non-zero-sum LIBOR Games have been modelled and then solved using a standard Bayes Nash solution. It has been shown that collusive behaviour between LIBOR panel banks, or between banks and money market brokers, can lead to LIBOR fixings that deviate from what could be regarded as the 'actual' funding costs of the banks. However, collusive behaviour is not a prerequisite for such outcomes. Assuming banks are rational and act out of self-interest, their endowments (such as LIBOR-indexed derivatives portfolios), or the stigma attached to signalling a relatively high funding cost, can provide LIBOR panel banks with sufficient incentives to submit quotes deviating from their actual funding cost. The trimming process, widely regarded as a hurdle for outright and single-handed manipulation, is shown to be overwhelmingly ineffective. Moreover, binding rules or constraints introduced in order to enhance transparency provide disappointing results. Therefore, it has been demonstrated that the LIBOR games are characterised by an inherent structure whereby banks have the means, opportunities and incentives to submit deceptive quotes, leading to LIBOR fixings that deviate from the 'actual' average bank funding cost. Banks are given the chance to influence the LIBOR in a direction that is beneficial to them - stemming from the 'exclusive privilege to be able to play the LIBOR game', in other words to participate in the LIBOR fixing process.

Moreover, the dissertation has argued that the 'actual' short-term money market rate can be seen as a kind of fundamental value, or focal point, towards which the LIBOR should aim. By treating the LIBOR as the outcome of a of *p*-beauty contest game, where the behaviour of the LIBOR banks are guided by higher order beliefs, a process is created whereby they are not solely dependent on their own incentives and constraints. Instead, potential deception can be seen as being generated endogenously though the fixing process itself. Simply the anticipation of possible attempts by others to submit deceptive LIBOR quotes will prompt neutral banks to play 'dishonestly'. As a result, it has been demonstrated that deviations of the LIBOR

from what could be regarded as its fundamental value (the underlying money market), need not be of temporary, but of long-lasting and systematic, nature.

However, power cannot only be seen as a collective aggregate of individual decisions. The institutional dimension is this dissertation has highlighted the unique institutionalised social practises and conventions that form the rules of the 'LIBOR game'. LIBOR panel banks seen as a collective can be treated as special 'LIBOR clubs'. The regulation, or institutionalisation of power, with regards to the LIBOR, has been shown to be highly self-regulatory and closely linked to the interests of the LIBOR banks. An empirical case study has demonstrated that the 'ability to (re)write the rules of the LIBOR game' constitutes power - having direct implications on central bank policy.

Finally, by putting the LIBOR into the context of increasing structural power of the self-regulated markets, it has been shown that LIBOR banks have 'been able to gain by rewriting the rules of the LIBOR Game'. From a political economy perspective, the interests of the LIBOR banks have been served through different structural changes, ranging from financial innovation to deregulation.

As this dissertation has demonstrated, the power of LIBOR banks can be seen as being exercised through different dimensions. It is taking place at an almost individual level, through the fixing mechanism whereupon individual traders or bank employees submit their quotes. It can also become more systematic, and endogenous, as this process becomes rooted in daily routines. Finally, the power can be attributed to the specific networks and institutions forming the 'LIBOR clubs', and into a wider structural context. As such, LIBOR banks can be regarded as 'powerful'.

9.3. LIBOR and the Power of Central Banks

As discussed in Chapter 4, the other actor in this relationship, the central bank, has a completely different incentive structure, and ability to exercise power, from that of the LIBOR banks. However, the LIBOR is important for the central bank, and the

implications from the conclusions above therefore need to be addressed in a systematic way. Following the schema in Chapter 4 (by Dahl and Harsanyi respectively), let us expand the analysis by using a classification by Harsanyi (1962ab) in referring to the strength of A's power over B, or the opportunity costs to B of refusing to do what A wants him to do. The strength can be seen as subjective as it explains B's subjective motivation in complying with A. This can be structured in terms of four different influence techniques available to A.

The first influence technique relates to transparency and asymmetric information. According to Harsanyi, one influence technique available to A is to supply 'information' (or 'misinformation') on (allegedly) already existing advantages and/or disadvantages connected with various alternative policies open to the other power holder.

Central banks in general have gradually moved towards greater transparency in terms of monetary policy, often in tandem with adopting inflation targeting and gaining a more independent status. The transparency has, for instance, included the introduction of scheduled Monetary Policy Committee meeting dates; the disclosure of minutes from these meetings; and the publication of the central bank's own inflation forecasts. Lately, several central banks, such as the Riksbank and the Federal Reserve, have also begun publishing their own repo rate projections. As mentioned in Chapter 8, Norges Bank has gone even one step further, by publishing its own 'NIBOR forecasts'. This transparency has resulted in increased predictability of central bank policy under uncertainty – something market participants have benefitted from.

Chapters 6 and 7 in this dissertation have illustrated that, given the unique institutional mechanism of the LIBOR, there are a number of ways in which the LIBOR fixing could be differ from the 'actual' money market rate. Banks can have underlying incentives to submit deceptive quotes, and the cost of attempting to do so might be small. In particular, the stigma attached to submitting high quotes can lead to a LIBOR that is below the average funding cost of the representative banks. Therefore, the outcomes of the LIBOR games lend support to the anecdotal evidence that, particularly since 2007, the LIBOR has been a poor indicator for the levels

where money market trades have actually been taking place between large banks – and that it consistently has been below, or even well below, the 'actual' money market rate.

The LIBOR serves as a variable in the central bank's decision making process by being the first step in the monetary transmission mechanism. Therefore, if this relationship deteriorates, or becomes more unpredictable, the effect of a repo rate change through the monetary transmission mechanism becomes uncertain. Unless central banks have been consistently aware of the issues with the LIBOR, and been able to quantify potential deviations, policy decisions must have been affected. If the LIBOR is not, at all times, a trustworthy indicator of the first step of the monetary transmission mechanism, it should be treated with some scepticism. However, as demonstrated in Chapter 8, the power to change the definition of the LIBOR, or to communicate this rule change, is not in the hands of the central banks. Instead, decisions with regards to rule or institutional regime changes are done within the LIBOR clubs themselves, or in collaboration with their lobby organisations. This also has implications, as it further distorts the balance of transparency between the central bank and the banks.

In sum, the trend towards increasing central bank transparency can be seen has having been unilateral. A similar process towards transparency has not taken place with regards to the LIBOR panel banks or the LIBOR fixing mechanism. If LIBOR panel banks were to submit deceptive quotes, the wrong 'market signal' would be picked up by the central bank, having a direct impact on the decision making process by, for instance, speeding up or delaying a repo rate move. Moreover, the decomposition into rate expectations, credit and liquidity risk would be distorted and might affect decisions regarding liquidity injections, collateral requirements and possible credit policy actions. We could therefore argue that the strength of central bank power in terms of using information is significantly weakened by the lack of information, or even misinformation, transmitted by the LIBOR banks.

According to Harsanyi, 'conditional incentives' can also serve as an influence technique of power holder A. By setting up rewards and punishments, i.e. new

advantages and disadvantages subject to certain conditions, A is able to influence the future behaviour of B.

The central bank regularly grants certain banks various kinds of conditional incentives. For instance, it has the power to grant bank licences, thereby giving certain financial institutions privileges that are attached to 'being a bank'. However, these privileges are naturally also dependent on certain restrictions and conditions. The central bank also decides which banks within its jurisdiction are allowed to participate in its repo operations, thereby automatically giving banks incentives to act on behalf of the central bank in conducting its monetary policy.

A similar logic applies to the power of the central bank, sometimes along with the Treasury or Debt Office, to grant 'primary dealerships' in the local foreign exchange, money or bond markets. Co-operating banks are given certain privileges subject to specific rules. A central bank might, for instance, choose only to intervene in the foreign exchange markets through one or several of its primary dealers – giving them a slight, but important, informational advantage over other competing banks. Primary dealers in government debt instruments are likewise granted certain informational and reputational benefits under the condition that they comply with certain rules. Simply a reprimand could cause enough reputational damage to have a negative impact on otherwise profitable client business, and non-compliance might lead to expulsion from this 'club of banks'. Repo operations, foreign exchange interventions or issuance of government debt can therefore be managed within certain 'clubs', with the central bank being the logical manager of the club of banks.

From this perspective, LIBOR clubs look very similar to primary dealerships: a group of large banks controlling a money-related 'instrument' or 'price'. However, as demonstrated in Chapter 8, from an institutional perspective, they are totally different. The conditional incentives with regards to the LIBOR are not provided by the central bank, but by panel banks or the lobby organisations the banks themselves are represented by. As discussed in Chapter 5, the central bank lacks authority over banks over how the LIBOR clubs function and are unable to provide incentives for them to change the structure of these. Therefore, a reputational constraint to the LIBOR fixing process would not be set by the central bank, but by their lobby

organisations or by the banks themselves. In sum, despite its importance for central banking, the LIBOR is a specific instrument or benchmark outside of the traditional central bank remit of providing conditional incentives.

A third influence technique, according to Harsanyi, is for power holder A to provide certain new advantages or disadvantages to B, subject to no condition. To describe and analyse the use of such 'unconditional incentives', Harsanyi uses the example of a country A supplying arms to country B to attack a third country C. Country A could also withdraw facilities from B that reduces the ability of B to achieve a policy objective that that is undesirable for A.

Using the example above, we could see how country A providing troops to a 'friendly' nation B (or withdrawing them in case they turn unfriendly) requires some kind of monitoring that the troops actually are needed and/or are being used in combat or deterrence. Should country B 'pretend' that additional assistance is unnecessary, country A might have to act in a more decisive manner if and once the inability of country B to defend itself is revealed.

The central bank's role as Lender of Last Resort is arguably its most powerful unconditional incentive, by in effect serving as a negative constraint upon the banks' objective function as long as the central bank is perceived to be prepared and able to rescue banks. This function of the central bank makes banking unique compared to other competitive sectors of the economy. In this sense, the LIBOR has performed a central role since the beginning of the global financial crisis. As argued in Chapter 2, widening LIBOR-OIS spreads have served as signals as to how, when and to what degree the central bank should intervene in the money markets. As LIBOR quotes *should* include credit and liquidity risk premia, they should also serve as indicators of credit and liquidity risk in the financial system as a whole. However, submitting a high LIBOR quote might signal that the bank cannot access market funding and consequently be required to seek central bank assistance.

