Collateral consistent derivatives pricing

FRIC Practitioner Seminar, CBS

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Counterparty Credit & Funding Risk
Agenda

• The intuition behind collateral consistent pricing.

• The complexities of a multi CSA book
  − Which collateral assumptions hold for calibration instruments?
  − The ISDA Standardized CSA approach
  − Market fragmentation between CCP cleared and bilateral trades?

• Case studies in curve calibration
  − What are reasonable bounds for forward curves?
  − Arbitrages in fragmented markets?

• Pricing and hedging discounting risks under different CSA regimes?
  − The collateral valuation adjustment.
  − The cheapest-to-deliver optionality in CSAs
  − Hedge ratios with and without optionality?
Swaps in the old way

- In the “old” days (until Aug’07) many market participants had just one swap curve for each currency.
  - Forward rates - irrespective of tenor - were calculated on this.
  - Discount factors were also derived from this curve.
- This implicitly assumes:
  - No money market basis (e.g. 3s6s basis is zero).
  - No cross currency basis (e.g. EUR/USD basis is (close to) zero).
  - Traders can fund themselves at xIBOR.
  - Note that on a single curve, a Floating Rate Note trades at par at fixing time.
- These assumptions are no longer valid.
Swaps in the new way

• Need for **multiple** projection curves for each currency.
  
  − We cannot compute 3M xIBOR and 6M xIBOR forwards on the same curve.

• Need for a **single** discounting curve for each currency.
  
  − This should reflect CCS spreads.
  
  − But what should be my anchor in terms of currency and credit premium?
  
  − If your trade is collateralised, you should discount with the collateral rate.
  
  − What is your collateral rate?
The institutional setting

• The ISDA Master agreement
  - The legal umbrella underpinning netting.
  - Default and early termination provisions.

• ISDA Definitions
  - Sets standards for methodologies such as settlement of options, application of floating rates etc.

• ISDA Credit Support Annex (Credit Support Deed)
  - Defines the terms for collateralisation.
  - Sets Thresholds, Independent Amounts, Minimum Transfer Amounts and valuation frequency.
  - Eligible collateral and specifies interest earned.
The intuition behind collateral consistent pricing

Flow analysis: EUR Derivative - EUR Cash collateral

- Cash desk is passing through the liquidity – no haircuts or disagreement on valuation.
- Internal loop can be "closed" if \( r_{\text{Intern}} = r_{\text{OIS}} \)
- See Piterbarg (2010).

- For the setup to be arbitrage free, the trader needs to be discounted at the rate his cash position earns, i.e. \( R_{\text{Disc}} = R_{\text{OIS}} \).
- He could in principle hedge his cash exposure via an EONIA swap.
A benchmark case: A multi-currency calibration under EUR cash collateral

• Stylised market:
  - Only IRSs against 3M xIBOR.
  - 3M xIBOR-OIS basis swaps.
  - X-CCY basis swaps against 3M XIBOR.
  - Only swap instruments 1-30Y.

• Setup
  - Separate forward and discounting curves.
  - Single collateral assumption – all products are EUR cash collateralised.
  - Want a CCS consistent valuation setup.

• Approach
  - Calibrate jointly EUR3M and EUROIS=EURDISC curves.
Benchmark case – cont’d

• Approach cont’d:
  − Calibrate jointly USD3M, USDOIS and USDDISC curves...
  − ...requires EUR model as input since X-CCY legs have initial PV...
  − ...USDDISC curve is not dependent on USDOIS.

• Pricing implication
  − This creates a X-CCY dependence for the pricing of every USD cashflow.
  − Hedging tool for USD net liquidity is to trade USD fixed-EONIA float CCS...
  − ...this delivers the required EONIA floater to collateral mgmt.
The intuition behind collateral consistent pricing (cont.)

Flow analysis: EUR Derivative - USD Cash collateral

To produce the collateral posting in USD an Eonia/Fed-Funds CCS is entered.

Notice that there is a spread \( s \) on the EUR leg!

See Piterbarg (2012).

The discount rate needs to reflect the spread in the CCS.

In reality there may be multiple currencies, and hence a cheapest-to-deliver option for the collateral poster!
Calibration instrument assumptions

• Fundamentals
  - What do we mean by calibration instruments?
  - Our model tells where to price one product relative to others...
  - ...so we should calibrate it market prices at which we can execute hedges.

