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## US\$ interest rate and cross currency swaps after the LIBOR funeral: A corporate treasury primer

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# **Frankfurt School – Working Paper Series**

**No. 236**

## **US\$ Interest Rate and Cross Currency Swaps after the LIBOR Funeral**

### **A Corporate Treasury Primer**

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March 2025



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## Abstract

This paper examines the transition from LIBOR to SOFR in the US and maps out the consequences for European corporate treasurers by showing how the application of SOFR in cash products and derivatives differs from LIBOR. As interest rate and cross-currency swaps transition to compounded SOFR, corporates may face a trade-off between the higher costs of using Term SOFR versus facing operational difficulties with their internal treasury systems when using compounded SOFR in arrears. With respect to European corporates, challenges arising from the new in arrears conventions should be less pronounced since EURIBOR coexists next to €STR, which means that corporates may continue to use term rates set in advance when they choose to swap U.S. dollar exposure into euros.

Key words:

LIBOR  
Benchmark Reform  
SOFR  
Term SOFR  
RFRs  
Interest Rate Swaps  
Cross Currency Swap  
Corporate Treasury

JEL classification: G12, G23, G28

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## 1. Introduction

For decades, Interbank Offered Rates (IBORs) were the most important short-term benchmark rates in the financial world, serving as a reference for the pricing of a wide range of financial products. Both cash products as well as derivatives, especially interest rate swaps, were set and referenced on the London Interbank Offered Rate (LIBOR) – a volume worth the equivalent of US\$ 400 trillion in mid-2018 (Schrimpf and Sushko 2019).

The financial crisis changed the public perception of IBORs – declining interbank market activity and serious allegations of manipulation compromised the integrity of IBOR-benchmarks, creating a momentum for reform towards alternative reference rates. Authorities across jurisdictions began to develop and publish new or reformed benchmarks to largely replace IBORs, culminating in a speech by Andrew Bailey (2017) who announced that the publication of LIBOR could not be guaranteed beyond 2021 – a speech commonly referred to as the "LIBOR funeral".

In their search for reliable alternatives to LIBOR, regulators have largely opted for transaction-based risk-free overnight rates (RFRs). Although the concrete implementation varies across jurisdictions, with some entirely replacing LIBOR like the US and others opting for a dual approach like the Eurozone, the RFRs are meant to become the new main benchmarks in financial markets. However, the transition from credit-sensitive term rates to risk-free overnight rates creates challenges especially for the corporate treasury.

This paper aims to provide European corporate treasurers with the necessary knowledge to navigate in the new reference rate environment, covering everything from the most important methodologies of the new risk-free benchmark rates to the implications for the most commonly used financial products as well as the challenges that arise.

The rest of this paper is organized as follows: Chapter 2 provides a brief history of benchmark interest rates, with a special focus on LIBOR and its methodology. Chapter 3 discusses the benchmark reform by examining the initial LIBOR scandal and the concrete steps that were implemented thereafter by the authorities. Chapter 4 describes how the SOFR as an overnight rate can be applied as a term rate. Chapter 5 shows how the reform translates into the most important financial products, namely loans, interest rate swaps and cross-currency swaps and discusses the challenges for corporate treasuries. Chapter 6 summarizes our key results and concludes with a brief discussion of the limitations and the outlook for future challenges and research.

## 2. The role of Benchmark Interest Rates

### 2.1 Definition and literature overview

Benchmarks are an important element of financial markets. Trillions of dollars were negotiated by referencing the margin as a spread over IBOR-rates. Interest rate derivatives such as swaps, futures and FRAs (Forward Rate Agreements) directly rely on benchmarks and exhibit a variety of different reference rates that are used (Huang and Todorov 2022). This chapter provides a brief overview on benchmark concepts, before turning to the challenges of the transition from LIBOR to SOFR (Secured Overnight Financing Rate).

In general, benchmarks are typically used in Over-the-Counter (OTC) markets. It is easier for users to evaluate products, as benchmark prices can increase transparency (Duffie, Dworczak and Zhu 2017; Bessembinder, Maxwell, and Venkataraman 2006). This increased transparency has multiple positive effects: It reduces search costs for investors as they have a reference for price comparison. This leads to a positive influence on trading volume and liquidity. In practice, these considerations have largely been confirmed. Studies investigating the US corporate bond market have found that the introduction of the TRACE reporting system has largely (although not always) lowered bid-ask spreads of corporate bonds (see for example Bessembinder, Maxwell, and Venkataraman 2006 or Goldstein, Hotchkiss, and Sirri 2007).

Historically, most interest rate products were traded over the counter. And, although some changes in the market can be observed (e.g., the clearing of swaps at central counterparties), the basic structure has remained the same. Interest rate benchmarks emerged in the late 1960s but became particularly important in the 1970s, when variable rate lending increased strongly, due to the macroeconomic environment at that time with strong inflation and volatile interest rates. Corporates demanded loan products that would adapt to the changing interest rates, which in turn required transparent benchmark rates that could be used as a reference and were publicly available (Cox, Ingersoll and Ross 1980; Agmon, Ofer and Tamir 1981).

The role of benchmark rates became even more important with the emergence of the swap markets in the late 1970s and its rapid growth in the 1980s. As both interest rate and cross-currency swaps have floating legs, these products were in need of reliable reference rates to calculate the variable payments on a daily basis. On top of that, the payment frequencies may differ, which meant that swaps needed reference rates for these different tenors.

The benchmark interest rates that were used ranged from survey-based rates like the U.S. Prime Rate or LIBOR to observed market rates like T-Bills. This variety is one of the reasons for the large volume of basis swaps, exchanging two floating legs with different reference rates (BIS 1986).

## 2.2 LIBOR – Methodology and Success

LIBOR became the dominant benchmark and reference rate for products that rely on term rates to calculate their cash flows. LIBOR was standardized by the British Bankers' Association in 1986. LIBOR rates were calculated for a set of currencies and maturities that would grow over the course of decades. For each currency-maturity pair, there was a unique set of panel banks of which every bank would deliver a submission to the following question:

“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?”

This set of individual bank submissions was then ordered, before the top and bottom four responses were discarded. The remaining values were averaged, arriving at the LIBOR fixing for the respective currency-maturity pair (Hou and Skeie 2014; Tuckman 2023). On its height in 2012, LIBOR was calculated for 10 currencies; a figure that would drop to 5 currencies by October 2013 (Hou and Skeie 2014; Schrimpf and Sushko 2019).

As with every survey-based approach, the design of LIBOR possessed some weaknesses. The wording in the above-mentioned question is very ambiguous, such as the term “reasonable market size”. However, the process was very simple to implement, transparent and easy to understand as long as the individual submissions are known and trusted. This transparency is one of the reasons why LIBOR became so successful and the dominant reference rate. In fact, the simple design by the BBA back in 1986 created a rate that possessed almost all the necessary characteristics needed for a successful benchmark. Other posted rates such as the Prime Rate were only available for one tenor and showed great dispersion between the different banks (Duffie and Stein 2015). LIBOR rates on the other hand were reliably available on every business day for all relevant currencies and maturities as there was one entity in charge of administration, which was organized privately without influence from government bodies. The rates were survey-based, meaning that they did not respond to safe haven demands like T-Bill market rates and were thus also not exposed to pronounced volatility due to technical factors (Financial Stability Board 2014; Duffie and Stein 2015). LIBOR was a transparent benchmark rate for all relevant currencies and maturities that reflected banks’ funding costs without exhibiting volatility resulting from technical factors. However, the survey-based approach was largely based on trust as submissions were not necessarily backed by hard data points. This key drawback became apparent in the Great Financial Crisis – leading to the benchmark reform and transition to SOFR.

### 3. The Benchmark Reform

#### 3.1 LIBOR Scandal

Despite the popularity and transparency of LIBOR, the methodology also introduced a unique conflict of interest for the panel banks. According to Ellis (2011), banks with significant derivatives exposure are incentivized to misquote their respective borrowing costs to increase profits. This holds on an organizational level and on an individual level, since bankers’ bonuses are often dependent on profits. However, especially during times of financial distress, banks also have an incentive to artificially lower their reported funding cost to retain their creditworthiness and the reputation in the interbank market (Mollenkamp 2008).

Articles in the Wall Street Journal highlighted a potential misquotation of the LIBOR reference rate as early as 2008. In 2012, Reuters (2012) reported that the Federal Reserve Bank of New York was aware about potential manipulation since 2007 and reported those findings to senior Federal Reserve officials in 2008. Subsequently, articles and allegations claiming that the LIBOR benchmark was incorrectly submitted by the banks started to pile up. This led to investigations by the Commodity Futures Trading Commission (CFTC) and by the Financial Service Authority (FSA). They found that some of the panel banks falsely reported their funding costs to improve their proprietary trading positions (Gensler 2012), leading to record fines across the banking sector. This incident deeply disturbed the trust into the LIBOR benchmark rate and highlighted the flaws of the established system. In the aftermath, regulatory bodies across the globe combined their efforts in order to reform the system of reference rates, ensuring safety and stability for the global markets.

## 3.2 Reforms

The following chapter illustrates the most important aspects of the benchmark reforms in the Eurozone and in the United States. The euro and U.S. dollar markets are by far the biggest for OTC derivatives, as the outstanding notional exceeds US\$140 trillion, more than all other currencies combined (BIS 2024). Also the U.S. is the largest financial market, the authorities within are pioneering for other jurisdictions. Therefore, there are no major differences compared to the risk-free rates in the rest of the world. This paper covers the perspective of a European corporate treasurer.

### *United States*

In 2014 the Federal Reserve formed the Alternative Reference Rates Committee (ARRC), a committee consisting of Federal Reserve officials as well as representatives from selected market participants. This committee was tasked with exploring the possibilities for a new reference rate. The objectives of the ARRC included the identification of best practices for an alternative reference rate, evaluation contract robustness as well as the development of a concrete adoption plan, combined with metrics for the measurement of success and a timeline.

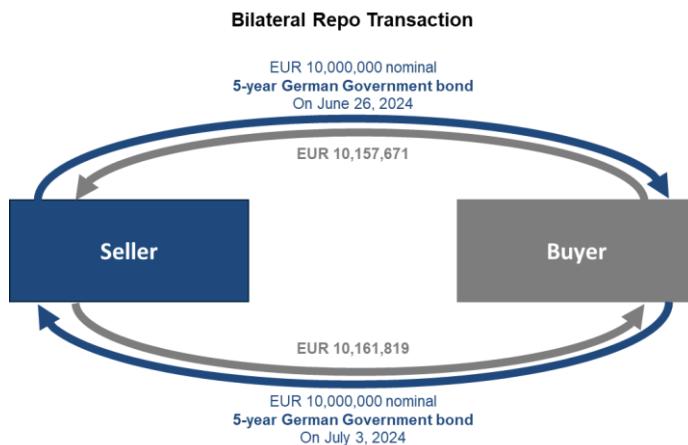
During their search for an alternative rate, the ARRC focused on a few key characteristics they deemed essential for a reference rate: Firstly, a reference rate should be nearly risk free. Secondly, the market on which the reference rate will be based should be deep and liquid, ensuring the availability of eligible data points at all times and providing an honest representation about the current state of the market. Furthermore, the reference rate should be robust over time and be useful for all market participants to provide a real alternative for the prevailing LIBOR rates. From a practical point of view, the new reference rate should be as easy to produce and maintain as possible. In the end, the ARRC narrowed it down to two types of interest rates as final candidates for the new reference rate (ARRC 2016).

The choice was between unsecured lending rates, the Effective Federal Funds Rate (“EFFR”), and General Collateral Repo Rates (“GC Repo Rates”). The EFFR covers “domestic unsecured borrowings in U.S. dollars by depository institutions from other depository institutions and certain other entities, primarily government-sponsored enterprises.” (New York Federal Reserve 2024a). EFFR shows consistent transaction activity and with a daily volume of US\$ 70bn. It is calculated as a volume-weighted median rates, which makes the calculation easy and transparent.

