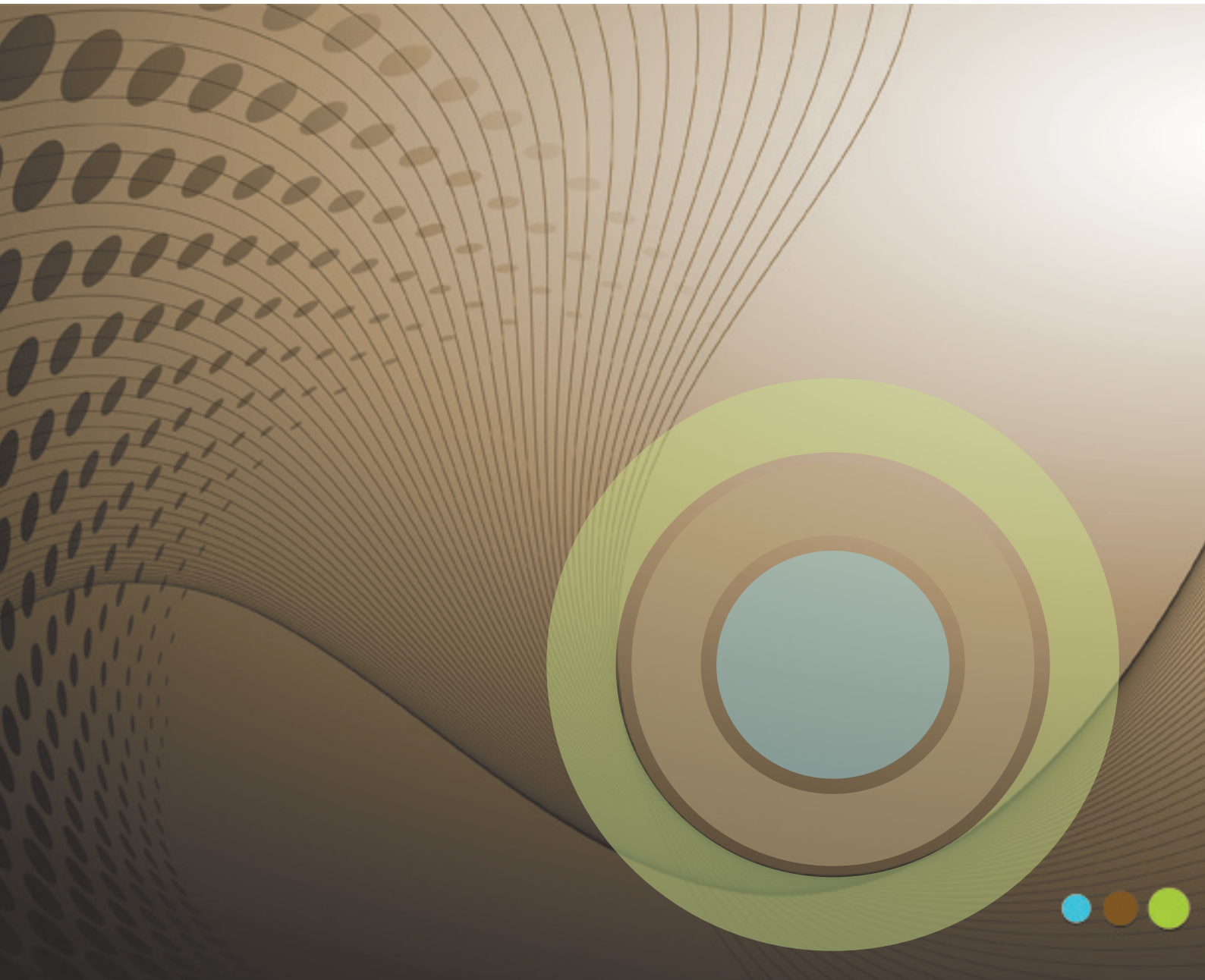# Derivatives valuation in practice
## The impact of OIS discounting on curves in a multi-curve world

Dr. Douglas Long, EVP Product Strategy

"The switch to OIS discounting has a material impact on the valuation of both collateralized and un-collateralized derivatives. The market's adoption of OIS discounting affects LIBOR, tenor basis spread and LIBOR discounting curves - the fundamental building blocks in pricing and risk managing all derivative and hedging contracts."

