Valuation and Risk Models

Weight: 30%

Content

Content

Session 3: Market Risk

1. Quantifying Volatility in VaR Models (☆☆☆)

2. Putting VaR to Work (☆☆☆)

3. Measures of Financial Risk (☆☆☆)

Session 4: Credit Risk

12. Country Risk: Determinants, Measures and Implications (☆☆)

13. External and Internal Ratings (☆☆☆)

14. Capital Structure in Banks (☆☆☆)

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Session 1

Brief

Basics concepts

- Valuation
  - Discount factor
  - Spot rate
  - Forward rate
  - Par rate
- Yields and spread
  - Yield to maturity (YTM)
  - Spread

Price Quotation and Calculation

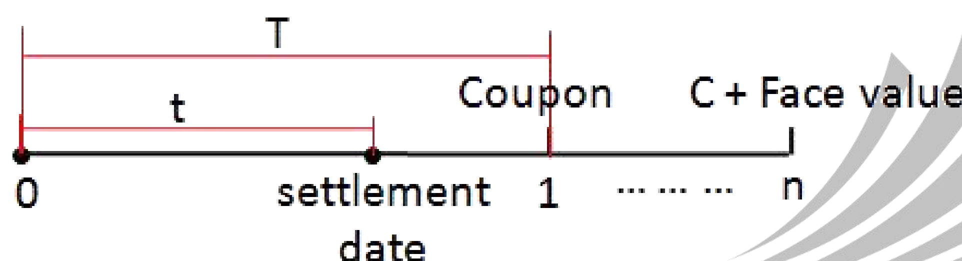
U.S. Treasury

- **T-Bills:** a discount instrument. The discount rate is expressed as a percentage of the face value.
- **T-Notes and T-bonds:** “32nds” convention.

Dirty price and clean price

- Full price (Dirty price) = Flat price (Clean price) + Accrued interest (AI)
- Accrued interest(AI):

$$AI = \frac{t}{T} \times Coupon$$



Discount Rate

Spot rates

- **Spot rates/zero rates**: A t-period spot rate, denoted as z(t), is the **yield to maturity on a zero-coupon bond** that matures in t-years.
- **Spot rate and discount factor :**

$$d(t) = \frac{1}{\left(1 + \frac{z(t)}{2}\right)^{2t}} \qquad z(t) = 2\left[\left(\frac{1}{d(t)}\right)^{\frac{1}{2t}} - 1\right]$$

- d(1.5)= 0.964132 → 1.5-year spot rate= 2.45%

Discount Rate

Forward rates

- **Forward rates:** are the interest rate on a bond or money market instrument traded in a forward market.

$$(1+z_A)^A \times (1+IFR_{A,B-A})^{B-A} = (1+z_B)^B$$

Maturity	Spot
0.5	1.60%
1	2.10%
1.5	2.45%

- Please calculate the 6-month implied forward rate from year 1 and year 1.5

$$(1+\frac{Z_{1.5}}{2})^3 = (1+\frac{Z_1}{2})^2 \times (1+\frac{f}{2}) \rightarrow f = 3.15\%$$

Discount Rate

Par rates

- **Par rate** is the rate at which the present value of a bond equals its par value. **(coupon rate)**

$$\frac{C_T}{2}\times\sum_{t=1}^{2T} d\left(\frac{t}{2}\right)+d(T)=1$$

Maturity	Discount factor
0.5	0.992063
1	0.979326
1.5	0.964132

$$\frac{ParRate\times 100}{2}\left[d(0.5)+d(1)+d(1.5)\right]$$

$$+d(1.5)\times 100=100$$

$$ParRate=2.44\%$$

Discount Rate

Pricing Bonds with Different Discount Rates

- **Example:** suppose a 1-year T-bond pays 4% coupon semiannually. Compute its price using the discount factors, spot rates, forward rates, and par rates.

Maturity	Discount Factor	Spot Rate	6-Month Forward Rate	Par Rate
0.5	0.992556	1.50%	1.50%	1.5000%
1.0	0.978842	2.15%	2.80%	2.1465%
1.5	0.962990	2.53%	3.29%	2.5225%
2.0	0.943299	2.94%	4.18%	2.9245%
2.5	0.921205	3.31%	4.80%	3.2839%
3.0	0.897961	3.62%	5.18%	3.5823%

Discount Rate

Pricing Bonds with Different Discount Rates

- **Answer:**

Using discount factors:

bond price=(2*0.992556)+(102*0.978842)=$101.83

Using spot rates:

bond price=$2/(1+0.015/2)+102/(1+0.0215/2)^2$=$101.83

Using forward rates:

bond price=2/(1+0.015/2)+102/[(1+0.015/2)(1+0.028/2)]=$101.83

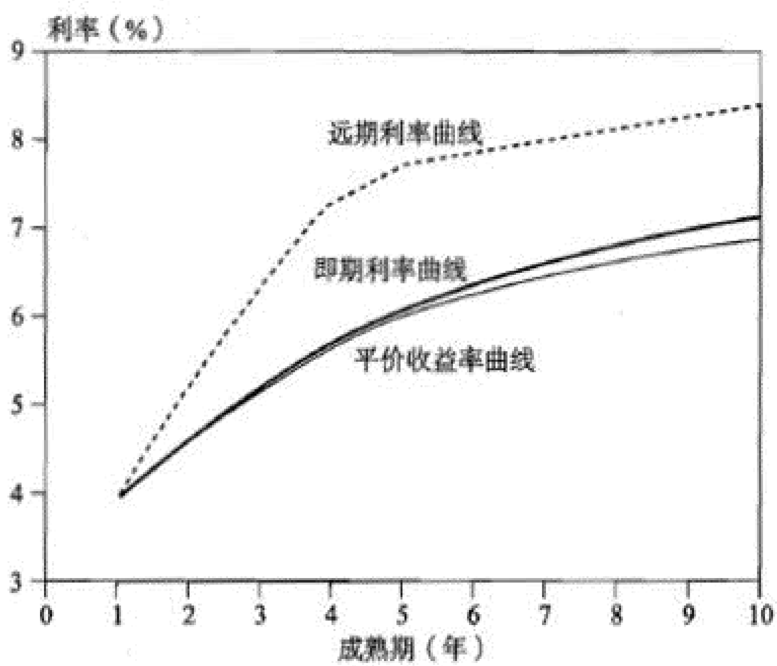
Using par rates:

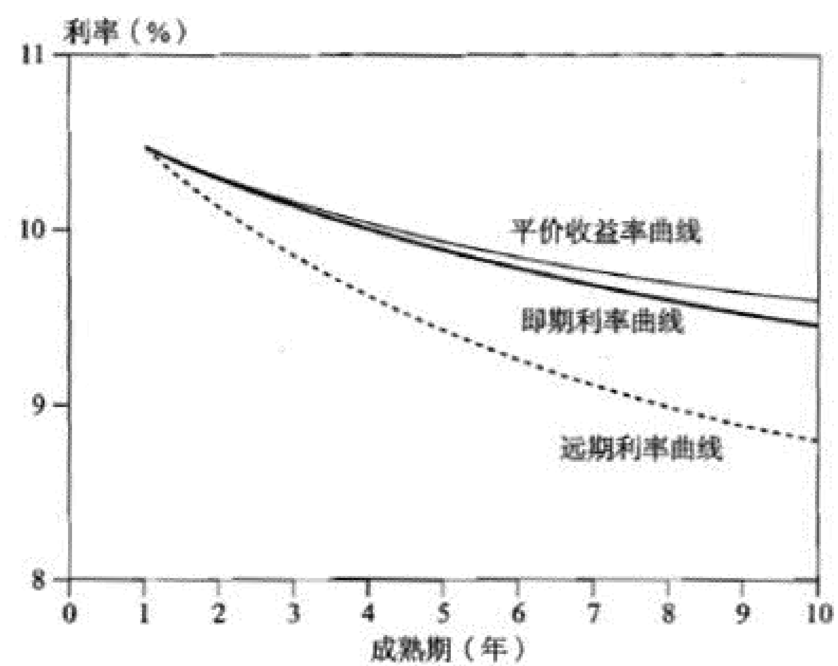
bond price=100+[(4/2-2.1465/2)(0.992556+0.978842)]=$101.83

Discount Rate

Relationship between spot, forward and par rates

- ✓ The relationship between yield and maturity/term is called the term structure of the yield. Why? They can be seen as weighted average of related ones.

