

Do two Libor reforms reduce the effect of incentives on submitted rates?

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**Abstract**

Do two Libor reforms reduce the effect of incentives on submitted rates?

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Libor is a set of survey-based reference interest rates for an estimated \$350 trillion in financial instruments. In 2013, administrators adopted several reforms designed to improve Libor. Two key reforms were (1) eliminate Libor collection for unpopular currencies and maturities, and (2) defer the public release of individual bank Libor submissions for 90 days. The intent of the first reform is to reduce bias and subjectivity by increasing the probability that an actual transaction is underpinning a Libor submission. The intent of the second reform is to reduce public signaling bias in the Libor submission; however, the period of anonymity granted in this reform also has the potential to increase bias from other directional incentives. Using an experiment, I examine whether estimates are less influenced by directional incentives when a closely-matching transaction is in the underlying dataset and whether a period of anonymity allows more influence of directional incentives. I collect data for two dependent variables but find statistically

significant results only using the second. I find that the influence of directional incentives decreases when a closely-matching transaction is in the underlying dataset but that it increases when participants have a period of anonymity. These findings lend support to the first key reform but show Libor administrators an unintended consequence of the second key reform.

## I. INTRODUCTION

Libor is a set of survey-based, short-term interest rates used as reference rates for an estimated \$350 trillion financial instruments such as variable rate loans and interest rate swaps. Libor is described in the financial press as the world's most important number (Broad, 2008). Many existing contracts reference Libor (usually as the Libor rate on a particular future day plus a fixed percentage), so the Libor rate determines the cash flows, net income, and balance sheet values associated with these financial instruments.<sup>1</sup> If the Libor rate is over- or under-stated by even a small amount, the aggregate financial consequences are substantial.<sup>2</sup>

A Libor rate is computed each business day for 35 currency-maturity combinations: five currencies for seven short-term maturity dates.<sup>3 4</sup> The current Libor administrator is IBA (ICE (Intercontinental Exchange) Benchmark Administration), which appoints a panel of banks for each currency. Daily, an assigned employee at each panel bank answers the following question for each maturity in that currency: "At what rate could you borrow funds, were you to do so by asking for and then accepting interbank offers in a reasonable market size just prior to 11am?" The published Libor rate for each maturity and currency is the interquartile mean of the responses to this question.<sup>5</sup> Submitted responses are subjective in that banks are projecting a

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<sup>1</sup> Brian Martin, Libor team head at Thompson Reuters said, "The number we produce goes on to determine the price of trillions of financial products all over the world." Quoted in Broad 2008.

<sup>2</sup> Bloomberg *Businessweek* September 3, 2012, "If the Libor rate was understated by 0.1 percentage point for only a few months, payments on more than \$300 trillion in mortgages, corporate bonds, and derivatives tied to the benchmark might have fallen short by about \$75 billion or so. If the problem lasted a few years, the shortfall could be close to \$1 trillion."

<sup>3</sup> Libor is published every business day for all currencies and maturities except the following holidays: New Year's Day, Good Friday, Easter Monday, Early May Bank Holiday, Spring Bank Holiday, Summer Bank Holiday, Christmas Day and Boxing Day. On these holidays, Libor is not published for any currencies or maturities. In addition, some currencies and maturities are not published if the fixing date is a holiday in the major financial center for that currency. <https://www.theice.com/iba/libor> retrieved 8 November 2016

<sup>4</sup> Prior to 2013, Libor rates were computed for 10 currencies and 15 maturities

<sup>5</sup> The highest and lowest 25% of submissions are excluded and the arithmetic mean of the remaining submissions is the Libor rate. Further details on Libor computation methods are provided in Appendix B.

future rate for that day just prior to 11:00 a.m. but forming the estimate earlier in the day, and the phrase “reasonable market size” is vague.<sup>6</sup>

In 2012, the Commodity Futures Trading Commission (CFTC) found email and text evidence that some banks were submitting “manipulated” Libor estimates (CFTC 2012). As a result, banks paid fines, CEOs resigned, litigants filed claims, employees went to jail, and Libor was reformed. Two key reforms are: (1) eliminate Libor collection for unpopular currencies and maturities, and (2) defer the public release of individual bank Libor submissions for 90 days.<sup>7</sup> Both reforms are designed to improve Libor. Using an experiment with directional incentives, I test whether these reforms change the effect of directional incentives on interest rates.

I use undergraduate accounting students from a large public university as participants in a 2-by-2 between-subjects experiment. I explain that each participant will be lending a small portion of a larger group loan, which has one interest rate. I ask each individual to submit an interest rate he or she wishes to earn on the loan. I also ask participants to submit the interest rate they predict the average person in the class submitted. The answers to these two questions are used as dependent variables for hypothesis testing. The first, submitted interest rate, reflects the behavior of the individual participant. The second, predicted interest rate, reflects the descriptive norm of the class. This second variable is important because it can affect future individual behavior. To help form these estimates, I give all participants information on the minimum and maximum rates expected by the online lending site and information on eight past loans that are similar to their loan in either amount or maturity but not both. I inform participants that the group loan interest rate is computed as the interquartile mean of the

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<sup>6</sup> According to Rauterberg and Verstein (2013), subjectivity in Libor as well as in other financial indices allows for professional judgment that can add both value and bias to the index.

<sup>7</sup> A complete list of reforms is included in Appendix B.

individual interest rates submitted. I induce an incentive for higher submitted interest rates by paying participants according to the group loan rate that is set for their class.

The first key reform addressed in this study eliminates Libor collection for a number of unpopular currencies and maturities.<sup>8</sup> The intent of this reform is to reduce bias in Libor submissions by increasing the likelihood that an actual closely-matching interbank loan is in the dataset underpinning a Libor submission. I test the effect of a closely-matching transaction in the underlying dataset by giving some participants information about a loan granted in the past week that is close in maturity and amount to their loan. The interest rate on this closely-matching loan serves as a benchmark. I tell other participants that a closely-matching loan is not available. Based on Kunda's (1990, 1999) motivated reasoning theory's mental justification to a dispassionate observer, I predict those given a closely-matching transaction submit lower interest rates closer to the benchmark than those without a closely-matching transaction. I do not find statistically significant support for this hypothesis using the first dependent variable, but do find support using the second dependent variable. The latter results show lower interest rates when a closely-matching transaction is available even with incentives for higher rates. This reduced influence of directional incentives lends support to the first key reform.

The second key reform delays the public release of individual bank Libor submissions. Before the reform, both Libor rates and individual panel bank submissions (identified with the bank giving the submission) were released on the day of submission. After the reform, only the overall Libor rates are released; individual submissions are held confidential for 90 days before public release. This reform's objective is to decrease the public signaling incentive and the

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<sup>8</sup> The Wheatley Review of Libor: Final Report, September 2012 page 36 recommends this reform because "the volume of transactions underpinning each Libor benchmark published vary considerable, with very few underlying trades in some currencies and maturities." This report also found that the Libor rates from certain currency/maturity combinations were not commonly used as reference rates in financial contracts.

potential bias it creates in Libor submissions.<sup>9</sup> During the financial crisis and its associated uncertainty, the public turned to bank Libor submissions as an easily-available, up-to-date signal of financial health. This public attention created an incentive for banks to report an artificially low expected borrowing cost to appear financially healthier to the public. By delaying the public release for 90 days, information contained in individual Libor submission is no longer up-to-date. However, the period of anonymity granted in this reform potentially reduces the need to justify actions to others and gives mental permission for self-interested behavior (Zimbardo 1969, Wallace 1999, Lerner and Tetlock 1999). Thus, as an unintended consequence of the reform, the period of anonymity may allow other directional incentives to affect estimates.

To experimentally test for increased influence of directional incentives due to a period of anonymity, some participants' submitted interest rates and identities are shown to all participants at the time of the experiment (immediate identification). Other participants' submitted interest rates and identities are only made available the following quarter in office hours (temporal anonymity). I predict that those granted a period of anonymity feel less threat of justification and therefore submit higher rates, consistent with self-interested behavior. I do not find statistically significant results consistent with this prediction using the first dependent variable, but do find support using the second. I find lower interest rates when participants are immediately identified even with incentives for higher rates. The results show a possible unintended consequence associated with the second reform.

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<sup>9</sup> The motivation for this reform is stated by IBA: "In order to help ensure the integrity of the rate, individual submissions are not published until three months after the submission date. This helps in two ways: firstly, it makes it harder for banks to set their submissions purely in line with other panel banks rather than at their own perceived funding costs; and secondly, it also protects banks from the negative signaling effects that their submissions might have on market perceptions of a bank's financial viability. This credit-signaling or 'stigma-effect' was one of the conflicts of interest which led to attempted manipulation of the rate." (ICE Libor Code of Conduct, 2016).

Combining both motivated reasoning theory and social identity theory leads to a prediction of an interaction between the presence of a closely-matching transaction in the underlying data set and the timing of identification. The difference in estimates due to delayed identification is expected to be larger for those participants given a closely-matching transaction compared to those without a closely-matching transaction. Without a closely-matching transaction, a wider range of estimates is justifiable so the threat of justification has little effect. With a closely-matching transaction, only a narrow range of estimates around the benchmark is justifiable, so the threat of justification has a larger effect. I do not find statistically significant support for this predicted interaction using the first dependent variable, but do using the second dependent variable. The latter results suggest that the two Libor reforms may work against each other. The first reform increases the likelihood of a closely-matching transaction in the underlying data set, which reduces the influence of incentives, yet the period of anonymity from the second reform increases the influence of incentives especially in the case when a closely matching transaction exists.

An experiment is ideally suited to answering this research question. The nature and direction of panel bank profit incentives cannot be observed from current disclosures. In contrast, this study specifically creates a profit incentive for participants. This methodology also allows me to manipulate the underlying data available when forming the submission. Without access to private bank information, I would not be able to determine the characteristics of this underlying information in an empirical research context. Additionally, this experiment enables a test of both pre- and post- reform conditions without additional confounding factors such as the financial crises, disillusion of major banks, panel bank changes, and Libor manipulation trials in this time frame that inherently affect empirical observations of Libor submissions.

Extant Libor research is primarily focused on empirical analysis of bank submissions and on using Libor rates to price interest rate derivatives (the Libor Market Model). This study adds to the body of Libor research by testing if two key Libor reforms have the intended improvements to Libor submissions. Additionally, this study confirms previous research supporting motivated reasoning's mental justification to a dispassionate observer. Finally, this paper contributes a manipulation of anonymity that is different from those previously used in anonymity experiments. Often, participants in an anonymity experiment are completely anonymous to the experimenter and to others. This experiment manipulates anonymity only for a period of time. In the real world, rarely are people completely anonymous for all time, so understanding anonymity for only a period of time advances our understanding of anonymity. The remainder of this paper presents background, hypothesis development, experimental design, results, and conclusions.

## **II. BACKGROUND**

Appendix B presents Libor institutional information. One important aspect of the Libor setting as it pertains to this experiment is the incentives panel banks face in a Libor context. Panel banks have two different and sometimes competing incentives related to Libor: the profit incentive and the public signaling incentive.

### **The profit incentive**

Panel bank members hold many financial instruments that reference Libor rates. The interest received or paid on these financial instruments is affected by Libor rates. For example, assume a bank holds a variable-rate mortgage receivable with interest as 3-month USD Libor on the first day of April plus 200 basis points. On the first day of April, the bank would have higher cash flows and higher net income with a higher Libor rate because a higher Libor rate on that day

means more cash received and more interest revenue on this variable-rate mortgage.

Additionally, the fair value of financial instruments that reference Libor is affected by future cash flows and future expected Libor rates. The fair value of this mortgage receivable is higher with a higher Libor rate because of higher expected future cash flows. A higher fair value means higher total reported assets and holding gains. Holding mortgage receivables that reference Libor creates a profit incentive for a higher rate. Conversely, holding mortgage payables that reference Libor creates a profit incentive for a lower rate. Thus, depending on a bank's holdings, the bank may profit from a higher or lower Libor rate on any given day. In fact, evidence collected by the Commodities Future Trading Commission (CFTC) shows traders asking for a low 1-month and high 3-month and 6-month Libor submission in the same day for the same bank.<sup>10</sup> On any given day one panel bank may benefit from a higher Libor rate while another may benefit from a lower Libor rate.<sup>11</sup>

### **The public signaling incentive**

From Libor's inception in 1986 through to June 30, 2013, each bank's individual Libor submission was publicly released at the same time the Libor rate was published. This publication was never intended to be a signal of bank health; however, during the financial crisis, a period in which financial health of banks was highly uncertain, the public looked to any available source of information about the current financial state of banks. The public turned to Libor submissions as an indirect signal of financial health of the submitting bank, especially as it

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<sup>10</sup> CFTC Docket No. 12-25 "United States of America Before the Commodity Futures Trading Commission" signed June 27, 2012, page 16. Barclay's Senior Euro Swaps Trader emailed the Barclays Senior Euribor Submitter: "We have some big fixing today. Is it possible to have a very low 1m and high 3m and 6m? Thx a lot for your help." Barclay's Senior Euribor Submitter responded, "Sure, will do."

