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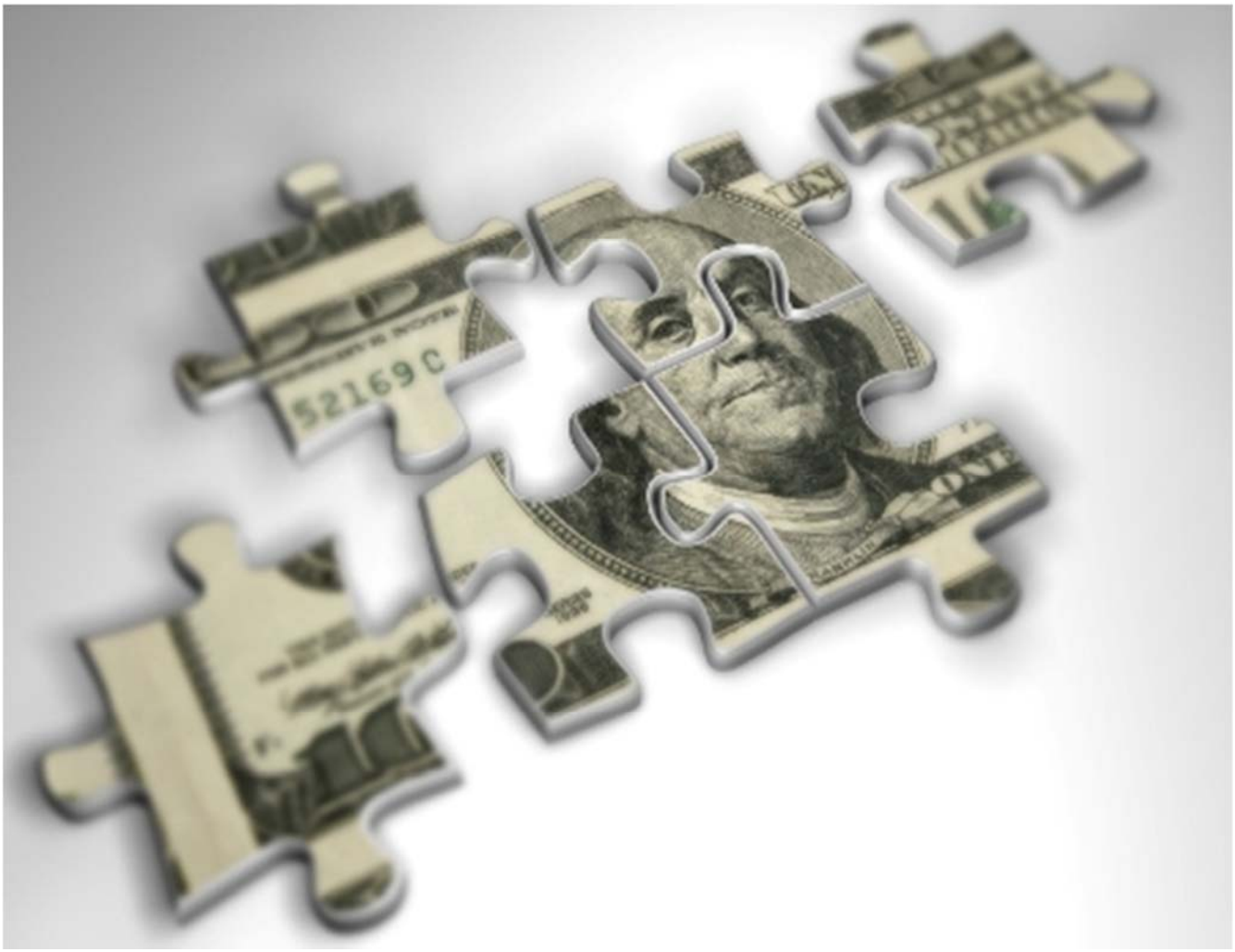

OTC Derivatives
Taking the "fun" out of funding?

