AMERIBOR:

A Better Credit-Sensitive Reference Rate

Marco Macchiavelli, Professor of Finance
University of Massachusetts Amherst, Isenberg School of Management

September 2024

Executive Summary

- Since the planned retirement of LIBOR, market participants have coalesced around the Secured Overnight Financing Rate (SOFR) as the new reference rate;
- As discussed in Section 2, SOFR is a secured overnight rate which does not capture the funding risk of commercial banks and the effective fed funds rate (EFFR) reflects artificial market segmentation and arbitrage trades instead of bank funding costs;
- Banks issuing loans indexed to SOFR can experience negative interest margins in times of stress, when bank funding costs increase but secured rates remain stable or even decline. This indeed happened during the Covid-19 crisis of March 2020;
- We show in Section 4 that AMERIBOR, a credit-sensitive reference rate, is much more correlated with LIBOR than both SOFR and EFFR, and especially so during periods of stress;
- Thus, banks should index their loans to AMERIBOR to better manage interest rate risk and maintain stable and positive net interest margins.

---

*Short Bio: After obtaining his PhD in Economics, Marco worked at the Board of Governors of the Federal Reserve for 7 years, covering matters including monetary policy implementation, quantitative tightening, and short-term funding markets. Later, he joined UMass Amherst as an Assistant Professor of Finance, conducting research that has been published in prestigious academic journals such as the Journal of Financial Economics and the Review of Financial Studies.
Current Affiliation: University of Massachusetts Amherst, Isenberg School of Management. Email: mmacchiavelli@isenberg.umass.edu. Disclaimer: Marco Macchiavelli serves as external consultant for American Financial Exchange (AFX), the provider of AMERIBOR.

1 Introduction

The London Interbank Offered Rate (LIBOR) was used as a benchmark rate for trillions of dollars in floating rate loans and derivatives (Klingler and Syrstad, 2021). Its appeal as a benchmark for loans comes from the fact that LIBOR measures the marginal funding cost of commercial banks. One of banks' primary goals is to keep positive and stable net interest margins. Thus, raising funding at LIBOR while issuing loans at a positive spread to LIBOR is intrinsically valuable. The Savings and Loans crisis of the late 1980s and the more recent banking panic of 2023 highlight the adverse consequences of poor interest rate risk management (Robinson, 2013; Granja et al., 2024).

As came to light in 2012, LIBOR was prone to manipulations and was ultimately retired. In search for a replacement, the Alternative Reference Rate Committee (ARRC) prioritized a rate based on a high volume of transactions which, as a result, would be challenging to manipulate. The rate that best fits this objective is the Secured Overnight Financing Rate (SOFR). Based on daily transaction volumes between $800 billion and $1.8 trillion, SOFR boasts far greater depth than any other short-term bank funding market. Chiefly for this reason, it was chosen by ARRC as the replacement for LIBOR.[1]

However, despite its depth, SOFR does not measure bank funding costs in the same way that LIBOR did and thus should not be used for the same purpose that LIBOR was used for. In this paper, we document that among four alternatives to LIBOR, namely AMERIBOR, SOFR, the effective federal funds rate (EFFR), and the overnight AA financial commercial paper rate (AA Fin), AMERIBOR has superior credit-sensitive properties. Specifically, we run a horse race among the alternative reference rates to establish which of them is more positively correlated with LIBOR.

We find that daily changes in 1-month LIBOR are much more strongly associated with daily changes in AMERIBOR than any of the other three overnight rates. This is true both in normal times and during stress events. Using the Covid-19 crisis of March 2020 as our laboratory, we indeed show that AMERIBOR even increases its positive comovement with LIBOR during the crisis, whereas both EFFR and SOFR move in the opposite direction to LIBOR. As a result, using SOFR as a benchmark for loans and credit lines may expose commercial banks to negative net interest margins in times of stress, when investors pay special attention to bank fundamentals. The finding that SOFR has

[1] See www.newyorkfed.org/arrc/ for more details.

unappealing cyclical properties when it comes to banks' interest rate risk management is not new. Indeed, Cooperman et al. (2023) find that the transition from LIBOR to SOFR may expose banks to additional risks and reduce their incentives to provide credit.

The rest of the paper is organized as follows: Section 2 discusses the distinction between commercial bank and dealer activities and how it affects the choice of an alternative reference rate for LIBOR; it also describes the main alternative rates and highlights why both SOFR and EFFR are not appropriate alternatives to LIBOR; Section 3 summarizes the need for a credit-sensitive rate; Section 4 presents the empirical analysis and the horse race among alternative rates; and finally Section 5 offers some concluding remarks.

2 Background: Commercial Banks vs Dealers

Commercial banks are responsible for originating loans and fund themselves with a mix of liabilities. Some of them, including retail deposits, are stable but hard to raise at short notice and in large quantities. Others, like federal funds, certificates of deposit, and commercial paper (altogether referred to as short-term funding markets), can be raised at short notice to finance immediate liquidity needs, such as those arising from credit line drawdowns. By capturing the cost of tapping these short-term wholesale funding markets, LIBOR is a useful benchmark for bank loans and credit lines. Indeed, a bank could raise funds at around LIBOR and charge a spread above it on its loans, thus earning a positive net interest margin.

