

Interest Received by Banks during the Financial Crisis: LIBOR vs Hypothetical SOFR Loans

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Abstract

The credit sensitivity of LIBOR helped lenders during the financial crisis. SOFR is not credit-sensitive and would not have provided that support. The cumulative additional interest from LIBOR during the crisis is estimated to be between 1% to 2% of the notional amount of outstanding loans, depending on the tenor and type of SOFR rate used. The amount of LIBOR business loans owned by banks could have been as high as about 2trn, and the overall additional interest income banks received thanks to LIBOR could have been as high as 30bn dollars. The analysis also shows that a compounded SOFR reduces insurance relative to a term SOFR. Keywords: LIBOR, SOFR, financial crisis. JEL: G21, G28, E43.

1 Introduction

LIBOR increased relative to risk-free rates during the financial crises. Lenders with outstanding loans indexed to LIBOR received additional income relative to what a risk-free rate like SOFR would have paid. This additional income hedged banks' increased funding costs and more generally provided support in a time of large losses. As USD LIBOR, and other IBORs, are replaced by reference rates that mostly do not include a term bank credit premium, it is important to understand the potential consequences of such a transition. This paper presents estimates of how much the credit sensitivity of LIBOR helped lenders during the financial crisis.

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In 2017, the Financial Conduct Authority (FCA) announced that by the end of 2021 market participants should have replaced LIBOR by an alternative reference rate (Bailey, 2017). LIBOR is phased out as a reference rate because the wholesale bank funding markets underlying it are not active enough to support a transactions-based determination of LIBOR. The Secured Overnight Financing Rate (SOFR) has been recommended as the alternative to USD LIBOR by the Alternative Reference Rates Committee (ARRC), the group of market participants convened by U.S. regulators to guide the transition away from LIBOR.

At the end 2021, SOFR has replaced LIBOR for the majority of new financial contracts. The lack of credit sensitivity in SOFR is recognized as a potential disadvantage for bank loans to businesses. Bloomberg's Short-Term Bank Yield Index (BSBY) has been developed as an alternative to SOFR. Like LIBOR, BSBY includes a term credit premium. Regulators have been critical of BSBY believing that it would share LIBOR's lack of robustness. It remains to be seen how widely BSBY or other credit-sensitive rates such as AMERIBOR or AXI will be used. For users who prefer a forward-looking term rate to compounding SOFR daily over one month or three months, term SOFR rates based on CME futures have become available in the second half of 2021. It remains to be seen how widely term SOFR rates will be used.

In this paper, I consider the counterfactual that business loans would have been indexed to a SOFR-based reference rate during the financial crisis. For the period from July 2007 to June 2009, which broadly covers the financial crisis, 1-month and 3-month LIBOR paid significantly more interest than hypothetical SOFR rates based on Overnight Treasury Repo or Overnight Index Swap rates. I estimate that only a small fraction of this difference would have been priced into SOFR loans. Based on that, I find that the cumulative additional interest from LIBOR was about 1% to 2% of the notional amount of outstanding loans, depending on the tenor and type of SOFR rate used. I find that the amount of LIBOR business loans owned by banks could have been as high as about 2trn dollars, and that the overall additional interest income banks received thanks to LIBOR could have been as high as 30bn dollars.

The analysis also shows that a compounded SOFR would have worsened the lack of insurance relative to term SOFR. This is due to the fact that emergency interest rate cuts during crisis periods affect loan payments faster with compounded rates, because payments are based on more recently determined rates than term rates. This identifies an another drawback of using compounded SOFR, in addition to the inconvenience of not knowing the rate until shortly before interest payments are due.

An additional contribution of the paper is to provide an estimate of the risk premium that would have been added to a SOFR loan relative to a LIBOR loan. LIBOR rates have

mostly exceeded overnight repo rates, and a SOFR loan would therefore require a larger spread on top of the benchmark to compensate for the expected difference between the two. In addition to that, the absence of credit sensitivity in SOFR requires a premium relative to LIBOR to compensate for the lack of insurance. Based on basis swap quotes and spot prices, I estimate the implied risk premium leading up to the financial crisis to be about 4.5 bps in annualized terms. This arguably low number suggests that LIBOR offered banks an efficient way to hedge funding risk.