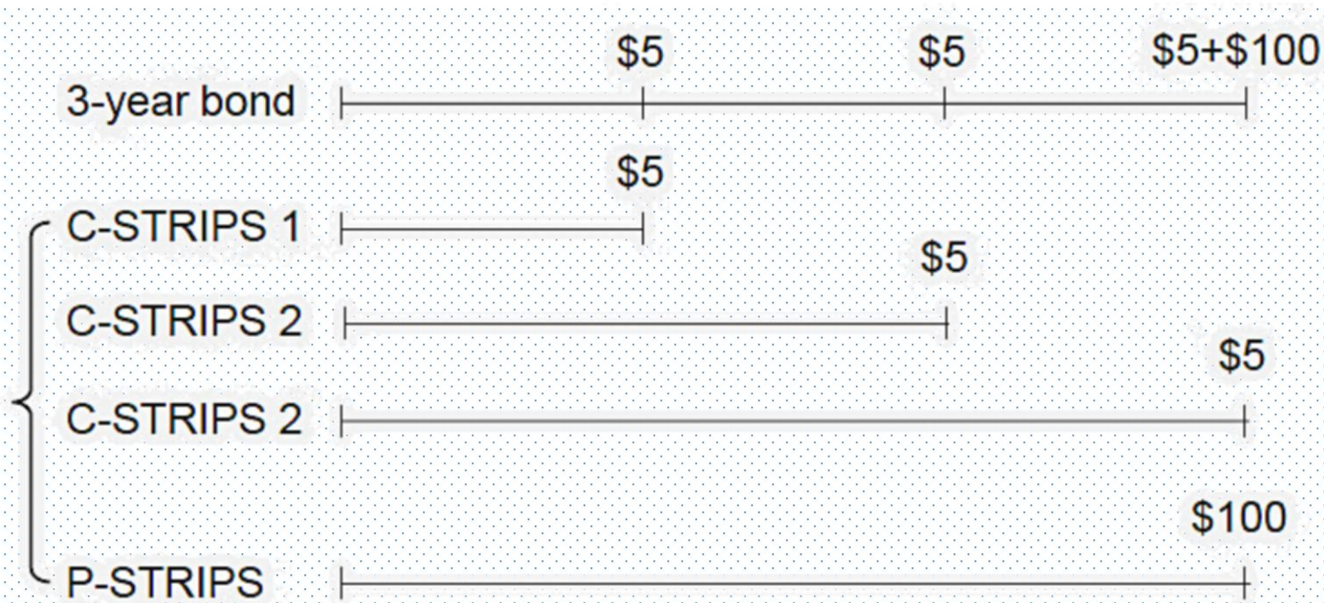




Discount Rate

Treasury STRIPS

- Principal (P-STRIPS) and coupon (C-STRIPS). Zero-coupon bonds issued by the U.S. Treasury are called STRIPS.



- Application: Bond replication

Discount Rate

Discount Factors & Swap Rates

- Example: Given the following swap rates, compute the discount factors for maturities ranging from six months to two years assuming a notional amount of $100.

Maturity	**0.5**	**1.0**	**1.5**	**2.0**
Swap rates	**0.65%**	**0.8%**	**1.02%**	**1.16%**

- Answer: $d(0.5)\times(100+\frac{0.65\%\times100}{2})=100 \quad d(0.5)=0.997$

$$d(0.5)\times\frac{0.8\%\times100}{2}+d(1.0)\times(100+\frac{0.8\%\times100}{2})=100$$

$$d(1)=0.992 \qquad d(1.5)=0.985 \qquad d(2)=0.977$$

Yield and Spread

Yield to Maturity

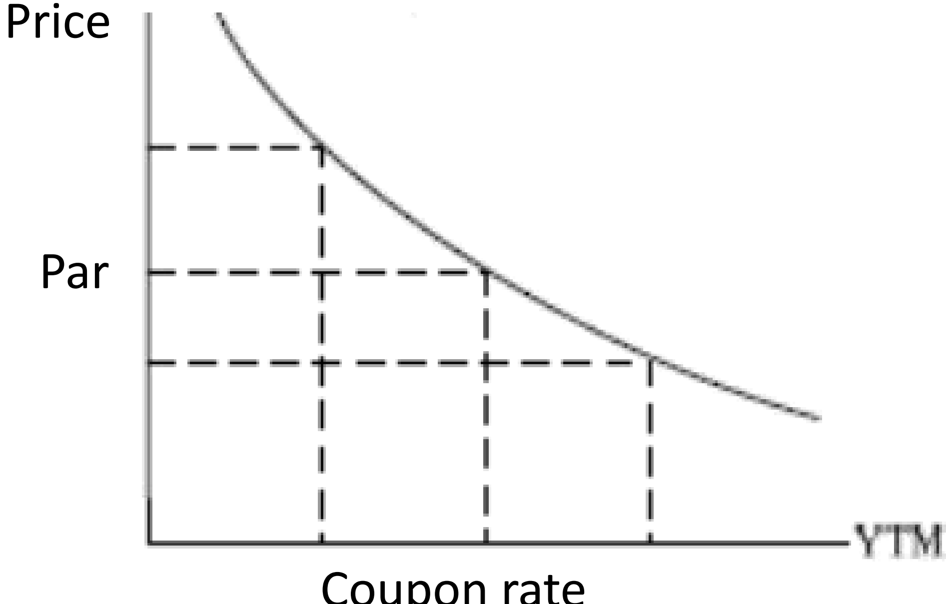
- YTM: is equivalent to its internal rate of return. The YTM is discount rate that equates the present value of all cash flows associated with the instrument to its price.

$$P = \frac{CF_1}{(1+YTM)} + \frac{CF_2}{(1+YTM)^2} + \ldots + \frac{CF_n}{(1+YTM)^n} = \frac{CF_1}{(1+z_1)} + \frac{CF_2}{(1+z_2)^2} + \ldots + \frac{CF_n}{(1+z_n)^n}$$

Yield and Spread

Relationship between bond price & YTM

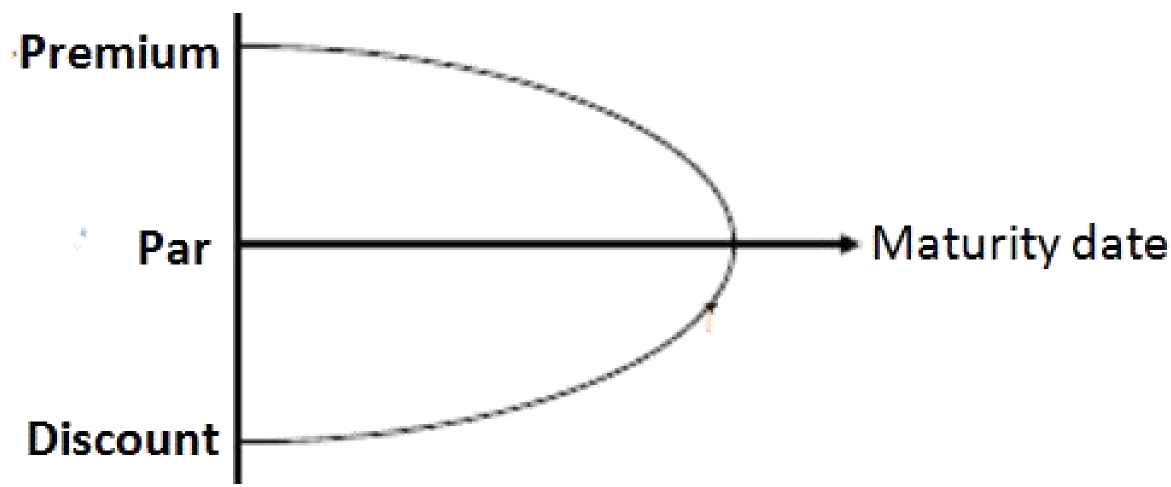
- The bond price is inversely related to the YTM
  - At premium: coupon rate > YTM
  - At par: coupon rate = YTM
  - At discount: coupon rate < YTM