October 2012

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Introduction

Prior to the global financial crisis, pricing of vanilla OTC derivatives was well understood and most attention was on so-called exotics. Credit and liquidity risk were mostly ignored as their effects were viewed as negligible. The old style framework for pricing financial instruments is now undergoing a revolution in order to address the shortcomings highlighted by the crisis and to incorporate, properly and completely, credit risk, collateral and funding considerations into a valuation framework.

Pricing financial instruments such as derivatives has always been relatively complex. However, certain aspects of valuation have been considered to be rather trivial. One of these is the use of Libor as a discount rate. Libor rates were generally thought to be preferable to Treasury bond rates due to better liquidity, lack of problems with technical factors (such as repo specialness and tax issues) and the close links between Libor rates and funding costs. In the good old days, a vanilla derivative such as a swap could be valued trivially by discounting cashflows on the Libor curve. Now the situation is massively more complex and the following factors must be accounted for as illustrated in Figure 1.

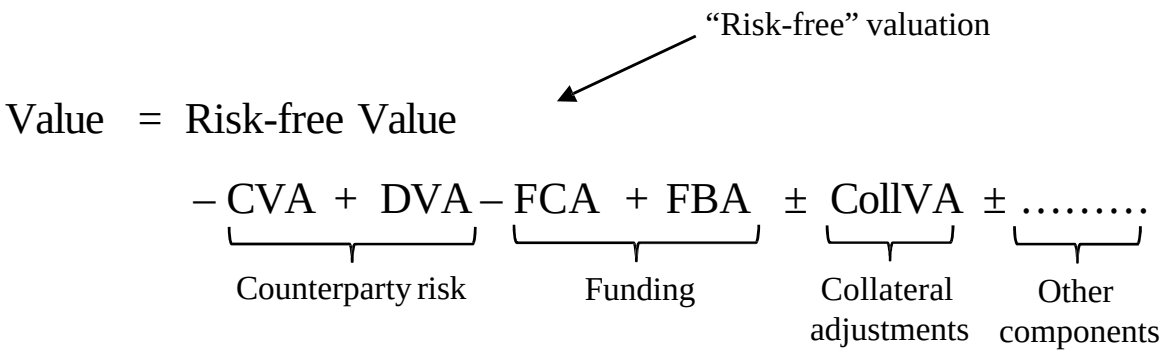

Figure 1. *Illustration of the current complexity of pricing an OTC derivative.*

The above components are:

- ***Risk-free valuation.*** The valuation of a hypothetical "risk-free" derivative, with no associated counterparty risk, funding costs or other components which need to be taken into account. Such a situation never exists in practice but this is an obvious base case from which to start.
- ***Counterparty risk.*** Due to counterparty risk, credit value adjustment (CVA) and potentially debt value adjustment (DVA) must be accounted for.
- ***Funding.*** The pricing of funding considerations, which can be both costs and benefits defined via funding cost adjustment (FCA) and funding benefit adjustment (FBA). Together these will be described as FVA (funding value adjustment).
- ***Collateral adjustments.*** If the relevant collateral rate is different to the risk-free rate used for valuation then this gives rise to an adjustment. Furthermore, there is optionality arising from receiving and posting collateral in different currencies and securities.
- ***Other components.*** Any other component that impacts on the value of a derivative which is not accounted for in the "risk-free" valuation should be also included. One obvious example is non-standard contractual termination events.

Counterparty risk and the valuation of CVA (and DVA) has been a much-discussed topic. In this article, we will therefore focus on the valuation, funding and collateral considerations in the above equation and their links to CVA.

Base case valuation – OIS discounting

The global financial crisis illustrated the credit risk embedded in Libor rates. One way in which this could be seen is via basis swap spreads, which represent the exchange of rates in the same currency. For example, the Euribor 3-month versus Euribor 6-month basis swap spread went from less than 1 bp to over 40 bps in October 2008 after the Lehman bankruptcy. This represents additional unsecured credit risk in the 3-month tenor versus the 6-month tenor. When banks were perceived as risk-free then such differences did not exist but as soon as this myth dissolved, basis swap spreads blew up dramatically.

