FINANCIAL STABILITY BOARD

Overnight Risk-Free Rates

A User's Guide

4 June 2019

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Executive summary

This document gives an overview on alternative nearly risk-free reference rates (RFRs). Furthermore, this document presents options how these RFRs can be used in cash products. The document is based on a recent paper published by the Alternative Reference Rates Committee (ARRC) and recent work of the National Working Group on Swiss Franc Reference Rates (CHF NWG). It intends to broaden the overview on RFRs and their usage to other currency areas.[1]

RFRs are overnight rates, which can be used as alternative benchmarks for the existing key interbank offered rates (IBORs) in the unsecured lending markets. The FSB has welcomed the progress by public authorities and private sector working groups in identifying and developing RFRs in many currency areas (see **Table 1** for a selected list).[2] RFRs have been identified because these rates are robust and are anchored in active, liquid underlying markets. This contrasts with the scarcity of underlying transactions in the term interbank and wholesale unsecured funding markets from which some interbank offered rates (IBORs) are constructed.

Table 1

Selected overnight RFRs

US Dollar	Secured Overnight Financing Rate (SOFR)	Secured Treasury repo rate
Sterling	Sterling Overnight Index Average (SONIA)	Unsecured wholesale rate
Japanese Yen	Tokyo Overnight Average Rate (TONA)	Unsecured wholesale rate
Euro	Euro Short-Term Rate (€STR)	Unsecured wholesale rate
Swiss Franc	Swiss Average Rate Overnight (SARON)	Secured general collateral repo rate

National working groups in several currency areas are also pursuing the development of forward-looking term rates derived from RFR derivative markets (see **Figure 6** in Annex 2 for the terminology).[3] The FSB recognises that there may be a role for such rates for certain cash products.[4] At the same time, the FSB has stated that it considers that the greater robustness of

1 See ARRC (2019), A User's Guide to SOFR, April, and National Working Group on Swiss Franc Reference Rates (2019), minutes of February 2019 meeting, February.

2 For a fuller accounting of RFRs across FSB member jurisdictions, see FSB (2018), Reforming major interest rate benchmarks: Progress report, p. 35 ff.

3 For instance, the ARRC sets a goal of seeing such a rate produced by the end of 2021 in its Paced Transition Plan, and the Sterling RFR Working Group conducted a market-wide consultation in July-October 2018, published findings from that work in November 2018, and has established a task force to take this forward. Following a public consultation, the Working Group on euro RFRs recommended in March 2019 a methodology for calculating a forward-looking term structure based on €STR and will analyse further both forward-looking and backward-looking approaches as potential fallbacks for Euribor. In Japan, the Cross-Industry Committee on Japanese Yen Interest Rate Benchmarks envisages that such a rate would be developed in around mid-2021. In contrast to that, the CHF NWG views a forward-looking term rate derived from SARON derivatives as unlikely to be feasible and recommends using a compounded SARON wherever possible.

4 FSB (2018), Interest rate benchmark reform: overnight risk-free rates and term rates, July.

overnight RFRs makes them a more suitable alternative than a forward-looking term RFR in the bulk of cases where an IBOR is currently used.

This note focuses on RFRs and not on forward-looking term rates. In derivatives markets, where there is a long history of use of overnight rates, many market participants are generally already quite familiar with the various structures of using such rates. But although there are many examples of the use of overnight rates in cash products, fewer participants in these markets are familiar with them. In seeking to clarify the ways in which overnight RFRs can be used in cash products, the FSB hopes to encourage adoption of these rates where they are appropriate.

1. Overview on RFRs

1.1 Current usage in financial products

Many market participants have become accustomed to using IBORs for cash products and derivatives since they emerged in the 1980s. On the other hand, there is in fact a long history of use of overnight rates in cash instruments, and in a number of currency areas overnight index swaps (OIS)[5] have traded for almost 20 years. Moreover, futures markets based on overnight rates are developing, notably in markets currently reliant on LIBOR, or already exist. Beside derivatives, there are also examples of overnight rate usage in cash products. Banks in the United States have a history of offering loans based on the Prime Rate, which is an overnight rate, or an overnight IBOR. Other countries have similar experiences; for example, in Canada, most floating rate mortgages are based on prime rates. More recently, there have been a number of floating rate notes issued based SONIA and SOFR.

