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## US Dollar swaps after LIBOR

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# **Frankfurt School – Working Paper Series**

**No. 235**

## **US Dollar Swaps after LIBOR**

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January 2024



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# US Dollar Swaps after LIBOR

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## Abstract

The main focus of this paper is a comprehensive overview of the US\$ reference rate reform, with a particular focus on its implications for USD interest rate swaps (IRS). This paper aims to shed light on the current situation and future developments in a changing financial landscape. This paper discusses the change from US\$-LIBOR to the Secured Overnight Financing Rate (SOFR) and the Chicago Mercantile Exchange (CME) Term SOFR as new reference rates. Main changes for US\$ IRS against SOFR is a fixing-in-arrears, a loss in the money market term structure, and a change of implicit credit spreads. As only clients are allowed to use CME Term SOFR, banks face basis risk in hedging in the interbank market. As the SOFR is linked to treasuries instead of bank risk, in a crisis the difficulties of banks will increase. Corporate treasuries face a less efficient IRS market, wider ask-bid-spreads, changes in credit spreads, and an increase in complexity as the US money market now differs considerably from the EURO world.

Key words:

LIBOR Reform  
LIBOR  
Secured Overnight Financing Rate  
SOFR  
Term SOFR  
CME Term SOFR  
RFRs  
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## List of Symbols

12M	12 months
1M	One month
1W	One week
2M	Two months
3M	Three months
6M	Six months
AMERIBOR	American Interbank Offered Rate
ARRC	Alternative Reference Rates Committee
BBA	British Bankers' Association
BSBY	Bloomberg Short-Term Bank Yield Index
CBA	CME Group Benchmark Administration Limited
CBA	CME Group Benchmark Administration Limited
CCP	Central Counterparty
CDS	Credit Default Swaps
CFTC	Commodities Futures Trading Commissions
CME	Chicago Mercantile Exchange
CSA	Credit Support Annex
DF	Discount Factor
EMMI	European Money Market Institute
DTCC	Depository Trust & Clearing Corporation
EFFR	Effective Federal Funds Rate
FCA	Financial Conduct Authority
FSB	Financial Stability Board
GFC	Global Financial Crisis
IBA	Intercontinental Exchange Benchmark Administration
IBOR	Interbank Offered Rates
ICE	Intercontinental Exchange
IOSCO	International Organization of Securities Commissions
IRS	Interest Rate Swaps
ISDA	International Swaps and Derivatives Association
LCH	London Clearing House
LIBOR	London Interbank Offered Rate
MMF	Money Market Funds
OIS	Overnight Index Swap
ON	Overnight
p.a.	Per annum
PV	Present Value
Repo	Repurchase Agreement
RFR	Risk-Free-Rates

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SDR	Swap Data Repository
SOFR	Secured Overnight Financing Rate
SR1	One month SOFR futures
SR3	Three month SOFR futures
UST	US Treasury



## 1 Introduction

Over the past three decades, financial markets have heavily relied on reference rates known as IBORs (Interbank Offered Rates). However, the emergence of a manipulation scandal surrounding these rates has led to a decade-long reform effort driven by global regulators. The primary objective of this reform is to restore confidence in these critical benchmarks. This reference rate reform represents one of the most significant changes in the capital markets within recent decades. While most jurisdictions have already completed their rate reform, others are still in the process. Consequently, it has become a major topic of discussion among market participants, policymakers, and regulators in the financial markets. This reform has far-reaching implications affecting a wide range of financial instruments and trading practices.<sup>1</sup>

One of those instruments affected by the reference interest rate reform are interest rate swaps (IRS). These derivatives play an important role in the global financial market serving as essential instruments for managing interest rate risks and cash flows. However, IRS are inherently linked to reference rates. The IRS market is one of the largest and most liquid derivative markets. According to the Commodities Futures Trading Commissions (CFTC) the total outstanding notional value of IRS is \$289 trillion as of 25. November 2022.<sup>2</sup>

Considering the scale of the swap markets and the critical functions IRS perform for market participants, substantial changes or disruptions in the reference rates underlying these instruments can have profound consequences.

## 2 Reference Rate Reform from LIBOR to new alternative rates

The transition away from IBORs carries immense implications for IRS and the broader financial market. In the context of the reform, a fundamental question arises: to what extent does such a significant shift in reference rates change the pricing, as for IRS they are essential for floating rate payments?

### 2.1 London Interbank Offered Rate (LIBOR)

IBORs are based on the interest rates that banks use to obtain funding by borrowing from each other for different periods, ranging from overnight to 12 months. Each bank calculates its estimated rate for borrowing unsecured funds from other banks. IBORs are determined by the average of these quotes, which are published by an independent agent or the administrator overseeing the process. Therefore, an IBOR provides indications for funding costs for banks.<sup>3</sup>

The popularity of IBORs can be attributed to their two primary roles in the financial markets. First, they are used as benchmark rates, reflecting a relative performance measure. Second, IBORs are used as reference rates on which financial instruments can contractually agree to set the contract terms. Specifically, the rate is primarily developed as a reference rate for floating

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<sup>1</sup> Cf. Financial Stability Board (2014), p. 3.

<sup>2</sup> Cf. Commodities Futures Trading Commissions (2022).

<sup>3</sup> Cf. ICE Benchmark Administration (2023a).

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rate financial contracts such as fixed income derivatives and variable rate loans. The fundamental advantage of IBORs, and therefore the driver of the rates' popularity as reference rates, is that they generally allow for easier standardization of financial contracts and, simultaneously, reduce the complexity with which the terms and conditions of floating rate tranches are determined.<sup>4</sup>

The most prominent IBOR was called the London Interbank Offered Rate (LIBOR), which was initially regulated by the British Bankers' Association (BBA). Starting 2014, the administration of the LIBOR was handed over to the Intercontinental Exchange (ICE) Benchmark Administration (IBA).<sup>5</sup> Banks quoted LIBOR for several currencies and maturities per currency. The latest set of currencies has been USD, EUR, JPY, GBP, and CHF, each for five maturities, overnight (ON), one month (1M), three months (3M), six months (6M), and 12 months (12M). For each of these currency and maturity pairs, LIBOR was determined by a panel of internationally relevant banks with access to the interbank unsecured funding market answering the following question on each trading day at 11 am:

*“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 11 am London time?”*<sup>6</sup>

The results are sorted in ascending order for each currency and tenor to calculate the respective rate as the interquartile trimmed arithmetic mean. Then the top and bottom four are deleted to reduce the effect of outliers. Finally, the arithmetic mean of the remaining values gives the rate for that day. The typical convention is that the rate is expressed per annum (p.a.) with a day count fraction of Actual/360. LIBOR is fixed in-advance since it is designed as a forward-looking rate. The number of panel banks excluded varies depending on the original size of the panel but typically amounts to around 50% (the top and bottom 25%). Typically, the LIBOR panel comprised London's largest and most creditworthy banks. However, the composition varied by currency. For US\$-LIBOR, Table 1 lists the latest banks in the panel (as of May 2023)<sup>7</sup>.

Table 1: LIBOR Bank Panel	
HSBC Bank plc	Crédit Agricole Corporate & Investment Bank
UBS AG	SMBC Bank International plc
Barclays Bank plc	Credit Suisse AG (London Branch)
Lloyds Bank plc	The Norinchukin Bank
Citibank N.A. (London Branch)	Deutsche Bank AG (London Branch)
MUFG Bank, Ltd	JPMorgan Chase Bank, N.A. (London Branch)
Cooperatieve Rabobank U.A.	Bank of America N.A. (London Branch)

<sup>4</sup> Cf. ICE Benchmark Administration (2023a).

<sup>5</sup> Cf. Hou/Skeie (2014), p. 1.

<sup>6</sup> ICE Benchmark Administration (2023a).

<sup>7</sup> Cf. ICE Benchmark Administration (2023a).

# US Dollar Swaps after LIBOR

Royal Bank of Canada	
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Back in 2012, the British Financial Service Authority made an estimate that the total value of contracts linked to LIBOR falls within a range of \$300 trillion to \$800 trillion.<sup>8</sup> However, in 2021, the Alternative Reference Rates Committee (ARRC) estimates that there are only \$223 trillion in outstanding exposures to USD LIBOR. This decrease is due to the ongoing transition from LIBOR to new alternative rates.<sup>9</sup>

The methodology on which IBORs are based has severe drawbacks, which led to the LIBOR scandal and, hence, to the reference rate reform. First, the key terms in the survey concerning time and size are, in fact, highly subjective and leave room for interpretation. Specifically, the survey refers to a "reasonable market size" and "just before 11 am."<sup>10</sup> However, for different respondents, these may have different definitions. Furthermore, the calculated interest rate is only hypothetical, not based on actual market transactions. Thus, a bank claiming to be able to borrow a reasonable market size for the stated term at the specified rate does not have to justify this claim with evidence. In theory, the trimmed mean result is expected to closely reflect actual market transactions, although, in practice, this may not necessarily be the case.<sup>11</sup> The methodology made it possible and provided an incentive for banks to manipulate the fixings of LIBOR.<sup>12</sup>

In 2012, some banks were found guilty of manipulating LIBOR for their benefit and misrepresenting their financial status, resulting in over \$10 billion in fines.<sup>13</sup> The scandal that began with LIBOR has spread beyond a single rate or market. Regulatory investigations have become more common in the post-crisis era, with allegations of rate manipulation also affecting EURIBOR and TIBOR. The scandal had far-reaching consequences for individual banks and the global financial system. It exposed conflicts of interest for panel banks, highlighting the need for reference rates not influenced by economic interests.<sup>14</sup>

## 2.2 Reference Rate Reform towards Risk-Free-Rates (RFR)

The manipulation scandal exposed conflicts of interest for panel banks, highlighting the need for reference rates not influenced by economic interests.<sup>15</sup>

### 2.2.1 Timeline of the Reference Rate Reform

The LIBOR scandal has resulted in a loss of trust in essential reference rates, which can lead to systematic risks and instability in the financial system. To address this, the G20 mandated the

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<sup>8</sup> Cf. Wheatley (2012), p. 76.

<sup>9</sup> Cf. Alternative Reference Rates Committee (2021d), p. 9.

<sup>10</sup> ICE Benchmark Administration (2023a).

<sup>11</sup> Cf. Hou/Skeie (2014), p. 2.

<sup>12</sup> Cf. Kansal/Melatur (2020), pp. 2f.

<sup>13</sup> Cf. Viciglione/Wagner (2023), p. 12.

<sup>14</sup> Cf. Beißer/Read (2021), p. 3.

<sup>15</sup> Cf. Beißer/Read (2021), p. 3.