However the ARRC suggested GC Repo Rates, which are based on Repurchase Agreement (“Repo”) transactions. A repurchase agreement can either be between two parties (“bilateral”) or include a third party. During a repurchase agreement, one party sells securities, usually highly liquid and highly rated fixed income securities, to another party and agrees to buy them back at a future point in time. The price at which the securities are bought back is normally higher than the initial selling price. This price difference is quoted on a “per annum” basis and is known as the Repo Rate. This type of transaction has the advantage that in case of a default of the securities seller, the other party is still in possession of the collateral and is able to sell it on the market (ICMA 2024a). A tri-party repo simply adds an intermediary in the middle which takes care of contractual details like collateral selection, payments and deliveries,

custody of collateral securities or collateral management (ICMA 2024b). A typical repo transaction is illustrated in Figure 1. Repos are widely used and exhibit an extraordinary trading volume compared to other rates. In December 2017 the Federal Reserve announced the publication of the Secured Overnight Funding Rate (“SOFR”), which effectively included all the characteristics previously laid out (Board of Governors of the Federal Reserve System 2017). This rate is calculated as a volume-weighted median, using bilateral and tri-party repo transactions (New York Federal Reserve 2024c).

**Figure 1: Stylized bilateral repo transaction involving a 5y German government bond**



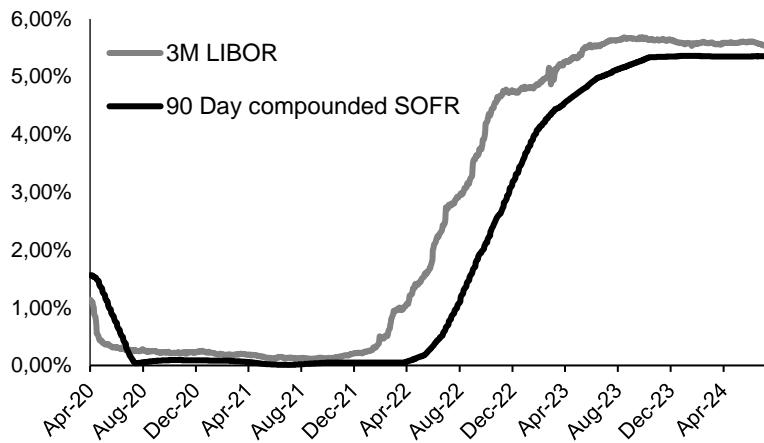
*Source: ICMA, own illustration*

In 2018, the ARRC formally made its decision, recommending the SOFR published by the Federal Reserve as alternative reference rate. In their view, the US\$ 700bn daily trading volume provided a broad coverage of the market and was a good representation of actual funding costs across a wide array of market participants. For the unsecured rates, the ARRC feared that the decline in unsecured, short-term lending, especially after the money market fund reform, would continue and the market would lose liquidity in the long term. In the end, the secured lending market was simply considered more resilient in times of financial distress. On March 5, 2021 the Financial Conduct Authority (“FCA”) announced that LIBOR publications will finally cease to exist on June 30, 2023, where a synthetic LIBOR based on a changed methodology was available during the transition period (FCA 2021).

In order to fully understand the consequences of the benchmark reform in the United States it is essential to highlight the differences between the LIBOR rates and SOFR. Contrasting, other jurisdictions like the Eurozone still use panel-based term rates. SOFR is primarily based on actual, executed transactions, whereas LIBOR only takes into account the idiosyncratic expectations of each panel bank regarding their own funding costs. Secondly, SOFR is an overnight rate, compared to the LIBOR rates as term rates. Therefore, it is difficult to create a rate for a longer time horizon (e.g. 6-months). Also, the daily SOFR rates are more volatile

compared to LIBOR. However, in case of longer time horizons, the compounded SOFR rates over these periods are on average less volatile than their respective LIBOR counterpart, as shown in Figure 2.

**Figure 2: 3M US\$-LIBOR vs. 90d compounded SOFR**



*Source: Bloomberg*

A crucial point in moving from LIBOR to SOFR is the notice of payment. SOFR is backward-looking and mostly fixed at the end of the interest rate period (in arrears), whereas LIBOR is a forward-looking rate, thus mostly fixed in advance. This leads to a substantial challenge for liquidity planning and IT system changes for corporate treasuries. The implications from the different methods of fixing are discussed in chapter 5. Also LIBOR reflects credit risk and term structure premium, while SOFR is based on secured lending transactions. Therefore, both components are eliminated. As credits are typically priced against the swap rate (mid swap), it is a challenge to reflect these changes in the new spreads.

#### *Eurozone*

In the Eurozone, the body responsible for the development of an alternative reference rate was the Working Group on euro risk-free rates and was announced by a group of European institutions in September 2017. The reference rate should firstly be based on broad, reliable market data. Furthermore, it should be nearly risk-free and sufficiently sensitive to monetary policy changes from the ECB. For the data, the Working Group on euro risk-free rates recommended using clearly defined transaction data. It should be easily accessible, and the calculation of the respective rate should be transparent, monitored by a reliable administrator. From all available rates, the working group identified 3 potential candidates: The GC Pooling Deferred Rate, the Repo Funds Rate and the Euro Short-Term Rate (“€STR”) (ECB 2018).

Finally, €STR, was announced by the ECB in September 2017 as a newly published, unsecured overnight borrowing rate, based on daily Money Market Statistical Reporting (“MMSR”) data (ECB 2018). For the calculation of the rate, only overnight unsecured fixed deposit transactions with a volume over € 1 million are considered. All eligible transactions are sorted, from the lowest rate to the highest rate. At each level, transactions are aggregated and the top and bottom 25% in terms of volume are removed. Finally, the remaining 50% of the volume-weighted distribution of rates are used to calculate the mean and arrive at the final

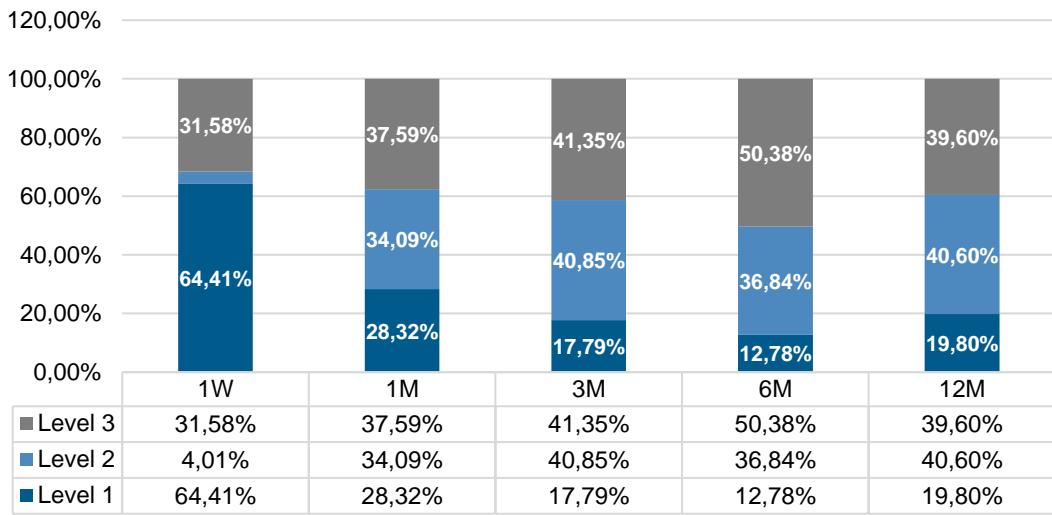
rate. A pro rata calculation is applied to volumes that span the thresholds for trimming to ensure that exactly 50% of the total eligible volume is used in the calculation of the volume-weighted mean (ECB 2021). The working group formally recommended €STR as the new overnight risk-free rate, replacing the prevailing EONIA.

In contrast to LIBOR the administrator of the EURIBOR rate, the European Money Market Institute, decided to rework their calculation methodology. Originally, EURIBOR was calculated similarly to LIBOR: Banks were submitting their estimated funding costs for a series of maturities. Then a percentage of the highest and lowest quotes were discarded to eliminate outliers and the remaining quotes were aggregated to form the EURIBOR rates (ISDA 2019). Under the new methodology, the EMMI opted for a hybrid approach. From now on, panel banks submit eligible transactions from the prior TARGET-day to the EMMI, which uses those quotes to calculate the EURIBOR rates. The submission of transaction data is based on a waterfall approach, consisting of three levels. For Level 1, the panel banks are only allowed to submit transactions from the prior TARGET-day, only at exactly the defined tenors. Should there not be any exact transaction data available, banks are allowed to move on to Level 2. For the second level, banks are allowed to submit transactions across the broader money market spectrum. These can include interpolated transaction data from adjacent defined tenors, transactions at non-defined tenors or historical level one contributions. Over the first two levels, the EMMI has the calculation authority. Originally, if there is no data for Level 1 and 2 available, the banks were allowed to submit quotes from their own data and models as Level 3 submissions (EMMI 2019) however this was abandoned in 2024.

Even though the reformed EURIBOR methodology aims at increasing the credibility of the EURIBOR benchmark and limiting expert judgement during the determination process, the results were insufficient. Figure 3 shows that as of April 2024, apart from the 1-week-tenor, no tenor of the EURIBOR rate is based on a majority of Level 1 contributions, which represent actual transactions. Instead, Level 2 and Level 3 make up the majority of contributions for the longer tenor, both including calculations and expert judgement (EMMI 2024).

EFTERM is the expected (i.e., forward-looking) average evolution of wholesale euro unsecured overnight borrowing costs of euro area banks over defined tenor periods, which is based on €STR-derivatives, and administered by the EMMI, which can be used to measure the market movements of interest rates during the days without an available data point. Finally the EMMI decide to use it to replace the Level 3 contribution, effectively eliminating expert judgement from the methodology (EMMI 2024).

**Figure 3: Contribution of the 3 levels of data submission for different tenors as of April 24**



Source: European Money Market Institute

## 4. Using an Overnight Rate as a Term Rate

### 4.1 SOFR as a Term Rate

SOFR is an overnight rate and thus, unlike LIBOR, does not have different maturities. However, in most financial instruments payments shall not be made daily, but periodically (mostly quarterly or semi-annually). These instruments therefore require reference interest rates that can be applied for these maturities and are available on a daily basis. Hence, the overnight SOFR rates must be converted into term rates in order to replace LIBOR as the reference interest rate.

Financial markets already have experience in dealing with overnight interest rates. The most important instrument in this regard is the overnight index swap, in which the floating legs are referenced to an overnight interest rate (before SOFR was introduced in the US, these products typically referenced the EFFR) and whose trading became established globally around 20 years ago (Choy 2003; ARRC 2019).

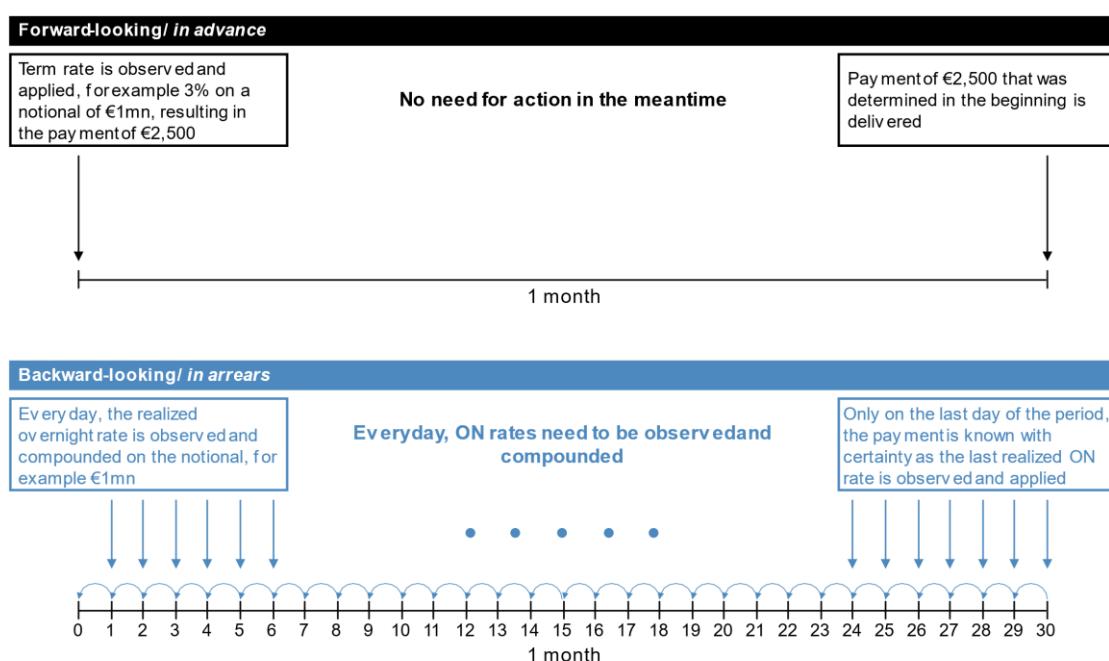
In order to convert an overnight rate into a term rate, the average of the overnight rate over the relevant interest period must be used. Assuming the interest period begins at  $t = 0$  days and ends in  $T = 90$  days, the resulting term rate is the average of all overnight rates that occur within this period. There are two main reasons for using averages instead of applying the overnight rate directly: Firstly, relying on a pure overnight rate would create a maturity mismatch for the product. If an overnight rate is applied for a payment covering an interest period of one or multiple months, the overnight rate will not capture the interest rate development over that period and hence will not accurately reflect the time value of money. Secondly, overnight rates exhibit idiosyncratic volatility. These day-to-day fluctuations make a pure overnight rate unattractive. Averages smooth out volatility, and are preferable in terms of accuracy as well as certainty of the amounts of payments. When designing the term rate via

averages of overnight rates, the average could be calculated arithmetically or compounded. Also either *realized* (backward-looking) or *expected* (forward-looking) overnight rates are used for determining the rate, which has an impact on the *notice of payments*.