A better proxy for a risk-free interest rate would be the OIS (overnight indexed spread). In Europe, the relevant OIS rate is Eonia, which is a weighted average of overnight unsecured lending rates in the European interbank market. In the US, the relevant rate is Fed Funds. The daily tenor of rates such as Eonia means they should carry only a small amount of credit risk. Like Libor, OIS can be observed across a term structure via OIS swaps, which involve a classic floating rate indexed to an OIS. During the global financial crisis, the spreads between Euribor and Eonia OIS swaps diverged significantly for the first time ever[1]. OIS is also the rate typically specified in a CSA since with daily margining a particular amount of collateral is only certain to be held for this period[2]. Hence, there are two reasons why OIS seems to be the correct rate for valuation: it is the rate with the least credit risk embedded and represents the underlying funding rate for collateralised derivatives.

Theoretically, OIS discounting is the correct way to value derivatives under the following assumptions:

- The transaction is covered by a symmetric (two way) CSA[3] with zero threshold, minimum transfer amount, rounding (and independent amount).
- Cash collateral is paid continuously[4] in the currency of the transaction[5], with the relevant OIS rate paid on collateral posted.
- The exposure and collateral value cannot move discontinuously.

Whilst these assumptions are somewhat stylised[6], they do give the most obvious base case ideal scenario. Interbank trades, centrally cleared trades and trades under the proposed SCSA (see later) all aim to be close to the above theoretical ideal. With this in mind, the general valuation shift to OIS discounting has not been surprising. However, this complicates matters for a number of reasons. Pricing a single interest rate swap (IRS) used to involve using the same rate (Libor) for both projecting the future cashflows and discounting them. OIS discounting complicates this process. Libor-OIS swaps are generally more liquid than OIS swaps and so OIS and basis curves[7] have to be built simultaneously from these market prices together with the prices of standard Libor based swaps. In this calibration, discounting is assumed based on OIS whilst cashflows are projected in the relevant rate (OIS or Libor). This "dual curve" problem means that standard simpler bootstrap methods[8] are not applicable. OIS curves in most currencies except USD are quite illiquid and calibration is not straightforward in these situations.

OIS discounting stems from the way in which transactions such as derivatives are collateralised which implies that return on the collateral is the obvious discounting rate. However, the problem is much broader than simply deciding upon the correct "risk-free" rate (OIS) and using the relevant additional curves in the valuation methodology.

Deviating from OIS

No OTC derivative can be perfectly collateralised and many are completely uncollateralised. This arises mainly due to the nature of the counterparties involved, such as corporates and sovereigns, without the liquidity and operational capacity to adhere to daily collateral calls. This creates a problem such as uncollateralised client trades needing to be hedged via collateralised interbank trades. In order to understand the deviation from OIS discounting, Figure 2 compares an actual trade with an ideal perfectly collateralised hedge trade which can be valued using OIS discounting alone. Whilst a perfectly collateralised trade does not occur in practice, this is the obvious base case scenario to compare to.

[1] In addition the difference between 3-month Libor and Fed Funds in the US was only 8 bps prior to the crisis and ballooned to around 40 times this amount (i.e. around 320 bps) in the aftermath of the Lehman default in October 2008.
[2] We note that this is not the only choice. OIS is simply an obvious benchmark of overnight lending and is typically used as a convenient "fair" return on cash collateral deposited overnight. However, for a long duration collateralised position, OIS is far from fair. Collateral posted against, for example, a large FX move in a cross currency swap may be unlikely to be returned for months or even years. Collateral agreements may reference other rates such as Libor, which clearly complicates the analysis.
[3] Credit support annex (by far the most common collateral agreement). The use of collateral has increased steadily as the OTC derivatives market has developed. The 2010 ISDA margin survey reports that 70 percent of net exposure arising from OTC derivatives transactions is collateralised.
[4] Obviously in reality there will be a delay on receiving collateral, which will be discussed later.
[5] Restricting collateral to the currency of the trade in question has obvious problems for multi-currency products (e.g. cross currency swaps).
[6] Although we note that the use of overcollateralisation (as in central clearing, for example) can overcome the problems with delays in collateral transfer and discontinuities (at least from the central counterparty's point of view).
[7] This defines the basis between Libor and OIS.
[8] This basically means a simple and sequential calibration procedure.

