- **Credit Introduction**
- **Credit Measurement**
  - PD
  - LGD
  - EAD
  - Correlation
- **Credit Management**
  - Counterparty
    - Netting
    - Collateralization
- **Credit Derivative**
  - Collateral Default Swap(CDS)
  - Total Return Swap (TRS)
  - Credit Linked Note (CLN)

The Credit Decision

- Credit: receive and pay later
- Credit risk: borrow will not pay
- Transaction
  - settlement risk
    - The counterparty will never pay for the good or service
  - financial obligation
    - that arises from the loan agreement. Credit risk that arises from trade credit is nearly indistinguishable from the credit risk that banks incur.
- Revaluation
  - Borrower's willingness and capacity
  - External environment and its effects
    - Business climate, country risk, operating conditions
  - Characteristic of the credit **instruments**
    - Secure/Unsecure?
    - Maturity/tenor
    - Senior/Subordinated?
    - Loan/bond covenants
    - Borrower repay early?
    - lender call the loan?
    - Convertible bond?
  - Quality and adequacy of risk **migrants**
    - Collateral pledged to
    - Loan guarantor
- **Qualitative - willingness**
  - Gather information
  - Face-to-face meeting
  - Name lending
  - Past: **moral** obligation, now: **legal** obligation
    - willingness is more important in less-developed **legal and financial** markets
- Quantitative - ability

    - Historical nature of data
        - Not up-to-date, unreliable, miscalculation
    - Difficult to make prediction
    -
- Borrowers
    - Corporation
        - Liquidity, Cash flow
    - Financial institutions
        - Asset quality, capital adequacy, earning quality
- Quantitively
    - PD, LGD, EAD, time horizon
- Bank failure or insolvency
    - Bank insolvency: have liquidity
    - Bank failure: no liquidity

The credit Analyst

- Risk management vs investment selection
    - **Risk management** (more common)
        - Bank examiners: robust, depth and liquidity
        - Public: research on potential counterparties
    - Investment selection
        - Fixed-income: **relative** value
- Primary vs secondary research
    - Primary research
        - Analyst-driven research, more detailed, more human effort, high cost
        - Microeconomic and macroeconomic (political, industry)
    - Secondary research
        - Research by rating agency
        - Shorter, quick efficient
- Type of Entity
    - Corporate credit analyst
        - specific industry knowledge
        - focus on one or two industries
        - firm size
            - public company: cheaper, a lot of public information
            - small company: more time and DD, primary research, increase cost
    - Sovereign
        - Macroeconomic, political, stability of banking system
- **Banking credit analyst**
    - Counterparty credit analyst
        - Credit limits, risk mitigants,
    - Fixed-income analyst
        - Fundamental and technical
    - Equity analyst
        - Fundamental and technical
        - ROE, company valuation
- Skills
    - Quantitative

    - Qualitative
    - Research skills
        - Overall sector
        - Large bank > small bank
- Audit
    - Qualified
        - Substantial doubt in going concern
        - Specific treatment inconsistent with accounting rules
        - Related-party transactions
- FS
    - Footnotes
    - Interim: quarterly or semi-annual

Rating Assignment Methodologies

- **Good Rating**
    - **Objectivity**: based on **credit** risk
    - **Homogeneity**: **comparable** among market segments, portfolios, and customer types
    - **Specificity**: distance to **default** event
    - **Measurability and verifiability:** correct expectations related to default probabilities which are back tested on a continuous basis.
- Methods
    - Heuristic: experts-based
    - Structural: merton, cash-fow
    - Reduced
        - Statistical: LDA, logistic Regression
        - Numeric: ANN
    - Clustering: PCA, factor analysis, cannocial
- **Experts-based: 4C**
- **Statistical-based classification**
    - Quantitative method
    - Focus on **unlisted** firms
- **Numerical approaches**
    - Optimal solution via trained
    - Neural network
- Rating migration matrix
    - Relative frequency
    - Discrete ADR = 1 – (1-F_t)^(1/t)
    - Continuous ADR = - ln (1-F_t) / t
- **Rating Agencies Methodologies**
    - Risk: financial and business
    - S&P: issuer
    - Moody: issuance
    - Fitch: issuer ratings based on potential defaults for publicly listed bonds
- **Agency and internal**
    - Internal: time-consuming and difficult
    - Agency > internal according to good rating
- **Structural and reduced form**
    - Structural (Merton) financial and economic assumption

    - Reduced form: statistical and numerical
        - Model risk
        - Aggregate into Top-down classification
    - Stat: Bottom-up and experts-based: bottom up
- Merton model
    - Apply to liquid, publicly traded firms
    - fall short of fully reflecting dependence of credit risk
- stats: LDA
    - Z-score
    - Original cut-off
        - $\textbf{new cutoff} = \textbf{original cut off} + \textbf{lg}\frac{(1-PD)}{PD}$ 对数几率
    - Original cut-off + ln (q_solv * /)
        - $\textbf{new cutoff} = \textbf{original cut off} + \textbf{lg}\frac{(1-PD)\times orrortinity\ cost}{PD\times LGD}$
- Stats: logit regression
    - Log default/ (1-default) = \sum w_i x_i
- Clustering
    - Cluster analysis
    - Hierarchical clustering
    - Divisive clustering
    - PCA
        - Communality (eigenvalue)
        - Eigenvalue > 1
    - Factor analysis
        - After PCA
        - Few Unobserved factors
    - Canonical correlation
        - Correspondence between a set of **independent** variables and **dependent** variables
- Cash flow simulation
    - Non-existent or relatively meaningless
    - Pro forma
    - Model risk
    - No historical data
- Heuristic vs numeric
    - Heuristic: human decision-making
        - Expert systems
        - Rule: Backward chaining or forward chaining
        - Fuzzy logic
        - Decision support system (DSS_
    - Numeric:
        - Neural network: biological
        - Nonlinear, recursive, independent
        - Over-fitting
        - No probability of default
    - Numeric > heuristic good rating criteria
- Apply qualitative
    - Binary: yes or no
    - Nominal: location
    - Ordinal: low, high

- Dummy: 0 or 1
- Steps
  - **Quantitative** model along with systematic **qualitative** data collection
  - Produced enough, build a new model includes new qualitative information

Credit Risks and Credit Derivatives

- **Merton 模型**
  - **算公司估值**
  - **算 PD 和 LGD**
- **Credit derivative**
  - Contract with payoffs dependent on a specified credit event
- Zero-coupon bond Face value F and maturity T
  - $V_T = D_T + S_T$
  - Equity (buy a call option): $S_T = \max(V_T - F, 0)$ 买入 call option
    - Call **option** with strike price F
  - Debt (buy a bond F and **sell put option**): $D_T = F - \max(F - V_T, 0)$
    - Sell put option with exercise price F
    - 买入 bond F，卖出 put option。
  - Debt (another way) 最直接，持有 bond V，卖出 equity 的 call option
    - $D_T = V_T - S_T = V_T - \max(V_T - F, 0)$
    - Buy a bond V_T and **sell the call** option
  - T-t= TTM 现在到结束的时间
  - $c_t - p_t = V - F \exp(-r \times t)$, r is interest rate
- Equity value

$$S_t = V \times N(d) - Fe^{-r(T-t)} \times N(d - \sigma\sqrt{T-t})$$

where:

$$d = \frac{\ln\left(\frac{V}{Fe^{-r(T-t)}}\right)}{\sigma\sqrt{T-t}} + \frac{1}{2}\sigma\sqrt{T-t}$$