# US Dollar Swaps after LIBOR

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Financial Stability Board (FSB) to review the current critical rates and develop plans for improvement. In July 2014, the FSB published a report titled "Reforming Major Interest Rate Benchmarks", which focused on the three most commonly used IBORs (LIBOR, EURIBOR, and TIBOR). According to the FSB, the starting point for the development of reliable reference rates should be the Principles for Financial Benchmarks published by the International Organization of Securities Commissions (IOSCO) in July 2013. The 19 principles presented in the report, developed by the IOSCO Board-level Working Group on Financial Market Benchmarks, address governance, benchmark quality, methodology quality, and accountability.<sup>16</sup>

In his speech, "The future of LIBOR," on July 27, 2017, UK Financial Conduct Authority (FCA) Chief Executive Andrew Bailey expressed concern about the ongoing lack of liquidity in the interbank money market and concluded that LIBOR has no future. Bailey suggested that LIBOR should be phased out by the end of 2021 and urged the market to move to other reference rates. As a result, the FCA and the remaining 20 LIBOR panel banks agreed to maintain LIBOR until the end of 2021.<sup>17</sup> In 2016, the FSB started a project with the International Swaps and Derivatives Association (ISDA) to create fallback rates for interest rate benchmarks. These fallback rates should ensure a smooth transition towards new reference rates for existing financial contracts linked to old rates that will not be published anymore. In July 2017, national public-private working groups were established for the five LIBOR currencies in their respective jurisdictions. Every jurisdiction has designed a unique reference rate for its currency, resulting in varying timelines and rates.<sup>18</sup>

Finally, on March 5, 2021, the FCA and IBA announced the phasing out of LIBOR panels. Effective from December 31, 2021, LIBOR for EUR, GBP, CHF, and JPY were discontinued. On the same day, USD LIBOR for 1W and 2M maturities were also published for the last time, while the remaining five maturities phased out after June 30, 2023. Furthermore, no new contracts referencing USD LIBOR are allowed after 2021, per regulator instructions.<sup>19</sup> An overview of the cessation dates can be found in Table 2.

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<sup>16</sup> Cf. IOSCO (2013), pp. 9-14.

<sup>17</sup> Cf. Bailey (2017).

<sup>18</sup> Cf. Beißer/Read (2021), pp. 9f.

<sup>19</sup> Cf. Alternative Reference Rates Committee (2021c), p. 2.

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<b>Table 2: IBOR Cessation Dates</b>		
<b>Jurisdiction</b>	<b>IBORs</b>	<b>Cessation</b>
United States	USD LIBOR	1W and 2M: 31. December 2021 All other tenors: 30. June 2023
Europe	EURIBOR	Reformed in November 2019
	EONIA	31. December 2021
	EUR LIBOR	31. December 2021
United Kingdom	GBP LIBOR	31. December 2021
Switzerland	CHF LIBOR	31. December 2021
Japan	JBA TIBOR	Reformed in July 2017
	Euroyen TIBOR	Reformed in July 2017, Possible cessation: end of 2024
	JPY LIBOR	31. December 2021

## 2.2.2 New US Dollar reference rates

The Federal Reserve System created the ARRC in November 2014. The group of private market participants, comprising regulators, banks, exchanges, and investment managers, was tasked with finding a reliable benchmark rate to replace USD LIBOR. After careful consideration, the ARRC selected the Secured Overnight Financing Rate (SOFR) as the new benchmark rate for the USD currency on June 22, 2017. SOFR captures the cost of borrowing cash overnight collateralized by US Treasury (UST) securities in the repurchase agreement (repo) market. The Federal Reserve Bank of New York publishes the SOFR daily at approximately 8:00 am Eastern Time since April 03, 2018.<sup>20</sup>

The calculation of SOFR is based on real transactions in the repo market, one of the largest and most active funding markets. In the repo market, dealers can obtain cash by selling securities to investors and at the same time buying them back using a forward contract. This market includes tri-party repos, where Money Market Funds (MMFs) and non-banks act as lenders (usually cleared through a third-party bank), inter-dealer repos (General Collateral Financing), and bilateral repo transactions between dealers and non-banks.<sup>21</sup> Each day the SOFR is calculated as a volume-weighted median of these transactions. This is done by ordering transactions from the lowest to the highest rate, adding their transaction volumes cumulatively until the 50th percentile of dollar volume is reached, and identifying the rate associated with those trades. The final rate is rounded to the nearest basis point at the time of publication.<sup>22</sup> Also published alongside the volume-weighted median rate are the 1st, 25th, 75th, and 99th volume-weighted percentile rates and the transaction volume underlying the rate.<sup>23</sup>

<sup>20</sup> Cf. Alternative Reference Rates Committee (2023a).

<sup>21</sup> Cf. Klingler/Syrstad (2021), p. 784.

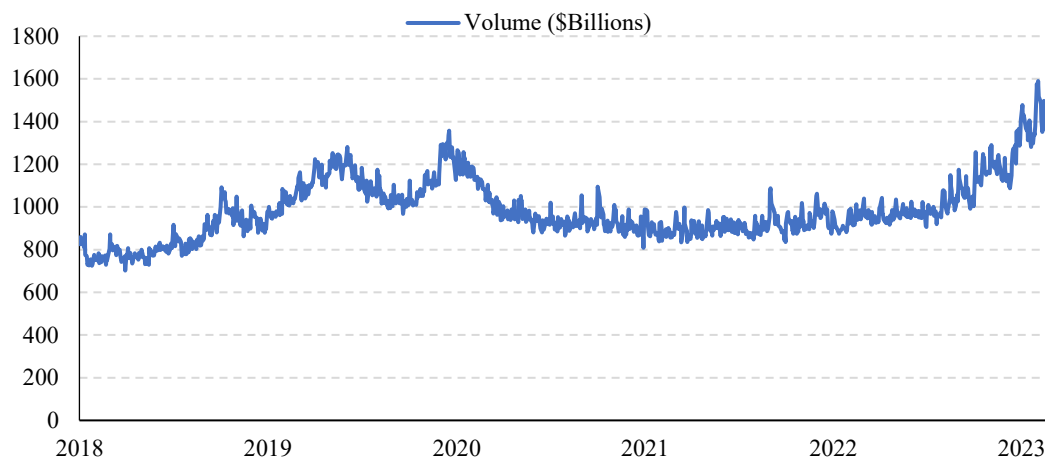
<sup>22</sup> Cf. Alternative Reference Rates Committee (2021a), p. 4.

<sup>23</sup> Cf. Federal Reserve Bank of New York (2023).

# US Dollar Swaps after LIBOR

While LIBOR was published for several maturities, SOFR is an overnight rate. The ARRC believes that most market participants can adapt to this by using compound or simple averaging over the relevant term. Hence, the New York Fed also publishes three compounded averages (Term SOFR) with tenors of 30-, 90-, and 180-calendar days and a SOFR Index that allows for the calculation of compounded average rates over customized time periods.<sup>24</sup> The formulas used to determine the Term SOFR and the SOFR Index can be found in appendix A.<sup>25</sup> They describe the geometric average of the SOFRs during the time till the maturity. In financial terms it is the compounded rate over the reference period. Since its publication in April 2018, the average daily transaction volume underlying SOFR has been more than \$980 billion. Figure 1 demonstrates that the transaction volume has regularly exceeded \$1 trillion and has never been less than \$700 billion.<sup>26</sup>

**Figure 1: Underlying Transaction Volume for SOFR**



*Source: Federal Reserve Bank of New York, as of 25. May 2023.*

Term SOFR is in contrast to LIBOR, a backward-looking rate. In order to receive a forward-looking rate, it can be calculated from transaction prices of SOFR futures contracts. The Chicago Mercantile Exchange (CME) began publishing the CME Term SOFR in April 2021.<sup>27</sup> The CME Term SOFR provides daily interest rates for 1M, 3M, 6M, and 12M tenors. It is calculated based on the work of Federal Reserve economists Heitfeld and Park. They created a method to determine a possible path of overnight rates that aligns with the observable averages implied by SOFR-based derivative contracts.

The methodology for the Term SOFR uses a combination of one month (SR1) and three months SOFR futures (SR3) to capture that the term structure is appropriately calculated. Unlike other forward-looking rates, no expert judgement is included in the data points. For the calculation, a total of 13 consecutive SR1 and 5 consecutive SR3 contracts are used to fully cover the tenors

<sup>24</sup> Cf. Federal Reserve Bank of New York (2020).

<sup>25</sup> Cf. Alternative Reference Rates Committee (2021a), pp. 8f.

<sup>26</sup> Cf. Federal Reserve Bank of New York (2023).

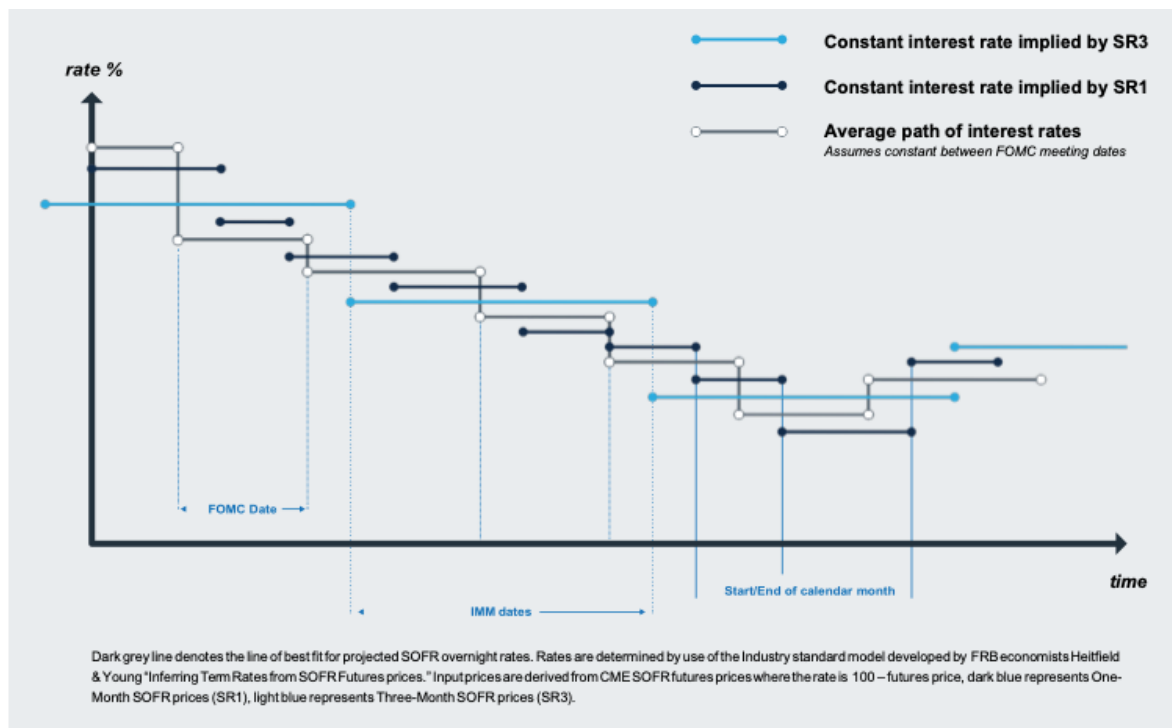
<sup>27</sup> Cf. CME Group (2021a).

