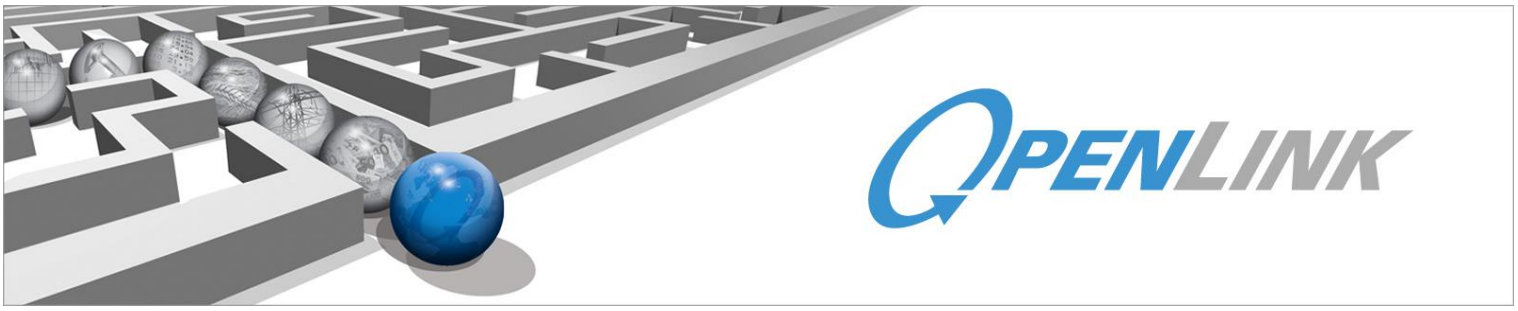

Recommendations for OIS Based Valuation

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Document Contents

1. Introduction

As a result of the 2007-2008 credit crisis, the curve building process has changed significantly and what was once a fairly straightforward procedure is now more complex. Several market trends emerged which are leading to a fundamental change in the valuation of OTC derivative transactions :

- Interbank offering rates started to price in the perceived credit and liquidity risk of financial institutions, causing spreads between LIBOR and Overnight Index Swap rates to widen significantly
- The basis spread between LIBOR rates of different maturities widened as well, illustrating a growing market bias towards shorter tenors and more frequent payments of interest (an indication of the perceived credit and liquidity risk inherent in the longer Libor rates)
- There has been a significant increase in the use of bilateral CSA agreements as well as the introduction of a new Standard CSA agreement (SCSA). OIS rates are increasingly being adopted as the funding rate for these collateralized transactions
- Various regulatory initiatives are requiring an increasing number of swaps to be centrally cleared with the posting of initial and daily variation margin (Dodd Frank, EMIR), and are instituting capital adequacy guidelines that place a significant risk weight to uncollateralized swaps. These initiatives are incentivizing more participants to undertake collateralized transactions

The result has been a move towards a multi-curve environment where the OIS curve is now considered to be the best proxy for the “risk free” rate and is used for discounting collateralized transactions while a separate curve, which matches the maturity of the underlying floating rate and is conditional on the OIS rates used for discounting, is employed for the projection of forward rates.

The purpose of this document is to provide direction on OpenLink’s approaches to OIS curve construction, configuration and usage. As the OIS market convention continues to evolve, we will be updating our methods accordingly if needed. The reader is directed to contact their account manager if they are interested in discussing our recommendations in more detail.

2. OIS Based Curve Constructions

2.1 Creating the OIS Discounting Curve – OIS.USD

This curve will be used primarily for discounting, but also as a projection curve for OIS indexed trades, such as FedFund swaps or OIS swaps. While the focus here is on the USD market and its associated OIS curves, the recommendations described herein can be applied in the same manner for other currencies that have adopted OIS discounting.

OpenLink currently has two approaches to constructing the OIS discounting curve:

- An iterative process which bootstraps the OIS curve using synthetic FedFund (FF) basis spreads (obtained by pairing up FF/Libor3M basis swap and Libor3M fixed/float swap to eliminate the Libor leg). This method is similar to the so called dual curve bootstrap, a term used by other industrial sources (e.g. Eris Exchange)

- A formula-based approximation of OIS swap rates utilizing Libor 3M swap rates and Libor3M/FF basis swap rates and accounting for compounding differences (e.g a Bloomberg-like curve)

Both approaches provide a close match to the leading market providers, especially when used with the Monotone Convex interpolation method (discussed in a separate document).