1.2 Averaged RFRs

In understanding how financial products have been able to use overnight rates, there is one key thing to keep in mind: these financial products either explicitly or implicitly use some kind of *average* of the overnight rate (averaged RFR), not a single day's reading of the rate (a discussion on different kinds of averages such as simple mean and compounded can be found in section 1.3).

The main reason why an average is used is in order to reduce the frequency of payments, as using a single day's reading with daily payments would technically be challenging with nearly no economic benefits. Using an averaged RFR still accurately reflect movements in overnight rates over a given period of time.

By using an averaged RFR any idiosyncratic, day-to-day fluctuations in market rates are smoothened out. This can be seen by comparing Figures 1 and 2. On a daily basis, each RFR can exhibit some amount of idiosyncratic volatility (**Figure 1**).

The amount of volatility can change over time and depends on a number of factors, including the monetary policy framework and day-to-day fluctuations in reserves' supply and demand, but regardless of these factors, using an averaged overnight rate smooths out almost all of this type of volatility (**Figure 2**). Although people often focus on day-to-day movements in

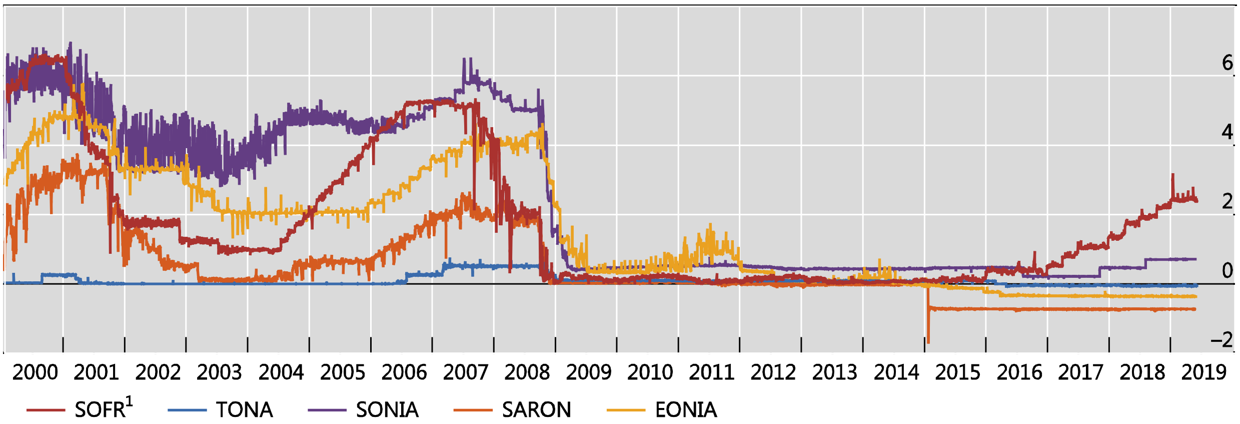
5 An overnight indexed swap (OIS) is an interest rate swap where the periodic floating payment is based on a daily compound overnight interest rate.

overnight rates shown in the first figure, it is important to keep in mind that financial contracts are expected to reference the type of averaged rate shown in the second.

Overnight risk-free reference rates overview

In per cent

Figure 1



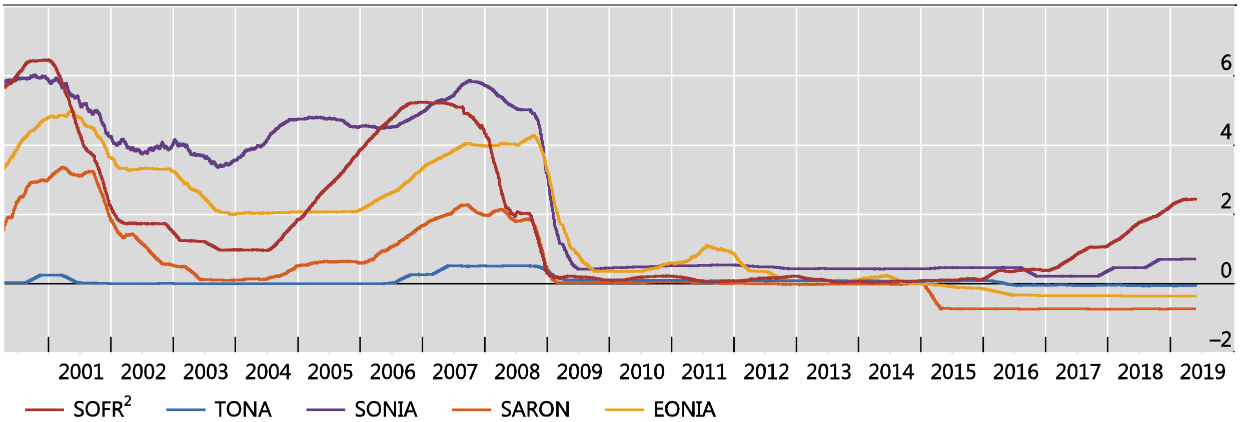
[1] Data from August 2014 to March 2018 represent modelled, pre-production estimates of SOFR. Historical repo data prior to August 2014 is taken from primary dealers' overnight Treasury repo borrowing activity (https://www.newyorkfed.org/markets/opolicy/operating_policy_180309).

