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Multi-curves

How banks and market actors manage the consequences of the liquidity crisis on interest rate derivatives

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Summary

The recent credit crisis has had two main effects concerning interest rates:

- The basis spreads between Libor of different tenors have widened. These different Libor rates became more and more independent from each other creating their own respective markets. As a result, they can no longer be modeled through a common process or a single set of market data. Each tenor requires a dedicated curve.
- New counterparty risk mitigation techniques have been developed. One of them, collateralization for derivatives transactions specified in a Credit Support Annex (CSA) – close to a margin call - became so widely used that the market now quotes collateralized swaps.

  This mechanism has to be taken into account when pricing deals.

The purpose of this document is to describe how the above mentioned main effects are impacting banks systems in terms of curve generation process, trade booking and risk management.

1 Multiple curves

During the recent crisis, global lack of liquidity and institutions' preference to receive short term payments resulted in widening spreads between Libor and Overnight rates as well as spreads between Libor of different tenors.
As a result, Libor with different tenors can no longer be modelled with the same curve. On the other hand, the links (basis swap quotes basically) between these different Libor rates have to be kept. This will allow hedging against liquid instruments.
In parallel and for no-arbitrage considerations, the curve used for discounting cash flows based on Libor has to be unique whatever the Libor tenor.

In term of risk mitigation, collateralization of derivative transactions has become a market standard. In simple terms (ignoring Thresholds and Minimum Transfer Amount) the process can be explained as follows. Both the trade and the previously posted collateral amounts are periodically marked-to-market. The party on the negative side then posts additional collateral. To account for its call frequency - daily in most cases– and the fact that the collateralized trade is –almost- risk free, the collateral is funded on an overnight rate and the trade cash flows are discounted on the same curve. The point becomes more complex when the nature of the collateral has to be taken into account. For example a trade denominated in € may be collateralized in $: Using the standard € OIS curve would not reflect the potential basis spread between the two currencies. A new OIS curve ("€ collateralized in $") has to be used.

In a nutshell, these two observations ("each Libor has its own processing" and "Collateralization is a market standard") have led to:

- Use OIS curves for discounting,
- Use different curves for forecast per tenors,
- Define a linkage hierarchy (implicitly by basis swap instruments) on the above curves.

Examples

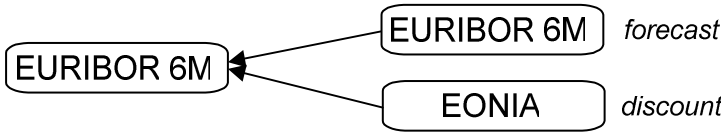
Consider a simple standard interest rate Swap trade based on EURIBOR-6M. On a non- multi-curve mode, we would simply use EURIBOR6M based curve for both forecasting and discounting:

$$\frac{\text{EURIBOR 6M}}{\text{EURIBOR 6M}} \Big/ \frac{\text{FIX}}{\text{EURIBOR 6M}}$$

As a consequence, the current trade is sensitive to only one single curve:

Risk Type	Currency	Index
IR	EUR	EURIB6M

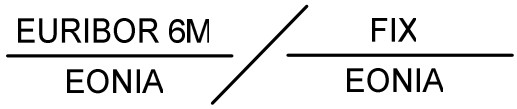
In a multi-curve mode, the EURIBOR-6M curve would need OIS based curve (in EURO market, we would consider EONIA) to build the corresponding zero-coupon rates:



As a consequence, the number of curves in the risk list is multiplied by 2:

Risk Type	Currency	Index
IR	EUR	EURIB6M
IR	EUR	EONIA

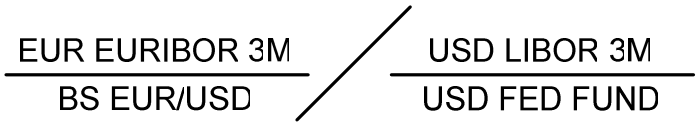
Finally, let's assume that this trade has a collateral contract which leads to a discount on OIS, the trade definition becomes:



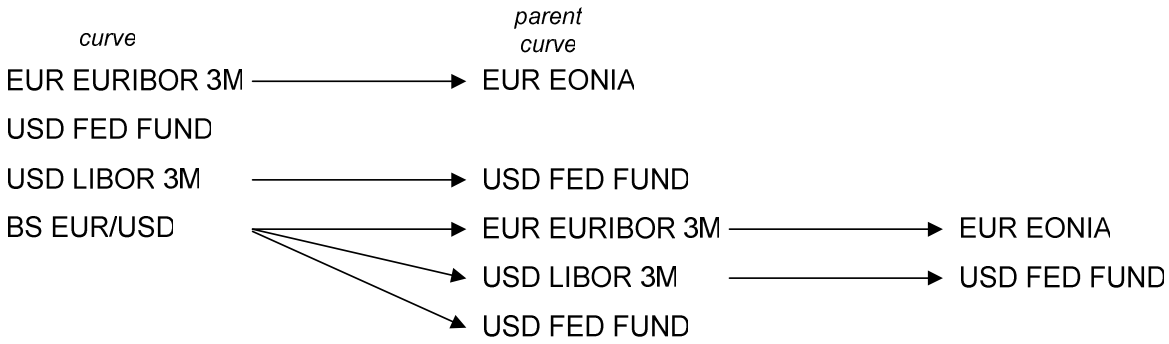
The number of curves remains the same but EONIA curve is now used at 2 different levels:

- Trade's cash flows discounting
- EURIBOR6M curve bootstrapping

Now consider a cross currency swap trade collateralized in USD. As a consequence, the EURO leg has to be discounted with a curve based on EUR/USD basis swap curve whereas the USD leg is discounted on the Fed Fund curve:



Knowing the curves dependencies, we are able to construct the following dependency tree:



We could have make the example even more complex by considering the fact that EURIBOR 3M is quoted through basis swaps against EURIBOR 6M.

2 Consequences on systems and process evolution

To fully implement the changes needed to address new post-crisis market conditions, it is important to ensure that valuation methods, systems and reports can handle both a discount and a forecast curve to price interest rate derivatives. This can be done at trade (forward and discount indexes are registered at trade level) or at system level (curves are then derived at trade level based on the currency, index, CSA…).

2.1 Definition of the curves hierarchy

We've seen through the examples above, that the number of curves and their relationship can be quite complex.
A first task consists in fully specifying these curves hierarchies.
This will depend on business factors such as: The instruments used for quoting (their liquidity), the desired granularity for hedging and the set of CSA handled by the institution.
More IT aspects should also be considered: The required algorithms to generate the curves, the technology to support the amount of data in term of performance, the providers to feed the quotes.

2.2 Multiple curve bootstrapping

LIBOR-based curves are now constructed using OIS curves – for discounting flows- , so the bootstrapping methodology has to be adapted in order to manage this evolution.
In some cases – based on the chosen hierarchy- one may have to handle circular dependencies preventing from generating the curves sequentially.

Any change applied on OIS curve (from any market movement or simply during a sensitivity computation) has to trigger the re-generation of all the depending LIBOR rate curves; so system should be adapted in order to keep track of the dependency tree. At this stage, we clearly highlight that the evolution of curves bootstrapping can potentially have an important impact on the systems performance.

2.3 Trade level

This depends on the way the system handles the discount and forecast curves.

Treasury and Capital Market Software have usually long technically supported separated discount and forecast curves at the trade level, so the evolution of such systems is not so heavy.

Another basic issue to be solved is the derivation of the discount and forecast indexes at trade level: Is the trade collateralized, through which CSA etc.
This automation will have to be applied for both new business and existing portfolio.

2.4 Analysis & Reporting

While they were originally designed to support a simplified single curve framework, Middle and Back office procedures have to be adapted to support multiple curves.

Middle office has to analyse market data exception and P&L explanation when multiple curves are in place; in addition sensitivity reports must be updated in order to assume multiple curves.

On the simple example of a P&L explanatory report: The delta part is no longer computed on a single risk but has to account for both the forecast and the discount risks.

Regarding Hedging; as previously described on the examples, an OIS based curve is involved in the discounting for both the trade itself and the Libor curve instruments. In order to monitor the impact of collateral management only, it is recommended to isolate the part of risk coming from the pure discounting on the trade from the risk generated on the Libor curves.
This means that a tool to monitor the effect of a curve on another one - OIS on Libor 6M, Libor 6M on Libor 3M etc… - must be provided.

2.5 Performances

The most challenging impact for any market participant is to be able to deploy all the mandatory changes to information systems including software, libraries, reports and even the usual practices but without impacting the software performances or degrade the quality of the computation results.

