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Credit Valuation Adjustment

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LEFEBVRE SARRUT

Bärchen est une entité du groupe Lefebvre Sarrut

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Counterparty Credit Risk

•CCR is the risk that the counterparty of a financial contract defaults before maturity and is therefore unable to meet its payment obligations

•CCR differs from traditional Credit Risk (on, say, loans) in 2 major respects:

- The uncertainty of exposure

In a loan or bond, exposure is equal to the amount lent. On derivative contracts exposure needs to be modelled.

- CCR is bilateral

We have exposure to our counterparty, who in terms has exposure to us

Default risk vs. CVA risk

- Default risk: risk of an actual counterparty default
- CVA risk: risk that the probability of default of the counterparty increases, leading to greater expected loss (CVA)
- Bond analogy: issuer default risk vs. Credit spread risk

CCR mitigation

- Diversification

  Diversification across numerous counterparties
- Netting

  Netting of positive MtM with negative MtM
- Collateralization

  Requiring securities/cash from a counterparty, of a value equal to the MtM
- Close-out

  Termination of all contracts with defaulted entity without waiting for the outcome of bankruptcy proceedings
- Termination events

  Break closes, either freely exercisable or contingent on specific events
- Hedging

  Hedging of exposures and counterparty risk using Credit derivatives

CVA

- CVA is the difference between the risk-free value of a trade (or portfolio) and its risky value
- It reflects the possibility of a counterparty defaulting
- More formally (assuming independence between probability of default and exposure):

$$CVA = \int_0^T EE_t * PD_{(t-1,t)} * LGD_t * DF_t \, dt$$

- Where:
  - LGD_t is the recovery rate upon default
  - EE_t is the Expected Exposure at t
  - $PD_{(t-1,t)}$ is the probability of default over period (t-1,t)

CVA – Corporate bonds analogy

- The Yield-to-maturity of a bond is the discount rate such that the PV of bond flows is equal to its (dirty) market price:

$$\mathrm{MP} = PV = \sum_{i=1}^{n} \frac{C}{(1+YTM_i)^i} + \frac{100}{(1+YTM_n)^n}$$

- The YTM on a corporate bond has 2 components: the Risk-free YTM, and a credit spread (s)

$$\mathrm{MP} = PV = \sum_{i=1}^{n} \frac{C}{(1+YTM_i+s)^i} + \frac{100}{(1+YTM_n+s)^n}$$

The difference between the PV of bond flows at the risk-free YTM and the PV at the risky YTM represents the expected loss on the bond, which the credit spread compensates

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One-way vs. two-way agreements

- Netting / Collateralization / Closeout / Termination events: agreements may be one-way (applied to one of the counterparties) or two-way (applied to both)

- One-way agreements are common when there is a big difference in the creditworthiness of the parties:

-Banks with hedge funds

-Government and banks

- Many OTC contracts have standardized CCR provisions

CCR mitigation

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  Diversification across numerous counterparties

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Netting

•Two firms may have entered into a number of derivatives transactions with one another

•Netting refers to the netting of the value of all the contracts in the event of bankruptcy

•Illustration:

- A and B have 2 exactly offsetting derivative transactions
- Transaction 1 is worth +$5m to A
- No netting: A faces exposure of $5m, B faces exposure of $5m
- Netting: Exposures = 0

•The lower the correlation between exposures, the higher the benefit of netting

Collateralization

- Exposure at time t is the difference between the close-out value of the trade (or netting set) and the collateral account balance
- cash: reinvested at o/n rate
- securities: used to secure funding much lower than unsecured rate (assuming rehypothecation is allowed)

- Close-out risk: Most banks estimate there could be 10 days over which the exposure might evolve without additionnal collateral being received as part of the standard default process

Termination events

- Unconditional termination events: break clauses
    - One/both counterparty may terminate trade on prespecified trade at outstanding replacement cost
    - Usually two-way
    - Example: 10y & every 5Y on 30Y IRS

- Conditional termination events: termination on some event taking place. Events: ratings change, management changes etc

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Current Exposure and Potential Future Exposure

•Current Exposure (CE): the greater of the Mark-to-market of transactions across a netting set and 0.

•Expected Exposure (EE): $EE_t = E(\max(Mtm_t, 0))$

•Potential Future Exposure (PFE): Maximum positive exposure on a given future date estimated at a stated level of confidence

•Peak exposure / Maximum PFE

Used to measure exposure against credit limits

Expected Exposure / Expected Positive Exposure

•Expected Exposure (EE): probability-weighted exposure measured on a given future date

