

London Interbank Offered Rate

FIN 3560-02: Financial Markets and Instruments

Professor Michael A. Goldstein, PH.D

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Inna Loseva, Karina Menagi, Michael Liachowitz, Nate Kolman

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Executive Summary

LIBOR plays an important role in the world of financial markets as a reference for various monetary and financial contracts. It is for this reason that we have decided to focus our paper on this subject. In analyzing LIBOR, we have focused on its history, its calculation, the fixing scandal, and the future viability of the rate. Learning of LIBOR's history and calculation has allowed us to understand the full scope of the scandal. Additionally, it has led us to question whether the rate will continue to be the world's most widely used benchmark for short term interest rates. With this question in mind, the purpose of our statistical analysis was to find the relationship between LIBOR and its alternatives in an unbiased market environment. We created a model that represented LIBOR before the financial crisis and then projected it through the crisis. This, in turn, gave us an unbiased view of the rate without market sentiment or market manipulation. We were able to use this data to analyze the effectiveness of new alternatives, such as ICAP's New York Funding Rate, in comparison to LIBOR. Through our statistical analysis we concluded that although new alternatives are available for LIBOR, or at least in the process of being developed, a large enough statistical difference does not exist to fully support terminating LIBOR.

Introduction

The London Interbank Offer Rate, often abbreviated as LIBOR, is the average of the interest rates at which banks are willing to lend to each other. Since LIBOR is calculated through a survey of banks and not actual transactions, the definition is constantly under revision. LIBOR is calculated by surveying the banks on the LIBOR panel of their interbank loan rate; the top and bottom quartiles are removed to hedge outliers and an average of the middle two quartiles is taken to calculate the LIBOR rate.

LIBOR was first founded by a Harvard graduate Minos Zombanakis in 1969 when he was working for Manufacturer's Hanover in London. He came up with the idea of LIBOR "when the bank organized one of the first syndicated loans pegged."¹ At the time however, the "LIBOR" rate was used to calculate the rate for an \$80 million loan to the Shah of Iran. Fifteen years later, it became increasingly apparent that a benchmark was needed; foreign currency trades, forward rate agreements, and interest rate swaps started to become more popular financial instruments for banks. In 1984, data started to be collected by the British Bankers' Association (BBA) in order to create a LIBOR rate. After two years of testing, the first official LIBOR rate was used in January 1986.²

When LIBOR was first introduced, in 1986, it was published under three currencies: the U.S. dollar, British pound sterling and Japanese yen. Eventually, this number grew to where it is today at sixteen currencies. After the Euro was introduced and the currency of many European nations transferred to the Euro, LIBOR was then fixed in ten different currencies: the Australian Dollar, Canadian Dollar, Swiss Franc, Danish Krone, Euro, British Pound Sterling, Japanese Yen, New Zealand Dollar, Swedish Krona, and U.S. Dollar.

For the first 12 years of LIBOR's existence, the shortest maturity was one month. However, LIBOR with a 1 week maturity was added in 1998 and in 2001, the 2 week and overnight LIBOR had also begun to be used. Currently, the following LIBOR rates that are produced are as followed: 1 day, 1

¹ "A Greek Banker Spills On The Early Days Of The Libor And His First Deal With The Shah Of Iran," Kirsten Ridley and Huw Jones

² <http://www.bbalibor.com/bbalibor-explained/historical-perspective>

week, 2 weeks, 1 month, 2 months, 3 months, 4 months, 5 months, 6 months, 7 months, 8 months, 9 months, 11 months, and 12 months.

From the inception of LIBOR, it was regulated by the BBA, the leading trade association for the UK banking and financial services sector. However, since the LIBOR fixing scandal, the BBA has been stripped of its ability to set LIBOR and transferred the responsibilities to U.K. regulators.³ The BBA had failed to properly regulate the LIBOR rate against manipulation.

³ “British Bankers' Association to be stripped of Libor rate-setting role,” Jill Treanor

LIBOR Scandal

In 2012, one of the most publicized financial events that occurred was the LIBOR fixing scandal. Although there was data that suggests there was a possibility of manipulation by the banks that served on the LIBOR panel as early as 2008, the scandal was confirmed when the Financial Services Authority (FSA), the U.K.'s regulatory agency, the U.S. Commodity Futures Trading Commission, and the U.S. Department of Justice fined Barclays over \$451 million dollars for understating or overstating their rate. The banks submitted these false rates in order to appear more financially healthy than they actually were and to make profit in the derivatives market. Following the discovery of Barclays' involvement in the LIBOR scandal, the FSA launched further investigations into other banks on the LIBOR panel including Royal Bank of Scotland, UBS AG, Lloyds Banking, JP Morgan, HSBC, and Deutsche Bank.⁴ In addition, there was evidence that the Federal Reserve of New York and the Bank of England had knowledge of the LIBOR fixing scandal but did not act upon it.⁵ The BBA also failed to successfully regulate LIBOR against manipulation. Therefore, the Managing Director of the Conduct Business Unit at the FSA, Martin Wheatley, relinquished the BBA of their regulatory duties and transferred the responsibilities to the FSA until a solution could be reached.⁶

Although there may be some speculation as to when the LIBOR rate fixing scandal first started, the first public examination of the LIBOR rate occurred April 16th, 2008, when the Wall Street Journal published an article entitled "Bankers Cast Doubt On Key Rate Amid Crisis." One of the primary reasons for concern of a possible fixing scandal was the unusually high difference between the 3-month LIBOR rate and the Eurodollar 3-month deposit rate. In late 2007, the 3-month LIBOR rate rose greatly and remained above the Eurodollar 3-month deposit rate (Exhibit 1). In addition, the financial crisis in 2008 lead to a near complete halt in interbank short term loans, which was one of the cause of unreliable

⁴ "JPMorgan, UBS Said Among Banks Queried in Libor Probe," David McLaughlin

⁵ "Libor (Barclays Interest Rate Manipulation Case)" New York Times

⁶ "Trust Matters as U.K. Regulator Suggests Libor Scrapping," Markets Media

LIBOR averages.⁷ This speculation allowed banks to understate their rates, which raised more red flags on the likelihood of possible LIBOR manipulation. In addition to the Eurodollar 3-month deposit rate, another indicator of the banks' rate is the cost of default insurance, or rather credit default swap prices. There has been a large disparity between the banks' reported rates and the calculated rates using the cost of default insurance (Exhibit 2). Furthermore, there has been an incredibly large gap between the LIBOR panel in the range of Credit Default Swap prices (Exhibit 3). During the crisis, banks did not want to submit a higher rate to the BBA because it would damage investors' confidence of a bank's financial health.⁸ While there had been some red flags indicating potential LIBOR manipulation at the time, it was all speculation; there was no solid evidence available. In fact, BBA Chief Executive Angela Knight said that "the current situation is extraordinary" regarding the financial crisis's effect on the LIBOR rate. In addition, a BBA spokesman said that there was "'no indication' that the default-insurance market provides a more accurate picture of banks' borrowing cost than LIBOR."⁹ Although there was no concrete evidence of LIBOR manipulation available, there was still some uncertainty if the LIBOR rate was truly accurate.

Since 2008 however, evidence of LIBOR manipulation has been made publically available that dates back to as early as 2005. On July 27, 2012, the FSA released a report revealing evidence of LIBOR fixing. In the report, the FSA stated that Barclays "breached Principle 5 on numerous occasions between January 2005 and July 2008 by making US dollar LIBOR and EURIBOR submissions which took into account requests made by its interest rate derivatives traders."¹⁰ According to the report, Barclays

⁷ The rates for short term loans between banks have become speculative due to the rising unwillingness of banks to loan to each other. There has been "little to no lending for [more than one week] time period..." It amounts to an average best guess" (Bankers Cast Doubt On Key Rate Amid Crisis, Mollenkamp)

⁸ "At times of market turmoil, banks face a dilemma. If any bank submits a much higher rate than its peers, it risks looking like it's in financial trouble. So banks have an incentive to play it safe by reporting something similar -- which would cause the reported rates to cluster together." (Study Casts Doubt on Key Rate, Mollenkamp and Whitehouse)

⁹ "Study Casts Doubt on Key Rate," Carrick Mollenkamp and Mark Whitehouse

¹⁰ FSA Final Notice, July 27th, 2012; Reference Number 112702

breached Principle 2, Principle 3, and Principle 5 as early as January 2005.¹¹ Starting in 2005, derivatives traders communicated with Barclays, one of the sixteen banks on the LIBOR panel at the time, via email and telephone. In the report, the FSA cited specific examples of LIBOR fixing by Barclays employees, including one conversation where the trader says, *“I really need a very very low 3m fixing on Monday – preferably we get kicked out. We have about 80 yards fixing for the desk and each 0.1 lower in the fix is a huge help for us. So 4.90 or lower would be fantastic.”* Following the exchange, the derivatives trader had another conversation with the submitter in which the submitter told the trader that, *“[X or Y] will be here if you have any requests for the fixings”* (Exhibit 5).¹² Barclays was only one of the seven banks that were probed; the other banks include Royal Bank of Scotland, UBS AG, Lloyds Banking, JP Morgan, HSBC, and Deutsche Bank.

While the FSA has found proof of LIBOR manipulation dating back to 2005, there seems to be speculation as to when the scandal actually started. There is a possibility that LIBOR fixing occurred before 2005 and the FSA could not find evidence. In a research paper drafted on August 12, 1998, by Jeremy Berkowitz, a member of the Federal Reserve Board at the time, theorizes that inaccuracies within LIBOR had been present even as early as 1996.¹³ Berkowitz theorizes that the “trimmed-mean” LIBOR calculation is not the most accurate way to calculate LIBOR, especially when there is contamination in the rate reporting.¹⁴ In a statistical standpoint, the theoretical accuracy of the trimmed-mean is “quite sensitive to faulty data in small samples. In fact, it is possible to show that a 10% trimmed-mean based on fewer than 20 observations can break down in the presence of even 2 outliers.”¹⁵ Currently, eighteen banks are surveyed and the highest and lowest four rates are removed in the process of calculating LIBOR. It was previously mentioned that seven banks are currently under investigation for providing

¹¹ Principle 5 “states that a firm must observe proper standards of market conduct.” Principle 3 “states that a firm must take reasonable care to organise and control its affairs responsibly and effectively, with adequate risk management systems.” Principle 2 “states that a firm must conduct its business with due skill, care and diligence.”

¹² “X or Y” was used to protect the identities of Barclays employees in the FSA report

¹³ Berkowitz points out three separate spikes in the 3-month LIBOR rate in early 2006 that were caused by unintended misreporting (Exhibit 7)

¹⁴ “Trimmed-mean” is the process of removing a given number of highest and lowest rates and taking the averages of the remaining rates

¹⁵ “Dealer Polling in the Presence of Possibly Noisy Reporting,” Jeremy Berkowitz 1998

false rates; in the event that these seven banks are found all guilty of LIBOR fixing, the trimmed-means calculation method will not indicate that it has the ability to protect against bias and misreporting. Berkowitz suggests that a more efficient way of calculating LIBOR would be to use the Huber-estimate, which could provide an accurate reading of LIBOR provided that there are less than or exactly seven false rates from the banks. However, the purpose of Berkowitz's paper wasn't to provide a suggestion or how to change the method of calculation, but rather to argue the Fed was nervous about miscalculating LIBOR almost fifteen years prior to the scandal being made public.

