Counterparty Credit Risk Exposure Measurement
An Introduction

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Outline

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  - Components of Credit Risk
  - Market Risk vs. Credit Risk

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Fundamental Concepts in Credit Risk Measurement

What is Credit Risk?

- **What is Credit Risk?**
  - Credit Risk represents the volatility (uncertainty) of losses due to credit events such as default or rating downgrades
- **Types of Credit Risks**

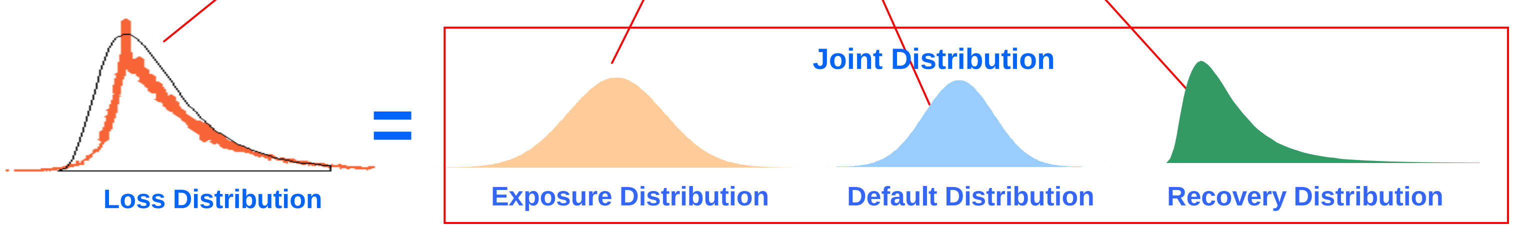
Lending Risk	**Borrower Defaults** **Loan value decreases because of** ▪ Decrease in credit quality of borrower ▪ Increase in general credit spread
Issuer Risk	**Issuer of security defaults** **Security's market value decreases because of** ▪ Decrease in credit quality of borrower ▪ Increase in general credit spread
Counterparty Risk	**Counterparty defaults** ▪ In an exchange, we pay but do not receive (Settlement Risk) ▪ Counterparty defaults before settlement and contract has positive value to us **Market value of counterparty risk has increased because of** ▪ Increase in the credit spread of the counterparty relatively to us ▪ Increase in counterparty exposure relative to its exposure to us

Components of Credit Risk

- **Exposure**
  - Amount that we can lose as a result of counterparty or borrower default
  - Exposure is dynamic for market-traded instruments
- **Credit Worthiness**
  - Probability of Default – the likelihood that a borrower/counterparty will default
  - Credit Rating Migration – Potential loss may occur when a borrower/counterparty migrates to a lower rating as PV of positions are discounted at higher risky rates
- **Loss Severity (Loss Given Default)**
  - In the event of default, the amount that we are likely to lose
  - LGD = 1 – Recovery Rate

Credit Loss Distribution

$$L_p(t) = \sum_{i=1}^{n} \max\left[X_i(t),\ 0\right]\ d_i(0,t)\ \left[1-\delta_i(t)\right]\ B(0,t)$$



Credit Exposure

- **Current Exposure**
  - Current replacement cost (amount that we can lose if the counterparty defaulted today)
  - For loan products, this is the loan principal plus accrued interest rates
  - For traded products, this is the current mark-to-market of the counterparty's portfolio
- **Potential Future Exposure**

  Estimate of future replacement cost (amount that we can lose if the counterparty defaulted at some time in the future)
  - Worst Case Exposure (Confidence Level Exposure)

    The maximum amount that we can lose as a result of counterparty default at a given time and confidence level
  - Peak Exposure

    The largest worst-case exposure across time up to he maturity of the longest contract in the counterparty's portfolio
  - Expected Exposure

    Average amount that we can lose at a given time as a result of counterparty default
- **Settlement Exposure**

  Risk that a settlement in a transfer system does not take place as expected.
  - Happens when one party defaults on its clearing obligations to one or more counterparties.
  - Settlement risk comprises both credit and liquidity risks.

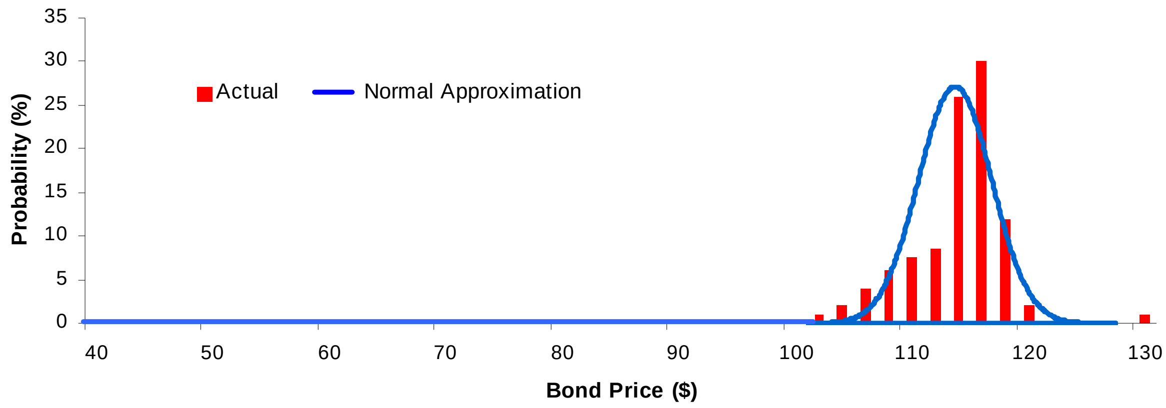
Market Risk vs. Credit Risk

- **Market Exposure**
  - Potential loss in market value of position if market risk factor goes against our position.
  - Example: If we are net long 100 shares of MSFT at $26 and the price goes to $20 a share, then we have a market loss of $600
- **Credit Exposure**
  - Potential loss if our aggregated position with a counterparty has a positive PV and the counterparty defaults.
  - Example: Assume we bought a MSFT call option on 100 shares from counterparty ABC at $26 strike. If MSFT moves to $30 a share and the counterparty defaults, we can potentially lose $400, assuming no recovery from counterparty ABC

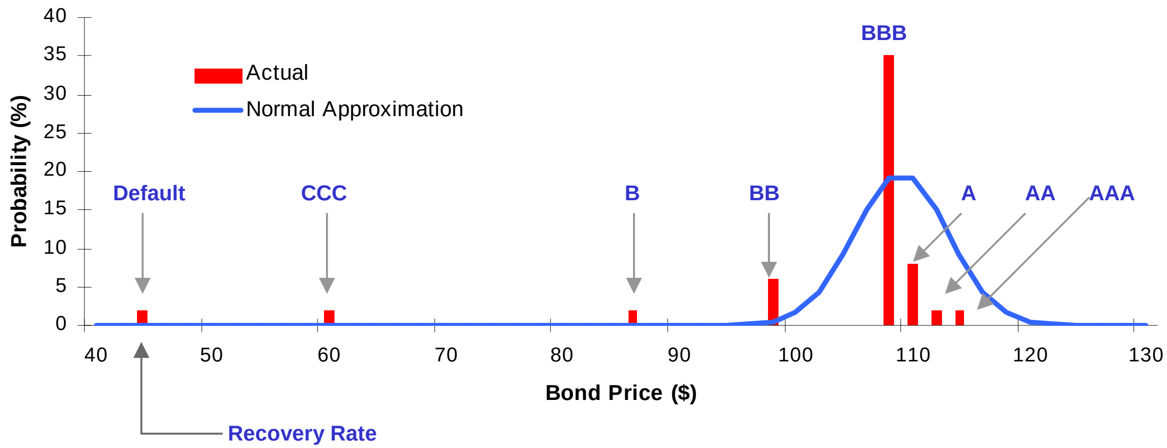
Attribute	Market Risk	Credit Risk
Time Horizon	❑ Short-Term risk (1-10 days) ❑ Single Step	❑ Long-Term Risk (Up to the longest tenor in a counterparty's portfolio since peak exposure may occur several years into the future) ❑ Multi-Step
Nature of Loss	❑ Adverse Market Move	❑ Loss is contingent on counterparty defaulting when we have trading gains
Distribution	❑ ~ Normal (Usually approximated as normal)	❑ Large Negative Skew Arises from significant (although small) probability of a large loss
Risk Mitigation	❑ Matching Positions Risk can be eliminated by offsetting positions	❑ Use of Netting Agreements ❑ Collateral Groups ❑ Mutual Terminations ❑ Obligor Diversification
Legal Issues	❑ Realization not dependent on legal issues	❑ Magnitude of risk is affected by enforceability of netting agreements

Market Risk vs. Credit Risk

Distribution of prices of a 10-yr BBB rated corporate bond (Semi-Annual Coupon of 7.5%)



Distribution of prices of a 10-yr BBB rated corporate bond driven by credit events



Rating	Transition Prob	Spread (bp)	Bond Price
AAA	0.02%	5	110.0
AA	0.33%	10	109.6
A	5.95%	20	108.9
BBB	86.93%	50	106.7
BB	5.30%	200	96.8
B	1.17%	400	85.4
CCC	0.12%	1,000	60.2
D	0.18%		44.1

Probability of Default and Credit Migration

S&P One-Year Transition Matrix

Average Annual Transition Probabilities (1981-2010)

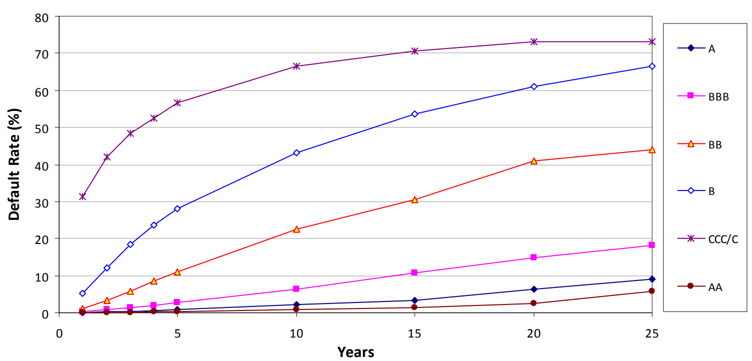
Initial Rating	AAA	AA	A	BBB	BB	B	CCC/C	D
AAA	90.89	8.33	0.56	0.06	0.08	0.03	0.06	0.00
AA	0.60	90.16	8.50	0.56	0.06	0.08	0.02	0.02
A	0.04	2.00	91.66	5.64	0.40	0.17	0.02	0.08
BBB	0.01	0.14	3.94	90.55	4.26	0.69	0.16	0.24
BB	0.02	0.05	0.18	5.78	84.05	8.06	0.83	1.03
B	0.00	0.05	0.16	0.26	6.18	83.13	5.07	5.15
CCC/C	0.00	0.00	0.22	0.33	0.99	15.33	51.92	31.21

Average Annual Transition Probabilities (2008-2009)