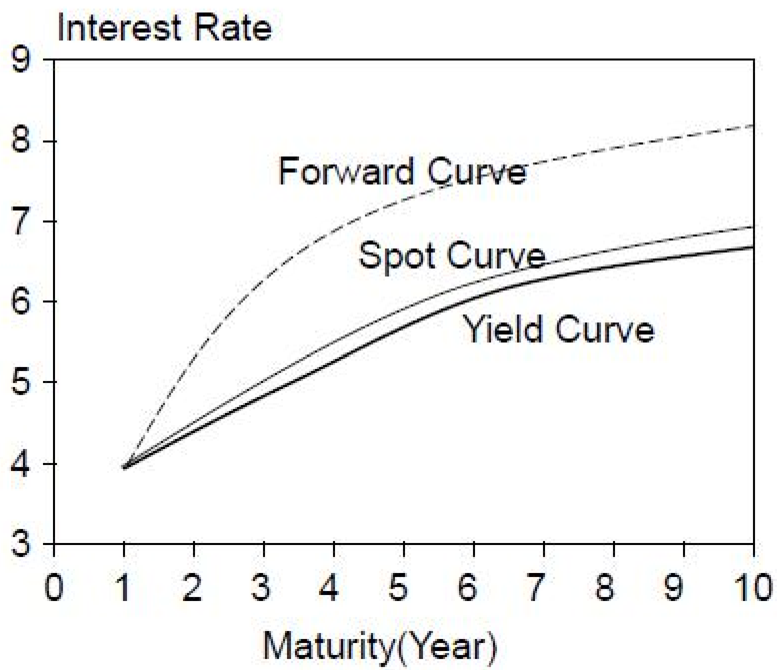
Yield and Spread

Constant-yield price trajectory

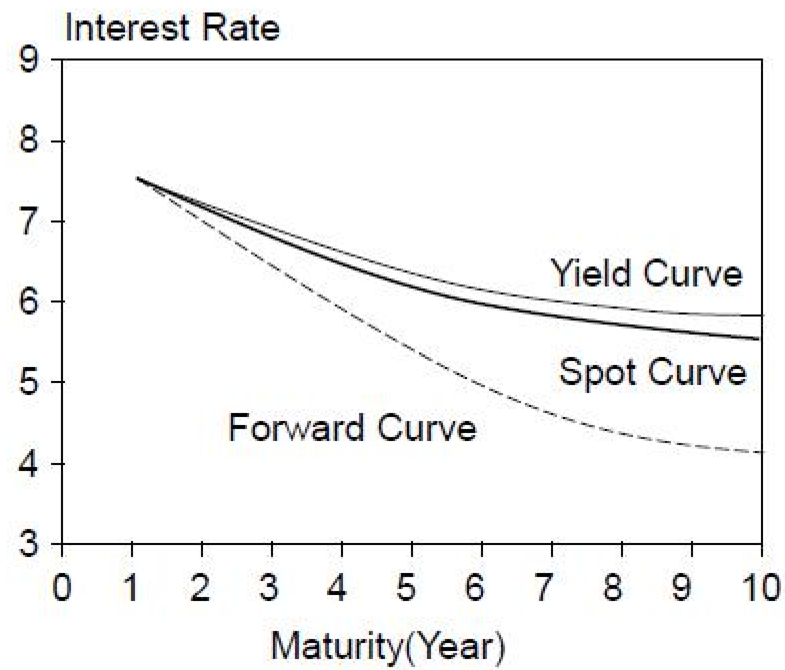
- **"Pull to par" effect**: if no default and the yield keep constant, bond price approaches par value as its time-to-maturity approaches zero.



Relationship between spot, YTM and forward rates



Upward-Sloping Term Structure



Downward-Sloping Term Structure

Yield and Spread

Spread

$$PV = \frac{PMT}{(1+z_1)^1} \quad \frac{PMT}{(1+z_2)^2} + \ldots\ldots + \frac{PMT+FV}{(1+z_N)^N}$$

$$= \frac{PMT}{(1+z_1' + \color{red}{Spread})^1} \quad \frac{PMT}{(1+z_2' + \color{red}{Spread})^2} + \ldots\ldots + \frac{PMT+FV}{(1+z_N' + \color{red}{Spread})^N}$$

Yield and Spread

Decomposition of the bond's profit or loss

- Explicit cash flows(i.e., Cash-carry)
- Total price appreciation (or depreciation):
  - **Carry-roll-down:** the price change due to the passage of time where rates move as expected but with no change in the spread.

Yield and Spread

Decomposition of the bond’s profit or loss

- ✓ **Rate change:** the price effect of rates changing from the intermediate term structure to the term structure that actually prevails at time t+1.
- ✓ **Spread change:** is the price effect due to the bond’s individual spread changing from s(t) to s(t+1).

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Session 1

One factor risk metrics (parallel shift)

Durations

- Macaulay duration

$$MacDur = \frac{\sum_{t=1}^{n} t \times PVCF_t}{\sum PVCF_t}$$

- Modified duration

$$ModDur = \frac{MacDur}{1+r}$$

$$\%\Delta Price \approx -ModDur \times \Delta Yield$$

- Money duration

=Mod Dur x Price (full) = - ΔP/ Δy

- Effective duration

$$EffDur = \frac{P_{-} - P_{+}}{2 \times (\Delta Curve) \times P_0}$$

One factor risk metrics (parallel shift)

Durations

- DV01

  =Money duration x 0.0001

- DV01 hedge:
  - ✓ change of hedging instrument

$$HR = \frac{\text{DV01(per \$100 of initial position)}}{\text{DV01(per \$100 of hedging instrument)}}$$

One factor risk metrics (parallel shift)

Convexity

- **Convexity** is a measure of the curvature (non-linear relationship) in the relationship between bond yield and price, the second derivative of the price to interest rates.

$$convexity = \frac{P_{-\Delta y} + P_{+\Delta y} - 2 \times P_0}{P_0 \times \Delta y^2}$$

- Price change using both duration and convexity

$$\Delta P \approx -P \times ModDur \times \Delta r + \frac{1}{2} \times P \times Convexity \times \Delta^2 r$$

$$\approx -DD \times \Delta r + \frac{1}{2} \times DC \times \Delta^2 r$$

One factor risk metrics (parallel shift)

Duration Properties

- Longer time-to-maturity usually leads to higher duration
- Higher coupon rate leads to lower duration
- Higher yield-to-maturity leads to lower duration

Convexity Properties

- Longer time-to-maturity usually leads to higher convexity
- Higher coupon rate leads to lower convexity
- Higher yield-to-maturity leads to lower convexity
- For bonds with same duration, the one that has the greater dispersion of cash flows has the greater convexity.

One factor risk metrics (parallel shift)

Barbell Vs. Bullet Portfolio

- Barbell strategy is formed when trader invests in long and short duration bonds, but does not invest in the intermediate duration bonds.
- Bullet strategy is formed when trader invests in intermediate duration bonds, but does not invest in the long and short duration bonds.
- For bonds with same duration, the one that has the greater dispersion of cash flows has the greater convexity.

