How to perform FTP & IRR Stress Testing post IBOR Transition

Karen Moss, ALM/BSM Senior Practitioner, Moody's Analytics   Q2, 2021
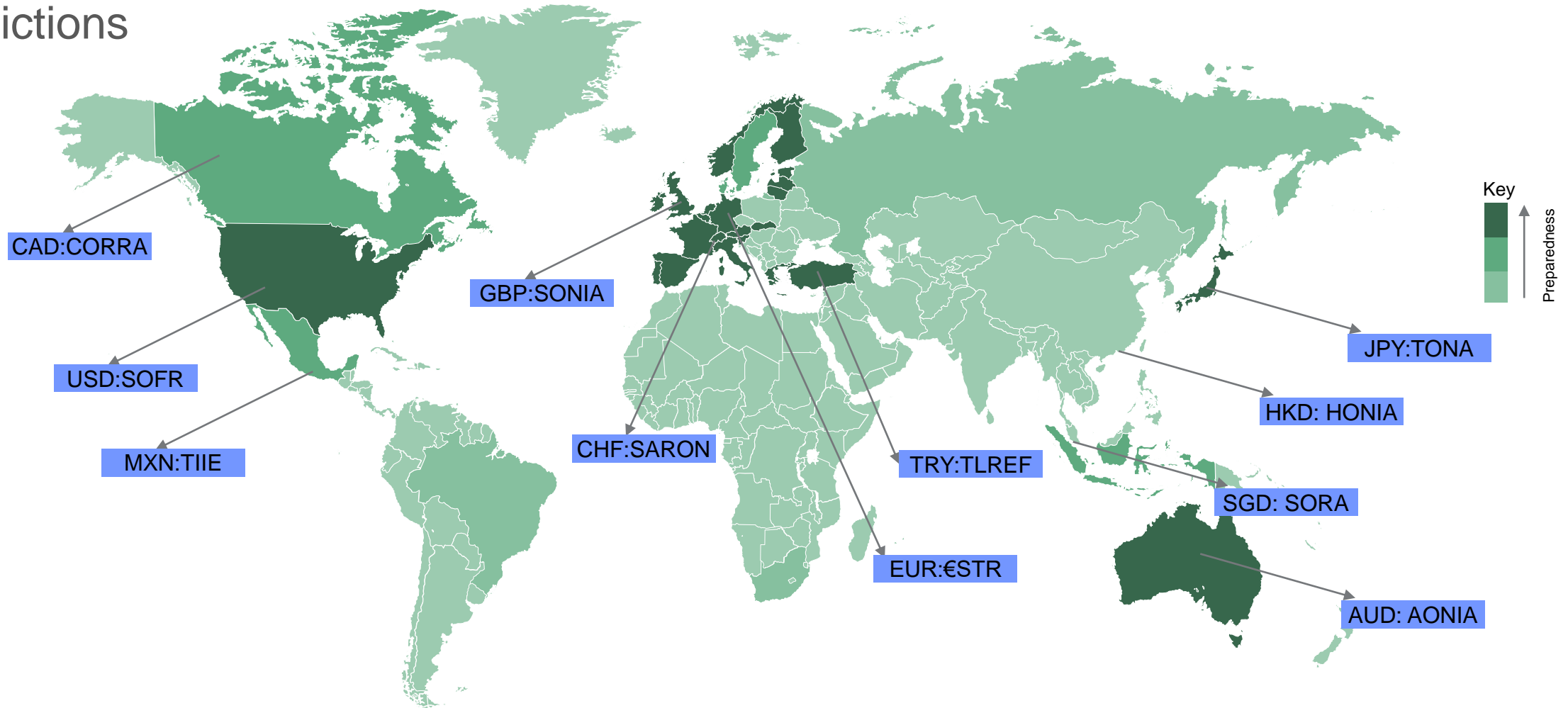
Agenda

1. IBOR vs ARR Products

2. ALM/FTP Software Enhancements

3. ARR Curves & Indices

4. IRRBB Worked Example

5. FTP Worked Example

6. Compounding & Accrual Methodology

7. Q&A

1 | IBOR vs ARR Products

LIBOR vs ARR Products

Alternative Reference Rates(ARRs) have been selected in some, but not all jurisdictions

Key

Preparedness

CAD:CORRA

GBP:SONIA

USD:SOFR

MXN:TIIE

CHF:SARON

TRY:TLREF

EUR:€STR

JPY:TONA

HKD: HONIA

SGD: SORA

AUD: AONIA

LIBOR vs ARR Products

Interest payments based on rates constructed and behaving differently

LIBOR characteristics

A. <u>Based on quotes</u> in interbank and wholesale funding markets.

B. Exhibit liquidity characteristics related to <u>bank credit premiums</u>

C. <u>Forward-looking</u> via terms embedding expectations of future rate moves

D. Prefix convention means <u>interest payments are known in advance</u>

Likely ARR Characteristics

A. <u>Based on executable transactions</u> of overnight trades in secured or unsecured markets

B. Closely track central bank policy rates and <u>exclude bank credit premiums</u>*

C. <u>Backward-looking</u> as derived from averages of daily overnight rates**

D. Postfix convention means <u>no notice of interest payment amounts</u> given

*Discussions persist as to whether the cash market can sustain RFRs without a credit premium element
**Trials are underway to attempt to develop forward-looking term rates derived from ARRs

Unless convention variations are utilised
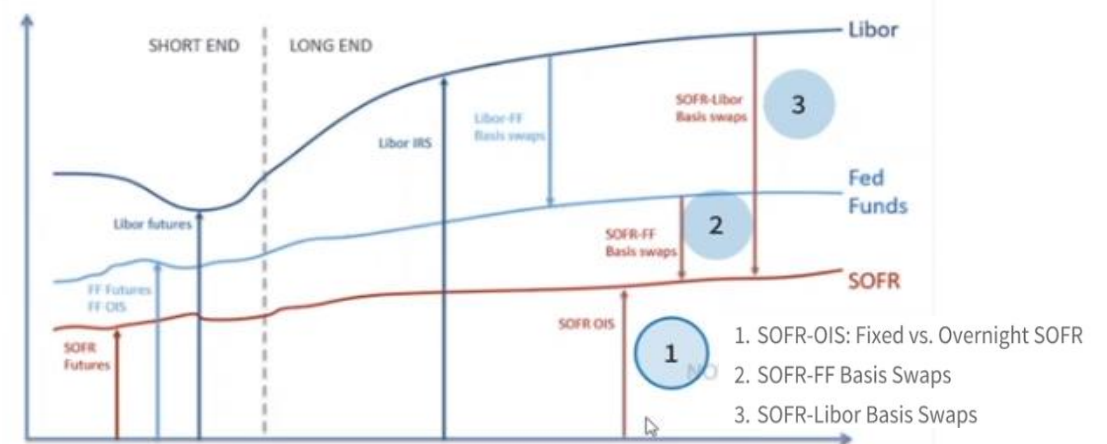
LIBOR vs ARR Products

Forward-looking ARR term rate 'curves' are needed for forecasting
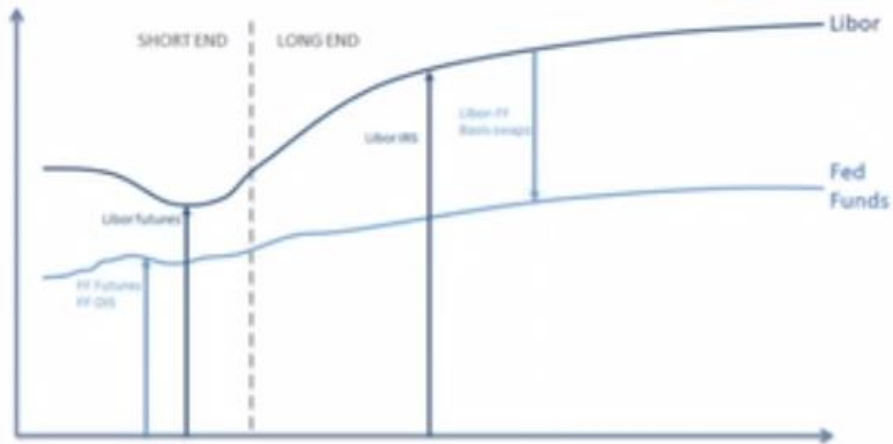
Building IBOR curves

