Credit Valuation Adjustment (CVA)

Counterparty credit risk pricing, assessment, and dynamic hedging

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Bank of Japan, June 14th, 2010

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1. Introduction

Introduction

- A critical element of the derivative business going forward will be to trade with on an uncollateralised or partially collateralized basis with counterparties.
- Previously, valuation of counterparty credit risk has largely been ignored due to relatively smaller size of the derivative exposures and the high credit rating of the counterparties which were generally AAA or AA rated financial institutions.
- As the size of the derivative exposure increases and the credit quality of the counterparties falls, the valuation of counterparty credit risk can no longer be assumed to be negligible and must be appropriately priced and charged for. Credit Valuation Adjustment or CVA is the process through which counterparty credit is valued, priced and hedged.
- We can no longer assume that derivatives exposures are “credit risk remote”. CVA is the credit reserve process and is analogous to MTM of bonds, loan loss reserves for loan or accounts receivables.
- CVA management involve managing of counterparty credit risk on the “Asset” side as well as “Liability” side risk and funding risk. This is analogous to Asset Liability Management for derivatives.
- CVA is important to create correct incentives for trading and avoid adverse selection. Risky counterparties migrate to banks without CVA. Negative funding trade migrates to non-CVA banks.

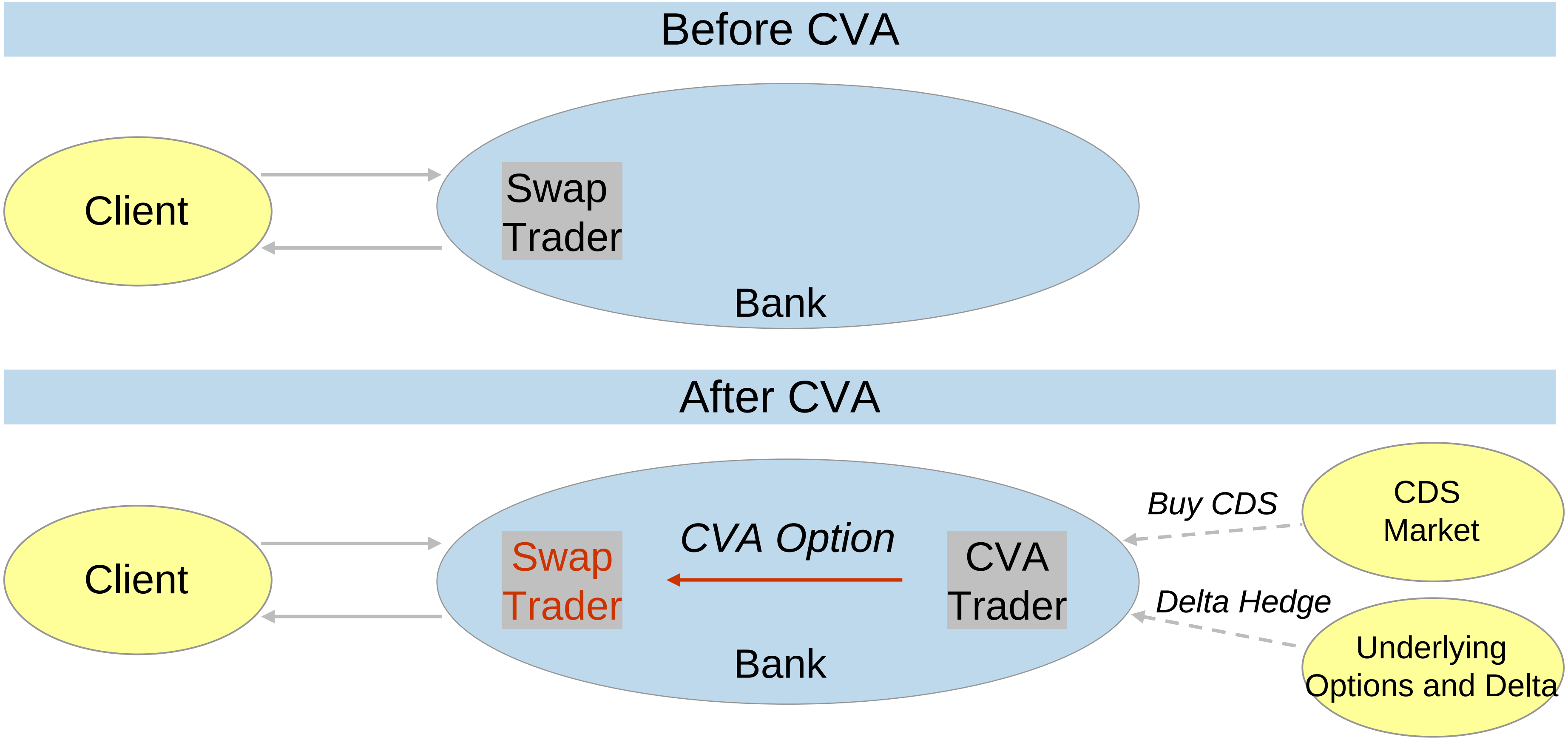
2. CVA Methodology

Introduction