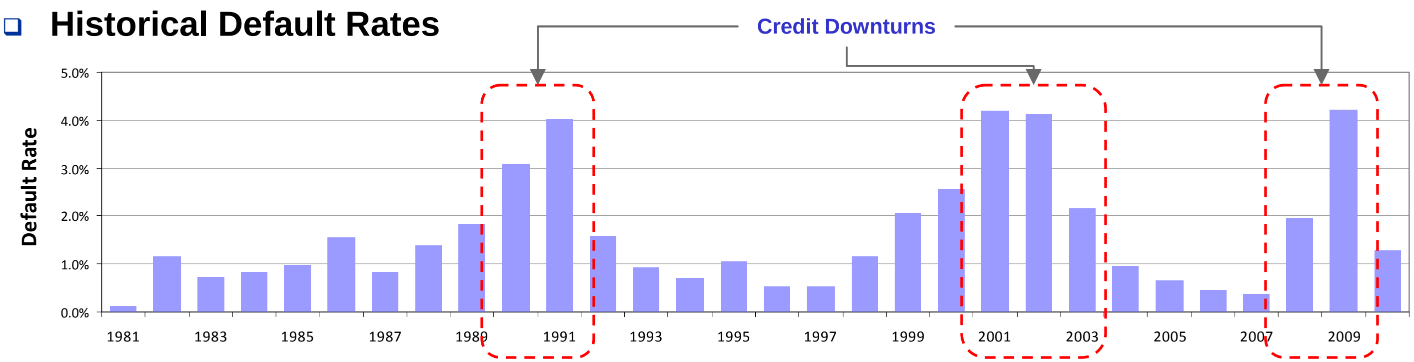
	AAA	AA	A	BBB	BB	B	CCC/C	D
AAA	88.96	7.36	1.84	0.00	0.00	0.61	1.23	0.00
AA	0.00	81.26	17.68	0.64	0.11	0.00	0.11	0.21
A	0.00	0.90	91.36	6.76	0.47	0.24	0.00	0.27
BBB	0.00	0.00	2.50	91.27	4.96	0.58	0.22	0.47
BB	0.00	0.06	0.00	4.48	82.76	10.99	0.88	0.83
B	0.00	0.00	0.04	0.09	3.31	79.86	9.23	7.46
CCC/C	0.00	0.00	0.00	0.00	0.00	8.93	41.96	49.11

Cumulative Default Rates

	Years								
	1	2	3	4	5	10	15	20	25
AAA	0.00	0.03	0.12	0.23	0.33	0.86	1.20	1.80	3.19
AA	0.02	0.06	0.13	0.23	0.34	0.92	1.36	2.48	5.87
A	0.08	0.20	0.36	0.54	0.73	2.07	3.30	6.36	9.09
BBB	0.24	0.73	1.27	1.99	2.74	6.43	10.63	14.71	18.23
BB	1.03	3.18	5.83	8.43	10.93	22.67	30.61	40.90	44.00
B	5.15	11.97	18.28	23.68	27.93	43.03	53.73	61.16	66.44
CCC/C	31.21	42.07	48.46	52.51	56.66	66.45	70.58	73.04	73.04
Investment Grade	0.12	0.35	0.61	0.95	1.29	3.03	4.64	7.08	9.99
Speculative Grade	4.74	9.55	14.08	18.01	21.33	34.10	42.77	51.38	55.23
All Rated	1.67	3.34	4.88	6.21	7.32	11.40	14.06	17.17	20.02



Historical Default Rates

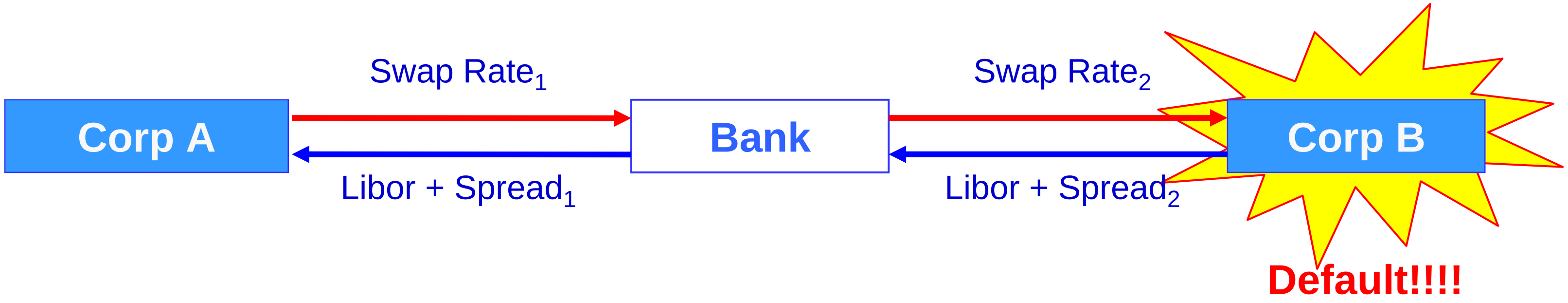


Counterparty Exposure Measurement

The Nature of Counterparty Credit Risk

Counterparty risks…

- **are by-product of privately-negotiated derivatives transactions**
- **create a chain of dependencies among derivatives counterparties**
- **lead to exposures that must be measured and managed**



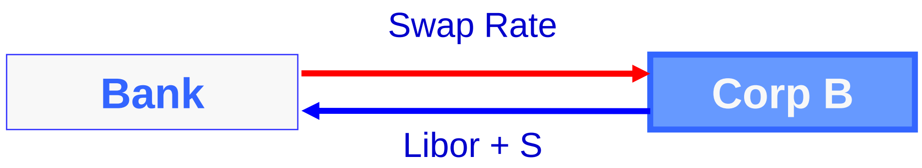
<u>Bank's exposure to Corporation B</u>

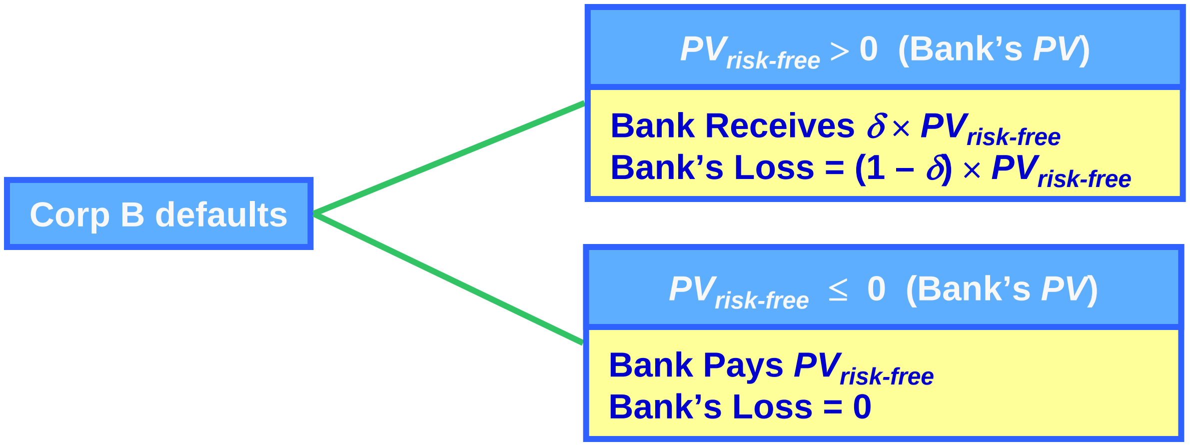
- Counterparty B defaults, LIBOR goes up and the swap has positive MTM to the Bank
- Since the Bank receives Libor + Spread (pays Fixed), the replacement value of the swap increases

<u>Bank's exposure to Corporation A</u>

- Counterparty A defaults, LIBOR goes down and the swap has positive MTM to the Bank
- Since the Bank receives a fixed rate (pays Libor + Spread), the replacement value of the swap increases

The Nature of Counterparty Credit Risk
Cash Flows in the Event of Default





Bank's Loss on Default = $(1 - \delta) \times \max(0, PV_{risk\text{-}free})$

$0 \leq \delta \leq 1$ **the Recovery Rate**

Expected Loss: $EL(swap) = PV_{risk\text{-}free}(swap) - PV_{risky}(swap)$

To compensate for EL: $PV_{risk\text{-}free}(swap + S) = PV_{risky}(swap)$

Difference Between Lending and Counterparty Credit Risk

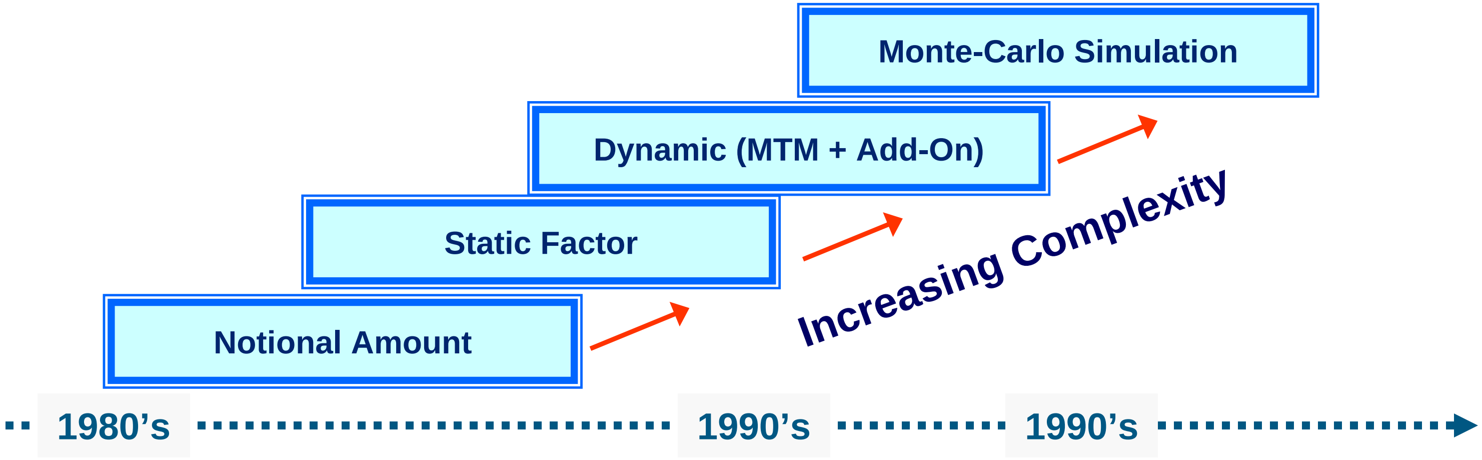
- **The market value of a derivative contract (e.g. swap or forward) with a counterparty could potentially be positive or negative**
  - Unlike loan wherein the Lender has only the exposure to the Borrower
  - In counterparty risk, either parties can have exposure to the other depending on the future state of the market

- **The magnitude of counterparty exposure depends on the uncertain future state of the market**
  - For most loans, there is less uncertainty in the magnitude of future exposure and very close to the notional for bullet loans
  - Counterparty exposures could only be described statistically

- **For large dealers, the exposures from various trades may offset each other at given states of the market**
  - For lending products, all loans add to the exposure at all times