» IBOR Futures at short end

» IRS swaps or Fed Funds Basis Swaps at long end

Source: FINCAD

1. SOFR-OIS: Fixed vs. Overnight SOFR
2. SOFR-FF Basis Swaps
3. SOFR-Libor Basis Swaps

Building ARR curves

» ARR Futures at short end

» OIS at long end- Liquidity is low! FF or LIBOR Basis swaps as an alternative?
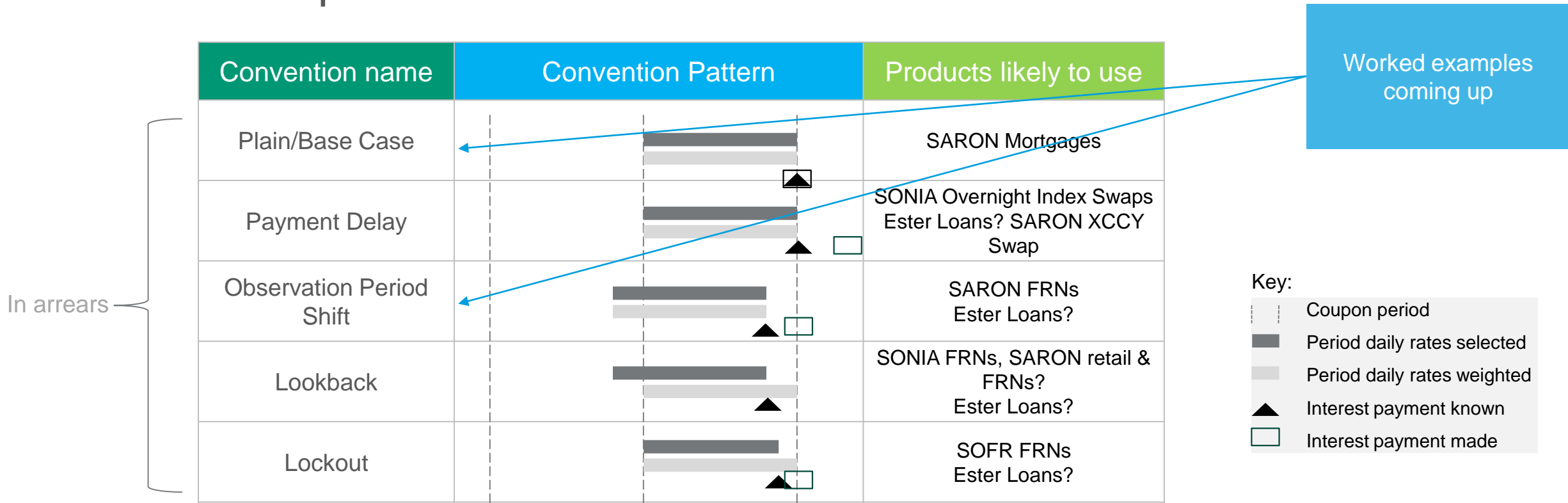
LIBOR vs ARR Products

Products linked to O/N ARR 'indexes' involve backward-looking averaging and will likely require conventions
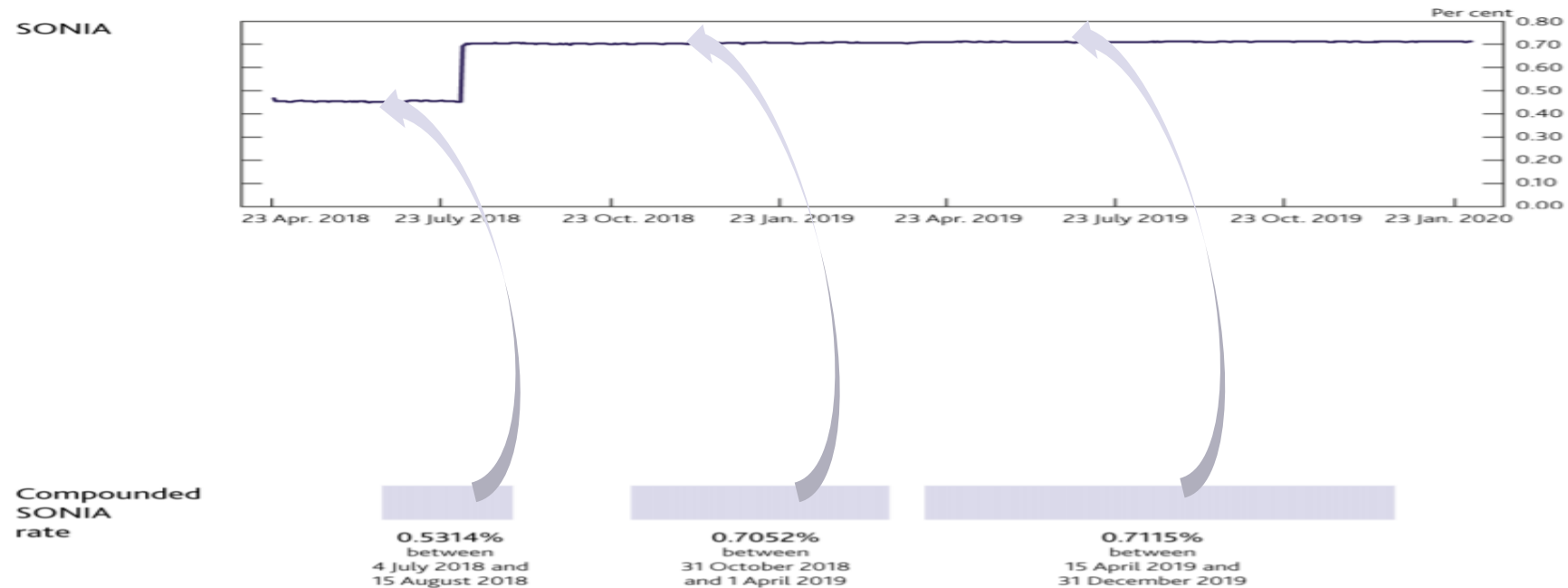
Source: Provision of compounded SONIA, Discussion Paper, Bank of England, Feb 2020

Averaging Conventions

Worked examples are for the Plain/Base case & Obs Shift conventions

Convention name	Convention Pattern		Products likely to use
Plain/Base Case			SARON Mortgages
Payment Delay			SONIA Overnight Index Swaps Ester Loans? SARON XCCY Swap
Observation Period Shift			SARON FRNs Ester Loans?
Lookback			SONIA FRNs, SARON retail & FRNs? Ester Loans?
Lockout			SOFR FRNs Ester Loans?