Paradoxically, regular and accurate indicators whether banks are in trouble are precisely what the central bank would like to obtain in order to fulfil its financial stability mandate. We can therefore see how the 'stigma' inherent in the LIBOR

fixing mechanism acts as a distortion of this influence technique. Likewise, the strength to act as a Lender of Last Resort might be weakened, and/or involve higher costs, should the potential recipients be in the position of 'deceiving'.

Finally, power holder A may also be able to rely on his 'legitimate authority' over B, or the latter's personal affection for A, leading B to attach direct disutility to disobeying A. As discussed in Chapter 4, the central bank naturally has legitimate authority over banks, and the currency, within its jurisdiction.

However, the LIBOR has its roots in the Eurocurrency markets, which at the outset were outside the jurisdiction of central banks. Likewise, when the various LIBOR-benchmarks were created in the 1980s, central banks were not part of the process. Instead, the LIBOR mechanism has always remained in the hands of a few large banks or their lobby organisations, such as the BBA and others.

The central bank can be seen as having the 'authority' to set the repo rate, which influences the short-term money market rate. This rate, in turn, is supposed to be reflected in the LIBOR. Disobedience, in the form of not submitting a LIBOR quote reflecting a repo rate adjustment or a liquidity injection, is at the discretion of the LIBOR banks. Here, the central bank lacks direct legitimate authority. However, the central bank might still have some authority with regards to what could be regarded as the banks' 'personal affection' of it. For instance, a bank might want to provide limited, but sufficient, 'hints' with regards to the deteriorating reliability of the LIBOR as a reflection of the money market. Hereby, the central bank can gain from the strength of its overall authority, without legally having to act upon the information provided. The LIBOR bank, in turn, might find that it has fulfilled a moral obligation towards the central bank, without having to fundamentally alter its profit-maximising objective. The influence technique in terms of having legitimate authority can therefore have a subjective element not captured in Dahl's classification.

Money market risk premia can also have broader political economy implications as a result of 'authoritative' power relationships. Deviations from the CIP, as well as widening TIBOR-LIBOR spreads, during the Japanese banking crisis were directly

affected by the financial strength of the borrowing Japanese banks (Spiegel, 2001). However, they were also affected by the policy of the Bank of Japan (or ultimately the Finance Ministry) through its ability or desire to act as Lender of Last Resort, and its willingness (and ability) to shield unsecured creditors from losses. The offshore premium faced by a borrowing Japanese bank was therefore a function of both the true economic characteristics of that bank and the expectations concerning government intervention in the event of its insolvency. Indeed, using an empirical study, Peek & Rosengreen (1999) argue that the Japan Premium played a major role in the shaping of government policy towards the banking sector. Government announcements that occurred in the absence of concrete actions appeared to be ineffective; injections of funds into the banking system decreased the Japan Premium, whereas actions to strengthen supervision increased the premium. This logic assumes, at the outset, that the central bank and government actions are perceived as uncertain, and the banks' willingness and ability to signal the correct level of financial strength (or the market's perception of it) of the borrowing banks as *certain*. However, as this dissertation has demonstrated, the LIBOR and the risk premia measured against it could be regarded as the complete opposite.

However, the Japanese banking crisis should not be seen as an isolated case. The history of Eurodollars, LIBORs, foreign exchange swaps and cross-currency basis swaps has taken place side-by-side to that of the globalisation of the banking system. Banks, and central banks, have become more connected. As McGuire & von Peter (2009) argue, the 'Dollar Premium' during the current global financial crisis appeared as too many banks had employed the same strategies accessing liquidity from the vast international vast pool of liquidity. However, no matter how integrated the systems are, the sole right to print currency remains with the individual central banks. As central banks did not restrict the foreign exchange exposures of banks, they in effect had to act as Market Makers of Last Resort in foreign exchange swaps. Thus, the emergency provision of international liquidity through bilateral central bank facilities, which have evolved to form interconnected swap networks, can be seen as the main innovation in central bank cooperation during the crisis. From a political economy perspective, the Federal Reserve has come to act as the global Market Makers of Last Resort as it has the exclusive right to issue dollars that has been in high demand. As such, it has cemented the position of the U.S. dollar as the

only true reserve currency, but also revealed the extent to which the euro has failed achieving such a status. The Federal Reserve has had the opportunity to act opportunistically, as the swap lines ultimately have protected American banks (with significant exposure to the Eurozone) and its domestic financial system (Kaltenbrunner et al., 2011).

However, whereas the Federal Reserve has the authoritative power to print dollars - and thereby being able exercise power over other central banks requiring the currency for the needs of the banks within their respective jurisdictions - the power over the USD *LIBOR* remains in the hands of 16 international banks. Therefore, the *visible* outcomes of domestic liquidity injections – or interventions in the form of U.S. dollar swap agreements – still depend on whoever submits the rates that should reflect this outcome. The legitimate authority over the LIBOR or the CIP (in terms of LIBOR) is thus neither in hand of the markets, the central banks or even the Federal Reserve - but of the LIBOR banks.

It could, perhaps, be tempting to stop the analysis of the power relationship there, having considered the approach by Dahl in Chapter 4, and its critique and extension by Harsanyi above. However, even though Harsanyi's classification adds a great deal to the understanding of the various influence techniques an actor might have in a bargaining situation, it crucially overlooks some of the most important features of the LIBOR story so far. The LIBOR, as a benchmark, can be seen as the 'vehicle' through which power is being exercised. The multidimensional approach used throughout this dissertation has served to shed light on some 'hidden' and 'invisible' forms of power within the mechanisms, institutions and structures of the LIBOR. As Gaventa (2006) notes, these forms of power need not be intentional in the first instance, but that can be self-producing and reinforcing processes. These aspects are central to the understanding of the LIBOR as a benchmark, and need to be conveyed.

Moreover, although the classification in terms of influence techniques is useful in the sense that it manages to capture many of the important elements with regards to the power relationship between central banks and banks, some of the key findings – and ramifications – seem to weaken or completely disappear. In effect, the problem

equates to Lukes' criticism of the 'one-dimensional' and 'one-dimensional' views of power.

First, the approach is too focused on individual behaviour and therefore overlooks that some decisions are made unconsciously or unintentionally, and that the bias of the system can be recreated and reinforced in ways that might not be directly derived from a particular agenda.

Second, the Dahl-Harsanyi framework still focuses on actual and observable conflict, whereas in fact the history of the LIBOR – on the surface – shows very little conflict. Indeed, as Lukes (1974: p. 27) notes, *'the most effective and insidious use of power is to prevent such conflict from arising in the first place'*. An almost permanent state of status quo has prevailed with regards to the LIBOR throughout its history. This, however, does not imply an absence of power being exercised.

Third, it fails to capture the shaping and maintenance of the perception of the LIBOR of being 'objective', and for this perception for having become and remained accepted. The approach does not account for a situation where the central bank not has suffered because they were *not aware* that they were harmed by the use of power. We can clearly see that the LIBOR story, as a narrative incorporating endogenous deception, secrecy and shaping of perceptions, can be viewed in terms of a *latent conflict* consisting of a contradiction between those exercising power (the LIBOR banks) and the *real interests* of those they exclude (the central banks). The issue then becomes how to define the real interests of a central bank acting in a democratic environment towards some kind of social good.

9.4. LIBOR as a Benchmark

Benchmarks in economics and finance are used as indicators for measuring and analysing performance and predictions of the future. Standardisation of benchmarks is useful as it solves a coordination problem actors would otherwise face. This standardisation is normally derived from some kind of best practise, consensus or

convention. Hereby, benchmarks tend to achieve an institutionalised character that legitimises this convention.

With regards to finance, components of a benchmark are, when possible, arrived at through a market-driven process. Stock market indices are simply economic data reflecting traded equity prices compared to a standard or base value. Market-determination can, however, sometimes be difficult to obtain. For instance, the assessment of creditworthiness of large institutions is historically done by a few credit rating agencies. The consequences of losing or gaining perceived creditworthiness are therefore dependent on this credit rating methodology having become a convention. Nonetheless, if other 'competing' and more market-determined methodologies gain ground, other benchmarks can emerge in parallel. The growing size of the CDS market has shown that new inventions in the market can be created alongside older conventions and begin to compete with them.

The 'governance' of a benchmark can be formal or more informal, depending on the type of benchmark. Widely used benchmarks, such as S&P500 or FTSE100, have robust standards implying a high degree of objectivity and integrity. Not only are the index rules and governance procedures, and any changes to them, transparent. The underlying stocks are required to be tradable and liquid (FTSE, 2012). The benchmarks reflect outcomes (prices) of actual market transactions. The composition and weighting of other indices, such as a government bond index, might be less straight-forward than for a stock market index. For instance, the World Government Bond Index[45] (WGBI) depends not only on rules, but also on the discretion of its governing body (Citibank). However, should the integrity of this process be questioned (for instance by Citibank buying or selling a particular bond prior to a change in the composition, or by giving in to pressure by a government to be included in the benchmark), Citibank would face a reputational loss by being perceived as taking advantage of its governing status of the benchmark. Therefore, any benchmark requires some degree of 'objectivity' to keep its integrity.

Financial derivatives require benchmarks from the start, as they are claims on counterparties for a change in an underlying asset, measurement or index. According

[45] Citigroup (2012)

to accounting standards (such as FAS 133), there must be an independent way to observe the underlying value to avoid conflicts of interest. With regards to derivative instruments, such as the German Bund future or overnight index swaps, the underlying benchmarks are generally derived from market-determined prices. However, as financial derivatives have become treated less as private arrangements between two counterparties, and more as tradables, derivatives themselves have increasingly gained status as benchmarks.

For cash-settled derivatives where a market for the underlying measurement is not obtainable, other types of benchmarks are used. For instance, inflation-linked derivatives treat the underlying benchmark as a kind of 'price' in the same way as a price of a market-determined financial asset. Therefore, the reliability rests with public agencies, such as the U.K. Office for National Statistics or the U.S. Bureau of Labor Statistics in collecting, calculating and publishing the monthly inflation index. The consumption basket might change from time to time, and disagreement might exist upon how this index should be constructed to most accurately reflect inflationary trends. However, the integrity of the index, and the public agency governing it, needs to remain intact.