### Backward-looking / in arrears

The use of *realized* overnight rates to calculate a term rate is preferable in terms of accuracy, as this precisely reflects what *actually happened* within the interest period. One drawback of this method is the impact on the *notice of payment*. As the notice of payments occurs at the end of the interest period, it is typically referred to as *in arrears*. As the time difference between the date on which the magnitude of the payment is known with certainty and the payment itself is very short this might create substantial difficulties for corporate clients in respect to liquidity planning and adapting treasury systems. Especially for borrowers prefer to know the amount of their payments well ahead of time (ARRC 2019). Therefore, while payments *in arrears* might be more accurate, it is operationally more difficult to implement. Figure 4 on the next page illustrates the differences of the different methods.

**Figure 4: Differences when using in advance compared to in arrears**



Source: Own illustration

### Forward-looking / in advance

Before the benchmark reform, the payments due on the floating leg of most contracts referencing LIBOR were determined or in advance of the interest period. Since IBORs were published for a variety of tenors, the maturity of the interest period and the reference rate applied were congruent. With the maturity mismatch between longer interest periods on the one side and overnight rates on the other, market participants can either apply an average of overnight rates that occurred in the previous period or use a term rate which is known in advance. Especially for liquidity planning corporates prefer the fixing in advance.

While banks are already experienced with financial instruments determining floating payments in arrears and are used to daily changing liquidity positions, other market participants like corporate or private borrowers tend to value certainty of the payment amounts as most important. In the UK for example, the “Working Group on Sterling Risk-Free Reference Rates” has issued an in-depth analysis focusing on the different use cases of term rates (Bank of England 2020). In this document, the working group laid out criteria along which it is possible to understand the different situations in which in advance or in arrears would be the most advantageous or recommended solution to be applied. Similar studies have been conducted by the ARRC (2019) and the Financial Stability Board (2018, 2021), Table 1 shows which method the bodies recommend for various products / clients in financial markets. These recommendations are primarily based on the assessment of how well the proposed method could be implemented. Depending on the conviction, the cells in the last column are therefore kept in different colors to illustrate the different gradations of feasibility the sources expect.

Creating an in advance solution by applying an average of overnight rates that occurred over the previous period to the beginning period would result in a mismatch and will thus be always outdated. The ARRC has suggested different hybrid models to cope with these mismatches, however, it is beyond the scope of this thesis to inspect those. Readers who are inclined to know more about these models may refer to the documents by the ARRC (2019, 2021a).

Mostly corporates in the US\$ world tend to apply a term rate constructed from derivatives based overnight rates. Such a term rate would be based on the new benchmark rates while exhibiting the same payment characteristics as LIBOR, since these rates would be available on a daily basis and could be used to determine payments in advance over different tenors. Possible ways of constructing such a term rate and the term rates that have been established in the markets are described at the end of the chapter.

**Table 1: Overview of different products and their recommended rates**

Product	Client details	Description	Recommended Rate
Bonds / Loans / Trade	Sponsor / Leverage Large Corporate	Corporate Deals / Sponsor lead acquisitions	Compounded <i>in arrears</i>
	Financial Institutions	Banks, insurance providers, asset managers, funds, broker dealers, ...	Compounded <i>in arrears</i>
	Mid to Large Corporates	Annualized revenue >US\$25m and deal size US\$10-US\$25m	Compounded <i>in arrears</i>
	Project Finance	Financing of major independent capital investments	Compounded <i>in arrears</i>
Loans / Trade	Real Estate	Commercial Real Estate firms	
	Export Finance	Funding for CapEx with export finance guarantee	
	Emerging Markets	Lending to Emerging Markets	
	SME Corporates	Annualized revenue <US\$25m	Alternative <i>term rate</i>
	Retail Mortgages	Retail clients	
	Wealth / Private Bank	-	

### The choice of simple and compounding interest

Apart from deciding on expected or realized overnight rates, market participants have to decide whether they want to use an arithmetic average (i.e., applying a simple interest convention) or a geometric average (i.e., applying a compound interest convention) of the overnight rates over the given period. The choice of how interest is accrued has quite important implications as it may create basis risk in the process of hedging. We explain both methods in this section very briefly.

Simple interest is a long-standing convention in which interest is calculated only on the principal amount. If applied on longer periods, the interest amount grows by applying the daily interest rate to the principal amount and summing up these individual payments. The principal amount stays unchanged.

Compound interest on the other hand applied the daily interest rate to the principal amount and the interest that has been accumulated but not yet paid, which effectively means that the former (not yet paid) interest payments are added on top of the principal. Economically, it captures the time value of money – in difference to the simple interest convention. Most products use compound interest, as this fits to a sequence of overnight investments.

## 4.2 Construction of forward-looking term rates

### Methodology

While the in arrears solution might work especially for financial institutions, most corporate and retail clients prefer an in advance solution that provides them with sufficient notice of the payment amount.

A forward-looking term rate based on SOFR needs to be based on derivatives that trade prices for longer maturities. Hence, when considering liquidity, a forward-looking SOFR term rate would either be based on futures referencing SOFR, OIS referencing SOFR or a combination of both (ARRC 2019, 2021). Interest rate futures pay the realized (simple or compounded) average of the rate they reference over a given period (usually a month or a quarter). Overnight index swaps reference overnight rates on the floating leg and pay the compounded average of the overnight rates that occurred over the respective period.

Theoretically, OIS referencing SOFR would return the “purest” forward-looking term SOFR rate. As the floating leg pays compounded SOFR in arrears at the end of each period, the fixed leg and therefore the fixed rate represents the traded interest rate for that period (e.g. 6 months). Hence, the fixed rate (i.e., the OIS swap rate) is a forward-looking SOFR term rate. OIS contracts are collateralized on a daily basis to reflect changes in the NPV. This collateral is discounted using the (SOFR) OIS curve, which means that SOFR OIS swaps do not require a multi-curve approach for its valuation.

Additionally, OIS are traded every day for all relevant maturities (1M, 3M, 6M, ...) which means that no interpolation is needed but the swap rate itself can be used as a sufficient forward-looking term SOFR rate.

The alternative instrument would be futures that reference SOFR. Just as Eurodollar futures that referenced LIBOR (usually 3M LIBOR), SOFR futures pay an average of SOFR over the given period. Interest rate futures typically reference periods of 1 or 3 months and apply an arithmetic average for the first and a compounded average for the latter. In difference to OIS, futures contracts have a fixed maturity when they are settled in cash (for interest rate futures in the US these are referred to as IMM dates). Inferring rates from futures is therefore more difficult compared to OIS. The Fed has published a working paper that laid out a potential framework for inferring these rates which is employed in practice, and will be explained later in the chapter.

In general, using OIS would be the best approach for inferring term SOFR rates in terms of accuracy. The ARRC has acknowledged that in two of their reports and emphasizes that “the forward-looking term rates are simply segments of the underlying SOFR OIS curve” (ARRC 2019). However, OIS are traded frequently over the course of a day and naturally experience intraday fluctuation. This raises the question: Which OIS rate is the “daily” rate? One might use the end-of-day prices, a volume-weighted average price, or another method. However, OIS are traded over the counter, meaning that aggregating all OIS trades that occurred over the course of the day is difficult, even for regulators, which poses serious problems. As described before, the main reason why LIBOR prevailed over other rates was the transparency

of how the rates were arrived at and a clearly responsible entity that managed and monitored the process of data collection.

The ARRC favors the approach of using futures as those are centrally traded on an exchange with one entity responsible for facilitating and settling the trades. This entity (i.e., the exchange itself) would be able to collect the data of all transactions necessary to calculate a rate for each specified maturity every single day. There would be no ambiguity about which rate to apply, as there would be one reference rate for each maturity available per day. The ARRC and similar bodies from other countries have recognized this tradeoff, too. The ARRC (2021a) for example favors an approach where term rates are calculated from futures as the data is timely available while controlling whether these rates are deviating too strongly from quotes observed in the OIS market. The practical solution via the CME that publishes a term SOFR rate closely follows these recommendations.

### **Differences of SOFR and IBOR term rates**

Independent of whether a term SOFR rate is applied in advance or in arrears, there are key differences to the term IBOR rates formerly used.

SOFR is a risk-free reference rate, as it reflects the conditions of collateralized overnight borrowings, which means it embeds no or a negligible credit risk, in difference to LIBOR as a credit-sensitive reference rate. As LIBOR rates reflected the conditions of unsecured interbank lending for different tenors, they consisted of a credit premium (credit spread) and a tenure (premium), as yield curves are typically non horizontal (Klingler and Syrstad 2021). Because term SOFR rates are averages of multiple (expected or realized) risk-free overnight rates, they will not exhibit any of these premiums, in difference to LIBOR. During the end of the negative interest period in the €-area, the market traded negative ON but positive 3 and 6-month rates. It is clear that by compounding negative ON it is impossible to get positive rates.

Market participants have made the argument, that loan revenues that are linked to credit-sensitive reference rates like LIBOR act as an implicit insurance to banks against risks to their funding costs (Marshall et. al. 2019, Jermann 2019). SOFR as a risk-free rate will not be as effective as LIBOR for hedging these risks (Jermann 2021). Especially during times of stress, where funding costs of banks rise, risk-free rates would not exhibit such an increase or would even fall (lender of last resort). A loan linked to a credit-sensitive rate would reflect this increase in funding costs while a loan linked to an RFR would not. In that case, the return on an RFR-linked loan would stay unchanged; while the banks' unhedged cost of funds would increase, resulting in a mismatch between the banks' assets and liabilities. As the banks will pass that risk by increased spreads to the client, RFR indexed loans will be more "expensive" for the user compared to LIBOR products.

The ARRC (2020a) emphasizes, a main reason for the benchmark reform was the declining market activity of unsecured term interbank borrowing. This raises the question whether the concerns are overstated as the exposure of banks to these sudden increases in costs of funds might be sufficiently small. Also, banks successfully deal with the remaining risk by applying the credit-spread component of their own funding risk on RFR-linked loans. In market practice, this is called "funding value adjustment" (Andersen, Duffie and Song 2019).

Another difference is that term rates based on overnight RFRs do not contain a term premium. The concept of a term premium is well known in the bond markets, especially for long-term yields (see for example Adrian et al. 2013 or Kim and Wright 2005). The term premium compensates lenders for committing funds over a longer period of time instead of “rolling” over. Term rates based on overnight RFRs however do not contain a term premium by definition, as the investors “rolls” from day to day, therefore never committing funds for a period of longer than 1 day. This means that apart from the credit premium, the spread that is paid by a borrower in a SOFR-linked loan will have also to reflect a term premium.

## 4.3 CME Term SOFR

### *Methodology*

In their 2nd Report, the ARRC already raised the question, whether a SOFR-derivatives-based term rate would be beneficial for the market, as this might ease the transition for users of cash products away from LIBOR. In May 2021, the ARRC published a number of factors, they deemed would be favorable for establishing such a term rate. For the role of sole administrator, the ARRC selected the Chicago Mercantile Exchange (CME) (ARRC 2021b).