The building blocks for constructing the OIS discounting curve include the following instruments and coverage range:

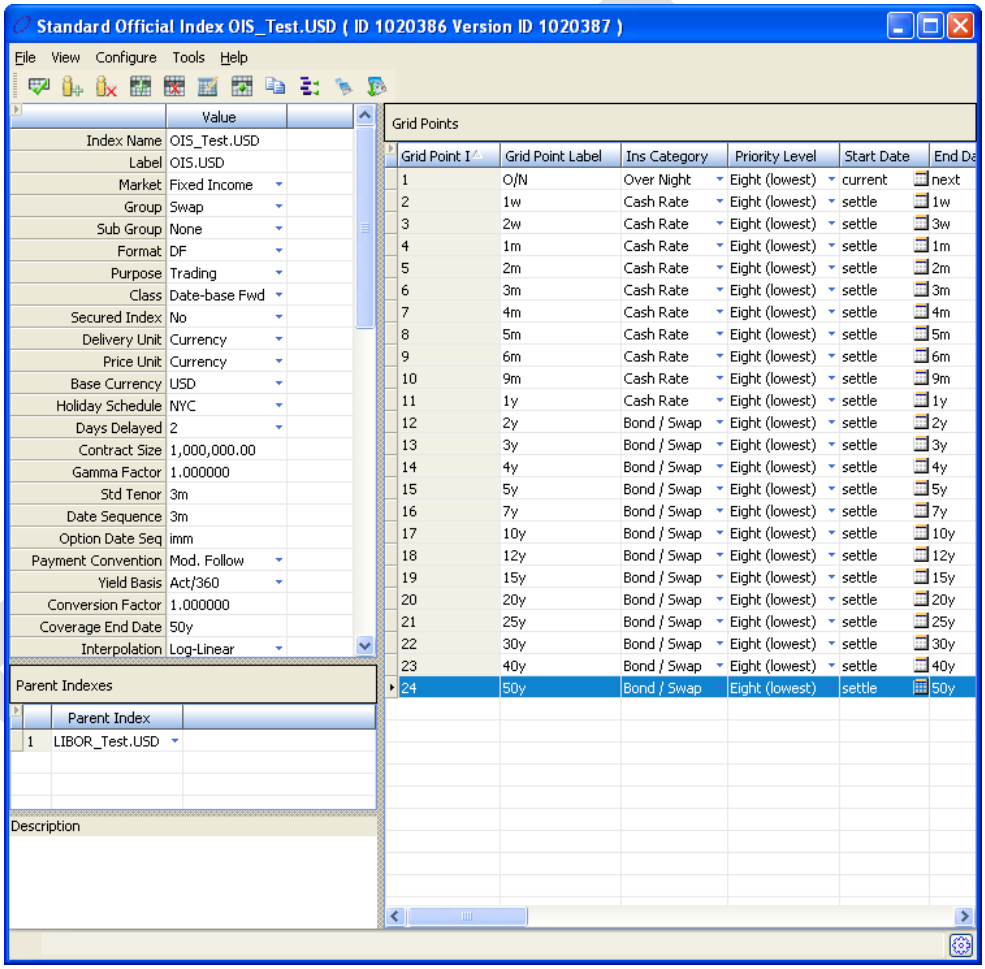
Instrument	Instrument Category	Coverage
OIS Based Cash Deposit	O/N, Cash Rate	Overnight to 1Y
Quoted OIS Swaps	Bond/Swap	1y to 5Y
FF/Libor Basis Swaps	Bond/Swap	7Y to 30Y
Extrapolated Libor/FF Basis	Bond/Swap	>30Y

For the extrapolated gridpoints (>30Y), we assume a constant Libor/FF Basis beyond the last quoted (30Y) basis swap

Index Definition

In the Endur/Findur application the index definition is set up as shown in Figure 1 below. Note that the conventional Libor curve is defined as the parent to this OIS curve and that FF basis swap rates are assumed to be the inputs to the longer end of the curve (i.e. for the FF/Libor Basis gridpoints). An alternative configuration can be used in which the OIS curve has two parents, the conventional Libor curve and the FedFunds basis curve (if the client has a FF basis curve already defined).

Figure 1 – Index Definition for OIS.USD



Cash Grid Point Definition

These are OIS based cash deposit instruments (with daily compounding) and have a payment period of 1y.