One factor risk metrics (parallel shift)

Portfolio duration and convexity

- Duration of portfolio = $\Sigma wj \times Dj$
- Convexity of portfolio = $\Sigma wj \times Cj$

Multi factor risk metrics (non-parallel shift)

Basics concepts

- Key rate
- Key rate ‘01s
- Key rate duration
- Forward bucket ‘01s
- Partial ‘01s

CONTENTS

Session 2

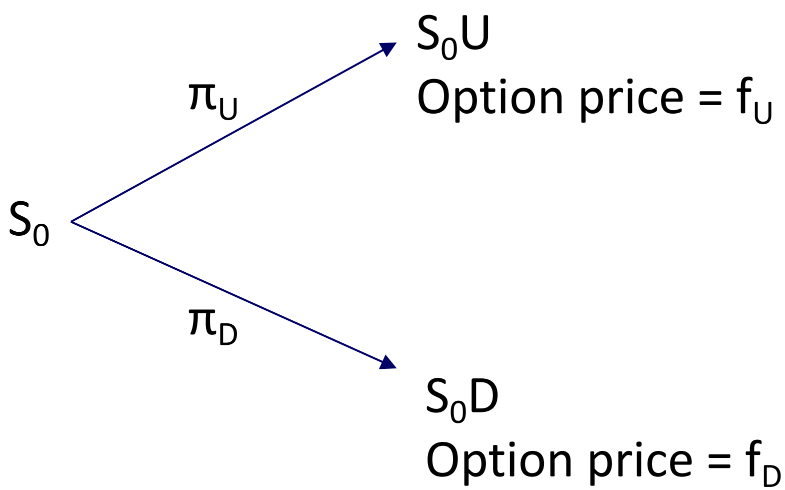
Risk Neutral Valuation

Risk Neutral Valuation

- 新增考点：　$\Delta=(cU-cD)/(SU-SD)$
- A risk-neutral world has two features:
  - ✓ The expected return on a stock (or any other investment) is the risk-free rate.
  - ✓ The discount rate used for the expected payoff on an option (or any other instrument) is the risk-free rate.
- The probability we use to weight the “up” and “down” state is risk-neutral probability.

Risk Neutral Valuation

Risk Neutral Valuation



$$[S_0 \times U \times \pi_u + S_0 \times D \times \pi_D] \times e^{-rt} = S_0$$

$$\pi_u = \frac{e^{rt} - D}{U - D}$$

$$U = e^{\sigma\sqrt{t}} \qquad D = \frac{1}{U} = e^{-\sigma\sqrt{t}}$$

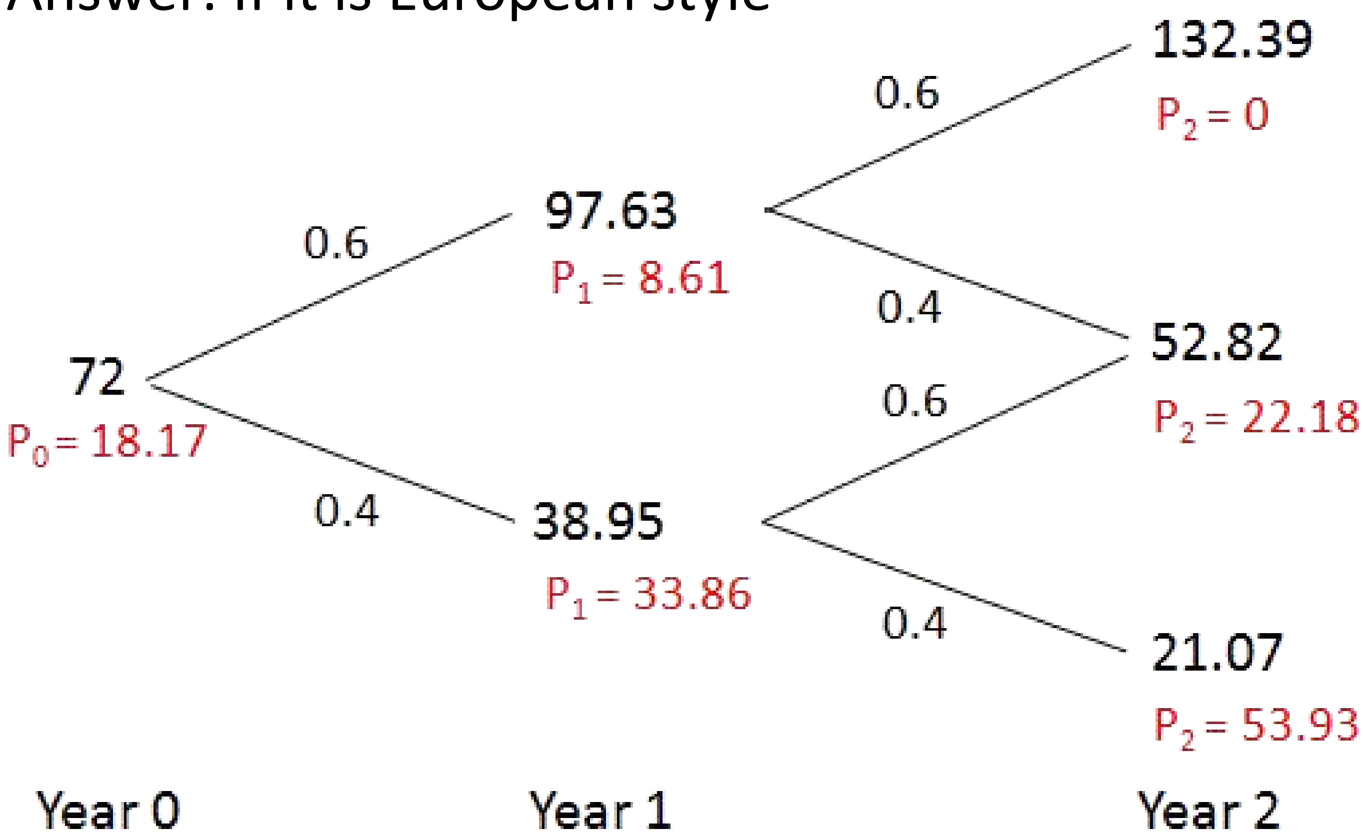
Two-steps Binomial Model

- Example: A non-dividend-paying stock is currently trading at 72, a put option on this stock has a exercise price of 75 and a maturity of 2 years. Suppose the interest rate is 3%, U = 1.356 and D = 0.541, π_U = 0.6 and π_D = 0.4. Calculate the put option value if it is European-style and American-style respectively.