Dealers, on the other hand, operate a different business model. They primarily make markets and provide leverage to hedge fund clients (Carlson and Macchiavelli, 2020). To finance both inventories and secured lending (reverse repo and margin loans) to clients, dealers raise cash from repo markets. In a stylized matched-book repo trade, dealers raise cash from the repo market and lend it to clients via reverse repos. The collateral posted in the repo market consists of the same securities obtained as collateral from clients, in a process called rehypothecation. Therefore, dealers' demand for repo financing is linked to the size of their inventories of securities and the demand for leverage by clients. For instance, larger Treasury issuance may lead to higher repo rates, as part of the new issuance is funded by dealers in repo markets. A similar mechanism in corporate bonds

is documented by Macchiavelli and Zhou (2022). Alternatively, hedge funds may require additional leverage to finance long positions in Treasuries as part of a basis trade (Kruttli et al., 2023). To finance an increase in Treasury reverse repos, dealers once again turn to the repo market.

SOFR happens to be the interest rate that captures the cost of overnight dealer financing against Treasury collateral. As such, it primarily follows Treasury collateral dynamics and demand for levered long positions in Treasuries by hedge funds. Occasionally, disturbances from the money market mutual fund industry may be noticeable in SOFR as well, as during the September 17, 2019 SOFR spike shown in Figure 1. Outflows from government funds ahead of corporate tax day and outsized Treasury issuance were indeed contributors to the SOFR spike (Anbil, Anderson and Senyuz, 2020). However, what is not captured in SOFR is the funding risk of commercial banks. Indeed, there was no stress in bank funding markets on September 17, 2019, as also shown by the behavior of AMERIBOR in Figure 1. Overall, bank funding costs ought to be measured using an unsecured bank rate.

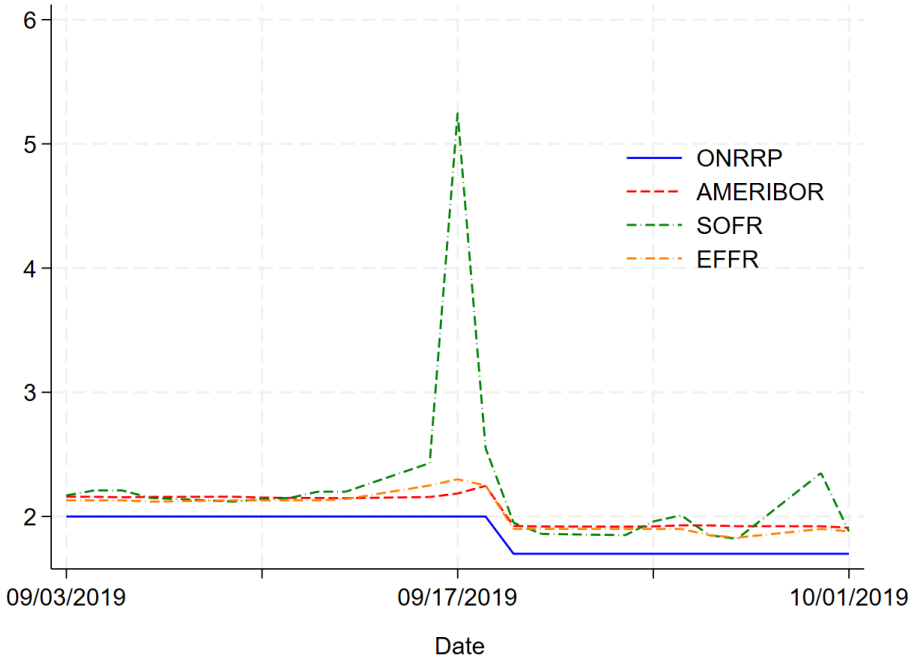

Figure 1: Overnight Rates around the SOFR Spike. The figure shows the evolution of selected overnight rates around the September 17, 2019 SOFR Spike. On the y-axis, rates are in percentage points. ONRRP is the Federal Reserve's Overnight Reverse Repo Rate.

2.1 Short-Term Funding Markets

Banks raise short-term wholesale funding at different tenors, from overnight to one year.[2] Rates on AA financial commercial paper (CP) at tenors greater than one week are not always present due to sporadic issuance. Similarly, issuance of certificates of deposit at a given tenor range is not always available. Indeed, the sporadic issuance of term instruments was one of the main reasons why CP rates were not chosen by ARRC as the replacement for LIBOR. On the other hand, overnight issuance is more consistent. Data from the Federal Reserve indicates that average daily issuance of overnight AA financial CP is around $6 billion, with foreign banks being the main CP issuers.

U.S. banks that are FHLB members can borrow on a collateralized basis via FHLB advances at tenors ranging from overnight to 30 years. In 2023, FHLBs had about $800 billion in outstanding advances, of which $450 billion due in less than one year (Federal Home Loan Banks, 2023). The FHLB system is comprised of 11 regional banks, each providing advances to members located in its own district. FHLBs prefer to lend on a collateralized fashion, but are willing to lend fed funds on an unsecured basis. When unsecured, they prefer to lend to banks that borrow for IORB arbitrage instead of urgent liquidity needs. In particular, each FHLB lends fed funds throughout the day to banks outside of its district in order to incentivize members to borrow on a collateralized basis (advances). Only after 3pm are FHLBs lending fed funds to banks in their own district.

Finally, banks borrow in the fed funds and eurodollar markets. In both markets, borrowing banks are mostly foreign and lenders are FHLBs in the fed funds market and asset managers and corporations in the eurodollar one.[3] Daily overnight fed fund and eurodollar volumes combined are around $250 billion, with $80 billion in fed funds only. To understand the poor performance of the EFFR as an alternative to LIBOR, let us shed light on the structure of the fed funds market next.