•Effective EE: Non-decreasing EE

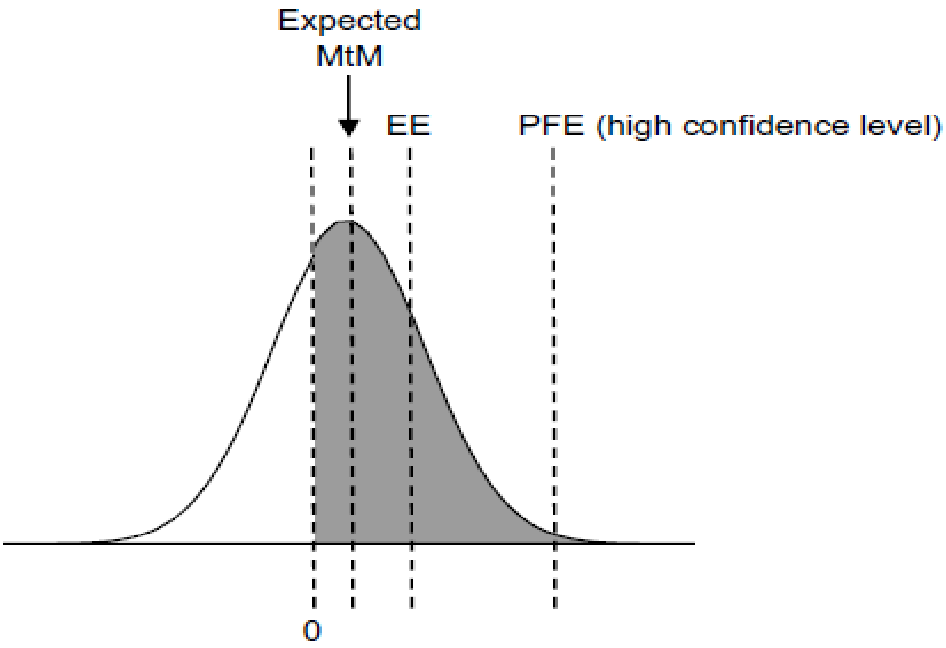
$$(\text{Effective EE})_k = \max\left[(\text{Effective EE})_{k-1}, \text{EE}_k\right]$$

•Expected Positive Exposure (EPE): the average of individual EEs for given forecasting horizon

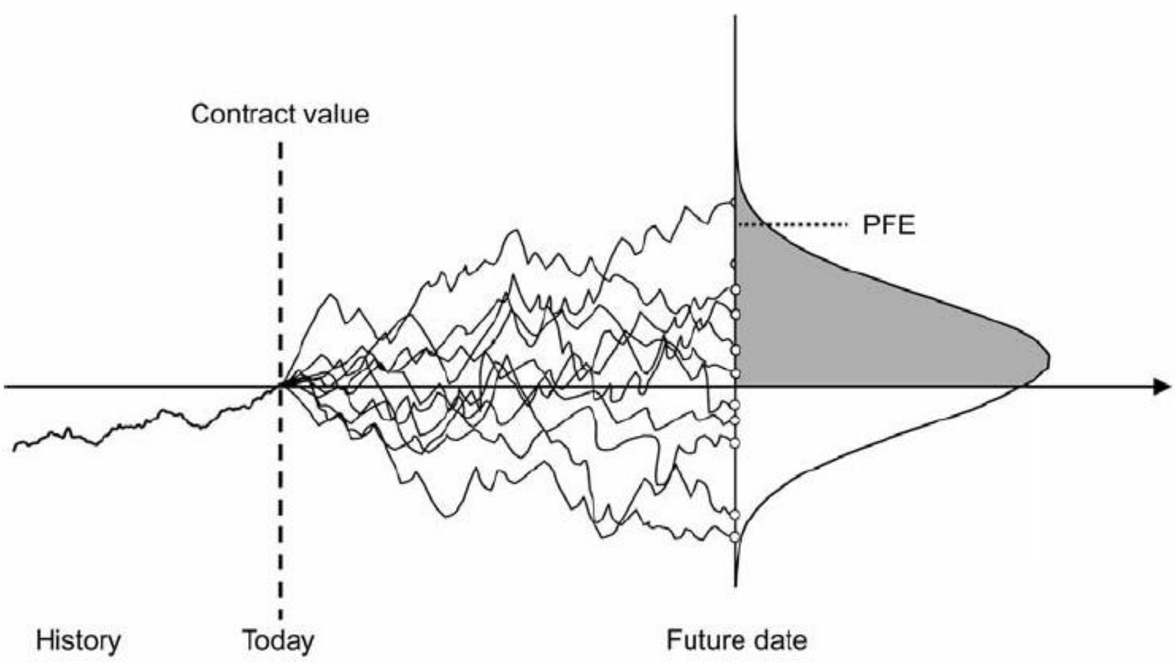
EPE is useful as a single-figure representation of exposure

•Used to compute economic capital

Exposure(s)



Exposure(s)



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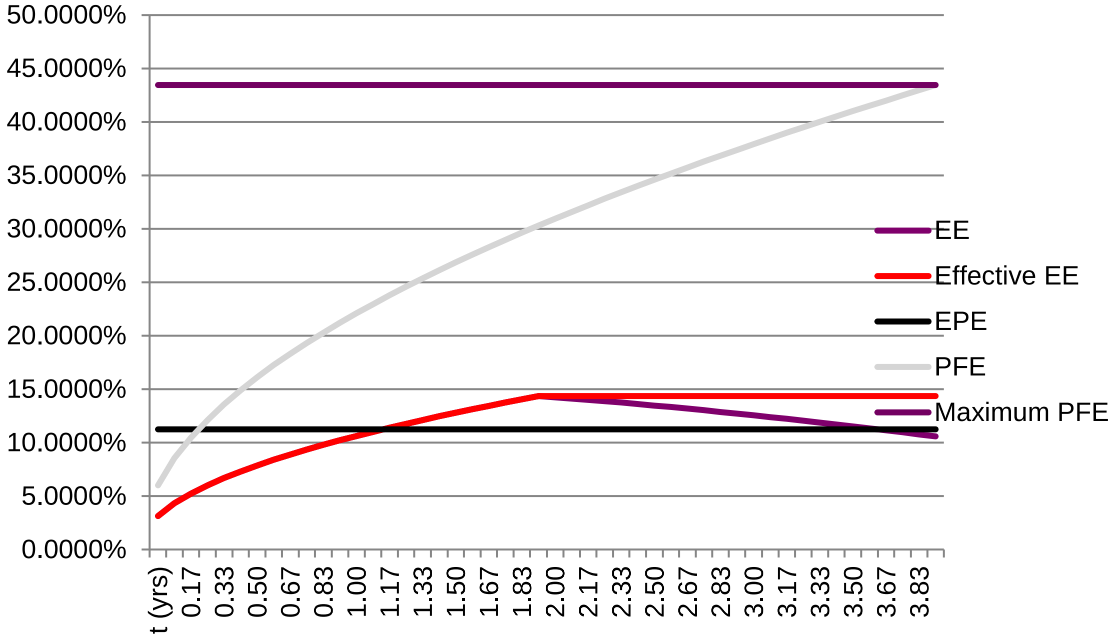
Exposure(s)