Markets, and thereby benchmarks, can be influenced by 'powerful' players such as large banks, hedge funds or central banks. The outcome might not at all times reflect fundamentals, let alone being regarded as 'democratic'. However, for a benchmark to be able to perform its function, it needs to be 'correct' in the sense that it should reflect what it is supposed to reflect.

Institutional arrangements, such as monetary policy regimes, require central banks to use benchmarks such as the LIBOR. Central banks are 'non-profit-maximising' institutions with an objective function targeting some social good. For inflation-targeting central banks, some kind of objective performance measure is obtainable through the benchmark of inflation used. Measuring the effectiveness of the monetary transmission mechanism is, however, more complicated as indicators such as credit risk or liquidity risk can be difficult to both define and quantify. This has implications upon the central bank's mandate and obligation to maintain financial stability. Various benchmarks have evolved to measure them explicitly, or become

approximated implicitly through the combination of various existing benchmarks (such as LIBOR-OIS and LIBOR-based CRS spreads). In contrast to economic indicators, such as inflation, these are assumed to be arrived at through a market-based process through voluntary exchange, rather than power.

If the LIBOR were to deviate from the 'actual' short-term interbank money market rate, two types of costs would arise. The first type refers to a (at least theoretically) measurable monetary value transfer to those having the power over the LIBOR process - from those that do not. Even though a majority of financial derivatives contracts should be treated not on a gross, but net, basis, a fraction of the outstanding LIBOR-based contracts used as a calculation base would represent a significant transfer of wealth. As this dissertation has shown, the LIBOR Game is *not* a zero-sum game. Therefore, non-LIBOR banks (such as other financial institutions, corporations, institutions or private individuals) would inevitably pick up some of these costs – either directly through LIBOR-indexed contracts, or indirectly through contracts relying on the integrity of the LIBOR.

The second type is more difficult to estimate, and not confined to monetary transfers. These would, for instance, include costs to investors, central banks and the society as a whole of receiving false signals with regards to the credit standing of large banks as a result of the stigma attached to signalling a relatively high funding cost through the LIBOR fixing mechanism. However, central banks are not targeting profit and loss. Decisions (or indecisions) resulting from such deviations are therefore unlikely to be measurable.

Allegations that the LIBOR, at times, has been subject to attempts of manipulation, have triggered a range of reform proposals on how to 'fix' the LIBOR to restore its credibility (see for instance HM Treasury, 2012). Although it is too early to comment on the likely outcome of these, some theoretical conclusions can already be drawn from this dissertation.

First, some reform proposals have pointed directly towards the fixing mechanism itself, and particularly the lack of binding rules. It has been suggested that regular checks could be conducted to ensure that individually submitted LIBOR quotes

reflect actual uncollateralised trades agreed upon between two parties in the market. However, as demonstrated through the game-theoretic approach in this dissertation, reputational constraints, in the form of requirements to trade at submitted LIBOR quotes, would require a high level of transparency that LIBOR banks might want to resist. Importantly, considering the asymmetry between the size of the actual tradable money market and the size of the incentives in terms of underlying derivatives portfolios or the stigma, banks might be prepared to make loss-making (albeit transparent) trades in 'prevailing market size' that would justify a specific submitted LIBOR quote from a regulatory perspective. Recent proposals to make STIBOR quotes 'almost completely' binding appear, at the outset, more radical (Blomqvist, 2012). However, as banks would only be required to trade in very limited amounts at the submitted rates, it is uncertain whether the incentive structure would fundamentally change.

Second, some reform proposals have been aimed at reducing the incentives to deceive. For instance, the LIBOR submission process could be made *less* transparent, by allowing individually submitted quotes not to be made public instantly. Hereby, it is argued, the stigma incentive for LIBOR panel banks being perceived as less creditworthy would be reduced. However, it is difficult to see how an even less transparent LIBOR would benefit policy makers, the wider public or the market as a whole long-term.

Third, it has also been questioned whether the definition of the benchmark should change, or whether it should be replaced by another benchmark altogether (see for instance Wheatley, Mackenzie & Masters, 2012). Theoretically, any market-based benchmark requires liquidity in the underlying asset, and should reflect new information about fundamentals (Wooldridge, 2001). It has become clear that the LIBOR does not fulfil this requirement. However, the LIBOR has almost come to have a monopoly-status in its segment, with hardly any 'competition'. Moreover, a competing benchmark would find it difficult to emerge automatically, given the large amount of outstanding derivatives contracts that would need to be re-negotiated and thus involve complicated legal obstacles. A 'broader' LIBOR, perhaps including a wider range of financial institutions, or the use of a tradable instrument (such as OIS or collateralized repos) as the underlying asset, would reduce the inherent connection

to credit and liquidity risk in the interbank market - and thereby alter its place in the first stage of the monetary transmission mechanism.

A fourth set of proposals have focused on constraints, aiming to increase the cost of future manipulation by making the LIBOR submission process a regulated activity and requiring stricter internal compliance rules. Hereby, it would become easier to impose financial penalties upon banks with insufficient controls, as well as individuals found guilty of trying to submit deceptive LIBOR quotes.

Fifth, reform proposals have also been directed at the size and composition of the LIBOR clubs. By including a larger number of banks, the likelihood of collusion, it is argued, would diminish. However, as demonstrated in chapters 6 and 7, deception can be systematic and endogenous to the fixing mechanism itself, and not an outcome of isolated individual behaviour or explicit collusion. It is also questionable how a set of stricter compliance rules (not to mention the risk of facing a regulatory penalty) will encourage new banks to enter the LIBOR panels. Non-LIBOR panel banks (previously not welcomed) might not want to join voluntarily, whereas penalised LIBOR-panel banks might find it worthwhile to stay.

Finally, plans to change the governance of the LIBOR by, for instance, transferring powers from the bank lobby organisation to some public authority suggest a more fundamental change. If implemented, such a decision would go to the roots of the LIBOR, namely its inherent independence from direct public oversight. This type of intervention – although still hypothetical – echoes the free banking debate, discussed previously in this dissertation, by asking who (the self-regulating market or the state) would be better equipped to exercise power. If the public has reason to distrust the LIBOR banks to the degree that the central bank (or some other public authority) has to decide how the money market rate is set, what should the role of banks be?

In sum, the proposals suggest that confidence seems to remain that the LIBOR, through regulation, can be restored or transformed to a market-like process that it in fact never was. This dissertation has demonstrated – explicitly and implicitly - that the majority of proposals aimed at regulation would fail to tackle the fundamental issues of the LIBOR.

A benchmark based upon a subjective assessment of the bank funding cost is problematic as long as banks are profit-maximising and have an interest in appearing good and sound. At the same time, the LIBOR has had an ability to reproduce and reinvent itself and thereby making it tightly connected to the financial system as a whole. It is a fundamentally anti-competitive process that has benefitted from deception and secrecy, but also from disguising itself as a competitive market. The LIBOR is a unique benchmark, founded upon the desire by banks to avoid state involvement. Yet, being a benchmark for the short-term interbank money market, it will always have a direct link to the power of the central banks. Any reform to the LIBOR, therefore, needs to carefully consider not only the social obligations that come with the privilege of being a 'bank', but also with the 'social good' central banks are meant to work towards. Deception is an inherent feature in the current LIBOR. The power to change it fundamentally, however, lies not with the banks only, but with those having power *over* the banks.

'People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices. It is impossible indeed to prevent such meetings, by any law which either could be executed, or would be consistent with liberty and justice. But though the law cannot hinder people of the same trade from sometimes assembling together, it ought to do nothing to facilitate such assemblies; much less to render them necessary.' (Smith, 1776: p. 117)

APPENDIX 1

Definitions, Fixing Mechanisms and Club Structures[46]

LIBOR[47]

i) Definition

The LIBOR (London Interbank Offered Rate) can be defined according to the question each LIBOR panel bank is asked to base its submission upon, which currently is as follows: *'At what rate could you borrow funds, were you to do so by asking for and then accepting inter-bank offers in a reasonable market size just prior to 11 am?'* Up until 1998, the question was slightly different, namely: *'At what rate do you think interbank term deposits will be offered by one prime bank to another prime bank for a reasonable market size today at 11am?'* The LIBOR is not necessarily based on actual transactions, as there is no binding rule. Furthermore, *''Reasonable market size' is intentionally left broadly defined: it would have to be constantly monitored and in the current conditions would have to be changed very frequently. It would also vary between currencies and maturities, leading to a considerable amount of confusion*.' The 'rates' should refer to deposit rates that are *'made in the London interbank market in reasonable market size'*; *'simple and unsecured'*; *'governed by the laws of England and Wales'*; and *'where the parties are subject to the jurisdiction of the courts of England and Wales'*. Furthermore, the rates must '*be formed from that bank's perception of its cost of unsecured funds in the interbank market. This will be based on the cost of funds not covered by any governmental guarantee scheme'*; *'represent rates formed in London and not elsewhere'*; *'be for the currency concerned, not the cost of producing one currency by borrowing in another currency and accessing the required currency via the foreign exchange markets';* and *'be submitted by members of staff at a bank with primary responsibility for management of a bank's cash, rather than a bank's*

[46] As of 24.07.2012
[47] British Bankers Association (2012ab)

derivative book'. Finally, 'funds' is referring to unsecured interbank cash or cash raised through primary issuance of interbank Certificates of Deposit.

