New challenges in interest rate derivatives valuation

Simple is not just simple anymore

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In the past, the valuation of plain vanilla swaps has been a rather simple problem, taught in finance classrooms

However, since the occurrence of the financial crisis, counterparty credit risk has become of paramount importance in derivatives valuation. This has led to a completely renewed valuation framework where what used to be simple has now become complex and what used to be complex is now… extremely complex.

This article deals with derivatives valuation, focusing on one of the most standard derivative contracts used in financial markets: the Interest Rate Swap (IRS). To understand how the credit crisis fundamentally affected the swaps market, it is necessary to understand how it used to work before the crisis occurred.

The classical framework

The 'classical' framework refers to what we learned as students in finance classrooms. It refers to how derivatives markets used to behave prior to the financial crisis of the late 2000s and consequently how financial engineers used to value derivatives in this context.

The valuation of an IRS in the classical framework follows the so-called 'discounted cash flows' procedure. With this method, the value of a swap is equal to the sum of the present values of all future cash flows (paid or received). Floating cash flows indexed on Libor are first estimated by computing the forward (Libor) rates. All (fixed and floating) cash flows are then multiplied by their corresponding discount factors.

The key information required in this process is the yield curve used for discounting the cash flows and computing forward Libor rates. This yield curve does not, per se, represent market observable data. In fact, it has to be mathematically built (calibrated) to be consistent with the market prices of liquidly quoted instruments (deposit rates, futures, forwards, swap points, etc.). In other words, considering IRS, liquid swaps are used to build the yield curve so that other non-quoted swaps can be valued consistently. As an example, in EUR, standard IRS exchange annual fixed payments against semi-annual payments indexed on 6M Euribor.

Stylised facts of the crisis

The credit crisis started around mid-2007. Prior to this, the absence of credit risk in interbank borrowing was implicitly assumed. In other words, banks in the Libor panel were assumed to be of excellent credit quality, so that there was no doubt about the creditworthiness of any Libor borrower.

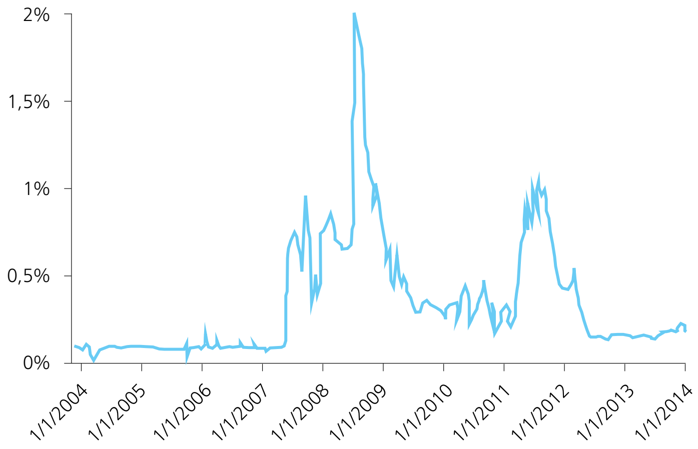
The crisis started when market participants realised this assumption was fundamentally incorrect. Historical time series of various market observables exhibit this phenomenon.

We illustrate here (see figure 1) one of the most salient market features: the spread between 3M Libor rates and the rates of 3M Overnight Indexed Swaps (OIS). This spread is often seen as a measure of credit risk premiums in the interbank market. Firstly, the floating payments of an OIS are equivalent to daily compounded overnight investments, i.e. investments that are considered as nearly risk-free due to their extremely short term (less than one day). Secondly, Libor deposits represent for the lender unsecured investments with a non-negligible term. As can be observed, the Libor-OIS spread used to be close to 0 prior to 2007, spiked due to the credit (2008-2009) and Eurozone sovereign debt (2011-2012) crises and is now back to more stable levels, yet notably higher than what it used to be before 2007.

The Libor-OIS spread denotes the level of reluctance of an investor to deposit for 3M in an AA-rated bank, in comparison with a risk-free investment. This spread level measures the risk for the bank of being downgraded within 3M. The pre-crisis levels close to 0 confirm the above 'no-risk' assumption made at that time.