- **What is market CVA?**
  - Market CVA is the credit reserve adjustment made to derivatives transactions to account for counterparty risk
  - Market CVA is bilateral at the financial reporting level. Bilateral CVA consists of
    - Asset CVA – this represents the expected cost of Citi's counterparty exposures (loans)
    - Liability CVA – this is the expected credit costs incurred by the counterparty (deposits)
  - Bilateral market CVA can be thought of as the net market value of an American option by **both sides** to default on the derivative

- **How is it calculated?**
  - The methodology to calculate both Asset CVA and Liability CVA is similar. In the formula below, we do not differentiate between asset/liability CVA.
  - CVA is the expected value of credit losses over the lifetime of the trade. i.e.
  - CVA at each time bucket = PV (EAD * (1 – Recovery Rate) * Probability of Default) where
    - EAD = Exposure at Default at each time bucket. This is predicted by EPE/ENE profiles
    - EPE/ENE = Expected Positive and Negative Exposures of the portfolio. These are generated using the market implied volatilities of market risk factors
    - Recovery Rate = 50% (Assumed)
    - Probability of Default = Derived through market CDS spreads
  - Bilateral CVA is the sum of the Asset and Liability CVA

Transaction flow of a CVA transaction

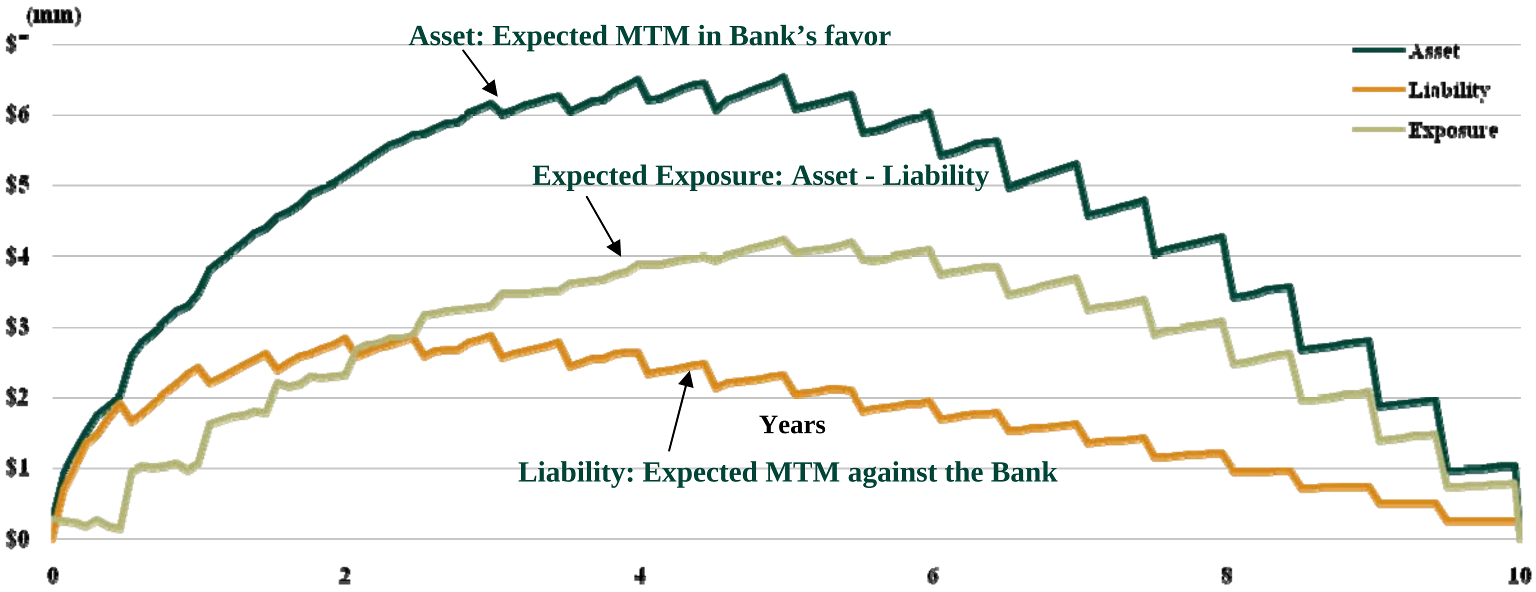


- The Swap Trader will pay a premium to the CVA trader to buy a CVA option
- The CVA option will protect the Swap Trader against any loss due to the default of the Client on the swap
- The CVA trader will hedge the Credit risk in the CDS market

How Do Banks Calculate a Credit Charge?

