White Paper:

The Move to OIS Discounting

The principles of discounting are generally understood but the details of how it is applied in the derivative market, and the consequences for end-users, are not always clear.

Introduction

While the principle of discounting is generally understood, the specific details and the consequences of the parameters chosen are not so well known. In particular the financial crisis triggered a divergence in interest rate curves which had consequences for banks, engendering costs which were passed on to the client. In this paper we cover:

1. Reminder of the need for discounting and the principles involved;
2. The consequences of the financial crisis;
3. The motivation for the migration to OIS discounting;
4. The implications of this choice for banks and their clients.

The need for a present value calculation

Interest rate derivatives by their very nature involve the payment and receipt of as yet unknown future cashflows. In order to correctly trade, risk manage, and account for these products it is necessary to assess the current value of these cashflows.

To do so a prediction of future interest rates is required, the reason being twofold:

- Interest Rate Swaps are typically composed of fixed, and therefore known, payments and initially unknown floating payments. A yield curve is needed to allow us to predict what rates
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  will apply when an exchange of payments is due;

- Once we have an estimate of all future payments we need to value you them in today's terms. Such a calculation to establish the current monetary value required to obtain the future value by risk-free investment is common throughout finance using a risk-free[1] interest rate curve.

The full calculation is provided in the appendix but the key point to note with regard to the evolution of yield curve conventions is that the curves used for the two points above do not need to be the same.

The curve used for the first point, (determining future rates), is constrained by the terms of the derivative itself. The floating leg of the contract will be based on a specified market rate such as Libor or Euribor, with a particular term. It is a yield curve for this interest rate that must be used.

[1] A truly risk free rate is a theoretical assumption. In reality only near risk free proxies are available.

For the second point (discounting) we have more choice with the only condition being that the yield curve we use gives an arbitrage-free value and in the currency of the contract.

There are three further complications in the case of collateralised derivatives:

1. The value of collateral exchanged needs to be agreed by the two parties involved;
2. Interest is paid on collateral held, with the rate specified in the CSA. Typically, this is an overnight central bank rate such as Fed Funds, under the assumption this is how the collateral will be held.
3. The collateral needs to be obtained at the funding rate of the posting bank. This rate is closely correlated with the interbank lending rate.

So in summary four rates are required:

1. The predicted future rates for cashflows;
2. The discount rates for present value;
3. The interest rate paid on collateral posted;
4. The funding rate of the posting institution.

It is important to note that 1 and 3 are set contractually, while 2 is set by market convention, and 4 by market rates.

The Impact of the Financial Crisis

In the happy world prior to the financial crisis both overnight central bank rates and interbank borrowing rates were considered risk-free so the rates listed above virtually coincided and nobody worried too much about the technical differences between them, with the currency interbank curve serving multiple purposes. However, the emergence of large spreads in interbank rates since the crisis demonstrates that credit and liquidity risk were implicit in the pricing and have become material.

This created a bifurcation in the market between;

- Collateralised trades between buy side market participants, hedging their client portfolio and requiring funding;
- Uncollateralised trades between banks and their clients, unfunded and with implicit credit risk.

(what about collateralised client trades?)

This difference is reflected in the choice of discount curve, the only one of the four rates listed in the previous section which can be adjusted. The only constraint on the choice curve is that it produce arbitrage-free valuations.

In the case of uncollateralised derivatives this is unproblematic as valuation is for internal purposes and therefore solely at the discretion of the party concerned[2].

However, the picture is different in the case of collateralised transactions. As it now reflects credit and liquidity risk, the interbank rate will be higher than the hypothetical risk-free rate, and as a result will produce a lower present value than that risk free rate. Continuing to use the interbank rate for discounting would mean that the party which is in the money would receive

[2] Obviously this ceases to be the case if the trade is unwound or novated, where a convention needs to be agreed.

collateral to a lower value than their actual potential loss.

In order to ensure that counterparties were correctly protected by collateralisation a new (near) risk-free rate was required. The obvious alternative would be to use rates from uncollateralized government securities, however they are only considered risk-free in the most highly-rated cases, and these provide an insufficient number of data points for construction of a full curve. Instead the industry accepted the OIS curve as a suitable proxy.

What is OIS

An overnight index swap (OIS) is a normal fixed/floating swap. The floating rate is indexed to an overnight interest rate, usually a central bank rate. Examples of such floating rates are:

- Funds Rate (USD);
- SONIA (GBP);
- EONIA(EUR).

Note that these are the same rates used in CSAs.