The CME publishes the Term SOFR every day on their website, for the most common maturities: 1 month, 3 months, 6 months, and 12 months. For the calculations, the CME uses 13 consecutive one-month SOFR futures (“SR1 futures”) and 5 consecutive three-months SOFR futures (“SR3 futures”), with settlement on the end of each quarter (March, June, September and December), since those futures are the most traded three-months contracts, according to Table 2.

The calculation methodology starts with the data collection. For each traded futures maturity the CME splits the trading day into 14 equal trading intervals. Ideally, there are executed transactions during each interval which can then be used as pricing points. However, should that not be the case, the midpoints of executable bid-ask-quotes are used as data points. An optimization algorithm is used to identify the set of prices for each interval with the lowest violations of the bid-ask-constraints. The interval prices are then aggregated on a volume-weighted basis.

**Table 2: Overview of different CME 3-months SOFR Futures**

The table shows the trading statistics for CME 3-months SOFR Futures of different maturities. Data Sources: Own depiction of the statistics from the Chicago Mercantile Exchange as of July 17, 2024

Month	Volume	Open Interest
Apr 2024	212	5,617
May 2024	26	3,053
Jun 2024	36,350	1,126,052
Jul 2024	821	3,750
Aug 2024	253	1,541
Sep 2024	418,571	1,128,973
Oct 2024	10	545
Nov 2024	-	282
Dec 2024	780,714	1,085,824

The model of the CME is based on a Heitfield and Park (2019) study and works on various assumptions. Firstly, it assumes, that the overnight rates follow a constant, piece-wise step function, which only jumps up or down after each Federal Reserve interest rate decision and remains steady in between. The respective jump size depends on the observed futures prices.

$$f(t, \theta) = \theta_0 + \sum \theta_K * 1\{1 > M_K\} \quad (1)$$

$M_k$  – Date of respective Federal Reserve policy announcement

$\theta_0$  – Initial Overnight Rate

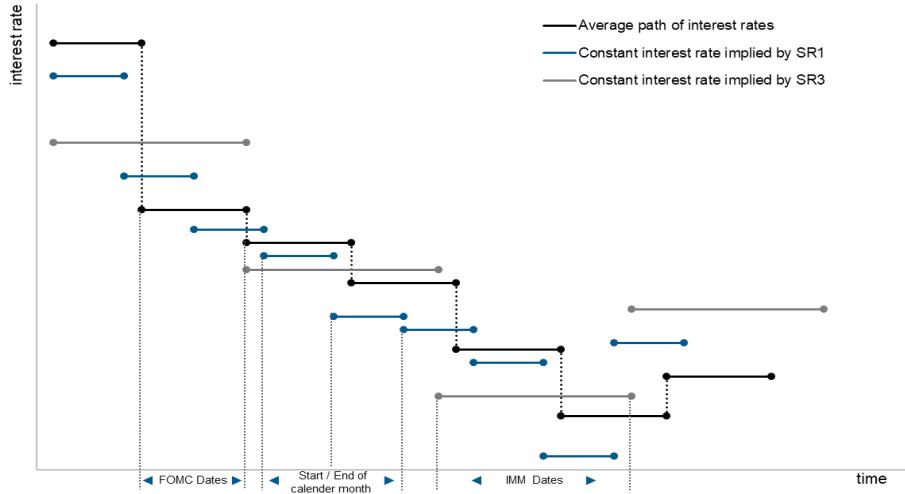
$\theta_K$  – Jump size

$f(t, \theta)$  – Overnight rate as of time t

$1\{\cdot\}$  – Binary function returning 1 if the statement in the parenthesis is true and 0 otherwise

To determine a path of expected overnight rates, an optimization algorithm is used to identify the ideal jump size, resulting in the minimum divergence of the projected overnight rate compared to the observed future prices. An example for such a projected path of overnight

**Figure 5: Fictitious, exemplary path of overnight rates based on the methodology of the CME**



rates is depicted in Figure 5.

Source: *Chicago Mercantile Exchange (2024)*

The CME employs the Broyden-Fletcher-Goldfarb-Shanno algorithm to determine the optimal interest rates path.

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

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 period

According to the CME Group, the algorithm reflects market expectations by minimizing the root mean squared error between projected overnight rates and futures implied market expectations. The model assumes an equal importance of all inputs (assigning each contract the same weighting) and that no jumps occur 18 months after the calculation date. To ensure gradual jump patterns, the model contains an error term which punishes larger jump sizes in cases where multiple patterns lead to the same solution. Term rates are then constructed by compounding the modelled forward rates (CME 2024b).

$$h(T) = \frac{360}{T} * \left[ \prod_{t \in \tilde{T}(T)} \left( 1 + \frac{f(t; \theta) * d_t}{360} \right) - 1 \right] \quad (3)$$

- $\tilde{T}(T)$ : Set of Business Days from the term start to date  $T$  days in the future
- $t$ : 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
- $f(t, \theta)$  – Overnight SOFR rate as of date  $t$

#### *Best practice recommendations*

With the first publication of Term SOFR, the ARRC issued a note regarding their best practice recommendations when dealing with products referencing on Term SOFR and amended this document with a clarifying update in April 2023. The main concern of the ARRC was that an excessive use of Term SOFR in the derivatives markets would deprive the underlying SOFR futures market of liquidity and robustness, thus raising the issue to potentially render the Term SOFR useless for cash products referencing this rate. Therefore,

the ARRC recommended a limitation for the usage of Term SOFR in financial derivatives, which was also backed by the Financial Stability Oversight Council (2022) as well as the Financial Stability Board (2021).

The ARRC stated that only hedging is recommended for parties with direct exposure to cash products referencing Term SOFR, e.g., Banks receiving Term SOFR out of a loan or borrowers having to pay Term SOFR. Interdealer hedging is strongly not recommended. The ARRC acknowledges the concerns from market participants that this might create a one-sided dealer market, where dealers might reach their risk limits which in turn could drive up the cost for hedging against Term SOFR. In their 2023 update, the ARRC granted an exception, where dealers are allowed to enter into a Term SOFR – SOFR Basis Swap with a non-dealer market participant e.g., hedge fund managers, bank treasurers or asset manager, without having direct exposure to Term SOFR cash products (ARRC 2023c). Although these are only recommendations published by the ARRC, they virtually have become regulation as the CME includes the compliance with the ARRC recommendations as a condition in their licensing agreement for the use of CME Term SOFR (CME 2024b).

To the knowledge of the authors no market participant is able to duplicate the CME SOFR term rate. Therefore it does neither resemble an easy understandable calculation method, nor a transparency in respect to the CME calculations. This is enforced by the fact, that the authors could only find very limited information about details of the calculation process. Also the fact that CME linked products cannot be hedged using the interbank market, leads to a further increase in client spreads. Also it is difficult for clients to find CME/SOFR basis swap quotes in the market, as interbank brokers are not trading these products.

## 5. Translation into products

The following chapter only covers the mostly used financial products by corporate treasuries.

### 5.1 USD loan market

In a post-LIBOR world, corporate loans demand a variety of decisions from corporate treasurers that have to be made in order to adapt to the new market environment. The majority of necessary changes are found in the U.S. dollar market, since the Eurozone decided against the total cessation of their respective forward-looking benchmark. With the extinction of LIBOR, new U.S. dollar loans cannot use this benchmark anymore and existing loan contracts may have to be amended to reflect the changes in the reference rate. Please note that this chapter only aims at highlighting major changes when dealing with loans. For more detailed information, readers may refer to the publications from the ARRC.

In November 2020 the Federal Reserve announced, that from December 31, 2021 onwards, newly concluded contracts are not allowed to reference LIBOR anymore. Contracts concluded before that date are not prohibited from using LIBOR as a reference rate but should at least include robust fallback language to prepare for the cessation of LIBOR in 2023 (Federal Reserve, FDIC and OCC 2020). For newly entered loans, the first choice to be made is whether to use SOFR in arrears or the CME Term SOFR. Theoretically, there would be a

third alternative, as one could use SOFR averages from previous periods, used as the reference rate for the next period. However, this would not reflect the actual market conditions during the interest rate period and is therefore not considered in this chapter.

The main difference is that the use of Term SOFR offers the possibility to determine the magnitude of the necessary payment in advance, whereas the SOFR in arrears payment is determined at the end of the interest period. Additionally, the CME Term SOFR is a screen rate published by the CME where in contrast SOFR averages and their respective calculation methods have to be determined individually in each contract, if the published compounded in arrears rates by the FED are not used. When deciding between those choices, it also has to be kept in mind that the associated hedging costs might differ.

Firstly, the contract parties have to agree on a calculation method for the respective SOFR average. As already outlined in chapter 4.1, the ARRC recommends either Daily Simple SOFR or Daily Compounded SOFR, where the simple interest is only calculated on the principal amount and the compounded interest takes into account the time value of money. Simple interest rates are easier to implement whereas compounded interest rates might have less hedging basis, compared to SOFR swaps (ARRC 2020c).

For the tenors of 1 month, 3 months and 6 months, the Federal Reserve of New York publishes these rates on a daily basis, calculated using the compounding approach (New York Federal Reserve 2024d). Due to the neutrality and credibility of the Federal Reserve as publisher, these issued averages could serve as a market standard for SOFR in arrears. However, at the time of writing there are no official statistics available on the use of the various interest rates within the US loan market.

When considering the use of SOFR in arrears, another important point is to determine the preferred convention for timely payment notice. Due to the fact that SOFR is based on actual transactions, it is only published with a one-day delay, meaning the interest rate for time T is only known in T+1. Therefore, a plain structure where the interest is due as soon as the final rate is known seems unfeasible, since the payment would be due on the same day. Hence, the ARRC suggested three alternative options: Payment delay, lockout period and a lookback structure.

A payment delay would simply shift the day where the payment is due k days into the future. OIS for example already make use of a payment delay structure, where payments are due two days after the calculation date. This makes hedging with OIS fairly easy and ensures that the full development of interest rates is reflected in the interest payment.

For the lockout or suspension period structure the respective rate is calculated k days before the end of the respective interest rate period. This effectively skips k days per interest period which might matter for investors, as SOFR developments during these days are not considered. Furthermore, it creates a slight hedging basis, as the payment structure does not exactly match the structure of OIS. A lockout period of 2-5 days is used in SOFR floating rate notes (FRNs).

The third option provided by the ARRC suggested a structure where for every day during the period a SOFR rate from  $k$  days earlier is used, where the ARRC observed a standard of a 3–5-day lookback period in SONIA FRNs (ARRC 2019). This structure is in line with the OIS payment structure which in turn eases the hedging process. Theoretically, one could use this approach with an observation shift, meaning that when calculating the compounded SOFR, the rate is weighted by the day count weight of the “lookback” day in the compounding. However, this can result in the borrower paying too much or too less interest. Therefore, a lookback period without a shift was favored by the members of the working group (ARRC 2020d).

**Figure 6: Overview of the different fixing conventions for using SOFR in arrears**

	(First Day of Interest Period)			(Last Day of Interest Period)		(First Day of Next Period)	
	SOFR for Day 1 published	SOFR for Day T-3 published	SOFR for Day T-2 published	SOFR for Day T-1 Published	SOFR for Date T Published		
Plain Arrears	Use SOFR for Day 1	Use SOFR for Day 1	..	Use SOFR for Day T-2	Use SOFR for Day T-1	Use SOFR for Day T	<b>Payment Due</b>
Arrears with Payment Delay	Use SOFR for Day 1	Use SOFR for Day 1	...	Use SOFR for Day T-2	Use SOFR for Day T-1	Use SOFR for Day T	<b>Payment Due</b> OIS generally settle on T+2
Arrears with 1-Day Lockout Period	Use SOFR for Day 1	Use SOFR for Day 2	...	Use SOFR for Day T-2	Use SOFR for Day T-1	<b>Use SOFR for Day T-1</b>	<b>Payment Due</b>
Arrears with 1-Day Lookback Period	Use SOFR for Day 0	Use SOFR for Day 1	...	Use SOFR for Day T-3	Use SOFR for Day T-2	Use SOFR for Day T-1	<b>Payment Due</b>

Source: ARRC (2020b)

For existing loans which have to be amended to include the results from the benchmark reform, these necessary decisions also apply. Additionally, the ARRC recommends the use of a Credit Adjustment Spread (CAS). This is due to the fact that SOFR does not include a credit component in contrast to LIBOR due to the calculation through secured lending transactions. Hence, the SOFR rate is structurally lower compared to the respective LIBOR counterpart (ARRC 2020c). Table 3 shows an example for the suggested Credit Adjustment Spreads for different maturities for the U.S. dollar. These spreads were calculated using a historical median value based on a five-year lookback period, which is meant to represent a whole business cycle. For this time horizon the median difference between the respective LIBOR and compounded SOFR is calculated, across all currencies and tenors in which LIBOR was available (ARRC 2020e). In practice, however, these extra margins can be subject to negotiation, depending on the respective legislation covering the contract. In the United States for example, it is mandatory to use the recommended ISDA fallback language, whereas in the United Kingdom companies are free to draw up their own fallback conventions (ARRC 2021c).

