

- Operation Risk
 - ERM
- Op Risk Data
 - Information risk Data Quality
 - Internal Data and Governance
 - Risk Category, RCSA, KRI, scenario analysis
 - External data
 - Subscription: First, ORX
- Risk Capital
 - Revenue-based: BIA, TSA/ASA
 - Loss-based Parametric: AMA (LDA)
 - 5-year, 3-year move to AMA
 - LDA: Poisson & lognormal, expected loss
 - Scenario: fat-tail, unexpected loss
 - insurance
 - Nonparametric: SMA (non-model, financial & internal loss)
 - 10year, 5-year move to SMA
- Generalized Extreme Value
 - GEV, POT (generalized pareto, linear approx. of the tail, VaR and ES)
 - Multivariate EVT (copula)
- Validation
 - Rating
 - Model
- Economic Capital
 - RAROC
 - Capital framework
 - Capital planning at BHC
- Liquidity
 - Liquidity risk (LVaR, LaR)
 - Liquidity and leverage

Enterprise Risk Management (ERM) and Firm-wide VaR

- ERM
 - Acceptable level of risk (risk appetite)
 - Target debt rating, estimate capital
 - The ideal mix of capital and risk
- Firm-wide VaR
 - Market, credit, operational risk
 - Independent: assume perfect linearity

Information Risk and Data Quality Management

- Dimensions Data Quality
 - Accuracy
 - Completeness
 - Consistency
 - Reasonableness
 - Currency

- Uniqueness
- Data Quality Scorecard
 - Simple metrics: base-level
 - Complex metrics
 - By issue, business process, **business impact (high-level)**
- Impact data quality
 - Data transformation, duplicate records, noisy records, missing records, nonstandard format

Operational Risk Management

- Definition
 - Inadequate or failed internal process, people and systems or external events.
 - Include **legal** but exclude strategic and reputation risk
 - Include technological risk
- Categories
 - Execution, Delivery and Process Management (EDPM)
 - Failed to settle a txn
 - Clients, products, and Business Practices (CPBP)
 - Internal Fraud
 - External fraud
 - Damage to physical assets
 - Business disruption and system failures
 - Employment practices and workplace safety
- **Three Lines of Defense**
 - Business Line Management
 - Identify and manage the risks
 - Independent corporate operational risk function (CORF)
 - Complement the business line
 - Challenge inputs from the business line managers
 - Independent review and audit
- Board of Directors
 - Establish, approve, and periodically review the framework
- Role of Senior Management
 - Robust governance structure
 - Implement system across the organization

Loss Distribution Approach (LDA)

- Frequency distribution 离散
 - Poisson, negative binominal, binomial 二项、泊松
- Severity distribution 连续
 - Lognormal, Weibull, Gamma, Exponential, Pareto, Transformed Beta
 - One parameter is insufficient to model severity
- **Expected loss and VaR**
- 组合分布

- 假如各有 3 种可能，次数 $0(p_1)$ 、 $1(p_2)$ 、 $2(p_3)$ ，损失 $l_1(q_1)$ 、 $l_2(q_2)$ 、 $l_3(q_3)$ 。
- 组合一共 $1+3+6=10=A(3,0)+A(3,1)+A(3,2)$ 种。注意，损失次数为 2 次时，2 次是独立的。
- 那么组合分布 loss-probability-loss*Probability
 - $0 - p_1 - 0$
 - **$L_1 - p_1 * q_1$**
 - $2 * l_1 - p_2 * q_1 * q_1$
 - **$L_2 - p_1 * q_2$**
 - $L_1 + l_2 - 2 * p_2 * q_1 * q_2$
 - $2 * l_2 - p_2 * q_2 * q_2$
 - **$L_3 - p_1 * q_3$**
 - $L_1 + l_3 - 2 * p_2 * q_1 * q_3$
 - $L_2 + l_3 - 2 * p_2 * q_2 * q_3$
 - $2 * l_3 - p_2 * q_3 * q_3$
- 期望损失
 - 所有组合的期望
 - $E(S) = l_1 * q_1 + l_2 * q_2 + l_3 * q_3$
 - $EL = p_1 * 0 + p_2 * E(S) + p_3 * 2 * E(S) = p_2 * E(S) + 2 * p_3 * E(S)$
- VaR at 95% = WCL(95%) – EL ?
 - find the combination whose probability > 95%
 - 按照严重程度顺序列出组合
 - 第一种顺序找到第一个值 > 95%。
 - 第二种是倒叙找到第一个值 > 5%。条件都是大于。
- Data
 - Internal data: selection of threshold
 - **External data: bias**
 - Insufficient, under-reporting, relevance
 - Scale bias: loss positively related to the scale
 - Truncation bias: minimum loss threshold not uniform across banks
 - Data capture bias: likelihood of capture a loss is related to size of loss
- Scenario Analysis
 - Presentation, availability, anchoring, huddle, gaming, confidence, inexpert, context
- Business Environment Internal Control Factors: RCSA, KRI
- RCSA
 - Identify and access risks with each BU
 - Controls are added
 - Risk metrics and other OpRisk initiatives are linked to RCSA