Two-steps Binomial Model

Two-steps Binomial Model

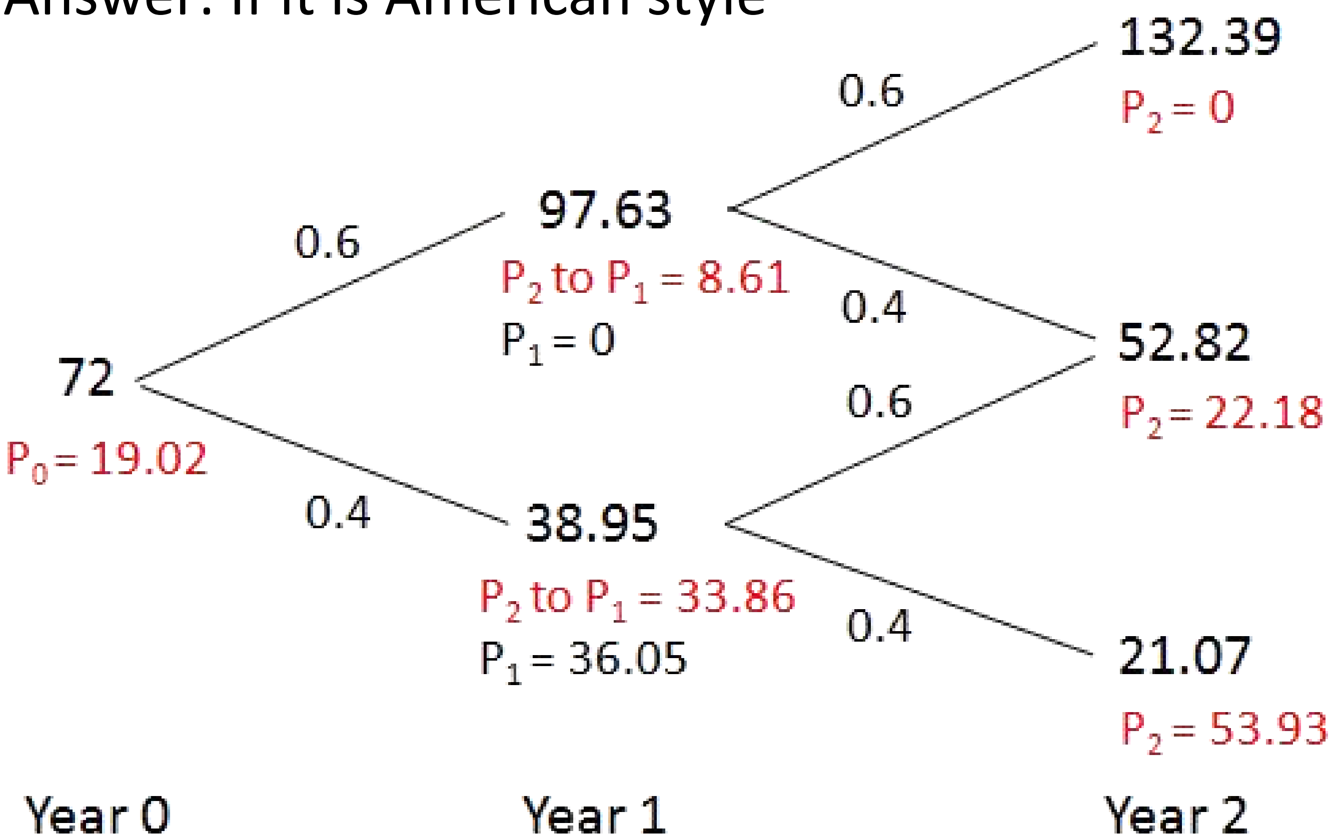
- Answer: If it is European style



Two-steps Binomial Model

Two-steps Binomial Model

- Answer: If it is American style



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Session 2

Black-Scholes-Merton (BSM) Model

Assumptions underlying the BSM model:

- European-style.
- Underlying asset price follows a geometric Brownian motion.
- Continuously compounded risk-free rate is known and constant.
- Volatility of the underlying asset return is constant and known.
- The underlying asset has no cash flow.
- The market is frictionless.

Black-Scholes-Merton (BSM) Model

Formulas for BSM model:

$$C_0 = S_0N(d_1) - Xe^{-R_f^c \times T}N(d_2) \qquad P_0 = Xe^{-R_f^c \times T}[1 - N(d_2)] - S_0[1 - N(d_1)]$$

$$C_0 = S_0e^{-qT}N(d_1) - Xe^{-R_f^c \times T}N(d_2)$$

$$C_0 = (S_0 - PV_{dividends})N(d_1) - Xe^{-R_f^c \times T}N(d_2)$$

Where: $$d_1 = \frac{\ln\left(\frac{S_0}{X}\right) + \left(R_f^c + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}, \quad d_2 = d_1 - \sigma\sqrt{T}$$

$N(d_1)$: Delta of call

$N(d_2)$: Risk-neutral probability that a call option will be exercised

$N(-d_2)$: Risk-neutral probability that a put option will be exercised

BSM Model - Warrants

BSM Model – Warrants

- Suppose that company has N shares and M warrants, strike price is K. Suppose that without warrant issue share price will be S_T. If warrants are exercised, share price immediately after exercise becomes $(NS_T + MK)/(N + M)$.
- The value of each warrant is computed as:

$$\frac{N}{N+M} \times \text{Value of regular call option}$$

- The reduction in the stock price is

$$\frac{M}{N+M} \times \text{Value of regular call option}$$

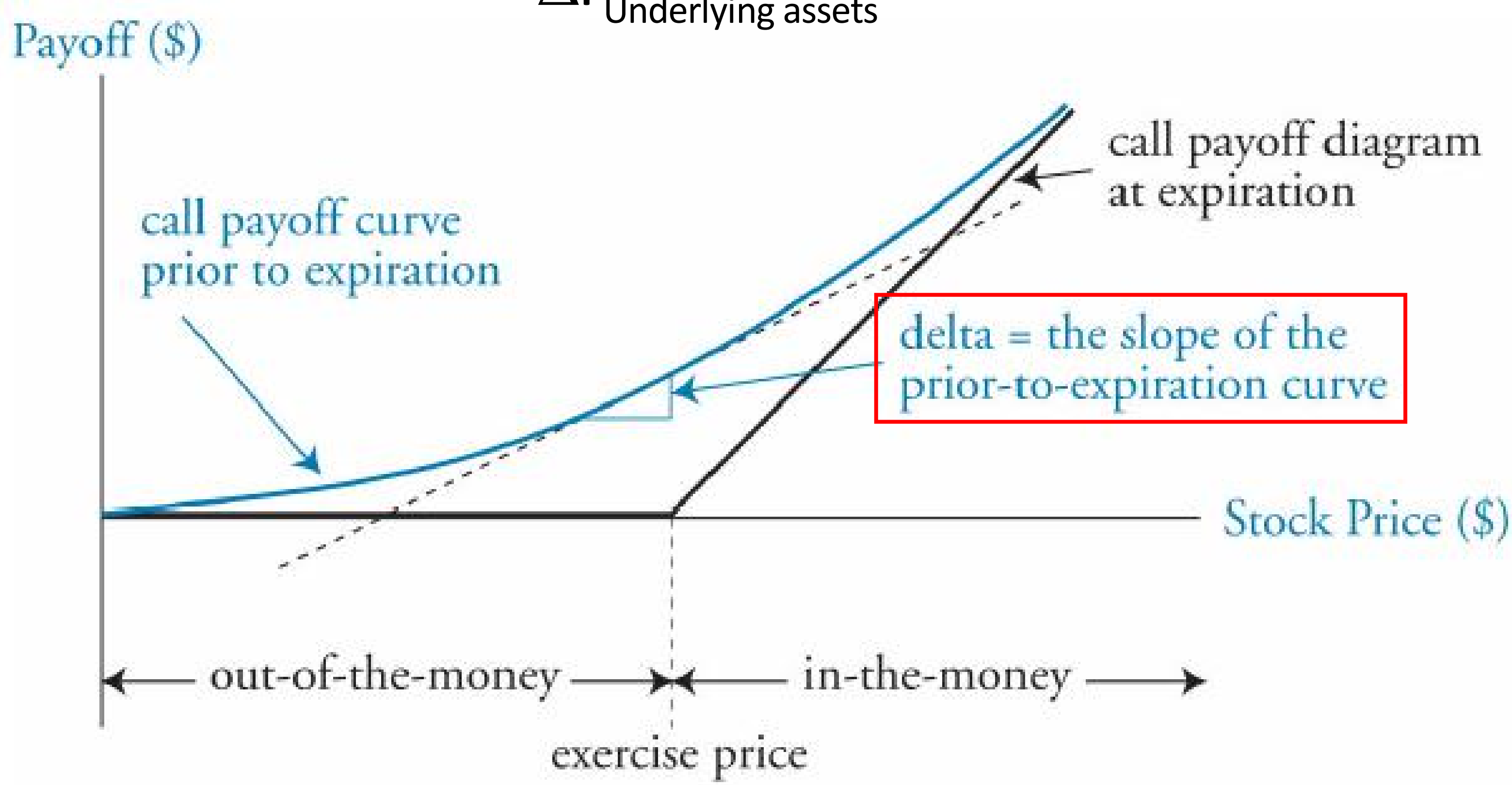
CONTENTS

Session 2

Delta

Delta (Δ)