LIBOR is fixed for 10 currencies: AUD, CAD, CHF, DKK, EUR, GBP, JPY, NZD, SEK and USD.

ii) Fixing Mechanism

LIBOR banks submit their quotes to Thomson Reuters between 11:00 a.m. and 11:10 a.m. Thomson Reuters endeavours to identify and arrange for the correction of errors in rates input by individual contributor banks prior to 11.30 a.m. – and publishes the LIBOR fixing and the individual contributor banks rates at or around 11.30 a.m. London time after the trimming process has been done (each submission is ranked in descending order and then the highest and lowest 25% of submissions are omitted). The trimming mechanism is done *'to exclude outliers from the final calculation. By doing this, it is out of the control of any individual panel contributor to influence the calculation and affect the LIBOR quote.'*

The maturities are 1W, 2W, 1M, 2M, 3M, 4M, 5M, 6M, 7M, 8M, 9M, 10M, 11M and 12M; as well as overnight for CAD, EUR, GBP and USD and spotnext for AUD, CHF, DKK, JPY, NZD and SEK.

iii) The LIBOR Club Structure

Currently, the five major U.K. banks, as well as Deutsche Bank, are member of all 10 LIBOR panels. The complete list is as follows: Abbey National plc (EUR, GBP), Bank of America (USD), Bank of Nova Scotia (CAD), Bank of Tokyo-Mitsubishi UFJ Ltd (USD, GBP, EUR, JPY, CHF), Barclays Bank plc (ALL), BNP Paribas (USD, GBP), Canadian Imperial Bank of Commerce (CAD), Citibank NA (USD, GBP, EUR, CHF), Commonwealth Bank of Australia (AUD, NZD), Credit Agricole CIB (USD, GBP, JPY), Credit Suisse (USD, EUR, CHF), Deutsche Bank AG (ALL), HSBC (ALL), JP Morgan Chase (USD, GBP, EUR, JPY, CHF, AUD, NZD, DKK, SEK), Lloyds Banking Group (ALL), Mizuho Corporate Bank (GBP, EUR, JPY), Rabobank (USD, GBP, EUR), Royal Bank of Canada (USD, GBP, EUR,

CAD), Société Générale (USD, GBP, EUR, JPY, CHF, CAD), Sumitomo Mitsui Banking Corporation (USD, JPY), The Norinchukin Bank (USD, JPY), The Royal Bank of Scotland Group (ALL), UBS AG (USD, GBP, EUR, JPY, CHF).

The LIBOR as a benchmark is governed are by the independent Foreign Exchange and Money Markets Committee (FX&MMC). The British Bankers Association (BBA), advised by the FX&MMC, maintains a reference panel of between 6 and 18 LIBOR banks for each currency calculated. The aim is to produce a reference panel of banks which *'reflects the balance of the market'*. Individual banks are selected within this guiding principle and based upon three criteria: *'scale of market activity'*, *'reputation'* and *'perceived expertise in the currency concerned'*. The BBA is the leading trade association for the UK banking and financial services sector. It aims to influence decision makers through *'promoting a legislative and regulatory system for banking and financial services'[…]'which takes account of our members' needs and concerns and provides an effective and competitive market place in which their businesses can prosper'*. BBA also *'promote[s]and defends the [banking] industry'* by engaging *'with government, devolved administrations and Europe as well as the media and other key stakeholders to ensure the industry's voice is heard and to highlight the strength and importance of UK banking.'*

CIBOR[48]

i) Definition

The CIBOR (Copenhagen Interbank Offered Rate) is defined as *'the interest rate at which a bank is prepared to lend Danish kroner (DKK) to a prime bank on an uncollateralised basis. A prime bank is defined as a bank that under prevailing market conditions is among the most creditworthy. Therefore, all CIBOR panel banks are not necessarily prime banks. No CIBOR panel bank is required to deliver liquidity at its prevailing quote to the other CIBOR banks (or others). Each CIBOR bank shall strive to let its CIBOR reflect an interest rate level that is as realistic as possible. If the market for unsecured deposits does not function, or no trading takes place in the market, each CIBOR bank shall still submit quotes using his own subjective judgement of, where he judges that rates should be on the relevant day. When the submission takes place, each CIBOR bank shall assume that it has enough DKK liquidity for lending, regardless if this a realistic assumption or not.'* (Free translation from Danish)

ii) The Fixing Mechanism

Each CIBOR bank submits its quote at 10:30 a.m. The two highest, and the two lowest, quotes are omitted through the trimming process. The average is calculated using the remaining quotes and the CIBOR, as well as the individual quotes are published at 11:00 a.m.

The maturities are 1W, 2W, 1M, 2M, 3M, 4M, 5M, 6M, 7M, 8M, 9M, 10M, 11M and 12M.

iii) The CIBOR Club Structure

There are currently 8 CIBOR banks: Barclays Capital, Danske Bank, Deutsche Bank, Jyske Bank, Nordea Bank, Nykredit Bank, Spar Nord Bank and Sydbank.

[48] Danmarks Nationalbank (2012b); NASDAQ OMX (2012); Finansraadet (2011, 2012)

From 4 April 2011 Danmarks Nationalbank stopped collecting, calculating and publishing the CIBOR fixing. NASDAQ OMX publishes CIBOR on a daily basis at 11:00. The Danish Bankers Association (Finansrådet) has the overall responsibility for CIBOR, through a CIBOR committee – appointed by the board. The primary task of the Danish Bankers Association is *'to create good operating conditions for the banks'* and *'closely monitor the political processes and play an active and specific role in political decision-making that is relevant for the banks' business platform. In so doing, we target our efforts and communication at, for example, the Danish Parliament, the government and the EU.'*

EURIBOR[49]

i) Definition

The EURIBOR is defined as *'the rate at which Euro interbank term deposits are offered by one prime bank to another prime bank within the EMU zone.'*

ii) Fixing Mechanism

Each EUIBOR (Euro Interbank Offered Rate) bank is allocated a private page on which to contribute its data. Each private page can only be viewed by the contributing bank and by Thomson Reuters staff involved in the fixing process. Each EURIBOR panel bank submits its quote by 10:45 a.m. (CET) on each business day. At 11:00 a.m. Thompson Reuters processes the EURIBOR calculation, by omitting the highest and lowest 15% of all the quotes collected. The average of the remaining quotes (the EURIBOR fixing), and the individual quotes, is then published at 11:00 a.m.

The maturities are 1W, 2W, 3W, 1M, 2M, 3M, 4M, 5M, 6M, 7M, 8M, 9M, 10M, 11M and 12M.

iii) The EURIBOR Club Structure

Banks can qualify for the EURIBOR panel if they are active players in the euro money markets in the Eurozone or worldwide and if they are able to handle good volumes in euro-interest rate related instruments, especially in the money market, even in turbulent market conditions. Therefore, the current EURIBOR panel consists not only of banks in the Eurozone, but also other large EU and international large banks (43 in total): Erste Group Bank AG, RBI (Raiffeisen Bank International), Belfius, KBC, Nordea, Pohjola, Banque Postale, BNP-Paribas, HSBC, Société Générale, Natixis, Crédit Agricole s.a., Crédit Industriel et Commercial CIC,

[49] European Banking Federation (2012abcde)

Landesbank Berlin, Bayerische Landesbank Girozentrale, Deutsche Bank, Commerzbank, DZ Bank Deutsche-Genossenschaftsbank, Norddeutsche Landesbank Girozentrale, Landesbank Baden-Württemberg Girozentrale, Landesbank Hessen-Thüringen Girozentrale, National Bank of Greece, AIB Group, Bank of Ireland, Intesa Sanpaolo, Monte dei Paschi di Siena, Unicredit, UBI Banca, Banque et Caisse d'Épargne de l'État, ING Bank, Rabobank, Caixa Geral De Depósitos (CGD), Banco Bilbao Vizcaya Argentaria, Banco Santander Central Hispano, Confederacion Española de Cajas de Ahorros, CaixaBank S.A., Barclays Capital, Den Danske Bank, Svenska Handelsbanken, UBS (Luxembourg) S.A., Citibank, J.P. Morgan Chase & Co and Bank of Tokyo Mitsubishi.

A Steering Committee oversees the EURIBOR. The Steering Committee consists of 10 members: 7 from the Euribor EBF side, 3 from the Euribor ACI side. The Secretary General of the European Banking Federation is a permanent member of the Steering Committee under the Euribor EBF quota.

Association Cambiste Internationale (ACI) is the leading trade organisation for dealers in foreign exchange and money markets. Among the guiding principles of the EBF is *'to promote the principles of self-regulation and better regulation within the EU, so as to alleviate the burden on banks and improve their competitiveness; and work to win support for ever increasing regulatory convergence internationally, to advocate free and fair competition in EU and world markets, to lobby at EU and international level in support of the free market and to ensure that European banks face a level playing field on EU and global markets, operating free of unfair distortions of competition, to support banks' efforts to increase their efficiency and competitiveness, to support the banking industry's efforts to increase efficiency and improve customer service'[...]'Its aim is to ensure that the experience and the views of banks are taken into consideration in the shaping of relevant policies. The EBF also actively promotes the positions of the European financial services, and in particular the banking industry in international fora.'*

NIBOR[50]

i) Definition

'NIBOR is intended to reflect the interest rate level lenders require for unsecured money market lending in NOK with delivery in two days after trade. The interest rates published by the panel banks shall reflect 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. The rates are to be regarded as best possible estimates, not binding offers.'

ii) Fixing Mechanism

NIBOR (Norwegian Interbank Offered Rate) is calculated as a simple average of interest rates published by the NIBOR panel banks for each maturity, after omitting low and high rates. The NIBOR is based on interest rates published by the NIBOR panel banks via Thomson Reuters just before 12:00 noon every business day. The fixing mechanism is unique and based upon the CIP formula insofar that panel banks do not submit NOK money market rates directly, but submit USD money market rates and USD/NOK FX spot and swap points – thereby forming an implied NOK interest rate – continuously during the opening hours of the market. The NIBOR thereby becomes a snapshot at 12:00 noon. Through the trimming process, the highest quote and lowest quote are omitted. The NIBOR is calculated as the average of the four remaining quotes.

The maturities are 1W, 2W, 1M, 2M, 3M, 4M, 5M, 6M, 9M and 12M.

iii) The NIBOR Club Structure

The current NIBOR panel banks are DNB Bank ASA, Fokus Bank/Danske Bank, Handelsbanken, Nordea Bank Norge ASA, SEB AB and Swedbank.