CVA Premium= -Default Probability * (1 - Recovery) * Max(MTM , 0)

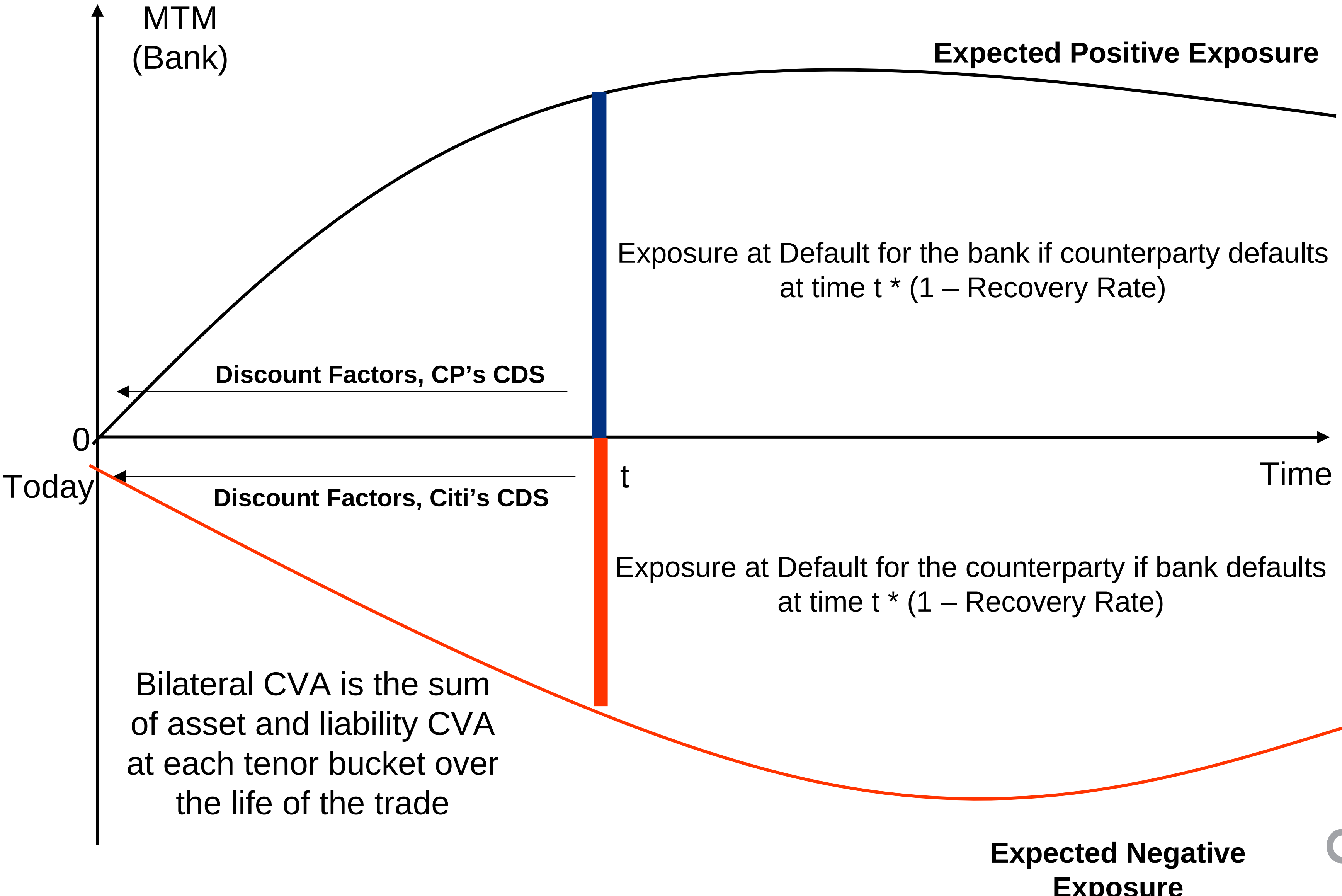
Counterparty Exposure develops as MTM changes over time



- Calculate the expected mark to market (MTM) value of the swap over time by calculating the Asset Profile - The expected MTM value for those situations when the Bank <u>is owed</u> money