<sup>11</sup> Evidence of this profit incentive was discovered in the investigation of banks in 2012 and 2013. Following are actual quotes from traders. From Barclays: "Hi Guys, We got a big position in 3m libor for the next 3 days. Can we please keep the libor fixing at 5.39 for the next few days. It would really help. We do not want to fix any higher than that." From UBS: "if you keep 6s [i.e. the six month JPY LIBOR rate] unchanged today ... I will \*\*\*\*ing do one humongous deal with you ... Like a 50,000 buck deal."

compared to its peers. The Libor submission is a rate the bank expects to *pay* to borrow money on the interbank lending market. A bank experiencing credit problems would naturally expect to *pay* a higher rate than a bank not experiencing credit problems. This public signal creates an incentive for a lower Libor submission that signals stronger financial health. Further discussion of these two incentives is found in Appendix B.

Just as with panel banks, individuals with high credit risk expect to *pay* a higher rate on a loan, and individuals with low credit risk expect to *pay* a lower rate. Thus, an individual's expected rate to *pay* can be an indirect signal of that individual's credit-worthiness and general financial health. In this experiment, I ask participants for a rate they wish to *earn* on a loan. Whether an individual is a high credit risk or a low credit risk, they want to *earn* at least the market rate of interest. Thus, the rate an individual wishes to *earn* is not an indirect signal of their credit worthiness or general financial health. Asking for the rate an individual wishes to earn allows me to unambiguously interpret the effect of my experimentally induced incentive on estimates. My experiment only includes a profit incentive and leaves the public signaling incentive to future researchers.

### **III. HYPOTHESIS DEVELOPMENT**

#### **Hypothesis 1**

Incentives affect subjective estimates, and a Libor submission is subjective. Kunda (1990, 1999) theorizes that directional incentives influence strategies for accessing information, the construction of an estimate, and the evaluation of beliefs about that estimate. She concludes that the resulting estimate is likely biased in the direction of the incentives. However, an individual is not free to conclude any estimate. According to Kunda (1990), individuals attempt

to be rational and to construct a justification in their mind that would persuade a “dispassionate observer.” The quality of the underlying data used to construct an estimate has been shown to constrain the influence of directional incentives on the estimate. Boiney, Kennedy, and Nye (1997) find the variance of underlying data affects resulting estimates of first year sales of new products. Armstrong, Davila, Foster and Hand (2007) find less bias in management forecasts of firms with high verifiability of underlying assets. In the Libor setting, panel bank submitters are generally bank employees working in Treasury Management that are looking at the currency market. They also know all the interbank currency lending and borrowing done by their bank in recent past. If the currency-maturity combination is popular for interbank borrowing, then the bank is more likely to have a closely-matching transaction in the underlying data set that can be used to help establish the estimate. Even when the bank has a closely-matching transaction, estimation is still required because the Libor submitted borrowing cost is in the future and based on “reasonable market size.” However, the actual closely-matching transaction narrows the range of justifiable estimates and is therefore expected to reduce the influence of directional incentives on estimates.

H1: Estimates are less influenced by directional incentives when the underlying data set used to establish the estimate includes a closely-matching transaction relative to the case when the data set does not include a closely-matching transaction.

## **Hypothesis 2**

Anonymity or deindividuation is theorized to give tacit permission for individuals to act in a self-interested and/or anti-normative way (Zimbardo 1969) and to feel less accountability (Wallace 1999, Lerner and Tetlock 1999). In sociology research, anonymity is associated with increased violence (Zimbardo 2007) and stealing Halloween candy (Diener, Fraser, Beaman and

Kelem 1976). In economic studies, Nogami (2009) manipulated anonymity and incentives using self-reported results of a coin flipping game and shows more lying when subjects are both anonymous and incentivized to lie. Nogami and Yoshida (2013) find anonymous participants that receive a monetary reward are more willing to break rules than the non-anonymous participants receiving a monetary reward. Franzen and Pointner (2012) find that anonymity leads to self-interested actions in the dictator game. Even though some studies have not found an effect of anonymity, a meta-analysis by Postmes and Spears (1998) found fifteen studies that manipulate anonymity to in-group with overall results of significantly more anti-normative behavior in the anonymous condition.

Anonymity is a continuum. Experiments often study complete anonymity in that subjects are not identified to the experimenter or to others in the class at any time. The adopted Libor reform involves a lesser degree of anonymity. Panel bank submissions are known to the regulator at all times and are known to others after 90 days. I call this temporal anonymity because banks are only anonymous to the public for a period of time. This degree of anonymity is not a typical experimental manipulation of anonymity. Anonymity operates by removing the threat of being seen, being known, and having to justify your actions to another. Although temporal anonymity offers only a degree of anonymity, I hypothesize that this degree of anonymity still reduces the threat of justifying your actions to others.

As discussed above, the submitter at a panel bank is a staff member generally working in Treasury Management and uses data from recent interbank borrowing transactions to form estimated future borrowing costs. These borrowing transactions limit the range of justifiable estimates for a Libor submission. In my experiment, all participants have an incentive to submit a higher rate but are given information that limits the range of justifiable estimates. Those

participants immediately identified are predicted to feel more threat of justification and, therefore, to submit a lower estimate. On the other hand, those given temporal anonymity are predicted to feel less threat of justification and, therefore, to submit higher estimates.

H2: Estimates are more influenced by directional incentives when identification is delayed (temporal anonymity) than when identification is immediate.

H2 predicts that those immediately identified feel more constrained by the threat of justification and will therefore submit *lower* estimates than those offered temporal anonymity. A competing hypothesis based on peer pressure makes the opposite prediction. A series of experiments by Asch (1956) shows the potential power of peer pressure.<sup>12</sup> In my experiment, the pay for an individual depends upon the rates submitted by everyone in their class. Both the individual and the class benefit from higher rates. Participants feel personal incentives and possibly peer pressure to increase their estimate. Personal incentives are equal whether identification is immediate or deferred, but peer pressure is stronger for those immediately identified because the participant's estimates will be immediately known by others. If a participant feels peer pressure toward a higher rate, the submitted estimates will be *higher* for those immediately identified than for those with temporal anonymity.

At the extreme, participants feeling personal and peer pressure may contemplate submitting a very high rate. In my experiment, I give participants a minimum and maximum rate from the online loan company and tell them that a rate outside this range may be rejected by the borrower. This maximum rate is designed to provide an upper bound that discourages submission of very high rates.

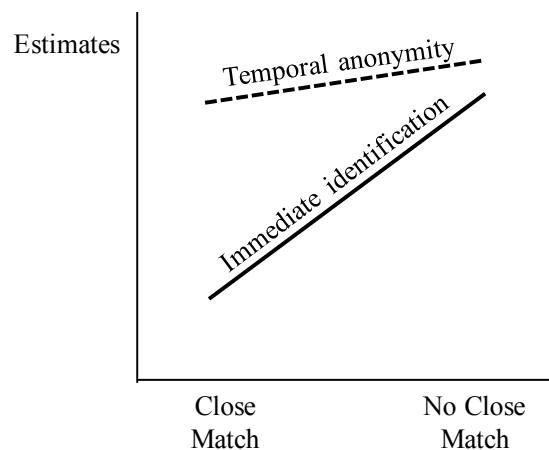
### **Hypothesis 3**

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<sup>12</sup> In the Asch experiments, subjects were given information leading to a right answer but confederate peers in their group all said the wrong answer was correct. Significantly more subjects submitted the incorrect consensus (confederate) answer rather than the correct answer.

The combination of H1's motivated reasoning theory (Kunda 1990, 1999) and H2's anonymity theories (Zimbardo 1969, Wallace 1999, Lerner and Tetlock 1999) leads to a predicted interaction between the presence or absence of a closely-matching transaction and the timing of identification. The presence or absence of a closely-matching transaction determines the width of the range of justifiable estimates (per H1). The timing of identification determines how strongly the participant feels the threat of justification (per H2). The predicted interaction is shown in Figure 1.

**Figure 1**  
Predicted interaction between Close match and Temporal Anonymity  
on Estimates Assuming an Upward Incentive



The distance between the temporal anonymity estimate and the immediate identification estimate is predicted to be larger within the close match conditions than within the no close match conditions. I'll first explain this predicted interaction from the point of view of the no close match conditions and then from the point of view of the close match conditions.

In the no close match conditions, all participants want a high rate, and the range of justifiable estimates is wide (per H1), which means high rates are easier to justify. Those immediately identified feel more threat of justification than those temporally anonymous (per

H2); however, since the range is wide, higher estimates are easier to justify. Both have mental permission to submit a high rate, with a predicted slightly higher rate for those temporally anonymous than those immediately identified (per H2). Reducing the threat of justification has little effect when the range of justifiable estimates is wide.

In the close match conditions, all participants also want a high rate, but the range of justifiable estimates is narrow and pulls estimates toward the benchmark interest rate of the closely-matching transaction (per H1). Those immediately identified feel more threat of justification than those temporally anonymous (per H2), so the estimate from those immediately identified is expected to be lower (closer to the benchmark) than the estimate from those temporally anonymous. Thus, in the close match conditions, the difference between the immediate identification estimate and the temporally anonymous estimate is expected to be significantly larger than the same difference in the no close match conditions. This interaction is reflected in H3:

H3: The effect of delaying identification on estimates is larger when the underlying dataset includes a closely-matching transaction than when the underlying data set does not include a closely-matching transaction.

## **IV. EXPERIMENTAL DESIGN**

### **Participants**

The sample consists of four classes of undergraduate accounting students at a large state university. The experimental task is simple and understandable to undergraduates studying accounting. Participants are given information to establish an estimate. For each loan, the size, interest rate, and maturity length is given. Participants are not expected to understand interest rate models or do complex calculations to establish the estimate. In the Libor setting, the person

preparing a Libor submission is a staff member generally working in the Treasury Management department using information from the bank's recent currency transactions to establish a Libor estimate. The staff member may have additional output from models but is not likely creating the models or performing complex computations. An undergraduate is a reasonable substitute for a staff member and is expected to be influenced by incentives in the same way. To test the three hypotheses, I collect data using a 2-by-2 between-participants experimental design. I distribute research materials in paper form to participants and ask them to write their name on their packet of materials.<sup>13</sup>

### **Setting and Incentive**

I establish the setting by telling participants they inherited money from a relative and have decided to invest this money by lending it through an online loan company that specializes in group loans, which pool many lenders together to make a single large loan to a borrower. Participants are assured that the borrower meets minimum credit risk standards and is expected to make all future loan payments.

Next, I explain and illustrate how the group loan interest rate is calculated as the interquartile mean of the submitted interest rates for their class. I also explain the pay structure. I pay participants according to the group loan interest rate calculated for each class at the time of the experiment. The group loan interest rate is translated into dollars and cents, then rounded to the nearest dollar. For example, if the group loan interest rate is 6.58%, it is translated into \$6.58 then rounded to the nearest dollar, \$7, and participants are paid \$7 each. This pay structure creates an incentive for participants to submit higher interest rates.

### **Task and Information Given**

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<sup>13</sup> A complete copy of experimental materials is in Appendix A

On the third page of the experimental materials, participants learn about three types of information they will receive from the loan company to help them determine the rate they will submit. The three categories of information are (1) a range, (2) similar loans, and (3) a matching loan, if available. The range is the minimum and maximum rate suggested by the online loan company. I tell participants that rates outside this range may not be accepted by the borrower to establish upper and lower bounds for interest rate submissions. Similar loans are actual loans granted in the last week that are close to the loan in either size or maturity but not both. A matching loan, if available, is an actual loan granted in the last week that is close to the loan in both size and maturity.

Next is the actual experimental task. I give participants information as described above as well as details about the loan they are helping fund. The loan is a 7-year loan for \$9,600. Forty such individual loans will be combined to make a \$384,000 group loan with an interest rate that is the interquartile mean of the individual submitted interest rates. Participants in all conditions are given a suggested minimum (4.1%) and maximum (8.5%) for the submitted interest rate (the midpoint of this range is 6.3%). Participants in all conditions are also given information on eight recent loans that are identified as “similar” loans. Similar loans are defined as loans from the last week that are *either* within \$2,000 of the notional value *or* within one year of the maturity of their loan *but not both*. Thus, similar loans have notional values between \$7,600 and \$11,600 and maturities less than 6 years or more than 8 years; or they have maturities between 6 and 8 years and notional values below \$7,600 or above \$11,600. I give participants similar loans so that they have some data to use when determining the interest rate they wish to earn on the loan and because the panel bank employees preparing Libor submissions likely have similar loans in the dataset underpinning a Libor submission. Both the mean and the median of

the similar loan rates are 6.3%. Participant's desired interest rate is the first dependent variable used for hypothesis testing.

### **Close Match/No Close Match Manipulation**

I randomly assign participants within each class to the close match and the no close match conditions. In the close match conditions, a matching loan exists. A close match loan is defined as a loan within the past week that is *both* within \$2000 of the value of the loan *and* within one year of the maturity of the loan. In the experiment, the close match loan is a \$9,400 loan of 7 years granted one week previous to the experiment with an interest rate of 6.3% (the median and mean of the similar loan rates as well as the midpoint of the range given). Because the close match loan is not an exact match, participants have some subjectivity in setting the rate even in the close match conditions. In the no close match conditions, I tell participants that a matching loan is not available. This manipulation can be seen by comparing the two different page 5s in Appendix A.

The close match/no close match manipulation is designed to simulate the difference between a popular and unpopular currency-maturity combination. Popular (unpopular) currency-maturity combinations likely have (do not have) a closely-matching transaction in the underlying data set. This manipulation provides the opportunity to test the intent of the first reform to decrease bias and subjectivity in Libor submissions by increasing the probability that the underlying data set includes an actual closely matching interbank loan. In my experiment, I manipulate whether the underlying data set includes a closely matching transaction then observe the effect of directional incentives on interest rates.

