Counterparty risk and valuation adjustments

A brief introduction to XVA

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TLA

Three Letters Acronyms

- ✓ In the past years there has been a proliferation of TLAs: CVA, DVA, FVA, KVA … or *X*VA in general: Valuation adjustments of various kinds
- ✓ This is not (or, at least, not only) a matter of inventing clever names: more deeply, the underlying phenomenon is the recognition (at last!) of the importance of counterparty credit risk when evaluating financial instruments and – crucially – derivatives
- ✓ Open debate ongoing, both in academia and in the working practice

CCR (Counterparty Credit Risk, Basel Committee): the risk that the counterparty to a transation could default before the final settlement of the transaction's cash flows. An economic loss would occur if the transactions with the counterparty has a positive economic value at the time of default. […] counterparty credit risk creates a bilateral risk of loss: the market value of the transaction can be positive or negative to either counterparty to the transaction. The market value is uncertain and can vary over time with the movement of underlying market factors.

Motivation

Lessons from recent history

- Since 2007 (nb: stylized history crash course) …

✓ Troubles in US Real Estate market (*subprime loans*) ignited a crisis which hit some important US players: Lehman Brothers, Bear Sterns, AIG …

✓ … the fire reached Europe…

✓ … sovereigns were next in line…

✓ … we are witnesses (& living the consequences…) of the fallback

Was it really unpredictable?
Can we learn something for the future?

- Counterparty risk is for real
- Not only matter for historians, economists, policy makers
- Quants & risk managers are deeply affected and must play their part

Set-up> Risk neutral pricing

Black, Scholes, and Merton & Feynman and Kac

- ✓ The payout of an option can be replicated by investing in a portfolio of a stock and a risk-free asset (bank account)
- ✓ *If* it were possible to borrow or to lend money at the risk-free rate, this strategy would be *self-financing*
- ✓ Black, Scholes, and Merton derive a PDE, Feynman-Kac solution is equivalent to computing the present value, using the risk-free rate for the discounting, of an expected value in a risk-neutral world (nb: this approach leads to Monte Carlo techniques...)

Some assumptions to be appraised

- ✓ Freedom from arbitrage
- ✓ Risk neutral measure (P vs Q)
- ✓ Hedging strategy (Infinitely divisible assets? Transaction costs? Limitless shorting? …)
- ✓ And so on (Risk-free rate? Credit risks? Funding costs?)
- It is an exceedingly useful model, but we have to ask: do the assumptions hold ? At least reasonably?

A bit of notation

τ_A, τ_B default times of A, B respectively

$\Pi(a, b)$ sum of discounted cashflows in the time range $[a, b]$

$\mathrm{E_t}[X_t]$ expected value under risk-neutral measure Q

$Q[\omega]$ risk neutral measure of set ω

$\mathrm{R_A}, \mathrm{R_B}$ expected percentage recovery rate in case of default of A, B

$1(\omega)$ indicator function of event ω, *e.g.* $1(\tau < T)$ refers to the default event before time T

$\mathrm{D}(a, b)$ discounting factor from b up to a, $(b \geq a)$

$a^+ = \max(a, 0)$

The risk-free case

This used to exist…

Take a generic contract according to which, in the time frame $[t, T]$, (uncertain) cashflows $\Pi(t, T)$ will be exchanged between counterparties A and B, both of them risk-free (*e.g.* an IRS fixed versus floating)

The value of this contract, as seen by A and B, V_A^{rf} and V_B^{rf}, will satisfy

$$V_A^{rf} = \mathrm{E}_t[\Pi(t, T)] = -V_B^{rf}$$

This is an important feature, it means that (1) **a price** for the contract **exists**, and (2) that **A and B agree on its value**.

Unilateral Credit Valuation Adjustment

This is closer to reality

Now, what happens if B can default and A continues to be risk-free?

Cashflows received by B, as seen by A (V_A) will be less worthy, because there is a probability strictly > 0 of not receiving them

$$V_A = V_A^{rf} - UCVA_A(t) < V_A^{rf}$$

where

$$\mathrm{U}CVA_A(t) = E_t[(100 - R)D(t,\tau)1(\tau < T)\ (E_\tau[\Pi(\tau,T)])^+] =$$

$$= Q(t < \tau < T)E_t[LGD\ D(t,\tau)\ EAD|\tau < T]$$

Remember that we are under the risk-neutral measure.