Other market observable parameters exhibit the same kind of behaviour. Among others, basis swap (i.e. IRS where both legs pay floating coupons of different tenors and payment frequency) spreads also exhibited nearly zero levels before the crisis and increased dramatically since mid-2007.

Figure 1: 3M Euribor - EUR OIS spread



Source: Bloomberg

The 3M Libor-OIS spread denotes the level of reluctance of an investor to deposit for 3M in an AA-rated bank, in comparison with a risk-free investment

The 'Multi-Curve' framework

Libor-OIS and basis swap spreads are two examples of market observables drastically modified by the credit crisis. The consequence of these mutations for derivatives dealers is significant: their usual valuation framework no longer works, in the sense that it no longer matches the market prices of quoted derivatives. For instance, if calibrating the yield curve to market prices of OIS, valuation of standard IRS does not fit market prices; if calibrating the yield curve to standard IRS, valuation of basis swaps does not fit market prices, etc.

Clearly, the classical framework where one single yield curve fits all instruments' market prices in a same currency is no longer valid. A new pricing framework is necessary, with several different yield curves for each currency, each calibrated to a class of instruments. The construction of all these curves results in a gigantic optimisation problem involving all at once all available market instruments in any currency.

To be more specific, let us illustrate the process, starting with the EUR currency. A first yield curve can be calibrated using standard IRS. It is denoted 'Euribor6M' since standard IRS in EUR are indexed on 6M Euribor rates. A second yield curve can be built using OIS and is denoted 'Eonia', following the name of the overnight rate in EUR. A third yield curve, 'Euribor3M', can be calibrated using 3M-6M basis swaps, with Euribor3M and Euribor6M curves used respectively for each leg. Similar treatment can be applied to build e.g. 'Euribor1M' and 'Euribor12M' curves. The situation becomes even more complex when dealing with Cross-Currency Swaps (CCS) where both legs are denominated in different currencies. Consistency is therefore required between valuation of CCS and of mono-currency instruments.

In summary, the credit crisis and the realisation that interbank borrowing is not risk-free results in a strong complication of financial engineering techniques.

Discounting and collateralisation

The Multi-Curve framework described above is a complex mathematical construction but does it make sense after all? In particular, considering two different swaps that each pay a same future cash flow, their present values using two different curves will be different. Is this intuitive?

The reality today is that no strict answer exists for this question. At least some consensus exists in a particular case, where swaps are collateralised.

Generally speaking, swaps embed some counterparty credit risk, since counterparty default can occur on the next expected payment. The risk is still reduced since the exposure is limited to the difference between the next coupons to be exchanged. Nonetheless, the collateralisation mechanism has been created to prevent (at least, strongly reduce) counterparty credit risk and is more and more widespread in swaps markets. Under collateralisation, a transaction is daily marked-to-market and the counterparty with a negative value posts liquid assets (ideally cash) in collateral to compensate the loss of the other party in case of default. Daily adjustment of the collateral position ensures counterparty credit risk is very limited, since in case of default, the remaining party is left with an exposure equivalent to a one-day variation of mark-to-market.

Collateralisation has the advantage of reducing the counterparty credit risk of a swap position at nearly zero. In such a situation, any future cash flow should be discounted at some 'risk-free rate'. In other words, we should have a 'risk-free yield curve' at our disposal, used for discounting of any cash flow of a collateralised swap. The consensus today is that this discounting yield curve must be the one calibrated on OIS (e.g. the Eonia curve in EUR). We mentioned above that OIS rates can be considered as nearly free of credit risk. In practice, discounting future cash flows in a collateralised swap using the OIS curve is even more justified since posted collateral actually generates some interest, more precisely daily compounded overnight interest. As a consequence, discounting using the OIS curve is justified because it is equivalent to the interest received on collateral. The questionable assumption that OIS is risk-free is finally not even necessary.

To summarise the situation of collateralised swaps, future cash flows discounting must be made using the OIS curve while forward Libor rates computation must be performed using the ad hoc Libor curve (given the required tenor: 3M, 6M, etc.). Calibration of all these curves follows the process described above starting with the OIS curve. It is made possible since all swaps quoted in the market are assumed to be collateralised. What to do then with respect to discounting in non-collateralised swaps? Here, no consensus exists and research is still ongoing on the subject.