[50] FNO (2011)

The decision to approve a bank as a NIBOR panel bank is made by Finance Norway's Board on Banking and Payment Systems on the recommendation of the steering group. The NIBOR steering group consists of representatives from the NIBOR panel banks and has at least three members. NIBOR panel banks are required to be active price quoters in the Norwegian interbank market in which the redistribution of NOK liquidity occurs and has been such for a period of at least one year; and active price quoters for the relevant maturities during the opening hours of the market on all days on which the Norwegian market is open. Since 1 August 2011, the 'governing body' of the NIBOR is Finance Norway (FNO). The purpose of FNO is *'to strive for a strengthened Norwegian financial industry'*.

STIBOR[51]

i) Definition

The STIBOR (Stockholm Interbank Offered Rate) is defined as *'the interest rate that banks claim they can offer to offer unsecured Swedish Krona for various maturities to each other. In other words, it is the rate that banks are charged when borrowing money from other banks.'*

ii) Fixing Mechanism

STIBOR banks submit their quotes between 10:45 a.m. and 11:00 a.m. The STIBOR Fixing is compiled by NASDAQ OMX Stockholm as an arithmetic average of the rates quoted by selected banks. If the lowest and/or highest bid differs with 25 basis points or more from the second lowest and second highest bid it will be excluded from the calculation. STIBOR rates are compiled and published daily at 11:05.[52]

The maturities are T/N, 1W, 1M, 2M, 3M, 6M, 9M and 12M.

iii) The STIBOR Club Structure

There are currently 5 STIBOR banks: Danske Bank, Handelsbanken, Nordea, SEB and Swedbank.

[51] NASDAQ OMX (2012), Sveriges Riksbank (2012b)

[52] This rule came into effect when RBS departed from the STIBOR panel in 2012. Previously, the highest and lowest quotes were omitted, and the mean (STIBOR fixing) was calculated from the remaining four quotes.

TIBOR[53]

i) Definition

'Japanese Yen TIBOR shall reflect prevailing conditions in the Japan unsecured call market. Euroyen TIBOR shall reflect prevailing conditions in the Japan Offshore Market'. TIBOR banks quote *'what they deem to be prevailing market rates, assuming transactions between prime banks on the Japan unsecured call market (Japanese Yen TIBOR) and on the Japan Offshore Market (Euroyen TIBOR) as of 11:00 a.m. unaffected by their own positions etc. Therefore, the rates quoted by reference banks are not intended for use in trading by the reference banks.'*

ii) Fixing Mechanism

TIBOR (Tokyo Interbank Offered Rate) banks submit quotes as of 11:00 a.m. by inputting information into terminals by 11:20 a.m. The service provider tabulates the reference rates, calculates the TIBOR fixing (the highest two and lowest to quotes are omitted) and transmits the results to the Japanese Bankers Association (JBA). JBA reviews the results, and grants the service provider permission to publish the TIBOR. Upon receiving permission, the service provider transmits the Rates to information providers by 12:00 noon, which immediately publishes the TIBOR and the individual quotes.

The maturities are 1W, 1M, 2M, 3M, 4M, 5M, 6M, 7M, 8M, 9M, 10M, 11M and 12M.

iii) The TIBOR Club Structure

JBA is designated to decide upon the TIBOR panel bank compositions. It bases its selection on four criteria: market trading volume (for Japanese Yen TIBOR, on the Japan unsecured call market, and for Euroyen TIBOR, on the Japan Offshore Market); yen asset balance; reputation; and track record in providing rate quotes. The

[53]Japanese Bankers Association (2012ab)

selection also takes into account JBA TIBOR continuity and the variety of financial sectors to which reference banks belong. The current TIBOR banks are:

Mizuho Bank, Ltd., The Bank of Tokyo-Mitsubishi UFJ, Ltd., Sumitomo Mitsui Banking Corporation, Resona bank, Ltd., Mizuho Corporate Bank, Ltd., The Bank of Yokohama, Ltd., Mitsubishi UFJ Trust and Banking Corporation, Mizuho Trust and Banking Co., Ltd., Sumitomo Mitsui Trust Bank, Ltd. and The Norinchukin Bank (both panels); Saitama Resona Bank, Limited, Shinsei Bank, Limited, Aozora Bank, Ltd., BNP PARIBAS S.A., Shinkin Central Bank and The Shoko Chukin Bank (Japanese Yen TIBOR only); JPMorgan Chase Bank, National Association, Deutsche Bank AG., BNP PARIBAS S.A., Shinkin Central Bank and The Shoko Chukin Bank (Euroyen TIBOR only).

Among the tasks of the JBA is *'to support the banking business of member banks'* by amongst other things *'expressing opinions on financial system reform and other banking-related matters, researching banking-related matters and providing policy recommendations.'*

APPENDIX 2

The Endowment in LIBOR Games

In Chapter 6, the endowment refers to the *net* portfolio exposure to the LIBOR. In simple terms we are dealing with how much the net present value (NPV) of the portfolio would change given a certain change in the LIBOR (everything else being constant). This could, in other words, relate both to the realised profit and loss for a floating rate settlement today, as well as the change in the market valuation of future floating payments (benchmarked to the LIBOR) stemming from the change in the LIBOR. The easiest way to understand 'E', would be to regard it as the 'delta' or NPV of a LIBOR forward rate agreement (or a Eurodollar futures contract) done in the past. Consider an example where:

$M = L_{F(t0)} =$	1.00%
$\alpha =$	0.10%
$E =$	$10,000

In the example above, E^+ corresponds to having *sold* 400 Eurodollar futures contracts (having a tick value of USD 25), and E^- to having bought the equivalent amount. In FRA-terms, E^+ would be equivalent of having bought (or paid fixed) approximately USD 400 million worth of 3M LIBOR FRAs – and E^- of having sold (or received fixed) a similar amount.[54]

$L_{F(t0)}$ corresponds to the LIBOR fixing the previous day, which equals M. This rate is used to mark-to-market the outstanding FRA contracts (i.e. at 1.00%) or the Eurodollar futures contracts (i.e. at 99.00).

Assume L_F is not only the LIBOR fixing, but also that the fixing of the outstanding contracts takes place at t_2 (with settlement 2 business days later). The profit or loss stemming from the contracts will not only depend on the contract rate (in other words at what level they were done in the past), but where they will fix. Thus, the

[54] Whereas these amounts might appear large, they are fairly conventional in these particular markets.

payoff from the single-period games will depend on the movement in the LIBOR fixing from t_0 to t_2:

$$\pi_i = E_i\left(L_{F(t2)} - L_{F(t0)}\right) = E_i(L_F - M)$$

As α = 0.10%, LIBOR panel banks can submit 0.90% (M – α = 1.00% - 0.10% = 0.90%), 1.00% or 1.10%. Matrix A2.1 and A2.2 show the expected LIBOR fixings and payoffs from the endowments under these assumptions:

Matrix A2.1: Expected LIBOR Fixings

LIBOR Base Game	
E^+	1.0333%
E^0	1.0000%
E^-	0.9667%
LIBOR Collusion Game	
E^+	1.0722%
E^0	1.0000%
E^-	0.9278%
LIBOR Bribe Game (B<$704)	
E^+	1.0704%
E^0	1.0000%
E^-	0.9296%

As can be seen, for players with $E^{\neq 0}$, the expected LIBOR fixing always deviates from M in the first three types of games. Under scenarios with collusion or bribes, this deviation is larger.

Matrix A2.2: Expected Payoffs from Endowment

LIBOR Base Game	
E^+	$333.00
E^0	$0.00
E^-	$333.00
LIBOR Collusion Game	
E^+	$722.00
E^0	$0.00
E^-	$722.00
LIBOR Bribe Game (B<$704)	
E^+	$704.00
E^0	$0.00
E^-	$704.00

With regards to the expected payoffs from endowments – they are always > 0 for players with $E^{\neq 0}$. This can be seen as a monetary reward for players with portfolios benchmarked against the LIBOR being allowed to play the LIBOR game.

When it comes to the fourth type of game, with reputation and stigma, we get 6 different scenarios. The LBOR always deviates from M, with the exception of Scenario VI, and Scenario I for players with E^0:

Matrix A2.3: Expected LIBOR Fixings (Scenarios I-VI)

LIBOR Game with Constraints	Scenario I	Scenario II	Scenario III	Scenario IV	Scenario V	Scenario VI
E^+	1.0333%	0.9963%	0.9852%	0.9481%	0.9000%	1.0000%
E^0	1.0000%	0.9296%	0.9852%	0.9148%	0.9000%	1.0000%
E^-	0.9667%	0.9296%	0.9519%	0.9148%	0.9000%	1.0000%

The stigma has a significant impact on the expected payoff structure. Except for under Scenarios I and VI, players with E^+ can always expect a negative payoff from the endowment. Players with E^-, on the other hand, benefit greatly under the same circumstances:

Matrix A2.4: Expected Payoffs from Endowment (Scenarios I-VI)

LIBOR Game with Constraints	Scenario I	Scenario II	Scenario III	Scenario IV	Scenario V	Scenario VI
E^+	$333.00	-$37.00	-$148.00	-$519.00	-$1,000.00	$0.00
E^0	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
E^-	$333.00	$704.00	$481.00	$852.00	$1,000.00	$0.00

APPENDIX 3

Probabilities and Expected LIBOR Outcomes

In the single period LIBOR games, the outcomes (both the Libor fixing (L_F) and the LIBOR average (L_A)) depend on the strategies of each of the four players. The total number of possible outcomes is K^{N_0}, where K is the number of strategy choices, and N_0 is the total number of players. As the number of players is 4, and the strategy choices 3 (L^H, L^M and L^L), the total number of possible outcomes is $K^{N0} = 3^4 = 81$. Next, we use formula for the number of permutations (P) for a certain outcome:

$$\binom{N_0}{N_1} * \binom{N_1}{N_2} * \binom{N_2}{N_3},$$

where $N_1 = N_0 - U_1$, $N_2 = N_1 - U_2$ and $N_3 = N_2 - U_3$. Let U_1 be the number of the first type of strategy choice (L^H), U_2 the second type (L^M) and U_3 the third type (L^L). We can thus begin to work out the different possible outcomes, and the probabilities for these to occur.

Example 1: Let us work out the probability of precisely one player submitting L^H, two players submitting L^M and one L^L. The number of players is 4 => N_0=4, and the number of different quotes to choose from is 3 => K=3. If we call the number of 'L^H' for U_1, number of 'L^H' for U_2 and number of 'L^L' for U_3, we get probability $p(L^H, 2L^M, L^L) = \binom{4}{3} * \binom{3}{1} * \binom{1}{0} / 81 = 4 * 3 * 1 / 81 = 12/81 \approx 0.1481$.