**Table 3: Selected credit adjustment spreads**

The table provides an overview of the LIBOR rates for different tenors and their respective adjustment spread recommended by ISDA. Data Source: Bloomberg

LIBOR	Tenor	Spread Adjustment (bps)
USD	Overnight	0.644
USD	1 Week	3.839
USD	1 Month	11.448
USD	2 Months	18.456
USD	3 Months	26.161
USD	6 Months	42.826
USD	12 Months	71.513

Should the loan which has to be converted include an interest rate floor, the ARRC recommends adjusting the floor according to the suggested CAS. For example, if the original contract included a floor of 0 bps and the recommend CAS for that tenor would be 25 bps, the new suggested floor would be at -25 bps.

The lack of a credit component also means that companies no longer know their "true" credit spread on the market. In the days of LIBOR, the spread above LIBOR expressed the credit risk of a company above or below that of a creditworthy bank. With the SOFR interest rate, the new spread now refers to the credit risk of a company above that of a completely risk-free transaction, in this case Repos. Although CAS are applied to existing contracts, these can only be seen as an approximation for a hypothetical SOFR variant of a contract referencing LIBOR due to the considerably arbitrary selection of the lookback period of five years in the calculation. In practice, each company in the market must now find out its own spread again, which can take a significant amount of time (Heidorn and Meier 2024).

The largest problem with RFR compounded in arrears, identified by the ARRC (2019), is the very short notice of payments as the magnitude of cash flows is known at the end of the period with all realized interest rates averaged. However, even though overnight rates exhibit day-to-day fluctuations, corporates should be able to get prepared more and more as the end of the period approaches as the impact of the remaining overnight rates on the average gets smaller and smaller. As the volatility of overnight rates is comparatively small, corporates should be able to incorporate this risk into their liquidity and cash management framework. This is evidenced by jurisdictions like the UK. In the UK, Term SONIA is permitted but with strong limits (Bank of England 2021). Nonetheless, the transition to compounded SONIA in arrears has been smooth and successful, as no major difficulties or disruptions have been reported by corporate treasurers.

This was also indicated by feedback from market participants, as they stated that a short notice of payments in cash products is not really an issue for corporate treasuries. The only real challenge seems to be the reconciliation effort between the fixing and the payment date,

as bank systems still miscalculate from time to time and these errors have to be resolved in a very short time frame.

## 5.2 USD interest rate swaps

### Introduction into U.S: dollar interest rate swaps

U.S. dollar interest rate swaps (IRS) are one of the most commonly used financial derivatives, as their globally outstanding notional exceeded US\$ 160 trillion per June 2023 (BIS 2023). To truly understand the implications of the benchmark reform for the USD IRS market, it is helpful to recap how IRS actually work.

In a standard IRS, a stream of series of variable (floating) payments is exchanged for a series of fixed payments. The side that pays the fixed stream of cash flow is called “payer”, whereas the side that pays the floating payments is called “receiver”. The fixed cash flows are calculated using the fixed swap rate and are constant throughout the entire duration of the swap. On the floating leg, the payments depend on a reference rate and depend on future fixings.t. At inception of a typical IRS its NPV is equal to zero, by setting a fixed swap rate equating the present value of both legs. By using discount factor (DF) we get:

$$PV(\text{fixed leg}) = PV(\text{floating leg}) \quad (4)$$

$$\text{Swap Rate} * \sum_{i=1}^n DF_i = \sum_{i=1}^n \text{Floating Rate}_i * DF_i \quad (5)$$

To determine the floating payments at inception, the bootstrapping approach is used. By utilizing an observed interest rate curve in the market, the spot and forward rates are derived. By using these forwards, e.g. payments in the future could be locked in at this rate; the present value of each floating payment is calculated. Therefore the value of the float leg is known, and the fixed swap rate is chosen to equate the present value of both legs. Further details about the bootstrapping method can be found in Hull (2021).

In the single curve approach the same yield curve is used to determine both, the discount factors and the forward rates. This was the standard approach before the financial crisis (GFC). During the GFC and since then the fixed rate of IRS is also a function of the tenor of the floating leg. Typically longer tenors (e.g. 3- compared to 6-months) are dealt with higher fixed swap rates, as the implicit credit risk in the fixing of the floating payments must be mirrored in the fixed leg to get a NPV of zero.

As discount factors should be almost risk free, the market moved to use IRS against overnight rates (OIS) first using in the US\$ area the Fed Funds Rate (FFR) and later the SOFR. In the €-area the €STR is now the common reference rate. Therefore the OIS curve was applied to find the discount factors, but swap curves with the representative tenor have to be used to derive the corresponding forwards. This means that forwards with the length of six months (3 months) have to be derived from a swap curve with a tenor on the floating leg of 6 months (3 months). Since this method uses different curves for the determination of the discount factors and the forwards, it is referred to as the multi curve approach (Hull 2021). As the central counterpart adopted this method, and most swaps have to be cleared, this was market standard until 2023. As the collateral was also evaluated by using OIS, the approach was widely accepted until the LIBOR funeral. By moving to the new EURIBOR and €STR the €-market

stayed with the dual approach. By adopting the SOFR and having no successors for other tenors, the interbank US\$ swap market moved back to single curve.

### Utilization of interest rate swaps by corporates

In the context of corporate treasuries, the main use cases for IRS are risk and liquidity management. Most corporate liabilities are loans or bonds, which can either have fixed or floating payments. For one reason or another, it might be desirable for a corporate to change the contracted payment structure (Hull 2021). This is typically done via an interest rate swap. Figure 7 illustrates such a change, from a floating payment in the liability to a fixed payment. The corporate pays a fixed rate to the bank and receives a floating payment in return. The swap is structured in way that the spread the corporate receives on the floating side is equal to the floating payment it has to make on the liability side. Afterwards, the floating payment is channeled through to the bondholders, effectively cancelling out the reception of the floating payment from the swap. In the end, the corporate only pays the fixed rate to the hedge provider.

**Figure 7: Stylized overview of the hedging process (float to fix)**

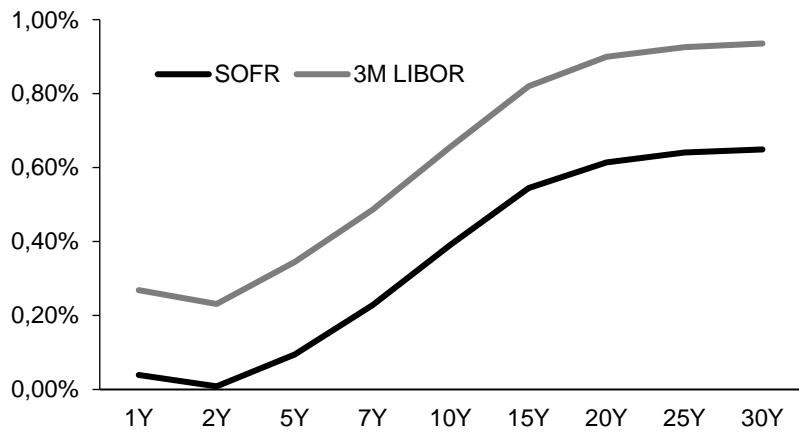


*Source: Own illustration*

### U.S. dollar interest rate swaps after the benchmark reform

After the Benchmark Reform, however, the floating leg of the swap is now linked to the SOFR swap curve. As shown earlier, LIBOR exhibits a structurally higher value compared to SOFR due to the missing credit and tenor component. Hence, a swap curve against SOFR is also structurally lower. Newly concluded swaps will show a significantly lower swap rate compared to their predecessors.

**Figure 8: Swap curve vs SOFR and swap curve vs. 3M LIBOR, as of 1 July 2020, in %**



*Source: Bloomberg*

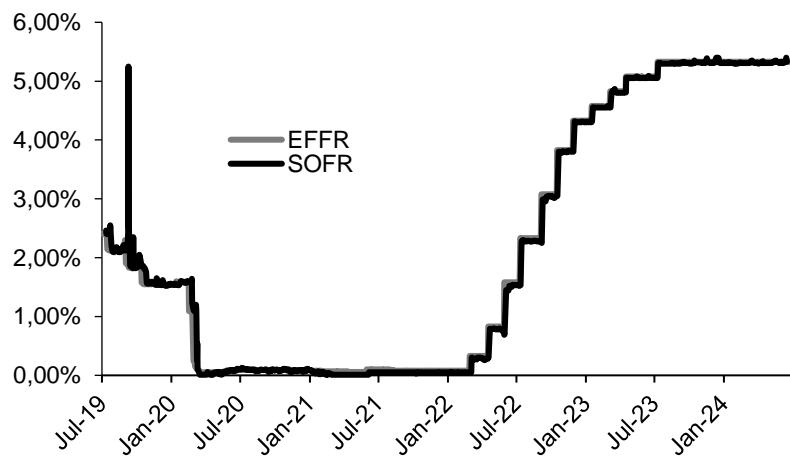
Furthermore, CCPs like the CME or the London Clearing House (LCH) have changed their discounting for swaps from OIS based on the FFR to OIS based on SOFR. Since both, SOFR and FFR are free of credit risk, both are equally suitable for the calculation of discount factors. Additionally, Figure 9 shows that both rates generally move in line, with only minimal deviations. Therefore, single-curve discounting is feasible again. In turn this also means that both, the discount factors and the floating payments are influenced by movements in SOFR, albeit not to the same extend. The changed discounting method caused a change in the risk profile for all existing swap contracts.

Another important point to consider are the fixing conventions. LIBOR was fixed in advance. Hence, the accrual period was in line with the interest period and the magnitude of the respective interest payment was known at the beginning of the interest period. With the emergence of SOFR however, fixing in arrears became the market standard. As already explained in chapter 5.1 there are a variety of options to choose from when deciding on a SOFR-in-arrears-structure for a cash product.

Cleared derivatives use the basic fixing in arrears structure with a two-day payment delay. Uncleared swaps are still free in choosing the most convenient convention. CME-Term-SOFR exhibits the same fixing structure as LIBOR, where the interest rate is determined at the beginning of the period. As described in chapter 4.3.2, Term SOFR is only permitted for derivatives hedging cash products, and most recently in basis swaps with non-dealer parties.

Similar to loans, the ARRC issued recommended fallback structures for legacy IRS referencing LIBOR with a maturity after the cessation date. Here, too, the credit adjustment spread methodology should be applied: The parties now pay SOFR plus the original spread and on top of the applicable CAS, drawn from the official ISDA recommendations as shown in chapter 5.1. As of July 3, 2023, all cleared swaps from the LCH, and the CME have transitioned successfully (Heidorn and Meier 2024).

**Figure 9: EFFR vs. SOFR, in %**



Source: Bloomberg

## Challenges for corporate treasuries

After the benchmark reform, the choice for corporate treasuries is now between compounded SOFR and CME Term SOFR. Compounded SOFR offers a more transparent methodology, but the exact amount of payable interest is only known on short notice at the end of the interest period. CME Term SOFR offers fixing at the beginning of the interest period but also has a rather complicated calculation method. This also makes it more difficult to draw additional information from the screen rate: On top of the function of being a reference rate, LIBOR also gave an indication regarding the mood in the interbank market, which otherwise could not be observed. This function is not provided by SOFR or Term SOFR. As the latter is administered now by a private institution, the CME demands a fee for the use of Term SOFR, which could be passed on onto the corporate end customer.