# US Dollar Swaps after LIBOR

published as the CME Term SOFR. The path of overnight rates can be derived by assuming that the overnight SOFR rates follow a piecewise constant step function and can only jump up or down the day after FOMC Policy Rate announcement dates and remain at those levels across all dates in between the FOMC Policy Rate announcement dates. The optimal path for the overnight SOFR rates is determined such that the implied value of selected SR1 and SR3 contracts under the optimal path matches the observed prices as closely as possible. The formulas and the optimization following the Broyden-Fletcher-Goldfarb-Shanno algorithm that minimizes the distance of the computed overnight rates to SR1 and SR3, can be found in Appendix B.<sup>28</sup>

Figure 2 illustrates an example of the piecewise constant step function followed by the overnight SOFR rates and the corresponding average overnight SOFR rates implied by each SR1 and SR3 contract.

**Figure 2: Constant steps for CME Term SOFR calculation**



Source: CME Group Benchmark Administration Limited (2023), p. 11.

The optimization method framework is based on several principles. Firstly, it aims to reflect market expectations by minimizing the root mean squared errors between the observed prices and the implied values of the 13 SR1 and 5 SR3 contracts. Secondly, it assigns equal importance to each input price with respect to the contribution to the error function in the optimization. Thirdly, CME assumes that no jumps will occur more than eighteen months after the as-of date. Finally, the penalty function is the second term of the optimization function and is aimed to

<sup>28</sup> CF. CME Group Benchmark Administration Limited (2023), p. 10-14.

## US Dollar Swaps after LIBOR

punish large jump size. This regularization term ensures that the optimization prefers gradual jump patterns of overnight SOFR rates rather than extreme jump patterns, should the two patterns lead to the same contract prices. The penalty function will select the equal jump size pattern to minimize the absolute value of the largest individual jump size, making the path for overnight SOFR rates smoother.<sup>29</sup>

Once the path of projected overnight rates is determined, the averages over the standard tenors are the CME Term SOFR, which are published on the business day after the day when futures data is sampled.<sup>30</sup> Formula 1 shows the calculation of the term rates based on the path of overnight rates where  $T$  is the set of business days from the term start date to date  $T$  in the future,  $t$  a business day in set  $T$ ,  $d_t$  the number of calendar days from date  $t$  to the next business day and  $f(t, \theta)$  the estimated overnight SOFR rate of date  $t$ .

$$h(T) = \frac{360}{T} \times \left[ \prod_{t \in T} \left( 1 + \frac{f(t; \theta) \times d_t}{360} \right) - 1 \right] \quad (1)$$

The publication of CME Term SOFR will occur on the next business day and is computed based on a reference period that begins two business days ( $T+2$ ) after the publication date (see Figure 3 for historical rates and a comparison). The CME Term SOFR is managed by CME Group Benchmark Administration Limited (CBA), which is supervised by the FCA and adheres to the IOSCO Principles for Financial Benchmarks.<sup>31</sup> The ARRC formally recommended CME Group's SOFR Term Rate in July 2021 as a possible replacement for USD LIBOR.<sup>32</sup> However, the ARRC outlined that only limited use of the CME Term SOFR is recommended to support a sustainable transition and ensure financial stability. For new contracts, CME Term SOFR can be used in addition to other forms of SOFR for business loan activity, especially for multi-lender facilities, middle market loans, and trade finance loans, where transitioning from LIBOR to an overnight rate has been difficult. Furthermore, CME Term SOFR can also be used for certain securitizations that hold underlying business loans or other assets that reference a Term SOFR and where those assets cannot easily reference other forms of SOFR. Any use of CME Term SOFR in derivatives should be limited to end-user-facing derivatives intended to hedge cash products that reference the CME Term SOFR. This limited use is critical to prevent the vulnerabilities that prompted the LIBOR transition from being reintroduced, such as having a disproportionate use of Term SOFR relative to the volume of transactions underlying it.<sup>33</sup>

<sup>29</sup> Cf. CME Group Benchmark Administration Limited (2023), p. 10-14.

<sup>30</sup> Methodology can be found in Heitfeld/Park (2019).

<sup>31</sup> Cf. CME Group Benchmark Administration Limited (2023), p. 5.

<sup>32</sup> Cf. Alternative Reference Rates Committee (2021e), p. 1.

<sup>33</sup> Cf. Alternative Reference Rates Committee (2023b), pp. 6f.



## US Dollar Swaps after LIBOR

Table 3 summarizes the main characteristics of new reference rates for various jurisdictions. <sup>34</sup>

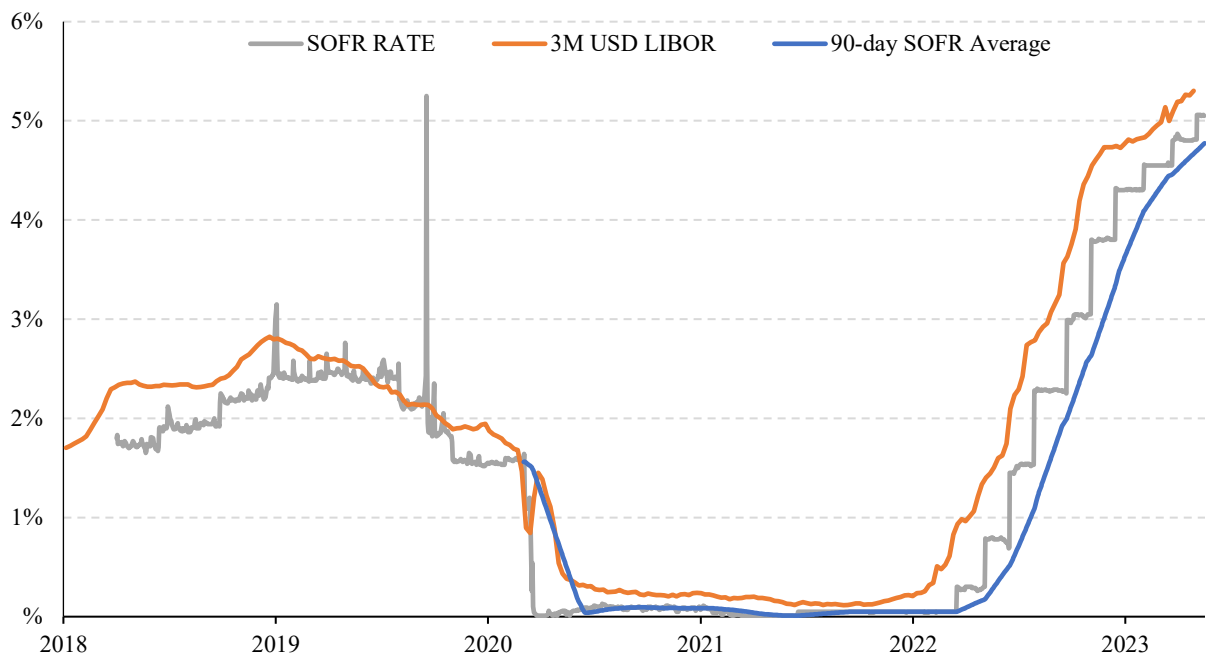
<b>Table 3: Overview of new Reference Rates</b>											
<b>Jurisdiction</b>	United States		Euro area			United Kingdom		Switzerland	Japan		
<b>New Rate</b>	SOFR	CME Term SOFR	Hybrid EURIBOR	€STR	Term €STR	Reformed SONIA	Term SONIA	SARON	Reformed JBA TIBOR	TONA	TORF
<b>Administrator</b>	Federal Reserve Bank of New York	CME Group	EMMI	ECB	EMMI	IBA		SIX	JBATA	Bank of Japan	QUICK
<b>Rates published</b>	May 2018	April 2021	November 2019	October 2019	November 2022	April 2018	January 2021	December 2017	July 2017	July 1985	April 2021
<b>Tenors</b>	ON	1M, 3M, 6M	1W, 1M, 3M, 6M, 12M	ON	1W, 1M, 3M, 6M, 12M	ON	1M, 3M, 6M, 12M	ON	1W, 1M, 3M, 6M, 12M	ON	1M, 3M, 6M
<b>Underlying Market</b>	Repo market	SOFR derivatives	Money Market	Money Market	€STR Derivatives	Money Market	SONIA derivatives	Repo market	Money Market	Money Market	TONA derivatives
<b>Secured?</b>	Secured	Secured	Unsecured	Unsecured	Unsecured	Unsecured	Unsecured	Secured	Unsecured	Unsecured	Unsecured
<b>Interest period</b>	Backward-Looking	Forward-Looking	Forward-Looking	Backward-Looking	Forward-Looking	Backward-Looking	Forward-Looking	Backward-Looking	Forward-Looking	Backward-Looking	Forward-Looking
<b>Transaction Based?</b>	Yes	Yes	Partly	Yes	Yes	Yes	Yes	Yes	Partly	Yes	Yes

<sup>34</sup> Data as per May 2023

## 2.3 Differences between US Dollar reference rates

This chapter examines the differences between US Dollar reference rates before the reform and the ones after it in greater detail. It is important to understand the factors affecting these benchmarks, as minor adjustments can have significant impacts on the valuations of financial products referring to those benchmarks.<sup>35</sup> When comparing the 3M USD LIBOR, SOFR, and 90-day compounded average of SOFR since April 2018, it is apparent that these rates have distinct drivers and risk factors. Figure 3 shows that the 3M USD LIBOR is, on average, higher than both SOFR-based rates.

**Figure 3: Historical comparison of LIBOR, SOFR, and SOFR Average**



Source: Bloomberg and Federal Reserve Bank of New York, as of 25. May 2023.

### Underlying market

The SOFR and the CME Term SOFR are based on actual transactions. In order to have reliable new rates, a change in the underlying market was required. LIBOR was determined solely by expert opinion in the unsecured interbank funding market. Since the interbank funding market alone does not provide enough liquidity, the underlying market determining the new RFRs includes bank and non-bank funding. Hence, using the wholesale funding market increases the volume of transactions and makes them more stable. Furthermore, the higher number of contributors helps to prevent manipulation of the rate by reducing the impact of each contribution. As a result, the new rates are more representative of the whole funding market and could be able to capture changing market structures better than LIBOR.<sup>36</sup>

<sup>35</sup> Cf. Klingler/Syrstad (2021), p. 784.

<sup>36</sup> Cf. Heidorn/Schaefer (2020), p. 9.