Evolution of Exposure Measurement Techniques

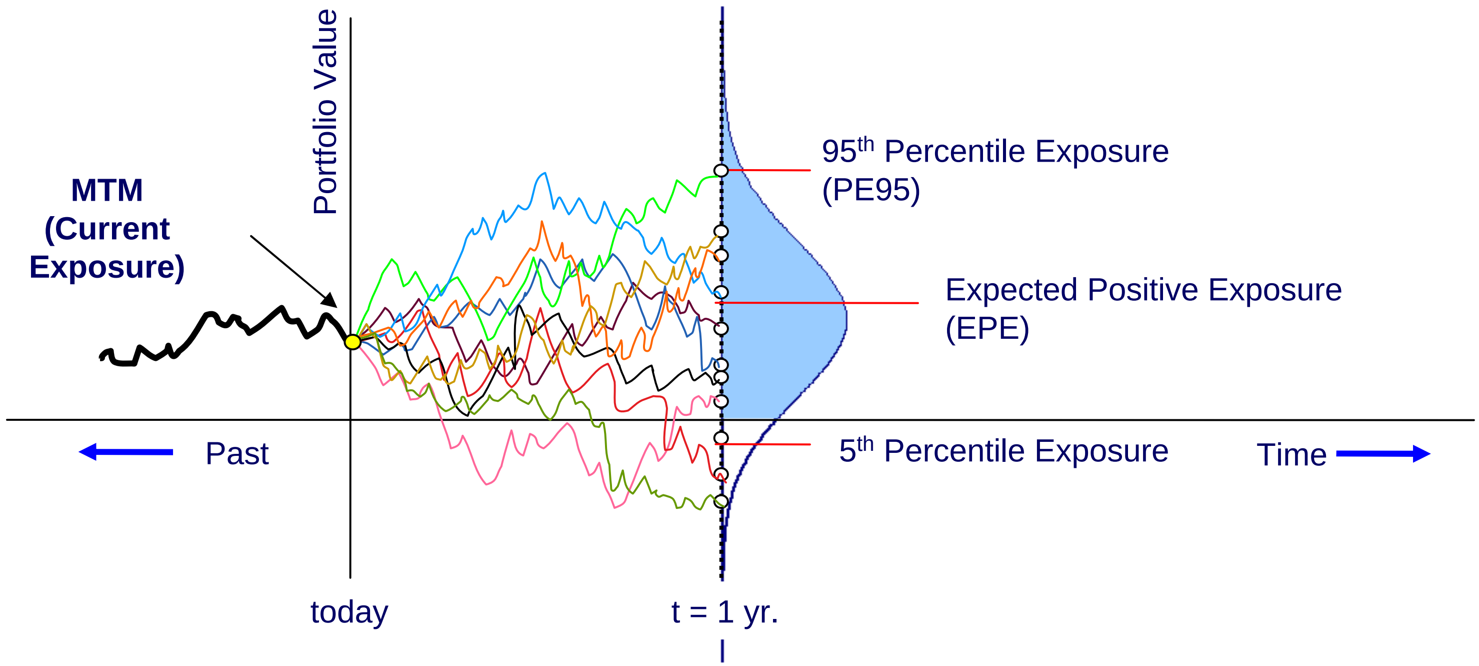
- **Notional Approach – Exposure equals notional amount**
  - Ignores the market value of the positions
  - Ignores the volatilities and correlations between market factors that determine the exposure
- **Static Factor – Exposure is equal to Notional x Factor**
  - Constant factor does not change with life of trade nor with the granularity of trade types
  - Ignores the current mark-to-market of trades
- **MTM + Add-On – Exposure is equal to MTM plus add-on determined by the notional x factor**
  - Although MTM is dynamic, the add-on is still static
- **Monte-Carlo Simulation**
  - Considers the volatilities and correlations of various risk factors that determine the exposure



Probability Distribution of Potential Future Exposure

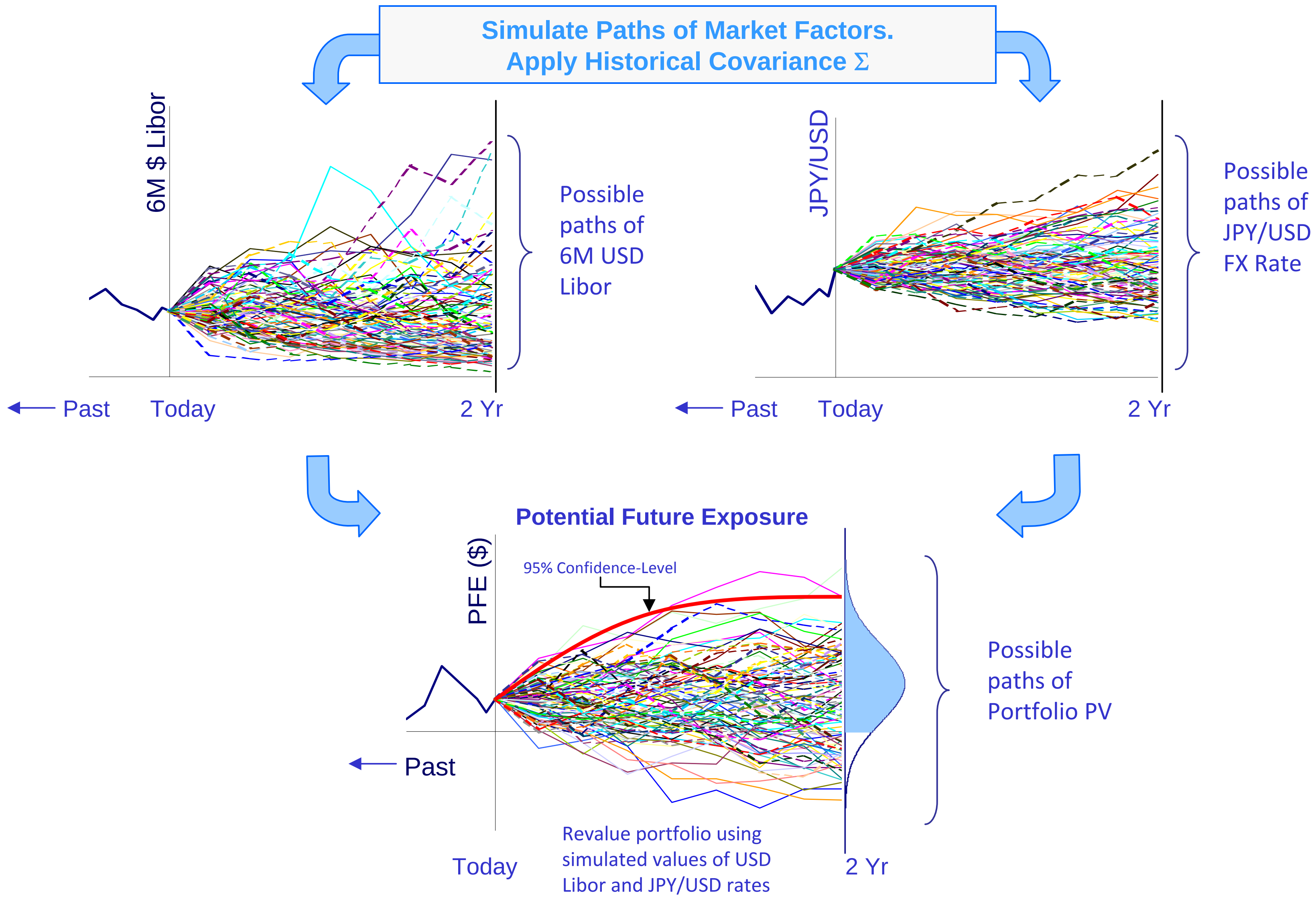
Credit exposure is asymmetric with the underlying market factor (rate, price, index, etc.). Market factor movements causing negative MTM do not result in credit exposure.

Potential Future Exposure
(at the 1-year simulation point)

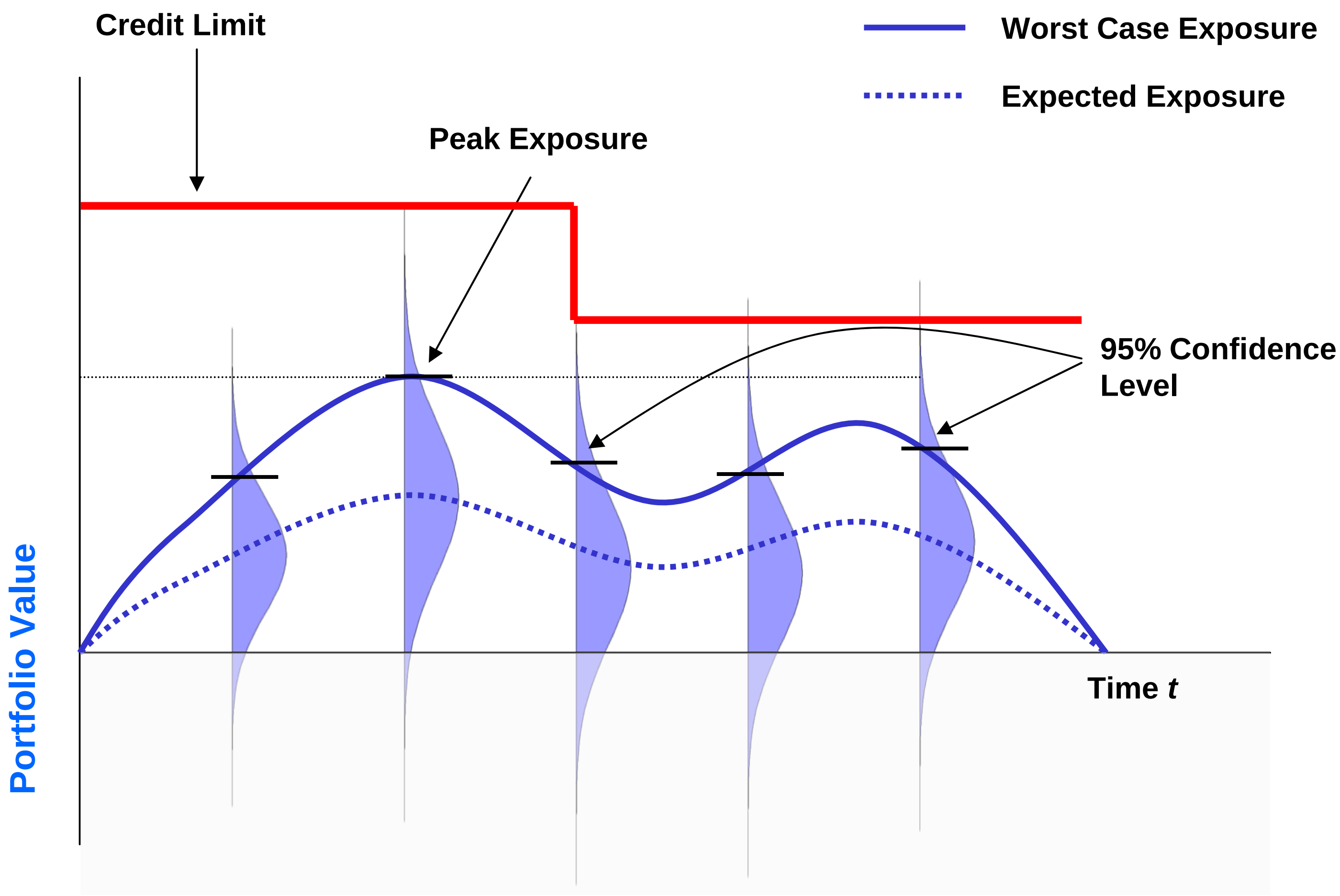


- Only outcomes in the shaded area result in exposure
- EPE is the average of the non-negative exposures. If there are 1,000 simulation paths, then EPE = Sum{max[0,Exposure(i)]}/1000
- PE95 is the 95th percentile exposure, i.e., the 950th largest exposure