The different LIBOR outcomes and probabilities (*p*) are summarised in Matrix A3.1 (with Example 1 as outcome number 8). The LIBOR average (L_A) and the expected LIBOR fixing (L_F) are in bold, having taken into account the probabilities of each possible outcome and the trimming process omitting the highest and lowest quote:

Matrix A3.1: LIBOR Outcomes and Probabilities

Outcome	L^H	L^M	L^L	P	*p*	Max	Min	L_A	L_F
1	4	0	0	1	0.0123	M+α	M+α	M+α	M+α
2	3	1	0	4	0.0494	M+α	M	M+3α/4	M+α
3	3	0	1	4	0.0494	M+α	M-α	M+α/2	M+α
4	2	2	0	6	0.0741	M+α	M	M+α/2	M+α/2
5	2	1	1	12	0.1481	M+α	M-α	M+α/4	M+α/2
6	2	0	2	6	0.0741	M+α	M-α	M	M
7	1	3	0	4	0.0494	M+α	M	M+α/4	M
8	1	2	1	12	0.1481	M+α	M-α	M	M
9	1	1	2	12	0.1481	M+α	M-α	M-α/4	M-α/2
10	1	0	4	4	0.0494	M+α	M-α	M-α/2	M-α
11	0	4	1	1	0.0123	M	M	M	M
12	0	3	4	4	0.0494	M	M-α	M-α/4	M
13	0	2	6	6	0.0741	M	M-α	M-α/2	M-α/2
14	0	1	4	4	0.0494	M	M-α	M-3α/4	M-α
15	0	0	1	1	0.0123	M-α	M-α	M-α	M-α
Sum				81	1.0000			**M**	**M**

Example 2: Consider outcome number 9 in Matrix A3.1, where one player submits L^H, one player L^M and two players L^L. The probability of this to happen is $p(L^H,L^M,2L^L)) \approx 0.1481$. The trimming process ensures that the highest and the lowest quotes will be omitted, i.e. M+α and M-α, yielding a LIBOR fixing of:

$$L_F = \frac{\sum_1^4 L_i - max\{L_i\} - min\{L_i\}}{2}$$
$$= \frac{\big((M+\alpha) + M + (M-\alpha) + (M-\alpha)\big) - (M+\alpha) - (M-\alpha)}{2} = M - \frac{\alpha}{4}$$

The LIBOR average is the simple arithmetic mean of the 4 quotes:

$$L_A = \frac{\sum_1^4 L_i}{4} = \frac{\big((M+\alpha) + M + (M-\alpha) + (M-\alpha)\big)}{4} = M - \frac{\alpha}{2}$$

Next, at the outset, we know that $p(E^+) = p(E^0) = p(E^-) = 1/3$, and hence $z_i^H = z_i^M = z_i^L = 1/3$. However, as player P_i *knows* his own E, he can work out the probabilities and outcomes given each of his own strategy choice, where $z_{n\neq i}^H = z_{n\neq i}^M = z_{n\neq i}^L = 1/3$, as shown in Matrix A3.2, A3.3 and A3.4. In other words, if P_i submits L^H, L_A=M+α/4 and L_F= M+α/3; if P_i submits L^M, L_A=M and L_F= M; and if P_i submits L^L, L_A=M-α/4 and L_F= M-α/3. Given his incentives and constraints as expressed in his payoff function, he chooses which strategy gives the best possible expected payoff.

Matrix A3.2: P_i Submits L^H

Outcome	L^H	L^M	L^L	Permutations	*p*	Max	Min	L_A	L_F
1	3	0	0	1	0.0123	M+α	M+α	M+α	M+α
2	2	1	0	3	0.0494	M+α	M	M+3α/4	M+α
3	2	0	1	3	0.0494	M+α	M-α	M+α/2	M+α
4	1	2	0	3	0.0741	M+α	M	M+α/2	M+α/2
5	1	1	1	6	0.1481	M+α	M-α	M+α/4	M+α/2
6	1	0	2	3	0.0741	M+α	M-α	M	M
7	0	3	0	1	0.0494	M+α	M	M+α/4	M
8	0	2	1	3	0.1481	M+α	M-α	M	M
9	0	1	2	3	0.1481	M+α	M-α	M-α/4	M-α/2
10	0	0	3	1	0.0494	M+α	M-α	M-α/2	M-α
Sum				27	1.0000			**M+α/4**	**M+α/3**

Matrix A3.3: P_i Submits L^M

Outcome	L^H	L^M	L^L	Permutations	*p*	Max	Min	L_A	L_F
1	3	0	0	1	0.0123	M+α	M	M+3α/4	M+α
2	2	1	0	3	0.0494	M+α	M	M+α/2	M+α/2
3	2	0	1	3	0.0494	M+α	M-α	M+α/4	M+α/2
4	1	2	0	3	0.0741	M+α	M	M+α/4	M
5	1	1	1	6	0.1481	M+α	M-α	M	M
6	1	0	2	3	0.0741	M+α	M-α	M-α/4	M-α/2
7	0	3	0	1	0.0494	M+α	M	M	M
8	0	2	1	3	0.1481	M+α	M-α	M-α/4	M
9	0	1	2	3	0.1481	M+α	M-α	M-α/4	M-α/2
10	0	0	3	1	0.0494	M+α	M-α	M-α/2	M-α
Sum				27	1.0000			**M**	**M**

Matrix A3.4: P_i Submits L^L

Outcome	L^H	L^M	L^L	Permutations	*p*	Max	Min	L_A	L_F
1	3	0	0	1	0.0123	M+α	M-α	M+α/2	M+α
2	2	1	0	3	0.0494	M+α	M-α	M+α/4	M+α/2
3	2	0	1	3	0.0494	M+α	M-α	M	M
4	1	2	0	3	0.0741	M+α	M-α	M	M
5	1	1	1	6	0.1481	M+α	M-α	M-α/4	M-α/2
6	1	0	2	3	0.0741	M+α	M-α	M-α/2	M-α
7	0	3	0	1	0.0494	M	M-α	M-α/4	M
8	0	2	1	3	0.1481	M	M-α	M-α/2	M-α/2
9	0	1	2	3	0.1481	M	M-α	M-3α/4	M-α
10	0	0	3	1	0.0494	M-α	M-α	M-α	M-α
Sum				27	1.0000			**M-α/4**	**M-α/3**

Assuming that all players act out of self-interest and are rational, and that this is public knowledge, we can work out the best strategy given each endowment – and systematically the different Bayes Nash equilibria under the different constraints and incentives. The different thresholds where players would choose to change strategy yield different 'scenarios', as the probability distribution is altered.

Example 3: Consider the situation in Table A4.9a in Appendix 4, with the constraint:

$\left(4\rho \leq \sigma < 4\rho + \frac{4}{9}E\right) \cap (0 < \rho < \frac{1}{9}E)$.

This scenario involves a fairly small reputational constraint, but the stigma incentive is large enough for players with E^0 to choose to play 'low', whereas players $E^{\neq 0}$ stick

to original strategies (as shown in Table A4.9b). Thus, using the probabilities below gives us the expected LIBOR outcomes respectively in Matrix A3.5, A3.6 and A3.7:

$$z^{H}_{n\neq i} = Prob\{s^{*}_{n\neq i}, L^{H}_{n\neq i}\} = 1/3$$
$$z^{M}_{n\neq i} = Prob\{s^{*}_{n\neq i}, L^{M}_{n\neq i}\} = 0$$
$$z^{L}_{n\neq i} = Prob\{s^{*}_{n\neq i}, L^{L}_{n\neq i}\} = 2/3$$

Matrix A3.5: P_i Submits L^H (Scenario II)

Outcome	$\mathbf{L^H}$	$\mathbf{L^M}$	$\mathbf{L^L}$	**Permutations**	***p***	**Max**	**Min**	$\mathbf{L_A}$	$\mathbf{L_F}$
1	3	0	0	1	0.0370	M+α	M+α	M+α	M+α
2	2	0	1	6	0.2222	M+α	M-α	M+α/2	M+α
3	1	0	2	12	0.4444	M+α	M-α	M	M
4	0	0	3	8	0.2963	M+α	M-α	M-α/2	M-α
Sum				27	0.1481	M+α	M-α	**M**	**M-α/27**

Matrix A3.6: P_i Submits L^M (Scenario II)

Outcome	$\mathbf{L^H}$	$\mathbf{L^M}$	$\mathbf{L^L}$	**Permutations**	***p***	**Max**	**Min**	$\mathbf{L_A}$	$\mathbf{L_F}$
1	3	0	0	1	0.0370	M+α	M	M+3α/4	M+α
2	2	0	1	6	0.2222	M+α	M-α	M+α/4	M+α/2
3	1	0	2	12	0.4444	M+α	M-α	M-α/4	M-α/2
4	0	0	3	8	0.2963	M	M-α	M-3α/4	M-α
Sum				27	0.1481			**M-α/4**	**M-10α/27**

Matrix A3.7: P_i Submits L^L (Scenario II)

Outcome	$\mathbf{L^H}$	$\mathbf{L^M}$	$\mathbf{L^L}$	**Permutations**	***p***	**Max**	**Min**	$\mathbf{L_A}$	$\mathbf{L_F}$
1	3	0	0	1	0.0370	M+α	M	M+α/2	M+α/2
2	2	0	1	6	0.2222	M+α	M-α	M	M
3	1	0	2	12	0.4444	M+α	M-α	M-α/2	M-α
4	0	0	3	8	0.2963	M-α	M-α	M	M-α
Sum				27	0.1481			**M-α/2**	**M-19α/27**

APPENDIX 4

Beliefs, Expected Payoffs and Expected LIBOR Equilibria

Table A4.1a: Beliefs (LIBOR Base Game)

LIBOR Base Game	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
E_i^0	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
E_i^-	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$

Table A4.1b: Expected Payoffs (LIBOR Base Game).Optimal Strategies in Bold.