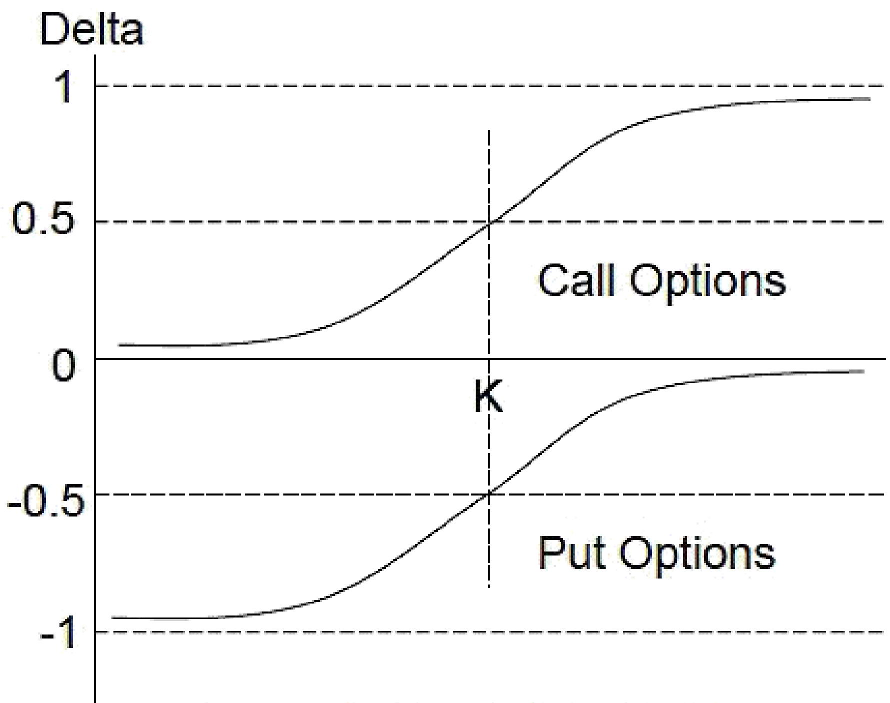
$$\text{Delta} = \frac{\Delta P_{\text{Option}}}{\Delta P_{\text{Underlying assets}}}$$



Delta

Delta (Δ)

- Most sensitive to changes of underlying assets at the money.



Call and Put Option Delta

Call option Δ range from 0 to 1

Put option Δ range from -1 to 0.

Long Call	$\Delta > 0$
Short Call	$\Delta < 0$
Long Put	$\Delta < 0$
Short Put	$\Delta > 0$

Delta

Delta (Δ)

- Delta for option (Non-dividend paying stock):

$$Delta_{call} = N(d_1)$$

$$Delta_{put} = Delta_{call} - 1 = N(d_1) - 1$$

- Delta for option (Dividend paying stock):

$$Delta_{call} = e^{-qT}N(d_1)$$

$$Delta_{put} = Delta_{call} - 1 = e^{-qT}[N(d_1) - 1]$$

- Forward delta: 1 or e^{-qT}
- Futures delta: e^{rT} or $e^{(r-q)T}$

Delta

Delta (Δ)

- Delta is also the hedge ratio.
- Delta-neutral portfolio: Combine the underlying assets with the options so that the value of the portfolio does not change with variation of the price of underlying assets.

$$N_{call} = -\frac{N_{stock}}{Delta_{call}} \qquad N_{put} = -\frac{N_{stock}}{Delta_{put}}$$

Gamma

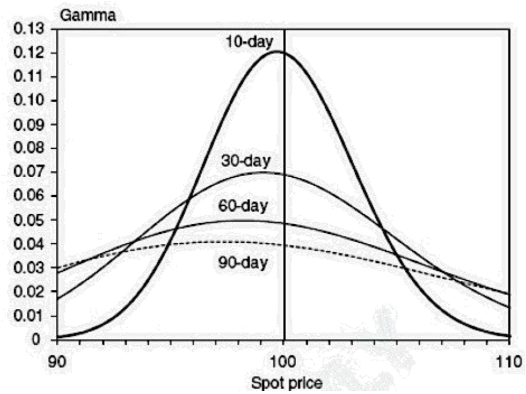
Gamma (Γ)

- Gamma is the same for call and put option.

$$\text{Gamma}_{\text{call}} = \text{Gamma}_{\text{put}} = \frac{\Delta \text{Delta}}{\Delta S}$$

Long Call	**Long Put**
$\Gamma > 0$	$\Gamma > 0$

- Gamma is largest when option is at-the-money. If the option is deep in- or out-of-the-money, gamma approaches zero.



Gamma

Gamma (Γ)

- Delta is a linear estimation for option and delta-neutral strategy only holds for very small changes in the value of the underlying asset. Gamma measures the stability of delta. If gamma is higher, rebalancing hedge ratio is more frequent.
- Delta neutral: Hedging underlying assets with small changes.
- Gamma neutral: Hedging underlying asset with larger changes.
- Create delta and gamma neutral:
  - ✓ Step one: Gamma-neutral by non-linearly instruments.
  - ✓ Step two: Delta-neutral by linearly instruments.

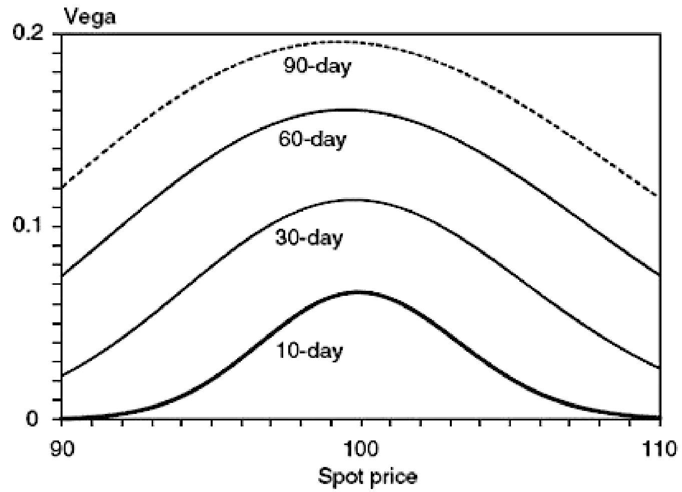
Vega

Vega (Λ)

- Vega for call option is equal to Vega for put option.

Long Call	Long Put
$\Lambda > 0$	$\Lambda > 0$

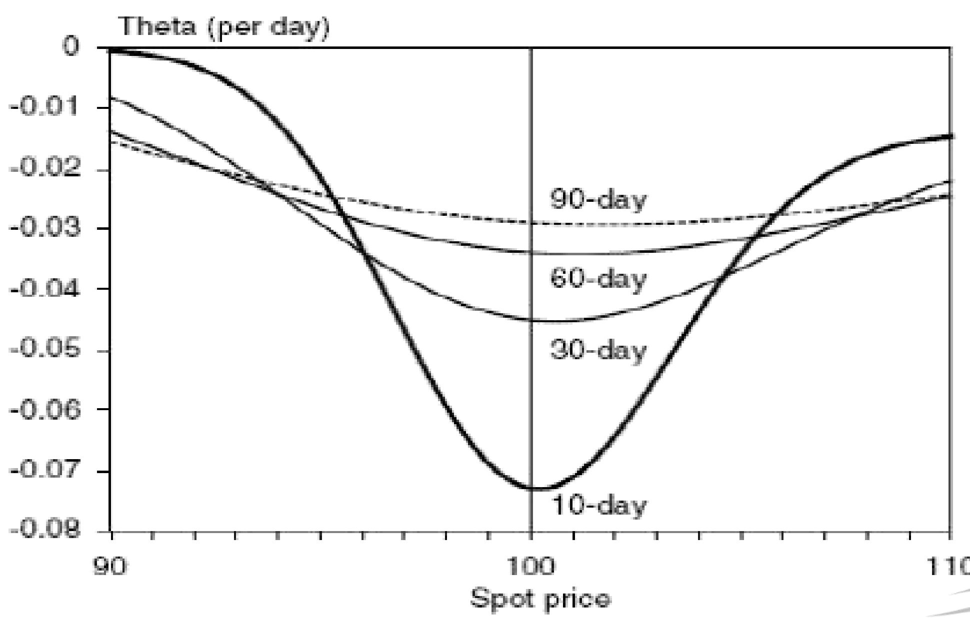
- Vega is largest when the option is at-the-money. If the option is deep in- or out-of-the-money, gamma approaches zero.



Theta

Theta (θ)

➤ As time passed, most options become less valuable, so theta is usually negative for long option. With exception to deep in-the-money put option. Short-term at the money option has a greatest negative theta.



Rho

Rho (ρ)

- The equity options are not as sensitive to changes in the risk free rate as they are to changes in the other variables.
- In the money calls and puts are more sensitive to changes in rates than out-of-the-money options.