Furthermore, as explained in chapter 4.3.2, banks and dealers have very limited possibilities to hedge themselves against Term SOFR, which in turn creates a one-sided market for these derivatives. This makes it more expensive for dealers to offer those to their clients and these costs could be passed on to the corporates. When now considering a reference rate for the cash product, the corporate treasurer must bear in mind that the reference rate in the swap has to match the reference rate in the cash products. For example, a Term SOFR linked bond hedged with a compounded SOFR swap would result in a significant basis risk which has to be avoided.

The separation of the swap market into two different markets could also have an impact: Corporate treasurers should expect less liquidity than before, as the markets will be smaller in terms of volume. This in turn could lead to higher bid-ask-spreads for the swaps as well as losses in efficiency (Heidorn and Meier 2024).

Another important aspect are the fixing conventions for compounded SOFR. As explained in chapter 5.1 there are a variety of options to choose from when considering using compounded SOFR. However, financial derivatives always use the basic in arrears structure combined with a payment delay of two days. In theory, this can lead to a mismatch in the fixing structure: If for example a corporate loan is fixed with a 5-day lookback period whereas the derivative used to hedge said loan is fixed on a basic in arrears basis, the result would be a 5-day basis risk. In an optimal world, corporates would simply align the payment in the swap with the fixing convention in the loan, subject to a capable treasury system.

It has been noted that even in situations where the corporate is not able to obtain their preferred fixing or reference rate in a product, it is still preferable to match the unwanted conventions in all products for the transaction compared to enter into an exposure to basis risk.

The issue corporates might incur is that banks may not always be willing to provide tailor made fixing conventions for each client and also might face difficulties with their own internal systems. Again, it can be argued that it should be easier for corporates with a broad bank coverage to obtain more flexible fixing solutions compared to smaller companies.

Another problem arising from the transition to RFR compounded in-arrears is the administrative challenge of resetting interest rates on a daily rather than quarterly or semi-

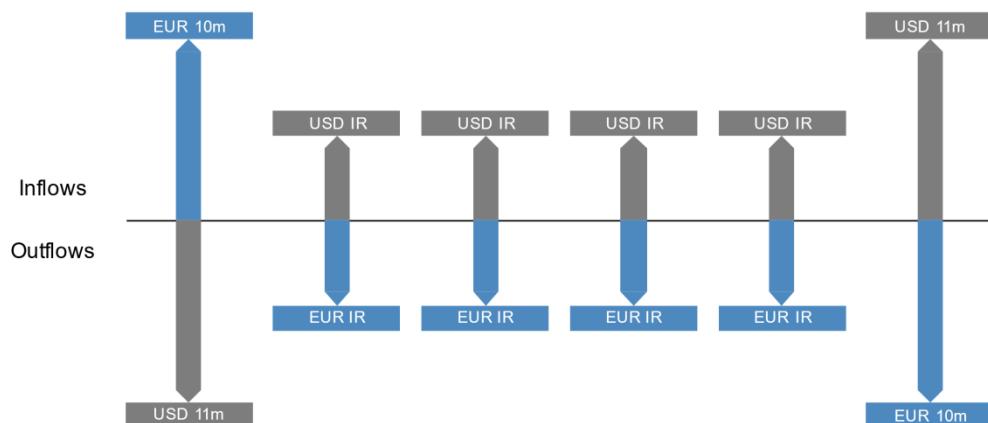
annual basis. Indeed, corporates have reported that their internal treasury management systems are not designed for resetting and fixing interest rates daily (Bank of England 2020; ARRC 2021a). Corporate feedback further suggests that the overhaul of their internal treasury management systems in order to be able to handle the new interest-determining methodology may be costly to achieve (Bank of England 2020). Corporates must therefore decide whether the costs of changing the internal treasury systems are higher or lower compared to the use of compounded RFRs in-arrears. For the euro area, corporates may leave this issue undecided as long as EURIBOR continues to exist – for the USD loans however, this issue is most pressing, since LIBOR was discontinued since 2023. With the CME Term SOFR, a forward-looking alternative approached, however, while the rate might be easier to handle with the established treasury systems.

### 5.3 EURUSD Cross-Currency Swaps (CCY)

#### Overview of cross-currency swaps

A cross-currency swap is used to exchange different currencies for a longer time period (at least one year) (Baba, Packer and Nagano 2008). A cross-currency swap involves exchanges of the principal amount and periodic exchanges of interest – usually on a quarterly basis (Figure 10). They are mainly used for hedging foreign currency exposure. The interest rates applied may be fixed on both sides (fix-fix swaps), floating on both sides (float-float swaps) or a combination of both.

**Figure 10: Stylized overview of cross-currency swap payment streams**



*Source: Own illustration (spot: Euro\$ = 1,1000)*

Figure 10 illustrates a swap where the company pays EUR interest and receives USD interest. The front and back exchanges of principal are based on the spot rate prevalent at inception of the swap. One might interpret the blue €-cash flows as the equivalent of issuing a €-

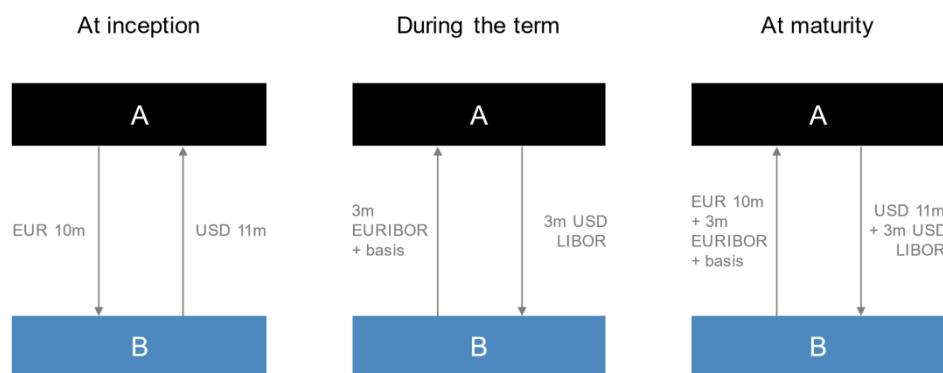
denominated bond and the grey US\$-cash flows as the equivalent of investing into a US\$-denominated bond. With USD as the original borrowing the cross-currency swap transforms it into a synthetic EUR-borrowing.

Cross currency swaps are often quoted as basis swaps with two floating legs denominated in different currencies. A major difference to interest rate swaps is the exchange of the nominal with the current currency spot rate and changing the redemption at the end back to the original currency using the same exchange rate. For USD/Euro swaps the market quotes a spread on the Euro leg with the US\$ leg being flat (Figure 11). (Changes to a fixed rate could be arranged by using a standard interest rate swap). As long as the covered interest rate parity did hold, the quoted spreads were minimal. Referring to the bond interpretation a cross currency swap can be duplicated by an exchange of two floating rate notes denominated in different currencies. As the interest differential was exchanged with every payment, the fair exchange rate at the end was today's spot rate (and not the forward).

The swap's value is calculated by revaluing the remaining cash flows of both legs at the current respective market rates, before converting the present values to a common currency via the current spot rate. As for all swaps, the swap's value is the difference of the value of both legs (Flavell 2012). For float-float swaps, changes in the swap's value only correspond to changes in the spot rate and the basis spread (at the fixing dates of the floating legs).

If both legs reference floating interest rates, the swap is referred to as cross-currency basis swap. Figure 11 below illustrates the functioning of a cross-currency basis swap.

**Figure 11: Stylized overview of the payment streams of a cross-currency basis swap**



*Source: Own illustration based on Baba, Packer and Nagano (2008), BNP Paribas (2015) and Brophy et al. (2019)*

Please note, that the non-USD leg (in this case the EUR-leg) quotes a basis which means that the interest payments are not exchanged flat but with a spread. Assume a 5y EURUSD cross-currency basis swap is quoted at -5 to -10 (bp). This means that the borrower of EUR will pay EUR interest -5 bp quarterly in exchange for receiving USD interest flat on the nominal. Vice versa, the borrower of USD funds will pay USD interest flat and receives EUR interest -10 bp. on the EUR leg. A negative basis can therefore be interpreted as an indicator for excessive demand for U.S. dollars, as the party borrowing USD is willing to receive less interest on her non-USD loan. This phenomenon already existed in the early beginning of the market (Fletcher and Taylor 1994, 1996) but particularly developed after the Great-Financial Crisis and has attracted strong interest from researchers, as it is inconsistent with the concept of covered interest parity (CIP). Various papers have been published, studying and attempting to explain why CIP does not hold in FX markets (see for example Baba and Packer 2009; Du, Tepper and Verdelhan 2018; Brophy et al. 2019).

### Utilization of cross-currency swaps by corporates

As shown before, cross-currency swaps exchange payment streams of different currencies and can therefore be used to transform the currency denomination of both assets and liabilities. Banks offer them to clients as an effective tool to manage FX risk – firms use them to hedge debt and net investments, denominated in foreign currency (see for example Danske Bank 2018). To illustrate this, we provide a simple example, illustrated by Figure 12 below. Assume a company has a bond outstanding, which is denominated in USD. It might want to access EUR markets, because it needs EUR funding. The company might use a cross-currency swap to convert its USD-bond into a synthetic EUR-denominated one. The combination effectively transforms the USD-bond proceeds into EUR as well as the subsequent interest payments. This is an important tool in the origination process. The corporate would compare funding alternatives. In this case, if issuing a bond in US\$ and swapping it to Euro is cheaper compared to direct Euro borrowing, the treasury would choose the indirect way. There is no general rule, which is the better alternative, the corporate always has to analyse the alternatives at the time frame of issuing the debt. However, in many cases it might be more attractive to borrow in the home market and using a cross-currency swap to generate synthetic funding in a different currency.

**Figure 12: CCY changing the currency denomination of a debt instrument**



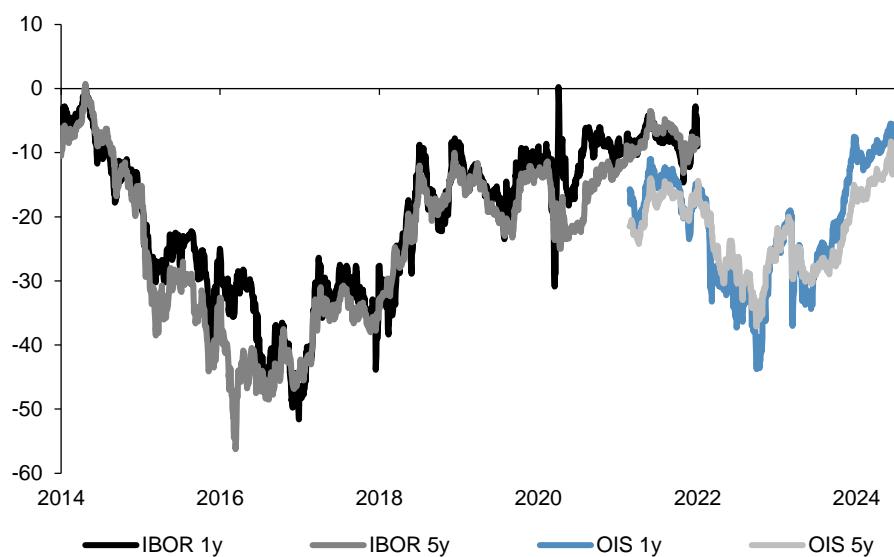
Source: Own illustration

By changing the currency denomination of its assets or liabilities, cross-currency swaps also provide the strategic option for a company to alter the currency denomination of both sides of its balance sheet, creating appropriate asset-liability currency matches. Assume a company with income cash flows mainly in EUR, but with a funding denominated in foreign currency. If the currency strengthens against the EUR, the company will inherit a larger liability

position and therefore larger EUR cash outflows to service the non-EUR denominated liability. By converting the liability into euros by the process described above, the changes in the swap value will offset the change in the loan value, thereby isolating its balance sheet from the risk of FX price movements. With the cross-currency swap, the company has converted an FX liability to match its asset side, swapping the interest expenses into the same currency as the firm revenues.

The same logic applies inversely, too. Many European companies may run their operations globally while having most of its liabilities funded in EUR. As foreign revenues grow, the currency mismatch on the company's balance sheet widens, which inherits liquidity risks if the market exhibits strong currency movements. Theoretically, companies would try to match their asset and liabilities by borrowing in the markets where its assets are accumulated. Practically however, a variety of reasons may render this option unfeasible. Using cross-currency swaps to synthetically create non-EUR debt provides a natural hedge for growing non-EUR assets.