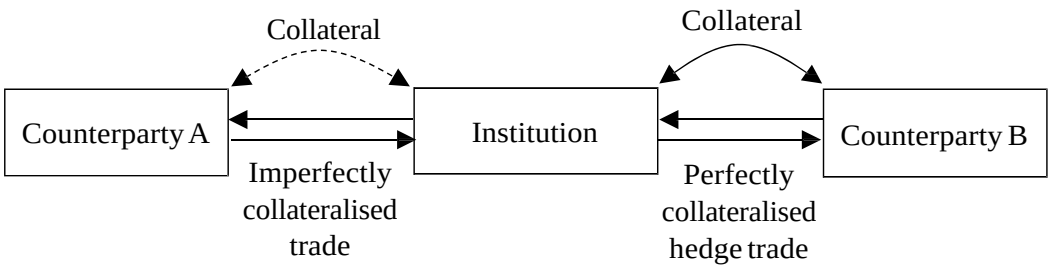

Figure 2. *Illustration of the way in which collateral optionality and funding becomes important. An institution is assumed to trade with Counterparty A with a partial collateral arrangement and is assumed to hedge with a perfectly collateralised trade.*

The above illustrates two important aspects that should be considered in addition to OIS discounting, CVA and DVA:

1. ***Funding.*** Due to the possible mismatch of collateral amounts in Figure 2, there will be funding costs and/or benefits.
2. ***Collateral optionality.*** This relates to the ability to optimise collateral posting between the two trades in Figure 2. For example, receiving cash and posting securities to obtain some overall economic advantage or balance-sheet benefit.

Funding

A counterparty which is not required to post collateral (non-CSA counterparty) will create a funding requirement for the institution trading with them. This relates to the need for the institution to offset or hedge the transaction under a CSA. For bilateral exposure, such as swaps, this can be both a cost and benefit as the transaction(s) may have both positive and negative value. FVA accounts for funding costs above the relevant index not already accounted for through (OIS) valuation. In such cases, the full impact of funding of the transactions in question must be considered. The concept of FVA (funding value adjustment, also known as liquidity value adjustment or LVA) aims to do this. FVA is similar in many ways to CVA and many of the components to calculate the two are shared.

The heart of FVA is the relevant funding rate of an institution. The different funding rates to consider are shown in Figure 3 which also shows the impact of the CDS-bond basis. Derivatives, due to their dynamic nature and the funding approach of banks, are not *term funded*[9]. The funding is generally short-term, although still significantly more expensive than OIS which essentially represents risk-free funding. Furthermore, regulation is pushing banks to rely less on short-term funding. Overall, this means that for an institution to define their appropriate funding curve represents a very subtle and difficult problem. Note also that there is a distinction between bond spreads (that define term funding costs) and CDS spreads (that define CVA and DVA). Another important consideration is that funding rates may be *asymmetric*, i.e. the rate at which an institution is able to borrow unsecured funds is not necessarily equal to the rate it is able to achieve when lending.

[9] Meaning, for example, that a 5-year swap is not funded via a 5-year bond issue.