This means that value for A is reduced for the loss rate in case of default ($LGD = 100 - R$) times the probability of defaulting until maturity $Q(t < \tau < T)$ and for the current value of the exposure to the counterparty, given the event of default (EAD, Exposure-at-default).

This is the so-called **unilateral CVA**.

UCVA features

It's a better approximation of reality: is it enough?

- ✓ It is *debatable* that A be *really* risk-free and that B could agree with it (Would you? Think at what happened in 2007 / 2008). At most, A can be (or can think of itself) much less risky than B, for some value of «much less»

- ✓ R (and, equivalently, LGD) are usually considered deterministic values: this is a huge simplification of reality and does not take into account the realistic probability that the amount one loses in the event of a default be correlated with the default process itself (nb: you have to think what R is exactly measuring when you read studies about it)

- ✓ $EAD = (\mathrm{E}_\tau[\Pi(\tau, T)])^+$, given a default at time τ, is the payout of a call (with strike 0) on the Net Present Value al the time of default. Thus, counterparty risk induces an optionality on the originary payoff → <u>financial products which were model-independent are no longer so, and one has to take care of volatility and correlations</u>

- ✓ Legal framework is crucial
    - ✓ What are we really talking about when we refer to «a default»?
    - ✓ How does the recovery process work?
    - ✓ Is it possible to set-up some mitigants?

Mitigants

Can we do something to avoid having to worry about this?

Some **approaches**

- ✓ In general, derivatives are regulated under the contractual framework standardized by ISDA
- ✓ Under the ISDA framework there is *netting*, which tends to reduce EAD
    - ✓ $(X_1 + X_2)^+ \leq (X_1)^+ + (X_2)^+$
    - ✓ But, take notice: this leads to the need of assessing the correlations among different contracts with the same counterparty
- ✓ In many cases (but <u>not always</u>) collateral can significantly reduce counterparty risk (and so, UCVA)
    - ✓ Eligible assets (cash or other asset with proper *haircuts*)
    - ✓ Valuation frequency
    - ✓ Cost
    - ✓ Thresholds
    - ✓ A lot of clauses in the so-called Credit Support Annex
    - ✓ All is fine, until collateral does not **create** counterparty risk (!)
- ✓ Collateral is not the end of the story
    - ✓ Gap risk
    - ✓ Re-hypotecation
    - ✓ Counterparty risk is morphed in liquidity risk (margin calls)
- ✓ Clearing houses?

Debit Value Adjustment

Can symmetry bring us closer to reality?

- If A is risk free and B is risky, as seen from the point of view of B, the NPV is worth more because in some cases (when B itself defaults) A will only receive the recovery and not the whole amount. **If B has the option to default**, the $UCVA_A$, which reduced for A the value V_A^{rf} , is a positive quantity which B must add. This is the Unilateral Debit Value Adjustment, $UDVA_B = UCVA_A$.
- $UDVA_B$ makes the contract more worthy for B, the worse B credit worthness the better (!) (it's strange, but it makes sense if one frames it like an «option» for B)
- We can recover symmetry between A and B (in doing so, we also restore the possibility to have a price at all for a given contract) by including default risk for both A and B. Cashflows, as seen from A, will be:

$$\Pi_A^D(t,T) = 1_{\text{both default after } T}\ \Pi_A(t,T) +$$

$$+\, 1_{B \text{ defaults before } A}\left[\Pi(t,\tau_B) + D(t,\tau_B)\left(R_B\left(NPV_A\ (\tau_B)\right)^+ - \left(-NPV_A(\tau_B)\right)^+\right)\right] +$$

$$+\, 1_{A \text{ defaults before } B}\left[\Pi(t,\tau_A) + D(t,\tau_A)\left(\left(\mathrm{NPV_A}\ (\tau_A)\right)^+ - R_A\left(-\mathrm{NPV_A}\ (\tau_A)\right)^+\right)\right]$$

- Taking the expectations one finds $\mathrm{E_t}[\Pi_A^D(t,T)] = E_t[\Pi_A(t,T)] - CVA_A(t) + DVA_A(t)$
- These are **bilateral (**and require to take careof who will default first, A or B)
- Bilateral Value Adjustment $\mathrm{BVA_A}(\mathrm{t}) = \mathrm{DVA_A}\ (\mathrm{t}) - CVA_A(t)$ and now it holds: $\mathrm{BVA_A}(\mathrm{t}) = -BVA_B(t)$

DVA features

Are you really sure about introducing such a quantity?