### **Temporal Anonymity/Immediate Identification Manipulation**

Each participant in the immediate identification conditions is told in the experiment's introductory materials that his or her submitted interest rate will be recorded next to his or her name and displayed on a screen in the room. Each participant in the temporal anonymity conditions is told in the introductory materials that his or her submitted interest rate will be recorded next to his or her name on a piece of paper that can be seen in the experimenter's office the following quarter during office hours.<sup>14</sup>

The immediate identification/temporal anonymity conditions are assigned, not randomized, in order to rule out possible effects of information sharing between classes as an alternative explanation of results. The two classes meeting earlier in the morning are assigned to the temporal anonymity condition and the two classes meeting later in the morning are assigned to the immediate identification condition. I was concerned that students may communicate about the experiment as the morning progressed. If they did communicate, I predict that the rates would naturally get higher throughout the morning. To alleviate this concern as an alternative explanation for results, I assigned the earlier-in-the-morning classes to the temporally anonymous conditions (hypothesized to submit *higher* rates in H2) and the later-in-the-morning classes to the immediate identification conditions (hypothesized to submit *lower* rates in H2). With the temporal anonymity conditions earlier in the morning, any effect of information sharing produces results *opposite* the direction of H2 predictions.

The immediate identification/temporal anonymity manipulation in my experiment is designed to capture the level of anonymity for banks before and after the reform that delayed public release of individual bank Libor submissions. Before the reform, both the Libor rates and individual bank submissions were released to the public on the day of submission. After the

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<sup>14</sup> The delay in identification in the experiment is 49 days because the experiment was given 7 weeks prior to the beginning of the next quarter.

reform, only the Libor rates are released and individual bank submissions are held for 90 days before public release. In my experiment, individual submitted interest rates are either released at the time of the experiment or deferred to the following quarter. This experimental manipulation offers only partial anonymity because (1) all research materials are submitted with a name and (2) all submitted rates are viewable either at the time of the experiment or later. I use the phrase “temporal anonymity” to refer to the anonymity only during the period of time the submitted rates are not known to the other participants. This manipulation provides the opportunity to test the intent of the second reform to improve Libor by delaying public release of individual Libor submissions. In my experiment, I manipulate the timing of identification then observe the effect of directional incentives on interest rates.

### **Additional Dependent Variable and the End of the Experiment**

On the last page of the experimental materials, I collect information for a second dependent variable for hypothesis testing. This dependent variable is the predicted interest rate of the average person in the class. In social influence theory, how others act in a similar situation is called a descriptive norm and is theorized to affect future decisions due to the conformity effect (Cialdini and Trost 1998). This theoretical relationship has been confirmed empirically in a variety of areas. Perceived descriptive norms change future behavior in college drinking (Neighbors, Dillard, Lewis, Bergstrom and Neil 2006) and internal control compliance (Tayler and Bloomfield 2011). Observed or manipulated descriptive norms change future behavior in littering (Cialdini, Reno and Kallgren 1990), cheating (Gino, Ayal, and Ariely 2009), car seat usage (Jeffrey, Whelan, Pirouz and Snowdon 2016), and vegetable consumption (Stok, Verkooijen, DeRidder, DeWiit, and DeVet 2014). Additionally, behavior of others, perceived as “everybody is doing it,” provides rationalization for white collar crime (Coleman 1989).

There is a reciprocal relationship between descriptive norms and individual decisions. Descriptive norms affect individual behavior (conformity effect) and individual behavior, in turn, affects predicted descriptive norms (projection effect). In my study, I ask participants for the submitted interest rate, which is their individual behavior. I then ask for predicted behavior of the average person in their class. When making this prediction, participants reference their own behavior but likely add self-righteousness bias. This bias is summarized by Klein and Epley (2016) as, “the tendency to believe one is more moral than others.” This bias is also commonly called the Lake Wobegon Effect, a reference to a fictional town in which all children are above average (Kruger 1999). Self-righteousness bias in my experiment means participants believe others will be more influenced by directional incentives than they individually are. If this bias is present, the predicted average interest rate likely shows a stronger influence of directional incentives than the submitted interest rate because the participant believes others will be more influenced by directional incentives than they individually are. This predicted average interest rate, in turn, forms a descriptive norm that has the potential to affect future decisions of the individual.<sup>15</sup>

The last page of the experimental materials also asks participants to state the maximum rate the participant considered justifiable. I expect this variable to mimic the participant’s submitted interest rate (my first dependent variable) and examine it on an exploratory basis. I then ask manipulation check questions and gather demographic information on the participants. To end the experiment, I wrote the submitted interest rates on a piece of paper next to the names

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<sup>15</sup> I’ll illustrate the importance of this dependent variable and its possible effect on future individual behavior with an example of speeding. I do not speed. I travel exactly at the speed limit of 60 mph, but I believe everyone else travels at 70 miles per hour because of the projection effect and self-righteousness bias. Although I may travel at 60 mph today, the belief that everyone else travels at 70 mph provides a justification for me to travel at 62 mph in the future on the day I’m running late to an important meeting.

of the students in the class. If the class is immediately identified, I displayed this piece of paper on a screen in front of the class. I entered the submitted interest rates into an Excel program that eliminates the highest and lowest 25% of submitted interest rates and computes the mean of the remaining submissions. I announced this group loan interest rate and the amount each participant will be paid to the class. I paid participants the following class session.

### **Experimental Design Choices Related to Incentives**

As previously mentioned, to create an incentive for a higher rate, I pay participants according to the group loan interest rate for their class. In this section, I further discuss and justify three experimental design choices surrounding the incentive: (1) all participants have the *same* directional incentive; (2) the incentive is for a *higher* rate rather than a lower rate, and (3) there is only a profit incentive.

First, all participants have the same directional incentive so that I can unambiguously interpret results. The computational process of Libor assures that if bank submissions are biased due to directional incentives in opposite directions with equal number and magnitude, the interquartile mean remains unbiased with only the variance increasing. However, when more panel banks have an incentive in one direction than the other or if the incentive is of greater magnitude in one direction or the other, the resulting Libor rate may be biased. The situation of all having the same directional incentive can exist in the real Libor world. For example, most panel banks hold variable rate mortgage receivables and all will profit from a higher rate on the particular day when the variable rate is set for these mortgage receivables. A class-action lawsuit filed on behalf of mortgage-holders alleges a higher Libor rate near the first day of the month (the day when many mortgages set the rate) compared to the surrounding days on either side (Brodie 2012).

The second experimental design choice about incentives is that participants have an upward rather than a downward incentive. The bias in estimates is expected to be toward the incentive whether that incentive is upward or downward. If the incentive was for a lower interest rate, the submitted interest rates would be at the low end of the mentally justifiable range for those immediately identified and toward the minimum rate for those granted temporal anonymity. An incentive for a higher rate is operationalized because a higher interest rate is more naturally understandable in the experimental setting and enables a direct connection between the incentive and the payout to participants.

The third experimental design choice about the incentive is that I only include a profit incentive rather than both a profit and a public signaling incentive. As previously described, the public signaling incentive arises in Libor because banks are asked to submit a rate they expect to *pay* on a loan. A high (low) credit risk bank expects to pay a higher (lower) interest rate on a loan, thus an expected rate to *pay* may be a signal of credit risk. I ask participants to state an interest rate they wish to *earn* on a loan they are granting. The amount they want to *earn* does not signal their individual financial condition. The first reason I only include one incentive is so I can unambiguously conclude results are due to the one incentive rather than comparing strength of incentives. A second reason for including only the profit incentive, rather than both the profit and public signaling incentives, is because the profit incentive is more likely to recur in the future. The public signaling incentive arose during the financial crisis because of extreme uncertainty about bank health, which is less likely to occur regularly into the future. Studying the effects of reform in the future should logically use the incentive that is likely to exist in the future. I therefore focus on the profit piece and leave the public signaling piece to future researchers.

## V. RESULTS AND DISCUSSION

### Participants

The sample consists of four classes of undergraduate students at a large state university taking undergraduate accounting classes. The classes range in size from 34 to 40 and meet at four different times in the morning.<sup>16</sup> The participants range in age from 18 to 28 with an average age of 19.8 years. A majority of participants have real-world experience earning money based on an interest rate with 79 percent reporting they saved money in an interest-bearing account and 95 percent accurately concluding that a higher interest rate on a savings account resulted in higher interest payments.<sup>17</sup> Each class was paid according to the interquartile mean of the submitted interest rates for that class. The interquartile means ranged from 6.60 to 6.80 for the four classes, so all participants were paid \$7 each.

### Manipulation Checks

To assess the effectiveness of the profit incentive, participants were asked about their understanding of the pay structure. This question was answered correctly by 99 percent of the participants.

To assess the effectiveness of the close match/no close match manipulation, I asked participants to state whether a “matching” transaction was available to them in their information. Ninety-four percent of all participants responded correctly. Most of those who missed this manipulation check were in the no close match condition suggesting that the question may have been interpreted by some participants as asking whether or not a section called “matching”

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<sup>16</sup> The Institutional Review Board at the University of Washington approved the use of human subjects for this experiment.

<sup>17</sup> The results are inferentially similar if the 5% incorrectly answering are excluded.

existed in their given materials. To assess the effectiveness of the immediate identification/temporal anonymity manipulation, I asked participants whether they would be identified immediately to others in the class or whether the class submissions could be viewed next quarter in office hours. Ninety-five percent of all participants responded correctly. Results are inferentially similar excluding those who failed the manipulation checks.

### **Eliminating outliers**

The first dependent variable for hypothesis testing is the submitted interest rate. In the experiment, participants were given a minimum and maximum interest rate suggested by the online loan company and told a rate outside that range may be rejected by the borrower. Three participants submitted interest rates far outside the range. One submitted a rate of 25 percent which is nearly 3 times the upper limit of the range. This participant did not answer more than half the questions in the experiment. Two submitted rates of zero percent. I eliminated the three interest rates that were far outside the range given in the materials, leaving a final sample of 150.

### **Hypothesis Tests, Dependent Variable: Submitted Interest Rate**

Descriptive data on the first dependent variable, submitted interest rates, are presented in Table 1. The number of participants in each cell ranges from 36 to 38. The reason for the difference in cell size is threefold: (1) although the close match and no close match were prepared as every-other-packet, when they were distributed by rows in the classes; a miscounting

of a row and a student arriving late meant more close match packets were distributed in one class, (2) each class had different enrollments, and (3) I eliminated three extreme outliers.<sup>18</sup>

### ***Hypothesis 1—Close Match***

H1 posits that due to motivated reasoning and an upward incentive, the interest rates from those participants given a closely-matching transaction are lower than the rates from those without a close match. H1 test results are presented in Table 2 Panel A showing an analysis of variance. There is no significant main effect of Match (close match vs. no close match) on submitted interest rates (F-statistic=1.20 two-tailed equivalent p-value=0.28). Because H1 is directional, a one-tailed equivalent p-value is appropriate but is also not significant (one-tailed p-value=0.14).<sup>19</sup>

### ***Hypothesis 2—Temporal Anonymity***

H2 posits that due to the psychological effects of being temporally anonymous, those participants immediately identified to the others in their class submit lower interest rates than those participants who have temporal anonymity. H2 test results are presented in Table 2 Panel A showing an analysis of variance. There is no significant main effect of Identification (immediate identification vs. temporal anonymity) on submitted interest rates (F-statistic=0.39, two-tailed equivalent p-value=0.53). Because H2 is directional, a one-tailed equivalent p-value is appropriate but is also not significant (one-tailed p-value=0.27).<sup>20</sup> Peer pressure was an alternative hypothesis predicting that those immediately identified would submit higher rates than those temporally anonymous. One reason for the lack of statistically significant results for

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<sup>18</sup> The outlier “25” was in the no close match/immediate identification condition. One of the “0” outliers was in the close match/immediate identification condition. The other “0” outlier was in the no close match/temporally anonymous condition.

<sup>19</sup> If the three extreme outliers are included in the analysis of variance on submitted interest rates, match has an F-statistic of 1.63 and a one-tailed equivalent p-value of 0.10.

<sup>20</sup> If the three extreme outliers are included in the analysis of variance on submitted interest rates, identification has an F-statistic of 0.35 and a one-tailed equivalent p-value of 0.72.

H2 could be some participants feeling peer pressure so submitted higher rates in the immediate identification conditions. Another reason could be information sharing from those taking the experiment earlier in the morning to those taking it later in the morning, which may have driven the rates in the immediate identification conditions higher.

***Hypothesis 3—Interaction***

The analysis of variance in Table 2 Panel A also includes the interaction between Match (close match vs no close match) and Identification (immediate identification vs. temporal anonymity). The interaction assumed by ANOVA is different from the interaction predicted in H3 (Buckless and Ravenscroft 1990). In H3, I predict that temporal anonymity has a larger influence on those participants in the close match conditions than those in the no close match conditions. Figure 2 shows the predictions and contrast coding weights consistent with H3.