2.2 The Fed Funds Market

The fed funds market is the market where banks borrow reserves from one another. Prior to 2007, the Fed would maintain control over EFFR by engaging in temporary

[2]Tenors beyond one year are outside the purview of money markets and under the purview of bond markets.

[3]See Keating and Macchiavelli (2017) and the FR2420 instructions.

open market operations, making reserves temporarily more scarce or more abundant. If additional reserves were needed, the Fed would temporarily inject reserves and buy Treasuries (a reverse repo); if on the other hand reserves were too plentiful and the EFFR was about to drop too low, the Fed would temporarily drain reserves by borrowing cash against Treasuries (a repo).

Fighting the 2007 financial crisis, the Fed introduced the first round of quantitative easing (QE) to provide extra stimulus to the economy. With rates already at zero, large injections of reserves (the byproduct of QE) meant that very few banks needed to borrow reserves in the fed funds market. Thus, QE led to a loss in the control over EFFR, the policy rate. To regain control over the EFFR, the Fed started to pay interest on reserve balances (IORB). In principle, since banks can earn IORB on their reserve balances, they should only be willing to lend reserves at rates above IORB. Thus, the fed funds market (where banks borrow and lend reserves) should only see trades at rates above IORB. In other words, IORB should be the *floor*.

However, IORB turned out to be the *ceiling*. This is because of artificial market segmentation, whereby the largest fed funds lender, the Federal Home Loan Banks (FHLBs), cannot earn IORB. Indeed, FHLBs are U.S. government-sponsored enterprises and, as such, are not allowed to earn IORB on their reserve balances. Thus, they are willing to lend reserves at any rate above zero while banks are willing to borrow extra reserves from FHLBs at rates below IORB. Borrowing fed funds at rates below IORB to then earn the IORB overnight constitutes an arbitrage trade. In other words, most of the current fed fund trades are an artifact of market segmentation. Were FHLBs allowed to earn IORB, the arbitrage-driven fed funds trades (currently the vast majority of the fed funds market) would disappear and the Fed would have to target a more volatile EFFR, making monetary policy communications and credibility more challenging.

Expanding bank balance sheets for IORB arbitrage is costly for two reasons. First, banks need to increase leverage to do so. However, not all banks are subject to the leverage ratio in the same way. For most of the last decade, foreign banks had their Supplementary Leverage Ratio (SLR) computed at month- or quarter-end snapshots only. Thus, they could expand their leverage any other day of the month or quarter but the last without incurring any balance sheet costs. Second, starting in April 2011, the assessment base on which the FDIC fee is computed was widened from total domestic deposits to total

assets less tangible equity, thus adding wholesale borrowing (fed funds included) to the new assessment base. Notably, foreign banks are exempt from the FDIC fee.

In sum, as foreign banks are subject to no FDIC fee and no leverage constraint (other than at month- or quarter-end), they are willing to borrow fed funds at IORB minus a few basis points (bps) and leave the borrowed funds in their reserve accounts overnight, pocketing the IORB arbitrage spread. As previously noted, this arbitrage trade represents most of the fed funds market.

Indeed, as shown in Keating and Macchiavelli (2017), most of Eurodollars and fed funds borrowed are kept as reserve balances overnight, thus earning the IORB. As such, these funds are not borrowed to manage liquidity needs. Also, the vast majority of fed funds are lent by FHLBs. They prefer to lend to borrowers in need of funding via advances, which are fully collateralized, while they lend on an unsecured fashion (fed funds) to banks that are not in need of funding and thus highly unlikely to default on the fed funds loan. Therefore, most of the trades underlying EFFR (and OBFR) are not arising from liquidity needs. Instead, they are just meant to pocket an arbitrage spread.[4]

Aside from month-end, when foreign banks deleverage ahead of SLR reporting, EFFR displays limited volatility, which is convenient because the Fed communicates its monetary policy stance by targeting EFFR within the FOMC target range. Without conducting open market operations on a daily basis (as was the case prior to the Global Financial Crisis), having the EFFR predictably trading in a small interval within the target range makes monetary policy control easier and more credible. However, being used for arbitrage trades instead of funding needs, EFFR does not constitute a good replacement for LIBOR.

2.3 AMERIBOR

AMERIBOR is an overnight unsecured rate that measures bank funding costs. The index is calculated as the transaction volume weighted average interest rate of the daily transactions in the AMERIBOR overnight unsecured loan market on the AFX platform.[5] AFX is an electronic trade matching platform. Trading participants may include banks, credit unions, insurance companies, asset managers, dealers, and corporations. Lenders

[4]See the Appendix for a discussion of the small volume of fed funds borrowed by domestic banks.
[5]For more details, visit https://theafex.com/ameribor/.

pre-approve a set of counterparts they are willing to lend to, each with a credit limit or maximum lending amount. These credit limits can be adjusted daily. Settlement of funds occurs bilaterally between the lender and the borrower via Fedwire. A loan consists of a first leg where the funds move from the lender to the borrower, and a second and final leg where the borrower returns principal plus interest to the lender.