Various authors argue that each bank should discount future cash flows with its own funding curve, i.e. the OIS curve shifted by the bank's funding cost. Theoretically speaking, such a framework is flawed as it does not allow for two counterparties with different funding costs to agree on a same trading price. On top of that, this framework is opposed to a long-established principle in finance that the evaluation of an investment should depend on the risk of the investment and not on the way it is funded. Other authors argue that the best estimate of counterparty credit risk is provided in Libor quotations. As a consequence, they advise discounting using the Libor yield curve corresponding to the cash flow tenor (i.e. the same curve as for forward estimation). A third research avenue consists in developing a valuation framework for 'defaultable' swaps, where each instrument is a weighted sum between a risk-free instrument and the amount recovered in case of default.

The Dodd-Frank and EMIR regulations

American and European authorities both tried in recent years to push derivatives markets towards collateralisation of OTC transactions. As shown above, collateral has the advantage of clarifying the valuation process (and what some call the 'discounting dilemma'). More precisely, Dodd-Frank and EMIR regulations aim at the mitigation of counterparty credit risk by the creation of Central Counterparties (CCP). A CCP intervenes as intermediary in a swap transaction and requests significant collateral amounts from both parties. Initial as well as daily variation margins are requested in order to reduce counterparty credit risk. In case of default of one party, the accumulated margins and the high level of capitalisation of the CCP prevent contagion to other parties. Besides, regulations also impose the inclusion of a Credit Support Annex (CSA), a document that describes in detail the collateralisation terms and conditions, for transactions that are not centrally-cleared by a CCP.

Despite its obvious advantages, collateralisation also has some downsides. In a nutshell, it requires complex daily operations for management of the current collateral positions counterparty per counterparty, mark-to-market of the derivatives transactions, daily margin calls and resolution of valuation disputes with counterparties. Operational risk on these processes is thus significant. Collateralisation is also never perfect. Due to the requested operational treatment, collateral posting does not occur beyond certain thresholds. In other words, posted collateral never, in practice, perfectly matches the mark-to-market of the positions; residual counterparty credit risk remains.

Collateral management also covers more complex issues such as 'netting' and 'rehypothecation'. Netting refers to the possibility of considering the aggregated exposure of all open transactions with a counterparty in the collateral management. Intuitively, it is common sense but it still requires heavy operational treatment. Rehypothecation, however, refers to the possibility of using collateral posted by a counterparty for meeting its own collateral obligations. On the one hand, it is a fair mechanism to prevent large capital requirements to meet all collateral needs but, on the other hand, it may induce contagion of defaults across counterparties.

To the **point**:

- Valuation of interest rate derivatives, even the most simple ones like plain vanilla IRS, has now become complex due to the growing importance of counterparty credit risk
- Matching the market prices of quoted derivatives requires the use of a Multi-Curve valuation framework, where yield curves used to value different instruments are different, and where several curves may be necessary to value a single instrument. All these curves should be built consistently with each other in a large optimisation problem. Today's experts have not yet even reached a full consensus on how to deal with these complex issues in practice
- Transaction collateralisation has become of paramount importance and is strongly supported by current regulations. However, it is accompanied by an increased operational complexity and new technical issues

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Glossary

- **The London InterBank Offered Rate (Libor)** is the average interest rate estimated by a panel of AA-rated banks in London that they estimate they would be charged if borrowing from other banks. Libor is calculated every day at 11.00 a.m. UK time for different borrowing terms (1D to 12M). 'Euribor' is a similar standard related to the EUR currency for banks in the Eurozone.
- **An Interest Rate Swap (IRS)** is a financial derivative instrument in which two parties agree to exchange interest rate cash flows, based on a specified notional amount from a fixed rate to a floating rate (usually Libor).
- **An Overnight Indexed Swap (OIS)** is an IRS where the periodic floating rate is equal to the geometric average of an overnight rate (i.e. with 1D term) over every day of the payment period.
- **The discount factor at maturity T** is the present value of 1 currency unit paid at the future date T.
- **A yield curve** is a continuum of discount factors for all future points in time. It may be implied mathematically from the observed market quotations of various interest rate derivatives.
- **The forward Libor rate** is the estimate (under no-arbitrage assumptions) of the Libor that will be observed for a future payment period. It is calculated directly from the appropriate yield curve.