Paper 2

PRINCIPIA

# New curve calibration methods in an OIS environment

This second paper in the series examines the impact of switching to OIS discounting on curve construction. The extent of this impact can be subtle and depends on a number of factors including the steepness of the yield curve and the level of OIS vs LIBOR spreads.

What becomes clear is that market adoption of OIS discounting materially impacts the curves used in all derivative valuations, irrespective of whether that derivative is subject to OIS discounting.

## A quick recap on OIS

Under Dodd-Frank and European Market Infrastructure Regulation (Emir), swaps that are cleared by a central clearing house are subject to margin requirements, including collateral posted daily based on the mark-to-market value of the swap positions.

Collateral earns the Overnight Index Swaps rate (i.e. Fed Funds in the USA, or EONIA in Europe). Pre-crisis, the 3M LIBOR rate closely matched this rate as there was little perceived credit or liquidity risk associated with the interbank money markets. Today that is no longer the case. 3M OIS trades at a discount to 3M LIBOR.

Pre-crisis the average was approximately 8bp. During the peak of the crisis the average moved up to approximately 60bp and has now settled down, in the post-crisis environment, to about 25bp. Further market analysis on this can be seen in Principia's paper, 'Market drivers for multi-curve pricing: supplementary data and results'.

Papers 1 and 1a looked at the market dynamics that necessitated the adoption of a new 'risk free' discounting curve and the move to a multi-curve environment to understand the future cashflows and present value of interest rate derivatives.

Understanding both the first and second order effects of the introduction of OIS discounting in curve construction is a prerequisite to assessing its impact on cashflow projections, derivative valuations, risk sensitivities and the effectiveness of hedge accounting relationships.

## Simply discounting with OIS is not enough

Consider the construction of a USD curve environment. The LIBOR forward curve is normally constructed using LIBOR deposit rates, 3M LIBOR future prices and 3M LIBOR swap rates.

Pre-crisis, the market standard was to use this single LIBOR forward curve for LIBOR rate projections (assuming one was not already capturing the small tenor spread basis adjustments) and to calculate discount rates and discount factors. We now know that this 3M LIBOR curve no longer represents a 'risk free' curve, devoid of liquidity and credit risk. Today, the OIS curve represents the best 'risk free' rate for the construction of discounting curves for collateralized derivatives.

However, introducing OIS in a multi-curve environment is not simply a case of constructing an OIS curve to use for discounting when valuing collateralized or centrally cleared derivatives. That simple approach overlooks underlying subtleties in the way the market now quotes LIBOR swap rates and basis swap spreads.

## USD multi-curve market benchmarks

### 3M LIBOR curve
LIBOR deposit rates, 3M LIBOR futures prices, 3M LIBOR swaps rates

### 1M LIBOR curve
1M LIBOR deposit rate, 1M vs 3M swap spreads

### 6M LIBOR curve
6M LIBOR deposit rate, 3M vs 6M swap spreads

### OIS curve
Fed Funds effective ON rate, OIS swaps, 3M vs Fed Funds swap spreads

The introduction of OIS rates means that the assumptions and inputs that go into bootstrapping each curve are involved and has subtle and far-reaching implications.

# Building the OIS discounting curve

## OIS curve construction

Step one in the new multi-curve age is the construction of an OIS curve for discounting.

Today, the market practice for building an OIS curve is to obtain market rates and quotes for the Fed Funds effective overnight rate, 1W to 2/3Y OIS swap rates, and then Fed Funds vs 3M LIBOR swap spreads. In the primary currencies the OIS swap rate market is generally only liquid to the 2-3 year point. Fed Funds vs 3M LIBOR swap spreads are seen as the most liquid instruments that can be used to extend the OIS curve through to 30 years - key to valuing long dated derivatives.

The graphs in Figure 2 show the discounting factors calculated from the 3M LIBOR curve (as calculated in a single curve environment) against those calculated from the OIS curve.