Alternatives for LIBOR's future

It has become obvious that LIBOR currently has major issues. Across the board, a widespread sentiment has been reached: LIBOR needs massive overhaul. However, there has been much debate over how to mend the LIBOR recovery process. According to an article on the International Financial Law Review (IFLR), a poll of lawyers from the United States, UK, and Europe revealed that 81% are against the idea of ending LIBOR as a whole.¹⁶ The primary issue with getting rid of LIBOR altogether is that is currently estimated to be tied in \$350 and \$800 trillion in financial contracts globally.¹⁷ If LIBOR was suddenly scrapped, there would be a large void since it is a globally used benchmark. Currently, the FSA has devised a 10 point plan in fixing the issues that lie within LIBOR. There are many alternatives that are actively debated on what is the best method of dealing with these issues. However, the purpose of each alternative is twofold: restore trust in LIBOR as a financial benchmark and find a solution quickly in order to minimize the damage the scandal has created. One solution proposed by Martin Wheatley, is to have better LIBOR regulation. The FSA plans on creating a new panel starting in 2013 to regulate LIBOR in order to attempt to remove bias. If LIBOR is regulated by an independent panel, it "will take away the

¹⁶ "Barclays rate-fixing scandal: Libor Alternatives analysed," McNulty

¹⁷ "Libor scandal explained and what rate-rigging means to you" (USA Today): The actual dollar amount of financial contracts that use LIBOR often varies

notion that this was a system run by banks for the benefit of banks.”¹⁸ But, the main criticism of this idea is that there is some skepticism if it will actually stop financial abuses from occurring. Another solution is to alter the way LIBOR is calculated. Instead of using a system in which the rate is calculated based off a “self-assessment poll conducted among a panel of major banks,” another method of calculation based off of actual secured market securities should be used.¹⁹ In theory, this method works because the banks would no longer submit rates that would only serve the purpose of calculating LIBOR. Previously, banks were not obligated to lend at the rate they submitted. However, one glaring facet of this method is that the rates would not truly be reliable during a financial crisis when banks are reluctant to loan to one another. In addition, getting rid of LIBOR in favor for this new method would create chaos based on the amount of contracts that are currently tied to LIBOR. Lastly, policymakers are calling for stricter criminal sanctions for those who manipulate LIBOR. Although this has less to do with the actual benchmark and directed more towards banks, it should bring harsher penalties to those who would commit a similar crime. In order to regain trust in LIBOR as a benchmark, the process in which LIBOR is calculated must be reformed.

A personal reference, who wished to remain unnamed, provided his insight on the topic. According to his opinion, LIBOR should not be terminated, at least not in the short term. Because there are trillions of dollars still left in contracts associated with LIBOR, terminating the rate and replacing it with a different benchmark would put these contracts in jeopardy. A few months ago, Elizabeth Warren, a Democratic nominee for Senate in Massachusetts, publicly stated, “The LIBOR scandal is more than just the latest financial deception to come to light. It exposes a fraud that runs to the heart of our financial system.”²⁰

¹⁸ “FSA seeks to mend ‘broken’ Libor, not end it,” Huw Jones. Source of quote is Matthew Fell, director for competitive markets at the Confederation of British Industry

¹⁹ “How to mend the Libor Process,” David Rowe

²⁰ “Elizabeth Warren: ‘Libor Fraud Exposes Rot At The Core Of The Financial System,’” Alexander Eichler

Statistical Analysis of LIBOR

The overnight indexed swap (OIS) is the rate on a derivative contract for the overnight rate, which is the effective federal funds rate in the United States. The LIBOR-OIS spread, the difference between the LIBOR and OIS rates, is assumed to be a measure of the bank's health since it reflects what banks believe is the risk of default associated with lending to other banks. Therefore, it is a closely watched barometer of distress in money markets. Former Fed Chairman Alan Greenspan stated, "LIBOR-OIS remains a barometer of fears of bank insolvency."²¹ High spreads indicate problems in the banking industry.

As can be seen in the table in Exhibit 14, the financial turmoil has had a significant impact on the Libor-OIS spread. The sudden rise in the LIBOR-OIS spread, between 2008 and 2009, was due to a combination of greater uncertainty and price fixing. These factors contributed to the change in standard deviation from 3.651864 in the 2002-2007 time period to 48.38345 in the 2007-2012 time period. In addition, the mean rose 32.07402, variance rose 2327.622, kurtosis rose 9.114807, skewness rose 2.057566, minimum rose 4.05 and the max rose 326.62. All of these changes to the LIBOR-OIS spread represent the disruption that the financial crisis had on the banking industry. Throughout the recent financial crisis, the LIBOR-OIS spread continued to represent fears surrounding bank insolvency. Due to financial uncertainties and overall disruption within the banking industry (including the scandals), the 1 year LIBOR-OIS spread faced increase in volatility.

In order to see the change in relationship of LIBOR and OIS spreads, we ran a regression on the 1 year LIBOR and 1 year OIS rate from 2002-2006 and 2007-2012. When performing a linear regression analysis, we made a series of assumptions about the data: linearity, independence of errors, normality of errors, and equal variance. For the time frame of 2002 to 2006 these assumptions seem to stay strong (Exhibit 9). However, these assumptions breakdown in the 2007 to 2012 time frame as Exhibit 8 clearly illustrates a violation of both the normality of errors and equal variance assumptions. These violations can

²¹ "More Evidence That LIBOR Is Manipulated, and What It Means," Center for Geoeconomic Studies

be explained by the financial turmoil of the time. The normality of distributions of errors could be a result of data manipulation or liquidity loss. The violation of equal variance can be explained by the extreme volatility in the beginning of the financial crisis in 2008.

The p-values for both regressions before and after 2007 were equal to 0.000, thus verifying the significance of the variables (Exhibit 10). The 1 year OIS is a valid determinate of 1 year LIBOR rates of the 1 year OIS rates in predicting 1 year LIBOR rates on the USD; the regression is true. However, it is important to consider the violated assumptions within the regression after 2007. Thus, there is not enough valid evidence to show that the 1 year OIS rate has significance in determining the 1 year LIBOR based on the USD.

After running regression tests on the relationship between the 12 month OIS rate and the USD LIBOR 12 month rate for the time frames of 2002-2006 and 2007-2012, we concluded that there is a significant inconsistency in the correlation of LIBOR and OIS, resulting in a variance in the LIBOR-OIS spread in the past decade.

New York Funding Rate

In Exhibit 15, The Council on Foreign Relations compares 3 month LIBOR to ICAP's New York Funding Rate, NYFR, the former being based on *anonymous* reports from major banks. NYFR's rate is modified from LIBOR in several respects. ICAP does not publish individual bank reported rates nor does it publish the set of survey contributors. NYFR is based on a larger set of contributors and it collects midmarket rates, *not* offer rates. Rates are measured when the New York session and London Eurodollar trading is most active at 9:15 a.m. EST. Finally, the survey asks contributors to estimate market borrowing rates for a representative A1/P1 institution, *not* the contributor's own funding costs.²²

Under normal circumstances, LIBOR and NYFR are closely aligned. However, there is a large gap depicted between the two rates during the time of the AIG and Lehman Brothers crises in September

²² "A comparison of Libor to other measures of bank borrowing costs," Dennis Kuo, David Skeie, and James Vickery

of 2008. Specifically, during this time, a bank that would publicly disclose its ability to only borrow at elevated rates would put itself at risk of suffering a lending halt. Thus, it shouldn't come as a surprise that banks would not honestly disclose their rate reports, especially since their names were attached to them.²³ We wanted to replicate this graph and did so using Bloomberg data (Exhibit 15). Using the information provided with the graph, we can determine that it serves as additional evidence to prove that LIBOR was manipulated. Therefore, we came to the conclusion that we should next run a regression comparing the selected short term interest rates to the NYFR. Our regression starts at the date at which NYFR was first published: June 2, 2008.

Methods

In order to analyze the effectiveness of the new model, NYFR, to LIBOR we needed to create a model that represents unbiased estimate of interbank rates. We assumed that before 2007 LIBOR was a perfect representation of interbank lending (there was no previous manipulation), and used a linear regression model to represent its value. In determining the value we replicated a study done by Mark E. Schweitzer and Guan Venkatu in which 5 factors were initially used: fed funds rate, 6 month OIS, 1 year OIS, 6 month Treasury, and 1 month Treasury rates²⁴. We started out with the time frame of January 2, 2002 to December 29, 2006. Using these variables within the 2002 to 2006 time frame we looked to create a regression model that correctly estimated LIBOR's values. Running a regression with these variables, we obtained a p-value of 0.2323 for the 1 year OIS. Since this value is above .05 it is not statistically significant, and thus had to be removed. Rerunning the regression without that variable obtained p-values below .05 and thus statistically significant. At this point with 4 variables determined to be statistically significant we decided to run a Best Subsets regression, to validate the optimization of our model. The Best Subsets regression indicated that our model was the best with a R-squared of 100%,

²³ "More Evidence That LIBOR Is Manipulated, and What It Means," Center for Geoeconomic Studies

²⁴ The source of the variables used in the regression analysis is the economic commentary "Alternatives to Libor in Consumer Mortgages" by Mark E. Schweitzer and Guhan Venkatu

Mallows Cp of 5.0, and S of 0.025092 (Exhibit 11). With this evidence, we concluded that the best model includes all four variables.

This model now represented an unbiased model for LIBOR going forward. We next then projected the data forward using the variable data from 2007-2012. Having an unbiased estimate to what LIBOR theoretically should be we decided to test our model to the LIBOR OIS spread of the same period. As can be seen in the Exhibit 18, the new model does not deviate from its relationship to OIS nearly as much as LIBOR does, proving that our model is unaffected by market sentiments or manipulation.

Finally, with this unbiased rate in place we can use it to compare the effectiveness of the NYFR vs. Libor in representing the unbiased interbank lending rate. Running two regressions comparing the new unbiased model to the 3 month NYFR and the 6 month USD LIBOR rate, found little difference between the two. Returning r-squared values of 69.3% for the NYFR unbiased model regression and 70.2% for the LIBOR unbiased model, the models seem to be as effective as one another in returning unbiased LIBOR rates. However, it is important to note that this analysis does not factor the methods by which the rates are collected and the susceptibility to manipulation. Also, it is important to factor in that any manipulation during the period of 2002-2006 could have affected our initial unbiased model and thus skewed the results overall.

