CFAspace

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Academy of Professional Finance 专业金融学院

CFA Level II

Fixed Income:

Credit Analysis Models

CFA Lecturer: Nan Chen

Framework

Reading

Reading: Credit Analysis Models

- Expected Loss and Credit Valuation Adjustment – Credit Risk Measures
- Credit Scores and Credit Ratings
  - Impact of Credit Migration on Bond Price
- Structural Model and Reduced Form Model
- Credit Spread Analysis
  - Value of Risky Bond given Credit Risk Parameters
  - Interpret Changes in Credit Spreads
  - The Term Structure of Credit Spreads
- Credit Analysis for Securitized Debt

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Expected Loss and Credit Valuation Adjustment

EXAMPLE:
A 3-year, $100 par, zero-coupon corporate bond has a hazard rate of 2% per year. Its recovery rate is 60% and the benchmark rate curve is flat at 3%. Calculate the expected exposure, probability of survival, probability of default, loss given default and CVA.

Expected loss for any period
=Loss given Default (LGD) for that period x Probability of Default (PD) for that period

- **Loss given default (LGD)** =Loss severity x Expected exposure
  - *Expected Exposure*: the amount of money a bond investor in a credit risky bond stands to lose at a point in time before any recovery is factored in.
  - *Loss Severity*= 1- Recovery Rate, where recovery rate is the percentage recovered in the event of a default.

Expected Loss and Credit Valuation Adjustment

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Loss given default (LGD) =Loss severity x Expected exposure

Year	Expected Exposure	Loss Severity[d]	Loss given Default	Hazard Rate	Probability of Default (PD)	Probability of Survival(PS)	Expected Loss	PV of Expected Loss
1	94.260 [a]	40%	37.704 [e]	2%	2.000% [f]	98.000% [g]	0.75408	0.73211 [l]
2	97.087 [b]	40%	38.835	2%	1.960% [h]	96.040% [i]	0.76117	0.71747 [m]
3	100 [c]	40%	40.000	2%	1.921% [j]	94.119% [k]	0.76832	0.70312 [n]
								2.15271

a. Expected Exposure at Year 1=Bond Face Value discounted for 2 periods at 3% =$100/[(1+3%)^2]=$94.260

b. Expected Exposure at Year 2=Bond Face Value discounted for 1 period at 3% =$100/[(1+3%)^1]=$97.087

c. Expected Exposure at Year 3= Bond Par Value or Bond Face Value =$100

d. Loss Severity = 1- Recovery Rate=1-60%=40%

e. Loss given Default= Loss Severity * Expected Exposure =$ 94.260*40%=$37.704

Expected Loss and Credit Valuation Adjustment

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Expected loss for any period
=Loss given Default (LGD) for that period x Probability of Default (PD) for that period

- Loss given default (LGD) =Loss severity x Expected exposure
- **Probability of Default (PD):** the likelihood of default
  - Hazard Rate: The initial probability of default
  - Probability of Default in each subsequent year= the conditional probability of default given that default has previously not occurred
  - $PD_t = PS_{t-1} \times$ Hazard Rate
  - Probability of survival=1 – the cumulative conditional probability of default

Expected Loss and Credit Valuation Adjustment

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- **$PD_t = PS_{t-1}$ x Hazard Rate**
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f. $PD_1 = PS_0 * \text{Hazard Rate} = 100\% * 2\% = 2\%$

g. PS_1 = 1- Cumulative Probability of Default as of Year 1=1-2%=98%

h. $PD_2 = PS_1 * \text{Hazard Rate} = 98\% * 2\% = 1.960\%$

i. PS_2 = 1- Cumulative Probability of Default as of Year 2=1-(2%+1.960%)=96.040%

j. $PD_3 = PS_2 * \text{Hazard Rate} = 96.040\% * 2\% = 1.921\%$

k. PS_3 = 1- Cumulative Probability of Default as of Year 3=1-(2%+1.960%+1.921%)=94.119%

Expected Loss and Credit Valuation Adjustment

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l. PV of Expected Loss for Year 1 =$0.75408/[(1+3%)^1]=$0.73211

m. PV of Expected Loss for Year 2 =$0.76117/[(1+3%)^2]=$0.71474

n. PV of Expected Loss for Year 3 =$0.76832/[(1+3%)^3]=$0.70312

Expected Loss and Credit Valuation Adjustment

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Credit Valuation Adjustment (CVA): the sum of the present value of the expected loss for each period
Credit Valuation Adjustment (CVA) = Price of risk-free bond - Price of risky bond

ANSWER:
Price of risk-free bond = $100/(1+3%)^3=$91.51
Price of risky bond= Price of risk-free bond - CVA = $91.51-$2.153=$89.36

IRR if the Bond Defaults and IRR if the Bond does not Default

EXAMPLE:
A 3-year, $100 par, zero-coupon corporate bond has a hazard rate of 2% per year. Its recovery rate is 60% and the benchmark rate curve is flat at 3%. Calculate the expected exposure, probability of survival, probability of default, loss given default and CVA.

