Introduction to CVA and DVA

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Outline of the lecture

The purpose of this lecture is to introduce CVA, DVA and FVA

Main Learning Goals of the lecture:

- Concept of CVA and DVA
- Simple Example
- Wrong and right way risk
- CVA as a derivative
- Exposure calculations
- Calculating the CVA and DVA for a portfolio

Basel Definition of CCR

General terms

50.1 **Counterparty credit risk (CCR)** is the risk that the counterparty to a transaction could default before the final settlement of the transaction's cash flows. An economic loss would occur if the transactions or portfolio of transactions with the counterparty has a positive economic value at the time of default. Unlike a firm's exposure to credit risk through a loan, where the exposure to credit risk is unilateral and only the lending bank faces the risk of loss, CCR 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.

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[1] Basel Committee on Banking Supervision, Dec 15 2019

OTC Derivatives

- ⋆ OTC derivatives are contingent claims that are privately negotiated between two parties without the involvement of an exchange. OTC contracts can be highly specialized and formulated exclusively for the needs of the involved parties.
- ⋆ In contrast exchange-traded derivatives are highly standardized and the contract terms need to follow the specifications of the exchange. This makes the risk of not receiving the promised cash flows relatively low.
- ⋆ For OTC contracts there is no third party that guarantees that the payments agreed on are made and therefore the parties fully bear the involved credit risk : each party is fully exposed to the risk that the other party will not full its contractual obligations due to default.

Counterparty Credit Risk (CRR)

(i) CCR is the risk that a counterparty will default before the maturity of a contract and hence not be able to fulfill its obligations to the other party, as specified by the terms of the contract.

(ii) CCR mainly differentiates itself from other forms of credit risk in two ways:

1. The bilateral nature of the credit risk: the credit risk is present on both sides of the contract (differently for a loan for example).
2. The variability in exposure, which is a measure of how much capital is at risk: The exposure for a derivative position is equal to the PV, capped at zero. The exposure can be highly volatile depending on the underlying risk factors and the degree of leverage of the derivative in question.
3. Those properties differentiate the counterparty risk from *lending* risk (as bonds, loans or mortgages) (notional amount is usually known, only one party takes on credit risk).

Simple Example: Forward Contract

(a) Today at time t, a refinery company A enters a forward contract with an oil producer company B to buy N barrels of Dec 2022 contract for $K = F(t,T) = \$68$ per barrel.

(b) At the expiration T of the forward there are two scenarios:

1. The oil price $F(T,T)$ is higher than K, the contract is *in the money*. B has to pay A

$$N(F(T,T) - K)$$

2. The oil price is lower than K, the contract is *out of the money*. The refinery A has to pay B

$$N(K - F(T,T))$$

(c) From the point of view of A the potential exposure at expiry is

$$e^{-r(T-t)} \max(F(T,T) - K, 0)$$

Assumptions

(i) According to Basel III, *bank must add a capital charge to cover the risk of MtM losses on the expected counterparty risk (such losses being known as credit value adjustments, CVA) to OTC derivatives*.

(ii) Assuming that default is independent of oil prices and the payment in case of default happens at the expiry, the expected loss (therefore the CVA charge) can be calculated as

$$CVA_A = (1 - RR_B) PD_B C(F, K, t, T)$$

where RR_B is the recovery rate, PD_B is the default probability of company B before T and $C(F, K, t, T)$ is the call option written on Dec21 future with strike K.

(iii) This is exactly the cost of protection in case of default. The CVA charge will be always subtracted from the value of forward contract to arrive to the fair value.

DVA

(a) From the point of B, there is a risk that company A will default on its obligation (put option), resulting in CVA for B.

$$CVA_B = (1 - RR_A)PD_A P(F, K, t, T)$$

(b) This CVA represents DVA for company A (will be added). DVA represents an adjustment to the measurement of derivative liabilities to reflect the own credit risk of the entity

(c) IFRS rule 13 states that the fair value of a liability reflects the effect of non-performance risk, which includes an entity's own credit risk.

(d) Basel III introduced a specific requirement for a capital charge for potential losses due to risks associated with deterioration in the credit worthiness of a counterparty ie, a CVA.

(e) However, it does not consider it appropriate that own credit adjustments (DVA) be reflected in calculating a bank's common equity as part of its required capital.

Managing Counterparty Risk

There are many ways to mitigate or limit counterparty risk.

1. *Diversification*: spreading exposure across different counterparties.
2. *Netting*: being legally able to offset positive and negative contract values with the same counterparty in the event of their default.
3. *Collateralisation* : holding cash or securities against an exposure.
4. *Hedging* : trading instruments such as credit derivatives to reduce exposure and counterparty risk (such as CDS)
5. *Central Counterparties (CPP)*. CPP guarantee the performance of transactions, they act as intermediaries to centralize counterparty risk between market participants.

Breakout Room 1

Question: Consider the same example of a forward contract between the refinery company A and the oil producer B. Assume that

1. $N = 10,000$ barrels, $T = 1$ year.
2. Probabilities of default over horizon T: $PD_A = 0.015$, $PD_B = 0.03$, interest rate $r = 0.01$ RR: 40%
3. Future price $F(0,T) = \$68$, volatility of Dec22 future oil prices $\sigma = 0.4$. K

Calculate CVA and DVA charge under assumptions:

(i) No collateral

(ii) Posting collateral of $20,000$ by company B. nothing to do with DVA

(i) $CVA_A = (1-RR_B)PD_B\, C = (1-40\%)\times 0.03\times e^{-0.01\times T}$

$CVA_B = (1-RR_A)PD_A\, P$

Wrong and Right Way

(i) One may question the assumption of independence in the previous example: the rise of oil should be benefit the credit quality of oil producers: the increase in the exposure of A to the producer B is accompanied by the decrease in the probability of default by B.