The disparity between the two can be seen in our three chosen points in time: pre-crisis, at the peak of the crisis and post-crisis. The discount factors for the OIS curve are higher than those from the LIBOR curve.
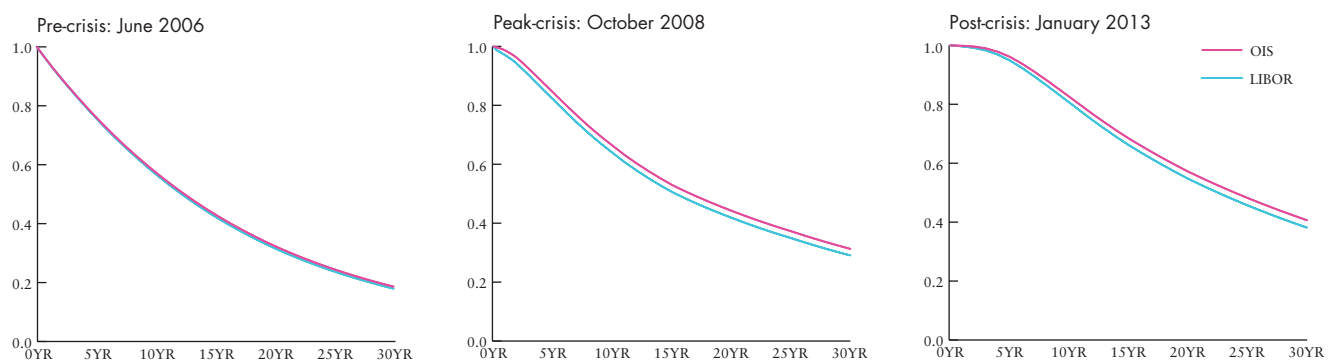
Most significantly, we can see that post-crisis, the difference in discount factors is almost as significant now as it was at the crisis peak.

Figure 1. LIBOR & OIS Spot Rate Curves: Pre-, Peak-, Post-Crisis
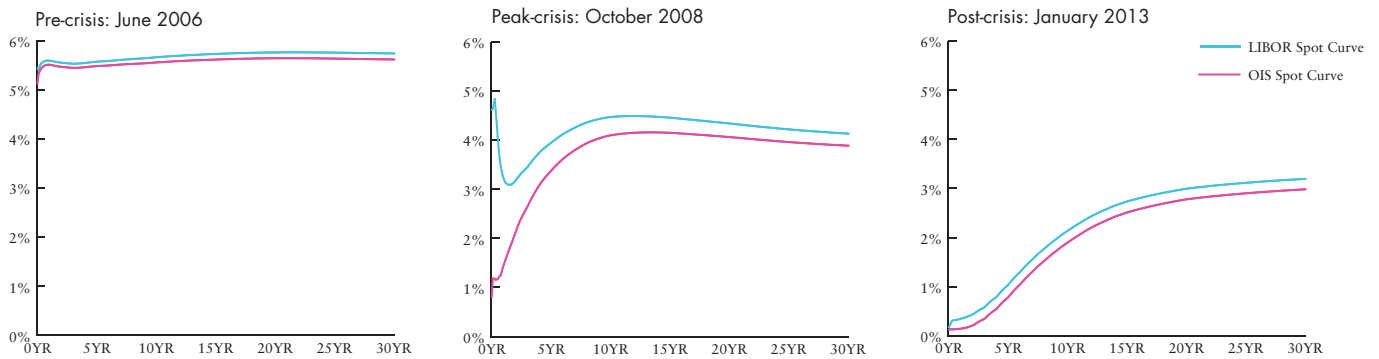


Source: Tullett Prebon, Principia SFP

Figure 2. LIBOR & OIS Discount Factors: Pre-, Peak-, Post-Crisis



Source: Principia SFP

# Dual curve calibration

## Interdependencies between the LIBOR and OIS curves

Consider the inputs used to construct the USD LIBOR forward curve, central to interest rate swap and derivative valuations. In the case of the 3M LIBOR curve, deposits or 'cash rates' are used to construct the short end, futures rates are used for the mid-term points and then, LIBOR swap rates are used.