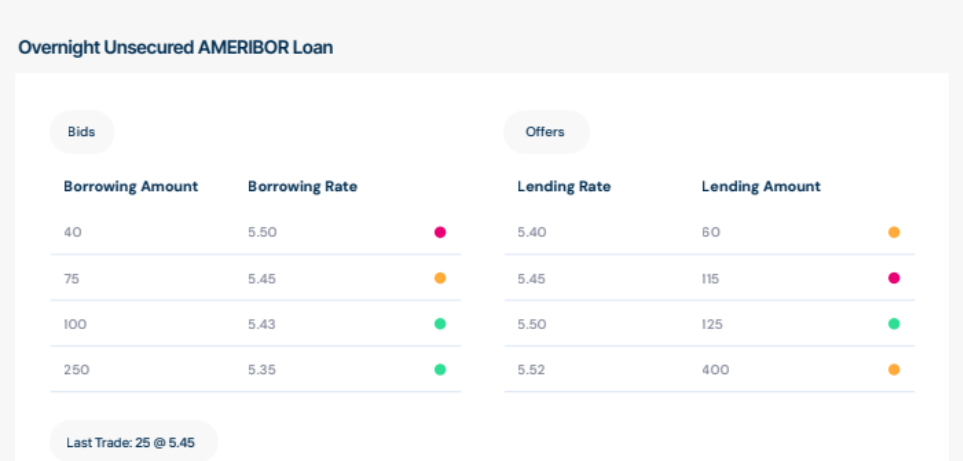

Figure 2: AFX Book. The figure shows the AFX platform as seen by approved participants. Bids consists of borrowing amounts for each borrowing rate. Offers consist of lending amounts for each lending rate. Since each lender can pre-approve a set of borrowers and set a lending limit to each of them, the bids and offers can overlap.

Once on the platform, approved participants see a central limit order book as shown in Figure 2. Bids show the amount that borrowers want to borrow at each rate. Each lender sees a set of bids customized to its pre-approved counterparts. Specifically, if the bid is from a borrower that is not pre-approved by the specific lender, the bid will appear with a red dot next to it. If, on the other hand, the bid is from a pre-approved counterpart, it displays a green dot next to it. Such trade can then be executed. Finally, if the bid is from an approved counterpart but for an amount greater than its credit limit, the bid appears with a yellow dot. Such trade can only be partially executed up to the credit limit amount. Bids appear from the highest to the lowest borrowing rate. The platform then provides the best execution for each lender.

Consider for instance the bids in Figure 2. An unapproved counterpart or a counterpart that has already hit the lender's credit limit wants to borrow \$40 million at 5.50%. Next, an approved counterpart wants to borrow \$75 million at 5.45%, but some of it exceeds the lender's counterpart credit limit, hence the yellow dot. Then, at 5.43% and 5.35% there are approved counterparts wanting to borrow \$100 and \$250 million

respectively, both within the lender's pre-approved counterpart credit limits. Therefore, if the lender wants to lend $100 million at no less than 5.45%, only a fraction of the amount will be executed and the rest will populate the outstanding offers.

Offers consist of lending amounts at each lending rate. Offers are displayed from the lowest lending rate to the highest. Some borrower may not be able to borrow at the lowest lending rate on the book because they are not in the set of pre-approved counterparts of the specific lender that made that offer. Borrowers that are not pre-approved or that have already borrowed up to their credit limit see a red dot next to the specific offer. Borrowers that are pre-approved but not for the entire amount of the order see a yellow dot next to the offer. Finally, borrowers that are pre-approved by a specific lender and want to borrow within the credit limit see a green dot next to the offer.

Since each lender can pre-approve a set of borrowers and impose a different credit limit to each of them, the bids and offers do not necessarily cross, as is the case in a standard central limit order book for equities. In other words, some lenders may be willing to lend at 5.40% or above while some borrowers are willing to borrow at 5.50% or below. However, these borrowers are not pre-approved by those lenders under consideration. Therefore, there can be some overlap of bid and offer rates on the AFX book.

AFX also offers two term indices, a 30-day and a 90-day average of the overnight AMERIBOR, that are used as benchmarks in floating rate loans and derivatives.[6]

3 The Need for a Credit-Sensitive Rate

As previously noted, both EFFR and SOFR are not fit for replacing LIBOR. The EFFR does not represent the liquidity needs of banks as virtually all trades are for IORB arbitrage purposes and the predominant fed funds lenders, FHLBs, refrain from lending fed funds (which are unsecured) to banks with liquidity needs. Indeed, FHLBs lend to banks in need of overnight liquidity using fully collateralized overnight advances.

SOFR is a secured rate based on overnight Treasury repos. Dealers raise repo funding to a small extent to finance Treasury inventories and to a larger extent to finance their secured lending to hedge funds wanting to take levered long positions in Treasuries. Thus, SOFR does not capture commercial bank funding needs either. Notably, this is the same

[6]See the AMERIBOR TERM-30 and the AMERIBOR TERM-90 white papers.

conclusion reached by a group of regional banks in a letter to U.S. banking regulators (Marshall et al., 2020).

After the sunsetting of LIBOR, we are thus left with no rate that captures the marginal funding costs of commercial banks. The latter need such rate to manage interest rate risk. Indeed, as discussed in Cooperman et al. (2023), many corporations drew down credit lines in March 2020 for precautionary reasons, and banks may have needed to fund such drawdowns by raising wholesale funding. The interest rate on credit lines is predetermined at a spread over a reference rate.