Simulation of Portfolio Potential Future Exposure



Counterparty Exposure Profile



Calculating the Exposure Metrics

	Trade 1	Trade 2	Discount Rate	Tenor
	Receive Fix	Receive Fix	4%	1 year
No. of Barrels	1,000	2,000		
Fixed Price	11	10		
Maturity (Yr.)	1	1		

Scenario #	Simulated Oil Price		Scenario #	Trade 1	Trade 2	T1 + T2 (W/O Netting)	T1 + T2 (With Netting)
1	10.6		1	369	-1,183	369	-814
2	9.1		2	1,848	1,774	3,622	3,622
3	10.7		3	303	-1,316	303	-1,013
4	9.1		4	1,784	1,646	3,430	3,430
5	9.7		5	1,215	508	1,723	1,723
6	8.2		6	2,735	3,548	6,282	6,282
7	11.4		7	-378	-2,677	0	-3,055
8	11.4		8	-392	-2,706	0	-3,098
9	8.8		9	2,159	2,396	4,555	4,555
10	10.6		10	364	-1,193	364	-829
11	9.4		11	1,556	1,190	2,746	2,746
12	10.1		12	848	-225	848	623
13	10.3		13	710	-502	710	208
14	10.0		14	991	60	1,051	1,051
15	10.7		15	321	-1,280	321	-959
16	9.9		16	1,087	252	1,339	1,339
17	11.8		17	-728	-3,378	0	-4,107
18	8.9		18	1,982	2,042	4,023	4,023
19	11.7		19	-656	-3,233	0	-3,889
20	9.2		20	1,749	1,577	3,326	3,326
Average	10.1	**Expected Exposure**		**893**	**-135**	**1,751**	**758**
		Expected Positive Exposure		**1,001**	**750**	**1,751**	**1,646**
		Potential Future Exposure (PE95)		**2,159**	**2,396**	**4,555**	**4,555**

Bank has two one-year forward trades with a Counterparty:

<u>Trade 1</u>
Bank Receives a Fix Price of $11 per barrel of oil and pays floating price for 1000 barrels

<u>Trade 2</u>
Bank Receives a Fix Price of $10 per barrel of oil and pays floating price for 2,000 barrels

-378 + -2677 = -3,055

Max(-378,0) + Max(-2677,0) = 0

EPE without Netting ≥ EPE with Netting

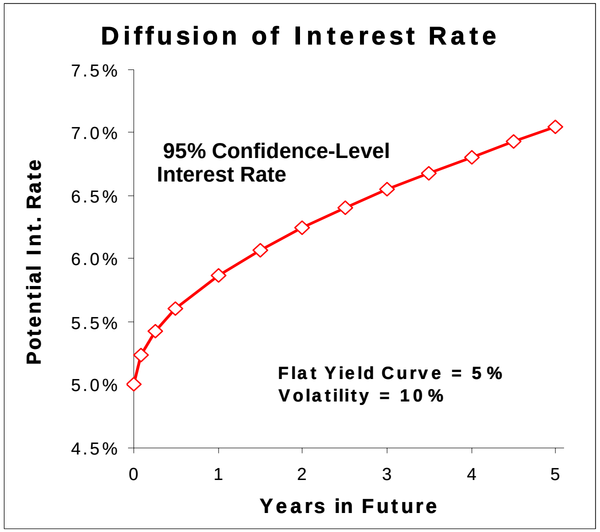
Average($V_{1,1}$…$V_{1,20}$)

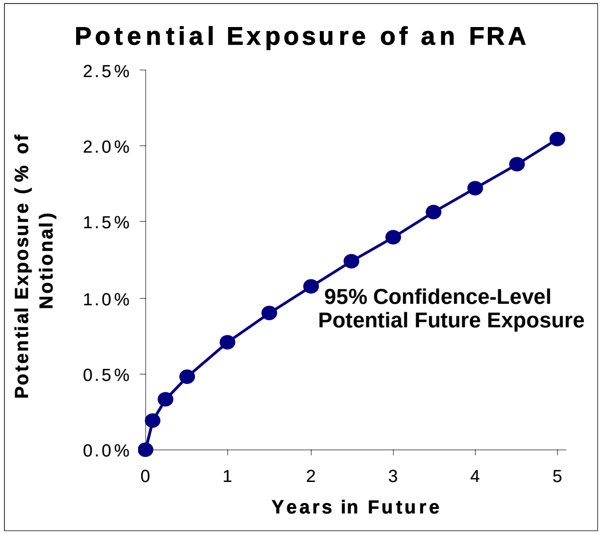
Sum{Max($V_{1,1}$,0)+….+ Max($V_{1,20}$,0)}

95th Percentile Exposure
(19th Largest Exposure out of 20)

There are two main factors that determine how the potential future exposure varies with time: diffusion and amortization

- **Diffusion**
  - As time passes, the "diffusion effect" tends to increase exposure since there is greater potential for rates to move away from current levels
- **Amortization**
  - As time goes by, the "amortization effect" tends to decrease exposure as periodic payments are made reducing the remaining cash-flow that is exposed to default
  - For single cash-flow products (e.g., FX Forward), there is no "amortization" effect since cash-flow occurs only at maturity date. Exposure is purely due to diffusion.





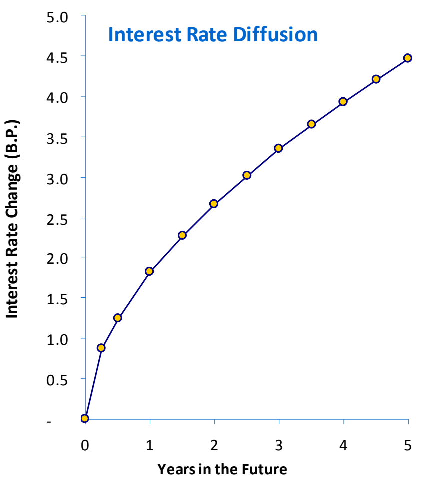
How Potential Future Exposure Evolves Over Time
Multiple Cash-Flow Product

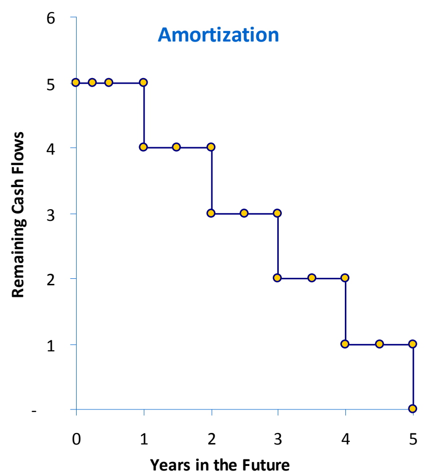
Time (years)	Projected Rates - 95% Confidence (%)	Diffusion (Potential Change in Interest Rate) (In Basis Pts)	Amortization (Remaining Cash Flows)	Diffusion × Amortization (%)	Potential Future Exposure (% of Notional)
0.00	5.00	0	5	0.0	0.0
0.25	5.87	87	5	4.3	3.7
0.50	6.25	125	5	6.3	5.4
1.00	6.82	182	5	9.1	8.0
1.50	7.27	227	4	9.1	7.9
2.00	7.66	266	4	10.6	9.5
2.50	8.01	301	3	9.0	8.0
3.00	8.34	334	3	10.0	9.2
3.50	8.64	364	2	7.3	6.7
4.00	8.93	393	2	7.9	7.5
4.50	9.20	420	1	4.2	4.0
5.00	9.46	446	1	4.5	4.5

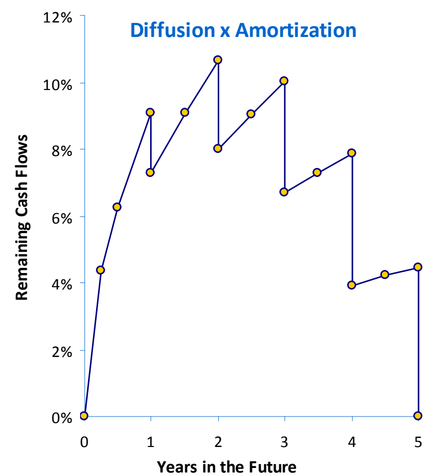
Example	
5-Year Interest Rate Swap	Pay Fix 5%
Payment Frequency:	Annual
Yield Curve (Flat):	5%
Interest Rate Volatility:	20%
Confidence Level:	95%

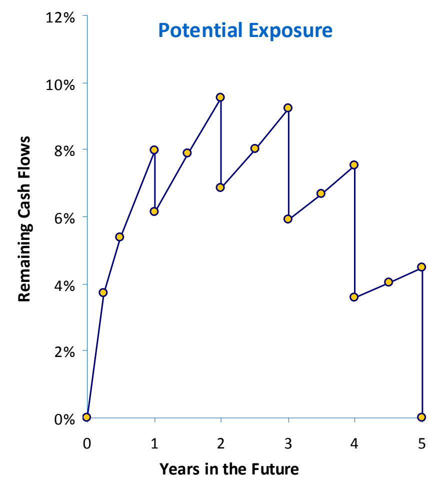
We assume interest rates evolve according to:

$$R(t) = R(0)\exp\left[-\tfrac{1}{2}\sigma^2 t \;+\; 1.65\sigma\sqrt{t}\right]$$



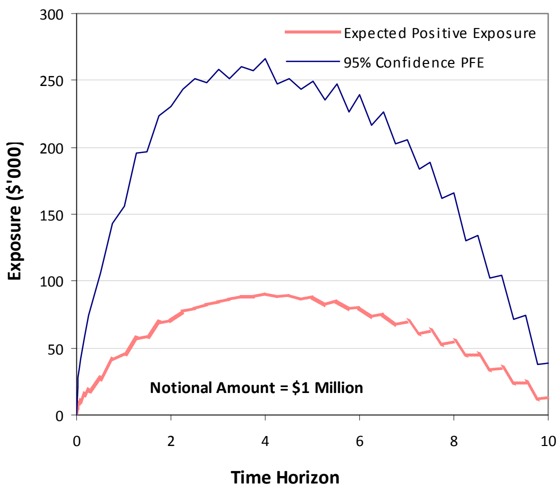




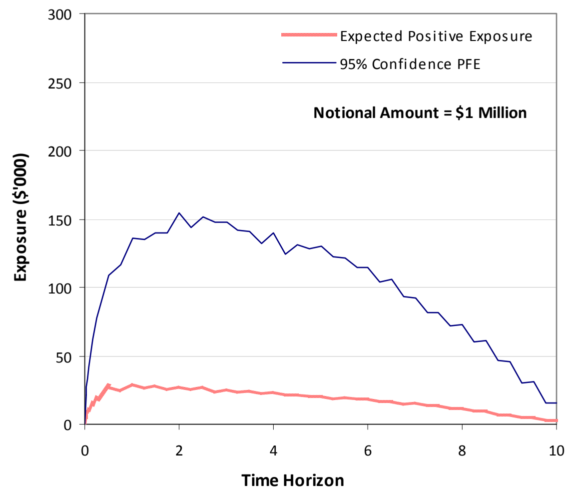


Potential Future Exposure Profiles of Derivative Products

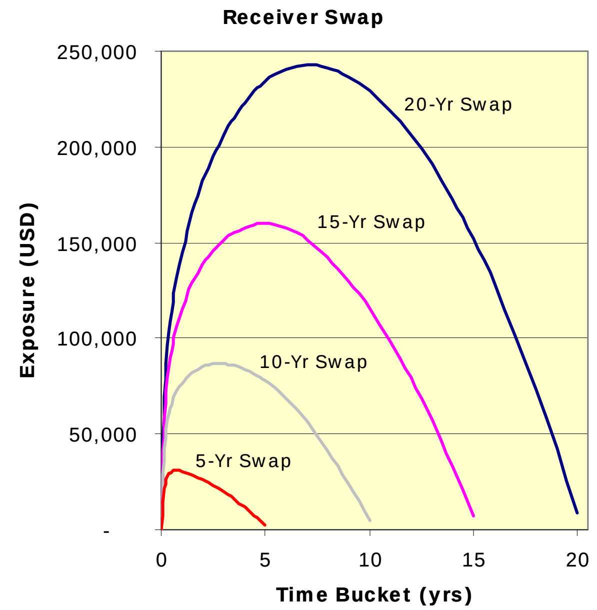
Payer Interest Rate Swap



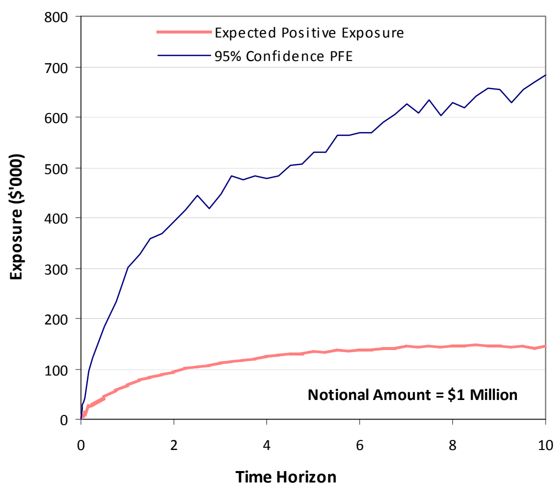
Receiver Interest Rate Swap



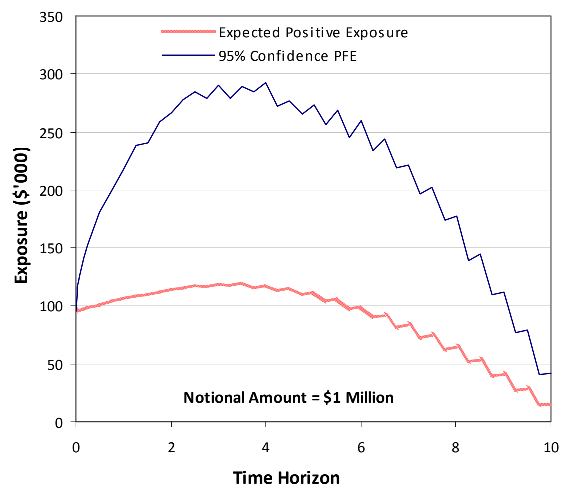
Effect of Maturity



Currency Swap

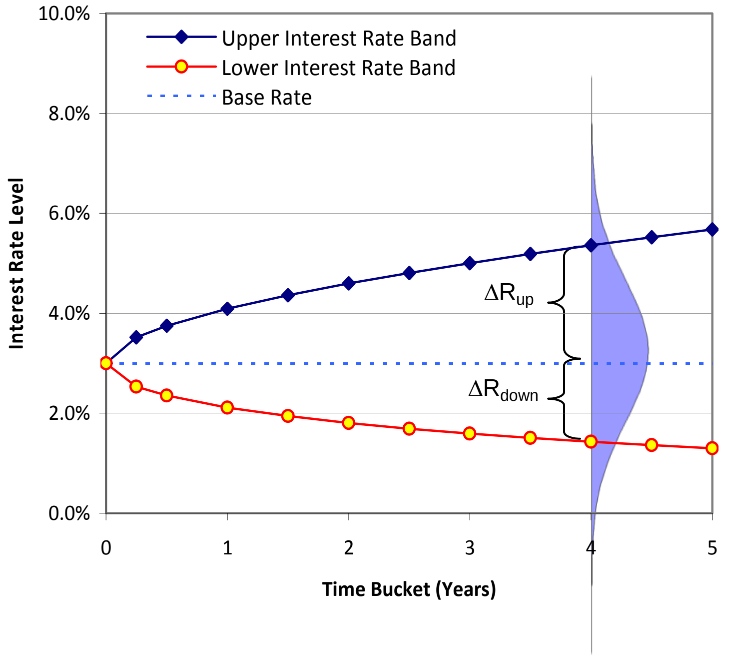


Interest Rate Cap

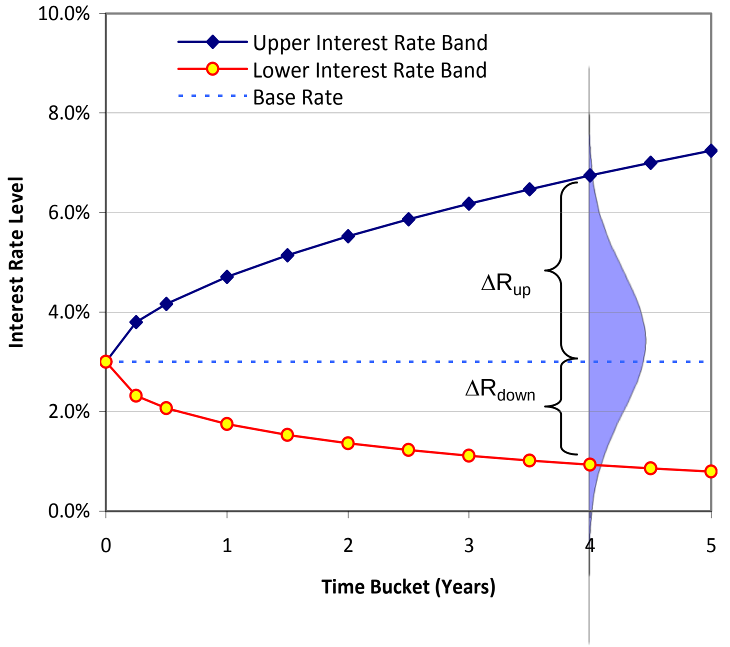


Evolution of Interest Rates and Potential Future Exposure

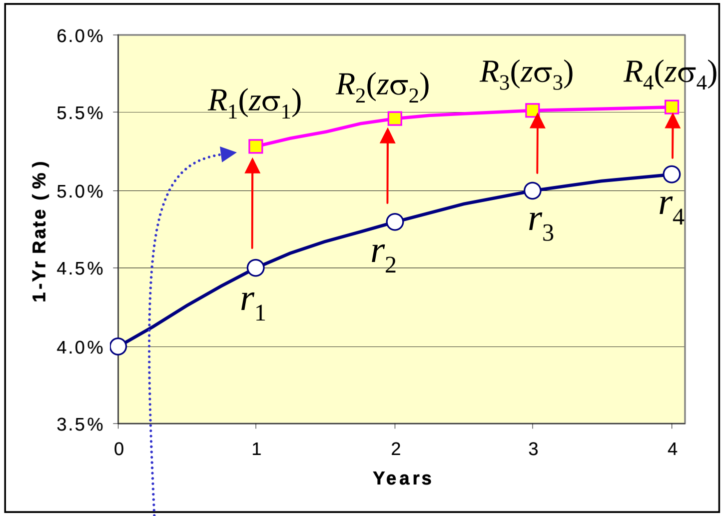
Interest Rate Evolution – 95% Confidence Interval (20% Volatility)

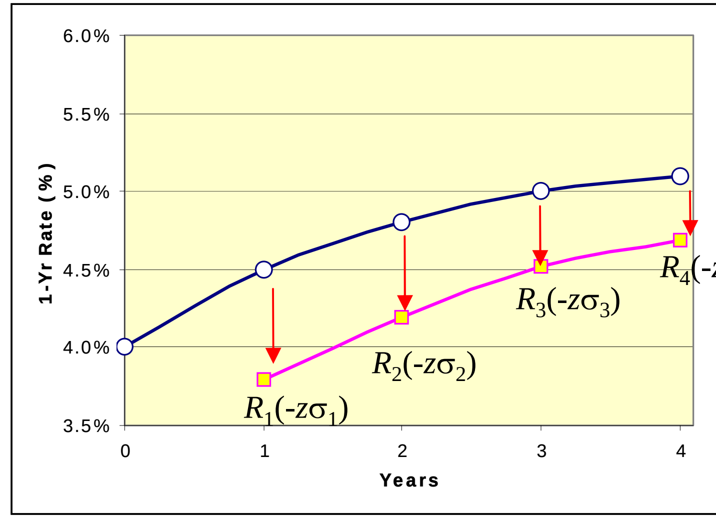


Interest Rate Evolution – 95% Confidence Interval (30% Volatility)



- **Asymmetry Between the Upper and Lower Confidence Bands**
  - Using a lognormal assumption, the upper confidence band of the interest rate distribution diffuses more than the lower band
  - This results in a Payer Interest Rate Swap (Bank Pays Fix and Receives Floating Rate) resulting in a larger exposure than a Receiver Interest Rate Swap (Bank Receives Fix and Pays Floating Rate)
    - In a Payer Swap the Bank has counterparty risk when interest rate goes up since the value of the swap to the Bank increases. The reverse is true for Receiver Swap.