The market's move towards OIS discounting has primarily been evident in the interest rate swap market. Swap dealers across the industry use OIS to discount cashflows when valuing these collateralized or centrally cleared derivatives. As such, market quotes for par LIBOR swap rates now assume OIS discounting, not LIBOR discounting. The relationship between LIBOR forward rates and par swap rates has to change.

A swap is a bilateral agreement to exchange a floating LIBOR rate against a known fixed rate over a defined period of time. In swap valuation, the LIBOR curve is used to calculate the floating leg payments and the fixed leg payments are known. A par swap is the fixed rate such that the discounted value of each leg's cashflow stream nets out to zero.

Now consider traditional LIBOR curve bootstrapping of the swap segment of the LIBOR curve. Here the next portion of the LIBOR forward curve is implied (thereby changing the floating leg cashflows and the discounting curve) such that the swap prices to par. We only need LIBOR curve benchmarks to build the LIBOR forward curve.

This bootstrapping approach has to change as the par swaps now assume OIS discounting. Taking market provided swap rates as a given, and then introducing OIS discounting into bootstrapping, results in a slightly different LIBOR forward curve when compared with the traditional curve bootstrapping approach. This is because the bootstrapping of the implied LIBOR forward curve now only affects the floating leg cashflows and not the discount of either leg (which is now preformed using the OIS curve).

Here we begin to see the interdependencies between LIBOR and OIS curves and how the two cannot be treated as mutually exclusive.

This "dual curve stripping" of the benchmarks used to build the LIBOR forward curve introduces important subtleties that are often missed. In swap valuations for example, simply using the OIS curve to discount net present cashflows fails to take into account that the benchmarks used to build your projected forward curves are now also OIS discounted swaps. By doing so, you are biasing the forward curve by not incorporating new market pricing conventions into the expected forward rates.

Figure 3 illustrates the impact of introducing dual curve calibration on the 3M LIBOR forward curve under the pre-, peak- and post-crisis environments.

The impact of dual curve calibration (i.e. introducing OIS discounting) on the forward LIBOR curve is varied and depends on a number of factors, including the LIBOR vs OIS spreads, the shape of the yield curve, and the absolute level of the yield curve.

Figure 3. The Impact on 3M USD LIBOR Forward Rates of Switching to Dual Curve Calibration with OIS Discounting (bp)
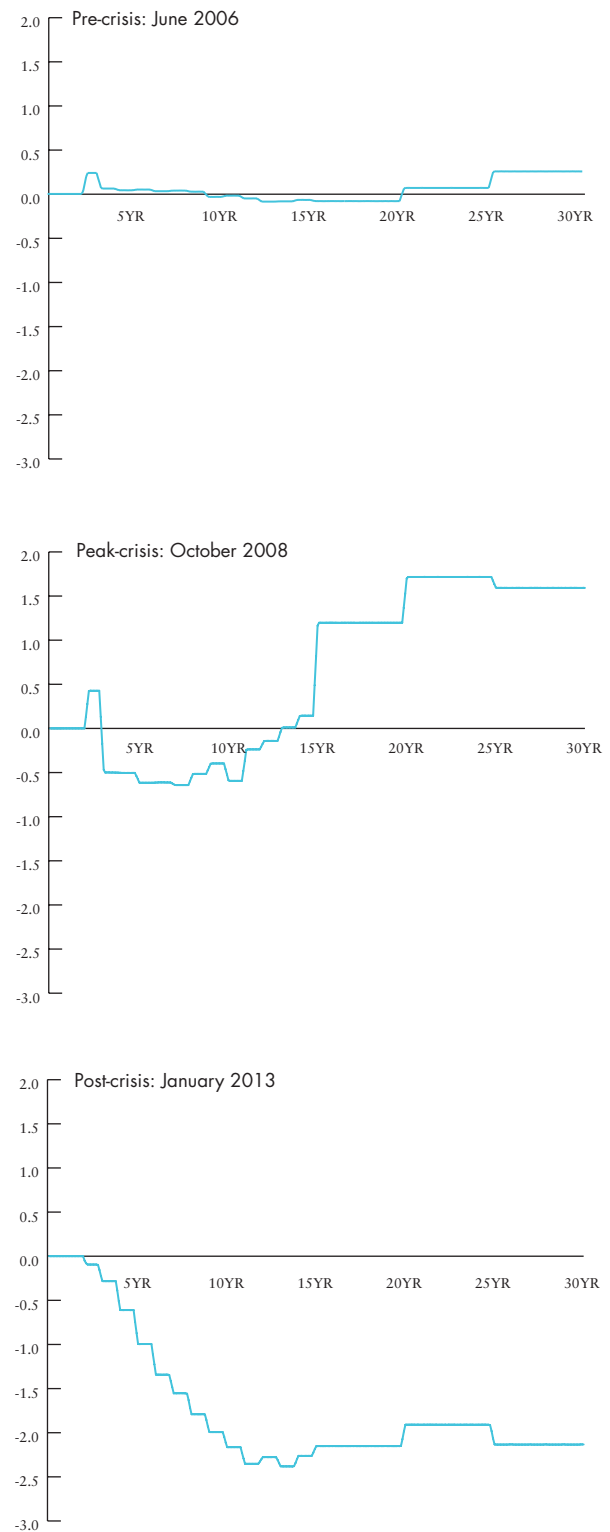