Asset vs Liability CVA

Expected Positive Exposure and Expected Negative Exposure (akin to the current PSLE concept) generates the Exposure-at-Default profile for both the counterparty and the bank. The graph below shows the EAD used to calculate CVA at time t, assuming MTM of 0



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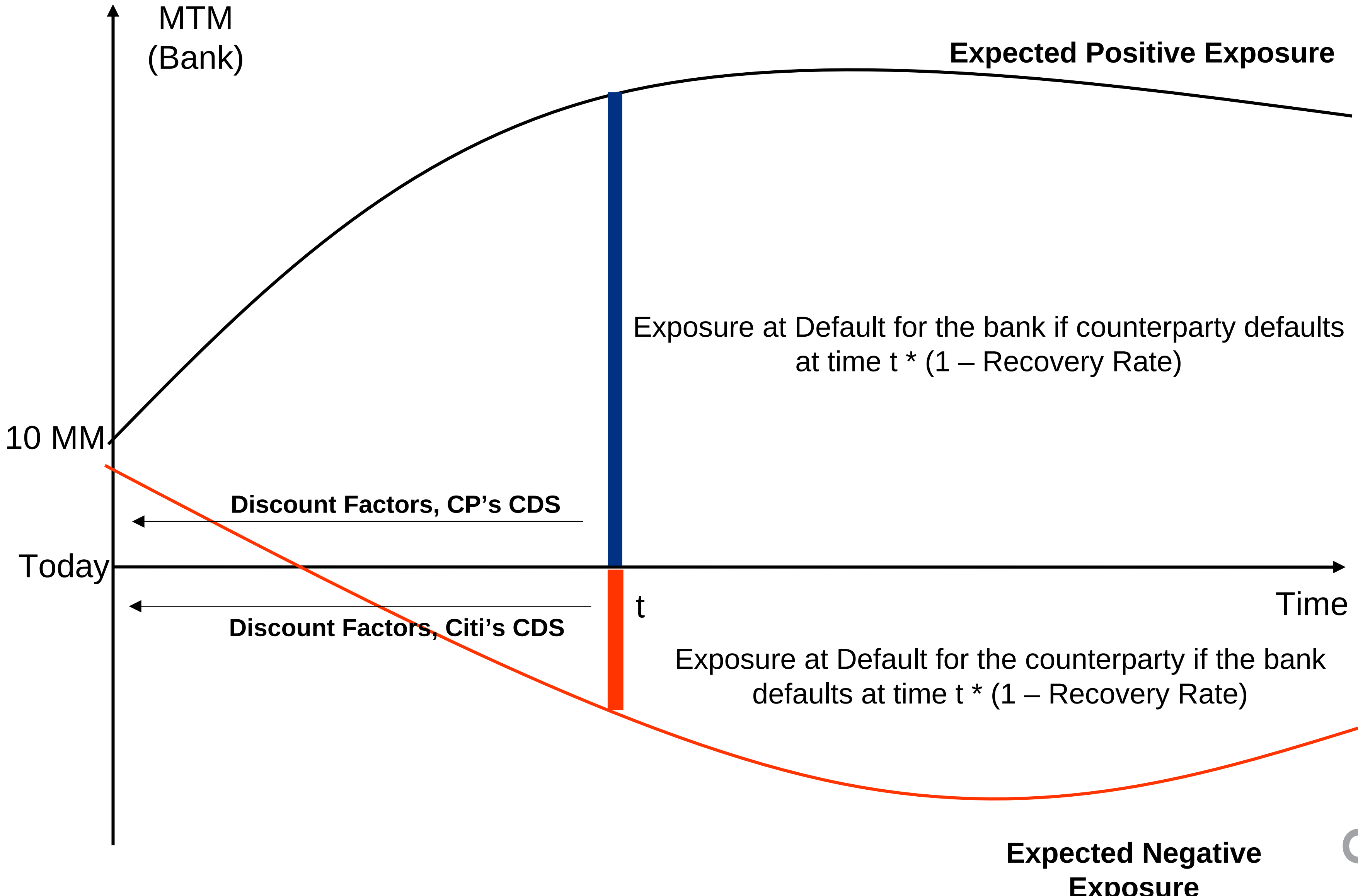
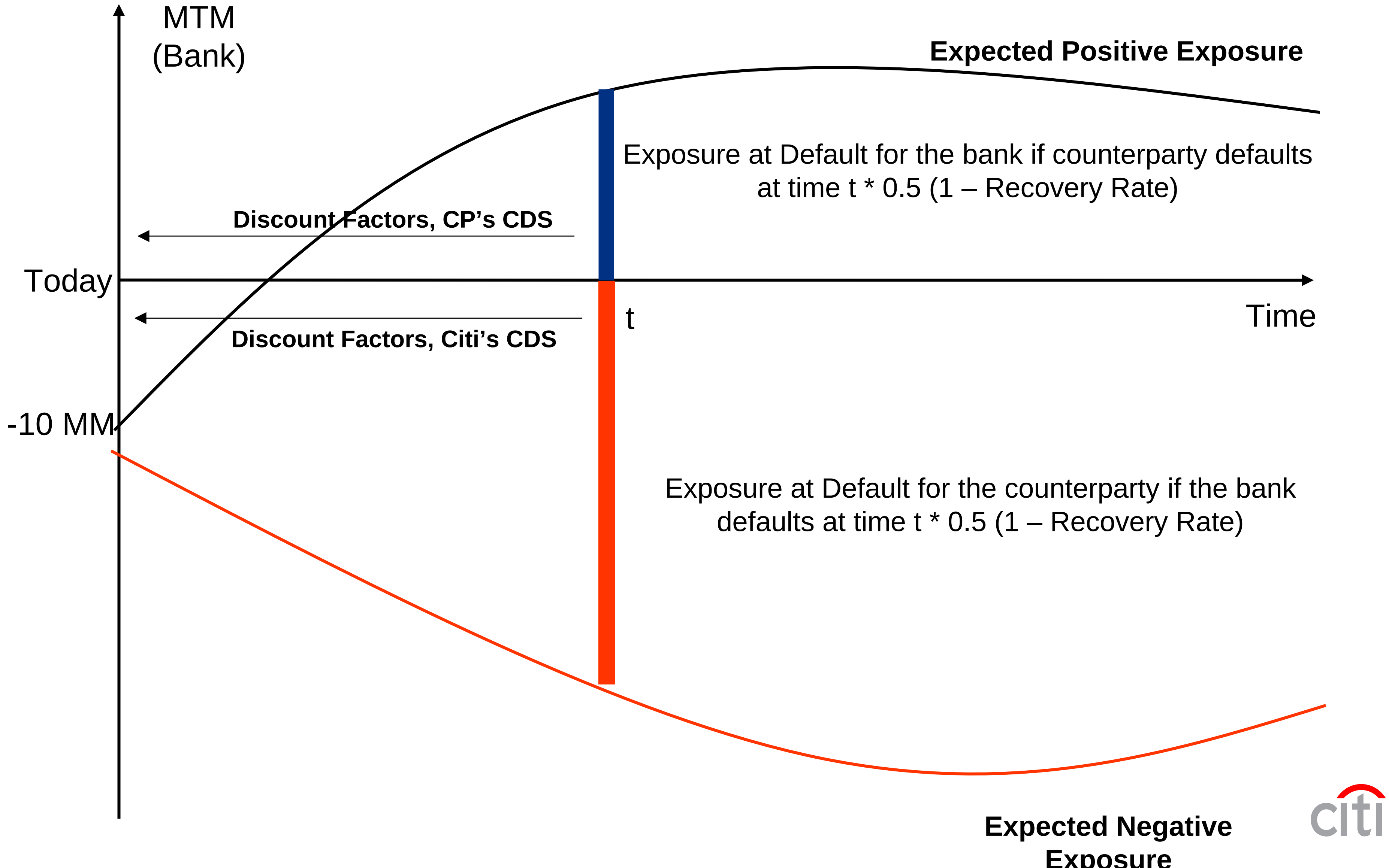
Asset vs Liability CVA