Sources: Federal Reserve Bank of New York; Bank of Japan; Bank of England; SIX (Swiss Infrastructure and Exchange); European Money Market Institute.

Overnight risk-free reference rates overview[1]

In per cent

Figure 2



[1] Three-month averaged. [2] Data from August 2014 to March 2018 represent modelled, pre-production estimates of SOFR. Historical repo data prior to August 2014 is taken from primary dealers' overnight Treasury repo borrowing activity (https://www.newyorkfed.org/markets/opolicy/operating_policy_180309).

Sources: Federal Reserve Bank of New York; Bank of Japan; Bank of England; SIX (Swiss Infrastructure and Exchange); European Money Market Institute.

1.3 Compound versus simple averaging: how an average can be calculated

An averaged RFR can either be calculated by using a *simple* or a *compound* average. The difference between them are generally small and other terms can be adjusted to equate the overall cost. Both methods are currently used in financial products.

- *Simple interest* is a long-standing convention, and in some respects is easier from an operational perspective. The averaged RFR in this convention is the simple arithmetic mean of the daily RFRs.
- *Compound interest* recognises that the borrower does not pay back interest owed on a daily basis and it therefore keeps track of the accumulated interest owed but not yet paid. The additional amount of interest owed each day is calculated by applying the daily rate of interest both to the principal borrowed and the accumulated unpaid interest. By using this convention, the frequency of payments can be less than daily without causing a potential loss of interest for the lender.

From an economic perspective, compound interest is the more correct convention. OIS markets also use compound interest, and thus other products that use compound interest will be easier to hedge. On the other hand, simple interest is easier to calculate and many systems already use it.[6]

It is important to understand that the difference between the two concepts is typically quite small at lower interest rates and over short periods of time. **Table 2** provides an illustrative example of the differences (the "basis") between simple and compound averages for different interest rates and frequencies of payment. Which method is used depends in the end on preferences to reduce basis risks, easier calculation and existing usage.

Table 2

Basis between compound and simple interest

	Loan Rate		
Loan Maturity	**1%**	**5%**	**10%**
1-month	0.0 bps	0.9 bps	3.8 bps
3-month	0.1 bps	3.0 bps	12.2 bps
6-month	0.2 bps	6.2 bps	25.0 bps

1.4 Notice of Payment: when is the next payment known?

Most of the contracts that reference an IBOR set the floating rate based on the IBOR at the *beginning of the interest period*. This convention is termed *in advance* because the floating-rate payment due is set in advance of the start of the interest period. But not all IBOR contracts take

[6] In the US most loan and floating rate note (FRN) systems using overnight LIBOR or the fed funds effective rate were built around the use of simple interest. However, SONIA FRNs have adopted a compound interest methodology.

this form; some IBOR swaps reference the value of the IBOR at the *end of the interest period*. This convention is termed *in arrears*.[7]