Source: Principia SFP

# Dual curve calibration continued

## Impact of curve steepness

As you can see in Figure 3, the biggest impact on the LIBOR curve was not near the peak of the crisis. This is explained by the fact that the yield curves during the pre-crisis and peak-crisis period were approximately flat. With a perfectly flat yield curve, the fixed rate on a par swap will be equal to the LIBOR forward rate projections. As such, the projected cashflows net to zero and there will effectively be no cashflow to discount with either OIS or LIBOR. Hence, there is no adjustment to the LIBOR curve.

The current steep yield curve environment however, accentuates the impact of dual curve calibration. The fixed side of a par swap generates more cashflows than the floating side for a period of time and then switches over to generate fewer cashflows. Switching between LIBOR and OIS discounting with this uneven distribution of cashflows across the term structure of the swap therefore has a material effect on its pricing.

The situation is more complicated in practice. When you begin to use swap rates to build the LIBOR forward curve, you must use the OIS curve to discount the projected cashflows of the market quoted benchmark swaps. The catch is that you can only bootstrap the LIBOR forward curve accurately if you also have the OIS curve to discount the projected cashflows. However, if you are using Fed Funds vs LIBOR swap spreads as benchmark instruments in your OIS curve construction, you will need the LIBOR curve to project cashflows for the LIBOR leg of the basis swap.

To resolve this and accurately build LIBOR and OIS forward curves, dual curve bootstrapping must be adapted to bootstrap the LIBOR and OIS forward curves simultaneously.

The bottom line is that implementing this new OIS discounting practice is fundamental to accurate valuation and cashflow projection. Without this, projected forward LIBOR rates could be materially different from what the market believes them to be.