**Figure 2: Contrast Code Weights**  
 Predicted interaction between Close match and Temporal Anonymity

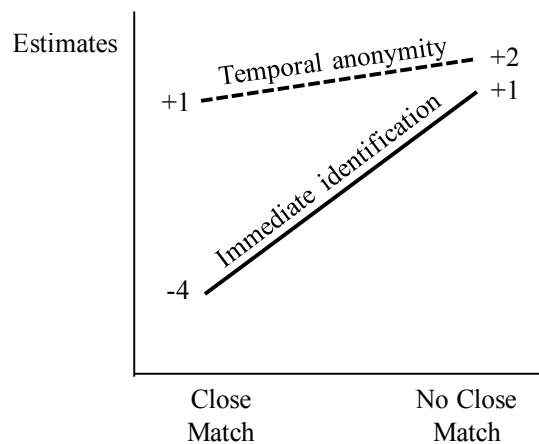


Figure 2 shows a smaller difference between the temporal anonymity and the immediate identification estimates in the no close match conditions and a larger difference in the close match conditions. Contrast code weights must sum to zero. I predict participants will submit the lowest rates in the close match/immediate identification, coded as -4 in Figure 2. The close

match draws the interest rate toward the benchmark (per H1) and the immediate identification increases the threat of justification so draws the interest rate toward the benchmark (per H2). I predict participants will submit the highest rates in the no close match/temporal anonymity condition, coded as +2 in Figure 2. The lack of a close match allows a wider range of estimates to be justifiable (per H1) and the temporal anonymity decreases the threat of justification (per H2) so the interest rates will be toward the upper bound.

I predict the no close match/immediate identification condition (coded +1 in Figure 2) to be slightly lower than the no close match/temporal anonymity condition (coded +2 in Figure 2). The lack of a close match allows a wider range of estimates to be justifiable (per H1), but immediate identification increases the threat of justification (per H2) so draws the rate slightly lower. Lastly, I predict the close match/temporal anonymity condition (coded +1 in Figure 2) to be significantly higher than the close match/immediate identification (coded -4 in Figure 2). The close match draws the interest rate toward the benchmark (per H1) but the temporal anonymity decreases the threat of justification so gives mental permission for a higher rate (per H2).

The contrast codes used reflect that the immediate identification/no close match condition and the temporal anonymity/close match condition will be equal; both are coded +1. Theory does not necessarily predict their equality. As a result, I report results using other contrast codes in the footnotes as robustness tests.

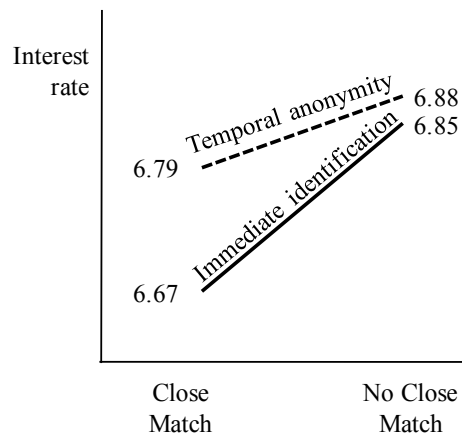
Panel B of Table 2 presents results of an analysis of variance using the above contrast codes, which are summarized below:

- no close match/temporal anonymity (+2),
- no close match/immediate identification (+1),
- close match/temporal anonymity (+1), and

- close match/immediate identification (-4).

The F-statistic of this analysis is 1.57, a two-tailed equivalent p-value=0.21 that is not statistically significant.<sup>21</sup> Panel C of Table 2 presents results of the simple effects tests. The t-tests expected to show directional differences are not significant.<sup>22</sup> Actual results are illustrated in Figure 3:

**Figure 3**  
Observed interaction between Close match and Temporal Anonymity  
Dependent variable: Submitted Interest Rate



### Hypothesis Tests, Predicted Average Interest Rate as Dependent Variable

On the last page of the experimental materials, I ask participants to predict the interest rate submitted by the average person in their class. This is a second dependent variable to test all three of the hypotheses. This dependent variable measures what participants expect others to do

<sup>21</sup> Results using weights of +2 +2 +1 -5 (F-statistic=1.58, two-tailed equivalent p-value=0.21) and weights of +1 +1 +1 -3 (F-statistic=1.44, two-tailed equivalent p-value=0.23) are similar.

<sup>22</sup> As additional analysis, I looked at the maximum justifiable interest rate. In the experiment, I ask participants for the maximum interest rate they feel is justifiable. According to Kunda's motivated reasoning (1990, 1999), a person formulating an estimate is mentally considering justification to a dispassionate observer. The maximum justifiable interest rate is designed to measure this underlying mental justification. I expect the maximum justifiable interest rate to behave in the same predicted pattern as the submitted interest rate. Results testing for the expected patterns using maximum justifiable interest rates are similar to those using submitted interest rates. The maximum justifiable interest rates are numerically consistent with predictions but not statistically significant.

in a similar situation, a descriptive norm that can affect future decision making. This descriptive norm may be influenced by the self-righteousness bias. If predicted average interest rates have the self-righteousness bias, (1) they are expected to be higher on average than submitted interest rates, and (2) they may more strongly reflect directional incentives because participants believe others are more affected by directional incentives than they individually are. Using the sample of 150, the predicted average interest rates are, on average, higher than the submitted interest rates. The average difference between an individual's predicted average interest rate and the submitted interest rate is 0.15, which is significantly different from zero (t-statistic=2.74, two-tailed p-value<0.01, untabulated). I report results for each hypothesis using this alternate dependent variable below.

Of the original 153 participants, 152 answered this question with no predicted average interest rates outside the range given in the materials. Descriptive data on predicted average interest rates are presented in Table 3. The number of participants in each cell ranges from 36 to 39. Reasons for differences in cell size are as stated previously.

### ***Hypothesis 1—Close Match***

Tests of H1 using the second dependent variable, predicted average interest rate, are presented in Table 4 Panel A. The analysis of variance shows a significant main effect of Match (close match vs. no close match) on predicted average interest rates (F-statistic=3.70 two-tailed equivalent p-value=0.06). Because H1 is directional, a one-tailed equivalent p-value is appropriate and is also significant (one-tailed p-value=0.03). The results are consistent with H1 and provide some support for elimination of unpopular currencies and maturities to increase the probability that an actual transaction supports a Libor submission thereby reducing bias in submissions.

### ***Hypothesis 2—Temporal Anonymity***

Tests of H2 using the second dependent variable, predicted average interest rate, are presented in Table 4 Panel A. The analysis of variance shows a significant main effect of Identification (immediate identification vs. temporal anonymity) on predicted average interest rates (F-statistic=1.92, two-tailed equivalent p-value=0.17). Because H2 is directional, a one-tailed equivalent p-value is appropriate to establish significance (one-tailed p-value=0.08). The results are consistent with H2 and reflect that directional incentives more strongly influence predicted rates when participants are anonymous for a period of time. This is an unintended consequence of the reform. The reform was designed to reduce public signaling bias by delaying the public release of individual bank Libor submissions.

### ***Hypothesis 3—Interaction***

Tests of H3 using predicted average interest rates are presented in Table 4 Panels B and C. Panel B of Table 4 shows the results of an analysis of variance using contrast coding weights as previously described:

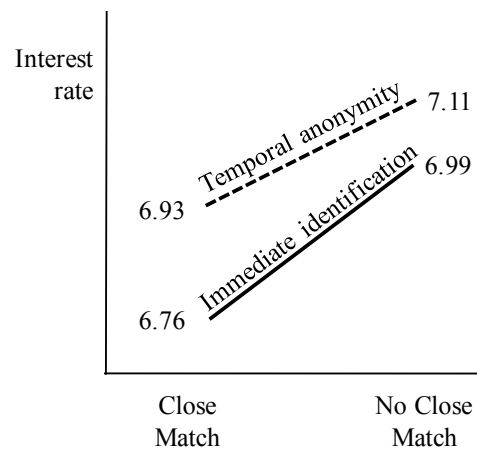
- no close match/temporal anonymity (+2),
- no close match/immediate identification (+1),
- close match/temporal anonymity (+1), and
- close match/immediate identification (-4).

The F-statistic of the model with the predicted interaction is 5.05, a significant two-tailed equivalent p-value=0.03.<sup>23</sup> Panel C of Table 2 shows results of the simple effects tests. Two of the four t-tests expected to show directional differences are statistically significant. Results using predicted average interest rates are illustrated in Figure 4:

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<sup>23</sup>Results using weights of +2 +2 +1 -5 (F-statistic=4.74, two-tailed equivalent p-value=0.03) and weights of +1 +1 +1 -3 (F-statistic=4.29, two-tailed equivalent p-value=0.04) are similar.

**Figure 4**  
 Observed interaction between Close match and Temporal Anonymity  
 Dependent variable: Predicted Average Interest Rate



The results using predicted average interest rates offer support for H3 and suggest that the increase in estimates from delaying identification is larger for those in the close match conditions than in the no close match conditions. Delaying identification (a feature of the second reform) results in more influence of directional incentives especially when a closely-matching transaction exists (which is more likely as a result of the first reform). A self-righteousness bias may explain why statistically significant results are found for the three hypotheses using predicted average interest rate but not using submitted interest rate.

## VI. SUMMARY AND CONCLUSIONS

This paper investigates two key Libor reforms and whether they improve Libor by reducing the influence of directional incentives. The first key reform is designed to reduce bias by increasing the probability that an actual transaction is underpinning a Libor submission. The second key reform delays public release of individual bank Libor submissions to reduce the public signaling incentive for banks to submit lower rates to signal financial health; however, the period of anonymity has the potential to increase bias from other directional incentives. In my

experiment, Hypothesis 1 tests whether the presence of a closely-matching transaction in the underlying data set reduces the influence of directional incentives on estimates. I only find statistically significant support for H1 using one of my two dependent variables (predicted average interest rates). The results provide only limited support for the first key reform.

Hypothesis 2 tests for an unintended consequence from the period of anonymity provided by the second reform. Consistent with H1, I only find statistically significant support for H2 using one of my two dependent variables (predicted average interest rates). These results indicate a potential concern to Libor administrators. They reflect that the period of anonymity allows bias from directional incentives to influence the Libor submission. This results is opposite the reform's intent.

Hypothesis 3 tests whether the existence of a closely-matching transaction and the delay in identification interact in such a way that the effect of delaying identification is larger in the close-match conditions. Consistent with both H1 and H2, I only find statistically significant support for H3 using one of my two dependent variables (predicted average interest rates).

Delaying identification (a feature of the second reform) results in more influence of directional incentives, especially when a closely-matching transaction exists (which is more likely as a results of the first reform). My results reflect that, unfortunately, the reforms may work against each other.

There are several implications of this study. First, my findings provide a potential explanation for some of the behavior contributing to the Libor scandal. During the economic crisis the interbank loan market was illiquid. When the interbank market is illiquid (liquid), panel bank members are less (more) likely to have closely-matching transactions upon which to base their Libor submissions. Liquidity of the interbank market fluctuates, but during the

financial crisis, the central banks offered currency loans to banks at little to no interest. These offers eliminated a great deal of interbank lending and, thus, removed closely-matching transactions from underlying data sets when preparing Libor submissions. Without closely-matching transactions, a wider range of estimates is justifiable, and submissions reflect more bias from incentives. It was during this period that banks were accused of manipulating Libor.

Second, my findings provide support for the newly-established methodologies suggested by the IBA for contributing banks. The current Libor administrator, IBA, recently published new guidelines for panel bank members to follow when establishing their Libor submission.<sup>24</sup> These guidelines acknowledge that the underlying data sets available to panel bank members will differ. The IBA suggests a “waterfall” of submission methodologies to ensure that Libor panel banks use actual past transactions where available. Level 1 of the waterfall is based on eligible transactions (similar to the close match conditions in my experiment). Level 2 is derived from transactions, including “adjusted and historical transactions, interpolation and parallel shift” (similar to the no close match conditions in my experiment). Level 3 is expert judgment. Results from my experiment suggest that submissions using Level 1 methodology are less likely to be biased by directional incentives than those using Level 2 or Level 3 methodologies. Requiring banks to submit their methodology level along with their Libor submissions will alert the Libor administrator to situations where bias may exist.

Third, my findings are relevant to other experimental studies that incorporated incentives and that grant subjects anonymity. Some experimental research gives participants a high degree of anonymity by, for example, identifying participants only with a number or hiding participants’ behavior from others in their group. Findings from my experiment show that behavior changes

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<sup>24</sup> The waterfall of methodologies is presented in Annex 1 of “Libor Code of Conduct Contributing Banks, Issue 3: 1 August 2016” published by ICE Benchmark Administration Limited.

when participants have incentives and a degree of anonymity. If an experiment includes both directional incentives and anonymity, the effect of the incentive may be overstated due to the anonymity. Results of the same experiment may be different if subjects had less anonymity.

This study is subject to a limitation that forms a suggestion for future research. My manipulation of temporal anonymity may grant more anonymity than the Libor reform, which delays reporting for 90-days. Participants with temporal anonymity could see submitted interest rates from their class the next quarter during office hours, which are limited to certain times and days. In the real world, anyone with a subscription to Thompson-Reuters can see individual bank Libor submissions anytime after the 90-days. Also, participants are not offered a chance to view submitted interest rates beyond the next quarter, yet panel bank submissions are known for a long period of time after the 90-day delay. Future research could try other manipulations of temporal anonymity to assess the generalizability of my manipulations to the Libor setting and further academic understanding of limited anonymity.