Parametric Approaches: Extreme Value

- Generalized extreme-value theory (GEV)
 - **Block maxima**: n samples drawn from $F(x)$, the maximum is M_n .
 - Three parameters
 - μ : location parameter, central tendency
 - σ : scale parameter, dispersion

- e: tail index, indication of the shape/heaviness of the tail
 - e>0: Frechet Distribution, heavy-tailed
- **Peaks-over-threshold (POT)**
 - X is drawn from F(x), u is a threshold value of x, we can define the distribution of excess loss over u is Fu(x)
 - F(x) can be any commonly used: normal, lognormal, t, etc .
 - U gets larger, Fu(x) -> generalized **Pareto** distribution
 - Two parameters
 - Beta: scale parameter
 - e: shape or tail index parameter, the same parameter with GEV
 - e>0 => light-tail: Gumbel distribution (normal or lognormal)
 - threshold
 - relatively high: more **applicable** but decrease the #observations
- Compare
 - GEV has more parameters and share one parameter with POT
 - POT: exceedances over a high threshold, GEV: maxima of a large sample
 - POT: few parameters but have to choose threshold
- ES and VaR with POT

$$VaR = u + \frac{\beta}{\xi} \left\{ \left[\frac{n}{N_u} (1 - \alpha) \right]^{-\xi} - 1 \right\}$$

$$ES = \frac{VaR}{1 - \xi} + \frac{\beta - \xi u}{1 - \xi}$$

-
- U is loss threshold, N_u is number of observations in excess of threshold, alpha is the confidence level
- (1-a) / (N_u/n)
- VaR is the VaR%
- ES
 - VaR is 4.45%, u=3, beta=0.75, e=0.22, then
 - ES = 4.45/(1-0.22) + (0.75 - 90.22*3)/(1-.022)=5.82%
- Increase u or e will increase VaR and ES

Capital Measures

- 对比
 - BIA 和 TSA/ASA（业务线）都是基于 gross income
 - AMA（业务线、风险类别）是基于 loss 还有其余的。
- BIA - GI
 - 15% * gross revenue, average of **positive** years in last three years
 - $BIA = \sum_i \max(GI_i, 0) / n_+ \times \alpha$ 只考虑收入为正的
 - 先最大化，再求和
- TSA - GI/BU
 - 8 lines, some 18%, 15%, 12%
 - 18% - trading & payment
 - Investment banking (corporate finance, trading and sales)
 - Settlement and payment services

- 15% - commercial and agency
 - Commercial banking
 - Agency and custody services
 - 12% - retail & asset
 - Retail banking/brokerage
 - Asset management
- $TSA = \sum_i \max(\sum_j GI_{ij} \times \beta_i, 0) / 3$ 先求和、再最大化、再求和
 - Each line can **offset**, but the maximum of zero (cannot be negative)
 - All the years can **offset** by dividing 3 (not positive years)
- ASA
 - Minimize double counting of risks
 - Exception
 - Retail and commercial banking: 15%
 - Gross income is replaced by **loans and advances** times a multiplier, 0.035
 - $GI \rightarrow \sum_i LA_i / 3 \times 0.035$
- Negative GI
 - Under pillar (minimum capital requirements) may be distorted
 - Recommends additional capital under Pillar 2 (supervisory review)
- AMA – **loss** based – BU/risk category
 - Own models (based on loss)
 - Requirements
 - Capture **fat-tail** losses (**99.9% one-year**)
 - Consider: **internal** loss data, **external** loss data, **scenario** analysis, business environment internal control **factors** (i.e., the four elements)
 - **Incentivizes** good behaviour
 - Methods
 - Should be made for **seven risk** categories 风险类别
 - Some on firm level and then to business level, some at business level
 - **Business line / event type** matrix, cell 业务线、风险类别组合
- LDA
 - **Internal** data as direct inputs, the rest used for **stressing** or **allocation**
 - Must have 5 years of internal loss, but can use **three** years when use AMA
 - Pros
 - Based on historical data
 - Cons
 - Data is short and not capture fat-tail
- Modelling Frequency 离散
 - Poisson (λ)
 - **Lower** λ are more skewed and leptokurtic
 - Binomial,
- Model severity 连续
 - **Lognormal** distribution
 - **Low frequency**: Generalized Gamma, Transformed Beta, Generalized Pareto, Weibull.
 - Density function must have **fat** tails