# US Dollar Swaps after LIBOR

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## Credit Risk and Collateralization

One important distinction between LIBOR and SOFR is the underlying credit risk. Since LIBOR is based on the unsecured interbank funding market, it contains bank credit risk premiums, and the rates are therefore influenced by the banking system's health.<sup>37</sup> SOFR, on the other hand, is considered nearly risk-free since they are collateralized with UST. Thus, LIBOR tends to be higher than the respective compounded SOFR due to the distinct underlying credit risks. LIBOR and SOFR are impacted differently in various market scenarios. While SOFR typically remains unaffected by shifts in credit spreads, LIBOR can be significantly influenced by such changes. Especially during instabilities, widening credit spreads can lead to increases in LIBOR but to lower SOFR due to the flight to quality, as SOFR is collateralized by UST.

Additionally, if there is low demand in UST, the rate in the repo market is higher than vice versa. Hence, supply and demand dynamics affect the UST repo rate, which then results in changes in SOFR.<sup>38</sup> In order to see these effects on the collateralized SOFR, it can be compared to the uncollateralized effective federal funds rate (EFFR). The EFFR measures unsecured borrowing between US depository institutions and other entities, including government-sponsored enterprises.<sup>39</sup> Between 2016 and 2018, the demand for UST grew due to the money market reform, which caused market participants to accept lower rates in exchange for the collateral, resulting in SOFR dropping below the EFFR. In early 2018, the US government increased the supply of UST securities, causing SOFR to increase.<sup>40</sup>

## Term structure

Usually, interest rates are not constant for every tenor. In a normal market scenario, the yield curve is upward-sloping. Hence, an investor will receive higher yields for longer horizons. This term structure of an interest rate reflects risk associated with the length of the interest period.

With the new methodology for SOFR, only ON rates can be determined. In order to get the rates for longer time horizons, all observed ON rates for the specific period are used to calculate a compounded average for this interest period. However, the average of ON rates is missing the term structure of interest rates, which is an essential driver of the rate. Thus, SOFR for longer interest periods will differ from LIBOR due to the missing term structure. In the past, the ON was mostly a liquidity indicator and, therefore, not suitable as an underlying for debt, especially since the correlation of ON to longer rates of the money market tended to be very low. Therefore, a geometric average of the ON fixed in arrears in the past tended, in many cases, to be very different from the corresponding LIBOR fixed in-advance.

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<sup>37</sup> Cf. Canales Saavedra, A. V. (2021), pp. 5ff.

<sup>38</sup> Cf. Schrimpf/Sushko (2019), p. 39.

<sup>39</sup> Cf. Federal Reserve Bank of New York (2022).

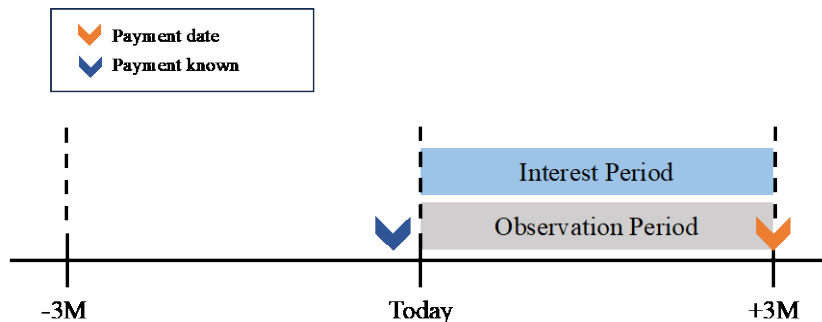
<sup>40</sup> Cf. Schrimpf/Sushko (2019), p. 39.

# US Dollar Swaps after LIBOR

## Fixing conventions

By methodology, LIBOR is a forward-looking term rate. Hence, in financial products, a variable payment linked to a LIBOR is usually known and therefore usually fixed two days before the beginning of the interest rate period. This convention is called fixing in-advance and aligns the observation period of LIBOR with the interest period of the financial contract, as illustrated in Figure 4.<sup>41</sup> The CME Term SOFR is also forward-looking fixing and therefore favorable for liquidity planning.

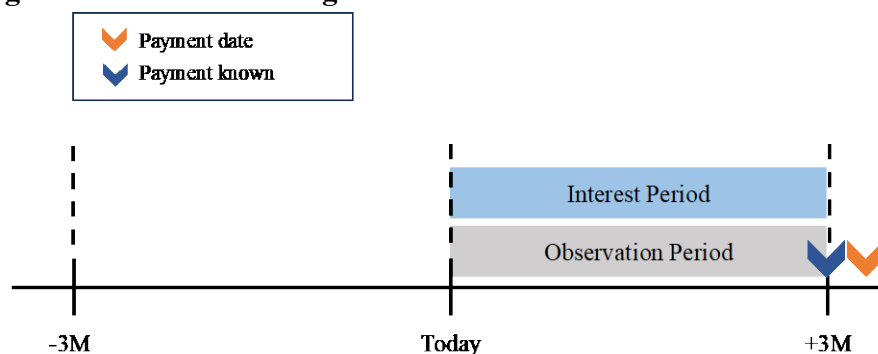
**Figure 4: In-advance fixing of LIBOR and CME Term SOFR**



Source: Financial Stability Board (2019a).

This fixing convention is usually not used for financial products linked to SOFR due to the different observation period. SOFR is based on overnight transactions and can, therefore, only be published with a one-day delay after the transactions. Hence, the observation period is backward-looking. In order to align observation and interest period, the fixing is usually in-arrears. This means a variable payment is not known at the beginning but at the end of the interest period. The payment date of the floating rate is often set one or two days after the fixing of the rate (Figure 5).<sup>42</sup>

**Figure 5: In-arrears fixing of SOFR**



Source: Financial Stability Board (2019a).

<sup>41</sup> Cf. Financial Stability Board (2019a), pp. 2-6.

<sup>42</sup> Ibid.

## 3 Effects on US Dollar Interest Rate Swaps (IRS)

In the past, the evaluation of IRS was very similar for all currencies. As EURIBOR is still fixed in-advance and is similar to the predecessor, the pricing method of EURO-denominated IRS is unchanged, but for US\$ IRS, due to the differences between SOFR and LIBOR, the evaluation had to change.

### 3.1 Introduction to IRS

An IRS is a contract in which two parties agree to exchange fixed and floating interest rates on future dates. The party paying the fixed rate is called the “payer”, while the party paying the floating rate is called the “receiver”. When entering into a swap agreement, the fixed rate (swap rate) is determined and remains constant throughout the entire duration of the contract. On the other hand, the floating rate relies on a reference rate and is not known at the beginning of the agreement. The payments are calculated by multiplying the corresponding interest rate with the principal amount. Only the difference in the interest rates is exchanged, not the principals.<sup>43</sup> The swap rate is determined in such a way that the initial value of a fair IRS is equal to zero. In other words, the present value (PV) of all cash flows of the fixed leg is equal to the PV of all the cash flows of the floating leg.

$$PV(\text{fixed leg}) = PV(\text{floating leg}) \quad (2)$$

The PV is calculated by multiplying each future cashflow by the respective discount factor ( $DF_i$ ).

$$\text{Swap Rate} * \sum_{i=1}^n DF_i = \sum_{i=1}^n \text{Floating Rate}_i * DF_i \quad (3)$$

To calculate the swap rate for the entire term, it is necessary to have both the DF and the future floating rates. However, as the floating rates at the start of the swap are unknown, they must be calculated as forward rates based on an interest rate curve. In addition, discount rates are determined by bootstrapping the swap rate curve.<sup>44</sup> There are two methods to calculate the fair swap rate: the single-curve approach and the multi-curve approach. Before the global financial crisis (GFC), the single-curve approach was the commonly used method. After the crisis, the multi-curve framework was introduced, and discounting shifted to the overnight index swap (OIS) curve. OIS rates based on Federal Funds Rates have minimal credit risk and are therefore more suitable for calculating the DF, while the forward rates are based on the fair swap curve. Hence, before the reference rate reform, most contracts used a multi-curve approach.<sup>45</sup>

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<sup>43</sup> Cf. Hull, (2019), pp. 210-233.

<sup>44</sup> Bootstrapping is a method for calculating spot rates from an interest rate curve by iteratively solving a set of equations. More information on the methodology can be found in Hull 2019.

<sup>45</sup> Cf. Awalee (2021), pp. 1f.

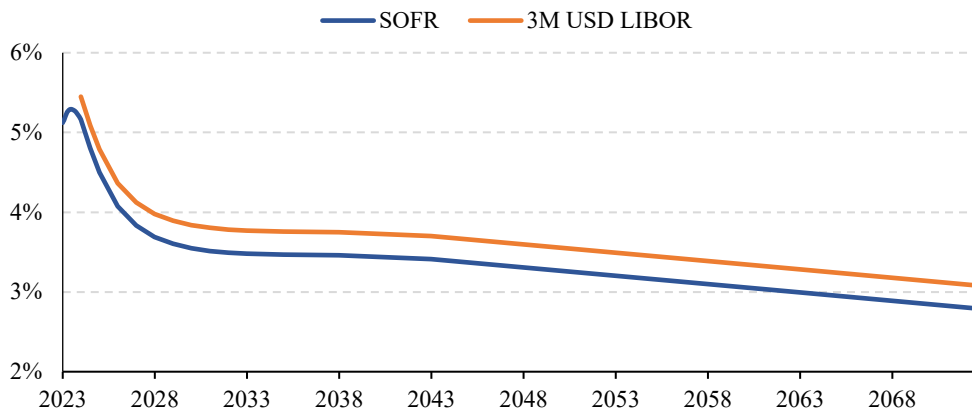
## 3.2 US Dollar IRS after the Reference Rate Reform

Switching from US\$-LIBOR to SOFR changes the cash flow of the floating leg, therefore evaluation and settlement procedures have to be adjusted.

### 3.2.1 Valuation

The concept of swaps remains unchanged, except that the floating leg is now linked to SOFR. This results in a change in the valuation of USD IRS. The forward rates are now based on the swap curve against SOFR and not against LIBOR anymore. The two swap curves, as of 16. June 2023, are shown in Figure 6. SOFR is usually lower than LIBOR due to the lower credit component and the missing term structure. Therefore, the fixed rate of an IRS is lower if the floating leg is referenced to SOFR instead to LIBOR, as both legs have to represent the same credit quality to get a NPV of zero at initiation.

**Figure 6: SOFR Swap Curve versus 3M USD LIBOR Swap Curve**



Source: Bloomberg, as of 16 June 2023.

Furthermore, the London Clearing House (LCH) and CME, some of the world's largest central counterparties (CCPs), changed the discounting for US\$ IRS from OIS based on Federal Funds Rate to OIS based on SOFR on October 16, 2020.<sup>46</sup> This means a single-curve approach is now standard again for US\$ IRS, with both DFs and forward rates based on SOFR. The main reason for changing the approach to multi-curve after the financial crisis was the inherent credit risk in the DFs based on LIBOR. Now, SOFR inheres almost no credit risk, and therefore, it is suitable to calculate the DFs.