Knowing this, we can see that the adoption of OIS discounting in the new world has many implications for the construction of not just LIBOR forward rates but all your generated curves.
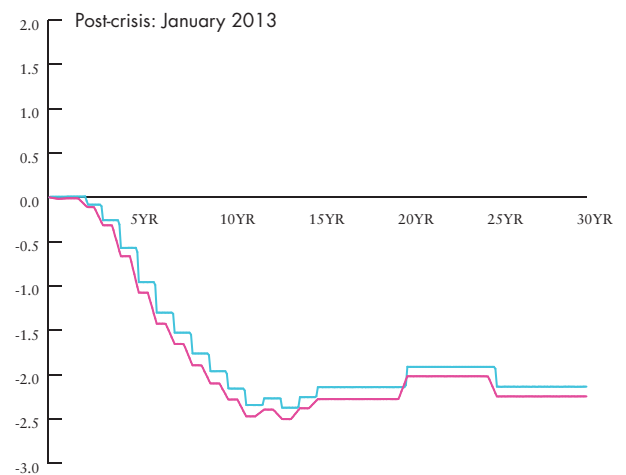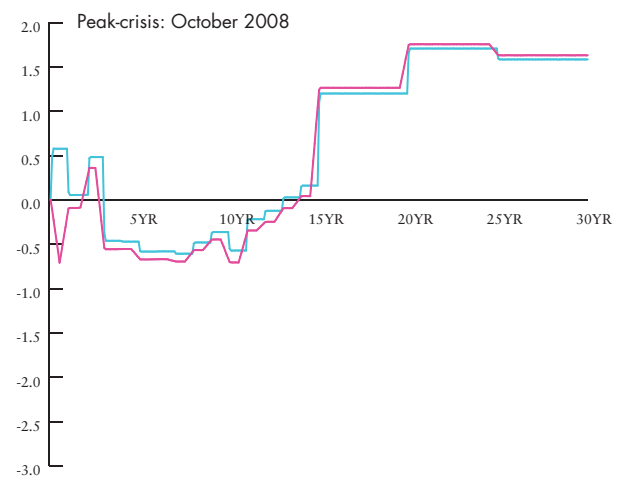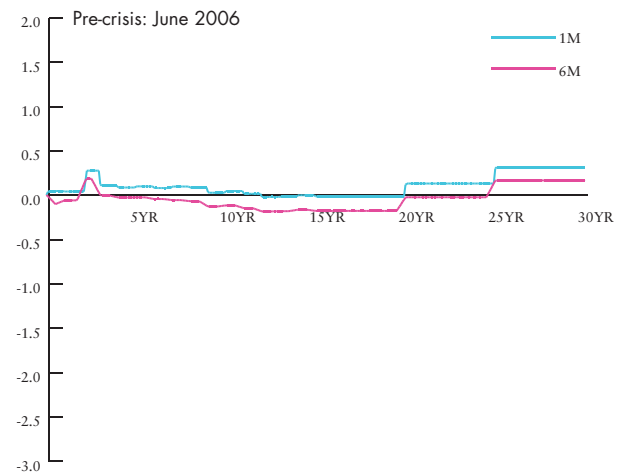
## Calibrating tenor curves

As discussed in the initial paper of this series, it is now necessary to use different tenor curves (1M, 3M, 6M etc) for swaps and derivatives valuation. The benchmarks used for these tenor curves are usually tenor basis swap spreads.

The same new rules apply to generating accurate tenor spread and basis curves as for the LIBOR forward curve. Pre-crisis, tenor spread adjustments were often ignored; the 3M LIBOR curve sufficed.

Now, not only must you use the appropriate tenor spread forward curve, but best practice dictates that you should also use OIS dual curve calibration to build this curve because the market quoted swap spreads, as with LIBOR swap rates, are also discounted using the OIS curve.

Figure 4. Impact on 1M and 6M USD LIBOR Forward Rates when Switching to Dual Curve Calibration with OIS Discounting (bp)



Source: Principia SFP

# Dual curve calibration continued

Unlike the par swaps used in the LIBOR curve construction, the benchmark swaps are floating tenor basis swaps that trade at par when a spread is applied to one of the legs.

The primary cause of the additional impact on the tenor curve with the switch to OIS discounting is the differential discounting of this fixed rate spread. The additional impact of switching to OIS discounting for these tenor spread adjustments is smaller than the impact on the LIBOR curve but it is directional. It can therefore partially off-set or widen the initial impact of dual curve calibration on the 3M LIBOR curve.

## Knock-on impact of OIS on LIBOR discounting

The adjusted dual curve calibrated LIBOR curve will also have a knock-on impact to the calculated LIBOR discount factors.

Figure 5 shows the impact when switching from LIBOR discounting to OIS discounting. Figure 6 shows the impact of using dual curve calibration on LIBOR discounting.

The two graphs show the basis point impact on the discounted value of a future cashfow.