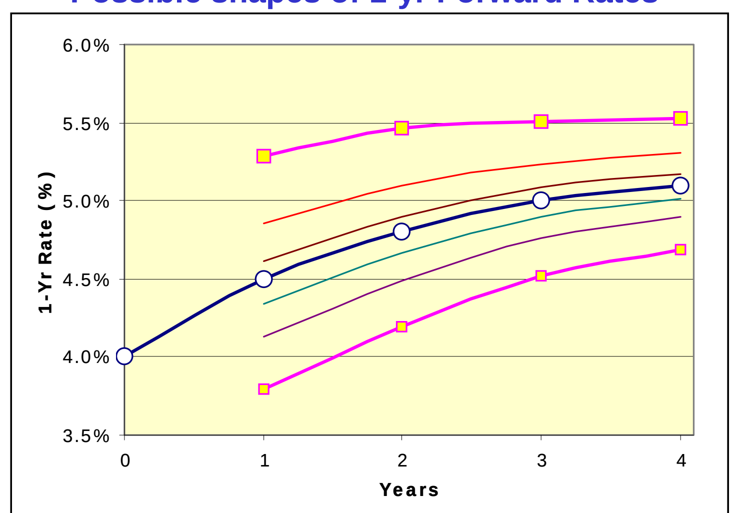




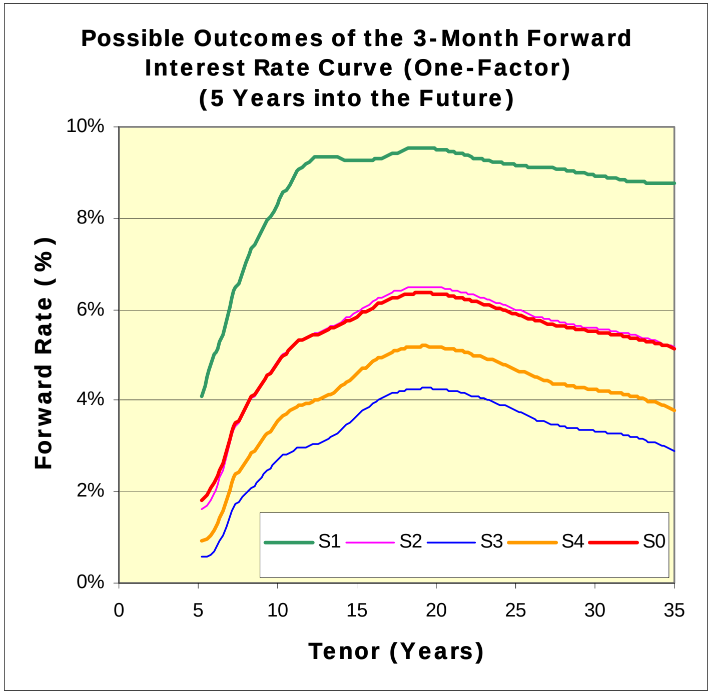
$R_1(z\sigma_1) = r_1 \exp[\,-0.5\,\sigma^2 + z\,\sigma_1]$

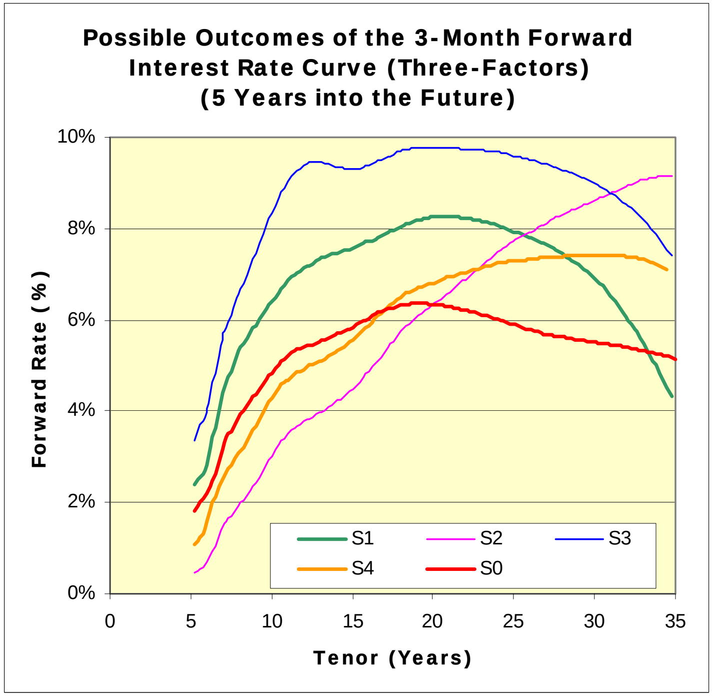
- In single-factor model, we use the same random number *z* for all parts of the curve.
- The random number *z* determines the direction of the curve.
- When *z* is positive, the whole curve shifts up and shifts down when *z* is negative.

Possible shapes of 1-yr Forward Rates



Risk Factor Evolution
Single-Factor vs. Multi-Factor Interest Rate Curve

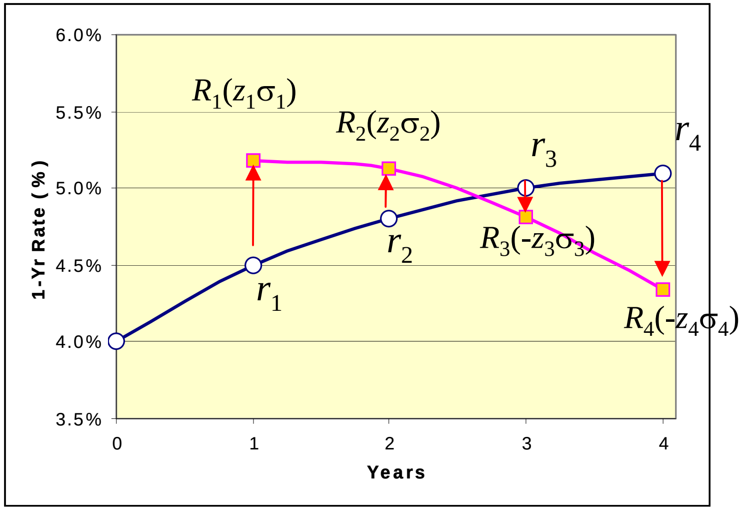


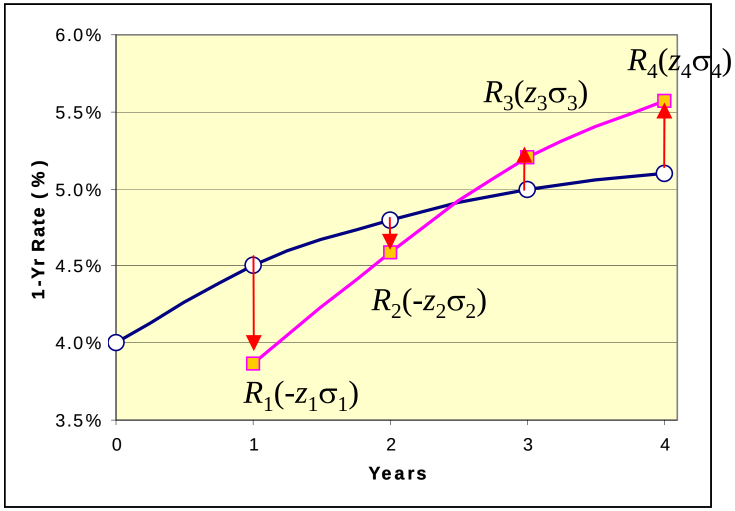


$$F_k(t) = F_k(0)\exp\left[-\tfrac{1}{2}\sigma_k{}^2 t + z\sigma_k\sqrt{t}\right]$$

$$F_k(t) = F_k(0)\exp\left(\sum_{i=1}^{3} z^i(t)\cdot PC_k^i\cdot\alpha^i - \frac{1}{2}t\sum_{i=1}^{3}\left(PC_k^i\cdot\alpha^i\right)^2\right)$$

Multi-Factor Interest Rate Curve

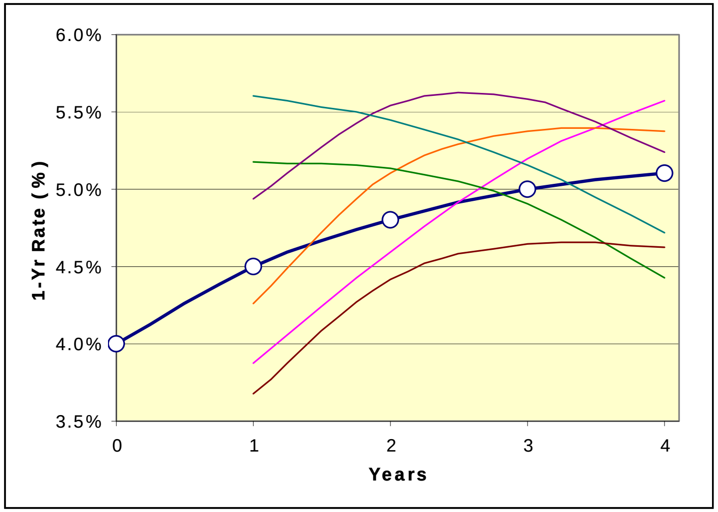




$$R_1(z_1\sigma_1) = r_1 \exp[-0.5\sigma_1^2 + z_1\sigma_1]$$

- The random numbers z_i's determine the direction of the curve.
- In multi-factor model, we use different z_i's for each part of the curve.
- When z_i is positive, the particular forward rate shifts up and shifts down when z_i negative.

Possible shapes of 1-yr Forward Rates



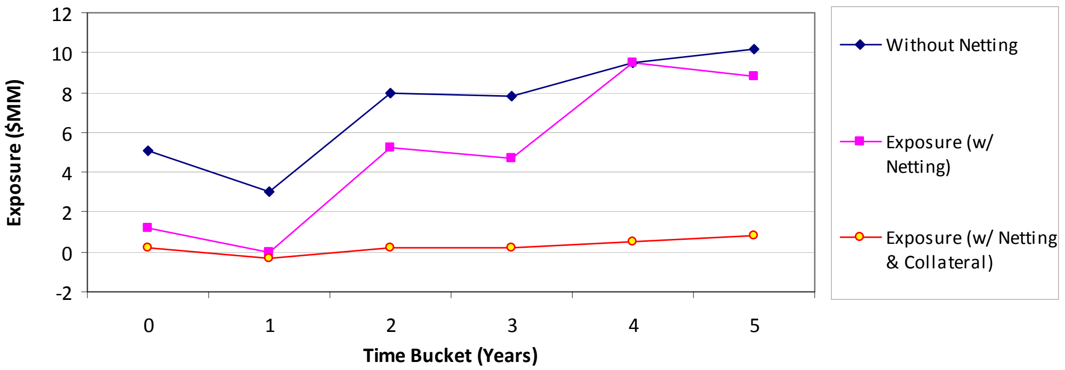
Traditional Approaches in Mitigating Counterparty Credit Risk

- **Netting**
  - ISDA Master Agreement
  - Allows negative and positive exposure to cancel each other in the event of default
  - Enforceability of the close-out netting provisions is crucial
- **Credit Enhancements**
  - Collateral Agreements (Credit Support Annex – CSA)
  - Early Termination Agreements (Derivatives contracts are terminated prior to their contractual settlement date, usually triggered by events of default)
  - Guarantees (Third-Party of Parent Guarantee)
  - Embedded Option to Cancel or Shorten Maturity (Liquidity Puts, Credit Triggers etc.)
- **Exposure Limits**
  - Confidence-Level Potential Exposure Limit (PE95) or Net Current Exposure Limit
  - Usually dependent on the credit quality of the counterparty