In related work, Jermann (2019), I study the lack of credit sensitivity of a LIBOR replacement within a dynamic general equilibrium model. The empirical results presented here are consistent with the results of that analysis. Namely, replacing LIBOR with a non-credit-sensitive rate for indexing loans could have significant adverse consequences for bank balance sheets during periods of financial distress. Berndt, Duffie and Zhu (2020) construct an index of the cost of unsecured funding for banks that can be used to introduce credit sensitivity alongside a SOFR index. Kuo, Skeie and Vickery (2018) measure the impact of LIBOR manipulation. They find that LIBOR broadly tracks alternative measures of bank funding costs during 2007-09, except for the two-week period after Lehman bankruptcy where LIBOR was below alternative measures by 20-30 basis points. Duffie and Stein (2015) review LIBOR manipulation and challenges for transiting away from LIBOR. Klingler and Syrstad (2021) study how the new benchmark rates in the US, UK and Europe vary with respect to regulatory constraints, reporting dates, and volumes of government debt outstanding.

In the rest of the paper, I start by describing the empirical approach. This is followed by the presentation of the estimated additional interest from LIBOR and the associated additional interest income on outstanding loans. A discussion section concludes.

2 Additional interest from LIBOR

The thought-experience is that there is a given amount of loans outstanding at the beginning of an unexpected crisis that lasts for a given time period. Over this period, the loans receive interest indexed to LIBOR. If the interest would have been determined by SOFR, what would the difference have been?

At the time of a loan commitment, it is typically expected that LIBOR would be somewhat higher than SOFR over the life of the loan. Therefore, a SOFR loan would include a somewhat higher spread on top of the benchmark index. I estimate this adjustment with a combination of derivative prices and averages of spot prices.

SOFR is an overnight rate, LIBOR loans typically use one-month or three-month (term) rates. It is expected that SOFR loans would either use a compounded SOFR rate over

periods of one or three months, or a term SOFR rate. I consider both options.

2.1 Realized spread

The additional interest from LIBOR relative to SOFR is computed in the following way. Consider the spread between one-month or three-month LIBOR and the overnight treasury repo rate compounded over the same period as the LIBOR rates,

$$s_t = L_t - O_t.$$

L_t is the LIBOR rate determined at date t with the interest payment due one or three months later. For SOFR, Reuters' overnight treasury repo rate is used. The overnight rate is compounded over one-month or three-months periods.¹ Assume the crisis starts at date t_0 and ends at t_1 . The cumulative spread over the crisis period is computed as the simple average

$$s_{0,1} = \left(\frac{N}{365} \right) \sum_{t=t_0}^{t_1} s_t,$$

appropriately deannualized with N , the number of days in the crisis period. LIBOR rates are corrected for day count convention by 365/360. For a given average spread, the cumulative spread obviously increases in the length of the crisis N . The crisis period is taken as the 2 years between 7/1/2007 and 6/30/2009, so the cumulative spread equals approximately twice the average (annualized) spread.

2.2 Priced and expected spread

From the realized spread, s_t , I subtract the spread adjustment that would have been priced into a SOFR loan. A market-based measure of this adjustment could be obtained from basis swaps that exchange LIBOR payments for SOFR payments over the maturity of the loan. No quotes are available for basis swaps indexed to overnight repo rates for the pre-crisis period. Quotes are available for a very similar contract, namely Federal Funds/LIBOR basis swaps. These swaps exchange three-month LIBOR for the Effective Federal Funds (EFF) rate averaged over the matching three-month period. The quote is expressed as a fixed

¹In particular, the compounded rate is

$$O_t = \left(\frac{365}{N} \right) \times \left(\prod_{j=t}^{t+N-1} \left(1 + \frac{O_j^d}{360} \right) - 1 \right),$$

where N equals either 30 or 91, and O_j^d is the overnight rate at date j .

add-on to the EFF leg. This corresponds to the adjustment a lender would make to convert a LIBOR loan into a loan indexed to an average of the EFF rate. The adjustment takes into account the forecast of the difference in the coupons as well as the relative riskiness of the two legs. In particular, if market participants expect LIBOR to increase relative to EFF during a crisis period, receiving the LIBOR leg would be more valuable and this would increase the quoted price of the swap. I use five-year basis swap quotes averaged over the three years before the crisis. This corresponds approximately to a broad portfolio of loans outstanding during the crisis.