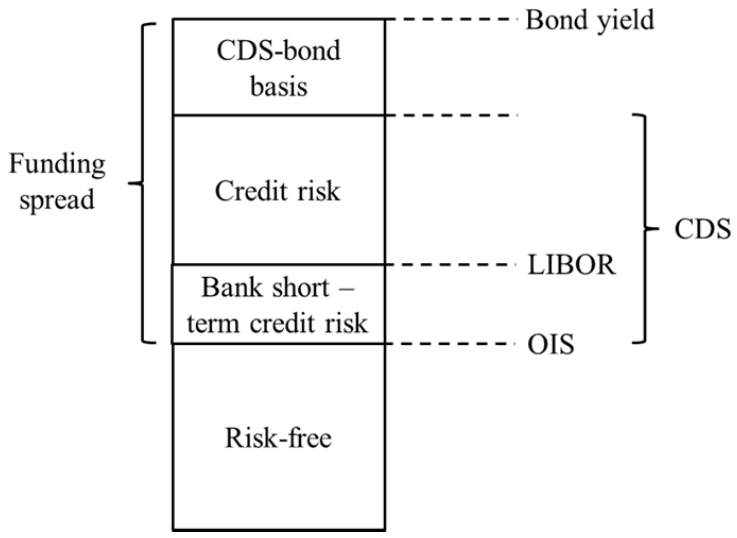

Figure 3. *Illustration of the differing funding rates depending on type of instrument and maturity together with the CDS-bond basis (note that a negative basis is illustrated although this is not necessarily the case in practice). The unsecured funding spread is defined with respect to the OIS rate.*

Consider Figure 4, which shows the cashflows and associated funding considerations for a payer interest rate swap[10] assuming an upwards sloping yield curve. In the early stages of the swap, the fixed cashflows being paid are expected[11] to be greater than the floating ones received. This creates a positive exposure which needs to be funded. The exposure increases cumulatively for the first few payments and then reduces as the projected floating payments start to exceed the fixed ones. This creates an overall funding cost based on the expected future value of the swap. The corresponding reverse receiver swap would have precisely the opposite profile, creating a symmetric funding benefit.

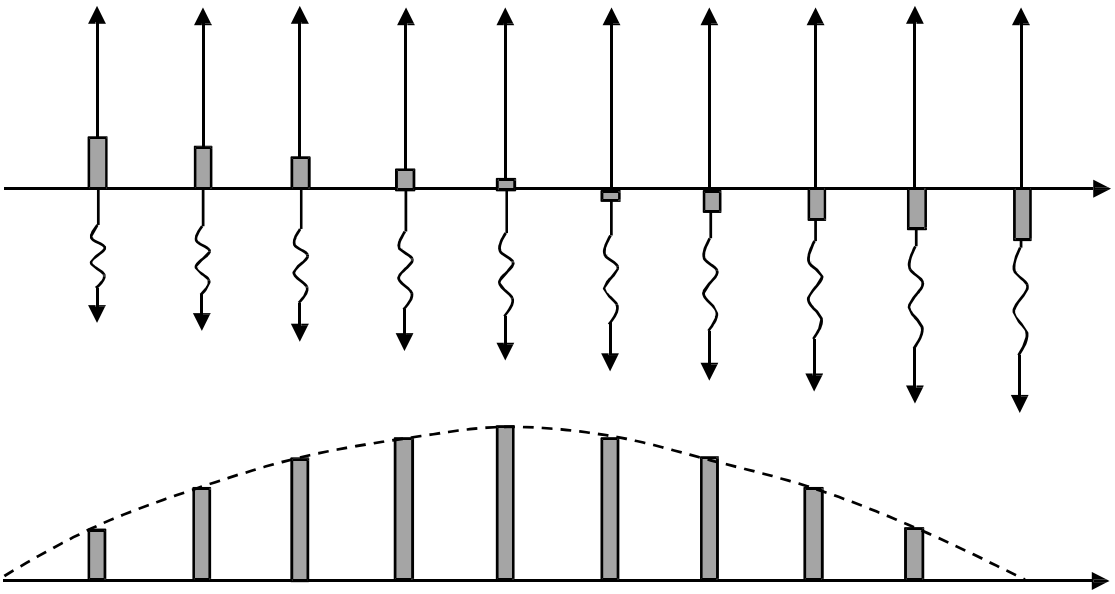

Figure 4. *(Top) Illustration of the funding needs on a payer interest rate swap which arises due to the future cashflow differential. The grey bars show the net projected funding cost with the bottom figure showing the cumulative effect over time and the resulting funding profile.*