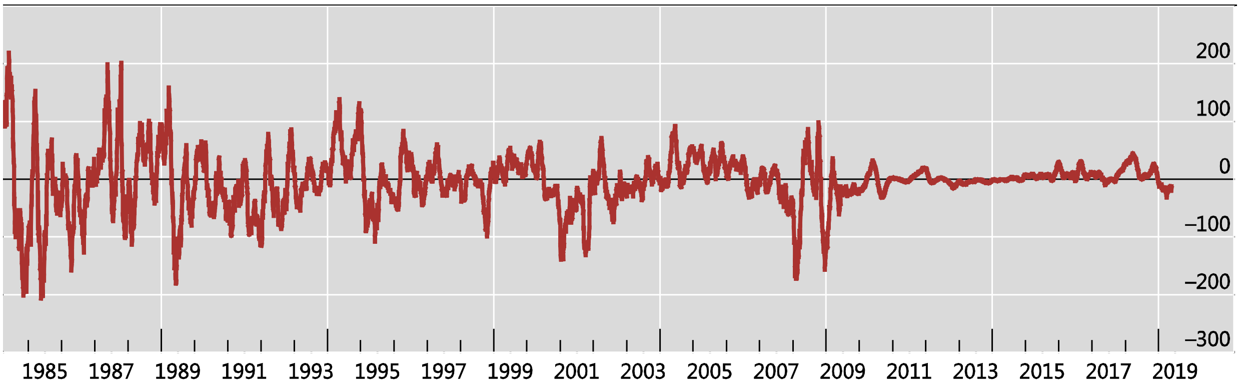
These conventions can also be used with overnight rates. An *in advance* payment structure based on overnight rates would reference an average of the overnight rates observed before the current interest period began, while an *in arrears* structure would reference an average of the rate over the current interest period. With an *in arrears* payment structure the rate is known at the end of the period.

The tension in choosing between *in arrears* and *in advance* is that borrowers will reasonably prefer to know their payments ahead of time – well ahead of time for some borrowers – and so prefer *in advance*, while investors will reasonably prefer returns based on rates over the interest period (i.e., *in arrears*) and will tend to view rates set *in advance* as "out of date". But this isn't an entirely new problem: an IBOR itself can often quickly become out of date. For example, in most adjustable rate mortgages (ARMs) in the USA, the adjustable rate is set annually based on a 1-month average of 1-year LIBOR that is set 45 days before the start of the next reset period. The rate is forward-looking, but even in just 45 days 1-year LIBOR can change radically and can itself become "out of date." The amount of basis this creates is shown in **Figure 3**, and historically it has been quite large at times. Although it may seem counterintuitive, the historical magnitude of the basis that would have been caused by using a compound average overnight rate in advance in ARMs is comparable to the basis that was caused using 1-year LIBOR.

Difference between 1-year USD LIBOR and 1-month average of 1-year USD LIBOR 45 days prior

In basis points

Figure 3



Source: Federal Reserve Bank of St. Louis; BIS calculations.

The basis between *in arrears* and *in advance* conventions will depend on the steepness of the yield curve. The basis is zero in case of a flat yield curve and/or will tend to net out over a full interest rate cycle. However, in any given period there may be differences and investors may either gain or lose. These differences will also depend on how frequently payments are made: the difference between an average of rates over the past month and an average of rates over the next month will typically be small, but the difference between an average of rates over this year

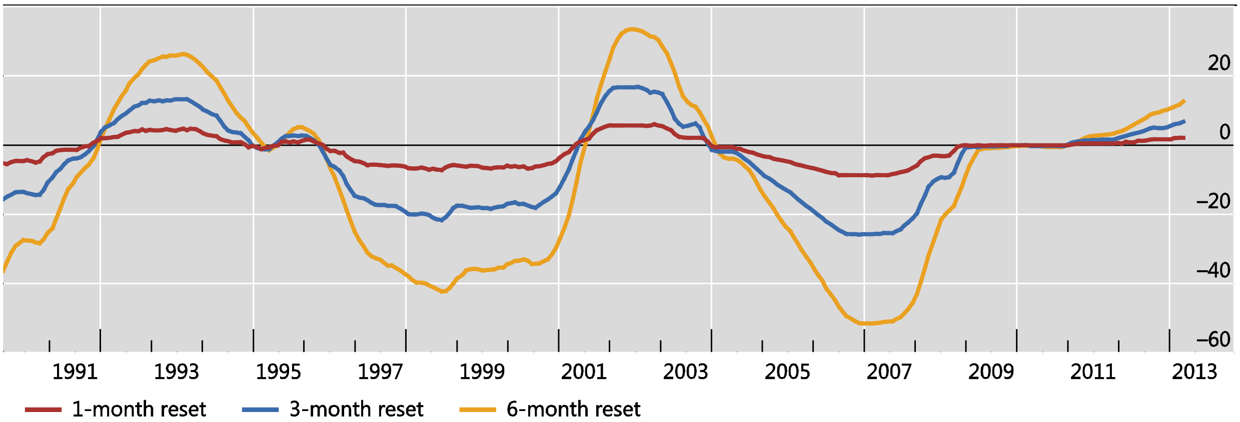
[7] Although this convention doesn't necessarily have to imply that payment is made after the interest period has concluded, payment will frequently be made 1-2 days after the period has ended.

and an average of rates over the next year may be larger just because rates can move by more over a year than they might over a month.