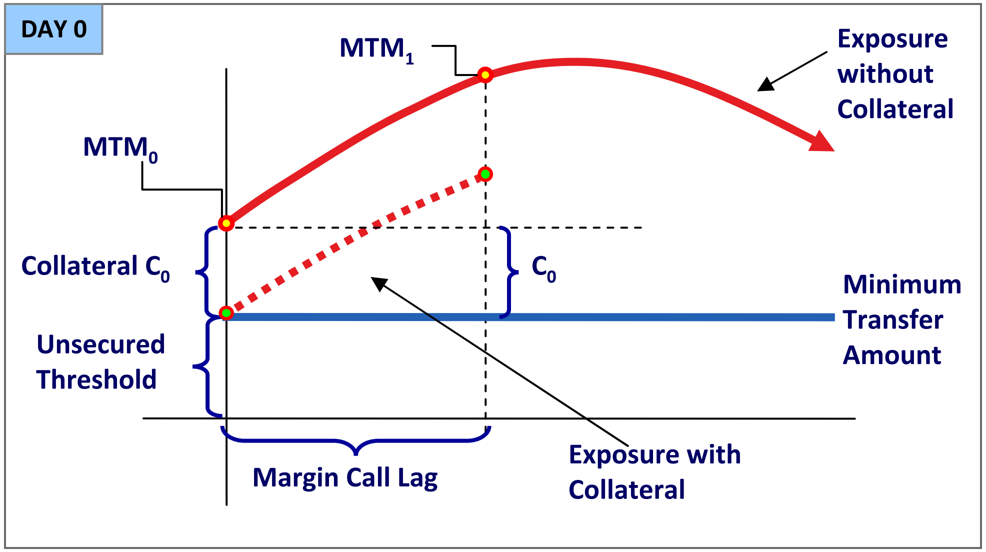
Sample Path of Counterparty's Exposures

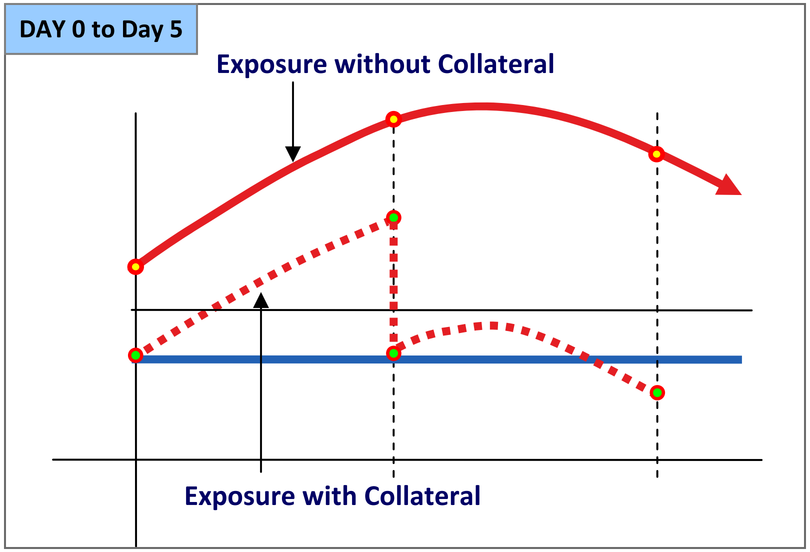
Trade Number	Time Bucket (Years)					
	0	1	2	3	4	5
Trade 1	-1.2	-1.0	2.5	3.0	1.2	-1.4
Trade 2	2.6	3.0	3.5	2.0	4.0	5.0
Trade 3	1.5	-0.3	-1.7	1.3	2.7	1.9
Trade 4	-2.7	-2.5	-1.1	-3.1	1.0	1.3
Trade 5	1.0	-1.5	2.0	1.5	0.6	2.0
Exposure						
Without Netting	5.1	3.0	8.0	7.8	9.5	10.2
With Netting	1.2	-2.3	5.2	4.7	9.5	8.8
Exposure (w/ Netting)	1.2	0.0	5.2	4.7	9.5	8.8
Collateral and Exposure						
Collateral Account*	1.0	-2.0	5.0	4.5	9.0	8.0
Exposure (w/ Netting & Collateral)	0.2	-0.3	0.2	0.2	0.5	0.8

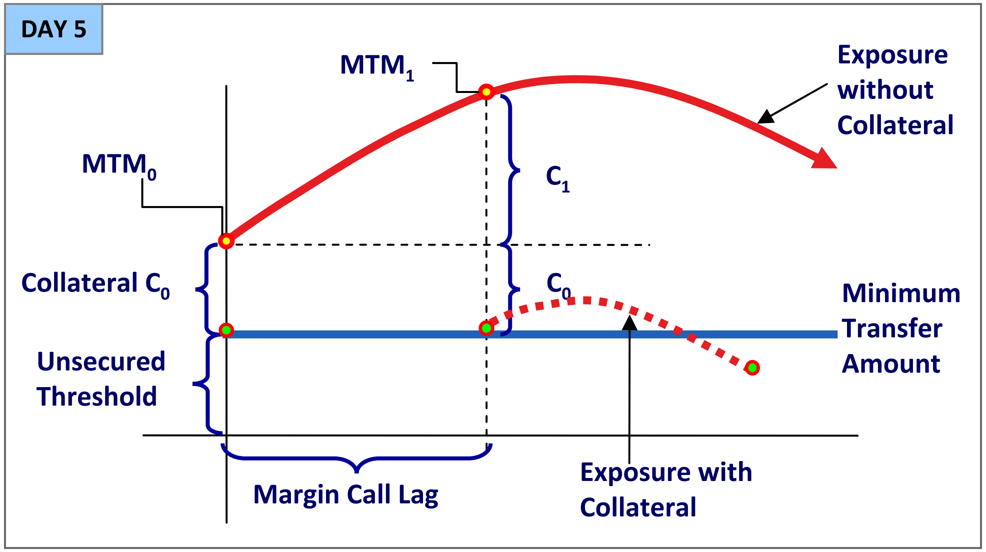
* Positive number means that we hold the collateral and negative means that we provide collateral to counterparty.

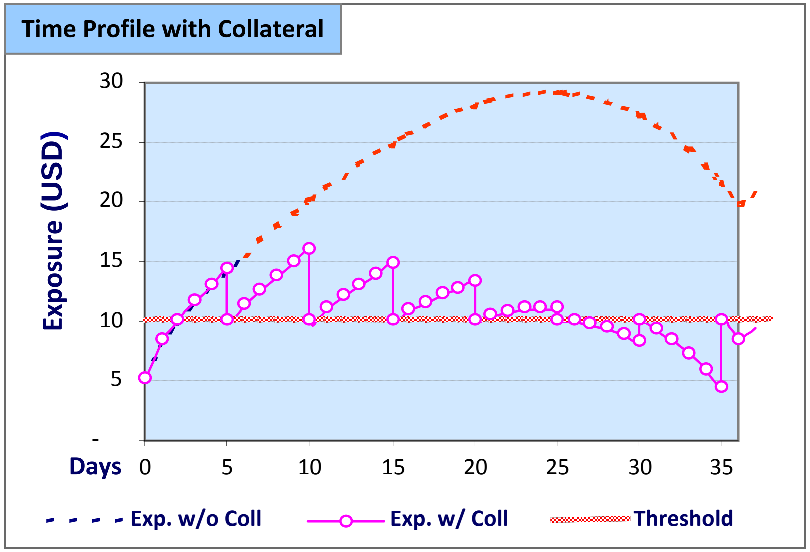


Impact of Collateral on Exposure









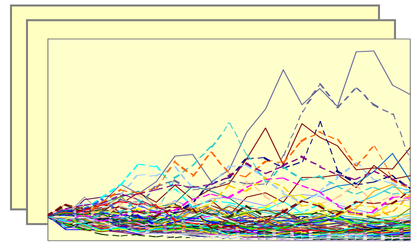
Counterparty Exposure Calculation Process

Market Data / Parameter Calibration

Years	HKD	KRW	SGD	TWD
0.5	33.48	12.38	66.85	14.92
1.0	32.49	19.18	40.88	22.42
1.5	31.56	22.97	31.96	23.13
2.0	30.67	24.42	27.63	23.18
2.5	29.84	24.89	25.18	23.18
3.0	29.05	25.03	23.68	23.18
3.5	28.30	25.07	22.70	23.18
4.0	27.59	25.09	22.05	23.18
4.5	26.91	25.09	21.61	23.18
5.0	26.27	25.09	21.30	23.18
5.5	25.66	25.09	21.08	23.18

Simulated Market Scenario
(Interest Rates, FX Rates, Credit Spreads, Commodities, etc.)

Correlated Market Scenarios



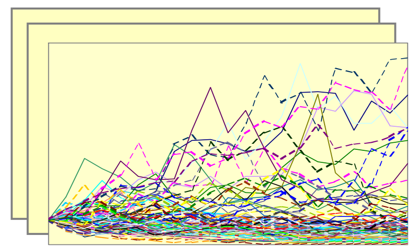
Trade Data

Prd	Deal Id	Inst Desc	Trade Date
COM	21846	Fixed/Float Swap	2-Oct-2002
COM	21949	Fixed/Float Swap	7-Oct-2002
COM	21956	Fixed/Float Swap	4-Oct-2002
COM	21958	Fixed/Float Swap	4-Oct-2002
COM	23222	Fixed/Float Swap	25-Oct-2002
COM	23224	Cap	25-Oct-2002
COM	23225	Floor	25-Oct-2002
COM	23226	Bermudan Swaption	25-Oct-2002
COM	23233	Power Financial Swap	25-Oct-2002

Valuation

- Full Revaluation
- P&L Grids
- Taylor Expansion
- Notional Factors

Simulated PV's



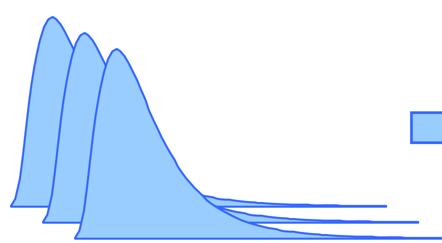
Netting, Collateral, Referential Data

CSD#	BA MTA	CP MTA	BA THRESHOLD	CP THRESHOLD
14567	1,000,000	500,000	50,000,000	20,000,000
34567	2,000,000	1,000,000	40,000,000	15,000,000
54789	500,000	100,000	20,000,000	10,000,000
46782	1,000,000	500,000	100,000,000	50,000,000
1120	500,000	500,000	30,000,000	25,000,000
3672	500,000	500,000	25,000,000	20,000,000
12567	1,000,000	500,000	100,000,000	50,000,000

Aggregation

- Collateralized
- Credit Lines and Availability
- Other Credit Mitigations

Exposure Distributions



Analytic Tools

- Limit Monitoring
- CVA
- Economic Capital
- Stress
- Regulatory Capital

Pricing Counterparty Risk

The Credit Valuation Adjustment (CVA)

What is Credit Valuation Adjustment (CVA)?