In arrears

Worked examples coming up

Key:
- Coupon period
- Period daily rates selected
- Period daily rates weighted
- ▲ Interest payment known
- □ Interest payment made

2 | RiskConfidence™ ARR Capabilities

RiskConfidence™: Alternative Reference Rate Capabilities

✓ ## Product Level: Backward Daily Averaging[1]

Product coverage:

Term Loans[2] & Deposits	Bonds	Swaps	Repo & Reverse	Call Deposits & Overdrafts	Facilities
√	√	√	√	√ newly launched	√ newly launched

Convention coverage (for both simple averaging & daily compounding [3]):

Plain / Base Case	Payment Delay [4]	Obs Period Shift	Lookback	Lockout
√	√	√ newly launched	√ newly launched	√ newly launched

✓ ## Rate Level: Alternative Reference Rate Handling

√ Input of historical rates

√ Input of overnight forecast index

√ Input of term yield curve

√ Generation of forward overnight rates from an inputted term yield curve

√ Discounting and valuation using term yield curve [5]

Notes: 1) newly launched means from version 7.1.5 onwards
2) constant installment amortizing loans included from 7.1.5 onwards.
3) backward daily compounding formula was aligned with ISDA methodology from v7.1.5 onwards. **Conventions referenceable in FTP formula from v7.1.7.**
4) Available for LOANDEPO table from v5.2 & REPO table from v6.2; **will be available for ACCOUNT/FACILITY/SECURITY & SWAP from 7.1.7.**
5) Pricing of Swaptions and Cancellable Swaps using ARRs is a further planned enhancement in 2021.

3 | ARR Curves & Indices

SOFR 'Term' Curve

To use for discounting for IRRBB

» A forward looking yield curve with term rates for a particular value date
» Can be used to generate forward o/n rates for all value dates in an index

Term curve at a specific value date

SOFR 'Term' Curve & COF Curve

To calculate Liquidity Premium for FTP

» These are forward looking yield curves with term rates for a particular value date
» These are used as prefix rates, like Libor, so no compounding necessary

Example: 90 day floating Loan LP takes 90 day point on the COF/All In curve 4.06% and deducts 90 day point on the SOFR term/IRS curve 3.06% i.e. LP is 1%
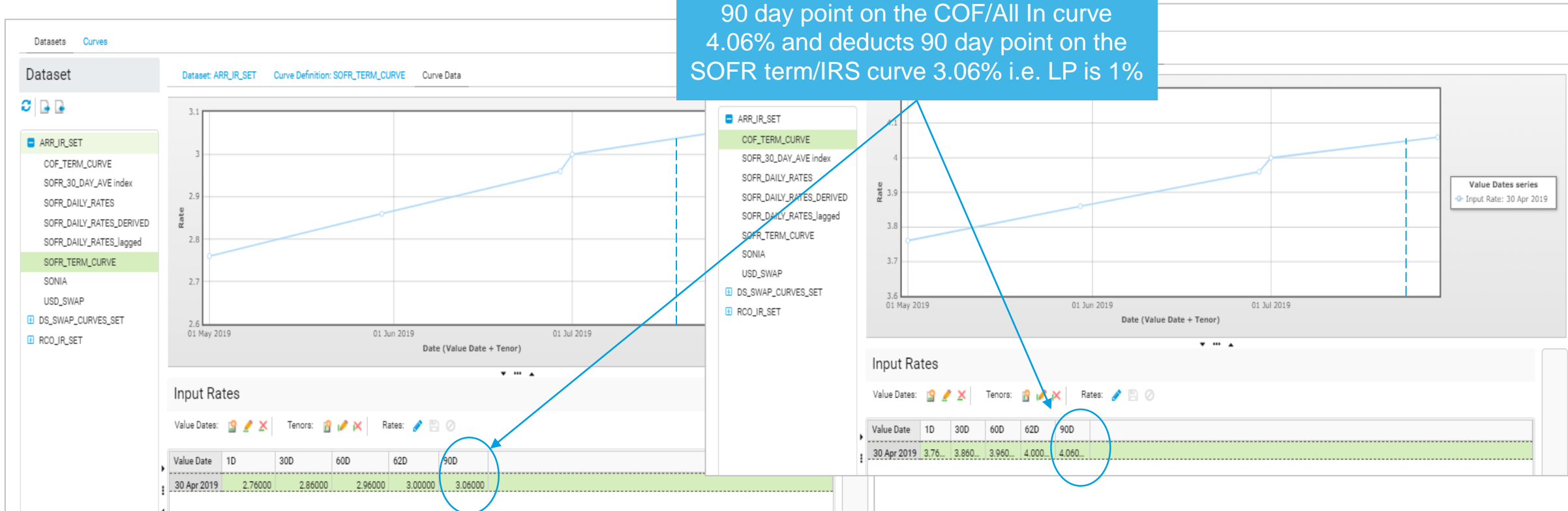
SOFR Daily Index

To calculate backward looking average floating interest payments

» This is an Index of forecast 1 Day rates at different value dates

» The rates can be compounded or simple averaged into a periodic interest rate at deal level

O/n index for Multiple value dates
(can include value dates prior to reporting date of IRR calculation)

Example: each of the 30 daily rates from 30th Apr to 30th May compounds to a rate of 2.42% paid on 30th May

Value Date	1D
30 Apr 2019	2.76000
01 May 20...	2.54000
02 May 20...	2.50000
03 May 20...	2.43000
04 May 20...	2.43000
05 May 20...	2.43000
06 May 20...	2.42000
07 May 20...	2.44000
08 May 20...	2.43000
09 May 20...	2.41000
10 May 20...	2.40000
11 May 20...	2.40000
12 May 20...	2.40000
13 May 20...	2.38000
14 May 20...	2.39000
15 May 20...	2.48000
16 May 20...	2.43000
17 May 20...	2.42000
18 May 20...	2.42000
19 May 20...	2.42000
20 May 20...	2.39000
21 May 20...	2.38000
22 May 20...	2.37000
23 May 20...	2.37000
24 May 20...	2.37000
25 May 20...	2.37000
26 May 20...	2.37000
27 May 20...	2.37000
28 May 20...	2.41000
29 May 20...	2.40000
30 May 20...	2.40000
31 May 20...	2.40000
01 Jun 2019	2.40000
02 Jun 2019	2.40000
03 Jun 2019	2.40000

Datasets   Curves

Dataset

Dataset: ARR_IR_SET   Curve Definition: SOFR_DAILY_RATES   Curve Data

ARR_IR_SET
COF_TERM_CURVE
SOFR_30_DAY_AVE index
SOFR_DAILY_RATES
SOFR_DAILY_RATES_DERIVED
SOFR_DAILY_RATES_lagged
SOFR_TERM_CURVE
SONIA
USD_SWAP
DS_SWAP_CURVES_SET
RCO_IR_SET

Input Rates

Value Dates: Tenors: Rates:

Two 90 day SOFR Loans
Deal Characteristics

» Two loans: both mature after 90 days but pay interest every 30 days
» Fixing rule denotes if daily rates are compounded or simple averaged into a periodic interest rate
» To populate a 5 day Obs Period Shift enter "-5" in the field 'At Next Coupon Date (Days)'

Selecting Fixing Rule 'Overnight Indexed Swap' enables backward compounding

Second loan has '-5' entered

Compounding Conventions
Set up for product level fixing rule- base case

Conventions displayed here:

» Obs Period shift

Source: RiskConfidence™ v7.1.7

Compounding Conventions
Set up for product level fixing rule- payment delay

Conventions displayed here:
» Payment delay of two days

4 | IRRBB Worked Examples

4

4.1 Worked Example for IRRBB Sensitivity

Compounded Interest Amounts
Base case vs +200bps shock- Plain SOFR Loan

» Interest amounts for the product which pays interest every 30 days are compounded
» Interest amounts will be higher in the +200 shock scenario (the shock applies instantaneously from the Reporting Date onward)

Note: as rate straddles RD then cashflow is calculated from RD to end_date but displayed rate is calculated from RD+1 to end_date