The above example suggests a rather simple treatment of the funding cost (or benefit) which is to discount cashflows at the relevant funding rate to account for the FVA. However, this cannot capture more complicated effects, such as one-way CSAs, CSAs with thresholds or asymmetric funding spreads for borrowing and lending.

[10] A swap paying the fixed and receiving the floating rate of interest.
[11] Based on risk-neutral valuation.

In such cases, the FCA and FBA of FVA must be valued explicitly. For example, in a CSA with a threshold, a positive exposure creates a funding cost only up to the threshold amount, after which collateral would be taken and the exposure above the threshold would be essentially capped, reducing the FCA term as illustrated in Figure 5. Correspondingly, the negative exposure defining the funding benefit would be also capped (at a potentially different threshold) reducing the FBA term.

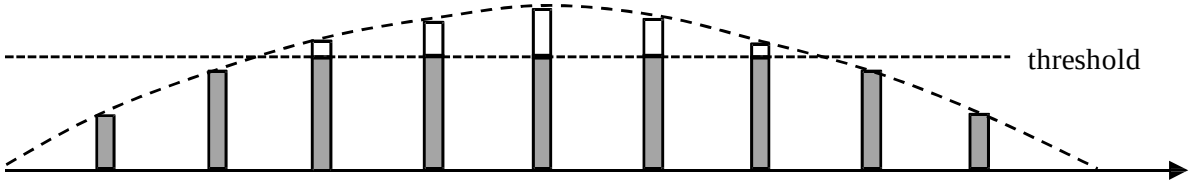

Figure 5. *Illustration of the funding cost for a partially collateralised trade. In such a case, the exposure must be funded up to the threshold (and a funding benefit is achieved up to the opposite threshold).*

The FCA and FBA terms can be calculated in a general framework using the quantities already required for computing CVA and DVA together with the relevant funding spread discussed above. Note that, even if an entire book was collateralised, funding would still be an issue due to non-symmetric collateral terms (e.g. different thresholds), different underlying portfolios[12], rehypothecation restrictions and the time delay in receiving collateral[13]. Hence, ideally FCA and FBA should be calculated for all OTC derivatives even if they are expected to be small in some cases. This allows more complex cases to be tackled such as assessing the funding on an uncollateralised trade hedged with a partially collateralised trade. Here, the funding costs (benefit) on the uncollateralised trade will be partially cancelled out by benefits (costs) on the collateralised trade due to collateral not being posted below the threshold.

Funding and DVA

The relationship between FVA and DVA is also worth mentioning and Figure 6 depicts the parallel between the two. FBA is similar to the well-known DVA component where an institution may price their own default as a benefit. The main difference between these components is a basis - the DVA is calculated with the CDS spread and the funding benefit with the funding spread (see Figure 3).

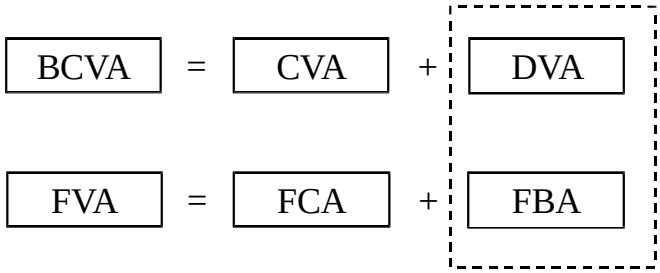

Figure 6. *Illustration of the link between funding and DVA.*

The above illustrates that treating DVA naively as a funding benefit is dangerous as it implies a double counting. The precise theoretical analysis of this problem is complex and depends on the precise assumptions made[14]. However, a practical consequence is that to consider DVA and FBA together is only possible if an institution believes that they can monetise their own default. There are ways in which this can be achieved such as selling CDS protection on highly correlated counterparties (or indices) or unwinding or novating trades. However, the DVA monetisation methods are imperfect and cause unintended consequences (such as the creation of wrong-way and systemic risk). If monetisation of DVA is considered problematic then there are two alternative frameworks for treating