**Figure 13: 1y and 5y EURUSD cross-currency basis spreads (2014-2024); data on 3M EURIBOR vs. 3M LIBOR available until end-2021, data on 3M €STR vs. 3M SOFR starts**



Source: Bloomberg

Consider a corporate could issue bonds both in U.S. dollar and euros. Furthermore, assume the spread of a euro-denominated bond with a maturity of five years would be 100bp, while the spread for a US\$ denominated bond would be 105bp. The EURUSD cross-currency quotes -10bp. In this situation, the corporate would opt to issue a dollar-denominated bond and swap the proceeds back into euros, synthetically issuing a euro-denominated bond at a spread of 95bp instead of 100bp. In this hypothetical case, the corporate utilized the basis to lower its funding costs in domestic currency. The history of EURUSD cross-currency basis spreads can be found in Figure 13.

## Cross-currency swaps before the benchmark reform

### *Bank to Bank conventions*

Before the benchmark reform, the floating legs of cross-currency swaps were referenced on the IBOR of the respective currency area. We focus on EURUSD cross-currency basis swaps in particular. The standard convention were quarterly interest rates, resets, and payments (Tuckman and Porfirio, 2003). The EUR leg referenced 3M EURIBOR + a basis spread, while the USD leg referenced 3M USD LIBOR. These rates were reset quarterly in-advance, meaning that the magnitude of the payments was known at the beginning of the period, but occurred at the end of the same period. The date at which the new rate is used is called the Reset Date. The IBOR rates were fixed in advance two 2 business days prior to the beginning of the interest period. As the rates on both sides were money market rates, the interest convention on both legs was linear ACT/360 (Figure 14).

The vanilla interdealer cross-currency swap was mark-to-market (MtM), meaning that changes in the market value of the swap are actively tracked. In an MtM swap, the change in the value of the swap is accounted for bilaterally or – if cleared – by the CCP. The risk resulting from changes in the swap value is usually curbed by providing collateral whose value corresponds to the market value of the swap. In an MtM cross-currency swap, this problem is tackled by fixing the notional on one side, while resetting the notional of the other side with the FX rate prevalent at the beginning of each interest period. The nominal reset took place every time the payments are exchanged, but the calculation of these payments was based on the nominal amounts reset at the previous period. The nominals exchanged at maturity were therefore the nominals that had been readjusted in the previous period (Barnes 2017). This process of notional adjustment under MtM is illustrated in Figure 15.

To determine the market value, the remaining cash flows of both legs were discounted by the OIS curve of the respective currency (EONIA for EUR, EFFR for USD) and then converted into a common currency at the current FX spot rate. As the swap legs did not reference OIS rates, but IBORs, the market value of the swap therefore depended on changes in the FX spot rate, changes in the OIS curve and changes in the basis spread.

**Figure 14: Fictitious EURUSD interdealer cross-currency swap before the reform**

Leg 1: Float	USD	Leg 2: Float	EUR	Valuation
Notional	11.6MM	Notional	10MM	Curve Date 01/11/2021
Effective	-- 01/11/2021	Effective	-- 01/11/2021	Valuation Date 03/11/2021
Maturity	1y 01/11/2022	Maturity	1y 01/11/2022	Collateral Curve USD SOFR
Index	3m USD LIBOR	Index	3m EURIBOR	Valuation Ccy USD
Spread	--	Spread	-8.5 bp	FX Rate 1.15945
Reset Frequency	Quarterly	Reset Frequency	Quarterly	
Pay Frequency	Quarterly	Pay Frequency	Quarterly	
Day Count	ACT/360	Day Count	ACT/360	
Fixing Lag	2 business days	Fixing Lag	2 business days	
Pay Delay	0 business days	Pay Delay	0 business days	
Reset Method	In Advance	Reset Method	In Advance	

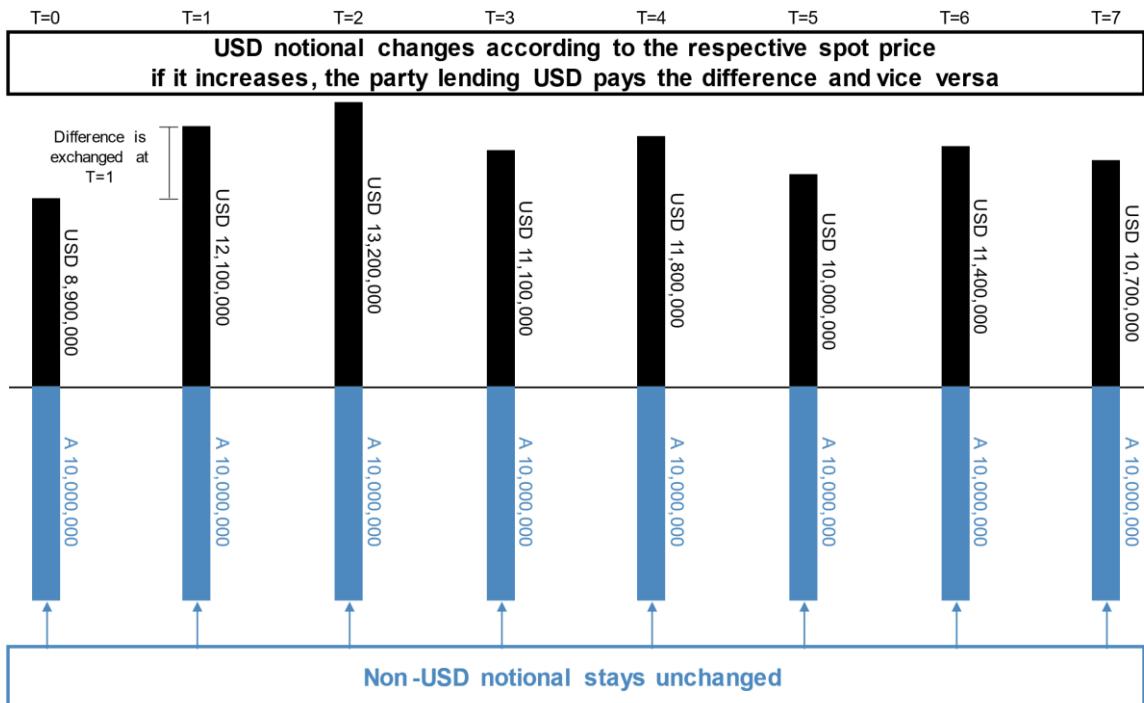
  

Accrual Start	Accrual End	Pay Date	Days	Reset Date	Payments	
					EUR leg	USD leg
01/11/2021	01/02/2022	01/02/2022	92	28/10/2021	3ME <sub>28/10/2021</sub> - 8.5bp	3ML <sub>28/10/2021</sub> + NotionalAdj
01/02/2022	02/05/2022	02/05/2022	90	28/01/2022	3ME <sub>28/01/2022</sub> - 8.5bp	3ML <sub>28/01/2022</sub> + NotionalAdj
02/05/2022	01/08/2022	01/08/2022	91	28/04/2022	3ME <sub>28/04/2022</sub> - 8.5bp	3ML <sub>28/04/2022</sub> + NotionalAdj
01/08/2022	01/11/2022	01/11/2022	92	28/07/2022	3ME <sub>28/07/2022</sub> - 8.5bp	3ML <sub>28/07/2022</sub> + NotionalAdj

Source: Bloomberg

To account for changes in market values, the interdealer market typically has to use a central counterparty clearing. In most cases collateral can be posted in one of the two currencies of the CCY.

**Figure 15: Functioning of a mark-to-market cross-currency swap**

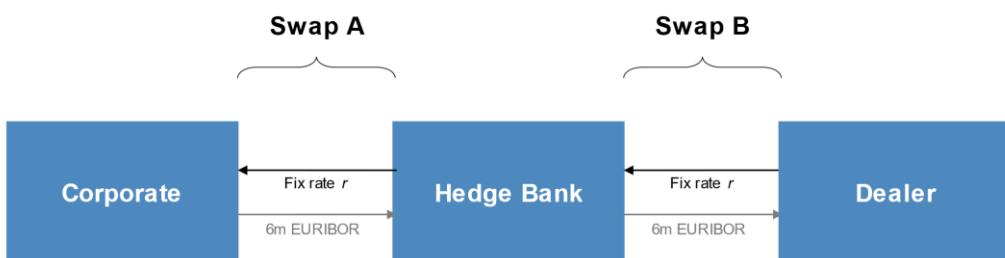


Source: Own illustration

### Bank-to-Customer conventions

While the interdealer market for cross-currency (basis) swaps had an established market standard, swap agreements between banks and their corporate clients naturally exhibited a strong variety of contracts. Swap agreements for hedging purposes were strongly customized, depending on the preferences of the corporate. While the interdealer market saw quarterly float-float swaps as standard, Dealer-to-Customer (D2C) contracts could see either fixed or floating payments – depending on the underlying cash product to be hedged – with different tenors (e.g., quarterly, semi-annually, annually) and differing reset dates. The bank then needed to enter into offsetting basis swap agreements to balance the resulting mismatches. While these differences may very well be hedged by the bank via additional interest rate or basis swap agreements with other dealers, another convention difference exposed banks to active risk management. The most important difference between interdealer and D2C convention was the inclusion of a Credit Support Annex (CSA). While collateralized swaps were standard in the interdealer market, D2C-derivatives saw collateralized as well as uncollateralized agreements between corporates and their hedge bank (Sills 2012). This also meant that many D2C-agreements did not involve a variable notional on one leg of the swap, so no exchange of principal at payment dates, as the swaps were not MtM. For banks, this created a challenge for collateral management for all sorts of derivatives offered for hedging, including interest rate and cross-currency swaps.

**Figure 16: Example transaction structure of a bank hedging a client IRS in the interdealer market**



Source: Bloomberg, own illustration

To illustrate the challenge, consider a bank providing a swap for a corporate client, hedging itself with an interdealer swap as shown in Figure 16 above. For simplicity, we assume that both swaps have the same conditions except for the CSA meaning that the interdealer swap is collateralized while the swap with the corporate is not. At inception, both swaps have a value of zero. Once the swaps are initiated however, market rates change, so the swap values change, too. In the books, as both swaps have the same terms and conditions, the gain in Swap A is always offset by the loss in Swap B and vice versa. However, since the interdealer swap is governed by a CSA, a positive value of Swap B means that the bank receives collateral that it doesn't need to post for Swap A. Inversely, a negative value of Swap B means that the bank needs to provide collateral for its interdealer counterparty but does not receive any collateral from Swap A, even though it has a positive value for the bank as the

D2C-swap is not governed by a CSA. This mismatch poses a potential risk to the bank that it needs to address via its risk management framework. These costs may lead the bank to charge increased transaction costs for the corporate client at inception of the swap in order to cope with potential “collateral costs” in the future. This is also known as “funding value adjustment”.

### **Cross-currency swaps after the benchmark reform**

With the “SOFR First” initiative by the Market Risk Advisory Committee (MRAC) of the Commodity Futures Trading Commission (CFTC), markets slowly started to adopt RFRs on both legs of cross-currency swaps instead of LIBOR. With the fourth phase of SOFR First, the MRAC finalized their recommendations for the new trading conventions. Cross-currency swaps referencing USD, CHF, JPY and GBP should utilize RFRs in each currency instead of LIBOR as of September 21, 2021 (CFTC 2021a). Markets adopted these recommendations accordingly, with data from the Swaps Data Repository (SDR) showing that RFR-linked (both legs) cross-currency swaps became the market standard after September 21, 2021 for GBPUSD, CHFUSD and JPYUSD. While RFR-linked cross-currency basis swaps accounted for around 20% of all trades before this date, this figure surged to over 90% thereafter. Since December 2021, almost all cross-currency basis swaps in these currencies have been referenced to RFRs on both legs (ARRC 2022).