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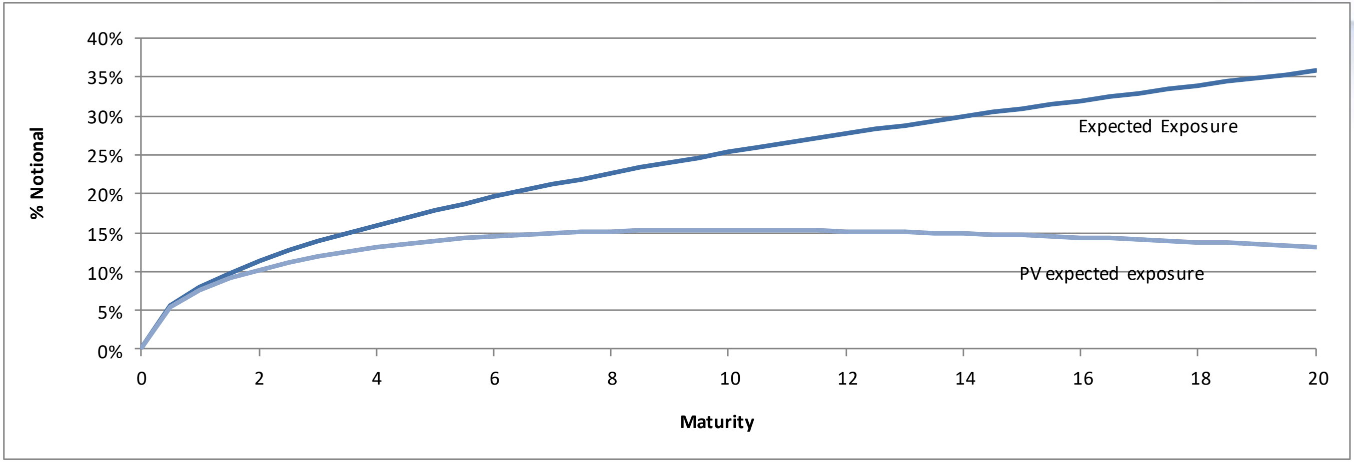
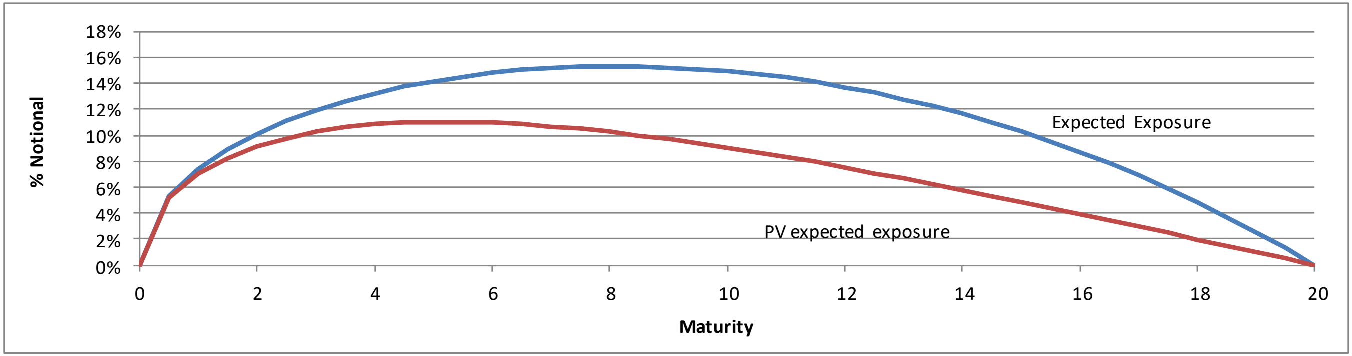
EE – Forward FX and IRS





Case Study (Excel)

- Take FX forward trade
- Compute EPE, PFE
- Compute Effective EE, Maximum PFE

Measuring exposures

3 main methodologies:

- Semi-analytical
- Option prices
- Monte Carlo

Exposures – semi-analytical

Mtm $= \mu + \sigma Z$, where Z is a standard normal variable

$$PFE_\alpha = \mu + \sigma\Phi^{-1}(\alpha)$$

$$EE = \mu\Phi\left(\frac{\mu}{\sigma}\right) + \sigma . t\phi\left(\frac{\mu}{\sigma}\right)$$

$$\text{if } \mu = 0, EE = \frac{\sigma}{\sqrt{2\pi}} \approx 0.4\sigma\sqrt{t}$$

$$EPE(\mu = 0) = 0.27\sigma\sqrt{T}$$

Exposures – from option prices

- $EE_t = E(\max(Mtm_t, 0))$
- Expected Exposure is a call option on Mtm at Strike of 0

- CVA for a swap (maturity T) can be thought of as a sum of swaptions weighted by probability of default * LGD

Exposures – Monte Carlo

Case study

Exposures on collateralized counterparties

$$EE_t = E(\ Max\ (MtM_t - C_{t-k}, 0)\ )$$

Where:

EE_t is the Expected Exposure at time t

MtM_t is the expected Mark-to-market at time t

C_{t-k} is the collateral balance at time t

Margin Period of risk (MPR) is the time delay between MtM and Collateral

2 components:

- Pre-default: due to thresholds, disputes, frequency etc
- Post-default: closeout time, replacement trades

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Exposures and netting sets

So far we have only looked at exposure at individual deal level (stand alone)

CVA should be computed at netting set level hence it is the mtm of the netting set that should be modeled

In section 5 we will look at Incremental CVA (as opposed to stand-alone CVA)

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Estimating PDs from Market prices

Recall that:

Credit spread = CPD * (1-R) / T

CPD: Cumulative Probability of Default

R: Recovery rate

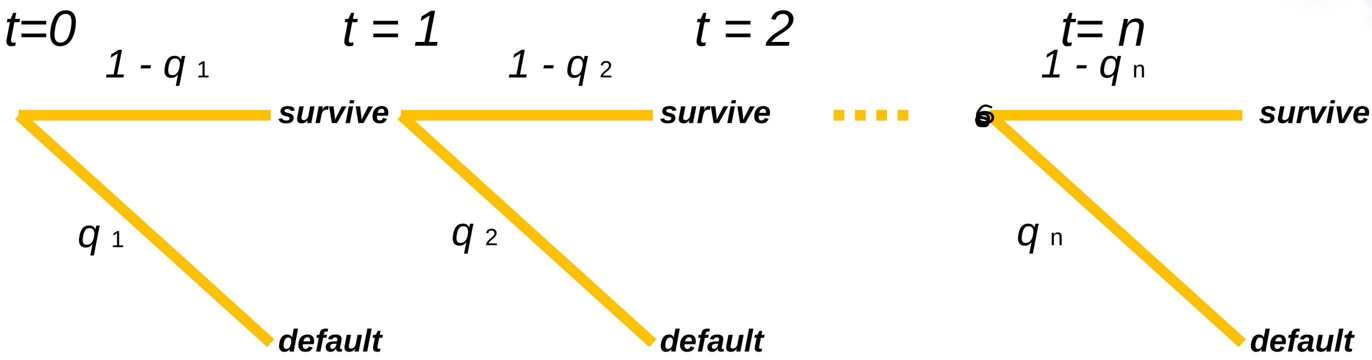
T: Maturity of Credit instrument

Estimating a PD from a market price involves, having assumed the Recovery rate R, finding the PD such that the credit instrument is fairly priced i.e.

CDS: both legs of the swap have equal value

Bond: the PV of expected cash flows equals the Bond market value

Default process



Z: Random year when default occurs

Default rate year-t = q_t

Survival probability past year-n = $P(Z > n) = (1-q_1)(1-q_2)\ldots(1-q_n)$

Probability of defaulting year-n = $P(Z = n) = q_n P(Z > n-1)$

Corporate Bond pricing

$$c\sum_{t=1}^{n}\frac{P(Z>t)}{(1+z_t)^t}$$

PV of coupons

+

$$\frac{P(Z>n)}{(1+z_n)^n}$$

PV of principal

+

$$R\sum_{t=1}^{n}\frac{P(Z=t)}{(1+z_t)^t}$$

PV of recovery

=

Market Value of the Bond

Exercice

Case study

- **Estimate the annual conditional probability of default (q) for the following bond:**

- **5-year bond**
- **Coupon of 4% annual (30/360 unadjusted i.e. equal annual coupons of 4)**
- **Discount rate (flat yield curve) of 1%**
- **(Dirty) market price of the bond 97.85**
- **Recovery 40%**

CDS pricing

Θ is the CDS level, z_t the zero rate for year-t, R the (assumed) recovery rate upon default, n the tenor of the CDS

PV spread leg PV default leg

$$\theta \sum_{t=1}^{n} \frac{P(Z > t)}{(1+z_t)^t} = (1-R) \sum_{t=1}^{n} \frac{P(Z = t)}{(1+z_t)^t}$$

By taking the 1Y CDS price, then the 2Y etc one may bootstrap a probability of default curve (having assumed a recovery rate R: 40% is a common assumption – used in Bloomberg)

Exercice

Case study

- **Estimate the term structure of unconditional PDs from CDS prices**

Credit Spread premium

- Market-implied PDs are consistently higher than historical default rates
- Typically market PDs are larger by a factor of 2 or 3 (and much more for high-quality credits)!