- Monte Carlo Simulation
 - 99.99% confidence level
 - Combination: Draw loss frequency, then draw loss severity
 - Order
- Scenario Analysis
 - Identify fat-tail events
 - Future: What if
 - Cons
 - Subjective, a few data points 数据少
 - Different methods for modelling risks for different **categories**
- Hybrid approach
 - Combine LDA and scenario analysis
 - LDA: expected loss, scenario: unexpected loss
 - Combine **scenario analysis** data points with **actual loss** data when modelling frequency and severity
- Insurance
 - Use **insurance** to reduce capital charge
 - But only maximum **20%** reduction
 - Insurance lower **severity** but not frequency

Standardized Measures Approach (SMA)

- SMA capital
 - Combine business indicator and Internal loss component
 - **Business Indicator (BI)**
 - Financial statement proxy of risk exposure
 - $BI = ILDC + SC + FC$
 - ILDC: interest, lease, dividend
 - SC: service charge
 - FC: fee charge
 - 3 year average
 - **Business component:** Five buckets

BI buckets in the BI Component		
Bucket	BI Range	BI Component
1	€0 to €1 bn	$0.11 * BI$
2	€1 bn to €3bn	$€110 \text{ m} + 0.15(BI - €1 \text{ bn})$
3	€3 bn to €10 bn	$€410 \text{ m} + 0.19(BI - €3 \text{ bn})$
4	€10 bn to €30 bn	$€1.74 \text{ bn} + 0.23(BI - €10 \text{ bn})$
5	€30 bn to $+\infty$	$€6.34 \text{ bn} + 0.29(BI - €30 \text{ bn})$

- 区间为 1b, 3b, 10b, 30b
- 第二个开始的系数为 0.11, 0.15, 0.19, 0.23, 0.29
- 第一个为基数为 110m, 410m, 1.74b, 6.34b
- **Internal loss component**
 - Loss component = $7 * \text{average total annual loss}$
 - + $7 * \text{average total annual loss above } 10 \text{ million}$
 - + $5 * \text{average total annual loss above } 100 \text{ million}$

- Internal loss **multiplier**
 - Bucket 1: 1
 - buckets 2-5: $\ln(e - 1 + \text{loss component} / \text{BI component})$
- **Capital Requirements**
 - bucket 1: BI component * 1
 - Bucket 2-5: $110M + (BI - 110m) * \text{loss multiplier}$

Validating Rating Models

- Validation
 - Validation group
 - Internal audit group
- Qualitative and quantitative validation are complements although a greater emphasis is placed on **qualitative** validation given its holistic nature 定性重要
- Qualitative - System Design
 - Proper application and usage of ratings
 - Obtain PD
 - **Completeness**: all relevant information
 - **Objectivity**:
 - **Acceptance**: easy to understand and shared
 - **Consistency**: make sense
 - Compare
 - Stat-based method: completeness, objectivity
 - Heuristic: acceptance, consistency
- Quantitative
 - Sample representativeness
 - Sample match population
 - **Discriminatory power**
 - Relative ability of a rating model to accurately differentiate between defaulting and non-defaulting entities.
 - Dynamic properties
 - Rating system Stability and attributes of migration matrices
 - **Calibration**
 - Relative ability to estimate PD
- Data Quality - Challenges
 - Completeness of data
 - Volume of available data
 - Representativeness of samples
 - Consistency and integrity of data sources
 - Adequacy of procedures used to ensure data quality
 - Lending technology: impossible to remain stable for even five years
 - Time horizon: From a full credit cycle
 - Use out-of-sample testing
- Data Quality – Validation
 - Focus on stability and degree of calibration
 - Central tendency in long term: back testing and stress testing
- Validating **Calibration**
 - Binomial test: single category at a time