Base Scenario Curves

Contract Reference	R L	Amount Type	Maturity	Fixing Date	Amount	Rate Type	Rate	Discount Factor
SOFR 30D Coup	V	I	30 May 2019	30 May 2019	2,022.19	SOFR_DAILY_RATES…	2.41494	0.99762
SOFR 30D Coup	V	I	01 Jul 2019	01 Jul 2019	2,132.13	SOFR_DAILY_RATES…	2.39865	0.99486
SOFR 30D Coup	V	I	29 Jul 2019	29 Jul 2019	1,908.64	SOFR_DAILY_RATES…	2.45396	0.99241
SOFR 30D Coup	V	N	29 Jul 2019		1,000,000	SOFR_DAILY_RATES…	0	0.99241

+200bp Shock Scenario Curves

Contract Reference	R L	Amount Type	Maturity	Fixing Date	Amount	Rate Type	Rate	Discount Factor
SOFR 30D Coup	V	I	30 May 2019	30 May 2019	3,693.3	SOFR_DAILY_RATES…	4.42006	0.99597
SOFR 30D Coup	V	I	01 Jul 2019	01 Jul 2019	3,914.96	SOFR_DAILY_RATES…	4.40433	0.99146
SOFR 30D Coup	V	I	29 Jul 2019	29 Jul 2019	3,468.09	SOFR_DAILY_RATES…	4.45897	0.98751
SOFR 30D Coup	V	N	29 Jul 2019		1,000,000	SOFR_DAILY_RATES…	0	0.98751

The 90 day loan paying interest every 30 days gives 3 compounded interest payments

Compounded rate from 30 individual overnight rates

Compounded Interest Amounts
Base case vs +200bps shock- Plain SOFR Loan

Base Scenario Curves

+200bp Shock Curves

Example 30D Intr Loan: each of the 30 daily rates from 30th Apr to 30th May compounds to a rate of 2.42% paid on 30th May

For this loan, all 30 rates underlying the compounding and discounting move up +200bps

Value Date	1D
30 Apr 2019	2.76000
01 May 20...	2.54000
02 May 20...	2.50000
03 May 20...	2.43000
04 May 20...	2.43000
05 May 20...	2.43000
06 May 20...	2.42000
07 May 20...	2.44000
08 May 20...	2.43000
09 May 20...	2.41000
10 May 20...	2.40000
11 May 20...	2.40000
12 May 20...	2.40000
13 May 20...	2.38000
14 May 20...	2.39000
15 May 20...	2.48000
16 May 20...	2.43000
17 May 20...	2.42000
18 May 20...	2.42000
19 May 20...	2.42000
20 May 20...	2.39000
21 May 20...	2.38000
22 May 20...	2.37000
23 May 20...	2.37000
24 May 20...	2.37000
25 May 20...	2.37000
26 May 20...	2.37000
27 May 20...	2.37000
28 May 20...	2.41000
29 May 20...	2.40000
30 May 20...	2.40000
31 May 20...	2.40000
01 Jun 2019	2.40000
02 Jun 2019	2.40000
03 Jun 2019	2.40000

Compounded Interest Amounts
Base case vs +200bps shock- Lagged SOFR Loan with Obs period shift

Base Scenario Curves

SOFR + obs shift: each of the 30 daily rates from 23rd Apr to 23rd May compounds to a rate of 2.45% paid on 30th May

Plain SOFR: each of the 30 daily rates from 30th Apr to 30th May compounds to a rate of 2.42% paid on 30th May

+200bp Shock Curves

Plain SOFR: all 30 rates underlying the compounding and discounting move up +200bps

Compounded Interest Amounts
Base case vs +200bps shock- Lagged SOFR Loan with Obs period shift

Base Scenario Curves

SOFR + obs shift: each of the 30 daily rates from 23rd Apr to 23rd May compounds to a rate of 2.45% paid on 30th May

Plain SOFR: each of the 30 daily rates from 30th Apr to 30th May compounds to a rate of 2.42% paid on 30th May

+200bp Shock Curves

SOFR + obs shift: only 25 overnight rates underlying the compounding move up +200bps.

Plain SOFR: all 30 rates underlying the compounding and discounting move up +200bps

Compounded Interest Amounts
Base case vs +200bps shock- SOFR Loan with Obs period shift

Conclusion: the product convention <u>will</u> impact the IRR sensitivity

Past Market Data

Past PD | Past Interest Rates | Past Exchange Rates | Past Economic Indices | Past Spreads | Past SABR Volatility | Past Local Volatility

Curve Name	Currency	Value Date	Maturity Date	Discount Factor	Zero Coupon Rate	Tenor	Market Rate
SOFR_DAILY_RATES	USD	22 Apr 2019	23 Apr 2019	1	0	1D	0.0237
SOFR_DAILY_RATES	USD	23 Apr 2019	24 Apr 2019	1	0	1D	0.0337
SOFR_DAILY_RATES	USD	24 Apr 2019	25 Apr 2019	1	0	1D	0.0437
SOFR_DAILY_RATES	USD	25 Apr 2019	26 Apr 2019	1	0	1D	0.02
SOFR_DAILY_RATES	USD	26 Apr 2019	27 Apr 2020	1	0	1D	0.03
SOFR_DAILY_RATES	USD	27 Apr 2019	28 Apr 2019	1	0	1D	0.04
SOFR_DAILY_RATES	USD	28 Apr 2019	29 Apr 2019	1	0	1D	0.0241
SOFR_DAILY_RATES	USD	29 Apr 2019	30 Apr 2019	1	0	1D	0.024

Curve Data

Rates:

SOFR_DAILY_RATES_lagged	
SOFR_TERM_CURVE	
SONIA	
USD_SWAP	
DS_SWAP_CURVES_SET	
RCO_IR_SET	

Date	Rate
30 Apr 2019	2.76000
01 May 20...	2.54000
02 May 20...	2.50000
03 May 20...	2.43000
04 May 20...	2.43000
05 May 20...	2.43000
06 May 20...	2.42000
07 May 20...	2.44000
08 May 20...	2.43000
09 May 20...	2.41000
10 May 20...	2.40000
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25 May 20...	2.37000
26 May 20...	2.37000
27 May 20...	2.37000
28 May 20...	2.41000
29 May 20...	2.40000
30 May 20...	2.40000
31 May 20...	2.40000
01 Jun 2019	2.40000
02 Jun 2019	2.40000
03 Jun 2019	2.40000

Base Scenario Curves

SOFR + obs shift: each of the 30 daily rates from 23rd Apr to 23rd May compounds to a rate of 2.45% paid on 30th May

Plain SOFR: each of the 30 daily rates from 30th Apr to 30th May compounds to a rate of 2.42% paid on 30th May

+200bp Shock Curves

SOFR + obs shift: only 25 overnight rates underlying the compounding move up +200bps.

Plain SOFR: all 30 rates underlying the compounding and discounting move up +200bps

Compounded Interest Amounts
Base case vs +200bps shock- SOFR Loan with Obs Period Shift

» Interest amounts will be different as the lagged loan compounds a different set of rates
» In the +200 shock scenario there are 5 days unshocked rates at the start of the first interest period

Base Scenario Curves

Contract Reference	R L	Amount Type	Maturity	Fixing Date	Amount	Rate Type	Rate	Discount Factor
SOFR 30D Coup	V	I	30 May 2019	30 May 2019	2,022.19	SOFR_DAILY_RATES...	2.41494	0.99762
SOFR 30D Coup	V	I	01 Jul 2019	01 Jul 2019	2,132.13	SOFR_DAILY_RATES...	2.39865	0.99486
SOFR 30D Coup	V	I	29 Jul 2019	29 Jul 2019	1,908.64	SOFR_DAILY_RATES...	2.45396	0.99241
SOFR 30D Coup	V	N	29 Jul 2019		1,000,000	SOFR_DAILY_RATES...	0	0.99241

