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# Credit Valuation Adjustment and Funding Valuation Adjustment

## Summary

- ◆ Credit Valuation Adjustment (CVA) Definition
- ◆ Funding Valuation Adjustment (FVA) Definition
- ◆ CVA and FVA Calculation: Credit Exposure Approach
- ◆ CVA and FVA Calculation: Least Square Monte Carlo Approach
- ◆ Master Agreement
- ◆ CSA Agreement
- ◆ Risk Neutral Simulation
- ◆ Credit Exposure Approach Implementation
- ◆ Least Square Monte Carlo Approach Implementation

## CVA Definition

- ◆ CVA is defined as the difference between the risk-free portfolio value and the true/risky portfolio value
- ◆ CVA is the market price of counterparty credit risk
- ◆ In practice, CVA should be computed at portfolio level. That means calculation should take Master agreement and CSA agreement into account.

## FVA Definition

- ◆ FVA is introduced to capture the incremental costs of funding uncollateralized derivatives.
- ◆ FVA is the difference between the rate paid for the collateral to the bank's treasury and rate paid by the clearinghouse.
- ◆ FVA can be thought of as a hedging cost or benefit arising from the mismatch between an uncollateralized derivative and a collateralized hedge in the interdealer market.
- ◆ FVA should be also calculated at portfolio level.

## CVA Calculation: Credit Exposure Approach

### ◆ Model

$$CVA = (1 - R) \int_0^T EE^*(t) dPD(0, t)$$

where  $EE^*(t)$  is the discounted risk-neutral expected credit exposure;  $R$  is the recovery rate and  $PD$  is the risk neutral probability of default.

### ◆ Pros

- ◆ Simple and intuitive
- ◆ Make best reuse of the existing counterparty credit risk system
- ◆ Relatively easy to implement

### ◆ Cons

- ◆ Theoretically unsound
- ◆ Inaccurate

## CVA Calculation: Least Square Monte Carlo Approach

### ◆ Model

$$CVA = V_f(t) - V_r(t)$$

where  $V_r(t) = E[Y(t, T)X_T] = E[D(t, T)(1 - 1_{X_T \geq 0}q(1 - R))]$  is the risky/true value;

$V_f(t) = E[D(t, T)X_T]$  is the risk-free value;

$D(t, T)$  is the risk-free discount factor;

$q$  is the risk neutral survival probability.

### ◆ Introduced by Xiao(1) and then Lee(2)

1. Xiao, T., “An accurate solution for credit value adjustment (CVA) and wrong way risk,” *Journal of Fixed Income*, 25(1), 84-95, 2015.

2. Lee, D., “Pricing financial derivatives subject to counterparty credit risk and credit value adjustment,” <http://www.finpricing.com/lib/derivativeCVA.pdf>

## CVA Calculation: Least Square Monte Carlo Approach (Cont'd)

### ◆ Pros

- ◆ Theoretically sound: can be rigorously proved.
- ◆ Accurate valuation
- ◆ Valuation is performed by Longstaff-Schwartz least squares Monte Carlo approach.

### ◆ Cons

- ◆ Calculation procedure is different from credit exposure computation.
- ◆ Hardly reuse the existing credit exposure system.

## Master Agreement

- ◆ Master agreement is a document agreed between two parties, which applies to all transactions between them.
- ◆ Close out and netting agreement is part of the Master Agreement.

- ◆ If two trades can be netted, the credit exposure is

$$E(t) = \max(V_1(t) + V_2(t), 0)$$

- ◆ If two trade cannot be netted (called non-netting), the credit exposure is

$$E(t) = \max(V_1(t), 0) + \max(V_2(t), 0)$$



## CSA Agreement

- ◆ Credit Support Annex (CSA) or Margin Agreement or Collateral Agreement is a legal document that regulates collateral posting.
- ◆ Trades under a CSA should be also under a netting agreement, but not vice verse.
- ◆ It defines a variety of terms related to collateral posting.
  - ◆ Threshold
  - ◆ Minimum transfer amount (MTA)
  - ◆ Independent amount (or initial margin or haircut)