For EURUSD cross-currency swaps, the adoption took a few months longer. On 2 December 2021, the MRAC published “Part II” of the RFR First initiative for cross-currency swaps that recommended adopting SOFR instead of USD LIBOR in all new cross-currency swaps activity with a USD LIBOR leg in the interdealer market from 13th December 2021 (CFTC 2021b). This recommendation received support from the EUR Risk Free Rates Working Group (ESMA 2021). While the market share of RFR-linked EURUSD cross-currency swaps had been growing steadily since September 2021, it reached over 90% in December 2021 and became market standard from 2022 at the latest, with nearly 100% of EURUSD cross-currency swaps being RFR-linked on both legs (ARRC 2022). This trend can be observed for other currencies as well – SDR data shows that with the beginning of 2022, RFR-linked swaps became the market standard for cross-currency swaps in general (ARRC 2023a) – similarly to the interdealer linear swap market (ARRC 2023b).

### *Bank-to-Bank conventions*

With the EUR leg referencing €STR (+ basis spread) and the USD leg referencing SOFR, the reset type was no longer in advance but in arrears. Interest rates on both legs are now compounded and reset daily over the interest period. As the payment frequency in the interdealer market is still quarterly, the legs reference 3M €STR and 3M SOFR in arrears. The new method not only meant that resets must occur daily but also removed the fixing lag. As interdealer cross-currency swaps are MtM, the nominal on the USD leg is readjusted quarterly on the payment dates. A challenge for the transition to RFR-RFR cross-currency swaps was the potential mismatch of payment lag conventions in the €- and US\$-OIS markets – T+1 for EUR and T+2 for USD (ARRC 2020a). In the cross-currency swap markets however, this mismatch has been resolved, with a payment lag of T+2 being the standard for both legs. Similar concerns arose regarding a possible mismatch in the day count convention, as both legs are now based on compounded daily rates settled in arrears. However, the old standard of ACT/360 still is the standard for both legs after the transition.

Looking at other European currencies such as the British pound sterling, cross-currency swaps exhibit different day count conventions (ACT/365 for the GBP leg, ACT/360 for the USD leg) but with aligned payment lags (2 business days). This causes little mismatches with GBP OIS swaps referencing SONIA since they do not settle with T+2 but T+0 and have no payment lag either, however, the impact should be marginal.

While interest rates are reset daily, compounded, and paid in arrears, the basis spread accrues linearly over the interest period. For a EURUSD cross-currency basis swap this means that €STR is compounded daily over the interest period. At the end of the period, the basis spread is added (i.e., subtracted as the spread is negative) on top of the compounded €STR.

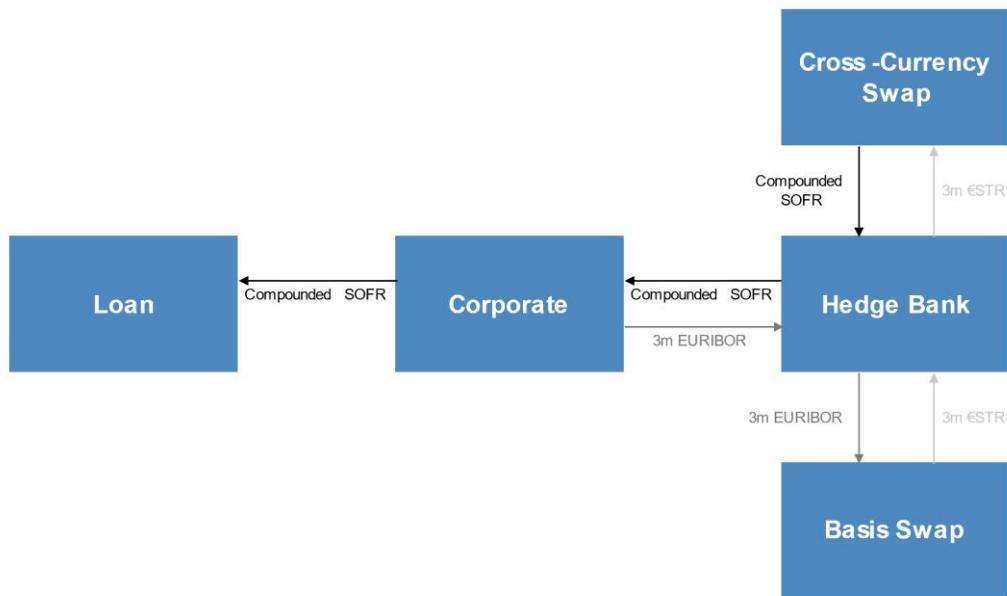
As rates are reset daily in arrears, they accurately reflect what happened over the interest period and do not become outdated, different from the IBOR-rates set in advance. Changes in the market value of a cross-currency swap therefore result from changes in the FX spot rate and changes in the basis spread. With regard to collateral for the daily margining under CSAs, there still is no established market standard. While some may prefer to post collateral in USD only, the market has also seen its first transaction with EUR as only transport currency in early 2023 (LCH 2023). Discounting curves were aligned with the new OIS rates, shifting from EONIA to €STR in EUR and from EFFR to SOFR in USD.

To sum up, cross-currency basis swaps are no longer reset once in advance of the interest period with payments occurring at the end. Interest rates are reset daily on both legs, then compounded over the interest period with the basis spread added at the end of the period, accruing linearly over time. The magnitude of payments is no longer known with certainty at the beginning of the period but at the end with a short notice of payment.

#### *Bank-to-Customer conventions*

While the interdealer market for EURUSD shifted to RFR-RFR, banks nonetheless continue to provide their customers (EUR)IBOR-RFR cross-currency swaps, by combining a vanilla cross-currency swap and a basis swap (see Figure 17).

**Figure 17: IBOR-RFR cross-currency swap for corporate clients**



*Source: Own illustration*

For many corporates, such a package reduces the “in-arrears burden” created by the benchmark reform in the US as EURIBOR, is still in existence. As banks can provide these hedges due to the EURIBOR-€STR basis swaps market, corporates not necessarily experience the operational difficulties associated with the transition from in-advance to in arrears if they synthetically convert their USD debt to EUR. If the swaps of these corporates are governed by CSAs, they nonetheless faced the issue of aligning the collateral interest and the discounting curves with the new benchmark rates €STR or SOFR.

Also after the reform, bank-to-client contracts are highly customized in accordance with the underlying cash product to be hedged, meaning that payment frequencies may range from monthly to annual payments, using either in-arrears €STR or in-advance EURIBOR on the EUR leg, with no clear tendency regarding the use of CSAs, collateralization and margining between the corporate and their hedge bank. This means that the issue described by Figure 15 before continues to persist.

#### *Challenges for corporate treasuries*

As mentioned in the last section, corporates may continue to use forward-looking EURIBOR instead of resorting to €STR on the EUR leg of their cross-currency swap. However, as the volatility of day-to-day EURIBOR-fixings has increased, this makes the trading of IBOR-linked IRS or basis swaps more difficult before 11am as market participants face elevated uncertainty regarding the fixing according to market talk. As the discussion about the future of EURIBOR and €STR is ongoing, corporates may face challenges if the D2C-market also starts shifting to RFR-RFR cross-currency and Fix-RFR interest rate swaps completely.

While the basis swaps market may allow for in advance solutions on the EUR-leg of cross-currency swaps, the opposite is true for the USD-leg. As previously described, trading of Term SOFR – SOFR swaps is strongly restricted by the CME. As a consequence, the creation of a cross-currency swap whose USD-leg references an in advance rate might be possible for banks but comes at cost for the client.

The problems corporates face with the new in arrears convention have been described in the chapter covering loans. For the euro area, corporates may not act immediately on these problems as IBOR continues to exist. If, however, the euro area transitions to €STR in full or the basis swaps market exhibits declining depth or serious liquidity issues, D2C-conventions could also adopt RFR-RFR or Fix-RFR as new standard, exposing European corporate treasurers to the same challenges as their US peers.

## 5.4 Floating Rate Notes (FRNs)

In difference to conventional bonds, a floating rate note (hereafter: FRN) has a variable coupon, with each coupon payment being linked to an underlying index. These floating coupons result in FRNs being much less sensitive to interest rate moves than their fixed coupon counterparts, which goes hand in hand with a low duration.

Although FRNs are mainly an instrument of government or government-related issuers (e.g.: government agencies) as well as financial corporations such as banks, it may nonetheless be used by corporates as the public alternative to variable-rate loans. However, as the predominant share of corporate bonds consists of fixed coupon bonds, this paper covers a brief description of the most important implications of the IBOR-SOFR transition.

Similarly to variable-rate loans, FRNs used to be referenced to the maturity-matched LIBOR or T-Bill rate of the respective currency the bond was denominated in. Similarly to other instruments, the transition to SOFR inherits problems, especially related to the short notice of payments when opting for an in arrears solution. However, while loans might use the CME Term SOFR as a forward-looking rate, this solution is not applicable to FRNs as the ARRC (2023c) does not recommend the use of CME Term SOFR for this instrument. Instead, FRNs have to adopt a SOFR in arrears structure.

As the in arrears structure provides for very late payment notices, as mentioned before, there are different conventions to allow for a reasonable time lead before notice of payment. However, to the best knowledge of the authors, the FRN market lacks a single standard / street convention which method is primarily used. This is mainly due to the absence of large, standard-setting issuer. Although the US Treasury FRN market is regularly tapped and highly liquid, these bonds cannot provide a general market standard, as they continue to reference T-Bill rates for several reasons. Hence, the US Treasury FRNs have not changed in their structure, differing from the rest of the market, which is primarily referencing SOFR (Klinger and Syrstad 2024). With this lack of standard setting, the market exhibits a variety of structures in SOFR-linked FRNs, both between the different types of issuers (e.g.: SSAs vs. financial institutions) as well as within these issuer groups. As nearly all methods proposed by the ARRC (2019b) can be found in the market, the paper briefly describes the options, which can be seen in Figure 6.

The ARRC (2019b) has proposed different conventions for FRNs, applied in a variety of ways by market participants. Some FRNs apply SOFR in the same way as a plain-vanilla in arrears structure, but use a lockout period of 2-5 days in order to allow for sufficient notice (e.g. FRNs issued by Bank of America). Other FRNs do not match interest and observation period, but implement a lookback period, usually in the range of 3-5 days, with no clear trend in the use of an observation shift. Finally, issuers may use a payment delay, where interest is calculated similarly to the plain-vanilla in arrears framework but is paid  $t$  days after the next interest period has started. Although the ARRC (2019b) has noted that this structure with a delay of 2 days would facilitate the hedging process using swaps the most, payment delay is not market standard but is instead treated very flexible in combination with the aforementioned conventions.

## 6. Conclusion

This paper examined the transition from LIBOR to SOFR in the US, provided a description and detailed history of benchmark interest rates, and mapped out the consequences for European corporate treasurers by showing how the application of SOFR in cash products and derivatives differs from LIBOR. First, SOFR – in difference to LIBOR – is not published for different maturities but an overnight rate only, meaning that market participants need to apply SOFR averages in arrears rather than a single observed rate in advance. Second, the in arrears convention means that market participants need to reset and compound the realized SOFR rates on a daily basis. As this solution may be neither feasible nor desirable for some market participants due to the short notice of payments and operational difficulties, a forward-looking term rate for SOFR has been developed, with the CME Term SOFR being the most prominent rate. Third, with interest rate and cross-currency swaps markets transitioning to compounded SOFR in arrears and a restricted interdealer market for derivatives referencing CME Term SOFR, corporates may face a trade-off between the higher costs of using Term SOFR versus facing operational difficulties with their internal treasury systems when using compounded SOFR in arrears.

With respect to European corporates, challenges arising from the new in arrears conventions should be less pronounced since EURIBOR coexists next to €STR, which means that corporates may continue to use term rates set in advance when they choose to swap U.S. dollar exposure into euros. However, as discussions about the future of EURIBOR are ongoing, euro swaps markets may see a transition to €STR in the future. As a consequence, the use of EURIBOR could either decline or become more costly in the future. This is a strong argument for European corporates, too, to overhaul their internal treasury systems to be prepared for a possible RFR-only scenario in the euro area.

Overall, the Benchmark Reform has increased the complexity in financial markets for corporate treasurers dealing with multiple currencies. The switch from forward-looking to backward-looking rates imposes a significant challenge on corporates and comes with higher cost, either through the overhaul of treasury systems or through the use of artificial term rates. Even though EURIBOR continues to exist in its current form, it would be advisable for corporate treasuries to prepare themselves for a risk-free rates world with daily compounding, as a full transition to risk-free rates might also be the future for the Eurozone

## 7. References

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