	Year 1 Cash Flow	Year 2 Cash Flow	Year 3 Cash Flow
Default	$56.56 [a]	$58.25 [b]	$60.00 [c]
No Default	$0.00	$0.00	$100.00

a. If default occurs, a recovery of 60% of exposure or 0.6 × 94.26 = $56.56 occurs.

b and c. in years 2 and 3, in case of default, the recovery amounts are 0.6 x 97.09= $58.25 and 0.6 x 100=$60 respectively.

If the bond defaults in year 1, the investor's IRR:

PV = –89.36, N=1, FV = 56.56, CPT I/Y = –36.71%

If the bond defaults in year 2, the investor's IRR:

PV = –89.36, N=2, FV = 58.25, CPT I/Y = –19.26%

If the bond defaults in year 3, the investor's IRR:

PV = –89.36, N=3, FV = 60.0, CPT I/Y = –12.43%

If the bond does not default over its life, the investor's IRR:

PV = –89.36, N=3, FV = 100.0, CPT I/Y = 3.82%

Compare the Credit Risk of Several Bonds using Expected Loss

EXAMPLE:

Given the following information, which bond has the least amount of credit risk?

Bond	Exposure(per $100 par)	Recovery(per $100 par)	Probability of Default	Expected Loss
A	98	50	2.50%	1.20 [a]
B	94	56	3.00%	1.14 [b]
C	89	49	4.65%	1.86 [c]

Expected loss = Loss given default (LDG) * Probability of Default

Loss given default = loss severity * expected exposure

Loss Severity = 1 – Recovery Rate

Loss given default (per $100 par value) = Exposure - Recovery

ANSWER:

a. Expected Loss for Bond A = (98-50)*2.50%=1.20

b. Expected Loss for Bond B = (94-56)*3.00%=1.14

c. Expected Loss for Bond C = (89-49)*4.65%=1.86

Based on expected loss, everything elseconstant, bond C is the most risky while bond B has the least credit risk.

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Credit Scores and Credit Ratings

Credit Scoring	Credit Ratings
used for small businesses and individuals	issued for corporate debt, asset-backed securities, and government and quasi-government debt
A higher credit score indicates better credit quality.	▪ Higher-rated bonds indicate better credit quality and trade at lower spreads relative to their benchmark rates. ▪ Three major global credit rating agencies -Moody's, Standard & Poor's, and Fitch Ratings ▪ Rating agencies provides a letter grade and outlook: positive, negative, stable.
FICO scores are higher for those with ▪ longer credit ▪ absence of delinquencies ▪ lower utilization(outstanding balance divided by available line) ▪ fewer credit inquires, and ▪ a wider variety of types of credit used.	▪ The issuer rating for a company is typically for its **senior unsecured debt**. ▪ **Notching** is the practice of lowering the rating by one or more levels for more subordinate debt of the issuer. ▪ Notching accounts for LGD differences between different classes of debt by the same issuer
Credit scores and credit ratings are both **ordinal ratings** (higher = better).	

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Impact of Credit Migration on Bond Price

How Credit Migration Impacts Bond Price?

- **Credit migration**: change in rating
- A change in credit rating generally reflects a change in the bond's credit risk.
- A change in credit risk results in a change in credit spread for the bond.
- Δ%P = – (modified duration of the bond) × (Δ spread): change in credit spread leads to change in price.

EXAMPLE:
Suppose a bond with a modified duration of 6.32 gets downgraded from A to BBB. The typical A credit spread is 99 bps, while the typical BBB credit spread is 127 bps.

Calculate the percentage change in price of the bond assuming that the bond is priced at typical spreads.

ANSWER:
Change in spread = (127 – 99) = 28 bps = 0.0028.

Δ%P = – (modified duration of the bond) × (Δ spread)
= –6.32 × 0.0028 = –0.0177 or –1.77%.

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Structural Models

Holding the company's equity is economically equivalent to owning a *European call option* on the company's assets.

Balance Sheet of a Simple Company at Time t	
Assets A_t	**Debt D(t, T)** Zero-coupon bond *maturity T *face value K
	Equity S_t

Asset = Debt + Equity

$A_t = D(t,T) + S_t$

At Time T,

If $A_T >= K$

The equity holders will pay off the debt and keep what's left over. $\Leftrightarrow S_T = A_T - K$

If $A_T < K$

The equity holders will default on the debt issue. $\Leftrightarrow S_T = 0$

the time T value of the equity is:

$$S_T = \begin{cases} A_T - K & \text{if} \quad A_T \geq K \\ 0 & \text{if} \quad A_T < K \end{cases} = \max[A_T - K, 0]$$

Structural Models

Owning the company's **debt** is economically equivalent to *owning a riskless bond* that pays K dollars with certainty at time T, and simultaneously *selling a European put option on the assets* of the company with strike price K and maturity T.