- **CVA is the market value of the credit risk due to counterparty default**
  - It is equal to the Net Present Value of expected future credit losses due to counterparty default
  - CVA = PV { (Expected Positive Exposure) $\times$ (Credit Spread) }

- **CVA is sensitive to both the exposure and the 2 counterparties credit spreads**
  - Adjustment can be positive or negative depending on which of the 2 counterparties bear a larger portion of the exposure and credit quality

Counterparty A

Rating:	AA-
Avg. CDS Spread:	130 bp
Avg. Exposure:	\$11 MM

Pay Fixed →

10-Year USD Interest Rate Swap

← **Pay Floating**

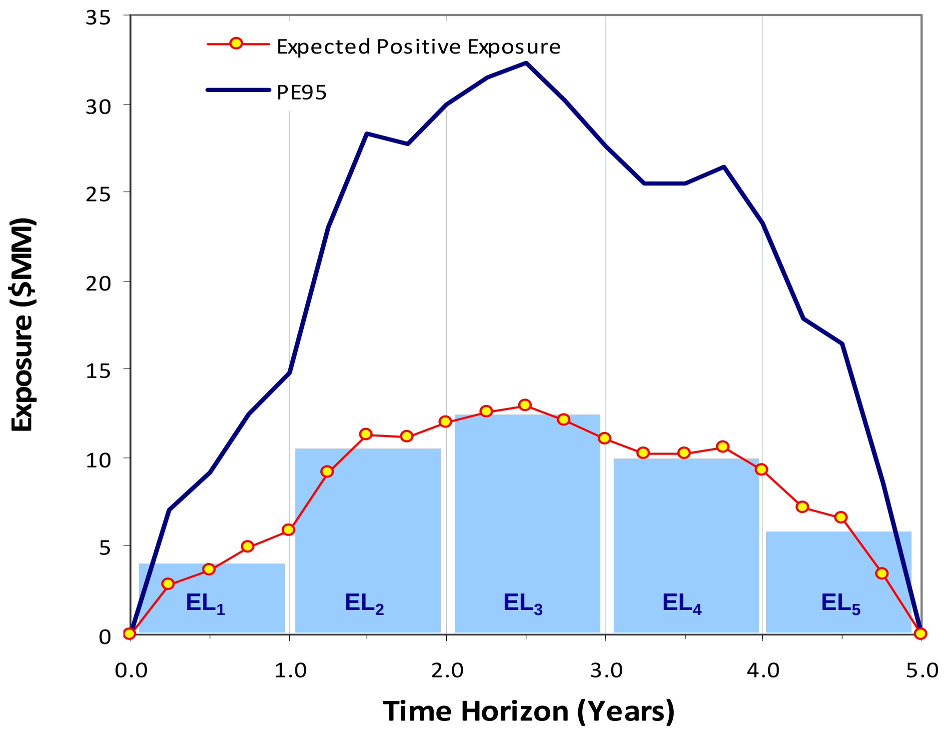
Counterparty B

Rating:	BB
Avg. CDS Spread:	245 bp
Avg. Exposure:	\$4.0 MM

  - CVA impacts P&L even when there is no counterparty default
  - Accurate pricing of credit risk is important to provide proper incentive to traders

- **During the Credit Crisis (2007-2009) mark-to-market losses were larger than default losses**
  - CVA losses were much larger than actual losses from counterparty default
  - Roughly two-thirds of counterparty losses were due to CVA losses and only a third were due to actual defaults (BCBS Dec 2009)

Calculating Unilateral CVA



$CVA = EL_1 + EL_2 + \ldots + EL_N$

$EL_k = EPE_k \times \Delta PD_k \times LGD_k \times DF_k$

EPE = Expected Positive Exposure
PD = Cumulative Probability of Default*
$\Delta PD = PD(t_{i+1}) - PD(t_i)$
LGD = Loss Given Default = 1 – Recovery Rate
DF = Discount Factor

*PD is bootstrapped from the credit spread using the valuation formula for credit default swap.
This is the PD of the counterparty as seen by the Bank and implied by the credit spread of the counterparty.

Time Horizon	Avg. EPE	Cumulative PD	Marginal PD	Discount Factor	EL
0	0	0.0%	0.00%	1.0000	0
1	2,871	1.0%	1.03%	0.9608	17
2	9,383	3.2%	2.15%	0.9231	112
3	12,403	5.8%	2.65%	0.8869	175
4	10,495	8.4%	2.60%	0.8521	140
5	6,613	10.9%	2.50%	0.8187	81
				CVA	525

Calculating Bilateral CVA

- **To calculate CVA, we make two adjustments**
  - Use current market-based implied volatilities and correlations to generate exposures (risk-neutral parameters)
  - Use current single-name credit spreads (if available) instead of historical default rates
- **Bilateral CVA considers the credit quality of both counterparties as well as the exposure of one vs. the other**
  - If every dealer demanded to be compensated for the risk they take without regard to the risk that their counterparty is taking, liquidity in the interbank market would dry very fast
- **Calculate market value of credit risk for both sides**
  - Calculate unilateral CVA of Counterparty A: CVA(A)
  - Calculate unilateral CVA of Counterparty B: CVA(B)
  - Counterparty A's Net CVA = CVA(A) – CVA(B)

Counterparty A

Rating:	AA-
Avg. CDS Spread:	130 bp
Avg. Expected Exposure:	$11 MM
CVA:	$2.7 MM

Pay Fixed →

10-Year USD Interest Rate Swap

← **Pay Floating**

Counterparty B

Rating:	BB
Avg. CDS Spread:	245 bp
Avg. Expected Exposure:	$4.0 MM
CVA:	$0.5 MM

Counterparty A's Net CVA = \$2.7MM - \$0.5MM = \$2.2MM

CVA(A) = \$11MM × 245bp × 10 years = \$2.7MM

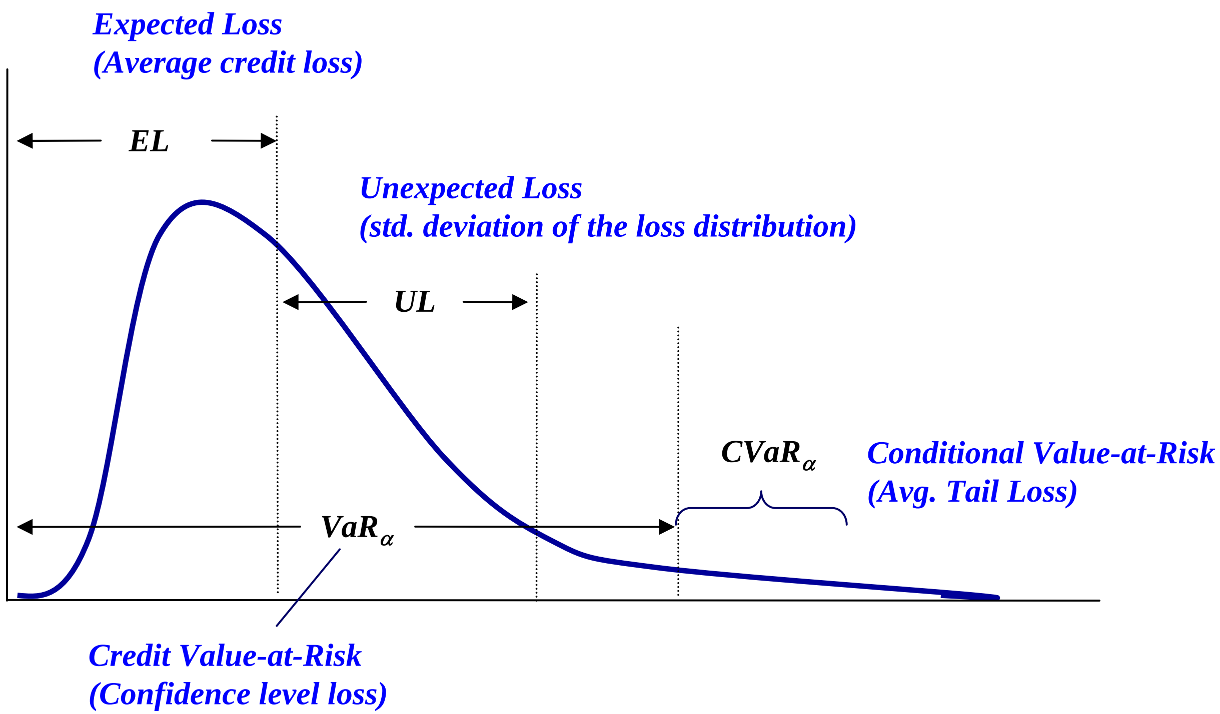
Counterparty B's Net CVA = \$0.5 - \$2.7MM = -\$2.2MM

CVA(B) = \$4MM × 130bp × 10 years = \$0.5MM

Credit Risk Capital

What is Credit Risk Capital?

- **Credit Risk Capital – Amount of money that a Firm needs to set aside to cover unexpected losses due to borrower or counterparty default**



- **Capital Requirement – Bank regulations set a framework under the Basel Accord on how banks and other depository institutions should calculate and handle heir capital requirements.**

The Basel Accord

- **A set of agreements set by the Basel Committee on Bank Supervision (BCBS)**
  - Provides recommendations on banking regulations in regards to credit risk, market risk and operational risk.
  - The purpose of the accord is to ensure that financial institutions have enough capital on account to meet obligations and absorb unexpected losses

- **The Accord uses the “three pillars” concept**
  - Pillar 1: Minimum Capital Requirements (addressing credit, operational and market risks)
  - Pillar 2: Supervisory Review (deals with all other risks a bank may face)
  - Pillar 3: Market Discipline– to promote greater stability in the financial system

- **Under Pillar 1, Credit Risk can be calculated using one of three approaches:**
  - Standardized Approach
    - Uses standard risk weights (e.g., 0% for short term govt. bonds, 20% for OECD banks, etc.)
  - Foundation IRB (Internal Ratings-Based) Approach
    - Banks are allowed to develop their own PD model but can use only regulator prescribed LGD and other parameters required for calculating Risk-Weighted Assets (RWA)
  - Advanced IRB Approach
    - Banks are allowed to develop their own empirical models to estimate Probability of Default (PD), Exposure at Default (EAD), Loss Given Default (LGD), and other parameters used in calculating RWA

Calculating Regulatory Capital

- **Regulatory Credit Capital under Basel II is equal to 8% of the Risk-Weighted Asset (RWA)**
  - RWA – Bank's asset weighted according to its credit risk
    - Example, loans secured by a letter of credit would have higher risk-weight than a mortgage loan that is secured with collateral or government securities have less risk-weight than corporate bonds
  - Risk-Weighted Asset (RWA) = Credit Risk Weight × Exposure at Default = CRW × EAD
  - CRW is the weight assigned to Bank's particular asset
  - EAD (Exposure at Default) is the time-weighted average of the Expected Positive Exposure (EPE) Profile times a multiplier equal to 1.4

- **Credit Risk Weight**
  - CRW is function of
    - Probability of Default (PD)
    - Loss Given Default (LGD)
    - Maturity of the Exposure (M)
  - Additional parameters R and "b" are functions of PD

$$CRW = LGD \times \left[N\left(\frac{N^{-1}(PD) + \sqrt{R}N^{-1}(0.999)}{\sqrt{1-R}} \right) \right] \times \left[\frac{1 + b \times (M - 2.5)}{1 - [1.5 \times b]} \right]$$

$$R = 0.12 \times \frac{\left(1 - e^{-50 \times PD}\right)}{\left(1 - e^{-50}\right)} + 0.24 \times \left[1 - \frac{\left(1 - e^{-50 \times PD}\right)}{\left(1 - e^{-50}\right)} \right]$$

$$b = \left(0.08451 - 0.05898 \times \ln(PD)\right)^2$$

- **CRW is based on a single-factor model where the default of a counterparty depends on the return of the counterparty's assets**
  - Single-factor is a stylized state-of-the-economy, and whereby the assets of the counterparty have a correlation equal to R