To quantify these effects, **Figure 4** shows the ex post basis between a hypothetical 5-year loan made using effective federal funds rate (EFFR) in advance versus one made in arrears for different interest periods (monthly resets, quarterly, and semi-annual).[8] The risk involved is on the order of ± 5 basis points with a monthly interest period, comparable to the size of the basis between simple and compound interest. The basis is larger for longer interest periods, but still contained. Any form of basis is inherently undesirable, but if market participants are generally willing to accept the kinds of potential basis that occur between simple and compound interest, then it isn't clear that the basis between in advance and in arrears payments structures should be viewed as problematic, at least for shorter payment frequencies.

Basis return spreads between "in advance" versus "in arrears" payments[1]

In basis points Figure 4



[1] On a hypothetical 5-year EFFR loan. Note that this Figure cannot show recent data as the last 5 years are required to calculate the spreads.

Source: Bloomberg L.P.

1.5 Publication timing of RFRs

By using an *in arrears* structure the remaining time from which the payment is known and has to be processed is very short. With the exception of SARON, which publishes its final fixing on the same business day after the market close, RFRs are published on a next day basis (see **Table 3**). These RFRs are published on the day that the overnight transaction is to be repaid rather on the day that the transaction is entered into. Given this, the borrower would only have a few hours' notice before payment was due using an in arrears convention for calculating the average of SOFR in the absence of any modification.[9] Many borrowers would need more time than this. This is also why OIS often use a payment delay of two days.

[8] In these and following simulations, the basis is calculated as the spread (expressed as an annual rate) that would need to be added to the in advance instrument in order to equate the ex post net present value of payments received with the in arrears instrument. Net present values are calculated using the internal rate of return on the in arrears instrument. A positive basis implies that investors would have required added compensation to have broken even on the in advance instrument, while a negative basis implies that investors would have gained from the in advance instrument and would have had to rebate some of the interest received to have broken even relative to in arrears.

[9] Because the Fed has the ability to correct and republish SOFR until 2:30 pm New York City time each day, users may wish to reference the rate after this time (e.g. 3:00 pm). Hence, there would be even less time for the payment.

Table 3

Publication timing of selected RFRs

SOFR	Published around 8 am the next business day
SONIA	Published at 9 am the next business day
TONA	Published at 10 am the next business day
€STR	Will be published by 9 am the next business day
SARON	Published at 6 pm the same business day

2. Options on how to use RFRs in cash products

The derivatives market based on RFRs, which already exists or is in the process of developing, is using an *in arrears* structure. The cash market based on RFRs existent so far also uses an *in arrears* structure. There have been a number of modifications to the conventions in order to allow for additional time for the payment within the *in arrears* framework. This isn't an issue for *in advance*, as the framework already allows for ample notice of the next payment due, but there are other decisions that need to be made about the period to calculate the averaged overnight rate. And finally, although these would be new concepts for the market in some respects, there are also potential hybrid conventions that combine aspects of both *in advance* and *in arrears* and that could prove useful.

Figure 5 sets out different possible conventions for using an averaged RFR in a cash product. The observation period thereby defines the period used to calculate the averaged RFR. The interest period defines the period on which the averaged RFR is applied to. It is worth to keep in mind that all options yield the same results in case the RFR remains constant and a simple mean is used to calculate the averaged RFR, even if the observation period is far shorter and does not overlap with the interest period. If a compounded convention is used to calculate the averaged RFR the length of the observation period affects the averaged RFR.