Value of risky debt = Value of a risk-free debt – Value of a put option on the company's assets

Value of risky debt = Value of a risk-free debt – CVA

➡ ***CVA= Value of the put option***

Balance Sheet of a Simple Company at Time t	
Assets A_t	**Debt D(t, T)** Zero-coupon bond *maturity T *face value K
	Equity S_t

The time T value of the company's debt is:

$$D(T,T) = K - \begin{cases} 0 & \text{if } A_T \geq K \\ K - A_T & \text{if } A_T < K \end{cases} = K - \max[K - A_T, 0]$$

$$= \min[K, A_T]$$

At Time T,

If $A_T >= K$

The debt holders get paid for K. ⇔ $D_T = K$

If $A_T < K$

The company defaults and debt holders will only be paid the value of assets. ⇔ $D_T = A_T$

Structural Models

➢ **Disadvantages of Structural Models:**

•Structural models assume a simple balance sheet structure. Complex balance sheets cannot be modeled.

•When companies have off balance sheet debt, the default barrier under structural models (K) would be inaccurate and hence the estimated outputs of the model will be inaccurate.

•One of the key assumptions of the structural model is that the assets of the company are traded in the market. This restrictive assumption makes the structural model impractical.

➢ **Advantages of Structural Models:**

•Structural models provide an economic rationale for default (i.e., $A_T < K$) and explain why default occurs.

•Structural models utilize option pricing models to value risky debt.

Reduced Form Models

- **Reduced form models** statistically model when default occurs**.**
- A key input into the RF model is the **default intensity**, which is the probability of default over the next (small) time period.
- Default intensity can be estimated using **regression models**, which employ independent variables including
  - company specific variables (e.g., leverage, beta, interest coverage ratio)
  - as well as macro-economic variables.

Structural Models	Reduced Form Models
The probability of default under the structural mode is *endogenous*.	Default under the RF model is a randomly occurring *exogenous* variable.

- **Advantages of Reduced Form Models:**

•RF models do not assume that the assets of a company trade.
•Default intensity is allowed to vary as company fundamentals change, as well as when the state of the economy changes.

- **Disadvantages of Reduced Form Models:**

•RF models do not explain why default occurs.
•Under the RF models, default is treated as a random event (i.e., a surprise), but in reality, default is often preceded by several downgrades.

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Credit Valuation Adjustment (CVA) = VND – Value of Risky Bond

- Credit Valuation Adjustment (CVA) = Value of risk-free bond - Value of risky bond

- Credit Valuation Adjustment (CVA) = Value given no default (VND) - Value of risky bond

Zero Volatility for Benchmark Rates:

EXAMPLE:

A $100 par, 3.50%, annual-pay, 5-year AA corporate bond is currently priced with a credit spread of 135 bps over the benchmark par rate of 2%.

Calculate the bond's CVA implied in its market price.

ANSWER:

Credit Valuation Adjustment (CVA) = Value given no default (VND) - Value of risky bond

VND for the bond = present value of bond's cash flows using benchmark YTM
N = 5, PMT = 3.50, I/Y = 2, FV = 100, CPT PV = 107.07

Value of the risky bond = present value of bond's cash flows using YTM incorporating credit spread = 2% benchmark rate + 1.35% credit spread = 3.35%:
N = 5, PMT = 3.5, I/Y = 3.35, FV = 100, CPT PV = 100.68

CVA = VND – value of risky debt = 107.07 – 100.68 = $6.39

Credit Valuation Adjustment (CVA) = VND – Value of Risky Bond

❖ Credit Valuation Adjustment (CVA)
= Value of risk-free bond - Value of risky bond

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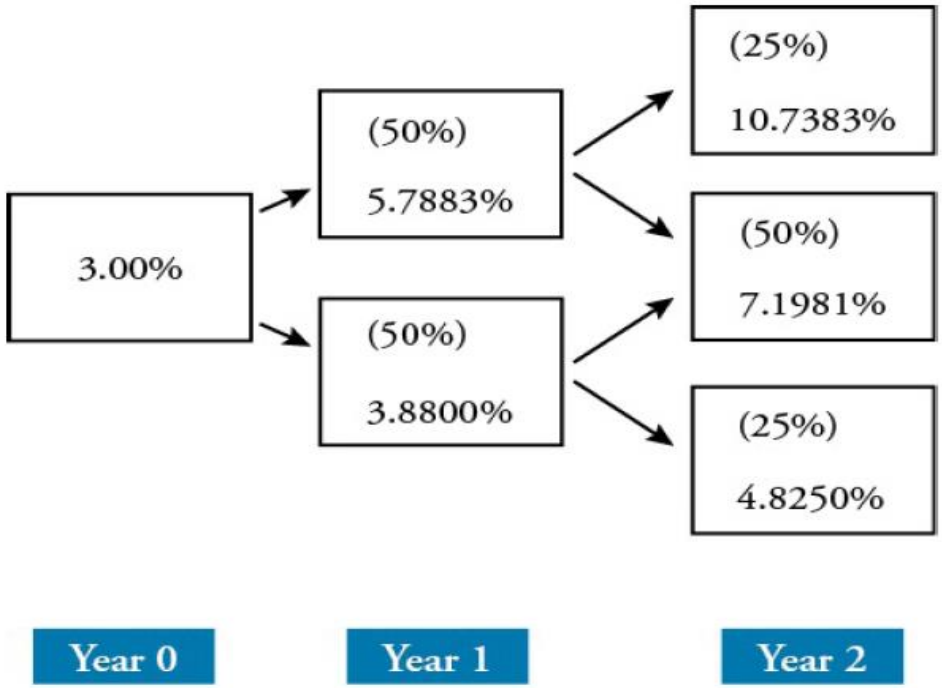
= Value given no default (VND) - Value of risky bond