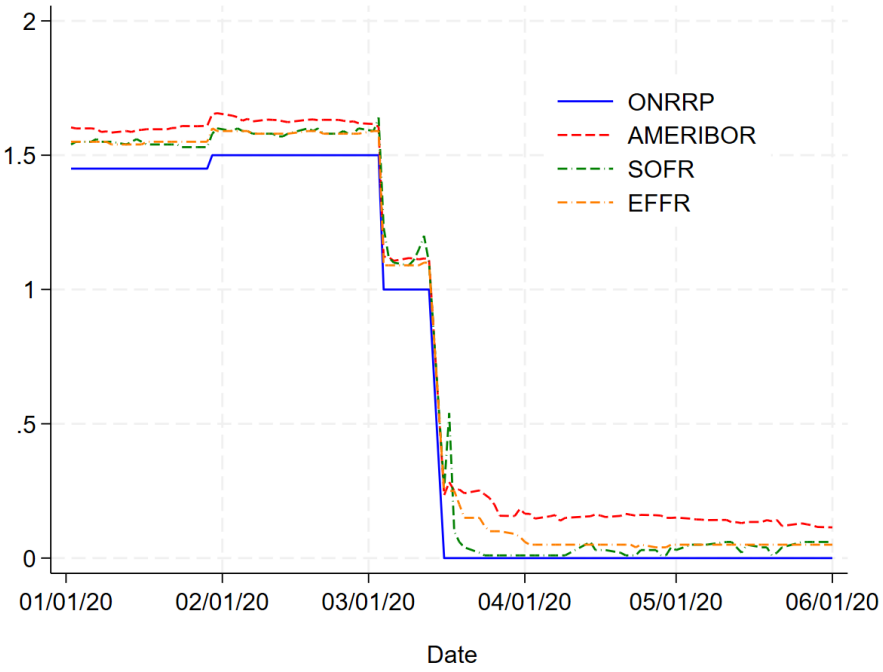

Figure 3: Overnight Rates around the Covid-19 Crisis. The figure shows the evolution of selected overnight rates around the Covid-19 crisis. On the y-axis, rates are in percentage points. ONRRP is the Federal Reserve's Overnight Reverse Repo Rate, which also corresponds to the bottom of the FOMC target range during this time period.

The current use of SOFR as the reference rate can prove to be deleterious, as SOFR moved in the opposite direction to bank funding costs at the height of the March 2020 Covid crisis. Indeed, as shown in Figure 3, the spread between AMERIBOR and SOFR, which printed at around 5 bps pre-crisis, widened to as much as 23 bps at the height of the crisis in late March 2020. As a result, banks may have received a lower rate on their credit lines indexed to SOFR than they could borrow at, thus incurring negative net interest margins on the trade. For this reason, we need a reliable reference rate that captures the marginal commercial bank funding cost, which is the focus of the next section.

4 Empirical Analysis

We collect 1- and 3-month LIBOR, AMERIBOR, SOFR, EFFR, and overnight AA financial commercial paper rate (AA Fin) from July 2, 2019 to January 22, 2022 to maximize the overlap across the mentioned rates. We then split the sample into a pre-crisis period up to March 3, 2020, when stress started to appear in credit markets; a crisis period between March 4 and March 23, 2020; and a post-crisis period following the deployment of significant emergency liquidity by the Federal Reserve (Li et al., 2021).

Table 1: Summary Statistics. Table 1 presents summary statistics for 1-month LIBOR, AMERIBOR, SOFR, EFFR, and the overnight AA financial commercial paper rate (AA Fin) in three sub-periods: July 2, 2019 to March 3, 2020 (pre-crisis); March 4, 2020 to March 23, 2020 (crisis); and March 24, 2020 to January 22, 2022 (post-crisis). The daily sample goes from July 2, 2019 to January 22, 2022, when all rates of interest are available. We exclude the two days surrounding each quarter-end to remove variation induced by regulatory window-dressing behavior. Results are qualitatively similar if we include quarter-ends. Rates are in percentage points.

	Mean	St.Dev.	25^{th}	50^{th}	75^{th}
Pre-crisis (159 observations)					
1m LIBOR (%)	1.90	0.25	1.69	1.80	2.11
AMERIBOR (%)	1.87	0.30	1.61	1.85	2.16
SOFR (%)	1.86	0.33	1.56	1.81	2.13
EFFR (%)	1.84	0.32	1.55	1.82	2.13
AA Fin (%)	1.80	0.30	1.53	1.77	2.08
Crisis (14 observations)					
1m LIBOR (%)	0.83	0.20	0.75	0.80	0.93
AMERIBOR (%)	0.75	0.44	0.25	1.11	1.12
SOFR (%)	0.72	0.51	0.10	1.09	1.12
EFFR (%)	0.71	0.46	0.25	1.09	1.09
AA Fin (%)	0.70	0.47	0.16	1.07	1.09
Post-crisis (433 observations)					
1m LIBOR (%)	0.16	0.15	0.09	0.12	0.16
AMERIBOR (%)	0.10	0.02	0.09	0.10	0.11
SOFR (%)	0.05	0.03	0.03	0.05	0.08
EFFR (%)	0.08	0.02	0.07	0.08	0.09
AA Fin (%)	0.071	0.015	0.07	0.07	0.08

Table 1 reports the summary statistics of the main rates of interest for each sub-period. As also evident from Figure 3, while AMERIBOR and SOFR trade on average at 1 bps spread prior to the crisis, their average spread widens to 3 and 5 bps during and after the crisis, respectively. Once again, a bank that borrows at AMERIBOR to fund the drawdown of credit lines linked to SOFR may experience negative net interest margins in times of market stress.