- Risk-averse investors will demand extra return over and above the expected loss to compensate for the risk of default: this is the Default Premium
- Investors will demand extra return to compensate them for the lack of liquidity, current or potential, of the credit instruments: this is the Liquidity Premium

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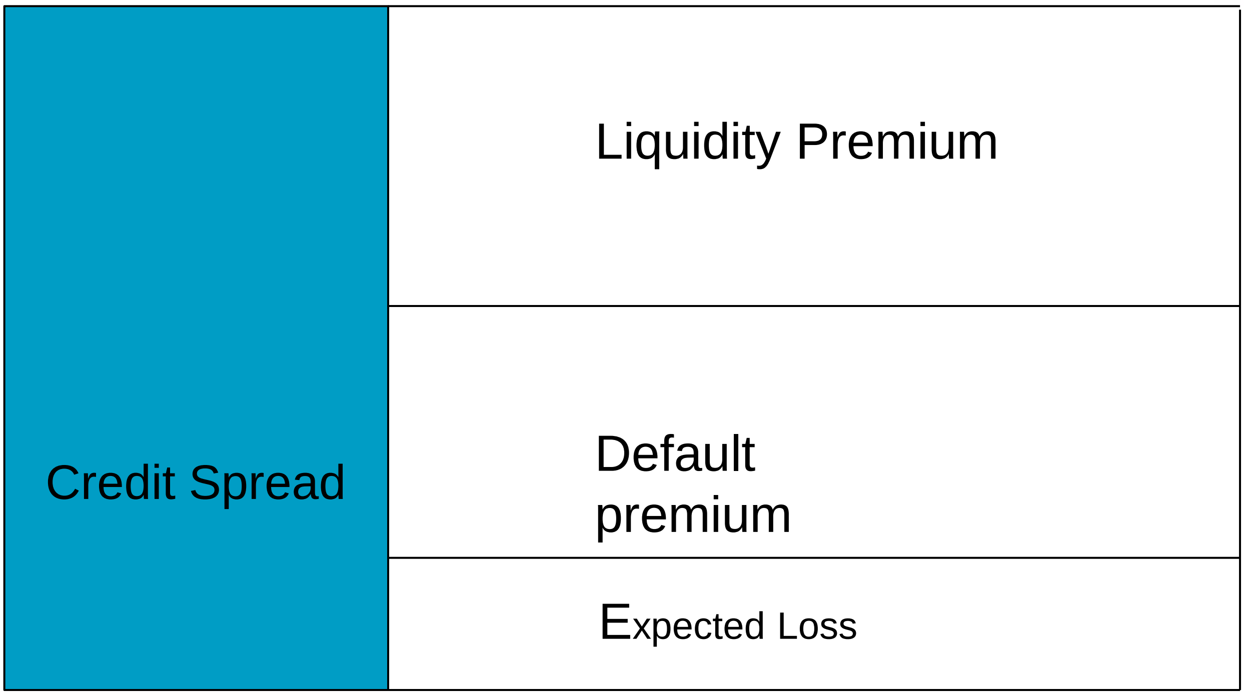
Components of credit spread



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CCR

There are 2 ways to handle CCR:

- Mitigate the Risk: Collateralization
- Charge for the Risk: CVA

CVA is limited with collateralized counterparties (though not 0 – see section on collateral)

CVA is particularly an issue for counterparties which are either unable or unwilling to post collateral:

- Corporates
- Governments / Supranationals

CVA

- CVA is the difference between the risk-free value of a trade (or portfolio) and its risky value
- It reflects the possibility of a counterparty defaulting
- More formally (assuming independence between probability of default and exposure):

$$CVA = \int_0^T EE_t * PD_{(t-1,t)} * LGD_t * DF_t \, dt$$

- Where:
  - LGD_t is the recovery rate upon default
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  - $PD_{(t-1,t)}$ is the probability of default over period (t-1,t)

CVA complexity – IRS example

- Sorenson & Bolier (1994), Gregory (2011)

- CVA for a swap (maturity T) can be thought of as a sum of swaptions weighted by probability of defaults

$$\text{CVA}_{\text{swap}} \approx \sum_{i=1}^{n} PD(i-1;i) * V_{swaption}(t;t_j;T)$$

- Where $V_{swaption}(t;t_j;T)$ is the value at t of a swaption of maturity t_j to enter in to a swap over $(t_j;T)$

CVA complexity

- CVA is an option on underlying exposure

- CVA should be done at counterparty level (not trade level)
- →All the correlations between the exposures must be specified
- → We are now pricing a highly exotic option

- Probability of Default must be known – use market-implied when available

- The previous formula/example assumed independence between exposure and counterparty. What about Wrong Way Risk (and Right Way Risk)?