Introduce Volatility in Future 1-period Benchmark Rates:

EXAMPLE:

For a 3-year, annual pay, 4% coupon, $100 par corporate bond using the benchmark interest rate tree shown below, calculate the VND for the bond and the expected exposure for each year.



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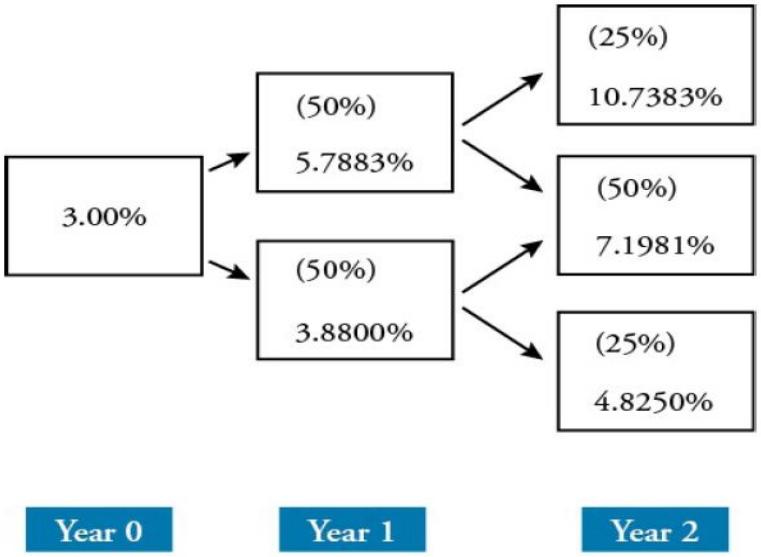

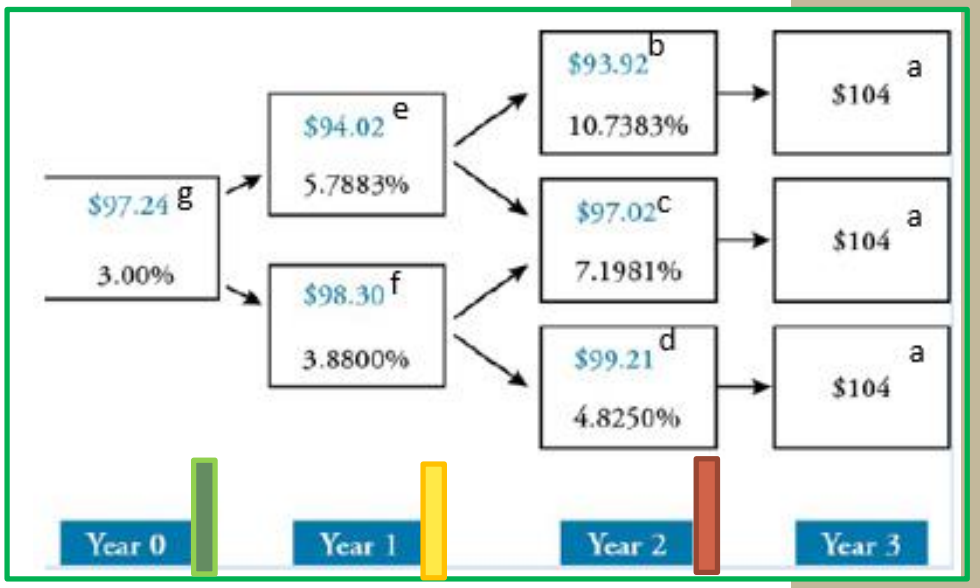

a. Value in Year 3=Par Value of Bond $100+ Coupon Payment $4=$104

b. Value at the top node in Year 2=$104/(1+10.7383%)=$93.92

c. Value at the middle node in Year 2=$104/(1+7.1981%)=$97.02

d. Value at the bottom node in Year 2=$104/(1+4.8250%)=$99.21

e. Value at the top node in Year 1=[(93.92+97.02)/2+4]/(1+5.7883%)=$94.02

f. Value at the bottom node in Year 1=[(97.02+99.21)/2+4]/(1+3.8800%)=$98.30

g. VND=Value at Year 0=[(94.02+98.30)/2+4]/(1+3.00%)=$97.24

Credit Valuation Adjustment (CVA) = VND – Value of Risky Bond

Introduce Volatility in Future 1-period Benchmark Rates:

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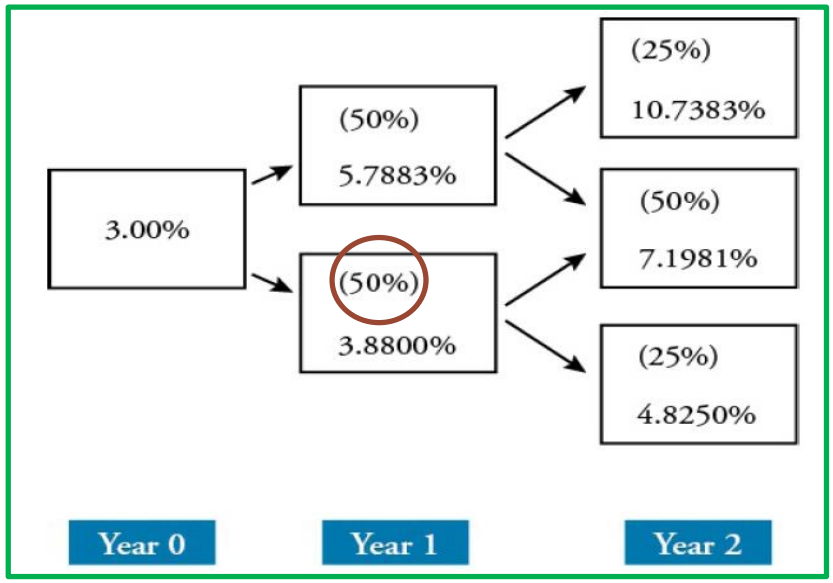

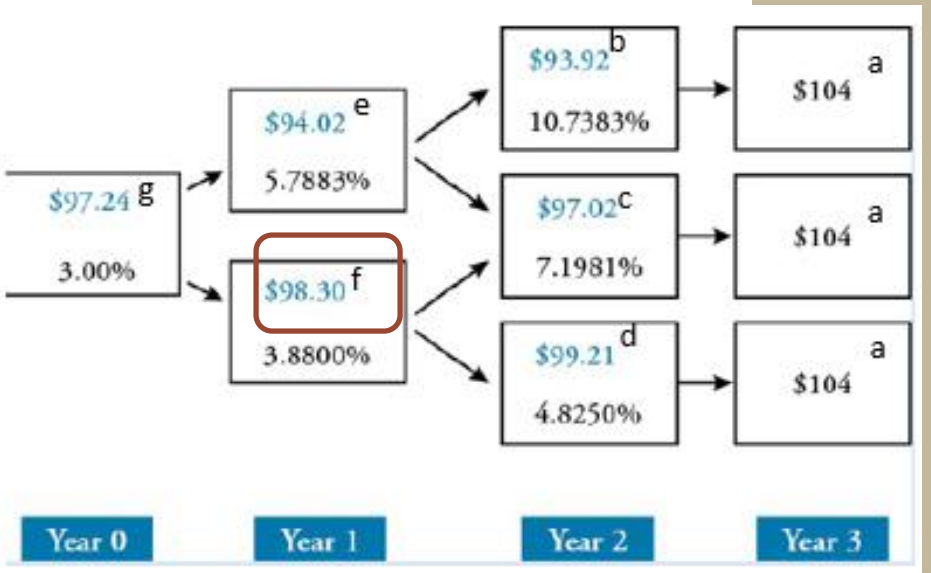

Expected Exposure for Year t = Σ (value in node i at time t × node probability) + coupon for year t

Expected exposure for Year 1 = (0.5)(98.30) + (0.5)(94.02) + 4 = $100.16

Expected exposure for Year 2 = (0.25)(93.92) + (0.5)(97.02) + (0.25)(99.21) + 4 = $100.79

Expected exposure for Year 3 = $104

Loss given default = Expected Exposure * (1-Recovery Rate)

Expected Loss = Loss given default (LDG) * Probability of Default (PD)