V = value of the firm
F = face value of the firm's zero-coupon debt maturing at T (only liability)
σ = volatility of the value of the firm
r = annual interest rate
N(d) = cumulative normal distribution function evaluated at d

- Relationship

Figure 2: Relationships Between Debt and Equity Values as Compared to the Inputs of the Merton Model

	Value of Firm, V	*Face Value of Debt, F*	*Time to Maturity, T*	*Interest Rate, r*	*Volatility of the Firm, σ*
Value of debt	+	+	−	−	−
Value of equity	+	−	+	+	+

- Credit spread of the debt

The credit spread can be calculated using the following formula:

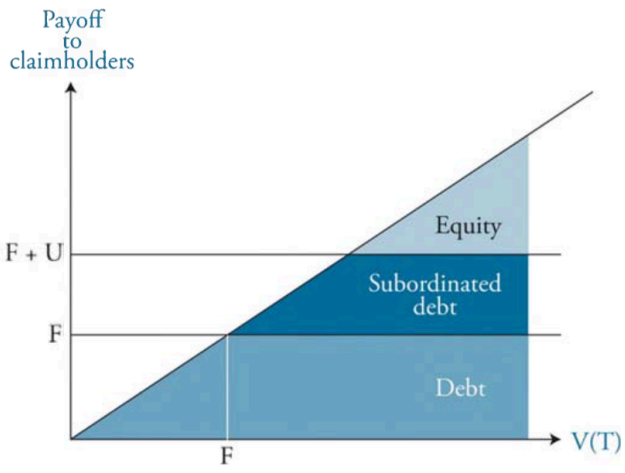
$$\text{credit spread} = -\left[\frac{1}{(T-t)}\right] \times \ln\left(\frac{D}{F}\right) - R_F$$

where:

$(T-t)$ = remaining maturity
D = current value of debt
F = face value of debt
R_F = risk-free rate

-
  - TTM increase, spread increase
  - Interest rate increase, spread decrease
- **Firm value and volatility**
  - Delta
    - Assume change in equity perfectly corrected with value of the firm
    - Delta : N(d1)
    - Volatility smirk
    - Non-constant volatility of equity is a violation of BSM
  - Geske compound option model
    - Assume firm value follows a **lognormal** with constant variance
    - 迭代法。
      - 给定 equity value 和 call option on equity
      - 用 BSM 估计 equity value
      - 然后用 compound model 估计 call option on equity
        - 调整 firm value 和 firm value volatility
      - 直到 2 个的输出相同
- Subordinate debt
  - Valuation
    - A long call option with strike price F
    - A short call option with strike price F+U

Figure 4: Subordinated Debt Payoff



  -
  - Firm value low, like equity
  - Firm value high, like senior debt

- 经济好，**sub** 是债务；经济不好，**sub** 是权益。波动大，权益大。

Figure 5: Relationships for Capital Components for Low vs. High Firm Values

	If Firm Value is Low Firm in Financial Distress			*If Firm Value is High Firm Not in Financial Distress*		
Variable	*Time to Maturity T*	*Firm Volatility* σ	*Annual Interest Rate r*	*Time to Maturity T*	*Firm Volatility* σ	*Annual Interest Rate r*
Senior debt	–	–	–	–	–	–
Subordinate debt	+	+	+	–	–	–
Equity	+	+	+	+	+	+

- **Interest rate dynamic**
  - Interest rate increase, Debt and firm value decrease
  - Vasicek model
  - In destress
    - Interest rate volatility high, debt value less sensitive
- **Applications**
  - **Lognormal with constant variance, one zero-coupon bond**
  - Works for debt **below investment** grade 非投资级别
  - Firm value **no** jump 不能 jump
  - No Complicated capital structure (different maturities, more than one bond)
  - 不能预测 spread
- PD 和 LGD
  - Challenge
    - Lack of public trading
    - Illiquid
    - Not normal
    - Most firms have **no** traded **equity**
    - Debt Not mark to market
  - Assume lognormal with constant volatility, one liability (zero-coupon)
  - u 是期望汇报 expected return

$$PD = N\left(\frac{\ln(F) - \ln(V) - (\mu)(T-t) + 0.5\sigma^2(T-t)}{(\sigma)\sqrt{T-t}}\right)$$

where:

N = cumulative normal distribution
F = face value of the zero-coupon bond
V = value of the firm
T = maturity date on bond
σ = volatility of firm value

Loss given default (LGD) is:

$$LGD = F \times (PD) - Ve^{\mu(T-t)} \times N\left(\frac{\ln(F) - \ln(V) - \mu(T-t) - 0.5\sigma^2(T-t)}{\sigma\sqrt{T-t}}\right)$$

-
- $PD = 1 - N(d_2) = N(-d_2)$, u is expected return
  - 债务和波动大，越容易违约。
- **LGD (put option 的未来值)**
  - $LGD = F \times N(-d_2) - V\, e^{u \times \Delta t} N(-d_1) = e^{u \times \Delta t} \times p_t$

Figure 7: Relationships for PD and LGD Relative to Variables in the Merton Model

	Value of Firm	*Firm Value Volatility, σ*	*Expected Return, μ*	*Time to Maturity, T*	*Face Value of Debt, F*
Probability of default, PD	–	+	–	–	+
Loss given default, LGD	–	+	–	–	+

-

Example: Compute PD and LGD

Suppose a firm with a value of $60 million has a bond outstanding with a face value of $50 million that matures in three years. The current interest rate is 6% and the volatility of the firm is 25%. What is the probability that the firm will default on its debt if the expected return on the firm, μ, is 15%? What is the expected loss given default?

Answer:

$$PD = N\left(\frac{\ln(50) - \ln(60) - (0.15)(3) + (0.5)(0.25)^2(3)}{(0.25)\sqrt{3}}\right) = N(-1.244) = 0.1069 = 10.69\%$$

$$LGD = 50(0.1069) - 60e^{0.15(3)}N\left(\frac{\ln(50) - \ln(60) - 0.15(3) - 0.5(0.25)^2(3)}{0.25\sqrt{3}}\right)$$

$$LGD = 5.345 - (94.099)N(-1.677) = 5.345 - (94.099)(0.0468) = 5.345 - 4.404 = 0.941 = \$941{,}000$$

-

- **Credit risk portfolio models**
  - Credit VaR
    - One year
    - Highly skewed, not normal, but **lognormal**
  - **CreditRisk+ - factors** 因子法
    - Common risk factors for each obligor
    - Obligors are uncorrelated
    - Factors: positive, mean of 1
  - **Credit Metrics – 组合折现法，概率转移矩阵 – KMV Credit Monitor**
    - Rating class
    - Migration matrix -> migrate probability
    - Estimate distribution of value
    - 1 year forward zero curves to get current price of one year
    - Expected bond value
    - 99% Credit VaR = 99%时的 **price – market price** (很接近开始的值)
  - **Moody's KMV – Merton** 权益来估值
    - Expected default frequencies (EDF) for each obligator: k = short + long/2
    - (A-K) / (A*sigma)
    - Allow for more **complicated** capital structure
    - Solve for firm value and volatility
    - Major advantage: use current **equity values** in the model
      - Change of event affect PD
    - Expected return from CAPM
  - **CreditPortfolio View** 宏观经济
    - Transition matrices: economic cycle or macroeconomic 经济
    - GDP, interest, unemployment
    - Autoregressive process
    - Sector index
    - Default rate based on index (logistic)
    - Decide which transition matrices to use
  - Limitations
    - Most do not consider: interest, spread, current economic
- Credit Derivative
  - Usually on OTC not exchange
  - Credit default put pays on loss due to default
  - CDS
  - TTOR: return for a LIBOR + spread
  - Swap:
    - Full two-way payment：无论是否违约，还是要支付
    - Limited two-way payment: 一个违约就取消