For example, the NPV of a $10k cashflow received in 10Y in the peak-crisis environment has approximately a 250bp (or $250 per $10,000) market value increase when switching from LIBOR discounting to OIS discounting (the NPV goes from $6,390 to $6,640).
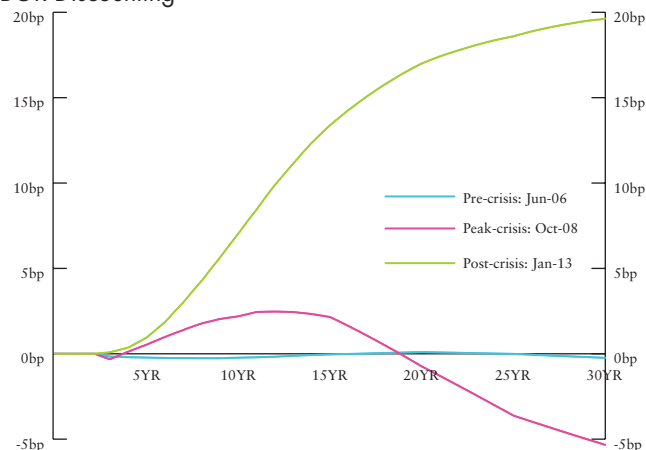
The impact of dual curve calibration on LIBOR discounting is smaller than the differences seen when switching from LIBOR to OIS discounting.

Figure 5. Impact when Switching from LIBOR Discounting to OIS Discounting
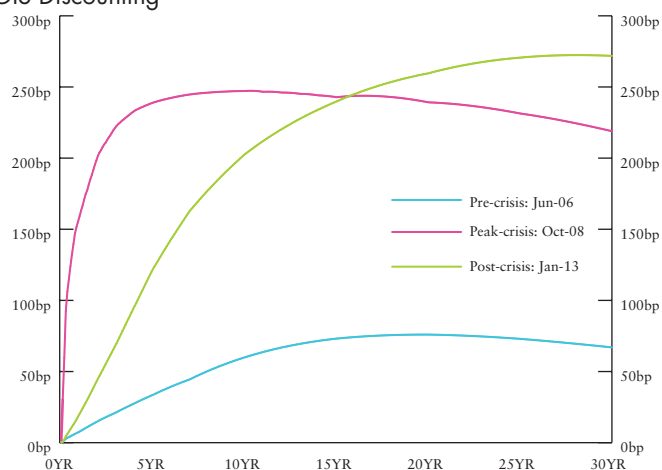


Source: Principia SFP

Figure 6. NPV Impact of Using Dual Curve Calibration for LIBOR Discounting



Source: Principia SFP

## OIS impacts all derivatives - not only collateralized

At first sight, the switch to OIS discounting appears only to be relevant for the valuation of collateralized and centrally cleared derivatives. It is evident here that this is not the case. The impact of the market's adoption of OIS discounting can have a material effect on the LIBOR, tenor basis spread and LIBOR discounting curves that are fundamental to the pricing and risk management of all derivative and hedging contracts.

## A practical solution

Principia SFP provides clients with a multi-curve valuation and risk management environment to forecast using appropriate tenor LIBOR forward curves and to select the relevant discounting curves for accurate, independent valuations.

Beyond valuations, the system is an end-to-end operational platform for derivatives portfolios allowing users to perform detailed impact analysis, risk management and the full operational implementation of OIS discounting into daily mark-to-market and hedge effectiveness processes. Principia also provides and automates delivery of extensive daily market data and curves as standard, for precise valuations, proven to closely match the interdealer market.

In a world moving towards central clearing, Principia users have the tools to implement industry best practices in the analysis, trading and risk management of vanilla and complex derivatives. With this single coherent platform, clients can streamline derivatives operations from trade capture and risk, through to accounting and central clearing.

# About Principia

Principia Partners LLC (Principia) provides a comprehensive single platform solution for the end-to-end management of structured finance and derivative investments. Global financial institutions and independent asset managers have used the award winning Principia Structured Finance Platform since 1995 to unify investment analysis, portfolio management, risk surveillance, accounting and operational control across the breadth of structured credit assets, fixed income investments and complex derivatives.

Dedicated support and continued development of functionality for credit and fixed income instruments is accompanied by a proven and fully integrated derivative valuation framework. This overall credit investment and market risk solution delivers the robust backbone necessary for deeper investment analysis, proactive risk surveillance and operational control across the credit investment and derivatives business.

Principia is based in New York, with an office in London and a technology center in Conshohocken, Pennsylvania.

For more information please visit:
www.ppllc.com

The full whitepaper series will be published online at:
www.ppllc.com/Principia_Derivatives_Valuation.htm

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