Contract Reference	R L	Amount Type	Maturity	Fixing Date	Amount	Rate Type	Rate	Discount Factor
SOFR 30D Coup -5 Ob...	V	I	30 May 2019	30 May 2019	2,039.12	SOFR_DAILY_RATES...	2.44681	0.99762
SOFR 30D Coup -5 Ob...	V	I	01 Jul 2019	01 Jul 2019	2,118.26	SOFR_DAILY_RATES...	2.38304	0.99486
SOFR 30D Coup -5 Ob...	V	I	29 Jul 2019	29 Jul 2019	1,916.71	SOFR_DAILY_RATES...	2.46434	0.99241
SOFR 30D Coup -5 Ob...	V	N	29 Jul 2019		1,000,000	SOFR_DAILY_RATES...	0	0.99241

Note: discount factors are the same

+200bp Shock Scenario Curves

Contract Reference	R L	Amount Type	Maturity	Fixing Date	Amount	Rate Type	Rate	Discount Factor
SOFR 30D Coup	V	I	30 May 2019	30 May 2019	3,693.3	SOFR_DAILY_RATES...	4.42006	0.99597
SOFR 30D Coup	V	I	01 Jul 2019	01 Jul 2019	3,914.96	SOFR_DAILY_RATES...	4.40433	0.99146
SOFR 30D Coup	V	I	29 Jul 2019	29 Jul 2019	3,468.09	SOFR_DAILY_RATES...	4.45897	0.98751
SOFR 30D Coup	V	N	29 Jul 2019		1,000,000	SOFR_DAILY_RATES...	0	0.98751

Contract Reference	R L	Amount Type	Maturity	Fixing Date	Amount	Rate Type	Rate	Discount Factor
SOFR 30D Coup -5 Ob...	V	I	30 May 2019	30 May 2019	3,308.05	SOFR_DAILY_RATES...	4.02192	0.99597
SOFR 30D Coup -5 Ob...	V	I	01 Jul 2019	01 Jul 2019	3,901.2	SOFR_DAILY_RATES...	4.38885	0.99146
SOFR 30D Coup -5 Ob...	V	I	29 Jul 2019	29 Jul 2019	3,476.17	SOFR_DAILY_RATES...	4.46936	0.98751
SOFR 30D Coup -5 Ob...	V	N	29 Jul 2019		1,000,000	SOFR_DAILY_RATES...	0	0.98751

Note: discount factors are the same

First coupon for the lagged loan doesn't increase by full 2%

IRRBB Sensitivity
Base case vs +200bps shock

Sensitivity: Plain SOFR Loan

Analysis Scenario Code ↓	Cash Flow Approach Code	Market Value	Outstanding Balance	Normalized Value	Npv	Npv Int
RCO_BASE	Rate		1,000,000	998,440.78	1,000,000	
RCO_BASE	Valuation	998,440.78	1,000,000	998,440.78	998,440.78	6,032.69

Analysis Scenario Code ↓	Cash Flow Approach Code	Market Value	Outstanding Balance	Normalized Value	Npv	Npv Int
RCO_IR_SHIFT	Rate		1,000,000	998,492.72	1,000,000	
RCO_IR_SHIFT	Valuation	998,492.72	1,000,000	998,492.72	998,492.72	10,984.69

Plain SOFR Loan:
- Delta NII zero
- Delta EV zero

Sensitivity: Lagged SOFR Loan

Analysis Scenario Code ↑	Cash Flow Approach Code	Market Value	Outstanding Balance	Normalized Value	Npv	Npv Int
RCO_BASE	Rate		1,000,000	998,451.88	999,991.28	
RCO_BASE	Valuation	998,451.88	1,000,000	998,451.88	998,451.88	6,043.80

Analysis Scenario Code ↓	Cash Flow Approach Code	Market Value	Outstanding Balance	Normalized Value	Npv	Npv Int
RCO_IR_SHIFT	Rate		1,000,000	998,103.37	999,935.73	
RCO_IR_SHIFT	Valuation	998,103.37	1,000,000	998,103.37	998,103.37	10,595.34

Lagged SOFR Loan:
- Delta NII -3.5%
- Delta EV -3.5%

4

4.2 Repricing Gap ARR Convention Considerations

Repricing Gaps & ARR Conventions

There are two options for rate (or 'reprice') cashflows for products with these conventions:

1. Recognise them as overnight resetting cashflows (in line with 'plain ARR products')
2. Recognise them as having an element of mismatch if hedged with plain ARR products

Selected Approach

The first approach has been selected to ensure nominal amounts appear in repricing gaps in line with the rate reset itself* (i.e. overnight for Alternative Reference Rates) as well as to ensure less complexity when analyzing repricing gaps.

Convention name	Convention Pattern	Products likely to use
Plain/Base Case		SARON Mortgages
Payment Delay		SONIA Overnight Index Swaps Ester Loans? SARON XCCY Swap
Observation Period Shift		SARON FRNs Ester Loans?
Lookback		SONIA FRNs, SARON retail & FRNs? Ester Loans?
Lockout		SOFR FRNs Ester Loans?

Key:
- Coupon period
- Period daily rates selected
- Period daily rates weighted
- ▲ Interest payment known
- ☐ Interest payment made

*This aligns with the approach recommended by regulators such as the HKMA

Rate Cashflows for ARR Conventions

Base case vs +200bps shock

Base Scenario Curves

Job ID	Analysis Scenario Code	Cash Flow Approach Code	Time Band Row ID	Total Inflow	Interest Received	Total Gap	Cumulative Gap
38,186	RCO_BASE	Rate	0				
38,186	RCO_BASE	Rate	1	1,000,076.67	76.67	1,000,076.67	1,000,076.67
38,186	RCO_BASE	Rate	2	0	0		1,000,076.67
38,186							

Analysis Scenario Code	Cash Flow Approach Code	Time Band Row ID	Total Inflow	Interest Received	Total Gap	Cumulative Gap
RCO_BASE	Rate	0				
RCO_BASE	Rate	1	1,000,067.94	67.94	1,000,067.94	1,000,067.94
RCO_BASE	Rate	2	0	0	0	1,000,067.94
RCO_BASE	Rate	3	0	0	0	1,000,067.94
RCO_BASE	Rate	4	0	0	0	1,000,067.94
RCO_BASE	Rate	5	0	0	0	1,000,067.94
RCO_BASE	Rate	6	0	0	0	1,000,067.94
RCO_BASE	Rate	7	0	0	0	1,000,067.94
RCO_BASE	Rate	8	0	0	0	1,000,067.94
RCO_BASE	Rate	9	0	0	0	1,000,067.94
RCO_BASE	Rate	10	0	0	0	1,000,067.94
RCO_BASE	Rate	11	0	0	0	1,000,067.94
RCO_BASE	Rate	12	0	0	0	1,000,067.94
RCO_BASE	Rate	13	0	0	0	1,000,067.94
RCO_BASE	Rate	14	0	0	0	1,000,067.94
RCO_BASE	Rate	15	0	0	0	1,000,067.94
RCO_BASE	Rate		0	0	0	1,000,067.94
RCO_BASE	Rate		0	0	0	1,000,067.94

+200bp Shock Curves

Job ID	Analysis Scenario Code	Cash Flow Approach Code	Time Band Row ID	Total Inflow	Interest Received	Total Gap	Cumulative Gap
38,186	RCO_IR_SHIFT	Rate	0				
38,186	RCO_IR_SHIFT	Rate	1	1,000,132.22	132.22	1,000,132.22	1,000,132.22
38,186	RCO_IR_SHIFT	Rate	2	0	0	0	1,000,132.22
38,186	RCO_IR_SHIFT	Rate					