Spread Risk and Default Intensity Models

- **Spread**
  - Difference in yields between risky bond and reference security
  - Yield spread: YTM bond – YTM benchmark
  - I-spread: YTM bond – linear interpretation of benchmark
  - Z-spread: basis points added to each spot rate on a benchmark curve

    - Asset-swap spread: spread floating leg of asset swap on a bond
    - CDS spread: market premium
    - OAS: z-spread for optionality of embedded option
        - Z-spread = OAS if no option
        - Z-spread > OAS for callable bond
        - Must be used for MBS
    - Discount margin: fixed spread – LIBOR
- DVCS (spread 01)
    - Smaller spread larger effects on bond price
        - $\frac{\Delta \text{spread}}{\text{spread}} \rightarrow \frac{1}{spread}$
    - Convexity
- Exponential distribution
    - Waiting time for an event (i.e., the time takes to default)
    - $f(x) = \frac{1}{\beta} \times e^{-x/\beta}$
    - β is the scale parameter
    - $\lambda = \frac{1}{\beta}$ rate parameter, hazard rate
    - $mean = \frac{1}{\lambda}, variance = 1/\lambda^2$
- Poisson
    - $\mathrm{P(X = x)} = \frac{e^{-\lambda}\lambda^x}{x!}$
    - λ average number of success per unit, average number of default per unit
    - $mean = variance = \lambda$
- Hazard rates
    - Default intensity,
    - $P(x < t) = F(t) = 1 - e^{-\lambda t}$ cumulative PD
    - Survival probability $S(t) 1 - F(t) = e^{-\lambda\, t}$
    - Marginal default probability: $\lambda e^{-\lambda t}$
    - Conditional probability $\frac{F(t+1)-F(t)}{1-F(t\,)} = 1 - e^{-\lambda} = F(1)$第一年的违约概率
- Risk neutral hazard rates from spreads
    - **Continuous** compound
    - hazard $*$ LGD $\cong$ spread spread 是用来补偿违约的
- CDS 用 CDS 的 spread 来估计违约强度
    - Bond market
        - Default probability are insufficient
        - Few issue zero-coupon bonds
    - CDS
        - Observable, Liquid contracts, more maturities, large number
- Hazard rate curves
    - Bootstrap
    - Few maturities, need to interpolation
    - **(PV of expected payments in default) = (PV of expected premiums paid)**
    - Time-varying hazard rates -> PD for each time range
- Spread curve (term-structure) and Default distribution
    - Spread: Upward sloping 违约增加
        - Default distribution: default unlikely in the near team but increase with time

    - Spread Downward sloping 短期高违约，但是可以活更久
        - **High** short-term default, but survive for a sufficiently long time if the firm can right itself
        - Deeper at the beginning, but flatter later
    - Default distribution: always upward
- Spread risk
    - Mark-to-market effect
        - shock CDS **curve parallel** up and down by 0.5bps
    - spread volatility
        - std of spreads
        - historical or forward-looking data

Portfolio Credit Risk

- 重点
    - Portfolio credit VaR
    - SFM VaR
    - Copulas VaR
- default correlation

Figure 1: Default Probabilities for Two Firms

Event	x_1	x_2	$(x_1\ x_2)$	*Default Probability*
Firm 1 Defaults	1	0	0	$\pi_1 - \pi_{12}$
Firm 2 Defaults	0	1	0	$\pi_2 - \pi_{12}$
Both Default	1	1	1	π_{12}
No Default	0	0	0	$1 - \pi_1 - \pi_2 + \pi_{12}$

-
- **Default correlation**

$$\rho_{12} = \frac{\pi_{12} - \pi_1\pi_2}{\sqrt{\pi_1(1-\pi_1)}\sqrt{\pi_2(1-\pi_2)}}$$

-
    - Cov(X,Y) = E(XY) – E(X)E(Y) =
    - Variance(X) = pi – pi^2 = p*(1-p)
- Correlation-based Framework
    - n portfolio, 2^n outcomes, n+1 + n*(n-1)/2 conditions
    - n*(n-1) pairwise correlations, set to a **single non-negative** parameter
    - some positions do not **fit** well
        - guarantees, revolving credit agreements, other contingent liabilities
        - CDS
        - convertible bonds
    - Limited data
- **Portfolio Credit VaR**
    - Credit VaR = Quantile of credit loss – expected loss
        - 和以前的 VaR 不太一样，以前的是 worst case loss (z*alpha -u)
    - Default correlation 不影响 expected loss

- correlation=1, a single portfolio
- correlation=0, binomial distribution
- more bonds, credit VaR decrease, worst case loss converges to expected

- **Single-Factor Model** 无条件和条件
  - Unconditional Mode $R_i = \beta_i \times R_M + \sqrt{1-\beta_i^2} \times \epsilon_i \sim N(0,1)$
    - $R_M \sim N(0,1), \epsilon_i \sim N(0,1)$
  - Each have a β_i correlation with the market
  - **Correlation** between each other $Corr(R_i, R_j) = \beta_i \times \beta_j$
  - Default Condition
    - If $R_i \leq k_i$, the logarithmic distance to the defaulted asset value
    - $k_i = \Phi^{-1}(\alpha)$就是 critical value，和对应的显著程度
  - Conditional independence 条件独立，市场回报已知
    - Once market return is realized, asset returns are independent of each other
    - $R_i - \beta_i \times \overline{R_M} = \sqrt{1-\beta_i^2} \times \epsilon_i \rightarrow R_i \sim N(\beta_i \times \overline{R_M}, \sqrt{1-\beta_i^2})$
    - As market goes from strong to **weak**, a smaller **idiosyncratic** shock will trigger default
- Conditional Default Distribution Variance
  - $\mu = \beta_i \times \overline{R_M}, \sigma = \sqrt{1-\beta_i^2}$
  - Unconditional cumulative probability of default $\Phi(k_i)$
  - Conditional cumulative probability $F(m) = \Phi\left(\frac{k_i - \beta_i \times \overline{R_M}}{\sqrt{1-\beta_i^2}}\right)$
  - All firms have the same β, k, π
    - Joint cumulative probability of default
    - $\Phi\binom{k}{k} = P(-\infty \leq R \leq k, -\infty \leq R \leq k)$
  - Default correlation
    - $\rho = \frac{\Phi\binom{k}{k} - \pi^2}{\pi \times (1-\pi)}$
- Credit VaR with SFM
  - Loss level of 0.01 (99% confidence level) -> k=-2.33
  - $k = \frac{k - \beta \times m}{\sqrt{1-\beta^2}} \rightarrow m = \cdots$
- Credit VaR with Copulas
  - Define the copulas function
  - Simulate default times
  - Obtain market values and P&L for each scenario
  - Compute distribution stats by adding terminal value result

Structured Credit Risk

- **Securitization Products**
  - **Covered bonds** 表内资产、有保证
    - On-balance sheet Securitization
    - Not true securitization
      - Principle and interest are **guaranteed**