Hence, since October 16, 2020, all cleared US\$ IRS are discounted with SOFR-based DFs, causing a shift in the valuation and the risk profile of already existing trades. A compensation process has been designed for existing swaps to minimize the financial impact. As compensation for the valuation and risk change, the CCPs provided a combination of cash and compensating EFR/SOFR basis swaps. After the discounting switch, an increase in trading

<sup>46</sup> Cf. CME Group (2020), p. 3.

## US Dollar Swaps after LIBOR

activities of SOFR-linked derivatives was observed, with LCH and CME reporting higher trading figures in October 2020. LCH's monthly SOFR swaps volume in terms of notional grew from USD 381.64bn in September to USD 628bn in October 2020, while CME saw a jump from USD 21.7bn to USD 98.2bn.<sup>47</sup> When swaps are not cleared by CCPs, they are usually traded bilaterally with a Credit Support Annex (CSA). Before the change in discounting, most CSAs used the Fed Funds rate as the interest rate and for discounting. However, with the ongoing transition, most new CSAs started referencing SOFR as the interest rate for the cash variation margin and as the base for DFs.<sup>48</sup>

Market data from Bloomberg as of June 16, 2023, shows that SOFR discount factors are mostly higher than OIS based on the Fed-Funds curve, especially for longer-dated cash flows. The difference in discount factors is negligible for tenors less than 2 years but greater than 1bp for tenors greater than 2 years and over 1.9bps for tenors greater than 20 years. This implies that a change in discount curves can significantly impact present values for longer-dated cash flows. The findings are summarized in Table 4.

<b>Table 4: Discount factors based on SOFR and Fed Funds OIS</b>			
<b>Tenor</b>	<b>SOFR</b>	<b>Fed Funds OIS</b>	<b>Difference</b>
1Y	5.1634%	5.1573%	0.61 bps
3Y	4.0740%	4.0599%	1.42 bps
5Y	3.6902%	3.6774%	1.28 bps
10Y	3.4795%	3.4669%	1.26 bps
20Y	3.4106%	3.3916%	1.90 bps
30Y	3.2040%	3.1799%	2.41 bps
50Y	2.7840%	2.7457%	3.83 bps

*Source: Bloomberg, as of 16 June 2023.*

The change in discounting 2020 had an impact on existing swaps. According to LCH and CME, the transition went smoothly, and trading volume in SOFR derivatives increased after it.<sup>49</sup> Most new contracts now use SOFR-based DFs, which are higher, especially for longer tenors. This results in lower valuations of future cash flows in swaps. Market participants must be aware of the discounting risks, which are based on changes in SOFR. Furthermore, since the single-curve approach is used, changes in SOFR affect discounting and the forward swap rates simultaneously but not to the same extent.

<sup>47</sup> Cf. London Clearing House (2023a) and CME Group (2023).

<sup>48</sup> Cf. Larrieu, X. (2020).

<sup>49</sup> Cf. London Clearing House (2020).

## 3.2.2 Credit Risk

One major difference in the reference rates is the underlying credit risk, as described in Chapter 2.3. SOFR is a secured overnight rate, unlike USD LIBOR. This means SOFR does not contain a term premium and is nearly risk-free. Hence the forward rates of the SOFR swap curve are lower than the ones of the LIBOR curve. As a result, the fixed swap rates market participants are willing to pay in exchange for floating SOFR are lower than for USD LIBOR. Furthermore, credit spread changes now do not directly impact swap rates anymore. Hence, in periods in which credit spreads are widening, SOFR may not increase while LIBOR does.

The new construction of the rates changes the ways how USD IRS can be used as a hedging tool. With LIBOR as the underlying rate, credit changes were always reflected in the floating leg of USD IRS. Hence, there was no basis in bank funding costs and LIBOR, which made these IRS the main hedging instrument for bank funding. Now, with the cessation of LIBOR, SOFR is the only remaining rate in the US and is not moving in line with bank funding costs. Thus, there is a basis between them, which leaves the bank exposed to credit risk, which cannot be hedged as easily as before the reform.<sup>50</sup>

Credit-sensitive rates could offer a solution to these issues. In other jurisdictions like in the Euro area, EURIBOR is, therefore, still widely used. In the US, credit-sensitive rates such as AMERIBOR and the Bloomberg Short-Term Bank Yield Index (BSBY) have been developed to reflect the credit risk of unsecured borrowing in specific markets. Despite this, regulators worldwide have expressed doubts about using these rates as a substitute for USD LIBOR, and they are currently not recommended. Hence, credit-sensitive rates are rarely used in derivatives transactions, like IRS. According to Depository Trust & Clearing Corporation (DTCC) swap data repository (SDR) data, only around 1,500 interest rate derivatives transactions refer to BSBY, compared to approximately 22,000 interest rate derivatives transactions referring to CME Term SOFR in 2022.<sup>51</sup>

## 3.2.3 Fixing conventions

Prior to the reference rate reform, the fixing convention for USD IRS usually has been fixing in-advance since this aligns the observation and the interest period. Furthermore, it helps corporations with their cash flow planning since they know the exact payment months before. Now, with the backward-looking SOFR, in order to align the observation and the interest period, fixing in-arrears is the standard convention for USD IRS. The payment will be booked with a two-day delay. Operationally, the convention of fixing in-arrears gives parties of USD IRS little time to plan their cash inflows and outflows, which is unfavorable for most market participants.

For cash products, a number of conventions were developed in order to allow for a longer period before paying, which can be found in Appendix C. However, for interest rate derivatives, only

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<sup>50</sup> Cf. Jermann, U. (2021a), p.1f.

<sup>51</sup> Cf. International Swaps and Derivatives Association (2023), p. 4.

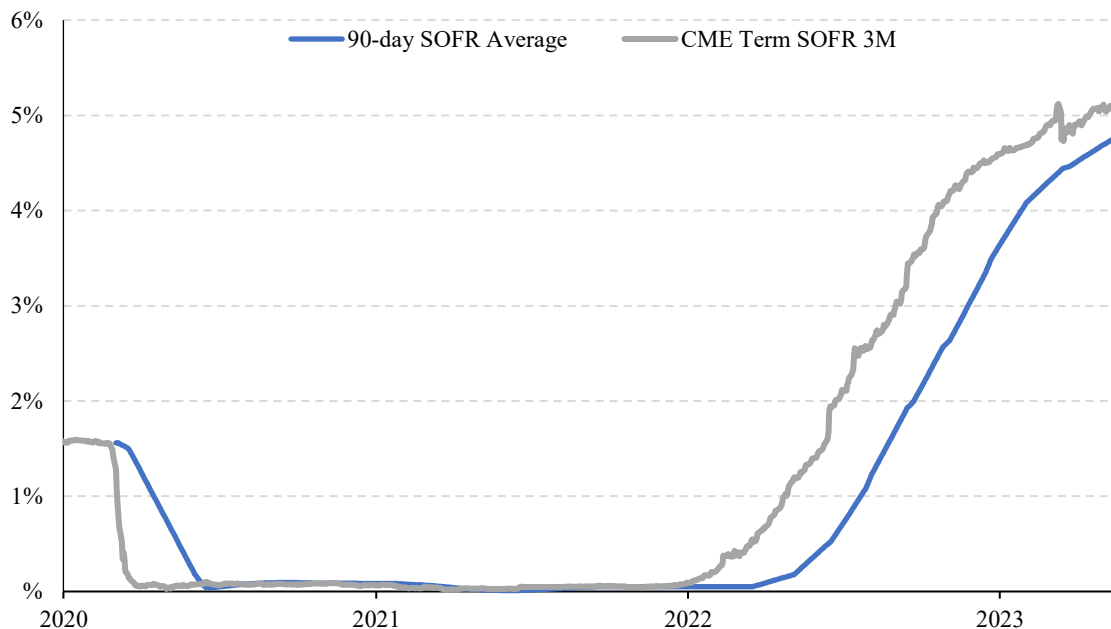


## US Dollar Swaps after LIBOR

the basic fixing in-arrears is permitted for cleared swaps. The standard convention is daily compounding fixed in-arrears with a two-day payment delay. For OTC swaps, on the other hand, both parties can agree on any convention most suitable for them.<sup>52</sup>

Besides SOFR, the CME Term SOFR offers a forward-looking reference rate that is fixed in-advance and can be used for IRS. The fixing conventions of the CME Term SOFR are analogous to USD LIBOR, with the fixing at the beginning and the payment at the end of the interest period without a payment delay. However, theoretically, there should be no significant basis between the CME Term SOFR and the compounded SOFR due to the construction based on the SOFR derivative markets. Therefore, both rates should come up with almost equal pricing of IRS.<sup>53</sup> Figure 7 shows the daily fixings of the 90-day compounded average of SOFR compared to the CME Term SOFR. The observable time lag in the average SOFR rate is due to the different observation period.

**Figure 7: CME Term SOFR versus Compounded SOFR**



*Source: Bloomberg, as of 16 June 2023.*

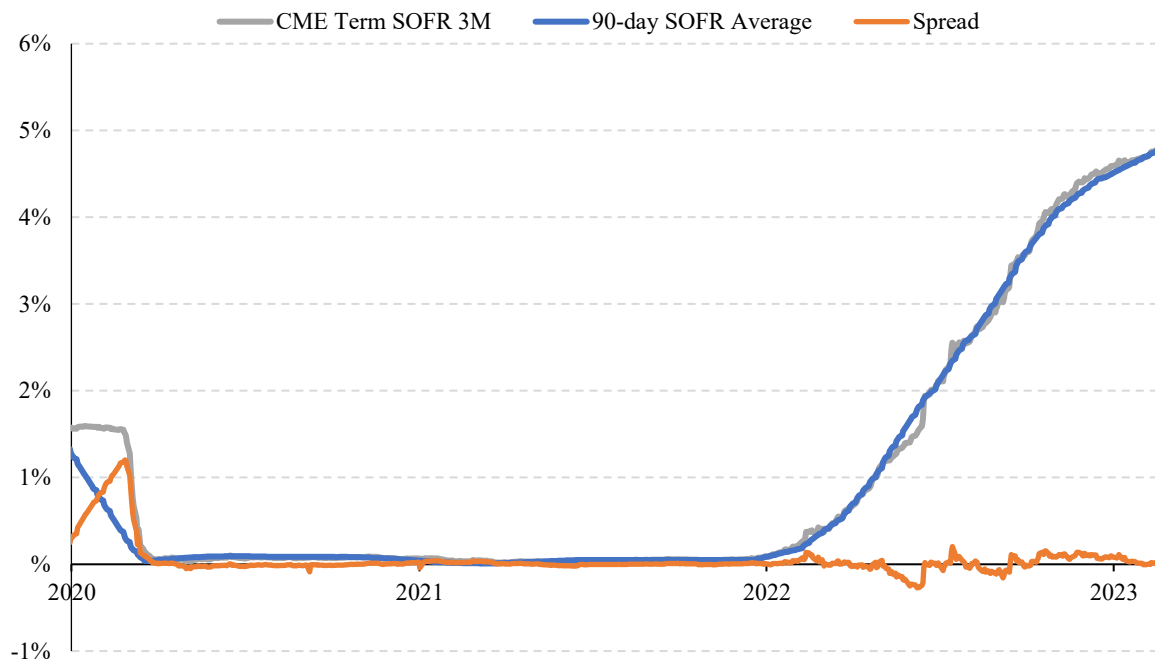
When the two rates are adjusted to the same interest period, in theory, they should be approximately the same. However, in praxis, there can be significant differences in some interest periods. Figure 8 shows the two rates aligned to the same interest period and the spread in the fixings.