Quoted OIS Swap Grid Points

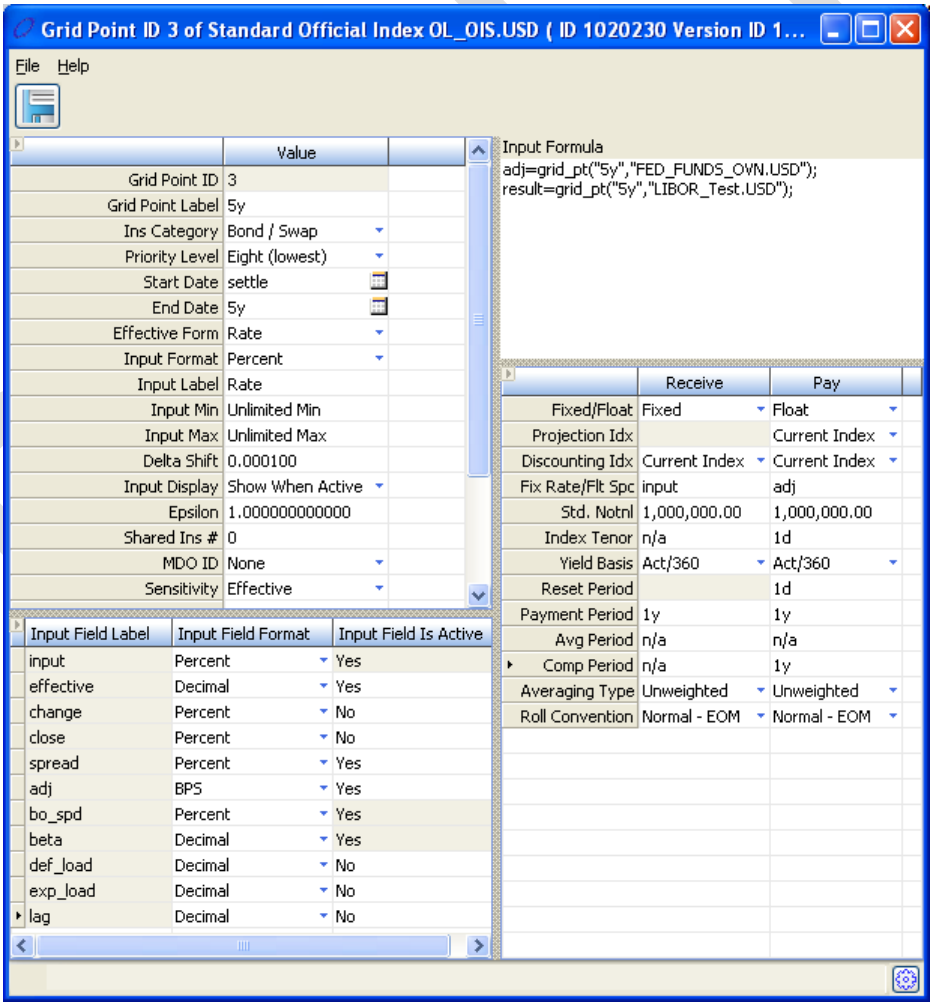
For swaps under 7 years, we use directly observable OIS swap rates as the input.

Fed Fund/Libor Basis Swaps

As mentioned above, for the longer end of the curve (5y to 30y) we can either calculate the rates by using synthetic FF/Libor basis swaps or we can use a gridpoint formula to approximate the OIS swap rate from Libor/FF basis and Libor swap rates.

- Synthetic FF/Libor swaps

For these swap gridpoints, the receive side will obtain the required fixed rate from the input value to the gridpoint on the parent Libor curve that has the same maturity date. In the figure below for example, the input value to the 5y grid point on the Libor parent curve will be used as the input to the fixed side of the 5y swap grid point on the OIS.USD curve. Similarly, the float side of the swap will take as its floating spread the input value from the FF basis parent curve's grid point with the same maturity. This input value is assigned to the gridpoint input field "adj".