Overall, there is little statistical evidence to support the removal of LIBOR. Both the 6 month USD LIBOR rate and the 3 month NYFR rate represent approximately 70% of the unbiased interbank lending rate. Through this analysis we have determined that both rates are statistically equal. However, this does not include analysis surrounding the market sentiment or manipulation. For that reason, it could very well be possible for LIBOR to be replaced by a “safer” rate in the future. In the meantime, due to LIBOR’s large influence on current market prices, it is highly unlikely that LIBOR will disappear. On the other hand, it is be more likely that LIBOR will be joined by other benchmarks, such as NYFR, to provide a more stable and risk free representation of interbank lending.

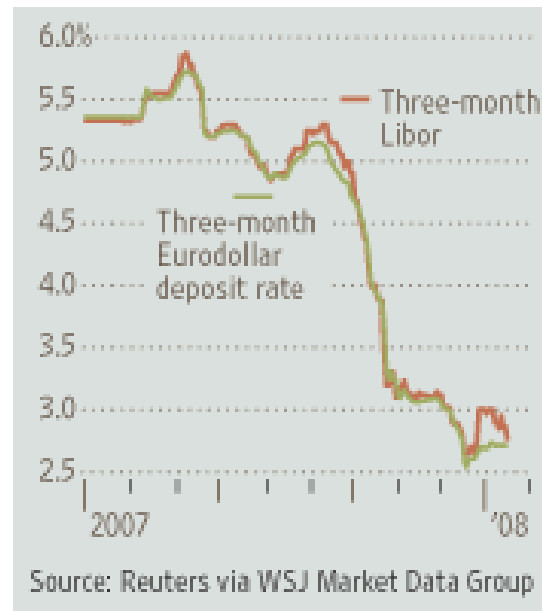
Conclusion

We do not know what the future holds; however, regardless of whether or not LIBOR will be replaced, one idea holds true: more regulation is needed in our financial system. Through our statistical analysis, we have learned that there is no other more statistically significant variable that would support replacing LIBOR. Even Warren Buffet remarked, "You get LIBOR, and you're talking about the whole world."²⁵ This is a key benchmark rate that has the capability of having major negative implications that would not only have an effect on a national level, but also on a global scale as well. In order to level out the playing field, the central banks should closely monitor counterparty risk and consider underlying liquidity and historical volatility of the markets.

²⁵ "Warren Buffett: Libor Scandal Involves 'The Whole World,'" Bonnie Kavoussi

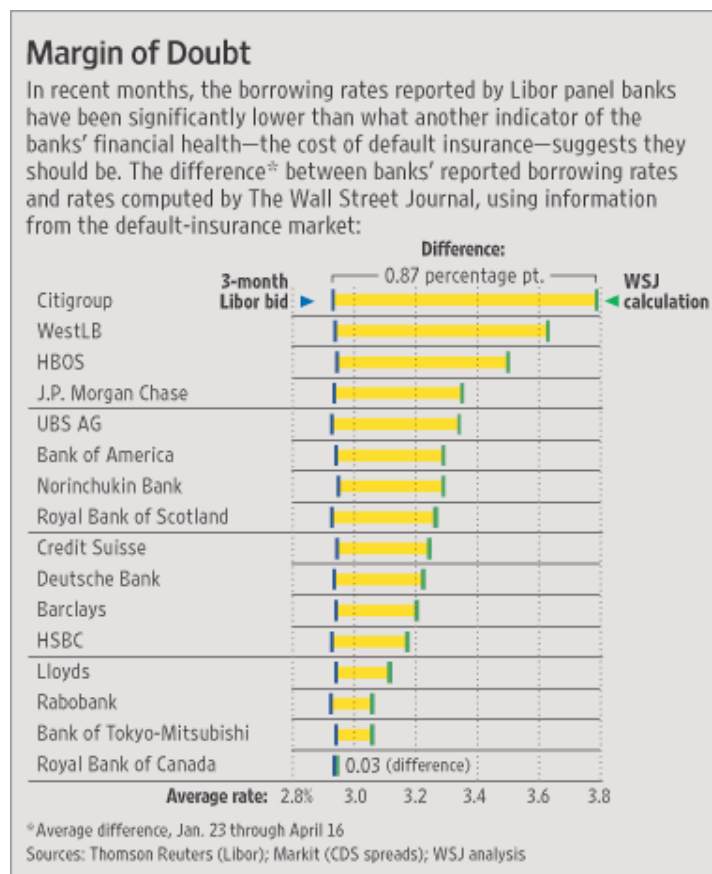
Exhibits

Exhibit 1:



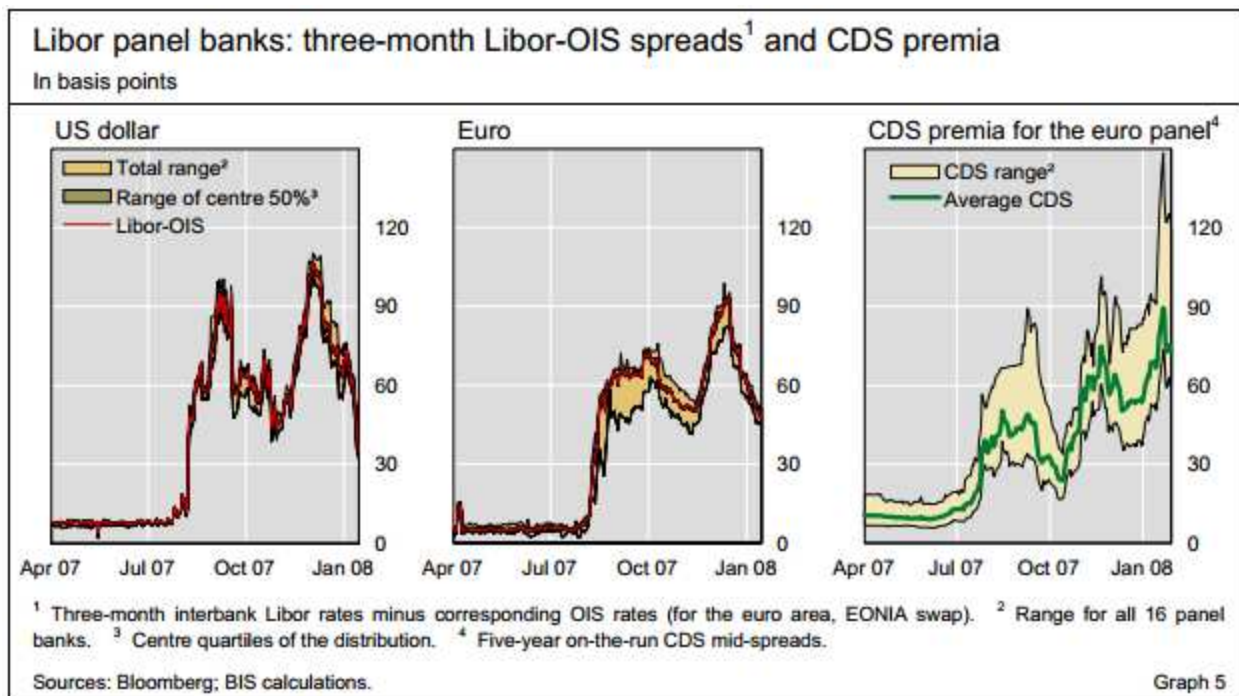
Source: WSJ: Bankers Cast Doubt On Key Rate Amid Crisis (Mollenkamp)

Exhibit 2:



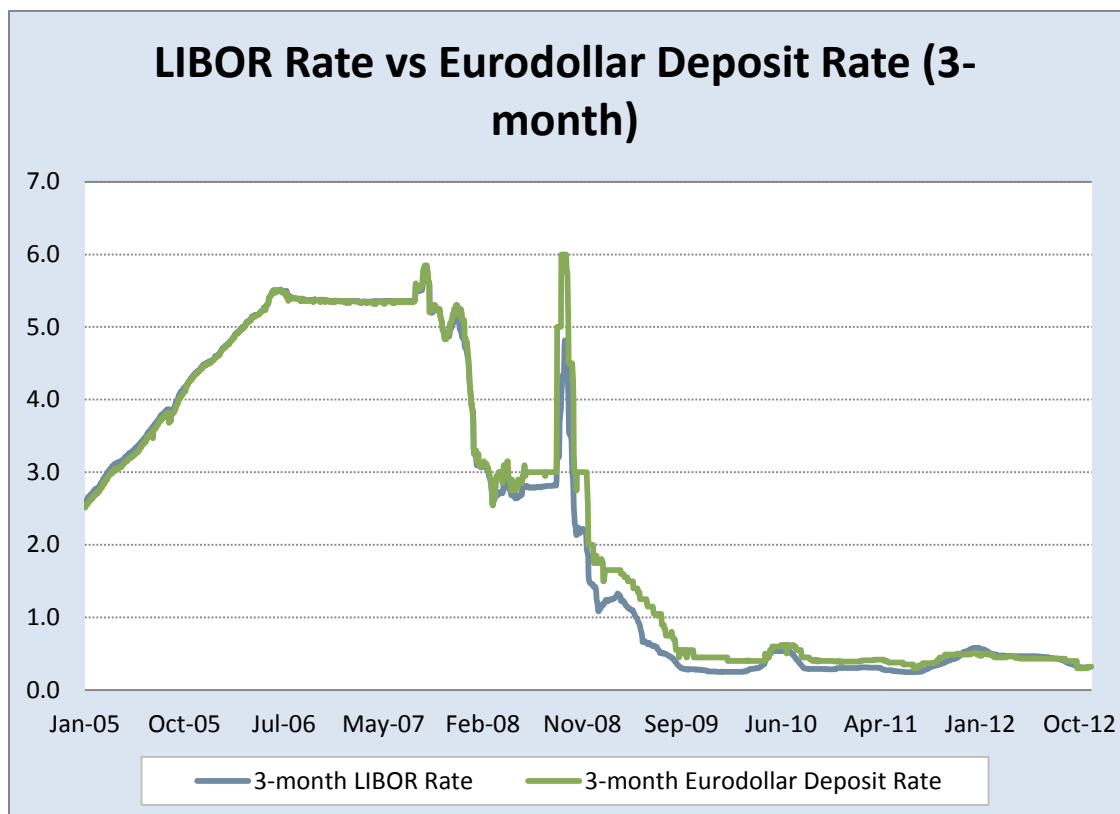
Source: WSJ (Study Casts Doubt on Key Rate, Mollencamp and Whitehouse)