Greek Letter	Long call	Short call	Long put	Short put
Delta	$\Delta > 0$	$\Delta < 0$	$\Delta < 0$	$\Delta > 0$
Gamma	$\Gamma > 0$	$\Gamma < 0$	$\Gamma > 0$	$\Gamma < 0$
Vega	$\Lambda > 0$	$\Lambda < 0$	$\Lambda > 0$	$\Lambda < 0$
Theta	$\theta < 0$	$\theta > 0$	$\theta < 0$	$\theta > 0$
Rho	$\rho > 0$	$\rho < 0$	$\rho < 0$	$\rho > 0$

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Session 3

Value at Risk (VaR)

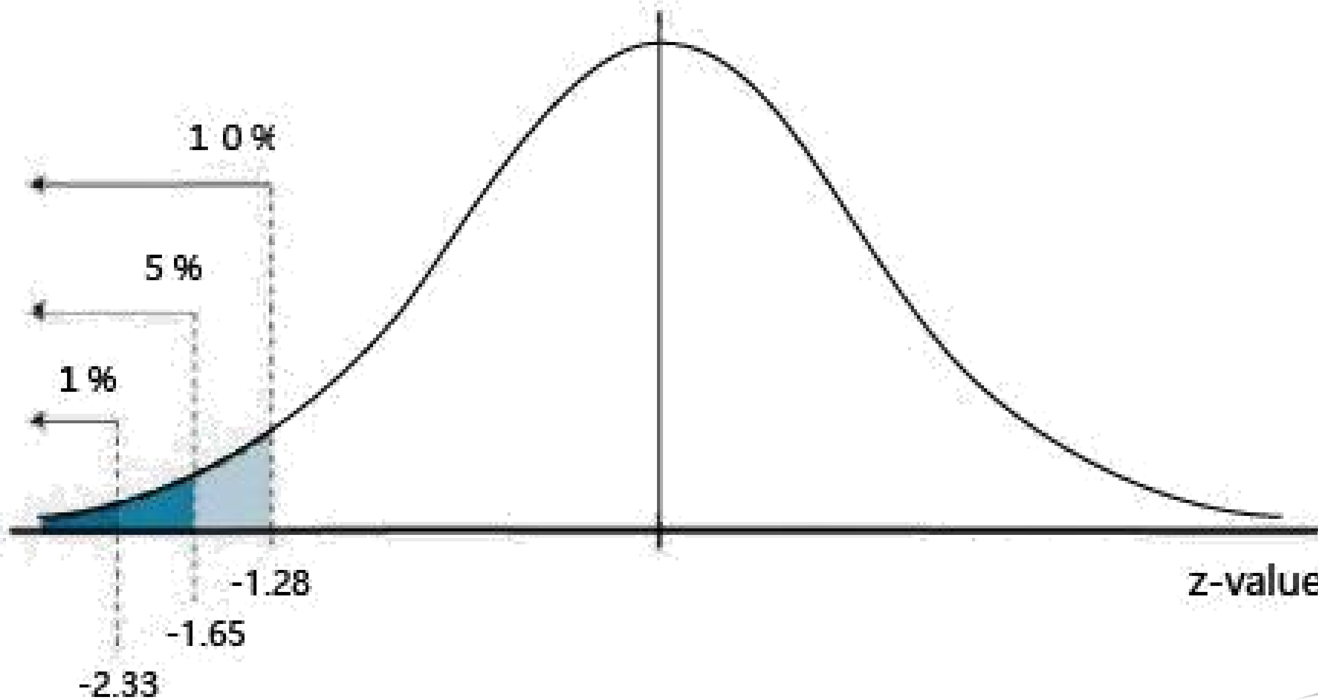
Value at Risk (VaR)

- Time horizon
- Confidence level
  - Interpretation of VaR: 99%, 1-Day, VaR=100,000

Value at Risk (VaR)

VaR measurement

- $VaR(X\%)_{dollar} = [E(R) - z_{X\%}\sigma] \times$ asset value
  - ✓ VaR Conversion: Time Horizon
  - ✓ VaR Conversion: Confidence Level



Coherent Risk Measures

Coherent Risk Measures

- Monotonicity

$$R_1 \geq R_2, \text{then } \rho(R_1) \leq \rho(R_2)$$

- Subadditivity

$$\rho(R_1 + R_2) \leq \rho(R_1) + \rho(R_2)$$

- Positive Homogeneity

$$\beta > 0,\ \rho(\beta R) = \beta\, \rho(R)$$

- Translation Invariance: Risk is dependent on the assets within portfolio.

$$\rho(c + R) = \rho(R) - c$$

Expected Shortfall (ES)

ES is a more appropriate risk measure than VaR:

- ES gives an estimate of the magnitude of a loss for unfavorable events. VaR provides no estimate of how large a loss may be.
- ES is the coherent risk measure, VaR is not. Since ES meet the property of subadditivity.

Spectral Risk Measure

Spectral Risk Measure

- ES is a special case of the risk spectrum measure where the weighting function is set for tail losses that all have an equal weight, and all other quantiles have a weight of zero.
- VaR is a special case where only a single quantile is measured, and the weighting function is set to one, and all other quantiles have a weight of zero.

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Session 3

01. Measures of Financial Risk

03. Quantifying Volatility in VaR Models

02. Putting VaR to Work

Regime-Switching Volatility Model

- Unconditional distribution Vs. Conditional distribution
- Capturing the conditional distributions of return which are always normal with a constant mean but either have a high or low volatility and resolving the fat-tail problem and other deviations, not capturing the extreme events.
- Stress testing, scenario analysis and extreme-value theory (EVT) can be applied to capture the extreme events in the tail.

Historical-based Approaches for VaR Estimation

Parametric Approach

- Historical standard deviation approach

$$u_t = \frac{S_t - S_{t-1}}{S_{t-1}} \qquad \sigma_n^2 = \frac{1}{n}\sum_{t=1}^{n}(u_{n-t} - \bar{u})^2 = \frac{1}{n}\sum_{t=1}^{n}u_{n-t}^2$$

- EWMA model

$$\sigma_n^2 = \lambda\sigma_{n-1}^2 + (1 - \lambda)u_{n-1}^2$$

- GARCH model

$$\sigma_n^2 = \gamma V_L + \alpha u_{n-1}^2 + \beta\sigma_{n-1}^2$$

Historical-based Approaches for VaR Estimation

Non-Parametric Approach

- Historical simulation method
- Multivariate density estimation (MDE)
- Advantages of nonparametric approach
  - ✓ Do not require asset returns distribution assumptions.
- Disadvantages of nonparametric approach
  - ✓ Large sample sizes are required.
  - ✓ Separating full sample of data into different market regimes reduces the amount of usable data for historical simulations.

Historical-based Approaches for VaR Estimation

Hybrid Approach

- Step 1: Assign weights for historical realized returns using an exponential smoothing process:

$$\frac{1-\lambda}{1-\lambda^{K}}\lambda^{t-1} \qquad \text{k: Number of returns}$$

- Step 2: Order the returns.
- Step 3: Determine the VaR for the portfolio.

Implied Volatility-based Approach

Implied Volatility-based Approach

- Using derivative pricing models such as BSM to estimate an implied volatility based on current market data rather than historical data.
  - ✓ Advantages: Forward-looking predictive nature. Implied volatility reacts immediately to changing market conditions.
  - ✓ Disadvantages: Model dependent (Depend on BSM model assumption). Empirical results suggest implied volatility is on average greater than realized volatility.