2.1 In arrears

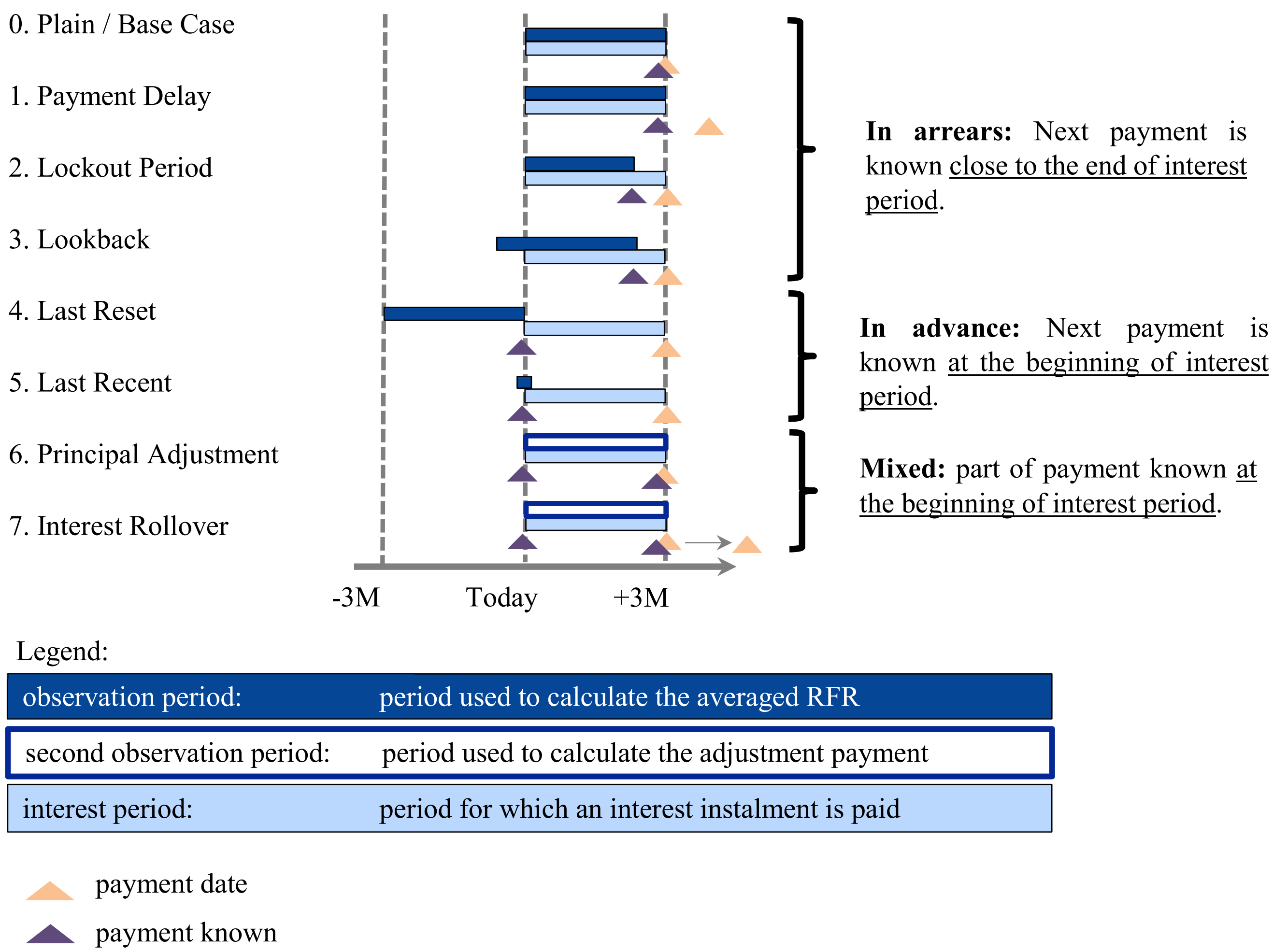
0. ***Plain / Base case:*** In the base case, the observation period is identical to the interest period. The notional is paid at the start of the period and repaid on the last day of the contract period together with the last interest payment. A plain in arrears structure reflects the movement in interest rates over the full interest period and payment is made on the day that it would naturally be due, but given the publication timing for most RFRs, this has the disadvantage of requiring payment on the same day that the final payment amount is known.[10]
1. ***Payment delay:*** In contrast to the base case, the interest payments are delayed by a certain number of days and are thus due a couple of days after the end of an interest period. The idea is to provide more time for operational cash flow management. In case of a lag of two days, the cash flow of the loan matches the cash flow of most OIS swaps,

[10] An exception is SARON, as SARON is published one business day before the overnight loan is repaid.

allowing to perfectly hedge the loan. In the last interest period, the interest payment is due after the repayment of the notional, which leads to a mismatch of cash flows and may be difficult to handle from an operational and credit risk perspective.