Credit Valuation Adjustment (CVA) = Sum of Present Value of Expected Loss

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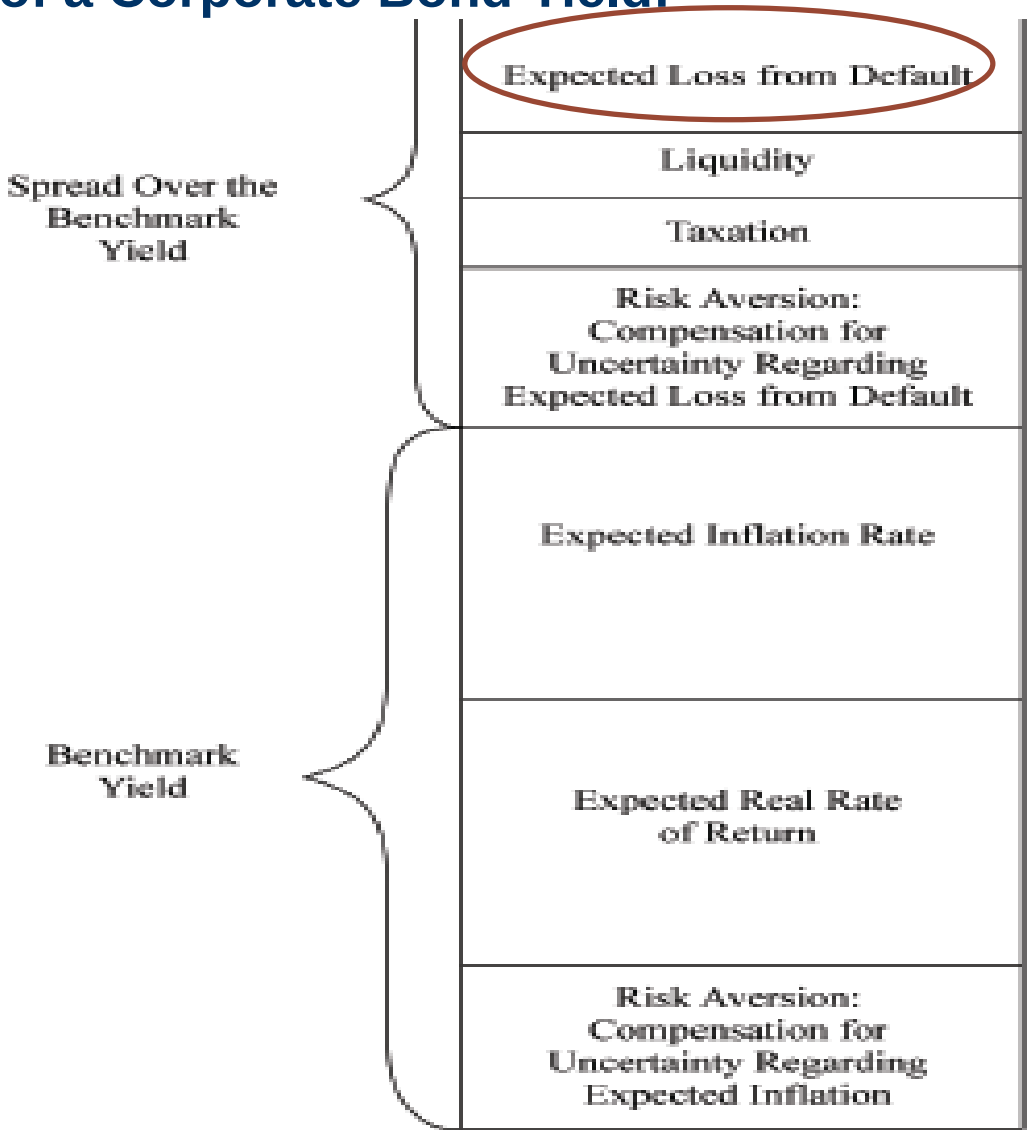
Interpret Changes in a Credit Spread

Components of a Corporate Bond Yield:



Interpret Changes in a Credit Spread

EXAMPLE:

A 3-year, annual pay, 3% XYZ corporate bond is priced at $102. The benchmark yield curve is flat at 1.75%.

A prepares a credit analysis assuming a hazard rate of 1.25% and a recovery rate of 70%:

Year	Expected Exposure	Loss Severity	Loss given Default	Hazard Rate	Probability of Default (PD)	Probability of Survival(PS)	Expected Loss	PV of Expected Loss
1	105.44 [c]	30%	31.63	1.25%	1.25%	98.750%	0.395	0.389
2	104.23 [b]	30%	31.27	1.25%	1.23%	97.516%	0.386	0.373
3	103.00 [a]	30%	30.90	1.25%	1.22%	96.297%	0.377	0.358
							CVA	1.12

B prepares a credit analysis assuming a hazard rate of 1.50% and a recovery rate of 60%, based on the expectations of a slowdown in the economy:

Year	Expected Exposure	Loss Severity	Loss given Default	Hazard Rate	Probability of Default (PD)	Probability of Survival(PS)	Expected Loss	PV of Expected Loss
1	105.44	40%	42.17	1.50%	1.50%	98.500%	0.633	0.622
2	104.23	40%	41.69	1.50%	1.48%	97.023%	0.616	0.595
3	103.00	40%	41.20	1.50%	1.46%	95.567%	0.600	0.569
							CVA	1.79

a. Expected Exposure at Year 3 =par value $100+coupon payment $3=$103

b. Expected Exposure at Year 2 =$103/(1+1.75%)+$3=$104.23

c. Expected Exposure at Year 1= $104.23/(1+1.75%)+$3 =$105.44

Interpret Changes in a Credit Spread

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A 3-year, annual pay, 3% XYZ corporate bond is priced at $102. The benchmark yield curve is flat at 1.75%.