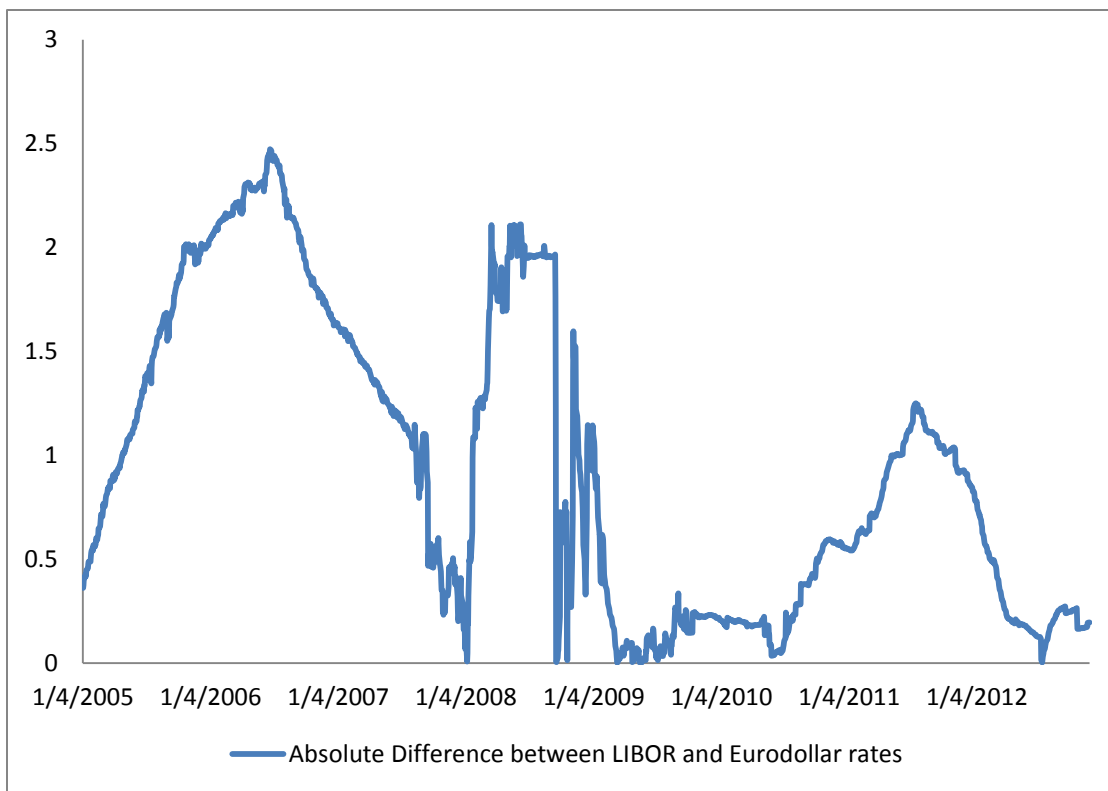
Exhibit 3:



Source: BIS Quarterly Review, March 2008

Exhibit 4:





The following graphs show that there was a large discrepancy between the LIBOR and the Eurodollar rates. The second graph shows the absolute difference between the LIBOR and Eurodollar rates to show the

Source: Federal Reserve Economic Data - FRED - St. Louis Fed

Exhibit 5:

56. The FSA has identified that:
- i. between January 2005 and May 2009, at least 173 requests¹⁵ for US dollar LIBOR submissions were made to Barclays' Submitters (including 11 requests based on communications from traders at other banks);
 - ii. between September 2005 and May 2009, at least 58 requests for EURIBOR submissions were made to Barclays' Submitters (including 20 requests based on communications from traders at other banks); and
 - iii. between August 2006 and June 2009, at least 26 requests for yen LIBOR submissions were made to Barclays' Submitters.
57. At least 14 Derivatives Traders at Barclays made these requests. This included senior Derivatives Traders. In addition, trading desk managers received or participated in inappropriate communications on, at least, the following occasions:
- i. on 22 March 2006, Trader A (a US dollar Derivatives Trader) stated in an email to Manager A that Barclays' Submitter "*submits our settings each day, we influence our settings based on the fixings we all have*". Manager A took no action as a result of this email;
 - ii. on 5 February 2008, Trader B (a US dollar Derivatives Trader) stated in a telephone conversation with Manager B that Barclays' Submitter was submitting "*the highest LIBOR of anybody [...] He's like, I think this is where it should be. I'm like, dude, you're killing us*". Manager B instructed Trader B to: "*just tell him to keep it, to put it low*". Trader B said that he had "*begged*" the Submitter to put in a low LIBOR submission and the Submitter had said he would "*see what I can do*"; and
 - iii. in July 2008, euro Derivatives Traders sent emails to Manager C indicating that they had spoken to Barclays' Submitter about the desk's reset positions and he had agreed to assist them. This followed instructions from Manager C for the traders to speak to the Submitter.
58. Barclays' Derivative Traders would request high or low submissions regularly in emails, for example on 7 February 2006, Trader C (a US dollar Derivatives Trader) requested a "*High 1m and high 3m if poss please. Have v. large 3m coming up for the next 10 days or so*". Trader C also expressed his preference that Barclays would be "*kicked out*" of the average calculation. Trader C's aim was therefore that Barclays' submissions would be high enough to be excluded from the final average calculation, which could have affected the final benchmark rate.

59. On Friday, 10 March 2006, two US dollar Derivatives Traders made email requests for a low three month US dollar LIBOR submission for the coming Monday:

- i. Trader C stated *"We have an unbelievably large set on Monday (the IMM). We need a really low 3m fix, it could potentially cost a fortune. Would really appreciate any help"*;
- ii. Trader B explained *"I really need a very very low 3m fixing on Monday – preferably we get kicked out. We have about 80 yards [billion] fixing for the desk and each 0.1 [one basis point] lower in the fix is a huge help for us. So 4.90 or lower would be fantastic"*. Trader B also indicated his preference that Barclays would be kicked out of the average calculation; and
- iii. On Monday, 13 March 2006, the following email exchange took place:

Trader C: *"The big day [has] arrived... My NYK are screaming at me about an unchanged 3m libor. As always, any help wd be greatly appreciated. What do you think you'll go for 3m?"*

Submitter: *"I am going 90 altho 91 is what I should be posting"*.

Trader C: *"[...] when I retire and write a book about this business your name will be written in golden letters [...]"*.

Submitter: *"I would prefer this [to] not be in any book!"*

60. The number of requests and the period of time over which they were made indicate that the Derivatives Traders made requests on a routine basis. Specific emails also indicate the requests were made regularly. For example, the following email exchange took place on 27 May 2005:

Submitter: *"Hi All, Just as an FYI, I will be in noon'ish on Monday [...]"*.

Trader B: *"Noonish? Whos going to put my low fixings in? hehehe"*

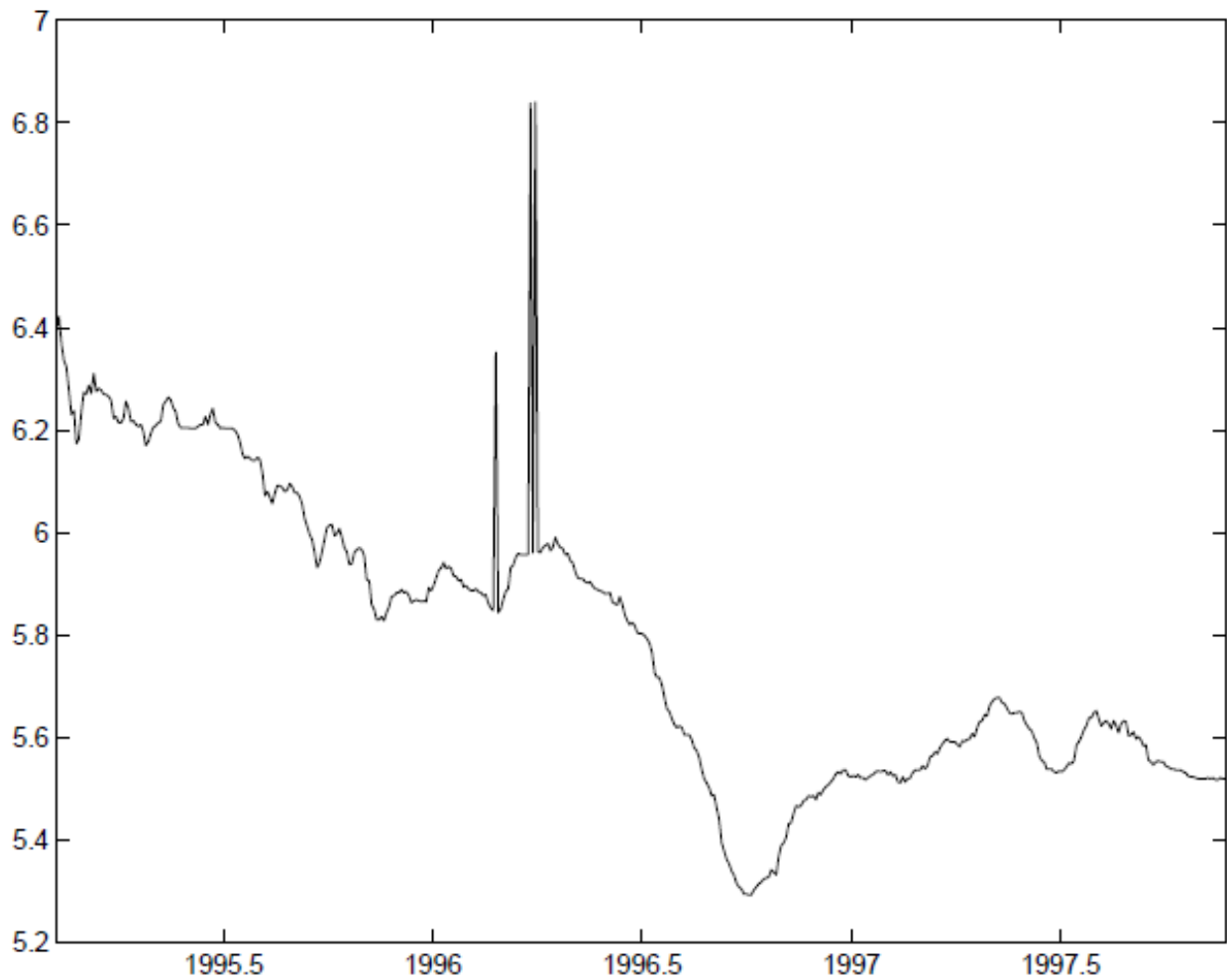
Submitter: *"[...] [X or Y] will be here if you have any requests for the fixings"*.

61. Trader D set calendar entries on at least 4 occasions in 2006 to remind him to make requests for EURIBOR submissions: *"Ask for Low Reset Rate"* and *"Ask for High 6M Fix"*.