Analysis Scenario Code	Cash Flow Approach Code	Time Band Row ID	Total Inflow	Interest Received	Total Gap	Cumulative Gap
RCO_IR_SHIFT	Rate	0				
RCO_IR_SHIFT	Rate	1	1,000,067.94	67.94	1,000,067.94	1,000,067.94
RCO_IR_SHIFT	Rate	2	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	3	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	4	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	5	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	6	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	7	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	8	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	9	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	10	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	11	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	12	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	13	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	14	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	15	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	16	0	0	0	1,000,067.94
RCO_IR_SHIFT	Rate	17	0	0	0	1,000,067.94

Overnight loans appear in overnight gaps

Conclusion: the product convention will not impact position in the repricing gaps

5 | FTP Worked Examples

5

5.1 Worked Example for FTP

FTP Components
For Floating SOFR Loan

» Three components are displayed here; one for the floating element and two to calculate Liquidity Premium
» The components refer to different reference curves

FTP Method	Reference Curve	Curve Type	Tenor	Floating Curve
Floating	SOFR_DAILY_RATES			Use FTP Reference Curve
Maturity	COF_TERM_CURVE	Interest Rate		
Maturity	SOFR_TERM_CURVE	Interest Rate		

For Floating component: compound using SOFR_DAILY_RATES index

For LP component:
- pick rate on COF_Term_Curve at maturity
- pick rate on SOFR_Term_Curve at maturity

SOFR Daily Index

To calculate Floating Rate

» To account for the 5 day shift, the Index of forecast 1 Day rates, is supplemented by actual past market rates from pre reporting date

Past Market Data

Past PD | Past Interest Rates | Past Exchange Rates | Past Economic Indices | Past Spreads | Past SABR Volatility | Past Local Volatility

Curve Name	Currency	Value Date	Maturity Date	Discount Factor	Zero Coupon Rate	Tenor	Market Rate
SOFR_DAILY_RATES	USD	22 Apr 2019	23 Apr 2019	1	0	1D	0.0237
SOFR_DAILY_RATES	USD	23 Apr 2019	24 Apr 2019	1	0	1D	0.0337
SOFR_DAILY_RATES	USD	24 Apr 2019	25 Apr 2019	1	0	1D	0.0437
SOFR_DAILY_RATES	USD	25 Apr 2019	26 Apr 2019	1	0	1D	0.02
SOFR_DAILY_RATES	USD	26 Apr 2019	27 Apr 2020	1	0	1D	0.03
SOFR_DAILY_RATES	USD	27 Apr 2019	28 Apr 2019	1	0	1D	0.04
SOFR_DAILY_RATES	USD	28 Apr 2019	29 Apr 2019	1	0	1D	0.0241
SOFR_DAILY_RATES	USD	29 Apr 2019	30 Apr 2019	1	0	1D	0.024

Conclusion: the product convention <u>will</u> impact IR component

SOFR_DAILY_RATES_lagged	30 Apr 2019	2.76000
SOFR_TERM_CURVE	01 May 20...	2.54000
SONIA	02 May 20...	2.50000
USD_SWAP	03 May 20...	2.43000
DS_SWAP_CURVES_SET	04 May 20...	2.43000
RCO_IR_SET	05 May 20...	2.43000
	06 May 20...	2.42000
	07 May 20...	2.44000
	08 May 20...	2.43000
	09 May 20...	2.41000
	10 May 20...	2.40000
	11 May 20...	2.40000
	12 May 20...	2.40000
	13 May 20...	2.38000
	14 May 20...	2.39000
	15 May 20...	2.48000
	16 May 20...	2.43000
	17 May 20...	2.42000
	18 May 20...	2.42000
	19 May 20...	2.42000
	20 May 20...	2.39000
	21 May 20...	2.38000
	22 May 20...	2.37000
	23 May 20...	2.37000
	24 May 20...	2.37000
	25 May 20...	2.37000
	26 May 20...	2.37000
	27 May 20...	2.37000
	28 May 20...	2.41000
	29 May 20...	2.40000
	30 May 20...	2.40000
	31 May 20...	2.40000
	01 Jun 2019	2.40000
	02 Jun 2019	2.40000
	03 Jun 2019	2.40000

Base Scenario Curves

SOFR + obs shift: each of the 30 daily rates from 23rd Apr to 23rd May compounds to a rate of 2.45% paid on 30th May

Plain SOFR: each of the 30 daily rates from 30th Apr to 30th May compounds to a rate of 2.42% paid on 30th May

SOFR 'Term' Curve & COF Curve
To calculate LP- base case convention

» LP calculated as the difference between the ALL IN curve and the SOFR term curve
» Due to the nature of the forward looking term rates, no compounding is necessary here

Example: 90 day floating Loan LP takes 90 day point on the COF/All In curve 4.06% and deducts 90 day point on the SOFR term/IRS curve 3.06% i.e. LP is 1%
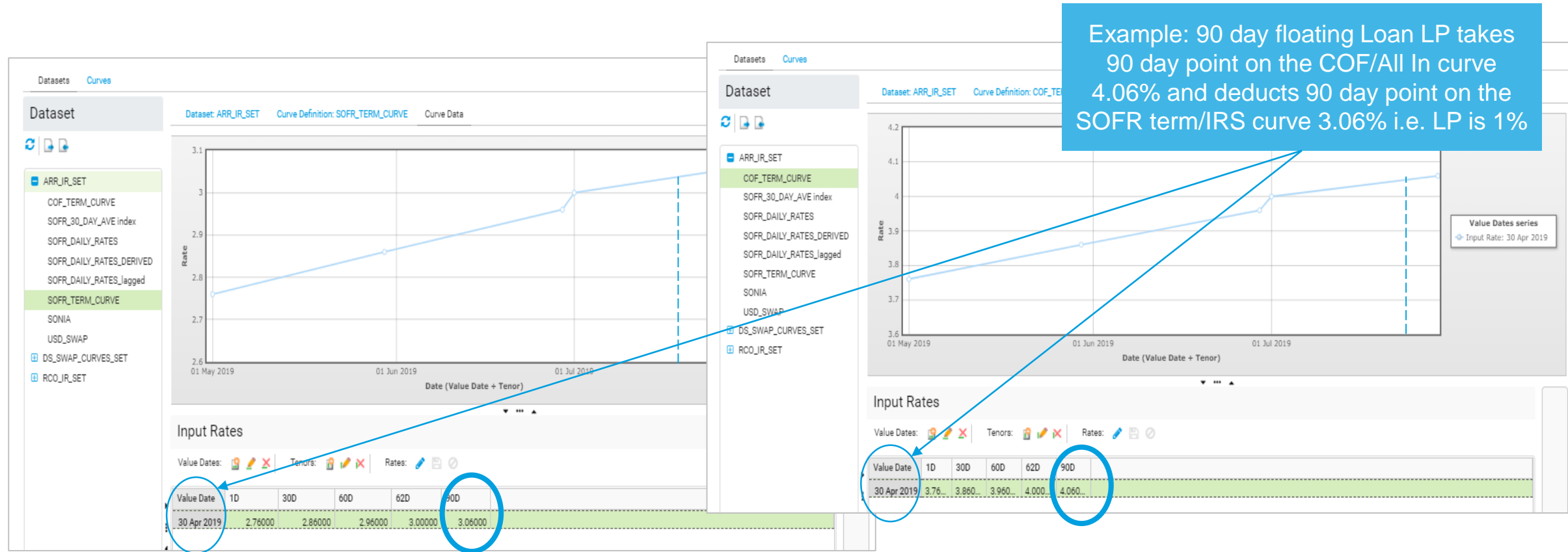
SOFR 'Term' Curve & COF Curve
To calculate LP- Obs period shift convention

» It is possible to pick from a curve with a value date before the reporting date