5Y USD IRS – Set-up

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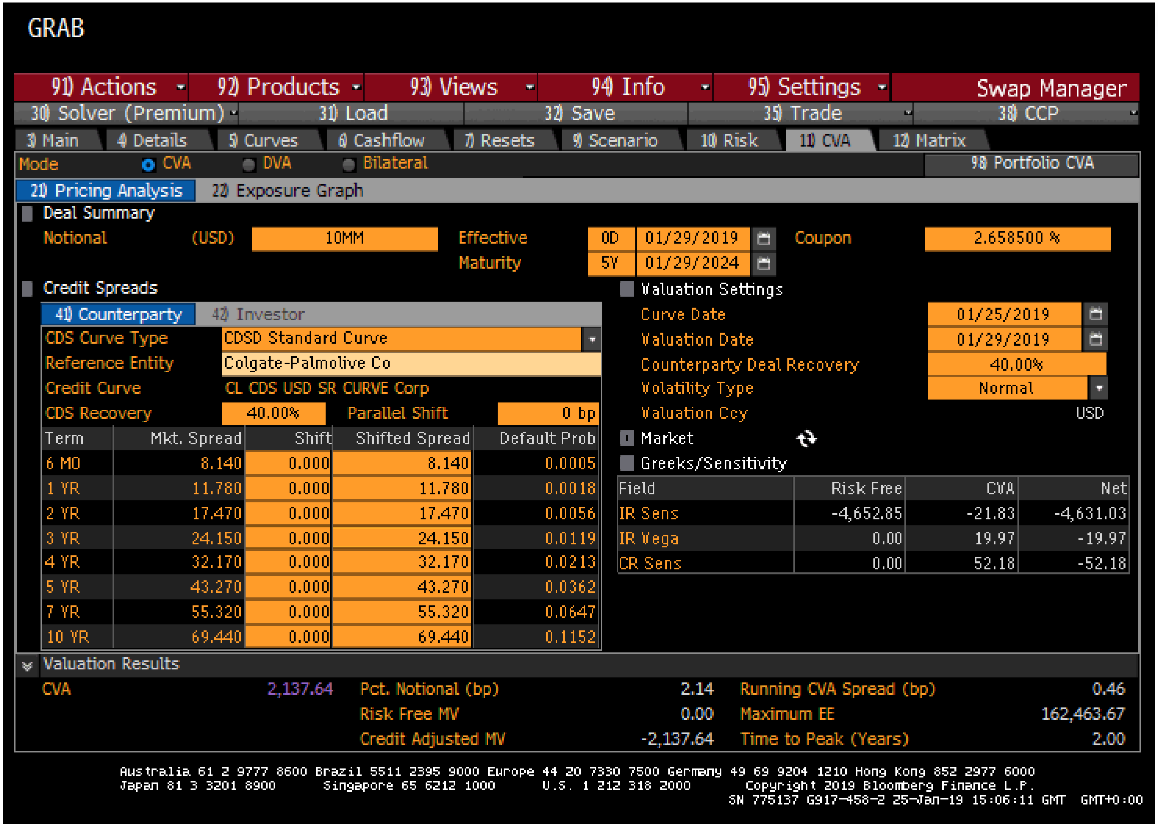
CVA on 5Y IRS with Colgate



Bilateral CVA

- Bilateral CVA takes into account the fact that both the counterparty and the bank may default
  - → As our own default becomes more likely, it becomes more likely that some cash-flows will not have to be paid to the counterparty (a benefit, called DVA – Debt Value Adjustment).
- Bilateral CVA = CVA – DVA
- Bilateral CVA allows both parties to agree on credit-adjusted Mark-to-market
- Citigroup in its press release on the first quarter revenues of 2009 reported a positive mark to market due to its worsened credit quality: “Revenues also included […] a net 2.5$ billion positive CVA on derivative positions, excluding monolines, mainly due to the widening of Citi’s CDS spreads”

Bilateral CVA and Accounting Rules

IFRS 13 (January 2013)

- CVA

– "The entity shall include the effect of the entity's net exposure to the credit risk of that counterparty or the counterparty's net exposure to the credit risk of the entity in the fair value measurement when market participants would take into account any existing arrangements that mitigate credit risk exposure in the event of default"

- DVA

– Non-performance risk "includes, but may not be limited to, an entity's own credit risk"

– IFRS 13 requires DVA through the concept of exit price

CVA/DVA Pricing – Simple example (E. Canabarro)

(Bilateral) CVA = $E_A.s_A - E_B.s_B$

E_A is the vector of pv-ed conditional exposures faced by c/p B with respect to A

s_A is the vector of market loss rates (Probability of Default * LGD)

E_B and s_B defined likewise

CVA/DVA Pricing – Simple example (Unilateral CVA)

E_A=\$200 s_A=2%

E_B=\$100 s_B=5%

Unilateral CVA (from A's point of view) = -100*5%=-5

Unilateral CVA (from B's point of view) = -200 *2%=-4

So if the risk-free value of the trade is \$-50 (as seen from A) then, after adjusting for CVA:

-Trade value to A = -\$55 (-50 -5)

-Trade value to B = +\$46 (+50-4)

CVA/DVA Pricing – Simple example (Bilateral CVA)

E_A=$200 s_A=2%

E_B=$100 s_B=5%

Bilateral CVA (from A's point of view) = 200*4% -100*5%=-1

Bilateral CVA (from B's point of view) = 100*5%-200 *2%=+1

So if the risk-free value of the trade is $-50 (as seen from A) then, after adjusting for CVA:

-Trade value to A = -$51 (-50 -1)

-Trade value to B = +$51 (+50+1)

Incorporating DVA allows counterparties to agree on the credit-adjusted value of a trade

CVA/DVA Pricing – Simple example (Bilateral CVA)

E_A=\$200 s_A=2%

E_B=\$100 s_B=5%

Now Bank A wants to assign its trades with B to C

s_C=5%

Bilateral CVA (from C's point of view) = 200*5% - 100*5%=+\$5

=> Credit-adjusted trade value = -\$50+5=-\$45

Assignment:

-A pays \$51 to C

-C pays 6 to B (so that its trade value is -\$45)

-Value of portfolio to B is now +\$45

Exercice

Exercise: CVA calculations, Trade assignment

Case Study: CVA on FX forward

CVA with netting

•The CVA impact of a new trade is at most equal to the CVA of the new trade computed on a stand-alone basis (worst case is no netting benefit)

•2 consequences:

- A customer should get better terms on a trade from a Bank with whom it has an existing relationship than from a 'new' Bank
- A bank will enter into trades which, on a stand-alone basis, have a negative risky PV (since with netting trades are profitable as long as profit > incremental CVA)

•Incremental CVA = CVA on netting set including new trade

- CVA on netting set excluding new trade

CVA on collateralized transactions

- CVA on collateralized transactions is often assumed to be non-material
- Whilst limited, CVA should still be reported (close-out risk)
- Most banks assume a close-out period of 10 days from last collateral posting
- Additionnal issues on collateralized transactions: thresholds, cash collateral vs. securities
- CVA can be ignored when the terms of the collateral agreement are sufficiently robust

CVA and one-way collateral agreements

•SSAs (Sovereigns, Supranationals and Agencies) traditionally impose one-way collateral agreements to their Bank counterparties, i.e. Banks post collateral to SSAs, who themselves do not post collateral to the Banks

•Eurozone sovereign crisis means

⇒large potential funding gaps for Banks

⇒Cost of one-way agreements has gone up

As a result some sovereigns (Ireland, Portugal) are now accepting two-way collateral agreements

Wrong-way risk (WWR)

Wrong-way risk: the risk that the exposure to a counterparty is adversely correlated with the credit risk of that counterparty

- Would you buy protection on the Republic of Turkey from a Turkish bank?
- Retail example: credit cards

Likewise, right-way risk: positive correlation

Basel III: Banks must develop system to identify exposures giving rise to WWR

Exercice

Case study: AIG

Terminology

- (Unilateral) CVA is sometimes called 'Asset CVA'
- DVA is sometimes called 'Liability CVA'
- Bilateral CVA is sometimes referred to simply as CVA

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Should Banks hedge CVA/DVA?

- If a Bank marks to market its CVA exposure but does not hedge it, it would suffer from P/L variability

- In a worsening credit environment Banks could lose a lot of money

CVA Desk

- CVA desks centralize and manage the CCR risks:

-Centralize: provide trading desks with counterparty credit insurance

-Manage: actively hedge positions

- They are subjects to trading limits but typically not assigned profit targets

CVA Hedging

- CVA hedging involves covering:

- Credit
  - Done primarily via Credit Default Swaps
  - when available

- Market
  - easy for linear parameters (IRS example: interest rates)
  - volatility more complicated (IRS example: swaptions)
  - correlation: unhedgeable

DVA Hedging

•There are 2 ways to hedge DVA:

1/ Buy back own bonds

- Problems: availability, capital

2/ Sell protection on oneself??

=> Sell protection on highly correlated names (or through index of financials)

- Some banks had sold protection on Lehmans to hedge DVA…

•Impact of DVA Hedging?

DVA P&L

- DVA P&L is roughly proportional to spread changes
  - ‘Roughly’ because of portfolio changes, volatility, DVA hedging

- Sep 2011: Big spread changes => big P&L impact

- E.g. Morgan Stanley 5Y CDS spread

  Jun11 162bps

  Sep11 492bps

=> $3.4bn DVA P&L (over one quarter!)

- Can we predict DVA P&L from spread changes?

Cross-gamma

- CVA is a credit hybrid option on an underlying exposure.
- The CVA option price is a function of the underlying MtM, the counterparty credit spread, heir volatilities and the correlation between the two (wrong/right way risk).
- Like all options, the hedge will have to be dynamically adjusted, by delta-hedging the underlying derivative and the CDS
- Simultaneous moves in underlying and credit will lead to imperfect hedges: a cross-gamma effect

CVA-CDS "loop"

Bank of England quarterly report, Q2 2010:

- "Specifically, CVA desks of banks with large uncollateralised foreign exchange and interest rate swap positions with supranational or sovereign counterparties have reportedly been actively hedging those positions in sovereign CDS markets. For example, for dealers that have agreed to pay euros to counterparties and receive dollars, a depreciation in the euro will result in a MTM profit and hence a counterparty exposure that needs to be managed (...)
- Given the relative illiquidity of sovereign CDS markets a sharp increase in demand from active investors can bid up the cost of sovereign CDS protection. CVA desks have come to account for a large proportion of trading in the sovereign CDS market and so their hedging activity has reportedly been a factor pushing prices away from levels solely reflecting the underlying probability of sovereign default."

CVA Hedging – could increase market risk?

•CVA desks tend to work in isolation, as opposed to banks looking at the full fair value of the trade

•One way to offset CVA sensitivity is to put more of the derivative on (since CVA is a downward adjustment)

=> Increases exposure?

Dynamic Hedging costs

•Derivatives traders will buy a CVA option from the CVA desk

•The CVA option will protect the derivative desk against CCR losses

•Like any option, the CVA option will need to be dynamically hedged:

- Buy CDS protection
- Delta-hedge the underlying option

•This will involve crossing bid-offers in both the underlying and CDS markets.