Source: FSA Final Notice, July 27th, 2012; Reference Number 112702

Exhibit 7:

Figure 1
Average Three-Month Libor Reported
by 16 Large Banks



Source: "Dealer Polling in the Presence of Possibly Noisy Reporting;" Jeremy Berkowitz 1998

Exhibit 8:

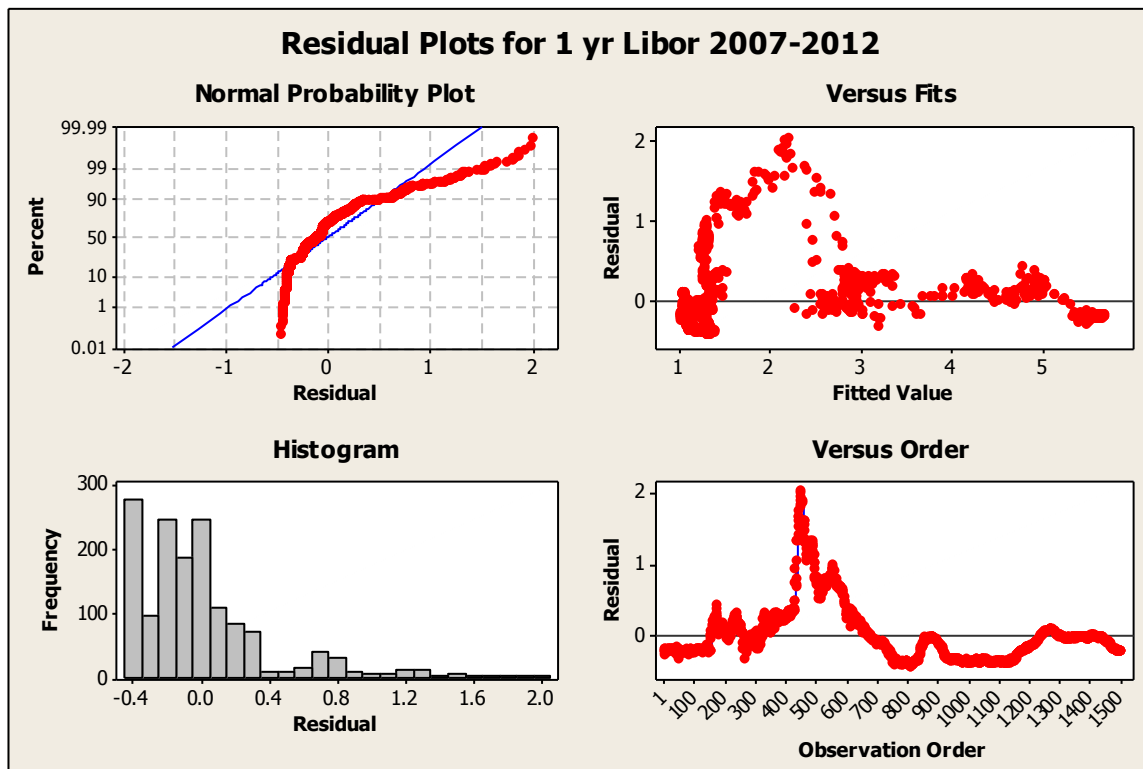
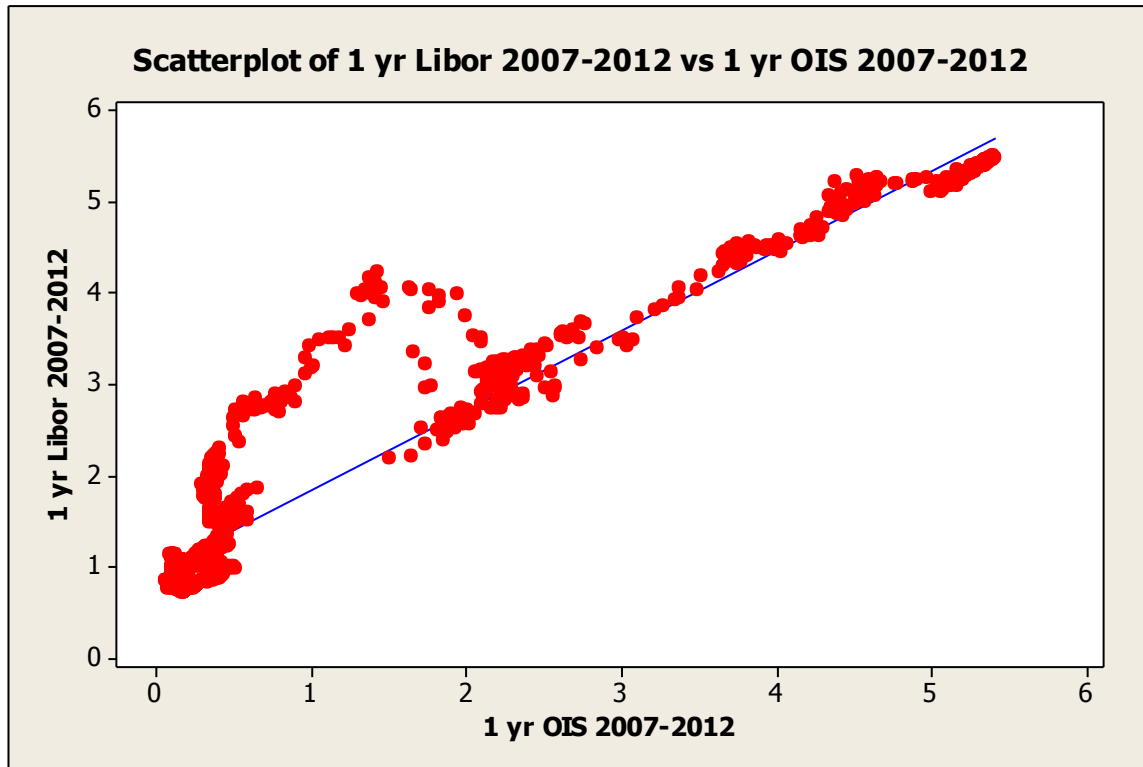


Exhibit 9:

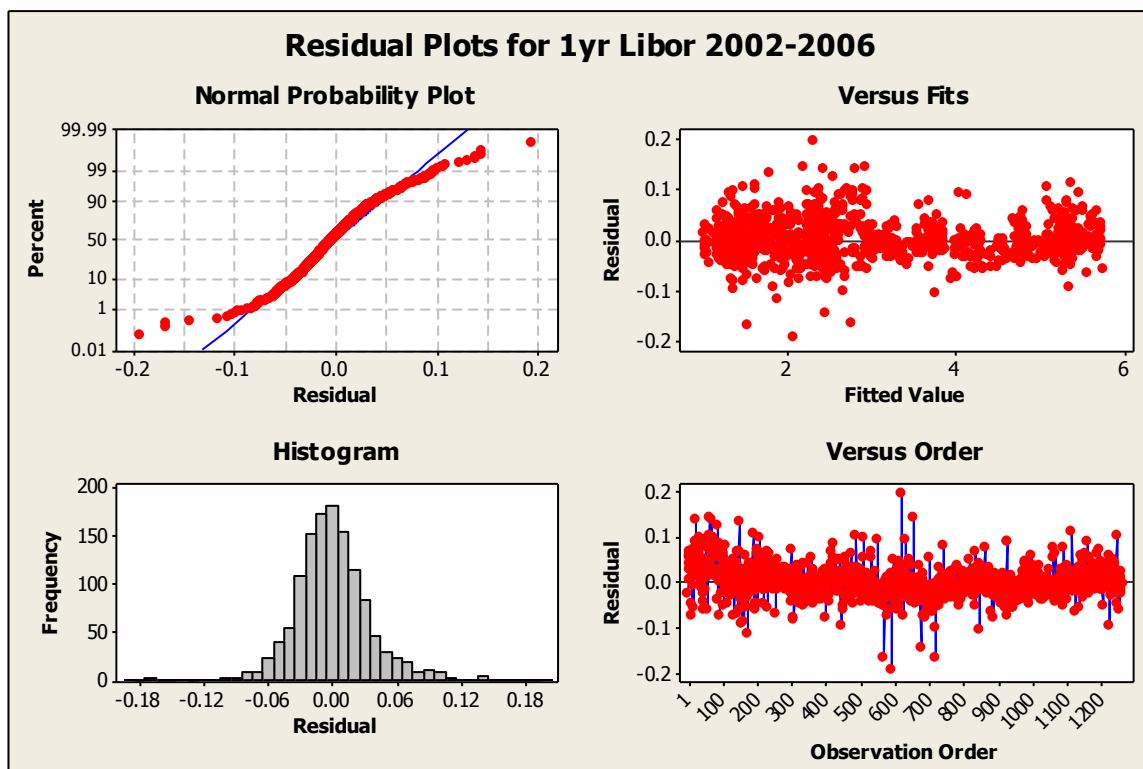
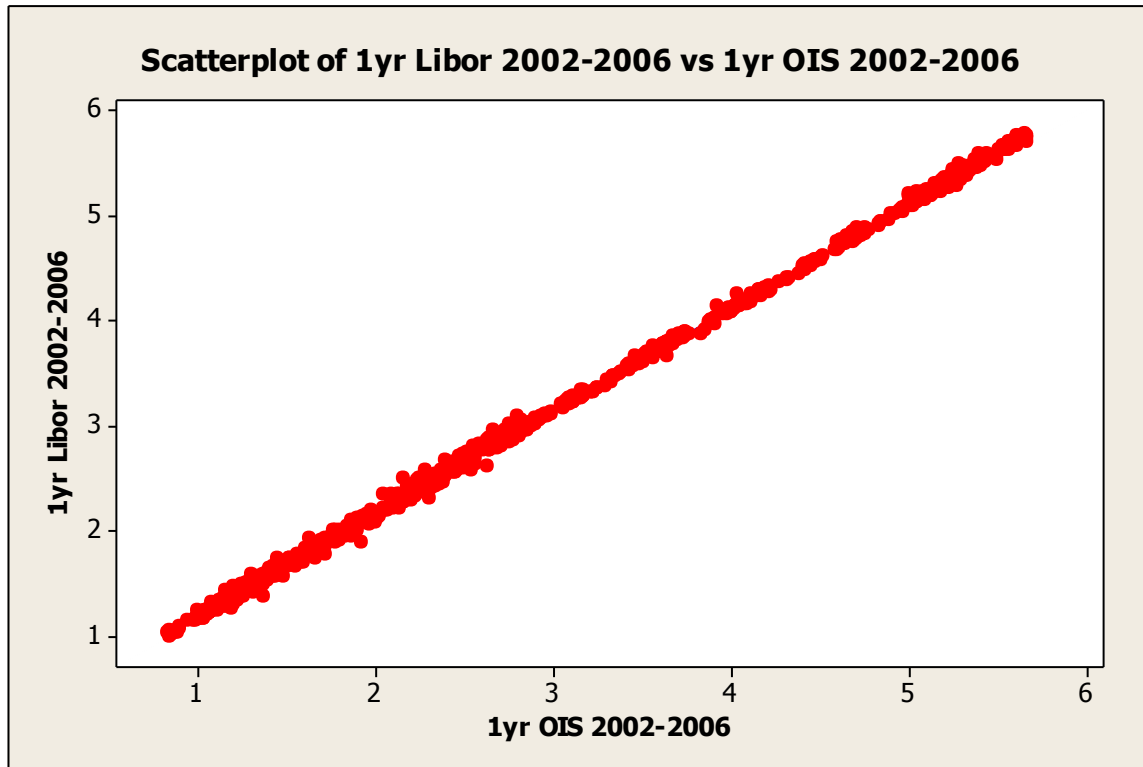


Exhibit 10:

Regression Analysis: 1yr Libor 2002-2006 versus 1yr OIS 2002-2006

The regression equation is

1yr Libor 2002-2006 = 0.188 + 0.981 1yr OIS 2002-2006

Predictor	Coef	SE Coef	T	P	VIF
Constant	0.188496	0.002099	89.79	0.000	
1yr OIS 2002-2006	0.980764	0.000645	1521.45	0.000	1.000

S = 0.0352431 R-Sq = 99.9% R-Sq(adj) = 99.9%

PRESS = 1.57054 R-Sq(pred) = 99.95%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	2875.2	2875.2	2314801.83	0.000
Residual Error	1261	1.6	0.0		
Lack of Fit	1115	1.4	0.0	1.42	0.004
Pure Error	146	0.1	0.0		
Total	1262	2876.7			

Regression Analysis: 1 yr Libor 2007-2012 versus 1 yr OIS 2007-2012

The regression equation is

1 yr Libor 2007-2012 = 0.957 + 0.878 1 yr OIS 2007-2012

1496 cases used, 12 cases contain missing values

Predictor	Coef	SE Coef	T	P	VIF
Constant	0.95724	0.01320	72.52	0.000	
1 yr OIS 2007-2012	0.878162	0.006030	145.63	0.000	1.000

S = 0.408310 R-Sq = 93.4% R-Sq(adj) = 93.4%

PRESS = 249.534 R-Sq(pred) = 93.41%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	3535.9	3535.9	21209.25	0.000
Residual Error	1494	249.1	0.2		
Lack of Fit	1059	217.7	0.2	2.85	0.000
Pure Error	435	31.4	0.1		
Total	1495	3785.0			

797 rows with no replicates

Exhibit 11:

```
Welcome to Minitab, press F1 for help.
MTB > Regress '6M LIBOR' 5 'FED FUNDS RATE' '6M OIS' '1YR OIS' &
CONT>      '6M Treasury' '1YR Treasury';
SUBC>      Constant;
SUBC>      Brief 2.
```

Regression Analysis: 6M LIBOR versus FED FUNDS RATE, 6M OIS, ...

The regression equation is

$$6M \text{ LIBOR} = 0.148 + 0.0554 \text{ FED FUNDS RATE} + 0.769 \text{ 6M OIS} + 0.0178 \text{ 1YR OIS} \\ + 0.126 \text{ 6M Treasury} + 0.0324 \text{ 1YR Treasury}$$

1225 cases used, 38 cases contain missing values

Predictor	Coef	SE Coef	T	P
Constant	0.147809	0.003287	44.97	0.000
FED FUNDS RATE	0.055443	0.004991	11.11	0.000
6M OIS	0.76901	0.02031	37.86	0.000
1YR OIS	0.01778	0.01799	0.99	0.323
6M Treasury	0.12626	0.02158	5.85	0.000
1YR Treasury	0.03240	0.02025	1.60	0.110

S = 0.0250922 R-Sq = 100.0% R-Sq(adj) = 100.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	5	2965.86	593.17	942111.73	0.000
Residual Error	1219	0.77	0.00		
Total	1224	2966.63			

Source	DF	Seq SS
FED FUNDS RATE	1	2898.36
6M OIS	1	67.42
1YR OIS	1	0.04
6M Treasury	1	0.05
1YR Treasury	1	0.00

Regression Analysis: 6M LIBOR versus FED FUNDS RATE, 6M OIS, ...

The regression equation is

$$6M \text{ LIBOR} = 0.147 + 0.0524 \text{ FED FUNDS RATE} + 0.783 \text{ 6M OIS} + 0.115 \text{ 6M Treasury} \\ + 0.0509 \text{ 1YR Treasury}$$

1225 cases used, 38 cases contain missing values

Predictor	Coef	SE Coef	T	P
Constant	0.146657	0.003073	47.72	0.000
FED FUNDS RATE	0.052419	0.003942	13.30	0.000
6M OIS	0.78289	0.01467	53.36	0.000
6M Treasury	0.11507	0.01837	6.26	0.000

1YR Treasury 0.050901 0.007700 6.61 0.000

S = 0.0250920 R-Sq = 100.0% R-Sq(adj) = 100.0%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	2965.86	741.47	1177662.20	0.000
Residual Error	1220	0.77	0.00		
Total	1224	2966.63			

Source	DF	Seq SS
FED FUNDS RATE	1	2898.36
6M OIS	1	67.42
6M Treasury	1	0.06
1YR Treasury	1	0.03

Best Subsets Regression: 6M LIBOR versus FED FUNDS RATE, 6M OIS, ...

Response is 6M LIBOR
1225 cases used, 38 cases contain missing values

Vars	R-Sq	R-Sq(adj)	Mallows Cp	S	F	E	D	1	6 Y	F	M R	U	N	T T	D	r r	S	6 e e	M	a a	R	s s	A	O u u	T	I r r	E	S y y
1	100.0	100.0	388.9	0.028788																								
1	99.9	99.9	3071.8	0.047010																								
2	100.0	100.0	140.3	0.026464	X	X																						
2	100.0	100.0	179.6	0.026844		X	X																					
3	100.0	100.0	42.2	0.025482	X	X		X																				
3	100.0	100.0	46.7	0.025527	X	X	X																					
4	100.0	100.0	5.0	0.025092	X	X	X	X																				

```
MTB > Regress '6M LIBOR' 4 'FED FUNDS RATE' '6M OIS' '6M Treasury' &
CONT>      '1YR Treasury';
SUBC>      Constant;
SUBC>      VIF;
SUBC>      Brief 2.
```

Regression Analysis: Libor2.0 versus NYFE 3M

The regression equation is
Libor2.0 = 0.128 + 0.463 NYFE 3M

1007 cases used, 33 cases contain missing values

Predictor	Coef	SE Coef	T	P
Constant	0.12784	0.01198	10.67	0.000
NYFE 3M	0.463210	0.009716	47.68	0.000

S = 0.285496 R-Sq = 69.3% R-Sq(adj) = 69.3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	185.27	185.27	2272.98	0.000
Residual Error	1005	81.92	0.08		
Total	1006	267.18			

Residual Plots for Libor2.0

```
MTB > Plot 'NYFE 3M'*'Libor2.0';
SUBC>    Symbol;
SUBC>    Regress.
```

Scatterplot of NYFE 3M vs Libor2.0

```
MTB > Regress 'Libor2.0' 1 'NYFE 3M';
SUBC>    GFourpack;
SUBC>    RType 2;
SUBC>    Constant;
SUBC>    Brief 2.
```

Regression Analysis: Libor2.0 versus NYFE 3M

The regression equation is
 $\text{Libor2.0} = 0.128 + 0.463 \text{ NYFE 3M}$

1007 cases used, 33 cases contain missing values

Predictor	Coef	SE Coef	T	P
Constant	0.12784	0.01198	10.67	0.000
NYFE 3M	0.463210	0.009716	47.68	0.000

S = 0.285496 R-Sq = 69.3% R-Sq(adj) = 69.3%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	185.27	185.27	2272.98	0.000
Residual Error	1005	81.92	0.08		
Total	1006	267.18			

Residual Plots for Libor2.0

```
MTB > Plot 'NYFE 3M'*'Libor2.0';
SUBC>   Symbol;
SUBC>   Regress.
```

Scatterplot of NYFE 3M vs Libor2.0

```
MTB > Regress 'Libor2.0' 1 '6M Lib';
SUBC>   GFourpack;
SUBC>   RType 2;
SUBC>   Constant;
SUBC>   Brief 2.
```

Regression Analysis: Libor2.0 versus 6M Lib

The regression equation is
 $\text{Libor2.0} = 0.0085 + 0.476 \text{ 6M Lib}$

1009 cases used, 31 cases contain missing values

Predictor	Coef	SE Coef	T	P
Constant	0.00854	0.01349	0.63	0.527
6M Lib	0.475717	0.009762	48.73	0.000

S = 0.281127 R-Sq = 70.2% R-Sq(adj) = 70.2%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	1	187.67	187.67	2374.62	0.000
Residual Error	1007	79.59	0.08		
Total	1008	267.26			

Residual Plots for Libor2.0

```
MTB > Regress '6M OIS' 1 '6M LIBOR';
SUBC>   GFourpack;
SUBC>   RType 2;
SUBC>   Constant;
SUBC>   Brief 2.
```

Exhibit 12:

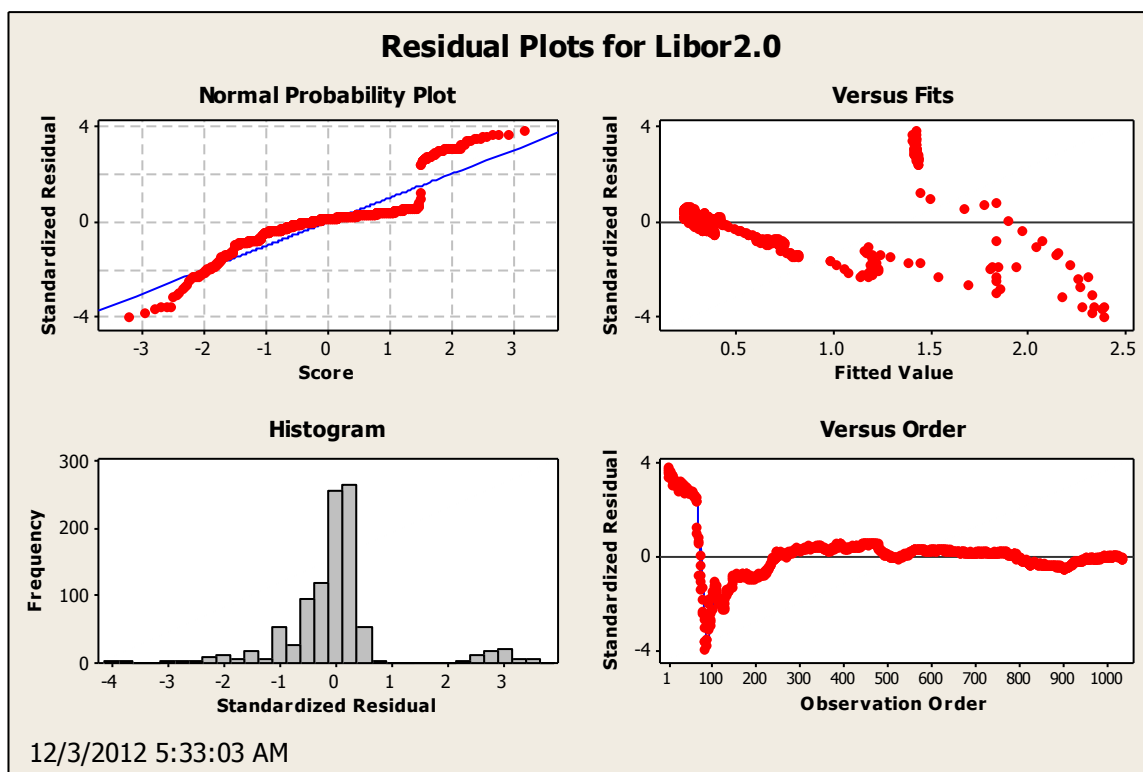
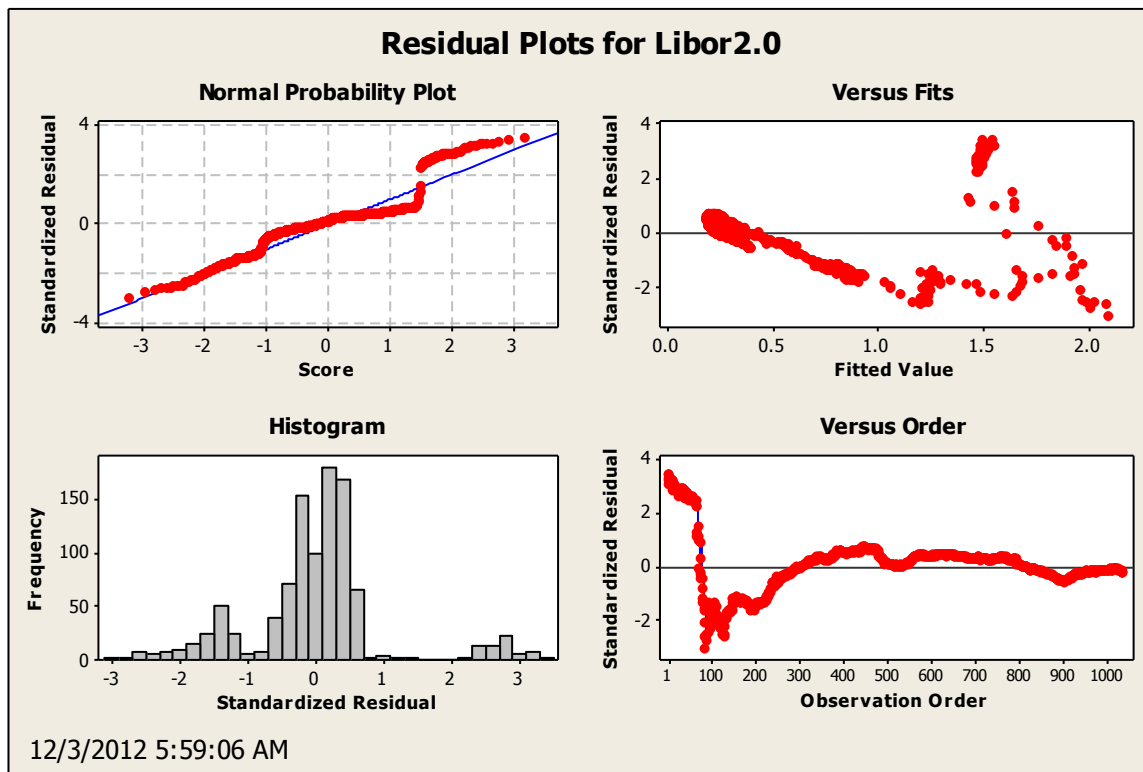
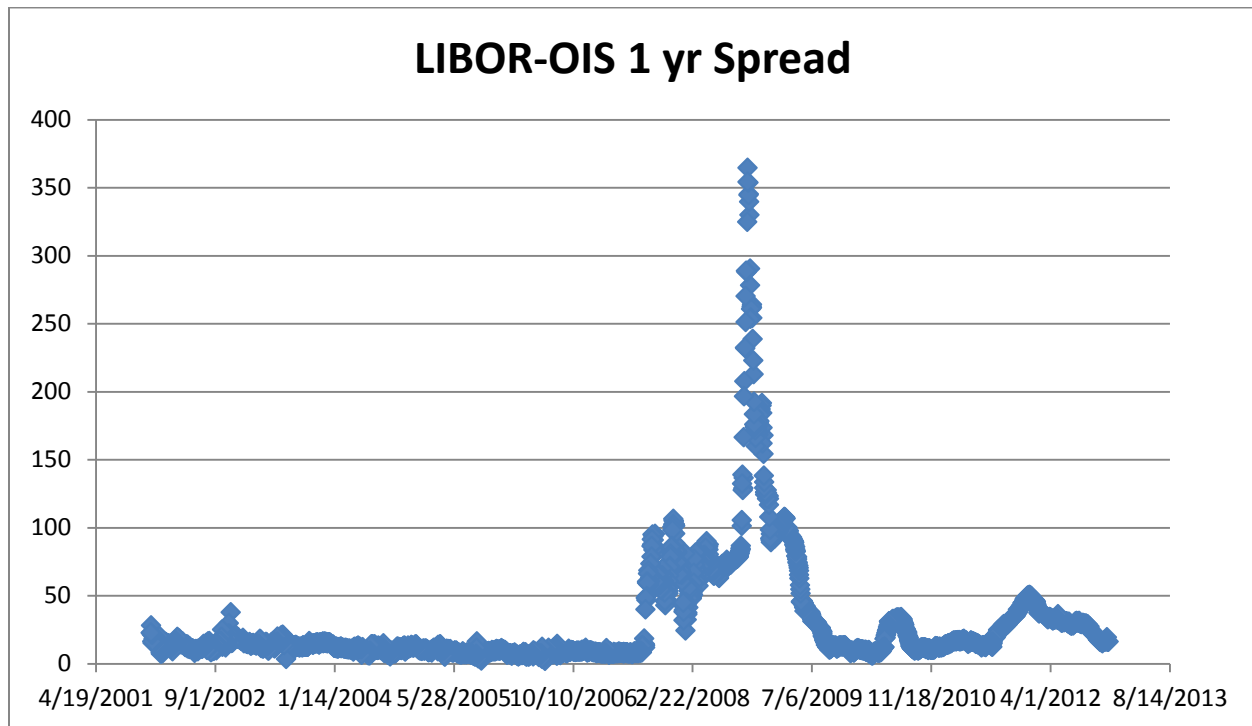


Exhibit 13:



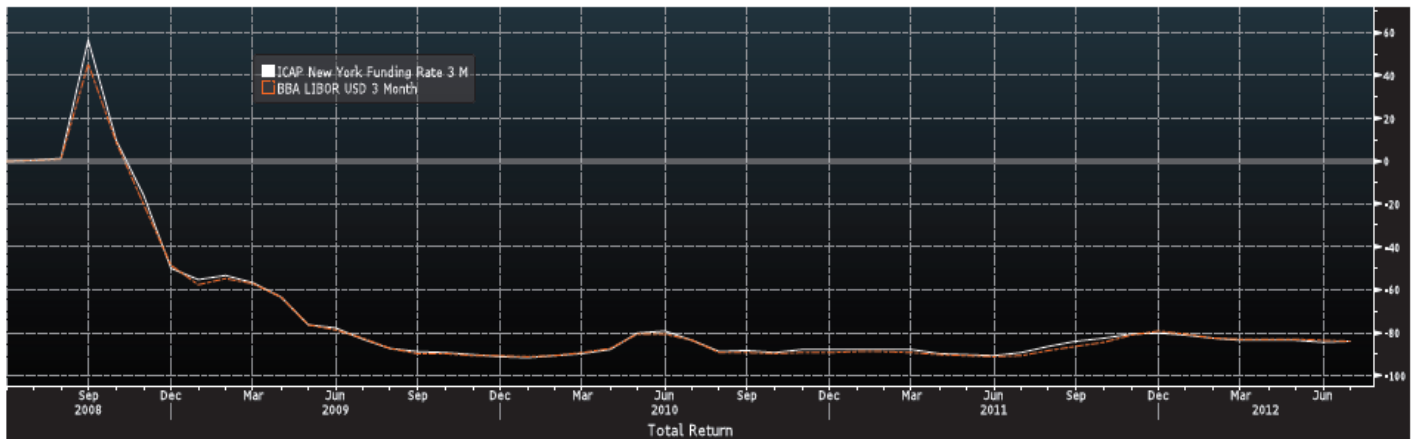
Source: Bloomberg

Exhibit 14:

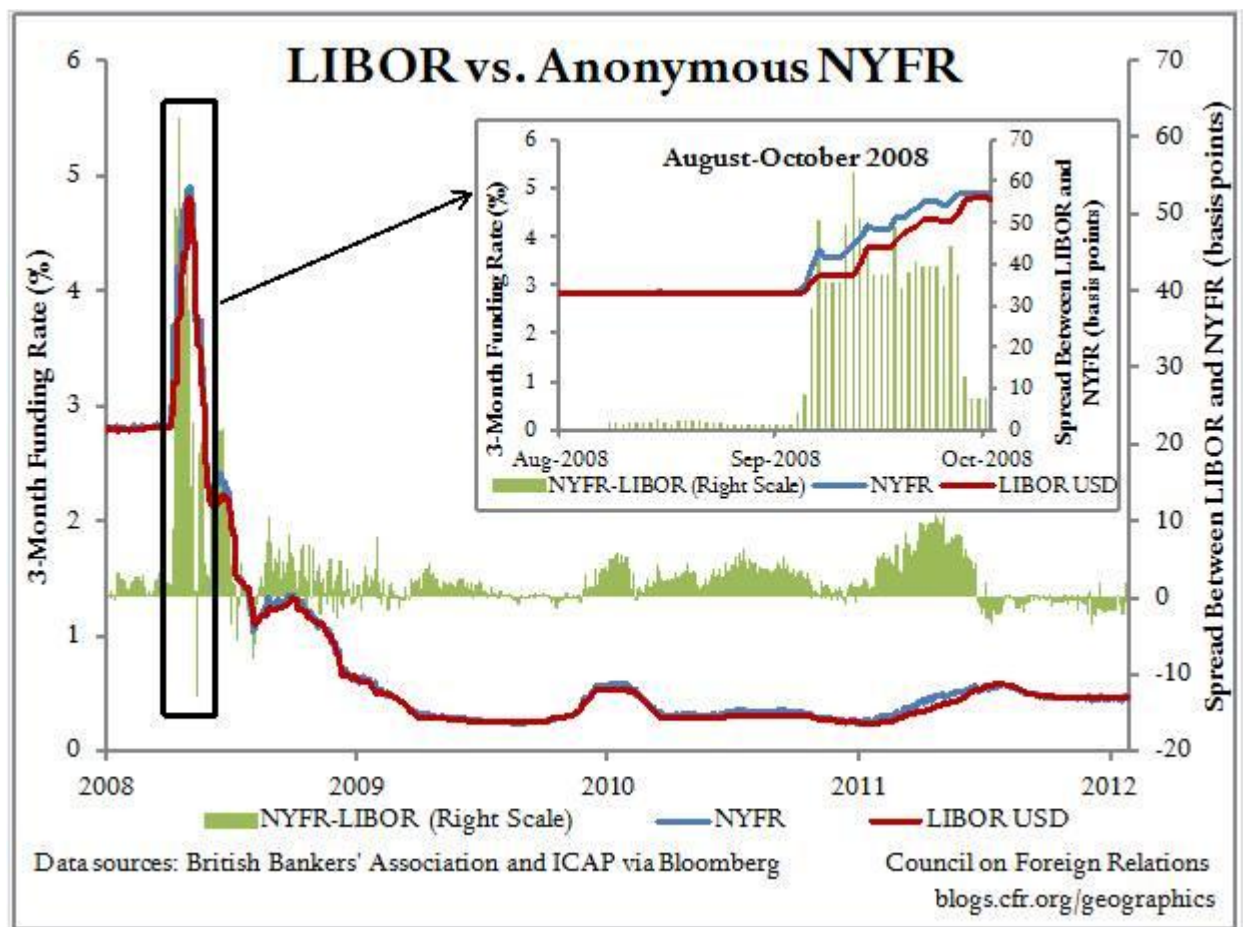
OIS Spread					
OVERALL		2007-2012		2002-2007	
Mean	28.68241	Mean	43.40793	Mean	11.33391
Std. Error		Std. Error		Std. Error	
Std. Dev.	39.08314	Std. Dev.	48.38345	Std. Dev.	3.651864
Sample		Sample		Sample	
Variance	1527.492	Sample Variance	2340.958	Variance	13.33611
Kurtosis	21.35917	Kurtosis	11.9942	Kurtosis	2.87939
Skewness	3.973208	Skewness	2.976888	Skewness	0.919322
Min.	1.91	Min.	5.96	Min.	1.91
Max	364.42	Max	364.42	Max	37.8
Count	2788	Count	1508	Count	1280