        - Not part of bankruptcy-remote structure
        - Investors have **recourse** against the originator
    - Mortgage pass-through securities 表外资产，提前偿还
        - True off-balance sheet
        - Agency MBS: implicit or explicit **government** guarantee
        - Default risk not true concern
        - Primary risk: **prepayment** of principal
    - CMO 顺序法，一个接一个，本金和利息
        - Tranche 顺序 tranche
        - **Waterfall** or sequential pay structure
        - Tranche 1 receive all principle and interest, and then after tranche 1 is retired, then tranche 2
- Structured Credit Products
    - Tranche have different risk 吸收损失
    - Junior tranche bears the first losses
- Asset-backed securities – most general
    - Pooled and trenched
    - MBS < ABS
    - CBO (bond), CDO (debt), CLO (loan), CMO (mortgage)
- Difference
    - Underlying collateral: loan, bond, debt, credit card receivable, auto loan
    - Size and number
    - Passive (auto loan or mortgage) or actively managed
        - Active: add or shed assets
    - Revolving pool
        - Loan proceeds are reinvested in new assets
- Capital Structure
    - Priority of tranches
    - Senior
        - Highest, Lowest coupon, safest
    - Mezzanine (junior)
        - Absorb loss only after equity is **completely** written down
        - Relatively **high** coupon or high spread
    - Equity
        - Lowest, absorb the first loss up to predefined level
        - Residual cash flow
        - Smallest part
- **Credit enhancement**
    - Internal:
        - Hard: over collateralization (claim < collateral)
        - Soft: excess spread (cash flow collected > payment)
            - Separate trust account
    - External: insurance, CDS
- Waterfall structure
    - OC trigger
        - First allocate to senior and junior
        - how to allocate excess between equity and accumulating trust
    - interest = coupon = LIBOR + spread
    - assume constant default rate

        - loan proceeds = P * coupon * (1-default) 影响收入
- Securitization Participants
    - Originator 贷款
        - Funds the loan
    - Underwriter 发行
        - Issuance of debt and equity
        - **Structure** the issue (size, coupon, trigger, sell)
        - Warehouse the collateral and face the risks of drop or note marketed
    - Credit rating agencies (CRA) 评级
        - Influence the issue by requiring enhancement
        - Influence the size of tranche
        - Conflict: allocate more to larger positions
        - **Solution**: own analysis and insurance
    - Servicer 收钱
        - Collect and distribute cash flow and fees
        - Provide liquidity
        - Conflict: foreclosure, delay to increase fee
    - Manager - actively
        - Solution: originator and/or manager to bear the **first** loss
    - **Custodian** and trustees
        - Administrative, verify documents, disbursing funds, transfer bunds
- Three-tire structure
    - 有违约时，影响收入的现金流
        - N * (1-PD) * each bond value * coupon%
    - 无论是否有违约，每个 tranche 的利息还是按照没有 default 的算
        - N* each bond value * weight_i* coupon_i
        - 按照原始本金
    - Recover of sale of defaulted asset
    - The recovered funds would earn interest over the remaining life
    - Flow
        - Senior > mezzanine > excess spread account (max) > equity
    - If L – B >0
        - Pay bond holder: senior and mezzanine
        - If L-B>K
            - K -> excess spread
            - L-B-K -> equity
    - Else
        - Pay L to bond holder, shortfall is B-L
        - Check accumulated fund
        - If can cover then cover, then suffer a write down
    - **Consider default and recovery**
    - Recovery the **principle** -> trust account
    - Last year
        - Recovery, no trust account, principle
        - Senior > junior > equity

The terminal cash flows are summarized as follows:

1. Loan interest = $\left(N - \sum_{t=1}^{T} d_t\right) \times (\text{LIBOR} + \text{spread}) \times \text{par}$
2. Proceeds (par) from redemption of surviving loans = $\left(N - \sum_{t=1}^{T} d_t\right) \times \text{par}$

3
eference to GARP Assigned Reading – Malz, Chapter 9

3. Recovery in final year: $R_T = 0.4d_T \times \text{par}$
4. Residual in trust account: $\sum_{\tau=1}^{T}(1+r)^{t-\tau}OC_t$

- Inflow
  - Interest + principle + recovery principle + OC * (1+r_t)
- Outflow
  - Pay Principle first (senior > junior > equity)

- Simulation
- **PD and default correlation**
- **Convexity**
  - **Default rate increase** （想成是 **bond price** 和 **interest** 的关系）
    - Equity decrease rapidly then moderately (**positive** convexity)
    - Senior decrease rapidly (**negative** convexity)
    - Junior: negative convexity at low default, positive convexity at high default
  - **Relation (equity** 高风险、高收益、依靠波动**; senior:** 不依靠波动 **)**
    - PD -> **mean** all decrease, VaR (equity decrease, senior increase)
    - Correlation -> **VaR** all increase, mean (equity increase, senior decrease)
    - **Equity** 的 **mean value** 和 **VaR** 一致；**senior** 的相反；**mezzanie** 从 **senior** 向 **equity** 变化
  - **Correlation**
    - Senior VaR increase, but incremental difference between high correlation (0.6 and 0.9) is small.
    - Senior well insulated: high default, correlation low

Figure 3: Increasing Default Probability (Holding Correlation Constant)

	Mean value	*Credit VaR*
Equity tranche	↓	↓
Mezzanine tranche	↓	↑ then ↓
Senior tranche	↓	↑

Figure 4: Increasing Correlations (Holding Default Probability Constant)

	Mean value	*Credit VaR*
Equity tranche	↑	↑
Mezzanine tranche	↓(at low default rates) ↑(at high default rates)	↑
Senior tranche	↓	↑

- **Measure default sensitives**
  - Default -01, shock up and down by 10bps
    - 1/20 [(mean value / loss based on π + 0.001) – (mean value / loss based on π – 0.001)]
    -
    - always positive
    - approach 0 as default is very high
    - more variation when default generated loss close to tranche attachment **point**
      - similar option to at-the-money
  - Risk
    - Systematic risk: correlation
    - Tranche thinness
      - Equity and mezzanine very think
      - Close to 95% or 99% credit VaR
    - Loss granularity
      - Loan level divarication
      - Few large loan increase tail events
  - **Implied correlation**
    - Market price and a **pricing** function 定价函数
    - For **each** tranche: Assume **constant** pairwise and **constant** market price
    - CDS -> risk-neutral default probabilities and recovery rate
    - Estimated Default and correlation -> fed into a copula
  - Structured products motivation
    - Originator:
      - lower cost of funding
        - Diversification, high reputation
        - Commercial mortgage pool, hard to diversify
      - Collect service fee
    - Investor

- Desire risk-return level via trenching

Counterparty Risk

- **Counterparty and lending**
  - Counterparty: refer to pre-settlement risk in most cases
  - Counterparty: bilateral, amount uncertain
  - Lending: unilateral, certain principle
- Exchange and OTC
  - counterparty risk in OTC but not exchange
  - repo
    - hair cut: credit = collateral * (1-haircut)
    - repo rate: repurchase price = credit * (1+ repo rate)
  - OTC derivative
    - Interest rate swap: no principle exchange, net interest (float and fixed)
      - **Largest outstanding** notional amount in the market
    - Foreign exchange swap: **exchange** principle
    - CDS:
- Players
  - Large: large banks
  - Medium: smaller banks for financial institution
  - Small
    - Sovereign entities, large corporation, small financial institution
    - **Specific and illiquid** derivative
  - Others
    - Collateral management, clearing service, trade compression
- measure
  - replacement cost: Mark to market (cost, bid-ask spread)
  - exposure: current, future, contingent
  - default: mean reversion, market -> risk-neutral -> implied -> no arbitrage
  - recovery
- Manage
  - High quality counterparties
  - diversification: more counterparties
  - cross-product netting
  - **close-out**: close after default and settle
  - **walkaway**: cancel if default, largest advantage if negative exposure and counterparty default 不用还债，还可以讨债 claim
  - CCP: redistribute
- Mitigating
  - Netting
  - Collateral: liquid and legal
  - Hedging: generate market risk
  - CCP: liquid, systematic, operational
- Quantify: CVA