- ✓ MtM $\mathrm{E}_t[\Pi_A^D(t,T)]$ grows as one's own credit worthiness worsens (DVA gains): one's liabilities are worth less because they will be paid with a lower probability: but this reduced outflow only happens in case of default

- ✓ Recall that we are under risk-neutral measures: computing a DVA as an expected value under such a measure would require to be able to set up a hedging strategy. How do you «sell protection» on your self (that is, the underlying asset of DVA?) One can do think about DVA heding via proxy (on other issuers which are thought of as «correlated» with one-self), but this can work for movement in spreads, not for jump-to-default cases

- ✓ BVA = DVA - CVA : a priori it doesn't have a fixed sign, it depends on correlation between the credit processes and the exposures

- ✓ But, without DVA the price cannot be symmetric: DVA computed by A **is** CVA computed by B

- ✓ Regulators are *skeptic* on DVA

Regulatory treatment

The swiss take on the matter

Basel III

Cumulative gains and losses due to changes in own credit risk on fair valued financial liabilities

75. Derecognise in the calculation of Common Equity Tier 1, all unrealised gains and losses that have resulted from changes in the fair value of liabilities that are due to changes in the bank's own credit risk.

Treatment of mark-to-market counterparty risk losses (CVA capital charge)

97. In addition to the default risk capital requirements for counterparty credit risk determined based on the standardised or internal ratings-based (IRB) approaches for credit risk, a bank must add a capital charge to cover the risk of mark-to-market losses on the expected counterparty risk (such losses being known as credit value adjustments, CVA) to OTC derivatives. The CVA capital charge will be calculated in the manner set forth below depending on the bank's approved method of calculating capital charges for counterparty credit risk and specific interest rate risk. A bank is not required to include in this capital charge (i) transactions with a central counterparty (CCP); and (ii) securities financing transactions (SFT), unless their supervisor determines that the bank's CVA loss exposures arising from SFT transactions are material.

Funding Value Adjustment

And related debate!

- ✓ We recalled that one of the assumptions of Black, Scholes, and Merton is to be able to borrow unlimited amounts
- ✓ Until 2007 funding costs for banks were reasonably close among them, and relatively «close» to what could be *thought of* as **the** risk-free rate (IBOR…)
- ✓ Now, instead, one must take into account funding costs for hedging, for collateral, for interests, for cashflows to be paid (even in the case of default!) and drawing a distinction between active and passive rate*:* this is *yet another* Value Adjustment to be factored in the evaluation of a contract, the Funding Value Adjustment (FVA)
- ✓ These flows, which need to be financed at a funding rate (which is different from the risk-free) depend on future – stochastic – values (e.g. collateral)
- ✓ They also depend on the level of aggregation of the derivative portfolio (counterparty level? desk level?) and on the possibility of collateral re-hypotecation
- ✓ Funding costs depend on creditworthiness (overlap with DVA?)
- ✓ We face a recursive problem: derivative pricing depends on funding costs which depend on the price (via the amount to be financed), and so on.

Is this the real life? Is this just fantasy?

- ✓ BCBS (2011): «*Under Basel II, the risk of counterparty default and credit migration risk were addressed but mark-to-market losses due to credit valuation adjustments (CVA) were not. During the financial crisis, however, roughly two-thirds of losses attributed to counterparty credit risk were due to CVA losses and only about one-third were due to actual defaults.* »
- ✓ Stress tests devides by EBA in 2014 and 2016 make explicit reference to CVA and DVA in an asymmetric manner («3.8.1 CVA impact on P&L and exclusion of DVA impact»)
- ✓ JP Morgan introduced FVA in its 2014 financial statements. In 2013Q4 it recorded a loss of about 1.5 bn USD (Bloomberg (2014), FT (2014):
  - ✓ The firm implemented a Funding Valuation Adjustment («FVA») framework this quarter for its OTC derivatives and structured notes, reflecting an industry migration towards incorporating the cost or benefit of unsecured funding into valuations
    - ✓ For the first time this quarter, we were able to clearly observe the existence of funding cost in market clearing levels
    - ✓ As a result, the Firm recorded a $1.5B loss this quarter

Brigo. Morini e Pallavicini (2013) sum it up: « *Counterparty and funding risk is a very complex, model-dependent task and requires a holistic approach to modelling that challenges the ingrained culture in most investment banks and in most of the financial industry. […] The attempt to standardize every risk to simple formulas is misleading and may result in the relevant risk not being addressed at all. […]* ***There is no easy way out.*** »