Note that the rehypothecation of collateral at a rate above the central bank rate to compensate for the lower amount determined by discounting with the interbank rate does not solve the problem, as any investment at above the risk-free rate introduces risk to the collateral value.

A further effect of the spread between the interbank rates, which in part determine the rate at which collateral is funded, and the overnight rates at which it is recompensed, is that it introduces a cost to the party posting collateral as the interest received no longer covers the cost of raising collateral. This cost is now passed on to the end-users of the uncollateralised derivatives which are being hedged.

The use of the OIS rate for discounting does not resolve these funding costs which have emerged. Continued use of the interbank rate for discounting would give a lower collateral transfer, and the overnight interest paid on this would as a result be lower as well as the funding costs for the collateral poster. Switching to the lower overnight rate for discounting means the collateral transfer is higher, as are the funding costs and the interest paid.

Appendix: How is the present value of a swap calculated

The valuation of a swap depends on a simple formula: the present value is the future value divided by interest rates.

More specifically:

(1)

$$PV = \sum_{C=1}^{j} a \times \frac{(N \times r_n \times d_n)}{(1 + r_d)^n}$$

Where

$\mathrm{PV} = \text{Present Value}$

$\mathrm{C} = \text{Coupon Payment Both Legs}$

$\mathrm{a} = +1 \text{ if Coupon received}, -1 \text{ if Coupon payed}$

$\mathrm{r}_n = \text{Fixed rate or Implied floating rate}$

$\mathrm{d}_n = \frac{\text{nr of days since last coupon}}{\text{nr days in a year}}$

$\mathrm{r}_d = \text{Discount Rate (OIS rate)}$

There are three rates in this equation:

1. The fixed rate which is simply the agreed swap rate in the transaction;
2. The implied floating rate (forward rate) which is derived from spot rates (Libor and swap rates) bootstrapped according to:

(2)

$$r_n = \sqrt[d_n]{\frac{(1 + S_{long})^{Y_{long}}}{(1 + S_{short})^{Y_{Short}}}} - 1$$

Where

$\mathrm{d}_n = \frac{\text{nr of days in period}}{\text{nr days in a year}}$

$\mathrm{r}_n = \text{Fixed rate or Implied floating rate}$

$\mathrm{Y}_{\text{long}} = \text{Year fraction} = \frac{\text{nr of days until spot}}{\text{nr days in a year}}$

$\mathrm{S}_{\text{short}} = \text{Spot Rate}$

Date	Spot Rates (S)	Year Fraction (Y)	Number of Days (dn)	Implied FW Rate (rn)
27-Jun-16	0.10%	-	-	0.10%
27-Sep-16	0.20%	0.26	0.26	0.20%
27-Dec-16	0.50%	0.51	0.25	0.80%
27-Mar-17	1.00%	0.76	0.25	2.02%
27-Jun-17	1.100%	1.01	0.26	1.40%
27-Sep-17	1.200%	1.27	0.26	1.60%
27-Dec-17	1.300%	1.52	0.25	1.80%
27-Mar-18	1.400%	1.77	0.25	2.01%
27-Jun-18	1.500%	2.03	0.26	2.20%
27-Sep-18	1.600%	2.28	0.26	2.40%
27-Dec-18	1.700%	2.54	0.25	2.61%
27-Mar-19	1.800%	2.79	0.25	2.82%
27-Jun-19	1.900%	3.04	0.26	3.00%

Table 1.1 Example Calculate Implied Forward Rates

3. The OIS discount rate.

How is the OIS discount rate determined?

As in the construction of any yield curve the following steps are required:

1. Choose the most liquid and dominant rate in each time horizon;
2. Use uniform conventions (ModFol, act/360);
3. Bootstrap the rates from their coupons to create zero coupon rates;
4. Use an Interpolation Algorithm to determine the interim rates.

However, there are a few problems in constructing the OIS yield curve:

<u>The short-term rates:</u> For the OIS curve these are constructed from the expectations of the reference rates that will be set at the scheduled meetings, which gives these short-term rates a quasi-static behavior. As a result, boot-strapping the OIS curve raises a number of challenges, in the construction of the curve and the interpolation.

<u>Seasonality in Reference Rates:</u> Reference rates may exhibit seasonality, for example, at month, quarter and year ends, or when there are large structural flows (e.g. tax payment

dates). Therefore, the short-term reference rate must be seasonally adjusted in the construction of the short-end of the OIS curve.

Longer Term OIS Rates: These rates can be treated similarly to swap rates where direct interpolation between quoted OIS rates introduces no significant errors. However, OIS rates greater than one year generally pay annual interest so a traditional boot-strapping approach should be used to back out the OIS curve beyond one year.