Netting, close-out

- **ISDA**

    - **Master** agreement, **standardize** OTC reduce **legal** uncertainty and mitigate credit risk
    - collateral, netting, and termination
    - cover multiple transactions by a single **legal** contract with an **indefinite** term
    - bilateral netting
    - legal opinion in most jurisdictions
- payment netting – **settlement** netting – increase operation efficiency
- close-out netting – **pre-settlement** netting
- netting
    - without: exposures are additive 可加性
    - with: reduce exposure, unwind positions, multiple position, stability
- acceleration clause 加速条款
    - accelerate future payments, i.e., rating downgrade
- close out
    - terminate: cancel + claim for compensation
    - negative MTM need to pay
    - positive MTM can claim and replace with another
    - cons
        - speed up distress -> time out
    - props
        - can re-hedge while waiting to receive a claim
- multilateral netting
    - CCP: valuation, settlement, collateralization
    - Disadvantage
        - **Mutualized** counterparty risk 风险共享
        - **Less incentive** to monitor other credit quality
        - **Redundant** trading positions 冗余
        - **Disclosure** 披露
- Netting effectiveness
    - **Negative** MTM benefit
    - Only **positive** MTM
        - up-front premiums (**options**)
        - Equality options, FX options, caps and floors, swaptions
    - Can be negative
        - Without up-front premiums
        - Swaps, futures, forwards, off-market instruments, wrong-way instruments
- Termination Features
    - Reset 重置
        - Terminate before becoming bankrupt
        - In-the-money -> at-the money
    - Break: Additional termination events (ATEs)
        - Terminate if declines to the bankruptcy point
        - Terminate at replacement value
        - Mandatory, optional, trigger-based
        - Bank paradox
            - Exercise early to be effective
    - Walkaway 不用还债，还可以讨债

        - Benefit from default of counterparty
        - No net liability, but can claim MTM exposure
    - Trade compression
        - Multilateral netting, reduce redundancies without changing risk profile
        - Standard coupons and maturity dates help compression

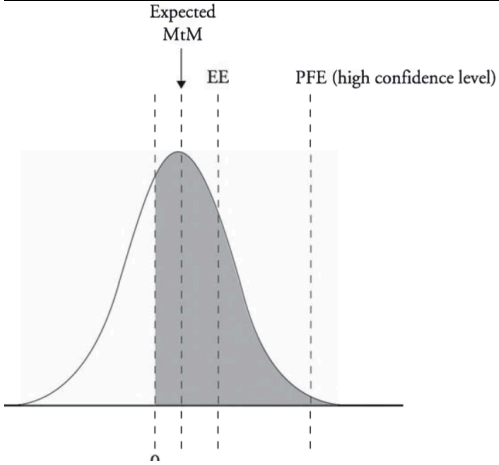
Collateral

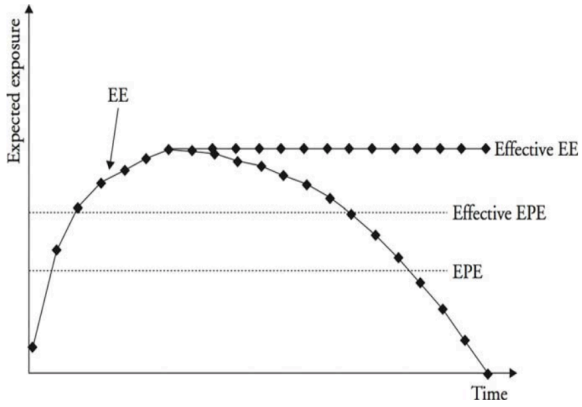
- Collateral management: **bilateral**
    - Reduce exposure
    - Reduce capital
    - More competitive pricing
- CSA
    - Evolved a few decades but no **legal** standards
    - Part of ISDA
    - Define all collateralization **parameters** account for scenarios
- Parameters
    - Threshold
        - When MTM excel threshold, post collateral
        - High credit
    - Minimum transfer amount
        - Minimum amount of collateral can be called
        - **Additive to threshold**
    - Rounding
    - Hair
        - $\text{credit} = \text{collateral} * (1 - \text{hair cut})$
    - Initial margin
        - Independent amount
    - Credit quality
    - Credit support amount
        - Called at a time
- Valuation Agent
    - Role
        - Credit exposure, market value, credit support amount, delivery/return collateral
    - Similar company: both can be the agent, but delay and disputes -> third party
- Governance
    - Include **maximum** number of trades
    - Focus on **majority** trades
    - Separate handle complexity or illiquidity and a small portion
    - Leave out: face frequent disputes
- Dispute
    - Exposure
    - Undisputed -> transferred
    - disputed -> identified -> quotes from market makers (4) for MTM
- features
    - substitution, reuse, rehypothecation
- CSA
    - Two-way: similar but can differ in parameters
    - One-way: one party post
    - Link to credit quality, equity, net asset, credit spread

- Risks
  - Market risks
    - Delay: minimum transfer and threshold
    - Normal delay: sending/receiving collateral
  - Operational risk
    - missed called, failed delivery
  - liquidity and liquidation risk
    - liquidation: transaction cost, ask-bid spread
      - slow: market risk
      - fast: liquidity risk
  - funding liquidity risk
    - no funding to settle obligation
    - illiquid: high risk
  - default risk
  - foreign exchange risk

Credit Exposure and Funding
positive and negative

	Positive		**Negative**	
Point 时间点	**E/MtM**	Exposure	**NE**	Negative exposure
Point 时间点	**EE**	Expected positive exposure	**NEE**	Negative Expected exposure
Time range 时间段	**EPE**	Expected positive exposure	**ENE**	expected negative exposure





Positive, maximum, effective

	Positive		**Positive Maximum**		**Positive Effective**	
Point 时间点	**E/MtM**	Exposure				
Point 时间点	**EE**	Expected positive exposure	**PFE**	Potential future exposure	**Effective EE**	Nondecreasing EE

Time range 时间段	**EPE**	Expected positive exposure	**Maximum PFE**	Maximum PFE	**Effective EPE**	Nondecreasing EPE

VaR and Exposure

	VaR	**Exposure**
Application	Risk management	Risk management Bond pricing
Time	Short	Many
Risk mitigant		Netting, collateral
Market trend variables (volatility, co-dependency)	No	Yes
Path dependency (Future payments, cash flow, cancellation, credit exposure)	**No**	**Yes**