Next, we formally study which of the alternative rates shares more similar cyclical

properties with LIBOR. Under the hypothesis that a reference rate is credit-sensitive, we expect a high and significant correlation with LIBOR. We start by estimating the correlation of LIBOR with each of the candidate reference rates separately. Due to the possibility of spurious relationships among highly persistent variables, we estimate the following time series specification in first difference:

$$\Delta LIBOR_t = \alpha + \sum_{k=0}^{2} \beta_k \times \Delta RATE_{t-j} + \epsilon_t, \tag{1}$$

where $\Delta LIBOR_t$ is the daily change in either 1-month or 3-month LIBOR and $\Delta RATE_t$ is the daily change in one of reference rates, AMERIBOR, SOFR, or EFFR. We include 2 lags of $\Delta RATE_t$ in addition to the contemporaneous change, and use Newey-West standard errors with 4 lags.

Table 2: Properties of Alternative Reference Rates. Table 2 presents estimates of the correlations between 1- or 3-month LIBOR and alternative reference rates, namely AMERIBOR, SOFR, and EFFR, as in Equation 1. We only show the contemporaneous correlations, since all of the lagged correlations are individually insignificant at the 5% level. The daily sample goes from July 2, 2019 to January 22, 2022. Panel A uses the full sample while Panel B excludes the 2 days surrounding each quarter-end. Rates are in percentage points. Newey-West standard errors with 4 lags are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)
	Δ 1m LIBOR			Δ 3m LIBOR		
Panel A: Full Sample						
Δ AMERIBOR	0.258***			0.073		
	(0.098)			(0.132)		
Δ SOFR		0.022			0.007	
		(0.018)			(0.011)	
Δ EFFR			0.253**			0.080
			(0.099)			(0.133)
Obs.	624	624	624	624	624	624
Panel B: Excluding Quarter-Ends						
Δ AMERIBOR	0.260***			0.073		
	(0.099)			(0.133)		
Δ SOFR		0.023			0.008	
		(0.019)			(0.012)	
Δ EFFR			0.255**			0.081
			(0.099)			(0.133)
Obs.	604	604	604	604	604	604

The results are displayed in Table 2. Panel A uses the full sample while Panel B removes the 2 days surrounding each quarter-end to avoid the inclusion of noise due to

well-known regulatory window-dressing behavior. Columns 1 to 3 use 1-month LIBOR as the dependent variable, while columns 4 to 6 use 3-month LIBOR. Since each of the lagged regressors are insignificant at the 5% level, we do not display them for ease of exposition. On the other hand, some of the contemporaneous correlations are statistically significant. Noticeably, changes in both AMERIBOR and EFFR are positively and significantly associated with changes in 1-month LIBOR, while daily changes in SOFR are not.

The reader may wonder whether the lack of a significant correlation between SOFR and LIBOR is due to the noise induced by quarter-end spikes in repo rates, as some dealers deleverage ahead of regulatory reporting dates. However, the lack of an association between LIBOR and SOFR persists even when removing the two days around quarter-end, as shown in Panel B. Another finding is that daily changes in each of the 3 overnight rates has no significant correlation with changes in 3-month LIBOR. This is possibly due to the fact that daily changes in 3-month LIBOR may be driven by term premia as well as changes in the expected future path of monetary policy. Also, since not all banks issue at 3-month tenors every day, it is possible that 3-month LIBOR relies on stale information, making daily changes in 3-month LIBOR less informative than 1-month LIBOR. These factors seem to play less of a role in the shorter-term 1-month LIBOR, which is the focus of the following analysis.

4.1 Horse Race Among Alternative Rates

Next, we include the alternative reference rates in the same regression to perform a horse race and see which of them performs best, especially in times of stress. We focus on the pre-crisis and crisis periods, thus excluding the post-March 24, 2020 period, when the Fed deployed unprecedented amounts of emergency liquidity which eliminated most bank funding risk. Specifically, we estimate the following time series specification in first difference:

$$\Delta LIBOR_t = \alpha + \beta_1 \times \Delta AMERIBOR_t + \beta_2 \times \Delta SOFR_t + \beta_3 \times \Delta EFFR_t + \epsilon_t, \quad (2)$$

where $\Delta LIBOR_t$ is the daily change in 1-month LIBOR and $\Delta AMERIBOR_t$ is the daily change in AMERIBOR. Similarly, $\Delta SOFR_t$ and $\Delta EFFR_t$ are daily changes in SOFR and EFFR, respectively. As before, we use Newey-West standard errors with 4

lags. In other specifications, we also interact the regressors and the intercept with the *Crisis* indicator which takes the value of one between March 4 and March 23, 2020.