•The CVA hedging my also have material impact on prices, especially in crowded counterparty situations

•Banks may try to assess dynamic hedging costs by running Monte-Carlo hedging simulations

CVA additional risks

Risks that may exist outside the scope of the risk management system:

- Crowded counterparty risk
- Dynamic hedging costs
- Out of the money
- Replacement costs

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Crowded counterparty risk

- Assume a counterparty has done the same (large) trade with many banks, who then all run the same dynamic hedging scheme
- The risk usually materialises when the credit spread and/or the exposure have moved far away from their values at trade inception
- Akin to a type of wrong-way risk associated with CVA hedging

- Examples: Sovereigns (cf CDS-CVA loop), monolines (cf AIG case study)

Out of the money risk

- Probabilistic models (such as used for VaR or CVA) are notoriously poor predictors of large market dislocations

- One has to pay attention to deep out-of-the-money exposures, which could, following large market movements, become significant

Replacement costs

- It is important not to underestimate the cost of putting on a replacement trade following a default (in what could be highly stressed market conditions – e.g. Lehmans)

Basel III

Basel Committee on the 2008 crisis:

> *"Mark-to-market losses due to credit valuation adjustments were not directly capitalised. Roughly two-thirds of CCR losses were due to CVA losses and only about one-third were due to actual defaults." BCBS 164, 04/2010*

Basel III introduces (severe) capital charges for CVA

CVA – Basel III (standard approach)

•Assumption of 50/50 split between systematic and specific risk

=> Index hedges will give moderate capital relief (correlation between CDS indices movement and individual names in reality higher than 50%)

CVA – Basel III (advanced approach)

Basel III CVA definition:

$$CVA = \left(LGD_{MKT}\right) \cdot \sum_{i=1}^{T} \underbrace{\max\left(0; \exp\left(-\frac{s_{i-1}t_{i-1}}{LGD_{MKT}}\right) - \exp\left(-\frac{s_i t_i}{LGD_{MKT}}\right)\right)}_{\text{Market-implied PD over } [t_{i-1};t_i]} \cdot \underbrace{\left(\frac{EE_{i-1}D_{i-1} + EE_i D_i}{2}\right)}_{\text{Average discounted exposure}}$$

- **Unilateral CVA (i.e. no DVA)**
- **Calculated at counterparty level**
- **Credit Spread risk only (no underlying exposure risk)**
- **Single name + index hedges only (+ CCDS)**
- **Market risk of CVA is then measured by the Bank's VaR model, sum of normal and stressed model**

CVA – Basel III

•Basel III: Use of CDS spreads (or proxy if not available)

“Whenever the CDS spread of a counterparty is available, this must be used. Whenever such a CDS spread is not available, the bank must use a proxy spread that is appropriate based on the rating, industry and region of the counterparty”, Basel committee

•Standardized approach is supposed to be more punitive BUT sometimes lead to a lower capital charge

- E.g. highly-rated counterparties with volatile CDS spreads

CVA – Basel III

- Hedges reduce capital charge much more for advanced model than the standardized one

- Basel III allowed hedges: Single-name CDS, CDS indices, CCDS

- Only the credit component of hedges feed into CVA VaR – the market risk factor will go into separate market risk VaR
- => Possible for hedge activity to increase overall capital charge

CVA – Basel III

The CVA capital charges may lead to attempts at securitizing CVA exposures

CVA securitization involves the CVA desk pooling a large number of counterparty exposures and selling tranches of risk to investors

Issues:

- Difficult for investors to assess and understand fully the risks associated with a pool of complex diverse financial derivatives undertaken with a large number of credits
- Difficulty for the issuing bank to obtain regulatory approvals

Case Study: SG

CVA and collateral

-MPR (Marginal Period of Risk): is the time delay when receiving collateral

-MPR stems from

- Collateral posting frequency, disputes, operational issues
- Closeout, liquidation, putting on replacement trades

-Basel II: MPR=10 days

-Basel III:

- minimum 10 days
- Netting sets of > 5000 trades and/or illiquid collateral and/or illiquid OTC trades: 20 days
- >2 disputes in the last 6 months: MPR>=20 days

CVA Accounting

•IFRS 13 (Jan 2013):

•CVA mandatory

•DVA: “(…) risk includes, but may not be limited to, an entity’s own risk”
=> Both CVA and DVA to be included for accounting purposes

•Based on the principle of ‘Exit price’
=> Implies use of risk-neutral PDs (based on CDS prices)
(Pre-IFRS:
If CVA seen as a reserve: use of historical PDs
If CVA seen as market price use CDS spreads)

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CCP and CVA

- The use of Central Counterparty Clearing is meant to solve the CVA problem
- Creates a new problem: CCPs are highly systemic institutions
- Assumption is that CCPs won't fail (heard this before?)

CVA and Collateralization

•No (little) CVA on collateralized exposures

However:

•Some counterparties are unwilling or unable to post collateral (corporates, sovereigns)

•Collateralization leads to liquidity and systemic risks, which are really difficult to quantify (can only stress test)

CVA – Stress Testing

- Stress Testing aims to address the shortcomings of the (probabilistic) market risk measures

- For CVA, a good stress testing program should address:
  - Wrong-way risk
  - Out-of-the money exposures
  - Large dynamic hedging costs

Partenaires caritatifs

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