- **credit exposure factors**
  - future uncertainty
  - periodic cash flow: regularly reduce risk, periodic but not equal -> more risk
  - combination of profiles
  - optionality
- collateral
  - delay in receiving collateral
  - variations in collateral value
  - granularity effects
  - path dependency
- PFE
  - A measure of credit and counterparty
  - Factor - Maturity
    - Bond/loan - stable and decrease linearly quickly
    - Interest swap – concave, a peak shape
    - FX – increase
    - Cross-currency: IR + FX -> increase
    - Option: increase (deep in the money)
    - CDS: increase and then flat, maximum is LGD
  - Factor – frequency
    - Pay frequently: more risk
    - Receive frequently: less risk
- Netting Benefit
  - individual: netting benefit = **no netting − netting**
  - EE: netting benefit = average no netting − average netting
  - E -> EE -> EPE
  - Negative correlation better
- Netting factor: small is better
  - netting factor = $\sqrt{\frac{1}{\mathrm{n}}+\left(1-\frac{1}{n}\right)\rho}=\sqrt{\rho+\frac{1}{n}(1-\rho)}$
    - n is the number of exposures, ρ is the average correlation
  - large n and small ρ is better
  - depend on initial MtM, negative is better

- Collateral on Exposure
  - Remargin period: take place to actually delivered
  - Steps
    - Valuation/margin call: exposure, market value
    - Receiving collateral: receive request -> **release** collateral
    - Settlement: sell collateral for cash
    - Grace period: additional time to deliver collateral
    - Liquidation/close-out and re-hedge
      - Liquidate the collateral, close out and re-hedge
  - Basel II: OTC Derivate (10day), repo (5 days)
- Measure Exposure During Remargin
  - $t = \frac{remargin\ period}{total\ trading\ days}$ years
  - σ_E is volatility **collateralized** exposure
  - $\text{EE} = \frac{1}{\sqrt{2\pi}} \times \sigma_E \times \sqrt{t} = 0.4 \times \sigma_E \times \sqrt{t}$
  - $\text{PFE} = \text{Z}_\alpha \times \sigma_E \times \sqrt{t}$ (99% -> 2.33 单边)
  - Collateral volatility (may increase the volatility)
    - $Collatered\ Exposure = Exposure - Collateral$
    - **Effective** variance $\sigma^2_{\text{CE}} = \sigma^2_{\text{E}} + \sigma^2_{\text{C}} - 2 \times \sigma_E \times \sigma_C \times \rho$
- Modelling Collateral
  - May be deficient due to terms (threshold, minimum transfer amount)
  - Exposure may increase between margin calls
  - Collateral is path-dependent
- Risk-Neutral and Real-world
  - Real-world: historical data
  - Risk-Neutral: market price (implied volatility)

Counter-party Risk Intermediaries

- SPV
  - Off-balance sheet
  - Bankruptcy-remote
  - Legal risk: consolidate originator with SPV
- DPC (derivative)
  - Bankruptcy-remote, capitalize
  - Market risk: offsetting contract
  - Support from originator
  - Internal credit risk management
  - Marking to market and collateral
- Monolines (insurance)
  - Only insure bond **repayments**
  - No collateral at the beginning
  - Concentrate systematic risk
- CCP
  - Reduce systematic risk
  - Market neutral: offset buy-seller side
  - Collateral, daily MtM
  - **Novation**: replace non-performing contracts with new ones when default
  - Loss mutualization
- Default

    - Novation: replace with new ones
    - auction: within clearing members
    - absorb realized loss
- **Loss waterfall - Loss mutualization**
    - Defaulting member **margin** account: collateral
    - Defaulting member default **fund** contribution
    - **CCP Equity**
    - Default Funds of Non-defaulting members
    - **Right of assessment**: additional contribution to default fund
    - Further liquidity support or CCP fail
- CCP
    - Advantages
        - Transparency (concentration), multilateral netting,
        - Liquidity (daily collateral settling)
        - Legal and operational efficiency (netting and collateral)
        - Loss mutualization
        - Default management: auction, stable
    - Disadvantages
        - Moral hazard
        - Adverse selection 逆向选择
            - member trade with CCP that offer best prices
        - Bifurcation 二分市场
        - Procyclicality 周期性
            - Positive correlation between event and economy state
- Impact
    - CVA (credit)
    - FVA (funding): uncollateralized OTC
    - KVA (capital): reserves
    - MVA (margin): increase, more margin

Default Probability, Credit Spread and Funding costs

- **Real-world and real-neutral**
    - Real-world: historical data
        - Real-world interest-free + inflation
        - **Risk management**: risk and return assessment
    - Real-neutral: market information
        - Real-world + liquid + default
        - **Hedge** decision
- Estimation approach
    - Historical data - real-world probability
        - Transition matrix
        - Cumulative: matrix multiplication
        - Mean-reversion: cumulative PD for investment increases for noninvestment grade
    - Equity-based - real-world probability
        - Merton: equity market data to estimate default pro probabilities
            -
        - KMV: built on Merton, relax several assumptions
            - Volatility and market value estimates

                - Distance to default: (A – K)/A \sigma
                - Historical default data and distance-to-default -> expected default
            - Credit Grade – no empirical data is not **utilized**
                - Observable market data and balance sheet information
                - Simple and easier to replicate
    - Risk-neutral approach
        - PD from observed credit spread and the market price of a traded credit security
        - Hazard * LGD = spread
- Recovery rates
    - Depend on each other
    - Recovery rates -> market prices of recovery swaps
    - From defaulted security
        - Vary by industries
        - Clustering of defaults during economic downturns
    - Higher default rates have a negative relation with recovery
    - Related to capital structure
    - Realized (Settled) vs eventual (actual)
- CDS
    - Physical
        - Delivery squeeze: many people need to buy to deliver increase the price
    - Cash
        - Settlement price: auction 30 days after default
- Credit Spread Curve
    - Most liquid
    - Choice of reference
    - Around a single, liquid observation to map the entire curve
- Portfolios of Credit Derivatives
    - CDS index
        - Equally weighted index
    - Fixed maturity and static constituents
        - Defaulted will be replaced by new names
    - Roll every six month, a new on-the-run CDS index series is created
- CDO
    - Index tranches
        - Capital structure for credit index
        - **Loss** distribution is divided into mutually exclusive ranges
        - Equity, mezzanine, senior, super-senior
        - [attachment point X%, detachment point Y%]
    - super-senior tranche [X%, Y%] loss range (EL=PD*LGD)
        - (number of defaults / n)* (1-recovery) = X%
        - Credit risk, not a major concern
        - Primary risk: counterparty risk
    - CDO
        - Senior, mezzanine, equity
    - Synthetic CDO
        - Custom-made for a specific transaction
        - **Separate** from the rest

    - Structured CDO
        - CLO, MBS, cash CDO -> more complex waterfall structure