(ii) This situation when a credit exposure to counterparty increases (decreases) as its credit quality improves (worsens) is called *right way* risk.

(iii) The opposite (unfavorable) situation is when the exposure and probability of default increase at the same time. This is called *wrong way* risk.

Examples

1. An airline enters a swap with an oil producer where airline pays fixed prices and receives a floating price. What kind of risk there is for the airline?
2. A company offers to post its own equity collateral. How would you respond?
3. Bank sells put options on its own stock to another company. What kind of risk does the company buying put options would have?

CVA as a derivative

In many ways CVA can be regarded as a hypothetical derivative in its own right. It is contingent on the default of the counterparty and the payoff is a function of the expected value and the recovery rate of the impacted underlying derivatives at the time of default. The key inputs are

1. Default Probability (DP)
   - Market observable CDS spreads
   - Market implied spreads (proxy)
   - Market Implied risky bonds or spreads
2. Exposure, the most challenging part, will be discussed next
3. Loss Given Default. Difficult to separate from DP, is typically based on an assumed level that is commonly used in the industry in order to isolate the DP. For example, for senior unsecured corporate bonds, it would be 60% , implying 40% recovery rate.

Beyond Counterparty Risk

There are other aspects of interest related to funding or capital costs, linked to the existence of counterparty risk.

1. *Funding:* Institutions face funding costs because they need to borrow to finance their activities. Funding costs are directly related to credit and counterparty risk: the greater it is, the greater the cost of funding will be
2. *Collateral*. Collateral posted ~~posted~~ against products to mitigate counterparty risk may also create a cost (or benefit)
3. *Initial Margin*: Some situations, such central creating, require posting of initial margin in order to mitigate counterparty risk (funding cost)
4. *Regulatory Capital* Banks face regulatory capital requirements for counterparty risk and CVA.

XVA's

Valuation adjustments (VA's) are given the generic term *XVA*. An XVA term quantifies the cost (or benefit) of a component such as counterparty risk, collateral, funding, or capital.

1. CVA+ DVA, counterparty default risk, own counterparty risk
2. Funding costs, funding benefits, FCA +FBA
3. ColVA, collateral value adjustment: defines the cost and benefits from embedded optionality in the collateral agreement (such as being able to choose the currency or type of collateral) or other non-standard terms
4. KVA, capital valuation adjustment: defined the cost of holding capital (typically regulatory) over the lifetime of the transaction
5. MVA (margin value adjustment): defines the cost of posting initial margin over the lifetime of the transaction.

Exposure Calculation

A standard method to evaluate the expected exposure is using a Monte Carlo simulation.

- Simulate stochastic paths for underlying market variables.
- Simulate Exposure profiles and split into a term structure of positive (used in CVA) and negative (used in DVA) exposures. The EPE term structure for each simulated exposure time can be calculated as

$$EPE(t) = \frac{1}{N}\sum_{i=1}^{N} \max\left(\sum_{s} MV_t^{i,s} df(t), 0\right)$$

  where

  t is times
  MV_t^s is collateral adjusted market value of each trade within netting set s at t
  $df(t)$ is the discount factor

Calculating the adjustment

1. In continuous time, under assumption of independence, the CVA is calculated as

$$CVA = (1 - R)\int_0^T v(t)q(t)dt$$

   where T is the longest maturity derivative, $v(t)$ the value of a derivative that has a payoff equal to the dealer's net exposure to the counterparty at time t and R as the recovery rate, and $q(t)$ is the probability density function of the risk-neutral time to default for the counterparty. (J. Hull, A. White, 2012)

2. It is impossible to track the exposure analytically continuously. Instead In practice, CVA is typically calculated using Monte Carlo simulation as described before. To approximate the integral, one can choose times $t = t_i$, $t_0 = 0, t_n = T$.

$$CVA = \sum_{i=0}^{T}(1 - R_t)EPE(t)DP_t$$

Revaluation, Bucketing and Scaling

The calculation of XVA with MC is computationally demanding. Suppose the total population of transactions involves

- $10,000$ simulations
- 100 time steps (path-wise simulation)
- 250 counterparties
- 40 transactions with each counterparty (average)

Then the total number of trades revaluations would be $10,000 \times 100 \times 250 \times 40 = 10,000,000,000$ $(10$ billion$)$. One needs Greeks too, so this number can be tripled - burden.

- *Approximations*: like Bermudan swaption approximate by European swaption.
- *Grids* giving the value of transaction can be used, they can be populated by front-office systems, and be in line with trading desk valuation models.
- *American Monte Carlo methods*: this is generic approach to utilizing future MC simulations to provide good approximations of the exposure at a given point in time, in path-wise simulation.

Accounting for a wrong or right way risk

The above calculations are valid under the assumptions of independence of expected exposure and defaults. There are different ways to deal with it.

1. Use a multiplier α to increase the exposure for a wrong way risk. Basel rules require the multiplier be 1.4, but allows banks to come with their models, with a floor 1.2 for α.
2. Another method is to set the expected exposure equal to the present value of the exposure that is k standard deviations above the average exposure for some values of k.
3. The third way was suggested in the paper by Hull, While 2012. Their approach is based on modeling a relationship between the hazard rate of a counterparty and a variable that can be calculated in the Monte Carlo simulation and that may affect the dealer's exposure to the counterparty. This relationship can be either deterministic or stochastic. One of the ways is:
   - Assume a relationship between the counterparty's hazard rate and a variable and the dealer's exposure to the counterparty.

Reference Book