## Risk Neutral Simulation: Interest Rate and FX

- ◆ Recommended 1-factor model: Hull-White

$$dr_t = (\theta_t - \alpha r_t)dt + \sigma_t dW_t$$

- ◆ Recommended multi-factor model: 2-factor Hull-White or Libor Market Model (LMM)
- ◆ All curve simulations should be brought into a common measure.
  - ◆ Simulate interest rate curves in different currencies.
  - ◆ Change measure from the risk neutral measure of a quoted currency to the risk neutral measure of the base currency.
- ◆ Forward FX rate can be derived using interest rate parity

$$F = S_0 \exp(r_s - r_q)t$$

## Risk Neutral Simulation: Equity Price

- ◆ Geometric Brownian Motion (GBM)

$$\frac{dr}{r} = \mu dt + \sigma dw$$

- ◆ Pros
  - ◆ Simple
  - ◆ Non-negative stock price
- ◆ Cons
  - ◆ Simulated values could be extremely large for a longer horizon.

## Risk Neutral Simulation: Commodity Price

- ◆ Simulate commodity spot, future and forward prices as well as pipeline spreads
- ◆ Two factor model

$$\begin{aligned}\log(S_t) &= q_t + \mathcal{X}_t + \mathcal{Y}_t \\ d\mathcal{X}_t &= (\alpha_1 - \gamma_1 \mathcal{X}_t)dt + \sigma_1 dW_t^1 \\ d\mathcal{Y}_t &= (\alpha_2 - \gamma_2 \mathcal{Y}_t)dt + \sigma_2 dW_t^2 \\ dW_t^1 dW_t^2 &= \rho dt\end{aligned}$$

where  $S_t$  is the spot price or spread;  $q_t$  is the deterministic function;  $\mathcal{X}_t$  is the short term deviation and  $\mathcal{Y}_t$  is the long term equilibrium level

- ◆ This model leads to a closed form solution of forward prices and thus forward term structure.

## Risk Neutral Simulation: Volatility

- ◆ In the risk neutral world, the volatility is embedded in the price simulation.
- ◆ Thus, there is no need to simulate implied volatilities.

## Credit Exposure Approach Implementation

- ◆ Obtain the risk-free value  $V_f(t)$  of a counterparty portfolio that should be reported by trading systems.
- ◆ The solution is based on the existing credit exposure framework.
- ◆ Switch simulation from the real-world measure to the risk neutral measure.
- ◆ Calculate discounted risk-neutral credit exposures (EEs) and take master agreement and CSA into account.
- ◆ One can directly compute CVA using the following formula

$$CVA = (1 - R) \sum_{k=1}^N [PD(t_k) - PD(t_{k-1})] EE^*(t)$$

## Credit Exposure Approach Implementation (Cont'd)

- ◆ Or one can compute the risky value  $V_r(t)$  of the portfolio via discounting positive EEs by counterparty's CDS spread + risk-free interest rate as the positive EEs bearing counterparty risk and negative EEs by the bank's own CDS spread + risk-free interest rate as the negative EEs bearing the bank's credit risk.

$$CVA = V_f(t) - V_r(t)$$

- ◆ Furthermore, you can compute the funding value  $V_F(t)$  of the portfolio via discounting positive EEs by counterparty's bond spread + risk-free interest rate and negative EEs by the bank's own bond spread + risk-free interest rate.

$$FVA = V_f(t) - V_F(t) - CVA = V_r - V_F$$

## Least Square Monte Carlo Approach Implementation

- ◆ Obtain the risk-free value  $V_f(t)$  of a counterparty portfolio that should be reported by trading systems.
- ◆ Simulate market risk factors in the risk-neutral measure.
- ◆ Generate payoffs for all trades based on Monte Carlo simulation.
- ◆ Aggregate payoffs based on the Master agreement and CSA.
- ◆ Compute the risky value  $V_r(t)$  of the portfolio using Longstaff-Schwartz approach.



## LSMC Approach Implementation (Cont'd)

- ◆ Positive cash flows should be discounted by counterparty's CDS spread + risk-free interest rate while negative cash flows should be discounted by the bank's own CDS spread + risk-free interest rate.
- ◆  $CVA = V_f(t) - V_r(t)$
- ◆ Moreover, you can compute the funding value  $V_F(t)$  of the portfolio using Longstaff-Schwartz approach as well
- ◆ Positive cash flows should be discounted by counterparty's bond spread + risk-free interest rate while negative cash flows should be discounted by the bank's own bond spread + risk-free interest rate.
- ◆  $FVA = V_f(t) - V_F(t) - CVA = V_r - V_F$



# Thanks!



You can find more details at  
<https://finpricing.com/faq/fxCurve.html>