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Session 3

Methods of VaR Measurement

Local valuation

- Linear method: Delta normal approach

$$\text{Fixed income security: } VaR(\Delta P) = \left| -D \times P \right| \times VaR(\Delta r)$$

$$\text{Option: } VaR(\Delta f) = \left| \Delta \right| \times VaR(\Delta S)$$

- Non-linear method: Delta gamma approach

$$\text{Fixed income security: } VaR(\Delta P) = \left| -D \times P \right| \times VaR(\Delta r) - \frac{1}{2} C \times P \times VaR(\Delta r)^2$$

$$\text{Option: } VaR(\Delta f) = \left| \Delta \right| \times VaR(\Delta S) - \frac{1}{2} \Gamma \times VaR(\Delta S)^2$$

Methods of VaR Measurement

Full revaluation methods

- Historical simulation
- Monte Carlo simulation
- Scenario analysis (Stress Testing)

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Session 4

Credit Risk

Credit Risk

- Single instrument
  - Expected loss (EL): EL = EA * PD * LR
  - Unexpected losses (UL): $UL = EA \times \sqrt{PD \times \sigma_{LR}^2 + LR^2 \times \sigma_{PD}^2}$

    $\sigma_{PD}^2 = PD \times (1 - PD)$
- Portfolio
  - Expected loss: $EL_p = \sum_{i=1}^{n} EL_i$
  - Unexpected loss (two assets):

$$UL_p = \sqrt{UL_1^2 + UL_2^2 + 2\rho_{12} UL_1 UL_2}$$

Unexpected Loss Contribution

Unexpected Loss Contribution

- Risk contribution (RC) is known as unexpected loss contribution (ULC)

$$ULC_i = \frac{UL_i \sum_j UL_j \rho_{ij}}{UL_p}$$

- For a two-asset portfolio, risk contributions of each asset

$$RC_1 = UL_1 \times \frac{UL_1 + (\rho_{1,2} \times UL_2)}{UL_p}$$

$$RC_2 = UL_2 \times \frac{UL_2 + (\rho_{1,2} \times UL_1)}{UL_p}$$

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Session 4

Credit Rating

Credit Rating

- Three major credit rating agencies: Moody, S&P and Fitch

	Moody	S&P	Fitch
Investment grade	Aaa	AAA	AAA
	Aa1	AA+	AA+
	…	…	…
	Baa2	BBB	BBB
	Baa3	BBB-	BBB-
Non-investment Grade “Junk” or “High Yield”	Ba1	BB+	BB+
	…	…	…
	Ca	CC	CC

Credit Rating Transition Matrix

Credit Rating Transition Matrix

Given the following ratings transition matrix, calculate the two-period cumulative probability of default for a 'B' credit.

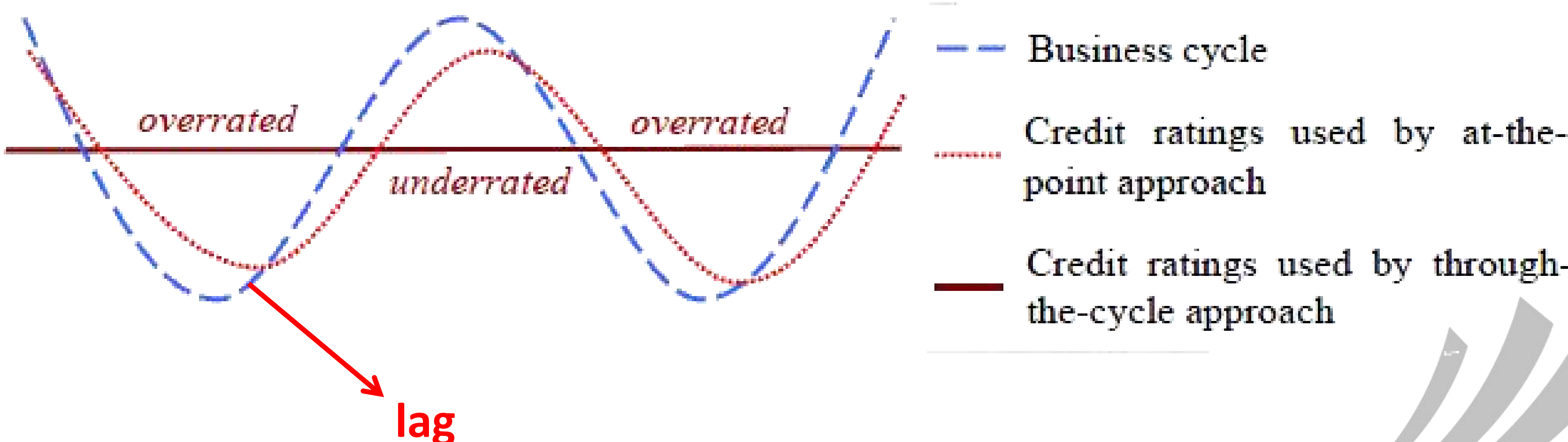
Rating at beginning of period	Rating at end of period			
	A	B	C	D
A	0.95	0.05	0.00	0.00
B	0.03	0.90	0.05	0.02
C	0.01	0.01	0.75	0.14
Default	0.00	0.00	0.00	1

Probability of default = 2% + 90% × 2% + 5% × 14% = 4.5%

Internal Credit Ratings

Internal Credit Ratings

- Through-the-cycle approach (long term): Underrated during growth periods and overrated during the decline of a cycle.
- At-the-point approach (short term): Procyclical, changing in ratings can lag the economic cycle.



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Session 4

Country Risk

Country Risk

- Source of country risk
  - Economic growth life cycle
  - Political risk
  - Legal risk
  - Economic structure
- Sovereign default spread

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Session 5

Operational Risk

Operational Risk Capital Measurement Approach

- Basic Indicator Approach (BIA)

$$ORC^{BIA} = 15\% \times GI_{Avg}$$

- Standardized Approach (TSA)

$$ORC^{TSA} = \frac{\sum_{3\text{ Years}} \text{Max}[\sum(GI_{1\text{-}8} \times \beta_{1\text{-}8}), 0]}{3}$$

Business Lines	Beta Factors
Corporate finance	18%
Trading and sales	18%
Retail banking	12%
Commercial banking	15%
Payment and settlement	18%
Agency services	15%
Asset management	12%
Retail brokerage	12%

Operational Risk

Operational Risk Capital Measurement Approach

- Advanced Measurement Approach (AMA)
  - The model must hold capital for one year 99.9% VaR.
  - Operational risk losses can be classified:
    - Loss frequency (Poisson distribution)
    - Loss severity (Lognormal distribution)
  - Loss frequency and loss severity are combined in an effort to simulate an expected loss distribution.
  - Having created the loss distribution, the desired percentile value can be measured directly.

Operational Risk

Data of AMA

- Internal data (High frequency low-severity losses, HFLS)
- External data (Data consortia, Data vendor)
  - ✓ The accepted scale adjustment for firm size is:

$$\text{Estimated loss}_{\text{Bank A}} = \text{External loss}_{\text{Bank B}} \times \left(\frac{\text{Revenue}_{\text{Bank A}}}{\text{Revenue}_{\text{Bank B}}} \right)^{0.23}$$

- Scenario analysis

Operational Risk

Power Law

- Power law is useful in extreme value theory (EVT) when we evaluate the nature of the tails of a given distribution.

$$P(V > X) = KX^{-\alpha}$$

V: Loss variable

X: Large value of V

K and α: Constants

- Power law holds well for the large losses experienced by banks. Loss data (internal or external) and scenario analysis are employed to estimate the power law parameters.

Operational Risk

Insurance

- Moral hazard
- Adverse selection

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Session 5

Stress Testing

Key elements of effective governance over stress testing

- Governance structure
  - Board of directors
  - Senior management
- Policies, procedures and documentation
- Validation and independent review
- Internal audit
- Other aspects of stress-testing activities
  - Stress-testing coverage
  - Stress-testing types and approaches
  - Capital and liquidity stress testing

Stress Testing

Three major differences in the definition of loss estimates between stress tests and VaR/EC measures:

- Economic capital or VaR methods, and stress test involve translation of scenarios into loss estimates. Stress tests usually focus on a few scenarios, whereas VaR measures commonly utilize a very large number of scenarios.
- Stress tests have examined a long period such as losses over nine quarters in the Dodd-Frank stress tests in the U.S. In contrast, VaR/EC models have focused on losses at a point in time, such as the loss in value at the end of a year.

Stress Testing

Three major differences in the definition of loss estimates between stress tests and VaR/EC measures:

- For many stress tests, ordinal rank assignments such as "base", "adverse“ and "severely adverse" have been done, but with little discussion of the cardinal probabilities attached to them.

You're the Champion!

Thanks for staying with us. You have finished this chapter.