Going forward

If it wasn't already complicated *enough*

- ✓ *Wrong way risk*
- ✓ Close-out amount
- ✓ Is it possible to simplify the full formula (BVA without the 1st to default?)
- ✓ Role of central clearinghouses
- ✓ Floating rate CVA (margin lending)
- ✓ Other valuation adjustments: KVA (regulatory capital), MVA (margin value adjustment), *etc*.
- ✓ Accounting

References

Something to read

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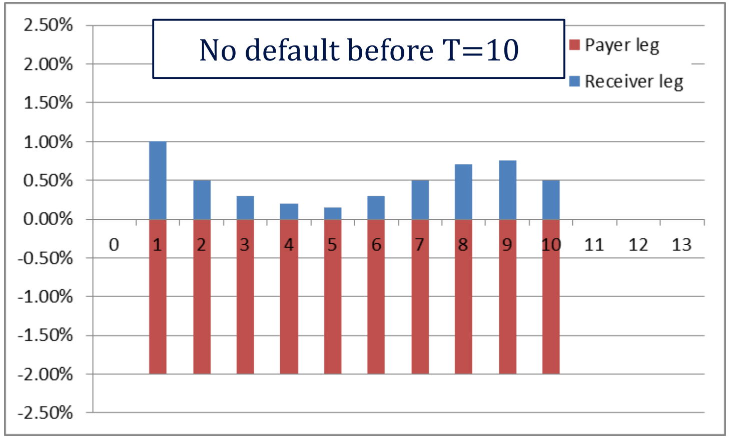
Cashflows example > 1

$T < \tau_A, \tau_B$

$$\Pi_A^D(t,T) = 1_{\text{both default after } T}\ \Pi_A(t,T) +$$

$$+\ 1_{B \text{ defaults before } A}\left[\Pi(t,\tau_B) + D(t,\tau_B)\left(R_B\left(NPV_A\ (\tau_B)\right)^+ - \left(-NPV_A(\tau_B)\right)^+\right)\right] +$$

$$+\ 1_{A \text{ defaults before } B}\left[\Pi(t,\tau_A) + D(t,\tau_A)\left(\left(\mathrm{NPV_A}\ (\tau_A)\right)^+ - R_A\left(-\mathrm{NPV_A}\ (\tau_A)\right)^+\right)\right]$$



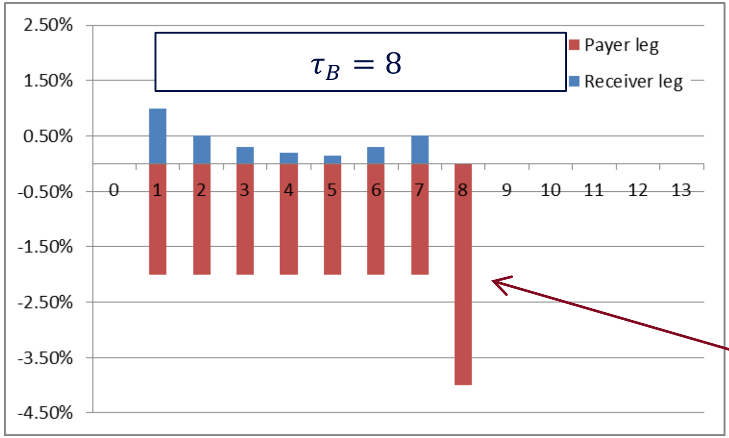
Cashflows example > 2

$\tau_B < T < \tau_A$

$$\Pi_A^D(t,T) = 1_{\text{both default after } T}\ \Pi_A(t,T) +$$

$$+\ 1_{B \text{ defaults before } A}\left[\Pi(t,\tau_B) + D(t,\tau_B)\left(R_B\left(NPV_A\ (\tau_B)\right)^+ - \left(-NPV_A(\tau_B)\right)^+\right)\right] +$$

$$+\ 1_{A \text{ defaults before } B}\left[\Pi(t,\tau_A) + D(t,\tau_A)\left(\left(\mathrm{NPV_A}\ (\tau_A)\right)^+ - R_A\left(-\mathrm{NPV_A}\ (\tau_A)\right)^+\right)\right]$$



In this scenario we consider the case: $NPV_A(\tau_B) < 0$