To improve on this adjustment, I make a correction for the small difference in level between EFF and overnight repo rates. This is computed as the difference in the averages of these two overnight rates over the same three-year period; specifically the three-month average of the EFF and SOFR compounded over three-month. To avoid using prices determined after the start of the crisis, I drop the last three month of data.

Combining the two gives the following spread adjustment to SOFR to make a SOFR loan equivalent to a LIBOR loan:

$$\begin{aligned} \text{SOFR spread adjustment} &= \text{FF/LIBOR Basis Sw} + \text{average(EFF - OR)} \\ 16.8 &= 14.3 + 2.5, \end{aligned}$$

this is in annualized basis points (bps). I can decompose this price adjustment into two components: the expected spread and the risk premium. The expected spread, estimated as the average over the three years prior to the crisis, is 12.2 and this implies a risk premium of 4.5 bps (based on unrounded values).

2.3 Other tenors and term SOFR

For the one-month interest period, no quotes for matching basis swaps are available. As an alternative, I estimate the expected spread based on the pre-crisis average of the realized LIBOR-SOFR spreads for the three years leading up to of the crisis. I add to this expected spread the risk premium estimated for the three-month interest period. With risk premiums typically increasing with maturity, this is likely to somewhat overestimate the adjustment. On the other hand, the risk premium for 3-month LIBOR minus overnight repo would probably be moderately larger than the risk premium for 3-month LIBOR minus EFF.

As an approximation to a hypothetical term SOFR, I consider Overnight Index Swap (OIS) rates with one-month and three-month maturities. As the spread adjustment, I use the average of the spread for the three years before the beginning of the crisis plus the risk premium computed as just explained.

LIBOR/SOFR Spreads		Realized	Priced	Expected	Additional
Compounded SOFR	1-month	1.41		0.23	1.08
	3-month	2.39	0.33	0.24	2.05
Term SOFR	1-month	1.15		0.17	0.90
	3-month	1.82		0.19	1.54

Table 1: Cumulative Percentage Spreads of LIBOR over SOFR for the Crisis, 7/2007 - 6/2009. "Compounded SOFR" is based on Reuters Treasury Overnight Repo rates. "Term SOFR" is based on OIS rates. The Priced Spread is derived from FF/LIBOR basis swap quotes with a 5-year maturity, averaged over the 3 years before the crisis. The Expected Spread is computed as the average of the realized spreads in the 3 years prior to the crisis (dropping the last month or 3 months before the crisis for the compounded rates which were only determined after the starting date of the crisis). The Additional Spread is the Realized Spread minus the Priced Spread for 3-month Compounded SOFR, for the other cases it is the Realized Spread minus the Expected Spread minus the risk premium from the 3-month Compounded SOFR. The reported spreads are computed for a two-year period, which corresponds to the length of the crisis period.

Table 1 reports estimates of the interest based on LIBOR relative to a hypothetical SOFR loan in terms of a percentage over the crisis period. For instance, for a loan with a 100 dollar notional amount, three-month LIBOR paid 2.39 dollars more than a hypothetical compounded SOFR index over the crisis period. A SOFR loan would have included an additional 0.33 dollars in fixed spread payments above the benchmark rate compared to a loan indexed to LIBOR. Taken together, the LIBOR loan paid 2.05 dollars more than the SOFR loan over the crisis. This additional 2.05 dollars can be considered an insurance payout banks received thanks to indexing loans with LIBOR as opposed to compounded SOFR. The cost for this insurance was 0.09 dollars, which is the risk premium in the spread adjustment (4.5 bps per year) over the two-year crisis period.