If MTM (from bank's perspective) moves in a positive direction, we record an additional CVA <u>charge (loss),</u> assuming everything else remains equal



Asset vs Liability CVA

If MTM (from bank's perspective) moves in a negative direction, we record a CVA gain, assuming everything else remains equal



3. Dynamic Hedging

What is Dynamic Hedging?

- CVA is a credit hybrid option on the contingent exposure of a derivative contract or a portfolio of derivative contracts. It is a call option on the MTM of these derivative contracts with an counterparty that can be exercised only upon a credit event of that counterparty.
- Like other options products, CVA can be hedged via dynamic hedging. This attempts to hedge the actual exposure of a derivative portfolio, using a Black Scholes style model.
- The CVA option price is a function of the underlying swap MtM, the counterparty CDS spread, their individual volatilities and the correlation between the two.
- The CVA option can be hedged by delta hedging with the underlying derivative (and/or option on the underlying derivative) and CDS.

Dynamic Hedging

Concepts

Dynamic Hedging

- Hedging the value of expected loss requires hedging its sensitivity to market factors and credit quality
- Because these factors move, and the CVA's sensitivity to them changes, hedging needs to be rebalanced

Friction

- Each individual market factor is hedged, but correlated moves will cause net losses
- Also, transaction costs *per se*, need to be accounted for

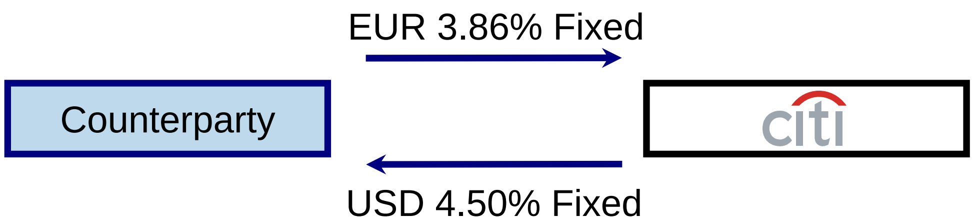
Time Decay

- As time passes, the life of the deal shortens and, all else constant, the expected loss falls
- Thus, like an option premium, all else constant, a CVA's value will fall over time

Dynamic Hedging - Example

Dynamic Hedging

- Hedging the value of expected loss requires hedging its sensitivity to market factors and credit quality
- A Cross Currency Swap CVA will be affected by:
  - FX rates and IR (we will focus on FX here) - these affect the expected MTM of the deal
  - Credit Quality – this affects the expected default probability
- An example:



- 5 Years / Principal: USD 100mm / Exchange at Inception and Maturity
- Counterparty CDS curve: 1 Year 81bps, 3 Year 85bps, 5 Year 93bps
- EURUSD Spot at inception: 1.3500

Dynamic Hedging - Example

Dynamic Hedging

- The CVA desk measures the sensitivity of expected loss with respect to each factor
- It then creates a hedge to offset that sensitivity
- For FX rate sensitivity:

Inception

	FX	5y Credit	CVA	Sensitivity to FX Moves: FX + 100	CVA	FX01	Hedge
T=0	**1.3500**	**93**	**382**	1.3600	403	21	2100

At inception, CVA is 382k

For a +100pip move, CVA increases by 21k

Hedge: Long EUR 2.1mm

- For Credit Curve sensitivity:

Inception

	FX	5y Credit	CVA	Sensitivity to Credit Curve Moves: CR + 10	CVA	CR01	Hedge
T=0	**1.3500**	**93**	**382**	103	420	38	7,600

At inception, CVA is 382k

For a +10bp widening, CVA increases by 38k

Hedge: Buy 7.6mm 5Y CDS*

*For illustration purposes, simplistic calculation: PnL = spread*tenor*notional

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Dynamic Hedging - Example

Dynamic Hedging

- For any individual move in market factors, its respective hedge will offset changes in expected loss
- For example, if FX moves +100 pips, and Credit Curve stays constant…

Inception

	FX	5y Credit	CVA
T=0	**1.3500**	**93**	**382**

FX Moves Only

	FX	5y Credit	CVA
T = 0	**1.3600**	**93**	**403**

PnL			
CVA	**FX Hedge**	**Credit Hedge**	**Net PnL**
(21)	**21**	**0**	**0**

FX Moves +100 pips

Expected Loss increases 21k; offset by gain in FX Hedge

No net gain or loss

- After the shift, sensitivities are recalculated and hedges are rebalanced

Sensitivity to FX Moves				Sensitivity to Credit Curve Moves			
FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge
1.3700	424	21	2100	103	443	40	8,000

FX hedge is unchanged at EUR 2.1mm

CDS hedge is increased to 8mm

Dynamic Hedging - Example

Dynamic Hedging

– Thereafter, if Credit Curve moves +10 bps, and FX stays constant…

After an FX Move

	FX	5y Credit	CVA
T = 0	**1.3600**	**93**	**403**

Now Credit Curve Moves

	FX	5y Credit	CVA	PnL			Net PnL
				CVA	FX Hedge	Credit Hedge	
T = 0	**1.3600**	**103**	**443**	**(40)**	**0**	**40**	**0**

Credit Curve Moves +10 bps

Expected Loss increases 40k; offset by gain in Credit Hedge

No net gain or loss

– After the shift, sensitivities are recalculated and hedges are rebalanced

Sensitivity to FX Moves				Sensitivity to Credit Curve Moves			
FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge
1.3700	466	23	2300	113	483	40	8,000

FX hedge is increased to EUR 2.3mm

CDS hedge is unchanged at 8mm

Credit Valuation Adjustment

Dynamic Hedging

- The aim of dynamic hedging is to ensure that changes in expected loss are neutralised
- That is:

Initial CVA + Dynamic Hedging = Prevailing CVA

- If the underlying deal is unwound, the Prevailing CVA is returned to the Sales Desk