[12] For example on one portfolio, a threshold may have been breached whereas on the other it may not.

[13] Whilst collateral can often be requested on a daily basis, there will still be some delay. Whilst this should be small (no more than a few business days), it does leave some residual funding requirements.

[14] For example, whether funding costs and benefits are symmetric and if a transaction such as a derivative can be posted as collateral.

counterparty risk and funding. These are:

- ***Asymmetric funding and bilateral CVA (CVA + DVA + FCA).*** Here, DVA is considered a funding benefit and is therefore consistent with accounting regulations that require both CVA and DVA to be quantified[15].
- ***Symmetric funding and CVA (CVA + FCA + FBA).*** This ignores DVA benefit and considers FBA. This approach is also in line with the Basel III rules for capital requirement[16], which ignore DVA. It is also consistent with the traditional treasury function in a bank which may consider funding costs and benefits as symmetric and offset across different trading desks.

Collateral optionality

Collateral agreements aim to solve counterparty risk and funding issues in OTC derivatives. However, there are also problems which arise from the currency and type of collateral that might be posted or received. Collateral arrangements are historically flexible allowing the posting of cash in different currencies, high quality debt (such as corporate or sovereign bonds) and sometimes other assets such as equities or gold. This creates a valuation problem linked to the ability of one or both parties in a transaction to optimise collateral posted. Often referred to as the "cheapest-to-deliver collateral" problem, this has an impact on valuation.

Since cash currency returns are typically tied to the OIS in the corresponding currency (Eonia, Sonia, Fed Funds) the choice of collateral currency materially affects the return received. Collateral should ideally be posted in the highest yielding currency, as defined by some base currency from the relevant OIS curves adjusted for forward FX. Non-cash collateral needs to be rehypothecated in a transaction such as a repo where another haircut will be required. The repo rate must be adjusted depending on the haircuts in the repo market and CSA respectively. This rate can be compared with the cash rates discussed above (although other factors may be more important such as the balance sheet opportunity of posting non-cash collateral).

The extent of the optimisation possible depends on whether a collateral arrangement allows substitution of collateral. If substitution is allowed then there is greater value to the net collateral poster as they may at any time replace the collateral with a more optimal choice (for example if OIS in one currency widens with respect to another). Collateral agreements not allowing substitutions (or requiring consent[17]) have less optionality but an institution can still optimise by posting the highest yielding collateral as additional collateral is required. Assessing the value of collateral posting is difficult, as it must account for all of the factors outlined above throughout the lifetime of the transactions in question. It is a path dependent problem as it depends on the future evolution of exposure and amount of collateral required in addition to the assessment of the cost or benefit derived from the actual collateral posted or received. The counterparty should also be expected to follow an optimal strategy.

Many aspects of CSAs are simply too complex to quantify rigorously as generally a tremendous amount of optionality exists over the type of collateral that can be delivered (and substituted) across both currency, asset class and maturity. Knowing the cheapest-to-deliver collateral in the future depends on many aspects such as the future exposure, basis swap spreads and haircuts. An alternative solution is to remove structurally the optionality to simplify the valuation problems linked to funding and CSAs. The ISDA Standard Credit Support Annex (SCSA) aims to achieve such standardisation and greatly reduce embedded optionality, whilst also promoting the adoption of OIS discounting. At the same time, the mechanics of a SCSA are focused on being closely aligned to central clearing collateral practices.