<sup>52</sup> Cf. CME Group (2022), p. 39.

<sup>53</sup> Cf. Alternative Reference Rates Committee (2021e), pp. 13f.

# US Dollar Swaps after LIBOR

**Figure 8: CME Term SOFR versus Compounded SOFR (Interest period aligned)**



Source: Bloomberg, as of 16 June 2023.

The ARRC recommends the use of the CME Term SOFR for business loans, including multi-lender facilities, middle market loans, and trade finance loans. However, it is not recommended for use in most derivative transactions. The ARRC advises that CME Term SOFR derivatives should only be used to hedge end-user exposure to cash products that also reference the CME Term SOFR. This does not include interdealer trading. This limitation of the use of the CME term SOFR in derivatives markets should support the liquidity of SOFR. A lack of this liquidity would affect the underlying derivatives markets, which are essential for the reliability of the CME Term SOFR. Consequently, dealers have no direct possibility to hedge their CME Term SOFR exposure and have to use overnight SOFR and SOFR averages instead. There are concerns among market participants regarding the emergence of a one-sided market of CME Term SOFR.<sup>54</sup>

## 3.2.4 Fallback conventions

The ISDA fallback has been triggered by the FCA Announcement on 5 March 2021. In order to preserve the value of existing contracts, the spread adjustment for the new reference rate should make it economically close to the old rate. Thus, USD LIBOR contracts are now referring SOFR plus the spread. Since SOFR is lower than USD LIBOR, the spread is positive for all tenors. It was fixed on 5 March 2021 and was calculated as the five-year historical median spread between SOFR and USD LIBOR. The five-year horizon was chosen because it should

<sup>54</sup> Cf. Alternative Reference Rates Committee (2023c), p.12.

## US Dollar Swaps after LIBOR

represent a full economic cycle.<sup>55</sup> Table 11 summarizes the spread adjustments for each of the USD LIBOR tenors.

<b>Table 5: ISDA Spread Adjustments for Fallback Rates</b>	
<b>USD LIBOR Tenors</b>	<b>Spread Adjustments</b>
ON	+ 0.644 bps
1W	+ 3.839 bps
1M	+ 11.448 bps
2M	+ 18.456 bps
3M	+ 26.161 bps
6M	+ 42.826 bps
12M	+ 71.513 bps

*Source: Bloomberg, as of 16 June 2023*

For cleared swaps, the CCPs conducted the transition even before the index cessation effective date. LCH and CME mostly have the same conversion methodology and dates. IRS linked to USD LIBOR were converted in several tranches in the first half of 2023. LCH converted basis swaps on April 21, 2023, and all other USD LIBOR on May 19, 2023.<sup>56</sup> CME's key dates for converting USD LIBOR cleared swaps are March 24, 2023, for basis swaps, April 21, 2023, as the primary conversion date, and July 3, 2023, for all remaining swaps. After the conversion date, legacy LIBOR contracts are not eligible for clearing anymore.<sup>57</sup>

In order to help market participants to transition away from LIBOR and facilitate a smooth wind-down of existing contracts, synthetic rates have been proposed. The FCA has conducted a consultation to explore the possibility of publishing synthetic USD LIBOR for specific tenors until September 2024. This is particularly helpful for legacy contracts that lack reliable fallback options. Under the proposal, IBA would be required to publish non-representative 1M, 3M, and 6M USD LIBOR settings under a synthetic methodology until the end of September 2024. It should be based on CME Term SOFR plus the relevant spread adjustment in the fallbacks published by Bloomberg. However, the fallbacks in the ISDA documentation still come into effect after the cessation, even if synthetic USD LIBOR is published after that time.<sup>58</sup>

### 3.3 Challenges and Practical Approaches from Users

Due to the different fixing conventions of the SOFR compared to LIBOR, the different implicit credit quality of the IRS, the loss of the tenure structure up to 12 months, and the emerging of

<sup>55</sup> Cf. Viciglione/Wagner (2023), p. 28.

<sup>56</sup> Cf. London Clearing House (2023b), p. 3.

<sup>57</sup> Cf. CME Group (2022), p. 4f.

<sup>58</sup> Cf. Financial Conduct Authority (2023).

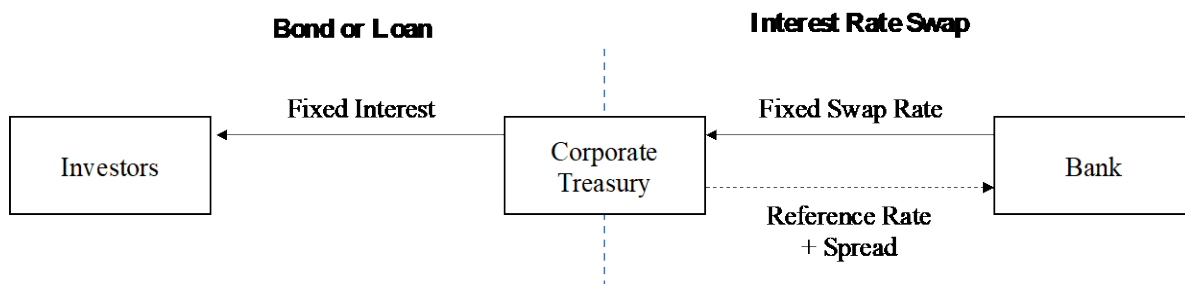
# US Dollar Swaps after LIBOR

split markets of IRS against SOFR and CME Term SOFR creates numerous challenges for bank and corporate treasuries.

## 3.3.1 Corporate Treasuries

Treasuries manage financial resources to support the business activities. They handle cash and risk management, as well as the transfer of money. Furthermore, treasuries are responsible for resource allocation, liquidity projections, and regulatory engagement.<sup>59</sup> IRS are commonly used by treasurers for funding and risk management. In the context of funding activities a company usually raises debt by contracting a loan with a bank or issuing a bond. The interest payment can be fixed or floating but this can be changed with an interest rate swap (IRS) without influence on the redemption.<sup>60</sup> This concept of changing fix to float is illustrated in Figure 9. Each arrow represents periodic cashflows.

**Figure 9: Use of USD IRS for changing fixed to floating interest**



*Source: Own illustration of corporate treasury transactions.*

Now, with the changes in the reference rates, the floating rate for a USD IRS is not LIBOR anymore, but Term SOFR or CME Term SOFR. All corporates have to choose between these two rates. As liquidity planning in most cases is one of the main goals in treasury management, they will prefer a fixing in-advance, and therefore opt for the CME rate. However, the logic of a 3 or 6-month LIBOR was very different. LIBOR was the quote for borrowing money till the respective maturity. Now it is either a sequence of overnights (Term SOFR) or an optimization to match the quotes of the futures with the expected path of the overnights (CME Term SOFR). First, the fixing is now very difficult to understand and in this sense intransparent. Second, a private institution is the provider, taking a fee for the use of the product. Third, the term structure is lost. Fourth, the credit spread in the overnight is lower compared to a 3 or 6-month rate. Fifth, the implicit risk is not a “good” bank anymore but treasuries (repos). Therefore, the credit spreads have to be adjusted. Table 5 gives a starting point, but as credit spreads for the same rating are changing considerably in time, an average over five years is not a good indicator for a new pricing of debt. For a company, finding its new spread level is not an easy task, and it will take many years of experience to get a solid history again. Sixth, the market for US\$ IRS interbank has to be against SOFR. Therefore, there will be two separate swap markets. As

<sup>59</sup> Cf. Bragg (2010). p. 3.

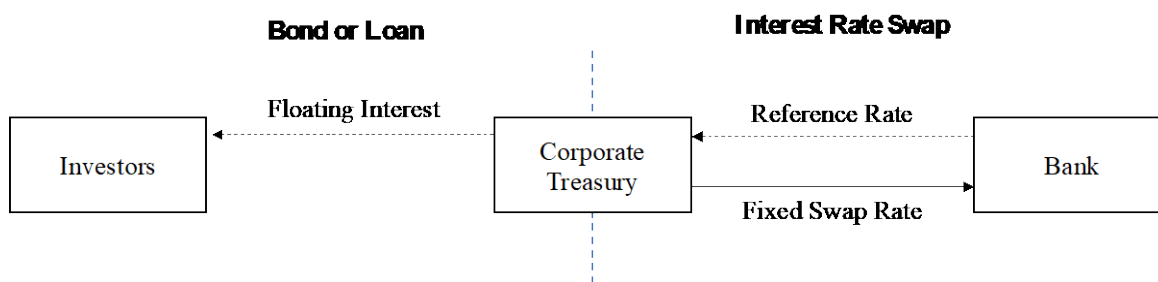
<sup>60</sup> Cf. Hull, (2019), pp. 210-233.

## US Dollar Swaps after LIBOR

interbank products against CME are not allowed, there is a substantial danger of limited liquidity, especially for corporates, as the market against CME will probably be smaller and one-sided. Seventh, the bank cannot hedge for the time the basis risk SOFR against CME, which could lead to an increase in ask/bid spreads to cover the additional risk. The changes in IRS markets will probably mean for corporate treasuries higher cost (increased ask/bid spreads), less liquidity (two US\$ IRS markets), and difficulties assessing the new credit spread. Last, the difference between the EURIBOR and the US\$ rates leads to increased complexity. A loss in efficiency in liquidity and risk management is very likely.

Sometimes, a company gets funding in exchange for floating interest payments, but it would like to have a certainty of future cash flows and, therefore, prefers a fixed rate. Thus, the company would enter into a payer position of an IRS. Before the reference rate reform, almost all floating cash products in the US were linked to the USD LIBOR. Hence, when entering into a USD IRS, which is linked to the same reference rate, the two payments economically cancel each other out. This concept is illustrated in Figure 10.

**Figure 10: Use of USD IRS for changing floating to fixed interest**



*Source: Own illustration of corporate treasury transactions.*

After the reform, cash products with floating rates can be linked to either compounded SOFR or the CME Term SOFR. Corporate treasuries have to check which of the rates is linked to the loan or bond and have to align the USD IRS with it. Furthermore, it is important to note that IRS can only be linked to the CME SOFR term rate for “end-user facing derivatives intended to hedge cash products that reference the SOFR Term Rate”<sup>61</sup> It is likely that corporate treasury now have to handle to different rates (SOFR and CME) in their books causing basis risk and again an increase of complexity.