CVA – CCR expected value

- **Pricing counterparty risk**
- **Credit value adjustment**
    - Expected value or price of counterparty credit risk
    - Risky value = risk-free value – CVA
    - $\text{CVA} = \text{LGD} \times \sum_{i=1}^{m} EE(t_i) \times PD(t_{i-1}, t_i)$
        - EE: discounted expected exposure
    - Assume no wrong-way risk 假定无错向风险
- CVA spread
    - $\frac{\text{CVA(t,T)}}{CDS_{premium}(t,T)} = \text{X}^{\text{CDS}} \times \text{EPE} = \text{spread} \times \text{EPE}$
    - $CDS_{premium}(t,T)$ unit premium value of a CDS
    - X^{CDS}: CDS premium at maturity date T, credit spread
- Impact
    - CVA will increase if spread increase
    - CVA lower for upward-sloping curve, higher for downward-sloping
    - CVA will decrease if
        - recovery rate increase
        - actual recovery - settlement recovery increase
        - netting
            - risk-free value of a new trade = new CVA - CVA
        - collateral increase (reduce expected exposure)
            - but minimum transfer and threshold increase CVA
- Incremental and Marginal
    - Incremental: **pricing** a new trade 定价
    - Marginal: break down into trade level to see contribution 贡献
        - Larger n, smaller marginal effects
- CVA to running spread
    - CVA / (Duration * principle) = xxx bps
- CVA to exotic products and path dependency
    - Exotic products
        - MC simulation
    - Path dependency
        - information on the entire path from present to future
- BCVA
    - BCVA = CVA + DVA
        - $\text{CVA} = \text{LGD} \times \sum_{i=1}^{m} EE(t_i) \times PD_C(t_{i-1}, t_i)$ 对手违约
        - $\text{DVA} = -\text{LGD} \times \sum_{i=1}^{m} NEE(t_i) \times PD_I(t_{i-1}, t_i)$ 自己违约
    - BCVA = CVA - DVA 也可以这样理解
    - Netting may be a disadvantage
- BCVA spread
    - $\frac{\mathbf{BCVA(t,T)}}{\boldsymbol{CDS_{premium}(t,T)}} = \mathbf{X_C^{CDS} \times EPE - X_I^{CDS} \times ENE}$
    - C: counterparty, I: institution

WWR

- Correlation between exposure and counterparty

- RWR and WWR (center of attention)
- Loan exposure, fixed for a specific time
- OTC derivative, fluctuates on market conditions
- **High** quality more WWR
- OTC put option
    - **Out-of-money put** have more WWR than in-the-money put
    - Economic fall, increase exposure,
- CDS
    - Economic fall, CDS gain,
- Foreign currency swaps
    - Japanese currency appraised, US depreciated
- Collateral
    - Reduce
    - Exposure jumps, benefit limited, currency devaluation
- CCP
    - Collateral and default fund contribution

Stress Test CCP

- CCP Measures
    - Exposure: current/peak/expected/expected positive
- CCR Risk
    - Credit risk
        - CVA, managed at inception or collateral
        - Focus on risk mitigation and credit evaluation
        - Manage **portfolio**
        - Measures: all kinds of exposure
    - Market risk
        - CVA (spread) and variability in CVA (VaR of CVA)
        - Incorporate **correlation**
        - **hedge** risk
    - Credit and market risk both
- Stress current exposure
    - Most common
    - Shortcoming
        - Aggregating results is challenge
        - No WWR
- Stress Expected Loss
    - Loan portfolio
        - Expected loss (EL): PD, LGD, EAD
        - Stress EL – EL
    - Derivative Portfolio
        - EAD -> Alpha * **EPE**
- Stress CVA
    - Unilateral CVA and bilateral BCVA
    - Stressed CVA (both PD and EE)
- Stress BCVA
    - BCVA$\sim = \mathbf{X_C^{CDS}} \times \mathbf{EPE} \times \mathbf{S_I} - \mathbf{X_I^{CDS}} \times \mathbf{ENE} \times \mathbf{S_C}$
    - S_I survival probability of financial 自己要存活，然后 CVA 才有价值

Retail

-

Credit Migration

- Collateral
- Guarantee
- Credit Enhancement

Credit Risk

- Default Mode
  - Default risk
  - Recovery risk
  - Exposure risk
- Value based
  - Migration risk
  - Spread risk
  - Liquidity risk
- Concentration risk in portfolio
- Portfolio correlation
- Counterparty Risk
- Settlement Risk
-

Loss

- Expected Loss
  - EL = EAD * PD * LGD
- Unexpected Loss / VaR / Economic Capital
  - UL = WCL(c%) – EL
- Catastrophic Loss
  - Expected Shortfall (1-c%)

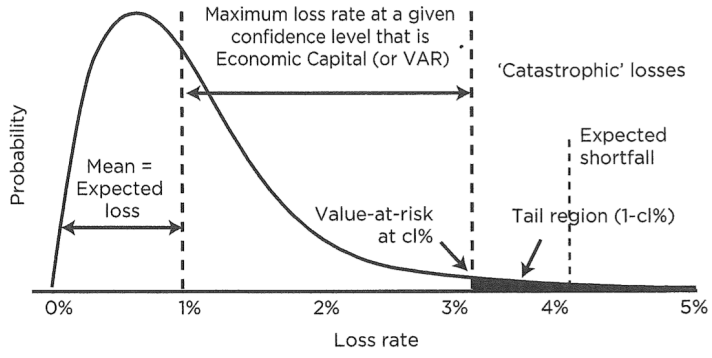


FIGURE 3-1 Loss rate distribution and economic capital.

Credit VaR

- **Credit loss**

    - Expected loss EL = PD * LGD * EAD
    - Worst case loss WCL
    - Unexpected loss UL = Credit VaR = WCL – EL
- Default correlation has no effect on EL but is an increasing function with UL.
- Portfolio VaR
    - n credits, default probability p, default correlation 0.
    - VaR 95%
- **Default correlation**
    - Correlation = COV(X,Y) / sqrt(Var(X) Var(Y))
    - COV(X,Y) = E(XY) – E(X) E(Y) = p(XY) – p(x) p(y)
    - Var(X) = n * p * (1-p)

Probability of Default in Rating System

- **Good Rating Systems**
    - Measurability and Verifiability
    - Objectivity and Homogeneity
    - Specificity
- **Probs**
    - Cumulative default probability
    - Marginal default probability
    - Forward probability (contingent to survival rate)
    - Survival Rate
    - Annualized Default Rate

Spread and Default

- Define
    - 1 dollar, probability of default: p, RR: recovery at default
    - risk free rate: r, yield to maturity: y
- PV equal
    - PV = 1 / (1+y), use yield to maturity
    - PV = (p * RR + (1-p)*1) / (1+r), use risk free and default
    - 1 / (1+y) = (1 – p * LGD) / (1+r)
- Spread
    - Spread y – r
    - (1+r)/(1+y) = 1 – p*LGD
    - P * LGD= (y-r)/(1+y) = spread / (1+y)
    -

Merton Model

- V: firm value, D: debt, E: equity.
- Equity
    - Call option on firm value V with strike price D
    - E = Max(V-D,0)
- Bond
    - Risky bond + put option = risk free bond
    - **Risky bond = risk free bond – put option**
    - D = V – max(V-D,0)= min(D,V)
- Model
    - Equity call = V N(d1) – K exp(-R_f *t) N(d2)

    - Bond = V – equity = K exp(-R_f t) N(d2) + V (1 - N(d2))
        - 1 – N(d2) = N(-d2)
    - R_f is the risk-free rate
- Default
    - d1 = (ln V/F exp(-r * t) + 0.5*s^2*t) / (s*sqrt(t))
    - d2 = (ln V/F exp(-r * t) – 0.5*s^2*t) / (s*sqrt(t))
    - r: asset expected return, not risk-free return
    - s: asset volatility
- **Default probability**
    - d2 is the distance to default
    - N(-d2) = 1 – N(d2)
- Characteristics
    - Follows lognormal diffusion process, no sudden change
    - Default can only occur at the debt maturity

KMV Model

- **Normalized distance to default**
    - Z = (A – K) / (A * s) = (1 – K/A) / s
    - K is the liabilities, K = short-term liabilities + 0.5 * long-term liabilities
    - A: Asset, Asset=Liabilities + Equity
    - s: asset volatilities