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**TABLE 1**  
*Descriptive Statistics: Submitted interest rate*

**Descriptive statistics - Submitted interest rate (mean, [standard deviation], n)**

<i>Time of identification</i>	<i>Match</i>		Row means
	Close Match	No close match	
Temporal Anonymity	6.79 [0.72] <i>n</i> = 38	6.88 [0.80] <i>n</i> = 38	6.83 [0.76] <i>n</i> = 76
Immediate Identification	6.67 [0.72] <i>n</i> = 38	6.85 [0.69] <i>n</i> = 36	6.76 [0.71] <i>n</i> = 74
Column means	6.73 [0.71] <i>n</i> = 76	6.86 [0.75] <i>n</i> = 74	6.80 [0.73] <i>n</i> = 150

Table C - 1 presents descriptive statistics for the first dependent variable, *submitted interest rate*, by experimental condition. In my experiment, I manipulate whether subjects are given a transaction that is a close match to the loan for which they are setting an interest rate (Close match vs. No close match) and the timing of identification of the participant to the class (Immediate Identification vs. Temporal Anonymity). These two manipulations result in four treatment conditions. I start with 153 participants then remove three extreme outliers leaving a sample of 150.

**TABLE 2**  
*Hypothesis tests: Submitted interest rate*

**Panel A: Analysis of variance – dependent variable is submitted interest rate**

Source	Sum of squares	d.f.	Mean square	F-statistic	p-value
<i>Model</i>	0.92	3	0.31	0.57	0.633
<i>Match</i>	0.65	1	0.65	1.20	0.276
<i>Identification</i>	0.21	1	0.21	0.39	0.534
<i>Match x Identification</i>	0.07	1	0.07	0.12	0.728
<i>Residual</i>	78.73	146	0.54		
<i>Total</i>					

**Panel B: Analysis of variance with disordinal interaction – dependent variable is submitted interest rate**

Source	d.f.	Contrast	F-statistic	p-value
2 1 1 -4 <i>Match x Identification</i>	1	0.702	1.57	0.212
<i>Denominator</i>	146			

Contrast code: Highest rates in No close match and Temporal anonymity highest (+2),  
Lowest rates in Close match and Immediate identification (-4),  
Greater Identification effect in Close match than in No close match conditions, so:  
No close match/Immediate identification (+1) and Close match/Temporal anonymity (+1)

**Panel C: Simple effects tests – dependent variable is submitted interest rate**

	Mean	Standard error	n	t-statistic	p-value one tailed
Close match <i>Immediate identification</i>	6.67	0.12	38		
<i>Temporal anonymity</i>	6.79	0.12	38	0.71	0.241
No close match <i>Immediate identification</i>	6.85	0.12	36		
<i>Temporal anonymity</i>	6.88	0.13	38	0.19	0.425
Immediate identification <i>Close match</i>	6.67	0.12	38		
<i>No close match</i>	6.85	0.12	36	1.05	0.148
Temporal anonymity <i>Close match</i>	6.79	0.12	38		
<i>No close match</i>	6.88	0.13	38	0.51	0.305

Table C - 2 presents the analyses for testing the three hypotheses. The dependent variable in all analyses is *Interest rate submitted*. I start with 153 participants, remove three extreme outliers, leaving a sample of 150.

Panel A presents an analysis of variance with independent variables Match (Close match vs. No close match), Identification (Immediate identification vs. Temporal anonymity), interaction of Match and Identification, and gender. The interaction assumed in this ANOVA analysis is different from the predicted interaction.

Panel B presents the analysis of variance comparable to the analysis in Panel A but with different contrast coding for the interaction of Match and Identification. No close match/Temporal anonymity (+2), No close match/Immediate identification (+1), Close match/Temporal anonymity (+1), Close match/Immediate identification (-4) consistent with hypothesis 3.

Panel C presents t-tests comparing the means of the four conditions. The effect of Identification is predicted to be greater in the Close match than in the No close match conditions.

All p-values are two-tailed equivalent unless otherwise noted.

**TABLE 3**  
*Descriptive Statistics: Predicted average interest rate*

**Descriptive statistics - Predicted average interest rate (mean, [standard deviation], n)**

<i>Time of identification</i>	<i>Match</i>		Row means
	Close Match	No close match	
Temporal Anonymity	6.93 [0.72] <i>n</i> = 38	7.11 [0.46] <i>n</i> = 39	7.02 [0.61] <i>n</i> = 77
Immediate Identification	6.76 [0.69] <i>n</i> = 39	6.99 [0.73] <i>n</i> = 36	6.87 [0.72] <i>n</i> = 75
Column means	6.84 [0.71] <i>n</i> = 77	7.06 [0.61] <i>n</i> = 75	6.95 [0.67] <i>n</i> = 152

Table C - 3 presents descriptive statistics for the second dependent measure, *Predicted average interest rate*, by experimental condition. In my experiment, I manipulate whether subjects are given a transaction that is a close match to the loan for which they are setting an interest rate (Close match vs. No close match) and the timing of identification of the participant to the class (Immediate identification vs. Temporal anonymity). These two manipulations result in four treatment conditions. I start with 153 participants. One did not answer the question for predicted average, leaving a sample of 152.

**TABLE 4**  
*Hypothesis tests: Predicted average interest rate*

**Panel A: Analysis of variance – dependent variable is predicted average interest rate**

Source	Sum of squares	d.f.	Mean square	F-statistic	p-value
<i>Model</i>	2.53	3	0.84	1.94	0.125
<i>Match</i>	1.61	1	1.61	3.70	0.056
<i>Identification</i>	0.83	1	0.83	1.92	0.168
<i>Match x Identification</i>	0.03	1	0.03	0.06	0.806
<i>Residual</i>	64.26	148	0.43		
<i>Total</i>					

**Panel B: Analysis of variance with disordinal interaction – dependent variable is predicted average interest rate**

Source	d.f.	Contrast	F-statistic	p-value
2 1 1 -4 <i>Match x Identification</i>	1	1.11	5.05	0.026
<i>Denominator</i>	148			

Contrast code: No close match and Temporal anonymity highest submissions (+2),  
Close match and Immediate identification lowest submission (-4),  
Greater effect of Identification in Close match conditions:  
No close match/Immediate identification (+1) and Close match/Temporal anonymity (+1)

**Panel C: Simple effects tests – dependent variable is predicted average interest rate**

		Mean	Standard error	n	t-statistic	p-value one tailed
Close match	<i>Immediate identification</i>	6.76	0.11	39		
	<i>Temporal anonymity</i>	6.93	0.12	38	1.08	0.141
No close match	<i>Immediate identification</i>	6.99	0.12	36		
	<i>Temporal anonymity</i>	7.11	0.07	39	0.87	0.194
Immediate identification	<i>Close match</i>	6.76	0.11	39		
	<i>No close match</i>	6.99	0.12	36	1.41	0.081
Temporal anonymity	<i>Close match</i>	6.93	0.12	38		
	<i>No close match</i>	7.11	0.07	39	1.31	0.098

Table C - 4 presents the analyses for testing the three hypotheses. The dependent variable in all analyses is *Predicted average interest rate*. I start with 153 participants. One participant did not answer the predicted average interest rate, leaving a sample of 152.

Panel A presents an analysis of variance with independent variables Match (Close match vs. No close match), Identification (Immediate identification vs. Temporal anonymity), interaction of Match and Identification, and gender. The interaction assumed in this ANOVA analysis is different from the predicted interaction.

Panel B presents the analysis of variance comparable to the analysis in Panel A but with different contrast coding for the interaction of Match and Identification. No close match/Temporal anonymity (+2), No close match/Immediate identification (+1), Close match/Temporal anonymity (+1), Close match/Immediate identification (-4) consistent with hypothesis 3.

Panel C presents t-tests comparing the means of the four conditions. The effect of Identification is predicted to be greater in the Close match than in the No close match conditions.

All p-values associated with F-statistics are two-tailed equivalent.

All p-values associated with t-statistics are one-tailed.

## Appendix A: Experimental materials

<div style="text-align: center; background-color: #808080; color: white; padding: 5px; margin-bottom: 10px;"><b>Welcome</b></div> <p>Thank you for participating in this research study.</p> <p>There is no specialized knowledge needed to complete this study.</p> <p>For participating in this study, you will receive 15 points on the quiz scheduled for today. Please enter your name so we can identify you as having completed this study.</p> <p>Name: <input style="width: 100%; height: 20px;" type="text"/></p> <div style="text-align: center; background-color: #808080; color: white; padding: 5px; margin-top: 10px;"><b>Background</b></div> <p>You inherited some money from a relative and have decided to invest this money by lending it through an online loan company that matches lenders and borrowers.</p> <p>This loan company arranges many types of loans and specializes in group loans, which pool many lenders together to make a single large loan to a borrower.</p>	<div style="text-align: center; background-color: #808080; color: white; padding: 5px; margin-bottom: 10px;"><b>The Group Loan</b></div> <p>You have identified a group loan in which you would like to participate as a lender. Individuals like yourself who choose to fund the loan will each contribute \$9,600. The loan will be paid back over 7 years. The borrower is a business that will use the money raised to expand operations.</p> <p>40 lenders will be pooled for this group loan so the total loan amount will be \$384,000.</p> <p>The borrower meets minimum credit risk standards set by the online loan company and is expected to make all future loan payments.</p> <p>Page 2 describes what to do next.</p>
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<div style="text-align: center; background-color: #808080; color: white; padding: 5px; margin-bottom: 10px;"><b>Individual Rate Submission</b></div> <p>Now that you have identified a group loan, your next step is to submit an interest rate you would like to receive.</p> <p>Each lender in a group loan submits an interest rate associated with his or her individual portion. These submissions are used by the loan company to calculate a single interest rate for the group loan.</p> <div style="text-align: center; background-color: #808080; color: white; padding: 5px; margin-top: 10px;"><b>Group Loan Interest Rate Calculation</b></div> <p>This is how the loan company computes the rate:</p> <ul style="list-style-type: none"> <li>The individual interest rate submissions are listed from lowest to highest</li> <li>The lowest 25% and the highest 25% of submissions are excluded.</li> <li>The group loan interest rate is the mean of the remaining middle 50% of submissions.</li> </ul> <p>To the right is an illustration showing the calculation of an interest rate for a \$360,000 group loan with 18 individual portions of \$20,000. Each lender submitted an interest rate and the loan company calculated the group loan rate. Note that the individual rate submissions vary.</p>	<table style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 15%;"></th> <th style="width: 15%;"></th> <th style="width: 15%;"></th> <th style="width: 15%;"></th> <th style="width: 15%;"></th> <th style="width: 15%;"></th> </tr> </thead> <tbody> <tr> <td rowspan="18" style="writing-mode: vertical-rl; transform: rotate(180deg); text-align: center; font-weight: bold;">Group Loan \$360,000, 9 years</td> <td>Lender #1</td> <td>\$20,000</td> <td>5.2</td> <td rowspan="3" style="font-size: 2em;">}</td> <td rowspan="3">Lowest 25% excluded from calculation</td> </tr> <tr> <td>Lender #2</td> <td>\$20,000</td> <td>5.7</td> </tr> <tr> <td>Lender #3</td> <td>\$20,000</td> <td>5.7</td> </tr> <tr> <td>Lender #4</td> <td>\$20,000</td> <td>6.1</td> <td rowspan="14" style="font-size: 4em;">}</td> <td rowspan="14" style="text-align: center; vertical-align: middle;"> <b>Group Loan Interest Rate</b>                      = Mean of remaining submissions                      = 7.22%                 </td> </tr> <tr> <td>Lender #5</td> <td>\$20,000</td> <td>6.5</td> </tr> <tr> <td>Lender #6</td> <td>\$20,000</td> <td>6.8</td> </tr> <tr> <td>Lender #7</td> <td>\$20,000</td> <td>6.8</td> </tr> <tr> <td>Lender #8</td> <td>\$20,000</td> <td>7.0</td> </tr> <tr> <td>Lender #9</td> <td>\$20,000</td> <td>7.4</td> </tr> <tr> <td>Lender #10</td> <td>\$20,000</td> <td>7.4</td> </tr> <tr> <td>Lender #11</td> <td>\$20,000</td> <td>7.5</td> </tr> <tr> <td>Lender #12</td> <td>\$20,000</td> <td>7.5</td> </tr> <tr> <td>Lender #13</td> <td>\$20,000</td> <td>7.6</td> </tr> <tr> <td>Lender #14</td> <td>\$20,000</td> <td>7.7</td> </tr> <tr> <td>Lender #15</td> <td>\$20,000</td> <td>8.0</td> <td rowspan="4" style="font-size: 2em;">}</td> <td rowspan="4">Highest 25% excluded from calculation</td> </tr> <tr> <td>Lender #16</td> <td>\$20,000</td> <td>8.1</td> </tr> <tr> <td>Lender #17</td> <td>\$20,000</td> <td>8.2</td> </tr> <tr> <td>Lender #18</td> <td>\$20,000</td> <td>8.2</td> </tr> </tbody> </table>							Group Loan \$360,000, 9 years	Lender #1	\$20,000	5.2	}	Lowest 25% excluded from calculation	Lender #2	\$20,000	5.7	Lender #3	\$20,000	5.7	Lender #4	\$20,000	6.1	}	<b>Group Loan Interest Rate</b> = Mean of remaining submissions = 7.22%	Lender #5	\$20,000	6.5	Lender #6	\$20,000	6.8	Lender #7	\$20,000	6.8	Lender #8	\$20,000	7.0	Lender #9	\$20,000	7.4	Lender #10	\$20,000	7.4	Lender #11	\$20,000	7.5	Lender #12	\$20,000	7.5	Lender #13	\$20,000	7.6	Lender #14	\$20,000	7.7	Lender #15	\$20,000	8.0	}	Highest 25% excluded from calculation	Lender #16	\$20,000	8.1	Lender #17	\$20,000	8.2	Lender #18	\$20,000	8.2
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## Your Task

Your task is to determine the interest rate you are going to submit. To help in this task you will be given three pieces of information from the online loan company.