LIBOR Base Game	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{\frac{1}{3}\alpha E}$	0	$-\frac{1}{3}\alpha E$
E_i^0	0	$\mathbf{0}$	0
E_i^-	$-\frac{1}{3}\alpha E$	0	$\boldsymbol{\frac{1}{3}\alpha E}$

Table A4.1c: Expected LIBOR Equilibria (LIBOR Base Game).Under Optimal Strategies in Bold.

LIBOR Base Game	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{M+\frac{1}{3}\alpha}$	M	$M-\frac{1}{3}\alpha$
E_i^0	$M+\frac{1}{3}\alpha$	$\boldsymbol{M}$	$M-\frac{1}{3}\alpha$
E_i^-	$M+\frac{1}{3}\alpha$	M	$\boldsymbol{M-\frac{1}{3}\alpha}$

Table A4.2a: Beliefs (LIBOR Collusion game)

LIBOR Collusion Game	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	$\frac{15}{27}$	$\frac{6}{27}$	$\frac{6}{27}$
E_i^0	$\frac{6}{27}$	$\frac{15}{27}$	$\frac{6}{27}$
E_i^-	$\frac{6}{27}$	$\frac{6}{27}$	$\frac{15}{27}$

Table A4.2b: Expected Payoffs (LIBOR Collusion game).Optimal Strategies in Bold.

LIBOR Collusion Game	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{\frac{13}{18}\alpha E}$	0	$-\frac{13}{18}\alpha E$
E_i^0	0	0	0
E_i^-	$-\frac{13}{18}\alpha E$	$\mathbf{0}$	$\boldsymbol{\frac{13}{18}\alpha E}$

Table A4.2c: Expected LIBOR Equilibria (LIBOR Collusion game).Under Optimal Strategies in Bold.

LIBOR Collusion Game	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{M+\frac{13}{18}\alpha}$	M	$M-\frac{13}{18}\alpha$
E_i^0	$M+\frac{13}{18}\alpha$	$\boldsymbol{M}$	$M-\frac{13}{18}\alpha$
E_i^-	$M+\frac{13}{18}\alpha$	M	$\boldsymbol{M-\frac{13}{18}\alpha}$

Table A4.3a: Beliefs (LIBOR Bribe Game)

$B < \frac{19}{27}\alpha E$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	$\frac{2}{3}$	0	$\frac{1}{3}$
E_i^0	0	0	0
E_i^-	$\frac{1}{3}$	0	$\frac{2}{3}$

Table A4.3b: Expected Payoffs (LIBOR Bribe Game).Optimal Strategies in Bold.

$B < \frac{19}{27}\alpha E$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{\frac{19}{27}\alpha E - B}$	0	$-\frac{19}{27}\alpha E - B$
E_i^0	0	$\mathbf{0}$	0
E_i^-	$-\frac{19}{27}\alpha E - B$	0	$\boldsymbol{\frac{19}{27}\alpha E - B}$

Table A4.3c: Expected LIBOR Equilibria (LIBOR Bribe Game).Under optimal Strategies in Bold.

$B < \frac{19}{27}\alpha E$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{M + \frac{19}{27}\alpha}$	M	$M - \frac{19}{27}\alpha$
E_i^0	$M + \frac{19}{27}\alpha$	$\boldsymbol{M}$	$M - \frac{19}{27}\alpha$
E_i^-	$M + \frac{19}{27}\alpha$	M	$\boldsymbol{M - \frac{19}{27}\alpha}$

Table A4.4a: Beliefs (Low Reputational Constraint)

$\rho < \frac{1}{9}E$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
E_i^0	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
E_i^-	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$

Table A4.4b: Expected Payoffs (Low Reputational Constraint).Optimal Strategies in Bold.

$\rho < \frac{1}{9}E$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{\alpha(\frac{1}{3}E-\rho)}$	$2\alpha\rho$	$\alpha(-\frac{1}{3}E-\rho)$
E_i^0	$-\alpha\rho$	$\boldsymbol{2\alpha\rho}$	$-\alpha\rho$
E_i^-	$\alpha(-\frac{1}{3}E-\rho)$	$2\alpha\rho$	$\boldsymbol{\alpha(\frac{1}{3}E-\rho)}$

Table A4.4c: Expected LIBOR Equilibria (Low Reputational Constraint).Under Optimal Strategies in Bold.

$\rho < \frac{1}{9}E$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{M+\frac{1}{3}\alpha}$	M	$M-\frac{1}{3}\alpha$
E_i^0	$M+\frac{1}{3}\alpha$	$\boldsymbol{M}$	$M-\frac{1}{3}\alpha$
E_i^-	$M+\frac{1}{3}\alpha$	M	$\boldsymbol{M-\frac{1}{3}\alpha}$

Table A4.5a: Beliefs (High Reputational Constraint)

$\rho \geq \frac{1}{9}E$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	0	1	0
E_i^0	0	1	0
E_i^-	0	1	0

Table A4.5b: Expected Payoffs (High Reputational Constraint).Optimal Strategies in Bold.

$\rho \geq \frac{1}{9}E$	L_i^H	L_i^M	L_i^L
E_i^+	$\alpha(\frac{1}{3}E - 3\rho)$	**0**	$-\alpha(\frac{1}{3}E + 3\rho)$
E_i^0	$-3\alpha\rho$	**0**	$-3\alpha\rho$
E_i^-	$-\alpha(\frac{1}{3}E + 3\rho)$	**0**	$\alpha(\frac{1}{3}E - 3\rho)$

Table A4.5c: Expected LIBOR Equilibria (High Reputational Constraint).Under Optimal Strategies in Bold.

$\rho \geq \frac{1}{9}E$	L_i^H	L_i^M	L_i^L
E_i^+	$M + \frac{1}{3}\alpha$	***M***	$M - \frac{1}{3}\alpha$
E_i^0	$M + \frac{1}{3}\alpha$	***M***	$M - \frac{1}{3}\alpha$
E_i^-	$M + \frac{1}{3}\alpha$	***M***	$M - \frac{1}{3}\alpha$

Table A4.6a: Beliefs (Low Stigma Incentive)

$0 < \sigma < \frac{12}{27}E$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	$\frac{1}{3}$	0	$\frac{2}{3}$
E_i^0	$\frac{1}{3}$	0	$\frac{2}{3}$
E_i^-	$\frac{1}{3}$	0	$\frac{2}{3}$

Table A4.6b: Expected Payoffs (Low Stigma Incentive).Optimal Strategies in Bold.

$0 < \sigma < \frac{12}{27}E$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{\alpha(-\frac{1}{27}E-\sigma)}$	$\alpha(-\frac{10}{27}E-\frac{1}{4}\sigma)$	$\alpha(-\frac{19}{27}E+\frac{1}{2}\sigma)$
E_i^0	$\alpha(\sigma)$	$\alpha(-\frac{1}{4}\sigma)$	$\boldsymbol{\alpha(\frac{1}{2}\sigma)}$
E_i^-	$\alpha(\frac{1}{27}E-\sigma)$	$\alpha(\frac{10}{27}E-\frac{1}{4}\sigma)$	$\boldsymbol{\alpha(\frac{19}{27}E+\frac{1}{2}\sigma)}$

Table A4.6c: Expected LIBOR Equilibria (Low Stigma Incentive).Under Optimal Strategies in Bold.

$0 < \sigma < \frac{12}{27}E$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{M-\frac{1}{27}\alpha}$	$M-\frac{10}{27}\alpha$	$M-\frac{19}{27}\alpha$
E_i^0	$M-\frac{1}{27}\alpha$	$M-\frac{10}{27}\alpha$	$\boldsymbol{M-\frac{19}{27}\alpha}$
E_i^-	$M-\frac{1}{27}\alpha$	$M-\frac{10}{27}\alpha$	$\boldsymbol{M-\frac{19}{27}\alpha}$

Table A4.7a: Beliefs (High Stigma Incentive)

$\sigma \geq \frac{12}{27}E$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	0	0	1
E_i^0	0	0	1
E_i^-	0	0	1

Table A4.7b: Expected Payoffs (High Stigma Incentive).Optimal Strategies in Bold.

$\sigma \geq \frac{12}{27}E$	L_i^H	L_i^M	L_i^L
E_i^+	$\alpha(-E-\frac{3}{2}\sigma)$	$\alpha(-E-\frac{3}{4}\sigma)$	$\boldsymbol{\alpha(-E)}$
E_i^0	$\alpha(-\frac{3}{2}\sigma)$	$\alpha(-\frac{3}{4}\sigma)$	$\mathbf{0}$
E_i^-	$\alpha(E-\frac{3}{2}\sigma)$	$\alpha(E-\frac{3}{4}\sigma)$	$\boldsymbol{\alpha(E)}$

Table A4.7c: Expected LIBOR Equilibria (High Stigma Incentive).Under Optimal Strategies in Bold.

$\sigma \geq \frac{12}{27}E$	L_i^H	L_i^M	L_i^L
E_i^+	$M-\sigma$	$M-\sigma$	$\boldsymbol{M-\sigma}$
E_i^0	$M-\sigma$	$M-\sigma$	$\boldsymbol{M-\sigma}$
E_i^-	$M-\sigma$	$M-\sigma$	$\boldsymbol{M-\sigma}$

Table A4.8a: Beliefs (Scenario I)

$\left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
E_i^0	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$
E_i^-	$\frac{1}{3}$	$\frac{1}{3}$	$\frac{1}{3}$

Table A4.8b: Expected Payoffs (Scenario I).Optimal Strategies in Bold.

$\left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{\alpha(\frac{1}{3}E-\rho-\frac{3}{4}\sigma)}$	$2\alpha\rho$	$-\alpha(\frac{1}{3}E+\rho-\frac{3}{4}\sigma)$
E_i^0	$-\alpha(\frac{3}{4}\sigma+R)$	$\boldsymbol{2\alpha\rho}$	$\alpha(\frac{3}{4}\sigma-\rho)$
E_i^-	$-\alpha(\frac{1}{3}E+\rho+\frac{3}{4}\sigma)$	$2\alpha\rho$	$\boldsymbol{\alpha(\frac{1}{3}E-\rho+\frac{3}{4}\sigma)}$

Table A4.8c: Expected LIBOR Equilibria (Scenario I).Under Optimal Strategies in Bold.