Poisson and Exponential Distribution

- Poisson: p(x) = exp(-r) * r^x / x!
- Hazard rate: r, over dt is r*dt
- Cumulative PD: F(t) = 1 – exp(-t)
- Survival distribution: S(t) = exp(-t) = 1 – F(t)
-

Single-Factor Model

- Alpha = beta * m + sqrt(1 – beta^2) * e
- E(a) = 0, Var(a) = 1
- Conditional cumulative default probability function
    - Assume m is known
    - e_i = (k_i – beta * m') / sqrt(1 – beta^2)
    - p =\Phi(e_i)

Other PD Models

- **Linear discriminant analysis**
    - Z-score function
    - The cut-off value is 2.675
- **Logistic Regression Model**
    - Log odds = log p / (1-p) = \sum w_i * x_i
    - pi = 1 / (1 + exp(- \sum w_i * x_i))

Credit Exposure

- Current Exposure (Replacement Cost)
- MtM

    - Market to market, can be positive or negative
- Expected Exposure (**EE**) (over **distribution**)
    - The **average** of the distribution of exposure at a **future** date
    - **Positive exposure = max(value, 0)**
- Expected Positive Exposure (**EPE**) (**over time**)
    - Weighted average over **time** of EE, where weights are the proportion that
- Negative Exposure (**NEE**)
    - From counterparty's point of view.
    - **Negative exposure = min(value, 0)**
- Expected Negative Exposure (**ENE**)
    - Weighted average of NEE over time
- Peak Exposure/Potential Future Exposure (**PFE**)
    - A high-percentile (95% or 99%) of the distribution at a future date
- Maximum PFE
    - Highest PFE value over time
- Effective EE (non-decreasing EE)
- Effective EPE
- Cross-currency swap
    - Interest rate swap (IRS) + foreign exchange (FX) forward contract

Credit Value Adjustment (CVA)

- CVA = LGD * \sum EE(t) * PD(t-1, t) * d(t)
- CVA = CS * EPE
- Incremental CVA
    - Accounts for change in CVA
- marginal CVA
    - break down netted trades to see the impact
- Stress test on loan portfolio
    - El_s = \sum PD * EAD * LGD
- Stress test on derivative portfolio
    - EL = \sum PD * alpha * EPE * LGD
- Stressed CVA
    -
- DVA and Stressed DVA
- CVA = EPE * counterparty credit spread
- DVA = ENE * institution credit spread
- BCVA = CVA – DVA
- Hazard rate = spread / LGD

Wrong Way Risk (WWR)

- Relation between **exposure** and **creditworthiness increase** risk
- RWR: buy oil from oil producer at fixed price
- Highest WWR: an out-of-money put option

CCP

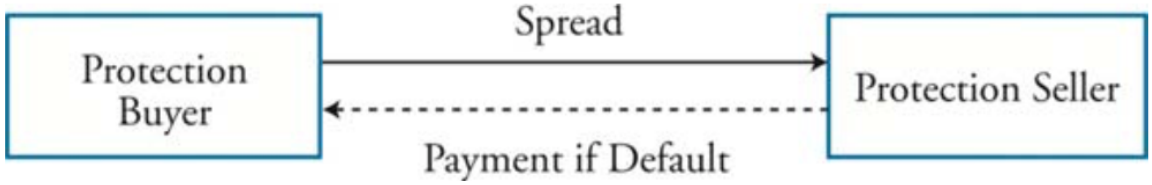
Mitigation Counterparty Risk

- Netting

    - Total exposure: \sum_i max(MtM_i, 0) 先最大化、再求和
    - Netting exposure: max(\sum_i MtM_i, 0) 先求和、再最大化
    - Netting factor = netting exposure / total exposure
    - Portfolio with **n** positions and average correlation **r**
        - Netting factor = sqrt(n + n*(n-1)*r) / n
        - Netting factor = sqrt(1/n + (1 - 1/n) *r)
- Collateral
    - Remargin period: between call and its receipt
    - Threshold: exposure level below which collateral is not called
    - Minimum transfer amount: minimum quantity or block transferred
    - Independently amount: initial margin
- Contract Clauses
    - Walk-away clause
    - Close-out netting
    - Acceleration
    - Termination
    - Novation
- Central Counterparties
    - Loss waterfall: initial margin, reserve contribution,
    - Initial margin: initial margin
    - Variation margin: daily change in positions
- Hedging
- Collateral Support Annex (CSA)

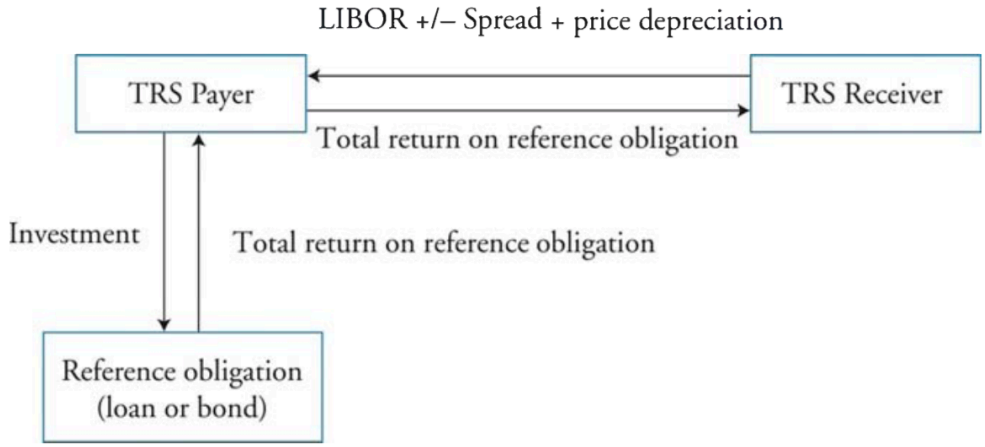
Credit Derivatives

- **Credit Default Swaps (CDS)**
    - Protection Buyer-seller
        - Buyer: periodic payment
        - Seller: contingent payment
    - Only market risk
    - Like a put option
    - Risk-free bond = Risky bond + CDS
    - Settlement
        - Cash-settled: pay par - market
        - Digital CDS: illiquid asset
            - Receive pre-agreed cash
        - Physically settled
    - First to default
    - Nth to default (correlation)



- **Total Return Swaps (TRS)**
    - Buyer-seller
        - Buyer (payer and risk seller): payment tied to reference **asset**
        - Seller: payment tied to reference **rate**

- Hedge against **credit risk** (default, deterioration) and **market** risk.



- **Credit-Linked Notes (CLN)**
  - A swap, principle is exchanged
  - Investor: CLN = Bond – CDS
    - Issue CDS and Buy a coupon
  - Issuer: CLN = CDS - Bond
    - Issues a coupon bond to investor and buy CDS from investor
  - Investors: a funded CDS, sellers who have funded the contingent credit loss
  - Protection Buyer-Seller
    - Buyer: issuer
    - Seller: investors
  - Lender receives an enhanced coupon
  - Least counterparty credit exposure for the protection buyer
  - Selling/issuing a CLN transfers credit risks to investors
  - The buyer pays the principle to the seller and receive regular coupon
  - If there is no credit event, the principle will be paid back to the investor.
  - Otherwise, CLN buyer receive the collateral.

Structured Products

- Securitization
  - Tranching
  - Waterfall
- Products
  - Covered bonds
  - MBS
  - CDO
- CDO
  - Cash-flow vs synthetic
- Internal credit enhancement