Source: OIS Spread data from Bloomberg and LIBOR data from FRED

Exhibit 15:

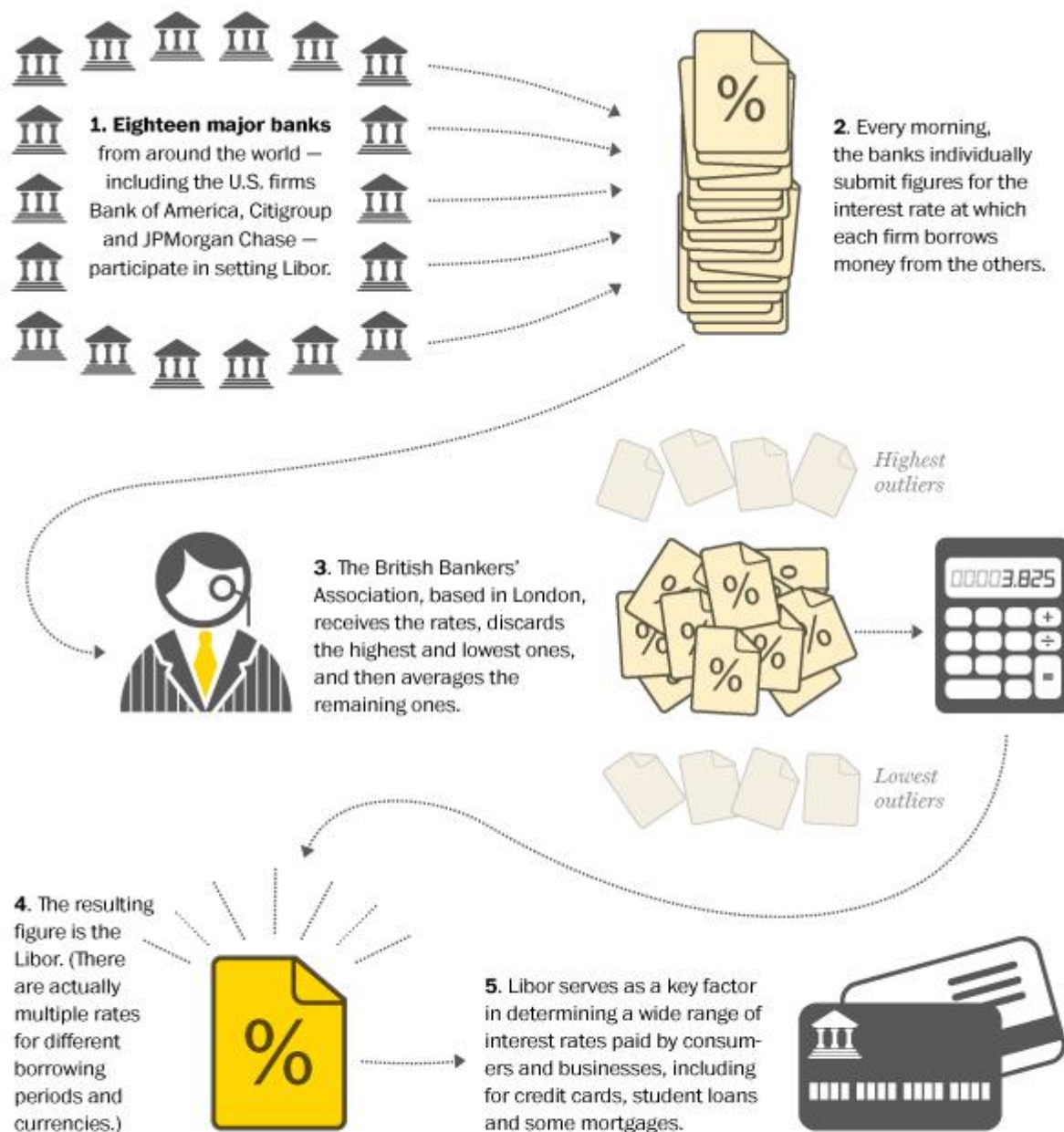


(LIBOR 3-month vs. ICAP New York Funding Rate 3-month)



Source: "More Evidence That LIBOR Is Manipulated, and What It Means," Center for Geoeconomic Studies

Exhibit 16:



Current scandal

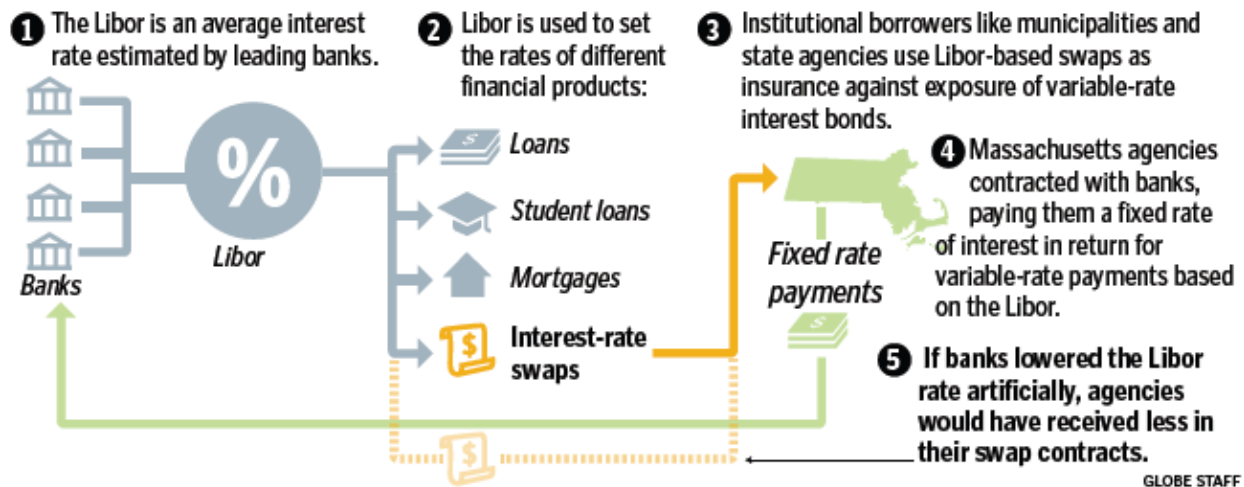
U.S. and British regulators fined one of those banks, Barclays, \$453 million in June for manipulating Libor between 2005 and 2009 by submitting false reports of borrowing rates.

The British bank admits to scheming to manipulate rates to increase profits and hide the reality of its distress during the financial crisis. Other banks are also expected to face charges.

Source: "What is the Libor?" Staff reports. The Washington Post

Exhibit 17:

How Libor scandal may have affected Massachusetts



■ BOSTON HARBOR CLEANUP

The Massachusetts Water Resources Authority has a \$350 million Libor-pegged investment to help offset borrowing costs for the harbor cleanup and other projects.

■ MASS TRANSIT

The MBTA had more than \$1.6 billion of swap contracts in the previous decade to help manage its high debt load.

■ COLLEGES

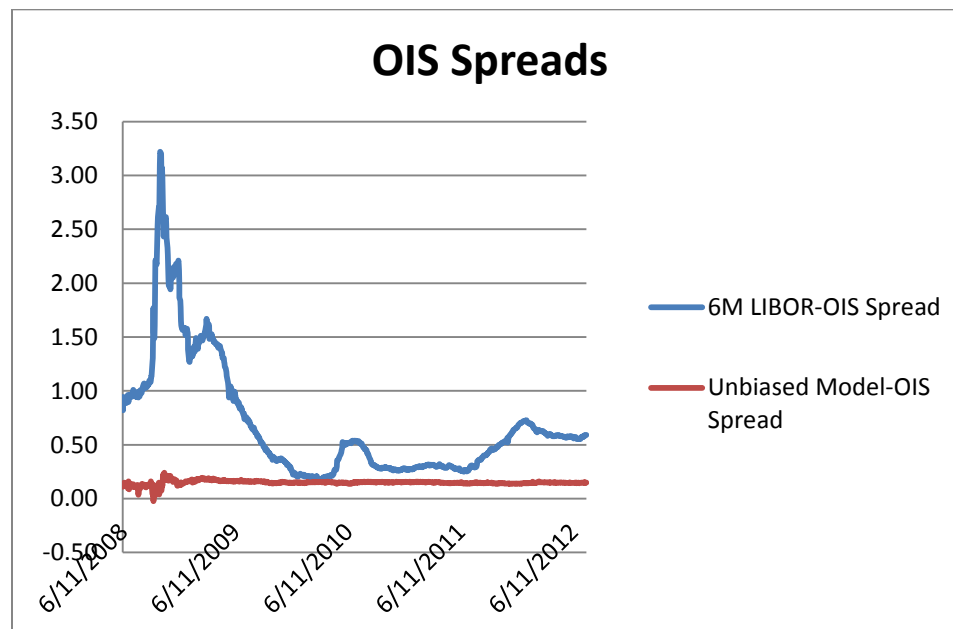
Many Bay State universities bought millions of dollars in Libor-linked swap contracts to help manage their finances and loan costs.

■ HIGHWAYS

Massachusetts officials routinely bought large swap contracts to cover interest rate costs for hundreds of millions of dollars in highway projects, including the Big Dig.

Source: “How LIBOR may have affected Mass,” Boston.com

Exhibit 18:



Source: Bloomberg

Honor Code

“I pledge my honor that I have neither received nor provided any unauthorized assistance during the completion of this work.”

Inna Loseva

Karina Menagi

Michael Liachowitz

Nathan Kolman