Figure 5

Options for using averaged RFRs



2. ***Lockout or Suspension period:*** In this option, the RFR is no longer updated (i.e. frozen) for a certain number of days prior to the end of an interest period (lockout period). During this time, the RFR of the day prior to the start of the lockout period is applied for the remaining days of the interest period. As a result, the averaged RFR can be calculated a couple of days before the end of the interest period. This option is predominantly used for SOFR floating rate notes (FRNs) with a lockout period of typically four days. One side effect of the lockout period is that the calculation of the interest rate might be considered to be less transparent for clients and more complex for product providers to implement. Also, the option involves interest rate risk that is difficult to hedge due to potential changes in the RFR during the lockout period.
3. ***Lookback:*** In contrast to the base case, the observation period for the interest rate calculation starts and ends a certain number of days prior to the interest period. As a result, the interest payment can be calculated prior to the end of the interest period. This

option is predominantly used for SONIA FRNs with an offset period of five days. This option involves slightly increased interest rate risk due to changes in the yield curve over the lifetime of the product. There are ways to hedge this risk, if required.

2.2 In advance

4. ***Last reset:*** In this option, interest payments are determined on the basis of the averaged RFR of the previous period. In order to ensure that the present value of this option is equivalent to the base case, a constant mark-up can be added to the averaged RFR. This mark-up compensates the effects of the period shift over the full lifespan of the product. The mark-up can be priced by using the OIS curve. In case of a decreasing yield curve, this basis would be negative. As a result, the product is more complex but interest payments are already known at the start of the interest period, as in the case of LIBOR-based products. The mark-up can also be seen as the price borrowers are willing to pay due to their preference to know the next payment in advance.
5. ***Last recent:*** In this option, a single RFR or an averaged RFR for a short number of days, are applied for the entire interest period. Given the short observation period, the interest payment is already known in advance and due on the last day of the interest period. In this option, the interest rate risk cannot be hedged with currently existing instruments.

2.3 Hybrid options

6. ***Principal adjustment:*** This option combines a first payment (instalment payment) known at the beginning of the interest period with an adjustment payment known at the end. The calculation of the instalment payment could be based on latest RFRs. The adjustment payment is calculated from the differential between the instalment payment and the averaged RFR during the interest period and paid at the end of the interest period by either party (i.e. additional payment by the client or a repayment by the product provider). As a result, part of the interest payment is known already at the start of the period.
7. ***Interest rollover:*** This option also combines a first payment (instalment payment) known at the beginning of the interest period with an adjustment payment known at the end. The difference to the previous option is that the adjustment payment is delayed. The adjustment payment can be made a few days later or at the end of the next period.

2.4 Summary

There is a trade-off between knowing the cash flows in advance and the desire for a payment structure that fully hedges against realised interest rate risk. The current derivatives market uses *in arrears* payment structures and the more different the option used for cash products is, the less efficient is the hedge of such a cash product. In the end, whether lenders can charge this difference or basis depends on the agreement between lenders and borrowers. Furthermore, for most cash products in order to be able to use one of the above options, infrastructure systems may need to be updated.

Annex 1: Compound and simple interest formulae

For some, it may be useful to note the mathematical formulas behind compound and simple interest conventions:

$$Compound\ Interest\ Formula = \left[\prod_{i=1}^{d_b}\left(1+\frac{r_i \times n_i}{N}\right) - 1\right] \times \frac{N}{d_c}$$

$$Simple\ Interest\ Formula = \left[\sum_{i=1}^{d_b}\left(\frac{r_i \times n_i}{N}\right)\right] \times \frac{N}{d_c}$$

Where

d_b = the number of *business days* in the interest period

d_c = the number of *calendar days* in the interest period

r_i = the interest rate applicable on business day *i*

n_i = the number of calendar days for which rate r_i applies (on most days, n_i will be 1, but on a Friday it will generally be 3, and it will also be larger than 1 on the business day before a holiday).

N = the market convention for quoting the number of days in the year.[11]

Tables 4 and 5 present an example of how these formulas would be used for a hypothetical 1-week SOFR loan.

[11] In the US, the convention for money markets is N = 360, while in the UK it is N=365.