- OIS Rate Approximation [1]

Here, let A,B and C denote the N-year Libor swap rate, OIS rate and FF basis spread, respectively. The OIS rate can then be approximated as:

$$OIS_N = \left(1 + \frac{(r_q - C)}{4}\right)^4 - 1$$

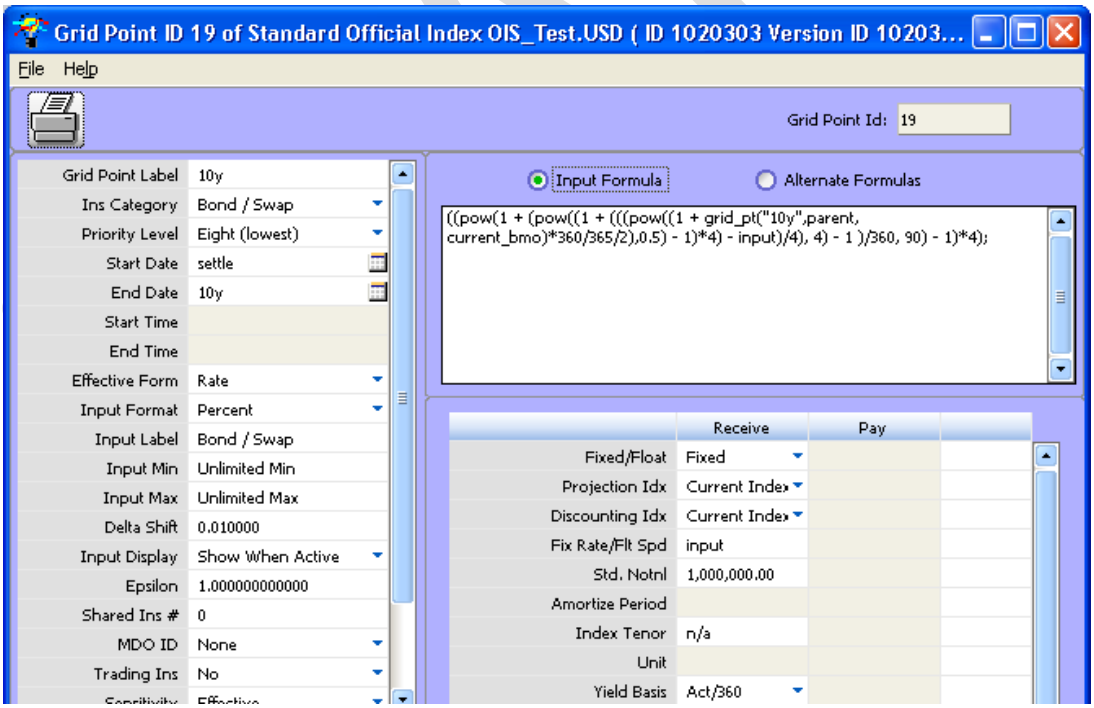
Where

$$r_q = \left(\left(1 + \frac{A \times \frac{360}{365}}{2}\right)^{\frac{2}{4}} - 1\right) \times 4$$

The below adjustment is then applied to obtain the OIS rate with compounding adjustment