Conclusion: the product convention <u>will</u> impact LP component

For 5 day shift the value date should be deal value date -5
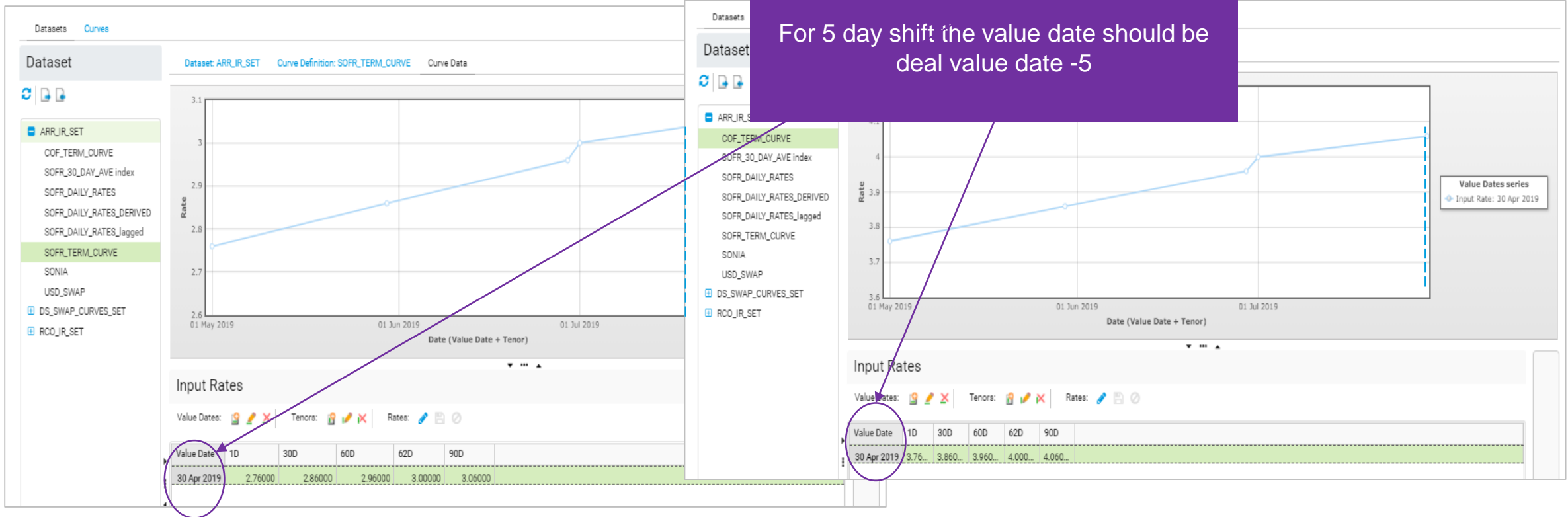
FTP Components
For Floating SOFR Loan

» Floating interest rate element selects rates from the overnight index
» The LP selects from term yield curves and can be set up in different ways- two alternatives are shown here

For a 5 day shift these rates could change with the value date of the curves as Reporting Date - 5

FTP Components
For Floating plain SOFR Loan

» The floating component is equal to 30 days of compounded SOFR daily rates.
» Liquidity premium is the COF less Term SOFR at the bullet maturity date

Compounded SOFR_DAILY_RATE index

4.06% COF @ Maturity
–
3.06% Term SOFR @ Maturity
=
1% LP

View Date	Analysis Scenario Code	Interest Rate Risk Spread	Funding Liquidity Spread	Custom 1 Spread
30 Apr 2019	RCO_BASE	0.02415	0.0406	0.0306

FTP Components
For Floating plain SOFR Loan

» The floating component is equal to 30 days of compounded SOFR daily rates.
» Liquidity premium is the COF less Term SOFR at the bullet maturity date

Compounded
SOFR_DAILY_RATE
index

4.06% COF @ Maturity
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3.06% Term SOFR @ Maturity
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1% LP

View Date	Analysis Scenario Code	Interest Rate Risk Spread	Funding Liquidity Spread	Custom 1 Spread
30 Apr 2019	RCO_BASE	0.02415	0.0406	0.0306

For a 5 day shift these rates could change with the value date of the curves as Reporting Date -5
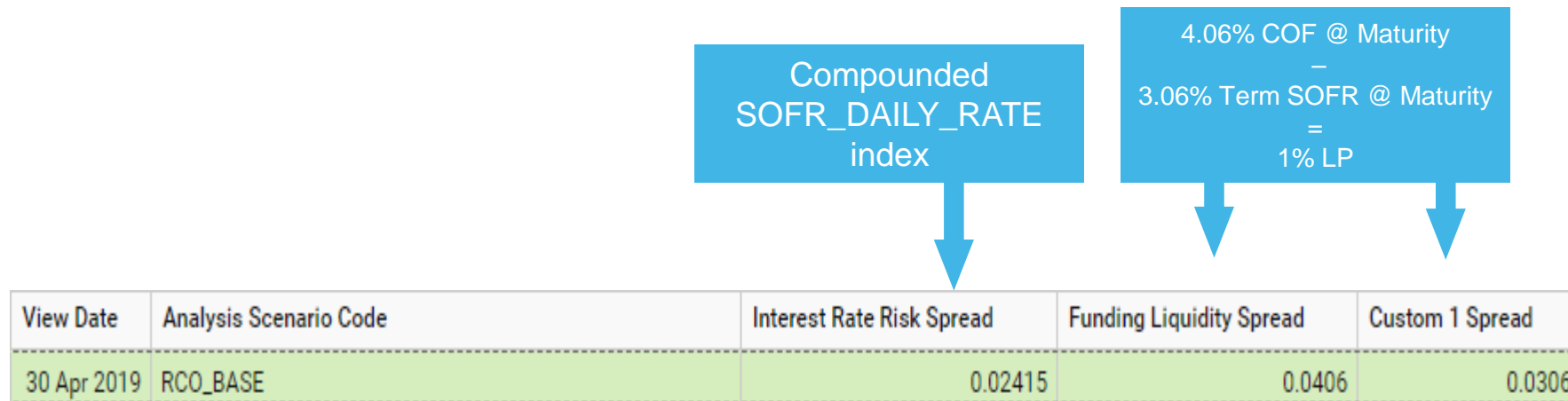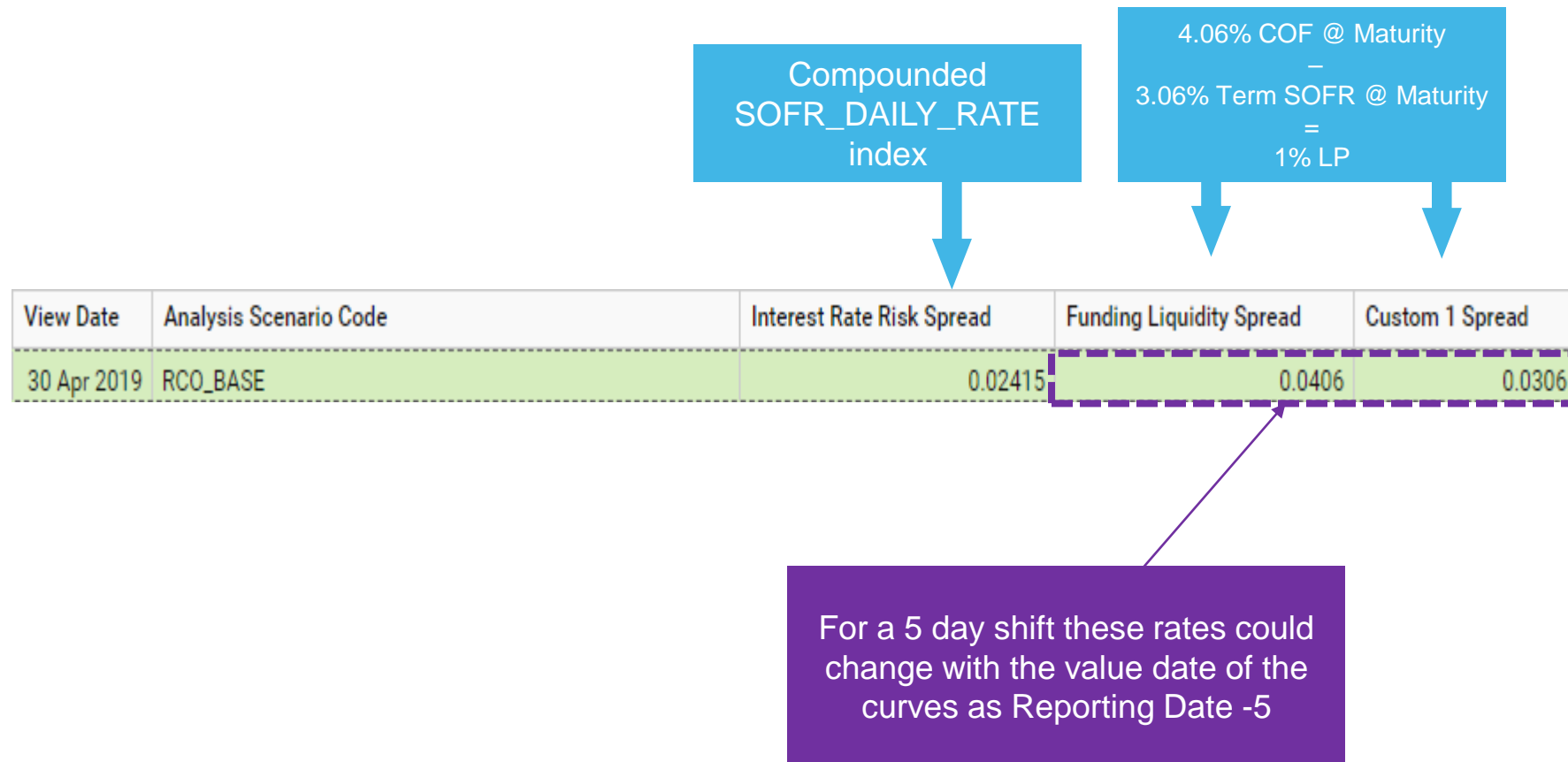
6 | Compounding & Accrual methodology