Figure 1 displays the time series of the realized spreads, s_t . As is widely known, LIBOR rates spiked dramatically relative to risk-free rates during the crisis periods.

As shown in the Table 1, the additional spread with compounded SOFR is larger than with term SOFR. That is, with a compounded SOFR rate, interest payments would have been lower during the crisis than with term SOFR. Figure 2 makes it clear why this was the case: the compounded rate incorporates surprise rate cuts during a crisis faster than a term rate. For instance, from April to September 2008 the overnight repo rate was at a relatively

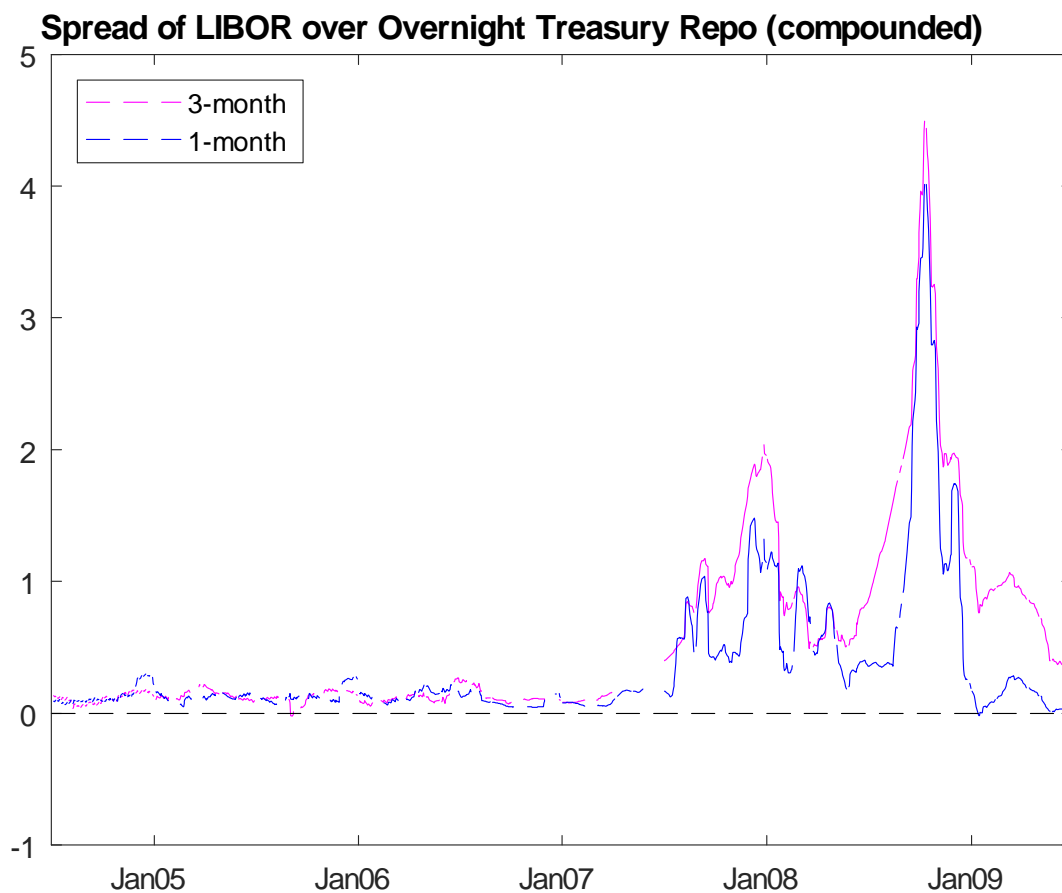


Figure 1: Realized spreads (differences in percent) between LIBOR and Compounded Overnight Treasury Repo rates for 1-month and 3-month terms. The crisis period covers 7.2007 to 6.2009. The average of the pre-crisis spreads is used to compute the expected spreads reported in Table 1.