- 1. RANGE:**  
The loan company gives you a minimum and maximum rate for the group loan interest rate. If the group loan interest rate (as calculated from submissions) is above the maximum, the business may not accept the group loan.
- 2. SIMILAR:**  
The loan company will give you information about actual loans granted in the last week that are SIMILAR to your loan. SIMILAR means the actual loans were **EITHER** within \$2,000 of your loan amount (a loan between \$7,600 and \$11,600) **OR** within one year of your loan maturity (6 to 8 years) **BUT NOT BOTH**.
- 3. MATCH:**  
If available, the loan company will give you information about an actual loan granted in the last week that is a MATCH to your loan. A MATCH means the actual loan is **BOTH** within \$2000 of the individual portion of your loan amount **AND** within one year of your loan maturity. If the group loan interest rate (as calculated from submissions) is too far above the MATCH loan's interest rate, the business may not accept the group loan.

## After completing the task...

After everyone in your group has completed the task and turned in their materials, the individual names of everyone in your group (including you) will be shown on the screen. Beside each name will be the interest rate submitted by that individual.

Your payment for participating in this study will then be calculated as described on the next page.

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## Your Task

Your task is to determine the interest rate you are going to submit. To help in this task you will be given three pieces of information from the online loan company.

- 1. RANGE:**  
The loan company gives you a minimum and maximum rate for the group loan interest rate. If the group loan interest rate (as calculated from submissions) is above the maximum, the business may not accept the group loan.
- 2. SIMILAR:**  
The loan company will give you information about actual loans granted in the last week that are SIMILAR to your loan. SIMILAR means the actual loans were **EITHER** within \$2,000 of your loan amount (a loan between \$7,600 and \$11,600) **OR** within one year of your loan maturity (6 to 8 years) **BUT NOT BOTH**.
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## After completing the task...

After everyone in your group has completed the task and turned in their materials, the experimenter will record the individual names of everyone in your group (including you) on a private piece of paper shown only to the experimenter. Beside each name will be the interest rate that person submitted. You may see the experimenter's private piece of paper next quarter during Baesler office hours T 1-2.

Your payment for participating in this study will then be calculated as described on the next page.

Page 3 of 6

### Your Payment

For participating in this study, you will receive a cash payment. The amount of the payment depends on the group loan interest rate computed by the loan company.

The group loan interest rate is translated into dollars then rounded to the nearest dollar. For example, if the group loan interest rate is 7.22%, this percentage is translated into dollars as \$7.22 then rounded to the nearest dollar, so each participant will receive \$7.

### Do you understand your payment?

1. If the calculated group loan interest rate for your group is 6.13%, how much is the dollar payment to each member of your group?
  - a. \$6
  - b. \$7

## You are now ready to begin the task

On the next page, you will be given RANGE, SIMILAR, and MATCH information as previously described.

Once you have evaluated the information and determined your individual interest rate submission, enter that interest rate in the box.

Page 4 of 6

Group Loan Amount

Individual Portion of Group Loan

Group Loan Maturity

Individual Portion of Group Loan Maturity

#### RANGE:

The lending site suggests that the interest rate on this group loan be within the following range based on the credit profile of the borrower and market conditions:

Minimum rate: 4.1%      Maximum rate: 8.5%

#### SIMILAR:

Actual loans granted in the last week with maturity within one year **OR** an amount within \$2,000 of the individual portion of this group loan

Customer #	Date	Amount	Maturity	Interest rate
012734	5-01-15	3,100.00	6 years	5.3%
012622	5-04-15	10,900.00	3 years	4.6%
013812	5-04-15	7,600.00	14 years	7.1%
011978	5-05-15	25,100.00	8 years	8.2%
015965	5-05-15	11,300.00	11 years	7.9%
011913	5-05-15	3,800.00	8 years	4.3%
015843	5-05-15	15,400.00	6 years	7.3%
011878	5-07-15	11,600.00	2 years	5.7%

#### MATCH:

##### AVAILABLE

Actual loan granted in the last week with maturity within one year **AND** an amount within \$2,000 of the individual portion of this group loan

Customer #	Date	Amount	Maturity	Interest rate
<b>011983</b>	<b>5-01-15</b>	<b>9,400.00</b>	<b>7 years</b>	<b>6.3%</b>

In the following box, please enter your individual interest rate submission for this **\$9,600 loan for 7 years**  
This rate will be used to calculate the group loan interest rate

Page 5 of 6

Group Loan Amount	\$ 384,000	Individual Portion of Group Loan	\$ 9,600
Group Loan Maturity	7 years	Individual Portion of Group Loan Maturity	7 years

**RANGE:** The lending site suggests that the interest rate on this group loan be within the following range based on the credit profile of the borrower and market conditions:

Minimum rate:	4.1%	Maximum rate:	8.5%
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**SIMILAR:** Actual loans granted in the last week with maturity within one year **OR** an amount within \$2,000 of the individual portion of this group loan

Customer #	Date	Amount	Maturity	Interest rate
012734	5-01-15	3,100.00	6 years	5.3%
012622	5-04-15	10,900.00	3 years	4.6%
013812	5-04-15	7,600.00	14 years	7.1%
011978	5-05-15	25,100.00	8 years	8.2%
015965	5-05-15	11,300.00	11 years	7.9%
011913	5-05-15	3,800.00	8 years	4.3%
015843	5-05-15	15,400.00	6 years	7.3%
011878	5-07-15	11,600.00	2 years	5.7%

**MATCH:** **NOT AVAILABLE** Actual loan granted in the last week maturity within one year **AND** an amount within \$2,000 of the individual portion of this group loan

Customer #	Date	Amount	Maturity	Interest rate
<b>No matching loan</b>				

In the following box, please enter your individual interest rate submission for this **\$9,600 loan for 7 years**  
This rate will be used to calculate the group loan interest rate

Page 5 of 6

<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px; text-align: center;">Some questions about the task...</div> <ol style="list-style-type: none"> <li>1. While determining your individual interest rate submission, what was the highest interest rate you considered justifiable? <div style="border: 1px solid black; width: 100px; height: 25px; margin-top: 5px;"></div></li> <li>2. What interest rate do you predict the average person in your quiz section will submit? <div style="border: 1px solid black; width: 100px; height: 25px; margin-top: 5px;"></div></li> <li>3. In the MATCH section near the bottom of page 5, was an actual loan available in your materials? <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <span>AVAILABLE</span> <span>NOT AVAILABLE</span> </div></li> <li>4. Which of the following two phrases did you read in your introductory materials? Circle a or b       <ol style="list-style-type: none"> <li>a. ...the individual names of everyone in your group (including you) will then be shown on the screen. Beside each name will be the interest rate that person submitted.</li> <li>b. ...the experimenter will record the individual names of everyone in your group (including you) on a private piece of paper shown only to the experimenter. Beside each name will be the interest rate that person submitted. You may see the experimenter's private piece of paper next quarter during Baesler office hours T 1-2.</li> </ol> </li> </ol>	<div style="border: 1px solid black; padding: 5px; margin-bottom: 10px; text-align: center;">Tell us about yourself...</div> <ol style="list-style-type: none"> <li>1. How old are you? <div style="border: 1px solid black; width: 60px; height: 25px; margin-left: 10px;"></div></li> <li>2. What is your gender? <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <span>MALE</span> <span>FEMALE</span> </div></li> <li>3. Have you ever saved money in an interest-bearing account such as a savings account? <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <span>YES</span> <span>NO</span> </div></li> <li>4. Which would result in more interest received on a savings account?       <ol style="list-style-type: none"> <li>a. A savings account paying 2% interest</li> <li>b. A savings account paying 3% interest</li> </ol> </li> <li>5. Have you ever borrowed money such as taking out a student loan? <div style="display: flex; justify-content: space-around; margin-top: 5px;"> <span>YES</span> <span>NO</span> </div></li> <li>6. Which would result in higher interest payments on a student loan?       <ol style="list-style-type: none"> <li>a. A student loan with 5% interest</li> <li>b. A student loan with 7% interest</li> </ol> </li> </ol> <div style="border: 1px solid black; padding: 5px; text-align: center; margin-top: 10px;">Thank You for Participating</div> <p style="text-align: right; font-size: x-small;">Page 6 of 6</p>
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## **Appendix B: Institutional Detail of Libor**

This appendix provides additional Libor institutional detail under the following headings:

- History of Libor development—a response to need
- How to calculate the Libor rate
- How liquidity of the interbank lending market affects Libor
- How one bank can hypothetically manipulate the Libor rate
- Bank incentives with respect to Libor: Profit and public signaling
- The Libor scandal: evidence of manipulation
- Empirical evidence of Libor rate manipulation
- Judicial, regulatory and legislative response to alleged manipulation
  - Penalties levied against banks and bank employees
  - Suggested Libor alternatives and reforms
- Bibliography for Appendix B

### **History of Libor development—a response to need**

In the late 1970s and early 1980s derivative financial instruments were becoming more and more common. Debt market participants recognized the potential value of a standardized interest rate index that could be referenced by different financial instruments. If both a variable rate loan and an interest rate swap referenced the same index rate, future interest rate risk could be hedged. Consequently, companies could hedge financial risk more effectively and at lower cost, and banks could make profits by facilitating these markets. In 1984, the British Bankers Association (BBA) and other

organizations within the banking industry introduced an interest rate index called the BBAIRS<sup>1</sup>, a predecessor to BBA Libor<sup>2</sup>.

BBA Libor was official introduced January 1, 1986. Initially, a Libor rate was calculated for only a few currencies and maturities, but by 2013, Libor was computed for 10 different currencies and for 15 different short-term maturities ranging from overnight to one year. With a change of administrator, “BBA Libor” became “ICE Libor” (Intercontinental Exchange Libor). The Libor current administrator is IBA (ICE Benchmark Administration). Due to reforms and other forces, ICE Libor is currently computed for 5 different currencies and 7 short-term maturities ranging from overnight to one year. Both BBA Libor and ICE Libor are simply referred to as Libor. Libor is still the predominant interest rate reference for interest rate swaps, interest rate futures, and other futures contracts. Many banks and other financial institutions tie the rates they charge on fixed rates loans to the current Libor rate. The eurodollar futures contracts, traded on the Chicago Mercantile Exchange, use 3-month US dollar Libor as the reference rate, and in 2011 traded over \$564 trillion US dollars.<sup>3</sup>

Collectively, Libor rates are the reference rates for an estimated range of \$300 to \$800 trillion worth of financial instruments<sup>4</sup>. An exact number is not known because contracts can reference Libor without any notification or payment to Libor regulators. Bloomberg Businessweek<sup>5</sup> illustrates the economic significance of Libor: “If the Libor rate was understated by 0.1 percentage point for only a few months, payments on more than \$300 trillion in mortgages, corporate bonds, and derivatives tied to the benchmark

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<sup>1</sup> BBAIRS stands for British Bankers Association Interest Rate Swap.

<sup>2</sup> BBA Libor stands for British Bankers Association London Interbank Offer Rate

<sup>3</sup> Financial Services Authority, Final Notice, 27 June 2012, paragraph 40.

<sup>4</sup> The Banker, August 1, 2012, Economist, July 7, 2012

<sup>5</sup> Bloomberg Businessweek September 3, 2012

might have fallen short by about \$75 billion or so. If the problem lasted a few years, the shortfall could be close to \$1 trillion.” Mollencamp (2008) points out, “(A)n extra 0.3 percentage points would add about \$100 to the monthly payment on a \$500,000 adjustable-rate mortgage, or \$300,000 in annual interest costs for a company with \$100 million in floating-rate debt.” *The Wall Street Journal* on August 27, 2012 referred to Libor as “the most important number in the world.” Even after all the controversies, the Libor rates continue to be widely used. ICE Benchmark Administration (IBA, the current administrator of Libor) reports, “In total, hundreds of trillions of dollars’ worth of interest rate exposure is tied to ICE Libor.” Investopedia adds, “Though Libor has endured controversies, its daily borrowing rates continue to be some of the most important numbers in finance.”<sup>6</sup>

As noted above, the value of an interest rate reference derives largely from its role in hedging interest rate risk. This is illustrated with the following example. Company ABC has a 10-year \$100,000 variable-rate loan with semiannual interest payments of 6-month LIBOR plus 30 basis points (Libor plus 0.3% interest). If ABC was concerned by its exposed to variable interest rates a decade into the future, ABC enter into a 10-year interest rate swap in which ABC pays a bank fixed semi-annual payments in exchange for receiving variable payments over the same time period of the loan, computing using the same interest rate index as specified in the variable rate loan.