### 3.3.2 Banks

Within banks, IRS are typically used for two different goals. First, trading desks act as market makers, provide liquidity for the swap markets, and take dealing positions in fixed income. Second, bank treasuries use IRS to manage the interest rate risk arising from lending and funding activities. As the deposits (liabilities) usually have a substantially shorter maturity than

<sup>61</sup> Alternative Reference Rates Committee (2021b), p. 3.

## US Dollar Swaps after LIBOR

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the assets due to the preferences of the clients, a bank has to manage its mismatch risk with a swap book. The IRS is essential for a functioning commercial banking system.

In IRS, trading desks act as the counterpart of market participants like institutional investors or corporate treasuries. Hence, in all scenarios introduced in Chapter 3.3.1, in which the corporate treasury department enters into a swap, a trading desk of a bank enters into the counter position. This means that if the treasury is the receiver of an IRS, a bank is the payer. A trading desk of a bank provides liquidity, and they are only trading on end clients' requests. As the initiation of the swap is from the customer, it is most likely that the bank wants to change the arising risks position with a hedge in the interbank market. To avoid basis risk, the hedge should be preferably linked to the same reference rate as the trade with the client. Before the reference rate reform, all of the USD IRS were linked to USD LIBOR, which could be easily hedged in the interdealer market. After the reform, requested USD IRS are linked to two different reference rates. As SOFR and CME Term SOFR are both used by end clients for a trading desk, only the SOFR can be traded in the interbank market.

With respect to IRS linked to the CME Term SOFR, however, the ARRC does not recommend that these derivatives should be traded in the interdealer market. Such activity could potentially undermine the underlying overnight SOFR derivatives required to calculate the CME Term SOFR. Thus, the robustness of the rate and its corresponding utility to market participants would be compromised.<sup>62</sup> But since trading USD IRS linked to CME Term SOFR is allowed for end clients' hedging their exposure, the bank ultimately enters in such derivatives, which they cannot directly hedge. Still, they could use SOFR for hedging the CME Term SOFR exposure, but as explained in Chapter 3.2.3 this will lead to basis risk.

In ARRC's 2021 Updated User's Guide to SOFR, multiple dynamic hedging strategies are introduced. Still, these practices involve more trades and, thus, more operational work and higher costs for market makers. Hence, banks oftentimes adjust their pricings for end clients' USD IRS linked to the CME Term SOFR. Furthermore, market makers currently raise concerns about the emergence of a one-sided market of CME Term SOFR. Since banks are now only entering IRS as receivers and clients as payers to hedge cash products. This results in unbalanced market conditions for these IRS.<sup>63</sup>

The other department in a bank trading IRS is the bank treasury. The responsibilities of bank treasuries are similar to the ones of corporate treasuries. The scenarios in Chapter 3.3.1 for changing fixed to floating or the other way around are similar for bank treasuries. But when it comes to asset-liability management, the missing credit component in the new reference rates exposes banks to new risks. Furthermore, banks engage in maturity transformation by borrowing short-term and lending long-term.<sup>64</sup>

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<sup>62</sup> Cf. Alternative Reference Rates Committee (2021b), p. 2.

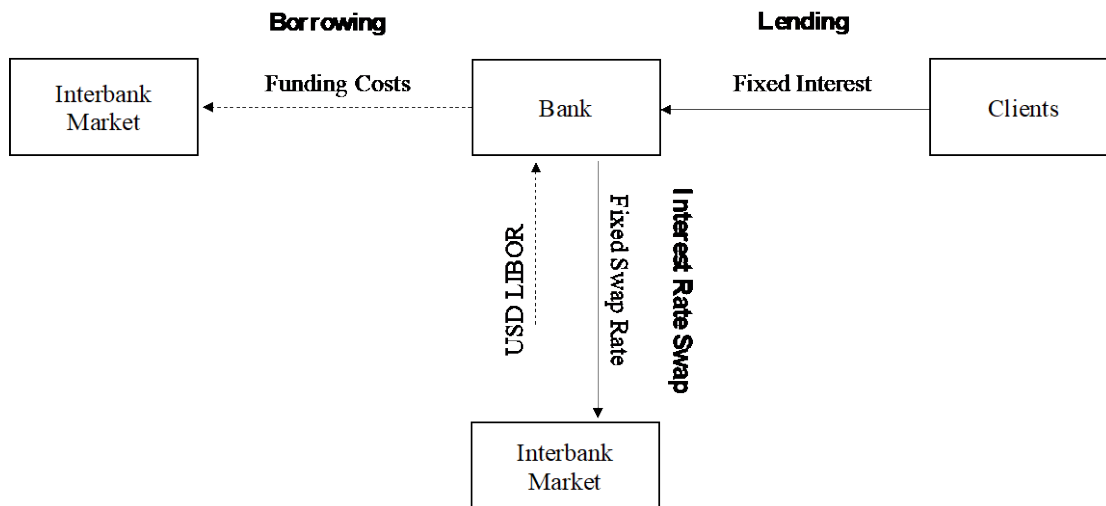
<sup>63</sup> Cf. Alternative Reference Rates Committee (2023c), p.12.

<sup>64</sup> Cf. Schrimpf/Sushko (2019), p. 45.

## US Dollar Swaps after LIBOR

Before the reference rate reform floating rate debt of the client and the banks were referenced to LIBOR. If there was a general increase in the credit spreads of financial intermediaries, this was a natural hedge, as the income of the bank increased in the same magnitude as the refinancing of these positions. After the reform, products are now linked to SOFR and represent the credit risk of the treasury repo-market. First, the income side of the bank will not react to a general increase in credit spreads for financial intermediaries, leading to additional risk, especially in a crisis situation. In the corona pandemic, the refinancing cost of banks increased dramatically and the new reference rate environment would have caused additional risk in a crisis. Secondly, the bank has to increase its credit spreads for debt clients, as the new rate is systematically lower than the old rate due to a change in implicit credit risk and loss of the tenure effects. It is necessary that the client understands the reason for the adjustment, and both parties have to have a common understanding of the magnitude of the adjustment (compare table 5). Figure 11 illustrates the concept of these transactions before the reference rate reform.

**Figure 11: Bank Treasury before the Reference Rate Reform**



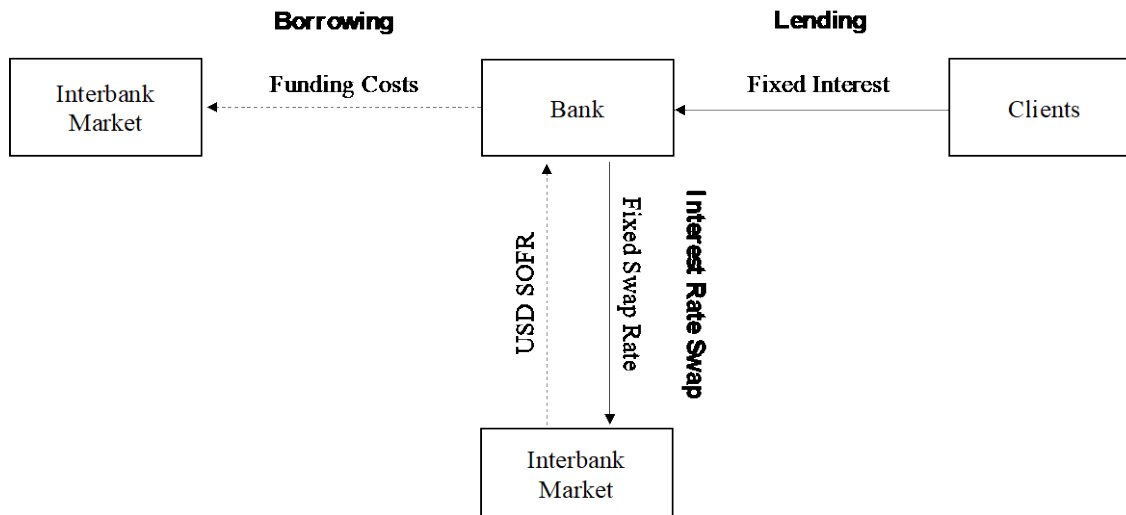
*Source: Own illustration of bank treasury transactions.*

The problem also arises with fixed-rate loans, which were swapped by the bank's treasury to reduce the maturity mismatch of the bank. After the reference rate reform, the funding of the bank is still also linked to the general credit quality of the banks, which was reflected in LIBOR, but the fixed-rate loans to the client remain unchanged. Now, the hedge cannot be done against USD LIBOR anymore but must be linked to SOFR. Hence, with a rise in financial credit spreads, the funding costs will increase while the income is not adjusted, as the floating rate of the IRS remains the same.<sup>65</sup> Figure 12 shows the concept after the reference rate reform.

**Figure 12: Bank Treasury after the Reference Rate Reform**

<sup>65</sup> Cf. Göbel/Heidorn/Huang (2022), p 38.

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Source: Own illustration of bank treasury transactions.

This issue is most pronounced during periods of market stress. In this case, it is likely that the SOFR, which is secured by USTs, will drop. During these periods, there will be a “flight to quality” and investors will invest more in USTs, as they are considered a safe haven. Also the Federal Reserve will take steps to make it easier for market participants to access funds. This decrease in SOFR will lead to a decrease in banks' interest income from SOFR-linked products. In the above example, the floating rate of the IRS would decrease. Conversely, LIBOR and funding costs increase when market stress occurs, as the likelihood of bank defaults increases. The bank may face significant losses during unstable market conditions due to this issue as it is no longer possible to use USD LIBOR as a natural hedge to mitigate this risk.<sup>66</sup>

In his study, Jermann (2021a) explores the impact of bank credit risk and aggregate productivity shocks on bank defaults, investment, and consumption rates. He concludes that replacing LIBOR with SOFR in business loans would result in a rise in bank defaults and a decline in both investment and consumption. Although the effects of this switch are insignificant during stable financial conditions, they become noticeable during large shocks, such as those experienced in the 2008 financial crisis.<sup>67</sup> At the onset of the Covid-19 pandemic and during the global financial crisis, SOFR declined while LIBOR increased. If banks had held SOFR loans instead of LIBOR loans during the global financial crisis, they would have lost interest equal to 1% to 2% of the face value of outstanding loans, which would have meant \$30 billion in missed interest income.<sup>68</sup>

Possible solutions for this issue include tradable credit-sensitive rates like AMERIBOR or BSBY. Since they are not recommended so far, those rates are not offering hedging possibilities for banks right now. The development of credit-sensitive rates has to be watched in the next years. One hedging solution right now could be Credit Default Swaps (CDS), which offer

<sup>66</sup> Cf. Jermann (2021a), pp. 1ff.

<sup>67</sup> Cf. Jermann (2021a), pp. 6ff.