ISDA compounding

» Previously RCO's compounding formula treated business and non-business days the same
» RCO current compounding formula has been enhanced to match ISDA compounding formulae

Previous RCO Compounding Formula

In the *Use Last Available with Implied Forward* mode, if you provide n overnight market rates $F_1, F_3, \ldots, F_n$ for a coupon period (from the BEGIN_DATE value to the END_DATE value), the software calculates the OIS rate as follows:

$$R_{start_date, end_date} = \left(\prod_{i=1}^{n} \left(1 + \frac{F_i}{NbDaysInYear}\right)^{n_i} - 1 \right) \times \frac{NbDaysInYear}{NbDaysInCouponPeriod}$$

where:

- $NbDaysInYear$ = the number of days in the year (either 360 or 365) according to the accrual basis of the contract.
- $NbDaysInCouponPeriod$ = the number of days for the coupon period according to the accrual basis of the contract.
- n_i = the number of days where F_i is applicable.

Note   The software converts the calculated rate from the accrual basis of the rates that you provided to the accrual basis of the deal if they are different.

Source: RiskFoundation product documentation v.7.0

ISDA Compounding Formulae

$$\left[\prod_{i=1}^{d_o} \left(1 + \frac{SONIA_i \times n_i}{365}\right) - 1 \right] \times \frac{365}{d}$$

where:

"d_o", for any Calculation Period, is the number of London Banking Days in the relevant Calculation Period;

"i" is a series of whole numbers from one to d_o, each representing the relevant London Banking Days in chronological order from, and including, the first London Banking Day in the relevant Calculation Period;

"$SONIA_i$", for any day "i" in the relevant Calculation Period, is a reference rate equal to the daily Sterling Overnight Index Average (SONIA) rate as provided by the administrator of SONIA to, and published by, authorized distributors of the rate as of 9:00 a.m., London time, on the London Banking Day immediately following that day "i";

"n_i" is the number of calendar days in the relevant Calculation Period on which the rate is $SONIA_i$; and

"d" is the number of calendar days in the relevant Calculation Period.

Source: www.isda.org/a/EHmEE/Supplement-number-55-to-the-2006-ISDA-Definitions.pdf

Difference is treatment of calendar vs business days

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

Where:

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

https://www.newyorkfed.org/markets/opolicy/operating_policy_200212

RCO Accrual Methodology
To calculate compounded rate accruals

» A loan where daily accruals are posted and the interest period straddles the RD will utilise actual rates only
» The daily accrual rate will get closer to the full coupon rate the closer the reporting date gets to the interest period end (when the true interest payment is fully known*)

Conclusion: accruals will not impacted by forecast rates

Daily accrual for this loan will be based on:
• 1 'actual' daily rate
• Excludes 29 'forecast' daily rates
Compounded into a single rate x principle/360
i.e. 2.76% x $1m / 360

Plain SOFR Loan: each of the 30 daily rates from 30th Apr to 30th May compounds to a rate of 2.42% paid on 30th May

Value Date	1D
30 Apr 2019	2.76000
01 May 20...	2.54000
02 May 20...	2.50000
03 May 20...	2.43000
04 May 20...	2.43000
05 May 20...	2.43000
06 May 20...	2.42000
07 May 20...	2.44000
08 May 20...	2.43000
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30 May 20...	2.40000
31 May 20...	2.40000
01 Jun 2019	2.40000
02 Jun 2019	2.40000
03 Jun 2019	2.40000

Datasets   Curves

Dataset

Dataset: ARR_IR_SET   Curve Definition: SOFR_DAILY_RATES   Curve Data

ARR_IR_SET
  COF_TERM_CURVE
  SOFR_30_DAY_AVE index
  SOFR_DAILY_RATES
  SOFR_DAILY_RATES_DERIVED
  SOFR_DAILY_RATES_lagged
  SOFR_TERM_CURVE
  SONIA
  USD_SWAP
DS_SWAP_CURVES_SET
RCO_IR_SET

Input Rates

Value Dates: Tenors: Rates:

7 | Q&A

MOODY'S | Better, faster decisions
ANALYTICS

RiskConfidence™: Alternative Reference Rate Capabilities

✓ ## Product Level: Backward Daily Averaging[1]

Product coverage:

Term Loans[2] & Deposits	Bonds	Swaps	Repo & Reverse	Call Deposits & Overdrafts	Facilities
√	√	√	√	√ newly launched	√ newly launched

Convention coverage (for both simple averaging & daily compounding [3]):

Plain / Base Case	Payment Delay [4]	Obs Period Shift	Lookback	Lockout
√	√	√ newly launched	√ newly launched	√ newly launched

✓ ## Rate Level: Alternative Reference Rate Handling

√ Input of historical rates

√ Input of overnight forecast index

√ Input of term yield curve

√ Generation of forward overnight rates from an inputted term yield curve

√ Discounting and valuation using term yield curve [5]

Q&A
Email us at:
RCOProductManagement@moodys.com

Notes: 1) newly launched means from version 7.1.5 onwards
2) constant installment amortizing loans included from 7.1.5 onwards.
3) backward daily compounding formula was aligned with ISDA methodology from v7.1.5 onwards. Conventions referenceable in FTP formula from v7.1.7.
4) Available for LOANDEPO table from v5.2 & REPO table from v6.2; will be available for ACCOUNT/FACILITY/SECURITY & SWAP from 7.1.7.
5) Pricing of Swaptions and Cancellable Swaps using ARRs is a further planned enhancement in 2021.

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