constant 2%. This 2% was also the federal funds target during that period. Due to the rapidly deteriorating conditions in financial markets, the Federal Reserve lowered its target federal funds rate between October and December from 2% to below 25 basis points. The overnight repo rate closely tracked this decline. Compounded SOFR, which averages over the next 3-month period, was progressively more affected in the weeks before October by the rate cuts. As shown in the figure, compounded SOFR declined smoothly ahead of the abrupt drop in overnight rates starting in October. More generally, as shown in the figure, compounded SOFR was below the daily repo rate for almost the entire crisis period during which the Fed lowered its target from 5.25 to 0.25-0%. Because rate cuts in emergency situations are mostly unanticipated, forward looking term rates such as LIBOR (or term SOFR rate) do not forecast this decline, and interest payments on term rates would only respond three months later. One would expect future crises of this type to result in unanticipated rapid cuts in short-term interest rates, and in such situations, interest payments based on compounded SOFR would decline faster than payments based on term rates. From that perspective, a compounded SOFR exacerbates the loss of insurance for banks from eliminating the credit sensitivity of the reference rate. In other words, the SOFR-based reference rate is not credit-sensitive, and in addition, a compounded overnight index immediately incorporates sharp rate cuts in a crisis.

Figure 3 shows that "Term SOFR" approximated by OIS rates was relatively stable around 2% from April to September 2008, and so was the 3-month LIBOR rate. Neither of these two term rates did anticipate in a significant way the increased financial turmoil requiring rate cuts in October. A "Term SOFR" rate would therefore have declined later than a compounded SOFR rate.

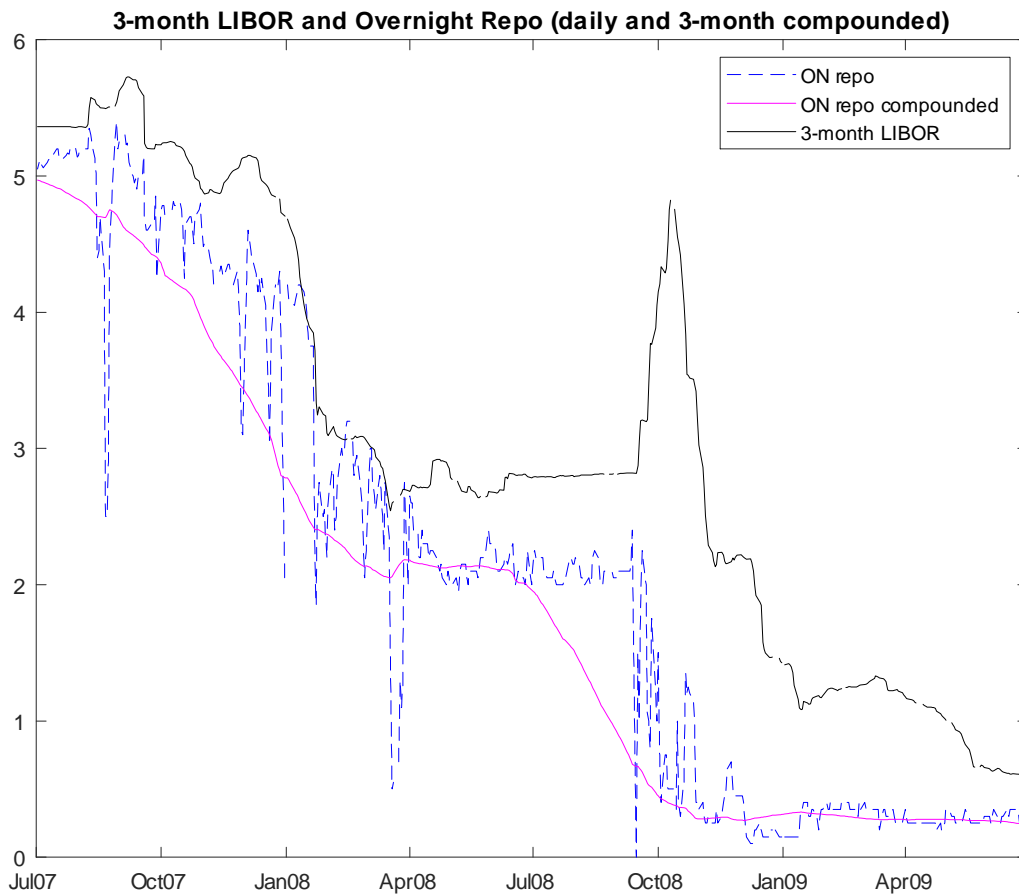


Figure 2: Interest rates during the crisis. The figure illustrates that with a reference rate based on a compounded overnight rate, surprise rate cuts result in faster declines in interest income than with a term reference rate.