<sup>68</sup> Cf. Jermann (2021b), p. 2.



protection against credit defaults.<sup>69</sup> However, buying credit protection on its own name probably is interpreted by the market as a high likelihood that the own credit quality is deteriorating. Therefore, it would be only sensible to buy a CDS on a financial index. Also, CDS spreads differ from loan spreads, leading to additional basis risk and probably higher costs for banks, as in tendency the CDS spread level is above the loan level for the same credit quality. This is again most pronounced in market stress, where CDS prices can be very volatile. Thus, using CDS for hedging bank funding cannot be a direct replacement for LIBOR.

In conclusion, there are new risks and costs for banks arising from the missing credit component in SOFR and from the regulatory prohibition to trade CME Term SOFR in the interbank market. These could potentially hinder banks' ability to effectively facilitate transactions within financial markets. Moreover, banks might pass on the additional costs resulting from these changes to their clients.<sup>70</sup>

## 4 Conclusion

IRS are crucial financial instruments used by banks, corporate treasurers, risk managers, and investors for various risk management purposes, such as aligning assets and liabilities, managing cashflows, offsetting interest rate risk, and speculation. Before the reform, the USD LIBOR was the standard reference rate, which is now replaced by SOFR. This changes the valuation for US\$ IRS from a multi-curve approach to a single-curve approach. Furthermore, fixing conventions change from in-advance to in-arrears, which is unfavorable for most market participants. Additionally, the SOFR does not capture credit risk changes. The transition of legacy LIBOR contracts is still ongoing but should be completed in 2024.

Market participants now face several challenges resulting from the reference rate reform. Use cases for USD IRS are being affected, necessitating adjustments and adaptations. While the practices of asset liability management for corporate treasuries stay mostly unchanged, they have to cope with a less efficient swap market, wider ask-bid-spreads and a change in credit spreads to name a few. Banks face a one-sided market in the case of CME Term SOFR, where only clients are allowed to hedge their cash exposure, but the banks are unable to hedge the IRS in the interbank market. Dynamic hedging approaches offer some assistance but require additional effort, leading to increased costs passed on to clients by banks.

Secondly, the elimination of LIBOR-linked IRS removes the natural hedging instrument for credit risk in the funding market of banks. As a result, banks are exposed to credit risk that cannot be effectively hedged. This risk becomes more prominent during market stress. To address this concern, market participants and authorities are exploring the development of credit-sensitive rates. However, there is currently no rate available that can accurately capture US banks' funding costs, leaving them exposed to risk on their balance sheets.

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<sup>69</sup> Methodology and function of CDS can be found in Hull (2019).

<sup>70</sup> Cf. Schrimpf/Sushko (2019), p. 40.

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While the EURO market is currently not facing similar issues, there is a potential for similar risks to arise if EURIBOR ceases to exist. Since the transition to new RFRs is an ongoing process in the interest rate markets, market standards are still evolving, and further changes may occur in the future. The new standard IRS for the USD markets is SOFR. However, it is important to note that the conventions described in this paper represent a snapshot of the current landscape and anticipated future developments, and they may change in the future. In conclusion, the reference rate reform represents a substantial endeavor with the goal of establishing stronger rates and improving the trustworthiness of the financial system. Nonetheless, the absence of a credit component in SOFR means that risks persist for market participants, particularly US banks. Therefore, it becomes crucial to develop solutions that enable banks to fulfill their role in financial markets and maintain stability in the banking sector.

From our point of view, the magnitude of the “mistakes” in the LIBOR fixing was small as the switch to SOFR led to a loss in efficiency in the financial market and higher default risks for banks during a crisis. We believe that this is a high price that society has to pay for the new approach.

## Appendix A

$$SOFR\ Average = \left[ \prod_{i=1}^{d_b} \left( 1 + \frac{SOFR_i * n_i}{360} \right) \right] * \frac{360}{d_c} \quad (4)$$

Where:

- $SOFR_i$  = SOFR applicable on business day  $i$
- $n_i$  = number of calendar days for which SOFR, applies (often 1 day, or 3 days for typical weekend)
- $d_c$  = the number of calendar days in the calculation period (that is, 30-, 90-, or 180- calendar days)
- $d_b$  = the number of business days in the calculation period
- $i$  = denotes a series of ordinal numbers representing each business day in the calculation period

$$SOFR\ Index = \begin{cases} 1.00000000, & i = April\ 2, 2018 \\ \prod_{April\ 2, 2018}^i \left( 1 + \frac{SOFR_i * n_i}{360} \right), & i > April\ 2, 2018 \end{cases} \quad (5)$$

Where:

- $SOFR_i$  = SOFR applicable on business day  $i$
- $n_i$  = number of calendar days for which SOFR, applies (often 1 day, or 3 days for typical weekend)
- $i$  = denotes a series of ordinal numbers representing each business day in the calculation period

## Appendix B

The optimization function is designed to solve the following minimization problem:

$$\min_{\theta} \left\{ \left[ \sum_{m=0}^{12} w_m^1 \times (P_m^1 - \hat{P}_m^1(\theta))^2 + \sum_{q=0}^4 w_q^3 \times (P_q^3 - \hat{P}_q^3(\theta))^2 \right]^{\frac{1}{2}} + \lambda \times \left[ \sum_k (\theta_k)^2 \right]^{\frac{1}{2}} \right\}$$

Where:

- $P_m^1$  and  $P_q^3$ : the observed blended prices of SR1 and SR3 contract with reference month  $m$  and reference quarter  $q$ , respectively;
- $\hat{P}_m^1(\theta)$  and  $\hat{P}_q^3(\theta)$ : the implied value of SR1 and SR3 contract with reference month  $m$  and reference quarter  $q$ , respectively;
- $w_m^1$  and  $w_q^3$ : weighting parameters for pricing errors of SR1 and SR3 with reference month  $m$  and reference quarter  $q$ , respectively;
- $\lambda$ : weighting parameter for penalty function.  $\lambda = \frac{0.1}{\sqrt{K}}$  where  $K$  is the number of scheduled FOMC meetings in the period.

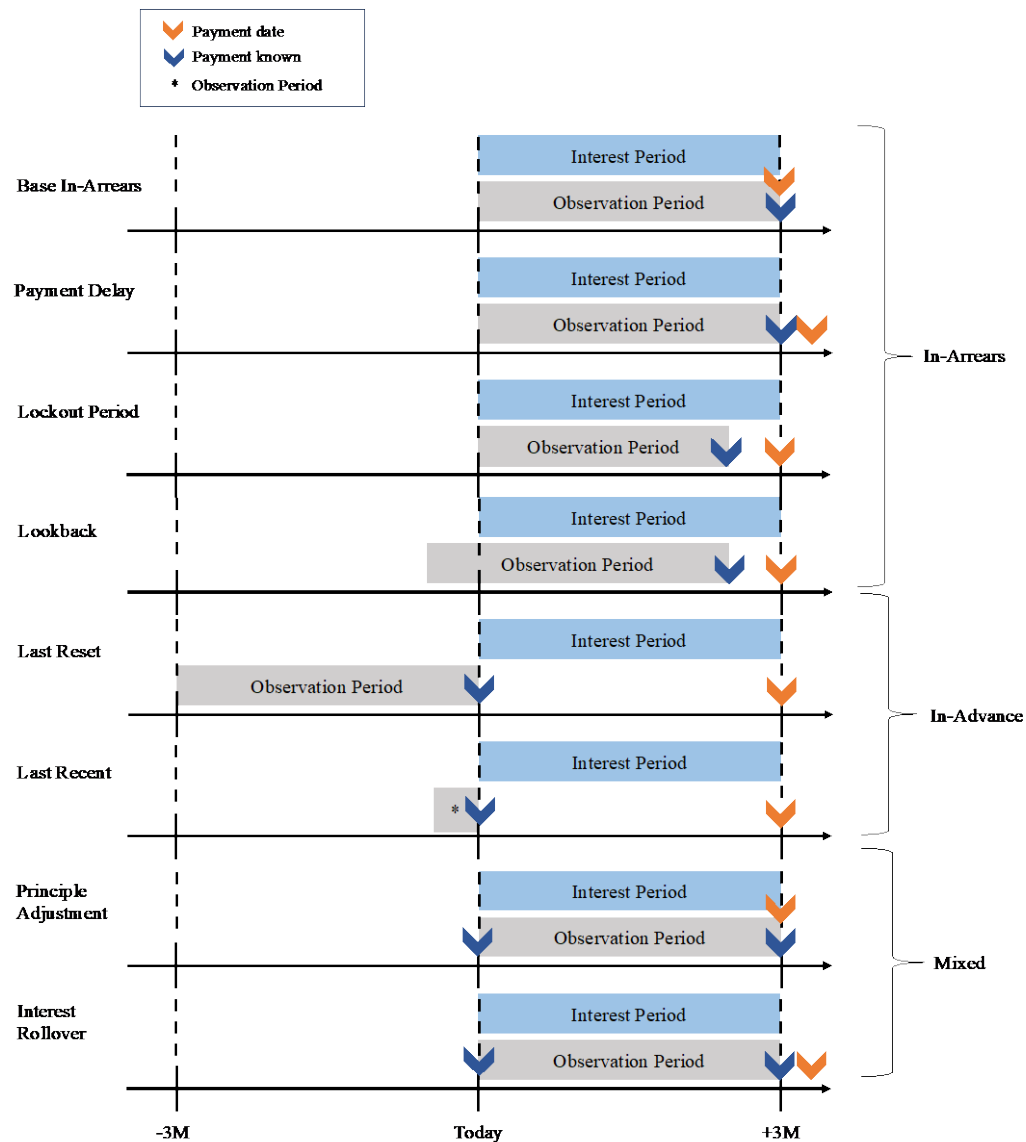
Term Rates are derived by compounding the overnight SOFR rates over one, three, six and twelve months. The compounding follows conventions listed as below:

$$h(T) = \frac{360}{T} \times \left[ \prod_{t \in \tilde{T}(T)} \left( 1 + \frac{f(t; \theta) \times d_t}{360} \right) - 1 \right]$$

- $\tilde{T}(T)$ : the set of Business Days from the term start date to date  $T$  days in the future. Each term tenor will start on (and include) two Business Days following the publication day, based on Following convention. The term rate will span the corresponding tenor (e.g., 1-month, 3-month, 6-month, 12-month which is represented by  $T$  days in the formula) in accordance with Modified Following conventions.
- $t$ : a Business Day in set  $\tilde{T}(T)$
- $d_t$ : the number of calendar days from date  $t$  to its next Business Day following the SIFMA US Holiday Schedule, if the next Business Day is no later than the end date of SOFR term rate; otherwise,  $d_t$  is equal to the number of days from date  $t$  to the end date of SOFR term rate.
- $f(t, \theta)$ : the overnight SOFR rate as of date  $t$ .

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## Appendix C



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