$$OIS'_N = \left(\left(1 + \frac{OIS_N}{360}\right)^{90} - 1\right) \times 4$$

This formula is replicated in the Endur/Findur application as shown below



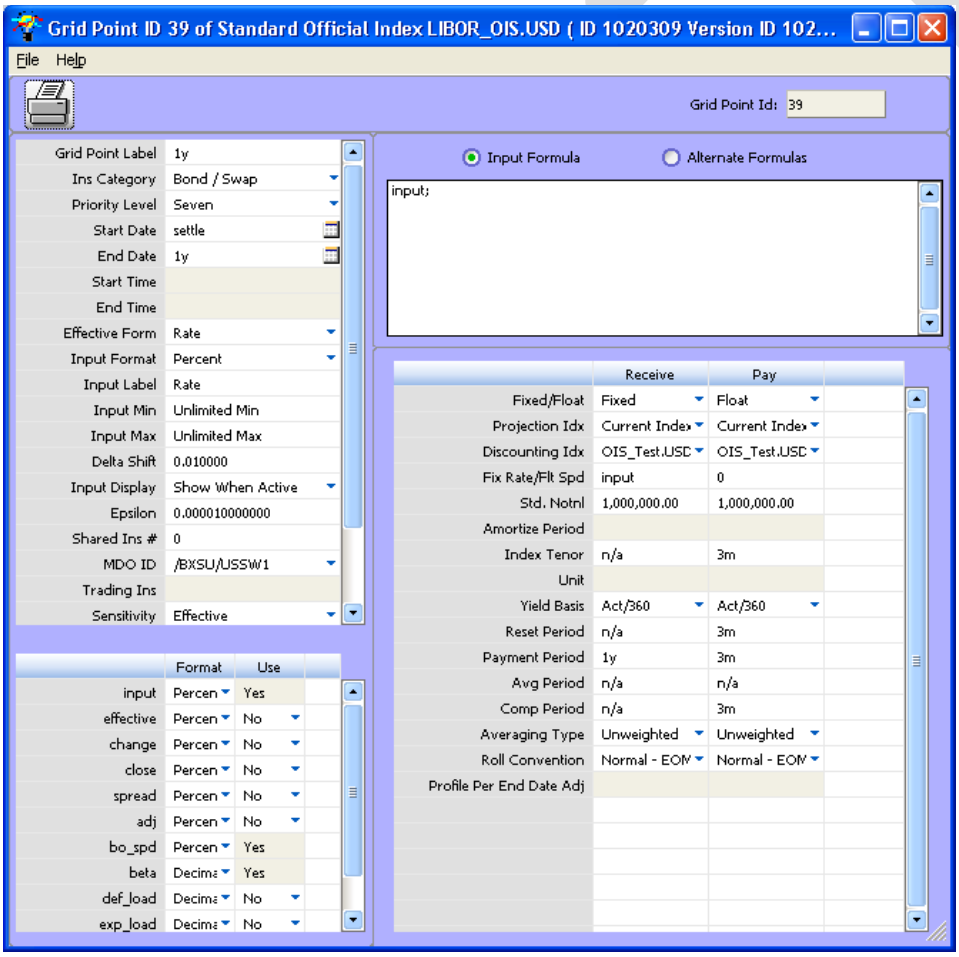
[1] Bloomberg – Extending USD OIS Curves Using Fed Funds Basis Swap Quotes

2.2 Creating the Benchmark (LIBOR3M) Projection Curve with OIS Discounting

Libor3M_OIS.USD

This curve is to be used *only* as a projection curve for 3M collateralized trades paired with OIS discounting. The parent to this curve is the previously constructed OIS.USD curve. The building blocks are the same as for the conventional Libor curve (3M Cash, EURO Dollar Futures, Libor Par Swaps). Both the Cash and Futures gridpoints are set up in the same manner as for the conventional Libor curve and will use "current" for the discounting index while the Swap gridpoints will use OIS.USD as discounting on both legs of the swap.

Swap Gridpoint



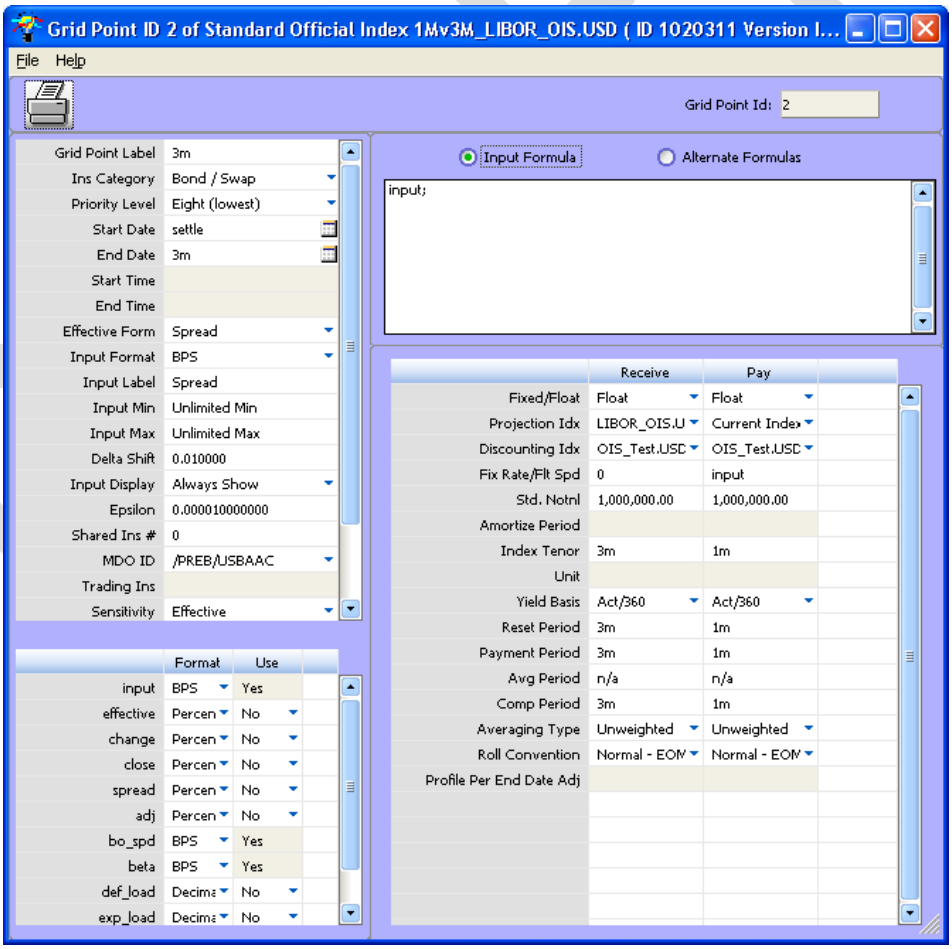
2.3 Creating curves for other Libor Tenors and Basis Curves with OIS Discounting