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2	104.23 [b]	30%	31.27	1.25%	1.23%	97.516%	0.386	0.373
3	103.00 [a]	30%	30.90	1.25%	1.22%	96.297%	0.377	0.358
							CVA	1.12

B prepares a credit analysis assuming a hazard rate of 1.50% and a recovery rate of 60%, based on the expectations of a slowdown in the economy:

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2	104.23	40%	41.69	1.50%	1.48%	97.023%	0.616	0.595
3	103.00	40%	41.20	1.50%	1.46%	95.567%	0.600	0.569
							CVA	1.79

ANSWER:

1. ***Using A's estimates of hazard rate and recovery rate, XYZ bond is currently most likely undervalued.***

Using the benchmark rate, XYZ bond's VND is calculated as:

N = 3, PMT = 3, I/Y = 1.75, FV = 100, CPT PV = 103.62

Value of risky bond = VND – CVA = 103.62 – 1.12 = 102.50

The market price of $102 for the bond <$102.50, implies that the bond is undervalued.

Interpret Changes in a Credit Spread

EXAMPLE:

A 3-year, annual pay, 3% XYZ corporate bond is priced at $102. The benchmark yield curve is flat at 1.75%.

A prepares a credit analysis assuming a hazard rate of 1.25% and a recovery rate of 70%:

Year	Expected Exposure	Loss Severity	Loss given Default	Hazard Rate	Probability of Default (PD)	Probability of Survival(PS)	Expected Loss	PV of Expected Loss
1	105.44 [c]	30%	31.63	1.25%	1.25%	98.750%	0.395	0.389
2	104.23 [b]	30%	31.27	1.25%	1.23%	97.516%	0.386	0.373
3	103.00 [a]	30%	30.90	1.25%	1.22%	96.297%	0.377	0.358
							CVA	1.12

B prepares a credit analysis assuming a hazard rate of 1.50% and a recovery rate of 60%, based on the expectations of a slowdown in the economy:

Year	Expected Exposure	Loss Severity	Loss given Default	Hazard Rate	Probability of Default (PD)	Probability of Survival(PS)	Expected Loss	PV of Expected Loss
1	105.44	40%	42.17	1.50%	1.50%	98.500%	0.633	0.622
2	104.23	40%	41.69	1.50%	1.48%	97.023%	0.616	0.595
3	103.00	40%	41.20	1.50%	1.46%	95.567%	0.600	0.569
							CVA	1.79

ANSWER:

2. Using the market price of the bond, the credit spread on XYZ bond is closest to 0.55%.

Benchmark YTM= 1.75% (given)

YTM for XYZ bond: PV = –102, N = 3, PMT = 3, FV = 100, CPT I/Y = 2.30%

Credit spread = YTM for XYZ bond – Benchmark YTM= 2.30 – 1.75 = 0.55%

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ANSWER:

3. Assuming the market price changes to reflect B's expectations of PD and recovery rate, the new credit spread would be closest to 0.61%.

Based on the revised PD and recovery rate, CVA = 1.79.