Table 3: Horse Race Among Alternative Reference Rates. Table 3 presents estimates of the partial correlations between 1-month LIBOR and alternative reference rates, namely AMERIBOR, SOFR, and EFFR, as in Equation 2. The daily sample goes from July 2, 2019 to March 23, 2020, when the Federal Reserve heavily intervenes to stabilize markets. Panel A uses the full sample while Panel B excludes the 2 days surrounding each quarter-end to remove variation induced by regulatory window-dressing behavior. Rates are in percentage points. Newey-West standard errors with 4 lags are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
			Δ 1m LIBOR	
Δ AMERIBOR	0.589**	0.622**	0.033	0.063
	(0.252)	(0.270)	(0.114)	(0.135)
Δ SOFR	0.013*	0.014*	0.007**	0.008**
	(0.008)	(0.008)	(0.003)	(0.004)
Δ EFFR	-0.338	-0.372	-0.079	-0.108
	(0.286)	(0.305)	(0.115)	(0.137)
Crisis			-0.012	-0.012
			(0.023)	(0.023)
Crisis × Δ AMERIBOR			2.085**	2.054**
			(0.826)	(0.832)
Crisis × Δ SOFR			-0.215***	-0.216***
			(0.068)	(0.068)
Crisis × Δ EFFR			-1.555*	-1.526*
			(0.893)	(0.899)
Obs.	177	173	177	173
Excluding Quarter-Ends		✓		✓

The results of the horse race among alternative reference rates are displayed in Table 3. Column 1 shows that a 1 bps daily increase in AMERIBOR is associated with a 0.6 bps increase in LIBOR. The association is statistically significant. Moreover, the additional contributions of changes in SOFR and EFFR are negligible, as indicated by the very small partial correlation of SOFR and the insignificant one of EFFR. Excluding quarter-ends (column 2) does not affect the results and, if any, it strengthens the association between AMERIBOR and LIBOR.

Next, columns 3 and 4 allow for the correlations between LIBOR and the alternative rates to change during the crisis period. Interestingly, changes in AMERIBOR during the crisis (Crisis×ΔAMERIBOR) are highly and positively correlated with changes in

LIBOR. On the other hand, SOFR and EFFR move in the opposite direction to LIBOR during the crisis. As a result, a bank that funds itself at LIBOR and with loans indexed to SOFR would see its net interest margins decline and possibly turn negative in times of stress. This wrong-way risk could have been mitigated (if not eliminated) had bank loans been indexed to AMERIBOR.

We provide robustness tests in Appendix B. One may argue that AMERIBOR and EFFR are highly positively correlated and that the inclusion of both could erroneously generate large and significant coefficients on AMERIBOR. To reassure the reader, we run additional regressions using only AMERIBOR and SOFR as regressors across various subsamples. The results are displayed in Table B.1. Across samples, AMERIBOR remains highly and significantly correlated with LIBOR, with a partial correlation between 26 and 38 percent. On the other hand, SOFR is at best only marginally correlated. The coefficient of SOFR is either not significantly different from zero or significant but negligible, with a partial correlation of 4 to 5 percent. Of notice, the partial correlation of SOFR with LIBOR during the crisis is negative, once again indicating that SOFR moves in the opposite direction to bank funding costs during times of stress. This wrong-way risk can expose banks to negative interest margins in times of stress if they rely on wholesale funding and extend credit linked to SOFR. To make the matters worse, crises are also times of acute investor attention to bank fundamentals.

Finally, Table B.2 adds the overnight AA financial commercial paper rate (AA Fin) to the horse race. The inclusion of AA Fin does not alter the positive and significant partial correlation of AMERIBOR with LIBOR. Moreover, the partial correlation of AA Fin is insignificant, thus adding no additional value beyond AMERIBOR.

5 Conclusion

In the aftermath of the LIBOR manipulation scandal, market participants under ARRC searched for an alternative reference rate. They chose a rate that is hard to manipulate but that does not measure commercial bank funding costs. Thus, banks indexing loans to SOFR may experience more volatile net interest margins, which can even turn negative in a crisis, when bank funding costs increase while SOFR declines.

In this paper we show that AMERIBOR, a reference rate based on overnight interbank

loans, has much better cyclical properties than the other alternative overnight rates considered, namely SOFR, EFFR, and the overnight AA financial commercial paper rate. Specifically, in a horse race among alternative rates, AMERIBOR is significantly and positively correlated with LIBOR. This is true both in normal times and especially in crisis times, when SOFR and EFFR negatively comove with LIBOR. As a result, banks should index their loans to AMERIBOR in order to better manage interest rate risk and keep net interest margins stable and positive at all times, even during crises.

References

Anbil, Sriya, Alyssa Anderson, and Zeynep Senyuz. 2020. "What happened in money markets in September 2019?" FEDS Notes.

Carlson, Mark, and Marco Macchiavelli. 2020. "Emergency loans and collateral upgrades: How broker-dealers used federal reserve credit during the 2008 financial crisis." *Journal of Financial Economics*, 137(3): 701–722.

Cooperman, Harry R, Darrell Duffie, Stephan Luck, Zachry Wang, and Yilin Yang. 2023. "Bank funding risk, reference rates, and credit supply." National Bureau of Economic Research Working Paper No. w30907.

Federal Home Loan Banks. 2023. "Combined Financial Report for the Quarterly Period Ended September 30, 2023." Available at https://www.fhlb-of.com.

Granja, João, Erica Xuewei Jiang, Gregor Matvos, Tomasz Piskorski, and Amit Seru. 2024. "Book Value Risk Management of Banks: Limited Hedging, HTM Accounting, and Rising Interest Rates." National Bureau of Economic Research Working Paper No. w32293.

Keating, Thomas, and Marco Macchiavelli. 2017. "Interest on reserves and arbitrage in post-crisis money markets." FEDS Working Paper.

Klingler, Sven, and Olav Syrstad. 2021. "Life after LIBOR." *Journal of Financial Economics*, 141(2): 783–801.