To illustrate how this works, assume that a bank offers ABC a swap in which ABC pays fixed 4% interest payments semi-annually ( $\$100,000 \times 6/12 \times 0.04 = \$2,000$ ) and ABC receives variable payments of  $\$100,000 \times 6/12 \times (\text{LIBOR} + 30 \text{ bps})$  from this

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<sup>6</sup> <http://www.investopedia.com/articles/active-trading/012214/introduction-trading-eurodollar-futures.asp> retrieved 7 November 2016.

bank. The 6-month LIBOR rate is determined on the first day of the semiannual period. If this rate was 2.84% in the future (which is below the fixed rate on the swap), then ABC is worse off with the hedge. ABC would pay \$2,000 to the swap bank. ABC would receive \$1,570 ( $\$100,000 \times 6/12 \times (2.84\% + 0.3\%)$ ) from the swap bank. ABC would also pay its obligation to the loan bank, which would also be \$1,570 in this semi-annual period. In this case ABC would have been better off not entering into the swap agreement. However, if the future 6-month Libor rate is 5.72% (which is above the fixed rate on the swap), then ABC is better off with the hedge. ABC would pay \$2,000 to the swap bank. ABC would receive \$3,010 ( $\$100,000 \times 6/12 \times (5.72\% + 0.3\%)$ ) from the swap bank. ABC would also make the \$3,010 interest payment to the loan bank. The swap hedges interest rate risk because ABC will pay a flat \$2,000 for each semi-annual interest payment regardless of the actual value of future interest rates that determine payments under the variable rate loan. In this case, the hedge is based on the identical reference interest rate on both the variable rate loan and the swap. If the reference rates differed across the swap and the loan (for example, if one referenced USD 6-month Libor and the other referenced a US Treasuries benchmark), ABC would retain some exposure to interest rate risk to the extent these different benchmarks varied differently through time.

### **How to calculate the Libor rate<sup>7</sup>**

The process of establishing Libor begins with BBA's selection of a panel of banks to represent each currency based on three criteria: (1) scale of market activity, (2) credit

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<sup>7</sup> Francesco Guerrera, the *Wall Street Journal's* Money and Investing editor, called the method of calculating Libor the "gymnastics-scoring-meets-clairvoyance method of calculation."

rating, and (3) perceived expertise in the currency concerned. The number of banks on the panel varies for each currency. Currently 17 banks are on the panel to determine the US dollar Libor rates. The following table shows the panel banks for the five currencies.<sup>8</sup>

	<b>USD</b> US Dollar	<b>GBP</b> Pound Sterling	<b>EUR</b> Euro	<b>CHF</b> Swiss Franc	<b>JPY</b> Japanese Yen
Lloyds TSB Bank plc	x	x	x	x	x
Bank of Tokyo-Mitsubishi UFJ Ltd	x	x	x	x	x
Barclays Bank plc	x	x	x	x	x
Mizuho Bank, Ltd.		x	x		x
Citibank N.A. (London Branch)	x	x	x	x	
Cooperatieve Rabobank U.A.	x	x	x		
Credit Suisse AG (London Branch)	x		x	x	
Royal Bank of Canada	x	x	x		
HSBC Bank plc	x	x	x	x	x
Santander UK Plc		x	x		
Bank of America N.A. (London Branch)	x				
BNP Paribas SA, London Branch		x			
Crédit Agricole Corporate & Investment Bank	x	x			x
Deutsche Bank AG (London Branch)	x	x	x	x	x
JPMorgan Chase Bank, N.A. London Branch	x	x	x	x	x
Société Générale (London Branch)	x	x	x	x	x
Sumitomo Mitsui Banking Corp. Europe Ltd	x				x
The Norinchukin Bank	x				x
The Royal Bank of Scotland plc	x	x	x	x	x
UBS AG	x	x	x	x	x

Every business day (except specific holidays), each panel member submits an answer to the following question for each currency-maturity combination: “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 11am London time?”<sup>9</sup>

<sup>8</sup> <https://www.theice.com/iba/libor> retrieved 7 November 2016

<sup>9</sup> The question used from 1986 to 1998 was “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?” It was changed to its present form in 1998 because the new definition “enables accountability” for the rates according to the BBA.

Under BBA, Banks neither publicly disclosed their means of computing the Libor submission, nor were they asked to provide support for their submissions. The BBA publication “Welcome to the BBA Libor” tells banks, “The rate which each bank submits must be formed from that bank’s perception of its cost of funds in the interbank market.” The BBA website suggests that banks have private information to establish their submission with the following statement, “[A] bank will know what its credit and liquidity risk profile is from rates at which it has dealt and can construct a curve to predict accurately the correct rate for currencies or maturities in which it has not been active” (BBA website, 2013). The guidelines for computing Libor rates have changed with IBA, the new administrator of Libor, to be consistent with recommendations from the Wheatley Review of Libor that suggests banks base submitted rates on actual inter-bank transactions.<sup>10</sup> The most current guidance is an August 1, 2016 document from the IBA entitled “Libor Code of Conduct: Contributing Banks,” IBA outlines three methodologies for computing a Libor submission:

- Level 1: The Volume Weighted Average Price of eligible transactions;
- Level 2: Submissions derived from transactions (including adjusted historical transactions, interpolation and parallel shift); and
- Level 3: Expert judgment, appropriately framed.

Under BBA, banks did not need to disclose their method of calculating any Libor submission. When the Commodity Futures Trading Board (CFTB) and the Financial Services Authority (FSB) investigated Barclays, it learned Barclay’s method of calculating its Libor submissions. Because these investigations made findings public, we

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<sup>10</sup> The Wheatley Review of LIBOR: final report page 28

have the unique opportunity to learn about Barclay's method of establishing its individual Libor submissions under BBA guidance. Because Barclays is on the Libor panel for all 10 currencies and also participates in the Euribor rate (an index rate similar to Libor but involving a much larger panel of only European banks), the submitters at Barclays are submitting 165 rates daily.<sup>11</sup> In testimony gathered by the Financial Services Authority (FSA) we learn that Barclay's submissions are prepared by liquidity managers:

Barclays delegates responsibility for determining and making its Libor and Euribor submissions to a number of individuals ('Submitters') on the Money Markets Desk within Barclays. These individuals are responsible for managing Barclays' liquidity position and are therefore best placed within Barclays to assess the rates at which cash may be available to Barclays in the money markets. Barclays' Submitters weigh up a number of factors relating to the interbank market each day in order to determine Barclays' Libor and Euribor submissions.<sup>12</sup>

Based on other evidence gathered by the FSA, both middle management and upper management at Barclays have authority over the Submitters and have influenced the ultimate Libor submission in the past.

Libor is not the only index that incorporates subjective, private information. For example, consumer price indices are regularly reviewed to determine the set of goods upon which the price index will be based. One of the most used index, the S&P 500, is based on the weighted value of 500 large companies. A team of analysts and economists at Standard & Poor's consider various factors such as market size, liquidity, and industry grouping when determining which companies to include in the index. These filters are subject to human discretion and professional judgment. Rauterberg & Vernstein (2013) speaking of indices state, "Libor is not unique in incorporating subjective intervention

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<sup>11</sup> As of July 1, 2013, Libor is collected for 5 currencies and 7 maturities so number of current submissions for Barclays is now considerably less than 165.

<sup>12</sup> Financial Services Authority, Final Notice, 27 June 2012, paragraph 35.

and judgment into its processes.”<sup>13</sup> Because of the subjectivity in the Libor index, the Libor administrator (the IBA currently and the BBA before) may question a Libor submission if it suspects fraud and expel the bank from the panel, but investigations are rare and no bank has ever been expelled from a panel for suspected fraud (Rauterberg and Verstein 2013).

Thompson Reuters (on behalf of the BBA and the IBA) gathers the bank submissions, checks for gross errors such as a misplaced decimal point, and computes the set of Libor rates to be published. The highest and lowest 25% of submissions are eliminated and the resulting published Libor rate is the mean of the remaining submissions, the interquartile mean. When determining how many observations to eliminate if, for example, 25% of the panel size is 4.5 banks, the number eliminated is rounded down so that fewer submissions are eliminated. To illustrate, assume the panel consists of 18 banks. One-fourth of 18 is 4.5 banks, which is rounded down to 4, and the highest 4 and lowest 4 bank submissions are eliminated.

This calculation has two advantages. First, the interquartile mean results in a smooth rate with lower volatility, which is better for markets according to Garcia (2012). Garcia compared the interquartile mean with a mean computed from a random selection of Libor submissions and found the interquartile mean resulted in less day-to-day volatility. Second, the published Libor rate is difficult to manipulate or be swayed by a single bank. If a single bank submission is extreme (due to purposeful manipulation or due to current credit problems at the individual bank), the submission is likely to fall in one of the tails eliminated during calculation.

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<sup>13</sup> Rauterberg and Verstein (2013) contend this subjectivity in indices is necessary because “human judgment is required to set the index’s goals and to evaluate methodologies that suit it.”

## **How liquidity of the interbank lending market affects Libor**

When banks are establishing a Libor submission, they are using current market information as well as their private bank information. Some banks are forming their submissions in a thinly traded inter-bank lending market, meaning that banks are not lending to each other. According to a 2007 survey by the European Central Bank, in the interbank loan market 70% of transactions were for overnight loans and 90% had a maturity length of one month or less. Bonner & Eijffinger (2012) confirm that in 2012 the unsecured interbank trading market continues to be largely composed of loans with maturities shorter than 30 days. Mervyn King, Governor of the Bank of England spoke to the U.K. Parliament in 2008 and described Libor as hypothetical in this context, “It is in many ways the rate at which banks do not lend to each other, ... it is not a rate at which anyone is actually borrowing.”

If the inter-bank market is illiquid or thinly traded, the banks have few, if any, actual matching inter-bank transactions to reference when computing their submission and regulators have few, if any, actual matching inter-bank loans to reference if questioning a bank’s individual Libor submission. Floyd Norris from the New York Times April 4, 2013 concluded when speaking of Libor, “So the rates are fictitious—or at least not based on any information that could be verified.” Andy Verity, BBC economics correspondent explained what illiquidity in the inter-bank lending market does to Libor submissions as follows (Verity 2016):

“Libor was asking for a submitter’s opinion—at what price could you borrow funds were you to do so? And the trouble was that often—and especially during the credit crunch—they hadn’t borrowed anything. Many of the banks on the panels did not even deal in the currencies about which they made submissions.

So how could they have a clue what to submit? Imagine you are an estate agent asked to value a house in an area where you have never done business before, and where no houses had changed hands for months. How do you know the price? It is hard to discern between an honest opinion and a dishonest one when it is necessarily a guess.”

Each bank on a currency’s panel was originally selected to be on that currency’s panel due to activity in that currency at some point in time; however, that activity may have subsequently diminished. The selection of panel bank members is fairly “sticky” rather than “fluid,” meaning that the panel of banks does not change based on changes in day-to-day activity in a currency.

### **How one bank can hypothetically manipulate the Libor rate**

The published Libor rate is the interquartile mean of the individual bank submissions so a bank cannot necessarily directly manipulate the Libor rate. If Bank A wanted a lower Libor rate, it may lower its Libor submission; however, if this rate is in the lowest quartile submitted, it is excluded from the calculation used to arrive at the published Libor rate. Bank A would not be successful in directly manipulating the published Libor rate via its individual submission; however, indirect manipulation is still possible. From the example above, if Bank A wanted a low published Libor rate and submitted an artificially low rate that was excluded, Bank A still manipulated the published Libor if Bank A’s unbiased submission should have been in the interquartile mean but another bank’s submission was included instead. This indirect manipulation of Libor is the basis for many of the current lawsuits against banks. A July 16, 2012 Bloomberg report said, “By making a submission too high to be included in the average, a single lender can push a previously excluded rate back into the pack to send the average

higher. By submitting a rate that falls too low to be included, the average can be nudged down as a previously excluded rate re-enters the pack.”<sup>14</sup>

Manipulation of published Libor is also possible if panel banks collude. For the USD Libor panel of 18 banks with the lowest and highest 4 eliminated, if 5 banks collude, they can directly manipulate the resulting rate. Abrantes-Metz<sup>15</sup>, Kraten, Metz, and Seow (2009) find some evidence of identical movements of submissions that is consistent with collusion activity; however, an alternative explanation of such empirical patterns is that banks are looking at similar loan offers in the marketplace or using similar predictive models when establishing their Libor submission. Snider and Youle (2010) find, “Libor quotes are much more clustered around the day’s fourth lowest quote than CDS (credit default swap) spreads are around the fourth lowest CDS spread.” This clustering may be a result of bank incentives interacting with the rate-setting mechanism and can be consistent with collusion activity or could be coincidental clustering.

### **Bank incentives with respect to Libor: Profit & Public signaling**

#### *Profit incentive with respect to the published Libor rate*

Panel bank members hold many financial instruments that are tied to Libor. The value of these financial instruments are therefore affected by Libor, and so the holding bank experiences profit or loss as a direct consequence of changes in Libor rates.

Additionally the amount of interest the bank will receive or pay is directly affected by the

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<sup>14</sup> “Fixing Libor: some preliminary findings” House of Commons Treasury Committee Second Report of Session 2012-13 Volume 1, paragraph 29.

<sup>15</sup> Professor Abrantes-Metz discloses that she has been retained by various plaintiffs that have filed or are considering filing lawsuits against the banks on the Libor panel.

current Libor rate. I illustrate the profit incentive with three different types of financial instruments: (i) a mortgage receivable, (ii) an interest rate swap, and (iii) a loan payable.