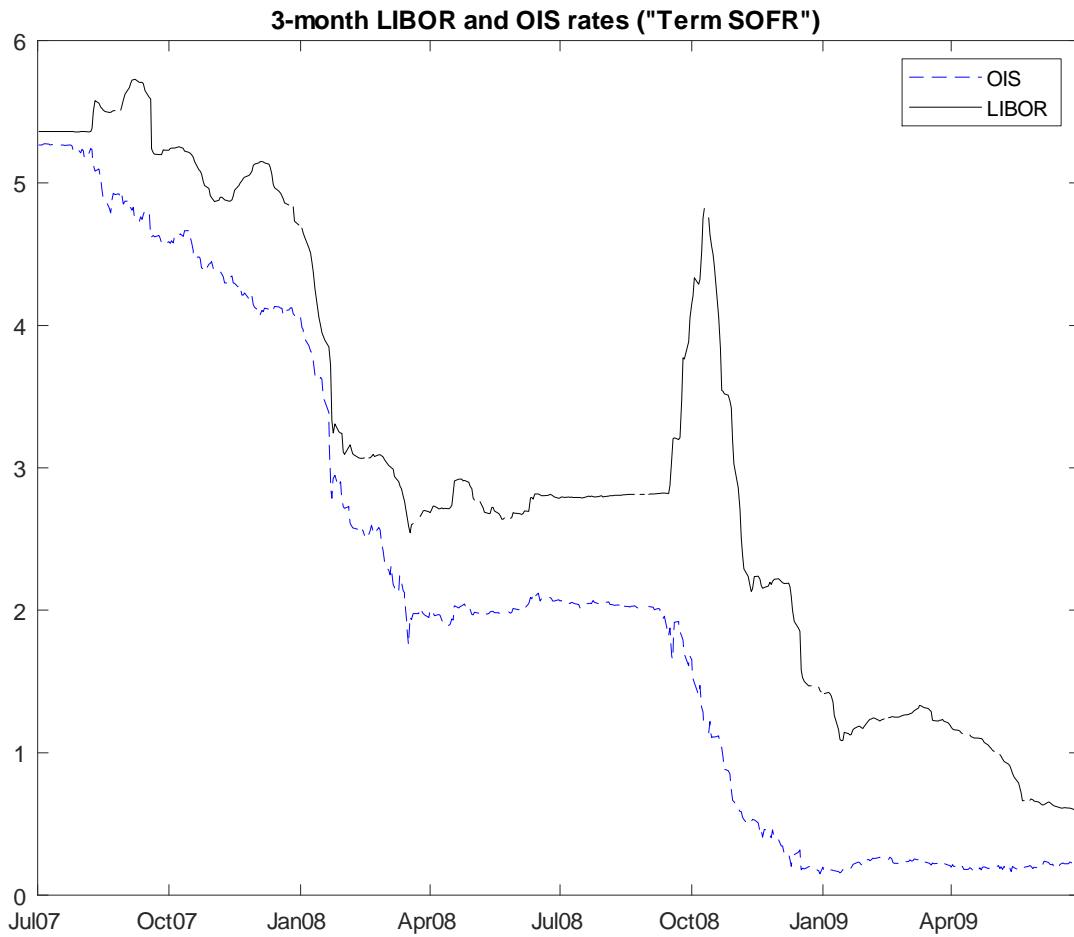


Figure 3: 3-month term rates during the crisis.