• ”The Market”
  - How is ”The Market” collateralised?
  - No single answer...
  - ...CSAs are bilateral agreements – and they vary substantially.
  - CCP collateralisation rules are however very clear.

• My calibration should depend carefully on the collateral assumptions that I will face once I start using the calibration instruments for hedging.
  - Each market segment offers one source of risk – but can be collateralised differently:
  - On several CCPs EUR trades are EONIA collateralised, USD trades are FF collateralised...
  - ...the same goes for the ISDA Standardised CSA.
  - But what holds true for FX products?
Changing the assumptions

• Back to USD:
  - Let us instead calibrate by using Fed Funds discounting...
  - ...most of "The Market" for USD swaps clears via LCH...
  - We are using the same market quotes for spot instruments...
  - ...but see slight changes in the 3M Fwd curve for 3M USD LIBOR.
• Intuition:
  - A par-swap rate is a weighted average of xIBOR forward rates.
  - Changing the discounting assumption alters the weighting of the individual fwd xIBOR rates.
  - A typical swap market calibration has many degrees of freedom.
• Conclusion:
  - Depending on your assumptions, you can easily misprice forward starting swaps with 1.0-1.5 bps.
  - This is huge in a market that trades with bid-offer spreads in the 0.25-1 bps range.
Changing the assumptions – cont’d

• Cross currency swaps:
  - The same effect holds true for CCSs.
  - In most markets, the fwd curves for the CCS breaks are less steep than xIBOR fwd curves...
  - ...this means that the discounting effect is smaller.

• ISDA Standardised CSA:
  - Is promoting USD cash collateral for FX products incl. CCS...
  - ...so Fed Funds discounting must be right...
  - ...but what about the fwd curves needed to price up this product?
    → This introduces a multi-step calibration requirement...
    → ...need to calibrate "silo" models first and subsequently introduce a new discounting curve.
Changing the assumptions – cont’d

• An aside on CCSs:
  - The basic building block for CCSs is in itself tricky…
  - ...MtM FX resets or constant notionals?
  - Should FX-Basis correlation be included?
  - Does the market standard CCS product rather warrant a full hybrid model?

• Conclusion:
  - The full sequential calibration of the silo-based model matters in certain curve segments.
  - Is obviously dependent on interpolation settings...
  - …but for plausible choices, the difference in a 5Y5Y EUR/USD CCS can be up 0.25 bps.
The intuition behind collateral consistent pricing

Flow analysis: EUR Derivative - EUR security collateral

• Security collateral can be financed at their respective repo rate.
• Note the role of haircuts: Cash desk potentially receives one, but collateral management will have to provide one in the CSA. Only differences in haircuts matter – and then becomes a question of unsecured funding rates.
Case study: Potential for market fragmentation in SEK

• CCP vs. Bilateral:
  - Clearing is not standard in all markets – yet.
  - In SEK, a large share of the IRS market is cleared but much is still bilateral.
  - Among the market makers security collateral is allegedly common place…
  - …and some of this is closer to STIBOR funded.

• CCP valuation vs. cash accrual
  - LCH.SwapClear uses STIBOR discounting for VM calculation…
  - …but still pays T/N rate on SEK cash.
  - First order (accrual rate) vs. second order (accrual balance) effect.

• Conclusion:
  - If there is still only one broker price, there should be fragmentation in the forward swap market.
  - Screen prices should be different.
Collateral valuation adjustments

• CSA optionality:
  − Many (older) CSAs contain long lists of eligible collateral.
  − If collateral can be freely substituted, this creates a cheapest-to-deliver option for the posting party.
  − This creates a need for an effective discount curve – created from more than one curve.

• Example:
  − Can choose between placing EUR cash earning EONIA and USD cash earning Fed Funds.
  − This is effectively a series of call options on the EONIA-FF CCS spread.

• Intrinsic value of CSA option:
  − Find the upper convolution of the EONIA disc curve and the Fed Funds adjusted curve (in fwd terms).
  − Use these forward rates to generate effective discount curve.
  − In the specific example, it is expected to be cheapest to deliver EUR for all 30Y years...
  − ...but there is a risk that USD will be cheaper.
The intuition behind collateral consistent pricing (cont.)