- (i) *Mortgage receivable:* Assume a bank holds a variable-rate mortgage receivable with interest as 3-month USD Libor on the first day of April or October plus 200 basis points. On the first day of April, the bank would profit from a higher Libor rate because that would determine the amount of interest received on this variable-rate mortgage.
- (ii) *Interest rate swap:* Assume a bank holds an interest rate swap in which it agrees to pay a variable amount (3-month USD Libor plus 300 basis points for example) and receive a fixed amount, the bank profits from a lower Libor rate on the day that the payment is due.
- (iii) *Loan payable:* Assume a bank holds a variable rate loan payable with interest at 3-month USD Libor plus 250 basis points fixed on January 1 of the year, it would profit from a lower Libor rate on that day because the bank would pay less interest.

Note that in all of the above examples, a bank can profit or lose based on the published Libor rate. A panel bank makes a submission that may or may not be included in the computation of the Libor rate.

#### *Public signaling incentive with respect to the published Libor submission*

From Libor's inception in 1986 through to June 30, 2013, each bank's individual Libor submission was publicly released at the same time the Libor rate was published. The stated reason for this public release was "transparency and public accountability for

the accuracy of submissions.”<sup>16</sup> Any interested individual can (a) see each bank’s submission, (b) see which submissions were eliminated as being too high or too low, and (c) confirm the calculation of Libor based on the set of submissions. This publication was never intended to be a signal of bank health; however, during the financial crisis, a period in which financial health of banks was highly uncertain, the public looked to any available source of information about the current financial state of banks.

The public turned to Libor submissions as an indirect signal of financial health of the submitting bank, especially as it compared to its peers. A bank’s submission is a weak signal of health but a signal that is readily available, up-to-date, and timely. This public signal creates an incentive for a lower Libor submission in general.<sup>17</sup> This signal is valuable when there is tremendous uncertainty about bank health as was the case during the financial crisis. The collapse of Northern Rock in September 2007 was followed by JP Morgan Chase’s acquisition of Bear Stearns in March 2008. Shortly thereafter Lehman Brothers filed insolvency in September 2008 then in October 2008 RBS and HBOS failed. FSA’s investigation of Barclays found that Barclays management was feeling the pressure of this attention. *Bloomberg’s* article (September 3, 2007) entitled “Barclays takes a money market beating” notes that Barclays’ Libor submissions were the highest of all contributing banks. It further posed the question, “What...is happening at Barclays and its Barclays Capital securities unit that is prompting its peers to charge it premium interest rates in the money market?” Senior management at Barclays expressed

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<sup>16</sup> From BBA Libor website: “This publication was originally intended as a mechanism to promote transparency and public accountability for the accuracy of submissions.”

<http://www.bbatrent.com/news/announcement-of-libor-changes> retrieved 7 November 2016

<sup>17</sup> As of July 1, 2013 the BBA voted to defer public release of individual bank Libor submissions for 3 months. Which is a reform tested in the experiment in the main body of the paper.

concern over this negative publicity.<sup>18</sup> Although Barclays' submissions were often the highest, evidence of communication between Barclays' managers and submitters clearly indicates at least some submissions were lower than they should have been. Tim Bond, a strategist at Barclays Capital said Barclays routinely lowered Libor submission to avoid public perceptions of ill health. Bond said, "We had one week in September where our treasurer, who takes his responsibilities pretty seriously, said: 'right, I've had enough of this, I'm going to quote the right rates.' All we got for our pains was a series of media articles saying that we were having difficulty financing."<sup>19</sup>

The *Economist* (July 7, 2012) states, "Banks that were weak would not have wanted to signal that fact widely in markets by submitting honest estimates of the high price they would have to pay to borrow, if they could borrow at all." This pressure to reduce a Libor submission was felt by every panel bank during the crisis. Christopher Matthews reports in *Time Magazine* July 9, 2012, "[B]ecause of the public nature of the submissions, there is a danger that a bank will understate its Libor submissions in order to boost markets' confidence in the institution."

One of the reasons the public signaling incentive is likely to have a substantial impact on published Libor rates is all banks are feeling the same directional incentive at the same time. The Libor computation process assures that if banks are directionally incentivized in approximately equal numbers in opposite directions, the published Libor rate can remain unbiased; however, whenever an incentive becomes felt by most of the

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<sup>18</sup> Financial Services Authority, Final Notice, 27 June 2012, paragraph 111

<sup>19</sup> Bloomberg, "Libor Banks Misstated Rates, Bond at Barclays Says (Update2)", by Gavin Finch and Elliott Gotkine, May 29, 2008 as quoted in "Fixing Libor: some preliminary findings" House of Commons Treasury Committee Second Report of Session 2012-13 Volume 1, paragraph 45.

banks, bias may flow through to the published Libor rate. During the financial crisis, most panel banks felt the public signaling incentive to reduce their Libor submission.

This public signaling incentive is the reason that Libor was reformed to defer the release of individual Libor submissions for 90 days. With such a deferral, the Libor submission would have lost a great deal of its value as a signal of current, up-to-date health. I assume that the public signaling incentive of the Libor submission is effectively removed by the reform delaying the identification of banks for 90 days in the study presented in the main body of this paper.

### **The Libor scandal: Evidence of manipulation**

Evidence gathered by investigators is primarily private communication between bank employees such as email and text messages. The United States Department of Justice and the Financial Services Authority found evidence that Barclay's was manipulating its Libor submissions in two periods:

- 1) From January 2005 to July 2008, fourteen Barclay's derivative traders made multiple requests to Barclays' Submitters, and the Submitters, in at least some instances, prepared the daily submission in accordance with the requests;
- 2) From September 2007 to May 2009, Barclays was manipulating its individual Libor submissions downward to appear more financially healthy to the public based on email and other communications between managers and Submitters.<sup>20</sup>

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<sup>20</sup> Financial Services Authority, Final Notice, 27 June 2012.

Evidence against other banks was also primarily from private email and text messages between bank employees.

### **Empirical evidence of Libor rate manipulation**

Articles printed in both business newspapers and academic journals have presented contradictory conclusions about the existence of Libor rate manipulation. The *Wall Street Journal* (April 16, 2008) released a controversial article suggesting that some banks might have understated their Libor submissions during the 2008 credit crunch. Others disagreed. The Bank for International Settlements stated in its March 2008 Quarterly Review that available data do not support manipulation. In October 2008, the International Monetary Fund in its Global Financial Stability Review concluded, “[I]t appears that U.S. dollar Libor remains an accurate measure of a typical creditworthy bank’s marginal cost of unsecured U.S. dollar term funding.”

Academic research has also searched for evidence of Libor manipulation by looking for manipulation of either the published Libor rate or the individual bank submissions, half or more of which are used to generate the published Libor rate. Empirical findings have been mixed. Abrantes-Metz et al. (2009) compare published Libor rates with other short-term borrowing rates to find “evidence consistent with the absence of a material manipulation of the average level of the Libor rate.” When looking at individual quotes, they do find some unexpected patterns such as clustering around the 5<sup>th</sup> lowest submission and individual rates from different banks that move in perfect synchronicity for a period of time. They label these patterns “apparent anomalies.” Abrantes-Metz and Villas-Boas (2010) apply Benford’s second digit law to individual

Libor quotes and find significant variation for certain time periods; however, this law is also violated for T-bill and Fed Funds rates. Krehviel and Adkins (2008) find the change in daily published Libor is not approximated by generalized Pareto distribution, which may make testing for anomalies through screening methods difficult. Snider and Youle (2010) test whether individual submissions from Citigroup and the Bank of Tokyo-Mitsubishi are a reflection of each bank's borrowing costs by comparing the Libor submissions to a measure of credit risk, the credit default swap (CDS) spread. Citigroup has a substantially higher CDS spread than Mitsubishi, suggesting the market perceives Citigroup as riskier than Mitsubishi, but the Libor submissions of Citigroup are slightly lower than those of Mitsubishi. Further analysis of CDS spreads leads Snider and Youle to conclude, "[T]he differences in banks' Libor quotes are not primarily due to differences in credit risk, something we would expect of their true borrowing costs." Academic empirical research searching for Libor manipulation has found some anomalies in individual submission but no conclusive evidence of manipulation of the published Libor rate.

### **Judicial, regulatory and legislative response to alleged manipulation**

*Penalties levied against banks and bank employees.* On June 27, 2012, Barclays was fined \$200 million by the Commodity Futures Trading Commission, \$160 million by the United States Department of Justice and £59.5 million by the UK Financial Services Authority. On December 19, 2012, Union Bank of Switzerland (UBS) agreed to pay regulators \$1.5 billion in fines because of attempts by UBS traders to manipulate Libor. In addition to the fines, two UBS individual traders were charged with criminal

conspiracy to manipulate Libor (U.S. Department of Justice, 2012). Rabobank was fined \$1 billion. Royal Bank of Scotland (RBS) was fined \$612 million. Additionally, individual traders at RBS have been arrested. The Council on Foreign relations summarizes punishments as of October 12, 2016. All told, global banks have paid over \$9 billion in fines. Over twenty people have been criminally charged by the UK and the US. In the UK, four have been convicted and six acquitted as October 12, 2016. In the US, four have been convicted and several others plead guilty. Trials are continuing.<sup>21</sup>

Lawyers are filing lawsuits against banks on behalf of their clients claiming losses from manipulated Libor rates. The *Economist* (August 4, 2012) declares the Libor situation the “stuff of dreams” for lawyers. On August 15, 2012 CNBC reports that seven banks (JP Morgan Chase, Barclays, Royal Bank of Scotland, HSBC, UBS, Deutsche Bank, and Citigroup) have been issued subpoenas by clients in the US for their alleged Libor manipulation. Macquarie Research estimates that banks face a potential legal liability of about \$176 billion. Those suing banks include cities, insurers, investors, and lenders who claim losses from allegedly artificially low Libor rates. Even those who lent money at fixed rates are claiming losses because they contend the fixed rate was set in reference to an artificially low Libor rate. On August 8, 2016, Barclays agreed to a \$100 million settlement for some of these lawsuits brought by state regulators.

This potential legal liability has caused some banks to request withdrawal from some of the Libor panels, especially since panel banks receive no remuneration for participating in the Libor process. The Libor administrator (IBA currently BBA in the past) has ended its collection of the Libor in Australian dollars due to “an exodus of

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<sup>21</sup> <http://www.cfr.org/united-kingdom/understanding-libor-scandal/p28729> Council on Foreign Relations website retrieved 7 November 2016

banks from the panel” (Reuters, March 28, 2013)<sup>22</sup>. Libor in the New Zealand dollar has also been discontinued due to bank withdrawals.<sup>23</sup> While no banks have withdrawn from the US dollar Libor panel yet, regulators are concerned that if banks withdraw, the Libor rate would be based on fewer submissions and thus more swayed by one individual bank’s financial condition. The Wheatley Review suggests that IBA be given power to mandate that banks submit Libor rates (Wheatley Report, 2012). The Wheatley Report investigated both the number of inter-bank trades in various currencies and how often the Libor rates in various currencies were used in financial instruments. For example, the number of mortgages referencing Australian dollar 6-month Libor versus the number referencing USD 6-month Libor. They found that some currencies and maturities are less traded and less referenced, so recommended ending Libor calculation for such currencies and maturities. Ending Libor calculations for some currencies and maturities was part of the Libor reforms adopted in 2013. This reform is tested in the experiment described in this study.

***Suggested Libor alternatives and reforms.*** Upon learning of manipulation, some have called for an index based only on actual rates. *Bloomberg Businessweek* (July 30-August 5, 2012) states, “Replacing the benchmark rate won’t be easy, but it is necessary.” Bloomberg is offering to create an index, the Blibor, on a pro bono basis that is based only on actual rates or, as they state, “based on realities more than assumptions” (*Wall Street Journal*, August 3, 2012). Many other substitutes have been suggested such as rates on bank issuances of commercial paper, the Sterling Overnight Interbank Average

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<sup>22</sup> Banks withdrawing include HSBC, Citibank, JP Morgan Chase, and UBS

<sup>23</sup> JP Morgan, Citibank, and HSBC all withdrew from the New Zealand Dollar Libor. The NZ dollar Libor had only 6 banks on its panel before these withdrawals.

Rate (Sonia), the prime rate, or the US Federal Reserve Funds effective rate. However, Richard Fernand, director of industry relations at the Chartered Financial Analyst (CFA) Institute explained one problem with any index based on actual short-term loan transactions, “If you want transaction-based data, you’re going to have to accept that there’ll be very little of it” (*The Banker*, August 1, 2012).

The other problem with a completely new index is the cost of renegotiating the \$300 to \$800 trillion financial instrument contracts currently referencing Libor. New contracts have a choice of whether to use Libor or to use a different reference rate (and the use of Libor has decreased since 2008); however, existing contracts already referencing Libor would be costly to renegotiate. If Libor is misstated, at least one party is advantaged so has little incentive to renegotiate. In 2009, an article in *The Banking Law Journal* recommended adding Libor disruption clauses to new loan facility contracts to facilitate future renegotiations (Scheinberg 2009).

Libor is not likely to be completely replaced, so the BBA and others are concerned that Libor maintains its viability and credibility as a reference rate despite all of the accusations, fines, and lawsuits. Martin Wheatley, the chief executive officer of Financial Services Authority (FSA) appointed a commission to reform Libor. The FSA is the British governmental organization that has taken regulatory authority over Libor from the BBA. As previously noted in prior discussion, his final report (*The Wheatley Review of Libor*, 2012) suggested several reforms including criminal penalties for manipulation of Libor submissions, fewer currencies & maturities, delaying individual bank submissions for 90 days, and directing banks to base their submission on actual

transactions and keeping supporting information for submissions. All of these suggested reforms were adopted in 2013. I examine two of these reforms in this study.

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