3 Outstanding loans and additional interest income

This section estimates the amount of loans owned by banks during the financial crisis. As a back-of-the-envelope calculation, it is assumed that all loans owned by banks during the crisis were based on commitments from before the crisis. This is a coarse approximation of reality, but has the benefit of transparency. One could consider refinements to include dynamic adjustments within the two-year crisis period. Unfortunately, the information content of the available data is limited for such a dynamic approach. For instance, only net flows are observed and it is not clear whether increases in loans outstanding are from prior commitments or new commitments. These issues are considered in the discussion section.

	7/2007-6/2009	LIBOR	Tenor (1M/3M)	Bank held
	trn	%	%	%
Syndicated loans	1.2	97	45/55	55
Corporate business loans (bilat.)	2.1	40	45/55	35
Noncorporate business loans	1.2	40	50/50	85
CRE/Comm. mortgages	3.7	40	10/90	46

Table 2: Outstanding Business Loans. Aggregate amounts are averages over the two-year period based on the Shared National Credit (SNC) Program for syndicated loans and the Fed's Financial Accounts for the other categories; Tables L.103, L.104, L.217-L.221. Estimates of the LIBOR proportions and tenors are based on Financial Stability Board (2014). The bank held share for syndicated loans is estimated based on studies using SNC, namely Aramonte et al (2019), Bord and Santos (2012), and Irani et al (2019). For the other categories, bank held corresponds to the depository institution amounts in the Financial Accounts.

I consider four types of business loans: Syndicated loans, bilateral corporate and non-corporate loans, and commercial mortgages. Amounts outstanding and properties of these types of loans are summarized in Table 1. Amounts are either from the Financial Accounts or, for syndicated loans, the Shared National Credit (SNC) Program. Total amounts outstanding of each of these categories exceed 1trn, with bank held amounts between a low of 35% for corporate business loans and a high of 85% for noncorporate business loans. Essentially all syndicated loans use LIBOR, while for the other types LIBOR shares are about 40%. Overall, three-month rates are somewhat more popular than one-month rates. These numbers are based on the information reported in Financial Stability Board (2014), which is partially based on "input from market participants." There are some six-month terms

for syndicated loans and corporate business loans. I am not directly including that in my calculations. Instead, for the estimates in Table 2, I have slightly increased the three-month share to account for that. The Financial Accounts report loans separately for depository institutions, these values are used for the bank held proportions. For syndicated loans, I combine information from Aramonte et al (2019), Bord and Santos (2012), and Irani et al (2019). For syndicated loans, nonbank investors include, most prominently, collateralized loan obligations (CLOs) and investment management firms. As documented by Liu and Schmidt-Eisenlohr (2019), banks are also significant investors in CLOs; this is not taken into account here.

Bank-owned LIBOR loans	Additional interest		
	7/2007-6/2009	"Comp. SOFR"	"Term SOFR"
	trn	bn	bn
Syndicated loans	0.64	10.3	8.0
Corporate business loans (bilat.)	0.29	4.7	3.7
Noncorporate business loans	0.41	6.4	5.0
CRE/Comm. mortgages	0.68	10.7	8.3
Total	2.02	32.1	25.0

Table 3: Additional interest on bank-owned LIBOR loans. Loan amounts and additional interest is computed based on the values reported in Table 1 and 2. In particular, LIBOR loan amounts owned by banks implied by Table 2 are multiplied by the additional spreads reported in Table 1.

The additional interest income banks received from LIBOR relative to hypothetical SOFR loans is reported in Table 3. The values are computed based on the interest rate spreads reported in Table 1 combined with the loan amounts in Table 2. As shown in Table 3, additional LIBOR interest amounts to approximately 30bn dollars. The additional LIBOR interest with compounded SOFR would be about 20% larger than with term SOFR.

Bank valuations bottomed out on March 6, 2009. On that day, the Fortune 500 top 20 commercial banks from 2007 had a combined market capitalization of 204bn dollars (see Appendix for details). From this perspective, the 30bn in interest income due to the credit sensitivity of LIBOR is not a trivial amount.

4 Discussion

For estimating additional interest income from LIBOR on outstanding loans, it is assumed that all loans owned by banks during the crisis were based on commitments from before the crisis. This section discusses some of the issues with this assumption. Explicitly accounting for maturing and refinanced loans would lower my estimates. On the other hand, SOFR indexing would have made it even more attractive for borrowers to draw down existing commitments, which could have increased my estimates.