- Note that, at any time, the purpose of a CDS hedge is to offset changes in CVA due to the change in credit quality
- If credit worsens such that default becomes almost certain, then CDS hedges done up to that point should have covered the increase in expected loss
- The outstanding CDS hedge *by itself* is not a hedge against loss from actual default
- In a Jump to Default (JTD) scenario, the lost deal MTM will be covered by the sum of the Prevailing CVA and the outstanding CDS position:

Deal MTM*(1-R) = Prevailing CVA + CDS Hedge*(1-R)

Credit Valuation Adjustment

Concepts

Friction

- Dynamic hedging for individual, separate market moves works as long as there is time to rebalance the hedges
- However, simultaneous market moves will not be covered by the sum of individual hedges
- This is because CVA sensitivity to one factor is changes, if another factor moves
- And at the time of hedging, such an effect cannot be assumed
- This is a cross gamma / correlation effect

Credit Valuation Adjustment

Concepts

Friction

- Recall the example used above
- FX and then the Credit Curve had moved one after the other, and the latest position was:

	FX	5y Credit	CVA
T = 0	**1.3600**	**103**	**443**

- The sensitivities were recalculated and the hedges rebalanced:

Sensitivity to FX Moves				Sensitivity to Credit Curve Moves			
FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge
1.3700	466	23	2300	113	483	40	8,000

- Now assume that FX and the Credit Curve move by the amount hedged for (+100pips/+10bps)
- But assume that they both move together, simultaneously

FX and Credit Curve Move Simultaneously

	FX	5y Credit	CVA
T = 0	**1.3700**	**113**	**508**

PnL			
CVA	**FX Hedge**	**Credit Hedge**	**Net PnL**
(65)	**23**	**40**	**(2)**

The increase in Expected Loss is more than the sum of the individual hedge PnL

This results in a net loss

Credit Valuation Adjustment

Concepts

Friction and Cross Gamma

- The amount of loss due to simultaneous market moves depends on correlation
- In addition, higher correlation requires more frequent rebalancing of hedges
- And this increases the total transaction costs *per se*

- Thus, for deals involving correlation, a ‘Friction’ adjustment is made
- That is:

Friction adjustment = Net loss from Correlation + Transaction costs

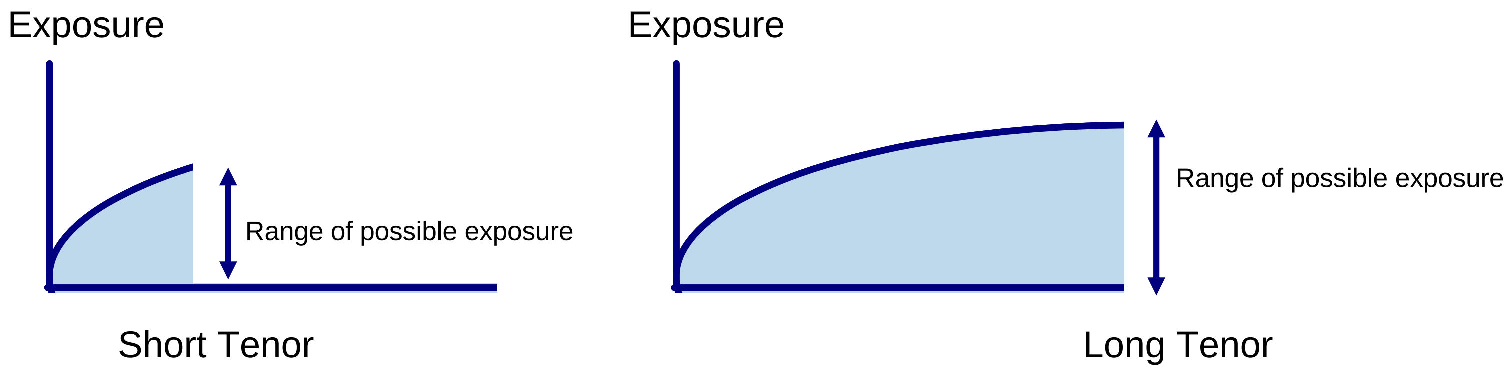
- Usually, it is priced via a shift in the credit curve assumption
- For example, a 100bps credit spread adjusted by 25% for Friction, would become 125bps

Credit Valuation Adjustment

Concepts

Time Decay

- CVA is forward looking, it measures *expected* loss
- Time to maturity has significant importance
- Longer tenor means a larger range of possible outcomes and a higher expected loss