A SCSA greatly simplifies the collateral process requiring:

- Cash collateral only.
- Only currencies with the most liquid OIS curves (USD, EUR, GBP, CHF and JPY).
- Zero thresholds and minimum transfer amounts.
- One collateral requirement per currency (cross currency products are put into the USD bucket).

The SCSA will require parties to calculate a single cash collateral requirement per currency per day. This gives rise to settlement (Herstatt) risk as different currency trades will essentially be separated into silos. With agreement, it will be possible to convert each currency amount into a single amount, with an accompanying interest adjustment

[15] This is optional under current European standards (IAS 39) but will become mandatory under IFRS13 from January 2013 onwards.
[16] Note that these rules apply to capital only and hence an institution cannot be required under Basel III to ignore DVA from their accounting PnL.
[17] Since the counterparty's optimal strategy would be not to give consent.

overlay (to correct for interest rate differences between the currencies and known as the "Implied Swap Adjustment Mechanism" or "ISA Method"). A "safe settlement" platform is being developed to eliminate further settlement risk. A SCSA simplifies bilateral collateralisation as much as possible, removing most of the optionality.

Central counterparties

Collateral posting through CSAs is becoming more widespread and streamlined (e.g. more cash usage) but another force is creating even more funding requirements. The Financial Crisis that developed from 2007 suggested that better ways of controlling counterparty risk needed to be found. Policymakers identified the widespread adoption of central clearing of OTC derivatives as one means of achieving this. Legislation such as the Dodd-Frank Wall Street Reform (passed by the US Congress in 2010) and the new European Market Infrastructure Regulation (EMIR) mandate that certain OTC derivatives transactions be centrally cleared through central counterparties (CCPs).

CCPs create collateral requirements similar to a symmetric CSA but with initial margin. The initial margin therefore represents an additional funding consideration on top of those described above. CCPs have the ability to increase initial margin requirements further, for example in response to a period of higher market volatility. The collateral requirements for CCPs are much simpler than in a standard CSA. One approach (for example, used by LCH.Clearnet) is to require collateral to be posted in the currency of the underlying transaction. Cross currency products are currently not cleared, partly due to the obvious problems this would create. This currency-mixing problem is also one of the reasons why cross product netting on margins is not recognised either.

It is also important to note that, according to the Dodd-Frank act, even for non-cleared OTC derivatives, a "swap dealer" must collect initial and variation margin at levels that are likely to be comparable with those for centrally cleared trades.

The funding spectrum

The conversion of counterparty risk to funding liquidity risk is an inevitable result of the completely realistic need to take collateral - but can it be pushed too far? A key decision for market participants and regulators alike is the concentration of various trading on the spectrum represented by Figure 7 and the risks that this presents. Whilst pushing to the left minimises counterparty risk, it also increases more opaque and complex funding liquidity risks. This is an important consideration that will be considered in a future article.

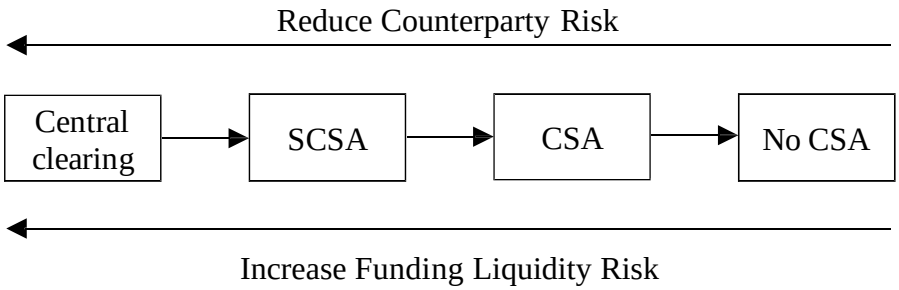

Figure 7. *Illustration of the increasing impact of collateral on counterparty risk and funding liquidity risk.*

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