Explicitly accounting for loans maturing during the crisis would lower the amount of outstanding loans. If loans are refinanced, then one would expect SOFR loans to be issued at similar conditions as LIBOR loans and the additional interest from LIBOR would be lower.

Borrowers have the ability to refinance loans. Bank loans are typically one-sided commitments from the banks. As loans are refinanced, one would expect SOFR loans to be issued at similar conditions as LIBOR loans and this would lower the additional interest from LIBOR. However, company-specific credit spreads added to the reference rate were higher during the crisis, reducing the incentive to refinance.

To the extent that borrowers draw down existing credit commitments during the crisis, this increases the outstanding amounts based on pre-crisis pricing. My calculations implicitly assume that any new outstanding loans during the crisis are based on pre-crisis commitments. That is unlikely to be entirely correct. However, the SNC Program (2020) data suggests that a significant share of existing commitments were drawn down by non-financial borrowers during the financial crises. As shown in Table 4, the share of outstanding loans in committed loans was 36% for 2007, for 2009, this ratio stood at 54%. In addition, the total committed credit in 2009 is barely higher than in 2008. Both of these facts suggest that banks experienced large drawdowns on their credit commitments during the crisis. Other evidence consistent with this view is presented by Ivashina and Scharfstein (2010) and Berrospide and Meisenzahl (2015).

\$ billions	Committed	Outstanding	Out/Committed
2007	2,275	835	0.36
2008	2,789	1,208	0.43
2009	2,881	1,563	0.54

Table 4: Committed and outstanding syndicated loans. Data is from the Shared National Credit (SNC) Program (2020) and covers credits with minimum loan commitments of \$20 million or more shared by two or more regulated

financial institutions (banks).

The discussion of these three points suggests that my estimate of the additional interest income could be considered as an upper bound. However, another consideration are the potential additional drawdowns on loan commitments during the financial crises if loans would have been priced with SOFR. With LIBOR at times several percentage points above my hypothetical SOFR rates, it would then have been more advantageous to draw on existing loan commitments. As shown in Table 4, commitments for syndicated loans exceeded outstanding loans by at least 1trn throughout the crisis. Therefore, there was a lot of room for additional drawdowns. These additional drawdowns would have not only increased my estimate of the outstanding loans during the crisis but banks would have been forced to seek funding for these commitments at a very challenging time, and this could have further increased their marginal funding costs.

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Appendix

Fortune 500 Commercial Banks Top 20

2007 Rank	Identifier (RIC)	Company Name	Company Market Cap
1	C.N	Citigroup Inc	5,640,499,866
2	BAC.N	Bank of America Corp	20,100,357,146
3	JPM.N	JPMorgan Chase & Co	59,463,504,000
4	WFC.N	Wells Fargo & Co	36,487,261,847
6	USB.N	US Bancorp	15,480,363,209
7	COF.N	Capital One Financial	3,256,083,899
8	TFC.N	Truist Financial Corp	7,679,164,039
10	BK.N	Bank of New York	20,969,029,850
11	PNC.N	PNC Financial Services Group Inc	8,224,221,210
12	STT.N	State St Corp	7,766,742,837
14	FITB.OQ	Fifth Third Bancorp	744,828,729
15	RF.N	Regions Financial Corp	2,042,217,959
16	KEY.N	KeyCorp	2,651,619,856
19	CMA	Comerica	1,941,565,624
20	NTRS.O	Northern Trust Corp	10,587,601,843
18		Marshall & Ilsley	871,496,000
		Total	203,906,557,914

Friday, March 6, 2009

Not separate entities in March 2009

5	<i>Wachovia</i>	<i>Wells Fargo</i>
8	<i>Sun Trust</i>	<i>Truist</i>
9	<i>National City</i>	<i>PNC</i>
13	<i>BB&T</i>	<i>Truist</i>
17	<i>Mellon Financial</i>	<i>Bank of New York</i>