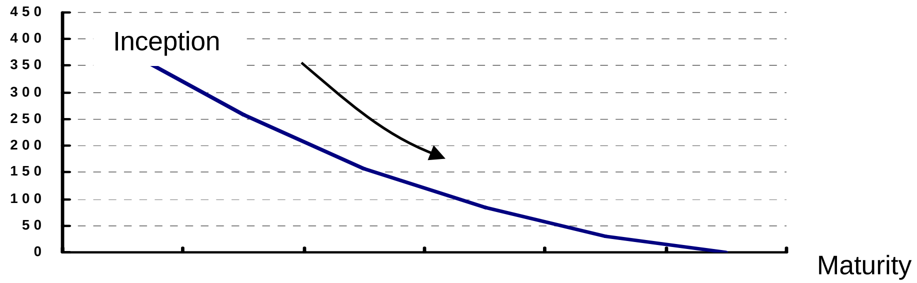
- The flipside to this: after inception, CVA value is subject to time decay

Credit Valuation Adjustment

Concepts

Time Decay

– When Sales desks transfer CVA value to the CVA desk, it is like paying an option premium
– The option protects Sales desks from risk of counterparty default, paying the MTM of a deal if default occurs
– At inception, CVA value is mostly time value – all else constant, this will fall over time
– In the example used above, time decay profile is:



– Time decay consists of (a) positive carry from asset side credit risk & liability benefit and (b) vega of the underlying market factors
– These are offset from (a) buying CDS and (b) buying options on underlying market factors
– As the MTM goes deep in-the money positive (or deep out-of-the money negative, the time decay split shifts from (b) to (a).

Credit Valuation Adjustment

Appendix – Dynamic Hedging and Cross Gamma Risk

Inception

			CVA	Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T=0	**1.3500**	**93**	**382**	1.3600	403	21	2100	103	420	38	7,600			

After an FX Move

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 0	**1.3600**	**93**	**403**	1.3700	424	21	2100	103	443	40	8,000	**(21)**	**21**	**0**

Now Credit Curve Moves

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 0	**1.3600**	**103**	**443**	1.3700	466	23	2300	113	483	40	8,000	**(40)**	**0**	**40**

FX and Credit Curve Move Simultaneously

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 0	**1.3700**	**113**	**508**	1.3800	534	26	2600	123	550	42	8,400	**(65)**	**23**	**40**

FX and Credit Curve Moves Simultaneously

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 0	**1.3800**	**123**	**578**	1.3900	607	29	2900	133	621	43	8,600	**(70)**	**26**	**42**

Credit Valuation Adjustment

Appendix – Time Decay

Effect of Time - Decreasing CVA

Inception

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T=0	**1.3500**	**93**	**382**	1.3600	403	21	2100	103	420	38	7,600			

FX and Credit Stay Constant, Time Passes

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 1Y	**1.3500**	**93**	**258**	1.3600	274	16	1600	103	286	28	5,600	**124**	**0**	**0**

FX and Credit Stay Constant, Time Passes

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 2Y	**1.3500**	**93**	**158**	1.3600	169	11	1100	103	176	18	3,600	**100**	**0**	**0**

FX and Credit Stay Constant, Time Passes

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 3Y	**1.3500**	**93**	**85**	1.3600	92	7	700	103	95	10	2,000	**73**	**0**	**0**

FX and Credit Stay Constant, Time Passes

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 4Y	**1.3500**	**93**	**30**	1.3600	34	4	400	103	34	4	800	**55**	**0**	**0**

FX and Credit Stay Constant, Time Passes

				Sensitivity to FX Moves				Sensitivity to Credit Curve Moves				PnL		
	FX	**5y Credit**	**CVA**	FX + 100	CVA	FX01	Hedge	CR + 10	CVA	CR01	Hedge	**CVA**	**FX Hedge**	**Credit Hedge**
T = 5Y	**1.3500**	**93**	**0**	1.3600	0	0	0	103	0	0	0	**30**	**0**	**0**

4. Risk and reserves

Residual Risks

- Liquidity Risk – Covers transaction cost including bid/offer spread and the sudden widening of bid/offer spread due to lack of liquidity.
- Recovery Risk – Covers the risk of the obligation's recovery value upon a counterparty default. E.g. Recovery locks.
- Gap Risk (Cross Gamma) – Covers the risk of a simultaneous move in credit and the underlying FX, IR or Equity rates.
- Correlation Risk – Covers the correlation assumed in the model and the change in correlation between credit and the underlying.
- Model Risk - Covers uncertainty in the model vs the actual market for unwind.
- Legal, netting and Documentation risk – Covers the legal and netting effectiveness of the CDS hedge and the enforceability of the ISDA swap documentation in various jurisdictions.

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