Libor1M_OIS.USD

This curve is to be used *only* as the projection curve for 1M collateralized trades paired with OIS discounting. The parent to this curve is the previously constructed OIS.USD curve. The building blocks for this curve are:

- 1M Cash Deposit (using 'Current' as the discounting index on the cash instrument)

- Libor1M/3M basis swaps (the 1M side will use 'Current' as its projection index and the 3M side will use the previously constructed Libor3M_OIS.USD as its projection index. Both sides will use OIS.USD as the discounting index)



A similar approach can be used for other Libor tenors such as 6M and other basis curves such as SIFMA and PRIME. For each of these curves, the Cash Deposit point(s) shall be consistent with the index and the basis swaps are respective basis swaps against Libor.

3. OIS Based Valuation Analysis

We recommend that users continue to book deals and perform their required EOD and risk reporting using their conventional or uncollateralized curves, at least initially. A separate set of OIS based curves should be implemented and maintained in the application and should only be used for ad hoc valuation and risk analysis; only after these curves become more widely accepted and their results better understood should they be incorporated into all areas of the application. For ad hoc valuation using OIS discounting, users can set up a Reval simulation with the following curve mappings:

-For projection indexes, map the relevant uncollateralized curves to their respective OIS based projection curves

-For discounting, map the Libor3M uncollateralized curve to OIS.USD

4. Further Discussions

4.1 OIS.USD bootstrapping using the OpenComponents Curve API Plug-In

In order to support OIS cash instruments longer than 1y whose stub convention is unique and to support synthetic FedFund Fixed/Float swap, a Curve API plug-in needs to be deployed. This plug-in will be provided as part of the implementation.

4.2 Convexity adjustment due to FedFund and OIS Differences

A FedFund swap is priced as an algorithmic average of a daily rate, whereas OIS is a daily geometric compounding rate. Due to this difference, there is a convexity adjustment when converting one rate to the other. When using the OIS curve constructed without the convexity adjustment to price a FedFund trade, one may experience on the order of 0.5 bp/year difference compared to OIS curve constructed with convexity adjustment. Such difference depends on the volatilities of the OIS rates. When pricing other non-OIS based trades, such as LIBOR trades, the error in the OIS discounting itself by neglecting convexity is much smaller, on the order of 0.1bp/year.

Our initial delivered Curve API plug-in will not incorporate this convexity adjustment. If a client's trading portfolio includes sizable FedFund based trades and OIS/FF convexity is important, we are happy to discuss our approaches to this topic in more detail.

4.3 OIS curves for other currencies

For EUR and GBP, we expect that there are straightforward OIS Fixed/Float swaps quoted in the market that can be directly used in building the OIS curves. One need not work out any synthetic instruments as we recommend doing for USD OIS curve. Still, one needs to create a set of OIS based projection curves in the same way as we recommend for USD curves.

For other currencies, the approach needs to depend on conventions of on these local markets. Also, for cross currency swaps, we still recommend the conventional approach of using uncollateralized curves for projection and separately constructed currency curves for discounting that price market instruments to par. Alternatively, one can use OIS based projection curves on both currencies, OIS discounting on one currency leg, and a re-bootstrapped discount curve on the other currency leg to preserve par pricing. Either approach needs to be validated against the client's specific trading requirement and their valuation and risk reporting needs.