$\left(0<\rho<\frac{1}{9}E\right)\cap(\sigma<4\rho)$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{M+\frac{1}{3}\alpha}$	M	$M-\frac{1}{3}\alpha$
E_i^0	$M+\frac{1}{3}\alpha$	$\boldsymbol{M}$	$M-\frac{1}{3}\alpha$
E_i^-	$M+\frac{1}{3}\alpha$	M	$\boldsymbol{M-\frac{1}{3}\alpha}$

Table A4.9a: Beliefs (Scenario II)

$\left(4\rho \le \sigma < 4\rho + \frac{4}{9}E\right) \cap (0 < \rho < \frac{1}{9}E)$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	$\frac{1}{3}$	0	$\frac{2}{3}$
E_i^0	$\frac{1}{3}$	0	$\frac{2}{3}$
E_i^-	$\frac{1}{3}$	0	$\frac{2}{3}$

Table A4.9b: Expected Payoffs (Scenario II).Optimal Strategies in Bold.

$\left(4\rho \le \sigma < 4\rho + \frac{4}{9}E\right) \cap (0 < \rho < \frac{1}{9}E)$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{\alpha(-\frac{1}{27}E - \sigma)}$	$\alpha(-\frac{10}{27}E + 3\rho - \frac{1}{4}\sigma)$	$\alpha(-\frac{19}{27}E + \frac{1}{2}\sigma)$
E_i^0	$\alpha(-\sigma)$	$\alpha(3\rho - \frac{1}{4}\sigma)$	$\boldsymbol{\alpha(\frac{1}{2}\sigma)}$
E_i^-	$\alpha(\frac{1}{27}E - \sigma)$	$\alpha(\frac{10}{27}E + 3\rho - \frac{1}{4}\sigma)$	$\boldsymbol{\alpha(\frac{19}{27}E + \frac{1}{2}\sigma)}$

Table A4.9c: Expected LIBOR Equilibria (Scenario II).Under Optimal Strategies in Bold.

$\left(4\rho \le \sigma < 4\rho + \frac{4}{9}E\right) \cap (0 < \rho < \frac{1}{9}E)$	L_i^H	L_i^M	L_i^L
E_i^+	$\boldsymbol{M - \frac{1}{27}\alpha}$	$M - \frac{10}{27}\alpha$	$M - \frac{19}{27}\alpha$
E_i^0	$M - \frac{1}{27}\alpha$	$M - \frac{10}{27}\alpha$	$\boldsymbol{M - \frac{19}{27}\alpha}$
E_i^-	$M - \frac{1}{27}\alpha$	$M - \frac{10}{27}\alpha$	$\boldsymbol{M - \frac{19}{27}\alpha}$

Table A4.10a: Beliefs (Scenario III)

$\left(4\rho - \frac{4}{9}E \leq \sigma < 4\rho\right)$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	0	$\frac{2}{3}$	$\frac{1}{3}$
E_i^0	0	$\frac{2}{3}$	$\frac{1}{3}$
E_i^-	0	$\frac{2}{3}$	$\frac{1}{3}$

Table A4.10b: Expected Payoffs (Scenario III).Optimal Strategies in Bold.

$\left(4\rho - \frac{4}{9}E \leq \sigma < 4\rho\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$\alpha(-\frac{4}{27}E - 2\rho - \sigma)$	$\boldsymbol{\alpha\left(-\frac{4}{27}E + \rho - \frac{1}{4}\sigma\right)}$	$\alpha\left(-\frac{13}{27}E - 2\rho + \frac{1}{2}\sigma\right)$
E_i^0	$\alpha(-2\rho - \sigma)$	$\boldsymbol{\alpha(\rho - \frac{1}{4}\sigma)}$	$\alpha(-2\rho + \frac{1}{2}\sigma)$
E_i^-	$\alpha(\frac{4}{27}E - 2\rho - \sigma)$	$\alpha(\frac{4}{27}E + \rho - \frac{1}{4}\sigma)$	$\boldsymbol{\alpha(\frac{13}{27}E - 2\rho + \frac{1}{2}\sigma)}$

Table A4.10c: Expected LIBOR Equilibria (Scenario III).Under Optimal Strategies in Bold.

$\left(4\rho - \frac{4}{9}E \leq \sigma < 4\rho\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$M - \frac{4}{27}\alpha$	$\boldsymbol{M - \frac{4}{27}\alpha}$	$M - \frac{13}{27}\alpha$
E_i^0	$M - \frac{4}{27}\alpha$	$\boldsymbol{M - \frac{4}{27}\alpha}$	$M - \frac{13}{27}\alpha$
E_i^-	$M - \frac{4}{27}\alpha$	$M - \frac{4}{27}\alpha$	$\boldsymbol{M - \frac{13}{27}\alpha}$

Table A4.11a: Beliefs (Scenario IV)

$\left(4\rho \leq \sigma < 4\rho + \frac{4}{9}E\right)$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	0	$\frac{1}{3}$	$\frac{2}{3}$
E_i^0	0	$\frac{1}{3}$	$\frac{2}{3}$
E_i^-	0	$\frac{1}{3}$	$\frac{2}{3}$

Table A4.11b: Expected Payoffs (Scenario IV).Optimal Strategies in Bold.

$\left(4\rho \leq \sigma < 4\rho + \frac{4}{9}E\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$\alpha(-\frac{14}{27}E - \rho - \frac{5}{4}\sigma)$	$\boldsymbol{\alpha\left(-\frac{14}{27}E + 2\rho - \frac{1}{2}\sigma\right)}$	$\alpha\left(-\frac{23}{27}E - \rho + \frac{1}{24}\sigma\right)$
E_i^0	$\alpha(-\rho - \frac{5}{4}\sigma)$	$\alpha(2\rho - \frac{1}{2}\sigma)$	$\boldsymbol{\alpha(-\rho + \frac{1}{4}\sigma)}$
E_i^-	$\alpha(\frac{14}{27}E - \rho - \frac{5}{4}\sigma)$	$\alpha(\frac{14}{27}E + 2\rho - \frac{1}{2}\sigma)$	$\boldsymbol{\alpha(\frac{23}{27}E - \rho + \frac{1}{24}\sigma)}$

Table A4.11c: Expected LIBOR Equilibria (Scenario IV).Under Optimal Strategies in Bold.

$\left(4\rho \leq \sigma < 4\rho + \frac{4}{9}E\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$M - \frac{14}{27}\alpha$	$\boldsymbol{M - \frac{14}{27}\alpha}$	$M - \frac{23}{27}\alpha$
E_i^0	$M - \frac{14}{27}\alpha$	$M - \frac{14}{27}\alpha$	$\boldsymbol{M - \frac{23}{27}\alpha}$
E_i^-	$M - \frac{14}{27}\alpha$	$M - \frac{14}{27}\alpha$	$\boldsymbol{M - \frac{23}{27}\alpha}$

Table A4.12a: Beliefs (Scenario V)

$\left(\sigma \geq 4\rho + \frac{4}{9}E\right)$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	0	0	1
E_i^0	0	0	1
E_i^-	0	0	1

Table A4.12b: Expected Payoffs (Scenario V).Optimal Strategies in Bold.

$\left(\sigma \geq 4\rho + \frac{4}{9}E\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$\alpha(-E - \frac{3}{2}\sigma)$	$\alpha\left(-E + 3\rho - \frac{3}{4}\sigma\right)$	$\boldsymbol{\alpha(-E)}$
E_i^0	$\alpha(-\frac{3}{2}\sigma)$	$\alpha(3\rho - \frac{3}{4}\sigma)$	$\mathbf{0}$
E_i^-	$\alpha(E - \frac{3}{2}\sigma)$	$\alpha(E + 3\rho - \frac{3}{4}\sigma)$	$\boldsymbol{\alpha(E)}$

Table A4.12c: Expected LIBOR Equilibria (Scenario V).Under Optimal Strategies in Bold.

$\left(\sigma \geq 4\rho + \frac{4}{9}E\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$M - \alpha$	$M - \alpha$	$\boldsymbol{M - \alpha}$
E_i^0	$M - \alpha$	$M - \alpha$	$\boldsymbol{M - \alpha}$
E_i^-	$M - \alpha$	$M - \alpha$	$\boldsymbol{M - \alpha}$

Table A4.13a: Beliefs (Scenario VI)

$\left(\sigma < 4\rho - \frac{4}{9}E\right)$	$z_{n\neq i}^{H}$	$z_{n\neq i}^{M}$	$z_{n\neq i}^{L}$
E_i^+	0	1	0
E_i^0	0	1	0
E_i^-	0	1	0

Table A4.13b: Expected Payoffs (Scenario VI).Optimal Strategies in Bold.

$\left(\sigma < 4\rho - \frac{4}{9}E\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$\alpha(\frac{1}{3}E - 3\rho - \frac{3}{4}\sigma)$	**0**	$\alpha(-\frac{1}{3}E - 3\rho + \frac{3}{4}\sigma)$
E_i^0	$\alpha(-\frac{3}{4}\sigma - 3R)$	**0**	$\alpha(\frac{3}{4}\sigma - 3\rho)$
E_i^-	$\alpha(-\frac{1}{3}E - 3\rho - \frac{3}{4}\sigma)$	**0**	$\alpha(\frac{1}{3}E - 3\rho + \frac{3}{4}\sigma)$

Table A4.13c: Expected LIBOR Equilibria (Scenario VI).Under Optimal Strategies in Bold.

$\left(\sigma < 4\rho - \frac{4}{9}E\right)$	L_i^H	L_i^M	L_i^L
E_i^+	$M + \frac{1}{3}\alpha$	$\boldsymbol{M}$	$M - \frac{1}{3}\alpha$
E_i^0	$M + \frac{1}{3}\alpha$	$\boldsymbol{M}$	$M - \frac{1}{3}\alpha$
E_i^-	$M + \frac{1}{3}\alpha$	$\boldsymbol{M}$	$M - \frac{1}{3}\alpha$

APPENDIX 5

NIBOR Rule Change: Empirical Results

Table A5.1: 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	

Table A5.2: [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 A5.3: [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 A5.4: [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 A5.5: [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	

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