Table 4

Calculating simple and compound interest

Simple interest on a one-week SOFR loan of $1 million drawn on 7 January 2019[12]

Secured Overnight Financing Rate (Percent, Annualised)	Number of Days Rate is Applied	Effective Rate (Not Annualised)	Principal	Principal + Accumulated Interest	Interest Charge for Next Business Day (Effective Rate*Principal)
2.41	1	0.0241/360 = 0.006694%	$1,000,000.00	$1,000,000.00	$66.94
2.42	1	0.0242/360 = 0.006722%	$1,000,000.00	$1,000,066.94	$67.22
2.45	1	0.0245/360 = 0.006806%	$1,000,000.00	$1,000,134.16	$68.06
2.43	1	0.0243/360 = 0.006750%	$1,000,000.00	$1,000,202.22	$67.50
2.41	3	3*0.0241/360 = 0.020083%	$1,000,000.00	$1,000,269.72	$200.83
---	---	---	$1,000,000.00	$1,000,470.56	
Payment Due	14 January 2019			**$1,000,470.56**	
Annualised Simple Rate of Interest:	$\left(\frac{360}{7}\right)\left[\frac{0.0241}{360}+\frac{0.0242}{360}+\frac{0.0245}{360}+\frac{0.0243}{360}+\frac{3\times 0.0241}{360}\right]$			= (360/7)*(.047056%) = **2.4200%**	

[12] See footnote 11 above.

Table 5

Calculating simple and compound interest

Compound interest on a one-week SOFR loan of $1 million drawn on 7 January 2019[13]

Secured Overnight Financing Rate (Percent, Annualised)	Number of Days Rate is Applied	Effective Rate (Not Annualised)	Principal	Principal + Accumulated Interest	Interest Charge for Next Business Day (Effective Rate* (Principal + Accumulated Interest))
2.41	1	0.0241/360 = 0.006694%	$1,000,000.00	$1,000,000.00	$66.94
2.42	1	0.0242/360 = 0.006722%	$1,000,000.00	$1,000,066.94	$67.23
2.45	1	0.0245/360 = 0.006806%	$1,000,000.00	$1,000,134.17	$68.06
2.43	1	0.0243/360 = 0.006750%	$1,000,000.00	$1,000,202.24	$67.51
2.41	3	3*0.0241/360 = 0.020083%	$1,000,000.00	$1,000,269.75	$200.89
---	---	---	$1,000,000.00	$1,000,470.64	
Payment Due	14 January 2019			**$1,000,470.64**	
Annualised Compound Rate of Interest:	$\left(\frac{360}{7}\right)\left[\left(1+\frac{0.0241}{360}\right)\left(1+\frac{0.0242}{360}\right)\left(1+\frac{0.0245}{360}\right)\left(1+\frac{0.0243}{360}\right)\left(1+\frac{3\times 0.0241}{360}\right)-1\right]$			= (360/7)*(.047064%) = **2.4204%**	

[13] See footnote 11 above.

Annex 2: Glossary

Averaged RFR: Approaches reflecting a sequence of realised overnight rates (RFR) (compounded or simple average in arrears and in advance) are referred to as backward-looking term rate or simply averaged RFR. Averaged RFR are not forward-looking as they do not reflect expectations.

Bps: basis points, i.e., units of 0.01%.

CHF NWG: National Working Group on Swiss Franc Reference Rates.

€STR: Euro Short-Term Rate.

EFFR: effective federal funds rate.

Forward-looking term rates: Approaches reflecting a sequence of expected overnight rates (cash- and derivatives-based, e.g. LIBOR and ICE-fix, respectively) are referred as forward-looking term rates. Those rates reflect market expectations over the tenor.

IBOR: interbank offered rate.

In advance: The averaged RFR of the last period is used. The averaged RFR is therefore known at the beginning of an interest rate period. However, the averaged RFR does not reflect market expectations and is therefore not forward-looking.

In arrears: Plain option of an averaged RFR. The rate is calculated and known at the end of an interest rate period.

LIBOR: London Interbank Offered Rate.

OIS: overnight index swap.

RFR: alternative nearly risk-free reference rate.

SARON: Swiss Average Rate Overnight.

SOFR: Secured Overnight Financing Rate.

SONIA: Sterling Overnight Index Average.

Term rate: A "term" rate is any rate with a tenor, e.g. any 3-month rate is a term rate. Hence, a 3-month averaged RFR is a term rate.

TONA: Tokyo Overnight Average Rate.

Figure 6

Terminology of term rates