Kruttli, Mathias S, Phillip Monin, Lubomir Petrasek, and Sumudu W Watugala. 2023. "LTCM redux? Hedge fund Treasury trading and funding fragility." Available at SSRN 3817978.

Li, Lei, Yi Li, Marco Macchiavelli, and Xing Zhou. 2021. "Liquidity restrictions, runs, and central bank interventions: Evidence from money market funds." *The Review of Financial Studies*, 34(11): 5402–5437.

Macchiavelli, Marco, and Xing Zhou. 2022. "Funding liquidity and market liquidity: the broker-dealer perspective." *Management Science*, 68(5): 3379–3398.

Marshall, Christopher, Thomas Feil, David Lindenauer, James Herzog, James Leonard, Scott Warman, John Trohan, Randall King, Deron Smithy, and Matthew Tyler. 2020. "Letter to Chairman Quarles, Comptroller Otting, and Chair McWilliams." Available at https://shorturl.at/cenBK.

Robinson, Kenneth J. 2013. "Savings and Loan Crisis: 1980-1989." Federal Reserve History, available at www.federalreservehistory.org/essays/savings-and-loan-crisis.

Appendix A: Domestic Borrowers in Fed Funds

A very small portion of fed fund trades is represented by domestic banks borrowing for genuine liquidity needs or to boost their Liquidity Coverage Ratio (LCR) under Basel III. In those instances where domestic banks borrow for genuine liquidity needs, other domestic banks tend to be the lenders. Under the LCR, large banks need to maintain enough high-quality liquid assets (HQLA) to withstand a hypothetical 30-day run. The intensity of the hypothetical run depends on the stability of their funding sources. Treasury repo or retail deposits are considered very stable while operational deposits and unsecured wholesale funding very unstable. To manage the LCR, banks need to maintain high levels of HQLA if they have very unstable funding sources. It turns out that unsecured wholesale funding from GSEs, including FHLBs, is considered quite stable. Only 25% of FHLBs borrowings count towards increasing the denominator of the LCR. On the other hand, the reserves that are borrowed in the fed funds market from FHLBs fully count as HQLA (the numerator of the LCR). Thus, at the margin the LCR numerator goes up by 100% while the denominator goes up by only 25%. Thus, borrowing fed funds from FHLBs also significantly boosts the LCR at the margin. As such, banks may decide to borrow fed funds even at rates above IORB to manage their LCR down.

Appendix B: Robustness Tests

In this section we present some robustness tests. In Table B.1 we run a horse race only between AMERIBOR and SOFR in case the reader is concerned about quasi collinearity between AMERIBOR and EFFR. Finally, in Table B.2 we also add to the horse race the overnight AA financial commercial paper rate. In all cases, AMERIBOR retains its significant and positive correlation with LIBOR while the other rates remain either insignificant or marginal at best.

Table B.1: Robustness—AMERIBOR and SOFR Horse Race. Table B.1 presents estimates of the partial correlations between 1-month LIBOR and the two main alternative reference rates, namely AMERIBOR and SOFR, similar to Equation 2. In columns 1 and 2, the sample goes from July 2, 2019 to January 22, 2022; in columns 3 and 4, from July 2, 2019 to March 23, 2020; and in columns 5 and 6, from March 4, 2020 to March 23, 2020. The samples in columns 2, 4, and 6 exclude the 2 days surrounding each quarter-end. Rates are in percentage points. Newey-West standard errors with 4 lags are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)
			Δ 1m LIBOR			
Δ AMERIBOR	0.258***	0.259***	0.264***	0.264***	0.382*	0.382*
	(0.097)	(0.098)	(0.099)	(0.099)	(0.199)	(0.199)
Δ SOFR	0.004**	0.005**	0.004	0.004*	-0.038	-0.038
	(0.002)	(0.002)	(0.003)	(0.002)	(0.116)	(0.116)
Obs.	626	606	177	173	14	14
Sample	Full		Excl. Post-crisis		Crisis Only	
Excl. Quarter-Ends		✓		✓		✓

Table B.2: Robustness—Including Overnight AA Financial Commercial Paper. Table B.2 presents estimates of the partial correlations between 1-month LIBOR and three alternative reference rates, namely AMERIBOR, SOFR, and the overnight AA financial commercial paper rate (AA Fin), similar to Equation 2. In columns 1 to 4, the sample goes from July 2, 2019 to January 22, 2022; and in columns 5 to 8, from July 2, 2019 to March 23, 2020. The samples in columns 3, 4, 7 and 8 exclude the 2 days surrounding each quarter-end. Rates are in percentage points. Newey-West standard errors with 4 lags are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
					Δ 1m LIBOR			
Δ AMERIBOR	0.271***	0.307**	0.299***	0.360**	0.380***	0.544***	0.382***	0.547***
	(0.088)	(0.121)	(0.098)	(0.140)	(0.123)	(0.155)	(0.127)	(0.157)
Δ AA Fin	-0.010	-0.058	-0.038	-0.118	-0.120	-0.320	-0.122	-0.323
	(0.120)	(0.196)	(0.133)	(0.222)	(0.146)	(0.244)	(0.152)	(0.247)
Δ SOFR		0.008		0.012		0.024		0.024
		(0.013)		(0.014)		(0.016)		(0.016)
Obs.	626	626	606	606	177	177	173	173
Sample	Full		Full		Excl. Post-crisis		Excl. Post-crisis	
Excl. Quarter-Ends			✓	✓			✓	✓