Expected collateral flow – 100M EUR 20Y IRS Payer

• Net Flow
  - Take forward Euribor rates and par fixed rate as given, assume EUR OIS discounting.
  - Forward curve is upward sloping
  - We pay out net the first 5 years, and receive net the last 15 years.

• Future Value as expected collateral balance.
  - Starts and ends at zero for the ATM trade.
  - Increases since we are owed more and more.
  - Decreases when we start to receive.
The intuition behind collateral consistent pricing (cont.)

Forward Cross Currency Basis Spreads – 1Y Forward CCS next 20Y

• ColVA
  - Consider the Collateral Valuation Adjustment if collateral should be posted in USD Cash rather than EUR Cash.
  - User the FV Net as the CCS notional profile, compute the value of paying the spread.
  - The spread is determined through the CCS with the Fed Funds rate flat on the one leg and Eonia plus a spread on the other.
The intuition behind collateral consistent pricing (cont.)
Discount Curve Risk wrt 1Y Forward CCS Spreads - 100M EUR 20Y IRS Payer

• Compute Discount Curve Risk wrt. 1Y Fwd swaps to derive 1st order Co1VA impact estimate from shifting collateral type.

• Example continued:
  − ATM, ITM (ATM-100bp), OTM (ATM+100bp)
  − Positive FV implies negative Fwd Disk Risk.
  − ITM/OTM have the extra disk risk from an annuity.
  − Result:

<table>
<thead>
<tr>
<th></th>
<th>ATM</th>
<th>OTM</th>
<th>ITM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact</td>
<td>203k EUR</td>
<td>-356k EUR</td>
<td>761k EUR</td>
</tr>
</tbody>
</table>

1st Order Co1VA: Disc Risk * CCS Spread

ATM Impact | OTM Impact | ITM Impact
Option adjusted collateral consistent pricing

• Realised volatility on CCS spreads:
  - Spot (normal) volatility is in the 20-50 bps range on an annualised basis.
  - Forward spreads are however less volatile.

• How to include volatility?
  - Simple model, can only EUR or USD cash.
  - Assume Gaussian model.
  - Collateral poster is long a series of caplets on CCS breaks, struck at 0 bps.

• Conclusion
  - Given the shape of the CCS fwd break curve, the short expiries are deep OTM...
  - …little effect on effective discounting curve.
  - But significant increases for long dated expiries (closer to ATM and higher vega).
Option adjusted collateral consistent pricing – cont’d

• Theory:
  – Fujii & Takahashi (2011) and Piterbarg (2012)

• Example:
  – 30Y EUR Payer, 100m 250 bps OTM.

• Risk:
  – Using the intrinsic approach, not CCS hedge is required (EUR trade, EUR cash is CTD with certainty).
  – But this will change as basis spreads increase → Risk will "jump".
  – Stability in hedges is an important argument for developing CTD models...
  – ...especially in "naive" bump-and-re-run" mode.

Note, this is a typical pension fund trade – a difference of 6% of the PV of derivatives can mean insolvency.

<table>
<thead>
<tr>
<th>Model</th>
<th>PV Initial</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intrinsic CTD</td>
<td>-46.67m</td>
<td>-</td>
</tr>
<tr>
<td>Option adj. CTD, 20 bps</td>
<td>-45.80m</td>
<td>878k</td>
</tr>
<tr>
<td>Option adj. CTD, 50 bps</td>
<td>-43.92m</td>
<td>2.756k</td>
</tr>
</tbody>
</table>
Option adjusted collateral consistent pricing – cont’d

• Option adjusted discount deltas:
  - Results in stable hedges.
  - Intuition fits well against USD cash-only benchmark case.
Conclusion

• There is a direct link between collateral terms and discount factors.

• This is important – it is not just for market makers in derivatives.

• It is not trivial to construct collateral consistent swap curves – and arbitrages are sometimes not far away.

• The "poor man’s” collateral consistent approach can bring most market participants far.

• While the value of CTD options embedded in CSAs is debatable – the risk implications are clear.
References

• Piterbarg, V. (2010), ”Funding beyond discounting: Collateral agreements and derivatives pricing”, Risk Magazine February, pp.97-102


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