Value of risky bond = VND – CVA = 103.62 – 1.79 = 101.83

YTM for XYZ bond: PV = –101.83, N = 3, PMT = 3, FV = 100, CPT I/Y = 2.36%

Credit spread = 2.36 – 1.75 = 0.61%

Framework

Reading

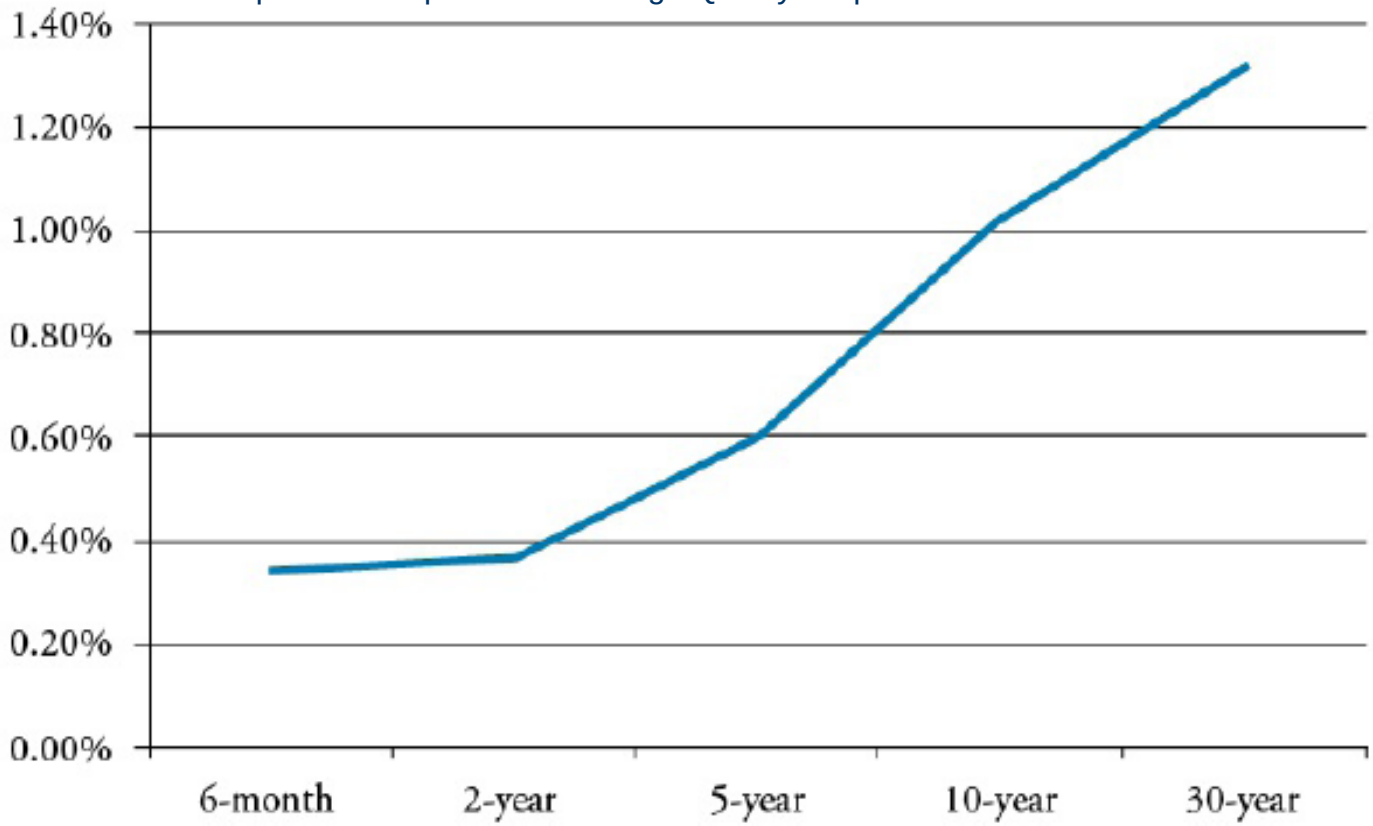
Reading: Credit Analysis Models

- Expected Loss and Credit Valuation Adjustment – Credit Risk Measures
- Credit Scores and Credit Ratings
  - Impact of Credit Migration on Bond Price
- Structural Model and Reduced Form Model
- Credit Spread Analysis
  - Value of Risky Bond given Credit Risk Parameters
  - Interpret Changes in Credit Spreads
  - The Term Structure of Credit Spreads
- Credit Analysis for Securitized Debt

The term structure of credit spreads

The term structure of credit spreads shows the relationship between credit spreads and maturity.

Example-Credit Spread Curve: High-Quality Corporates



Determinants of term structure of credit spreads

- **Credit quality:**
  - *AAA* term structures tend to be flat or slightly upward sloping.
  - *Lower-rated* sectors tend to have steeper spread curves, reflecting greater uncertainty as well as greater sensitivity to the business cycle.
- **Financial conditions:**
  - Spreads narrow during economic expansions.
  - Spreads widen during cyclical downturns.
- **Market supply and demand influence the shape of the spread curve:**
  - A credit spread includes a premium for lack of liquidity. Hence, less liquid maturities would show higher spreads.
  - Newly issued bonds are generally more liquid, when an issuer refinances a near-dated bond with a longer-term bond, the spread may appear to narrow for the longer maturity, possibly leading to an inverted credit spread curve.
- **Equity market volatility:**
  - Increases in equity volatility therefore tend to widen spreads and influence the shape of the credit spread curve.

Framework

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Credit Analysis of Securitized Debt

Components of Credit Analysis of Securitized Debt

Collateral Pool	▪ *Homogeneity* of a pool refers to the similarity of the assets within the collateral pool. ▪ *Granularity* of the pool refers to the actual number of obligations that comprise the overall structured finance instrument.
	❑ Short-term granular and homogenous structured finance vehicles: **statistical-based approach** ❑ Medium-term granular and homogenous obligations: **portfolio-based approach** ❑ Discrete and non-granular portfolios: evaluated at the **individual loan level**
Servicer Quality	▪ Investors in secured debt face the *operational and counterparty risk* of the servicers after origination. ▪ Indication of servicer quality: the servicer's past history.
Structure	One key structural element-**credit enhancement** ❑ Internal credit enhancement: (1) tranching of credit risk among classes with differing seniority; (2) overcollateralization; (3) excess servicing spread. ❑ External credit enhancement: third party guarantees.
	A special structure: **covered bond** ❑ Senior, secured bonds backed by a collateral pool as well as by the issuer. ❑ Covered bond investors have recourse rights.

CFAspace

Thank You!