Indeed, instead of considering one single curve to price a trade, we should now manage two different curves, one for forecasting and one for discounting. Moreover, the forecast curve uses an OIS based curve for the discounting and may depend on another forecast curve – when it is defined with Basis swaps quotes-: as described above, there's a curves dependencies tree to be handled.

Analysis and reports involving curve generations and pricings – sensitivity report for example- have now to manage more curves than in a single curve world and the computation process takes more time to produce results.
Though some pricing models –a change from a one-factor to a two factor model for example-may have some impact on the computation time, most of the additional time comes from the curve generation process (no longer linear with the number of curves because of the curve dependencies tree).

Pure IT techniques – use of a Grid for example- may not provide adequate answers to this performance issue and therefore process architectures and algorithms may have to be re-thought.

The following diagram draws the computation time per engine – Grid architecture- obtained for a sensitivity analysis on a portfolio of various standard interest rate derivatives booked on different currencies. The multi-curves hierarchy is simple here as it is made by a discount a forecast curves only –no basis swap curve-.
The switch from a single to a multi-curves mode has approximately multiplied the performance per a factor 4.
The pink line obtained through an optimisation consisting in grouping trades per risk factors illustrates the fact that the optimization of algorithms is worth being invested.

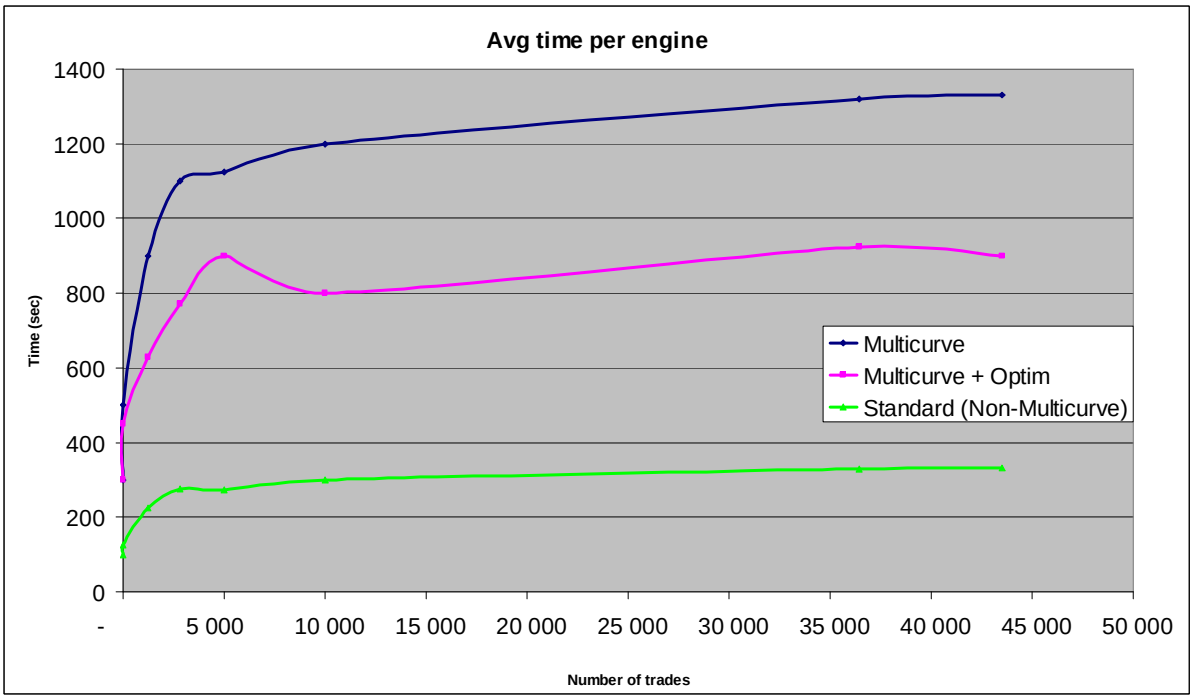


Figure 1: Evolution of computation performances due to the multi-curve mode.

3 Conclusion

The crisis that affected financial markets in the last years led market practitioners to revise well known basic concepts like the ones of discount factors and forward rates. A single yield curve is no longer sufficient to describe the market of interest rate products. But using different yield curves at the same time is quite challenging for institutions both in term of functional set-up and IT organizations.

Global Market Solutions is providing assistance to implement a multi-curve framework on TCM Software.
Please contact us for further information.