- Chi-square test: multiple categories at a time
- Normal test: a single category for more than one period
- Traffic lights approach: **back test** a single category more than one period
- Validation Discriminatory Power
 - Statistical test
 - Migration matrices
 - Accuracy indices
 - Classification tests (binomial, type I and II, chi-square test, normality test)
- Distribution of errors is key to assess forecasting reliability

Model Risk

- **Model Assumption Error**
 - Distribution is **stationary, constant volatility**
 - **Normal** Return
 - **Underestimate** #risk factors
 - **Perfect** capital market
 - Assume adequate **Liquidity**
 - **Misapply** a model
- **Model Implement Error**
 - #simulations in MC
 - Frequency of updating parameters
 - Outliers treatment
 - Estimating: duration, volatilities, correlations
- **Common Valuation and Estimation Errors**
 - Inaccurate data
 - Inappropriate length of **sampling** period
 - Increase #samples -> improve accuracy and reduce errors, but put too much weight on stale data
 - Problems with **liquidity** and **valuation**
 - Prices may not exist
 - Bid-ask spread may be too high
- **Model Migration: research or vetting**
 - Documentation
 - **Soundness** of model
 - Accept the model for one but reject it for another
 - Ensure the model reasonably represents the asset being valued
 - **Independent** access to financial rates
 - **Benchmark** modelling
 - Test an analytical model against a simulation or numeric approximation
 - Health check
 - Ensure model contains all the necessary properties
 - Stress test
 - use simulation to check the model's reaction to different situations
 - Build a formal treatment of model risk into the overall mgt procedures, periodically reevaluate model

- Case study
 - 2005 credit correlation episode
 - The correlation was assumed to be **static**
 - Subprime default models
 - Assume **positive** future house prices (price appreciation)
 - Assume **Low** geographical correlation
 - London whale trading loss
 - A **new** VaR model which lowered VaR by 50%
 - LTCM
 - Time horizon of capital should be time it takes to raise capital
 - 10-day VaR is too short
 - **Liquidity** risk not factored into traditional static VaR models
 - Correlation and volatility risks
- VaR Variation
 - Not much **uniformity** as to confidence level and time horizon
 - Even if confidence level and time horizon were standardized, different ways of measuring VaR lead to different results
 - Length of time series
 - **Technique** for estimating moments
 - **Mapping** techniques and the choice of risk **factors**
 - Decay factor if applying EWMA
 - MC simulation, randomization technique and the number of simulations

Risk Capital

- Regulatory capital
 - for banking and insurance
 - general benchmarks, minimal
- RAROC
 - Economic profits
 - Flexible: allow deferred/contingent compensation
 - Portfolio: buy/sell
 - capital management: add a new investing
 - risk-based pricing: take risk into account
- ROROC
 - Similar to Sharpe and NPV
 - $$RAROC = \frac{\text{netted revenue} \pm \text{transfer}}{\text{economic capital}} \times (1 - \text{tax rate}) = NI/EC$$
 - $\text{netted revenue} = \text{expected revenue} - \text{operating cost} - \text{interest cost} - \text{expected loss} + \text{economic revenue}$
 - $\text{economic capital} = \text{Unexpeted Loss}$
 - $\text{economic revenue} = \text{economic capital} \times \text{risk free rate}$
 - Cost of capital is the cost on capital, used to compare the investment
 - **Cost of capital** is the cost of economic capital
- Strategy risk capital: goodwill + burned-out capital
- Performance Measurement
 - Time horizon

- One year
 - Default probability
 - Point in time (PIT) or through-the-cycle (TTC)
 - PIT: short term exposure
 - TTC: long term strategy
 - Confidence level
 - Reduction will be dramatic if primarily exposed to operational/credit/settlement risk
- Hurdle rate
 - $(CE * R_{ce} + PE * R_{pe}) / (CE + PE)$
 - Decision
 - $RAROC > \text{hurdle}$, accept
 - $RAROC < \text{hurdle}$, reject
 - But leads to problem
- Adjusted ROC
 - $\text{Adjusted RAROC} = RAROC - \beta \times (R_M - R_F)$
 - Decision
 - $\text{Adjusted RAROC} > R_f$, accept
 - $\text{Adjusted RAROC} < R_f$, reject
- Diversification
 - Standard alone capital
 - Activity A: 50, B: 60, in total: 90
 - Full diversified capital
 - Benefits: $110 - 90 = 20$
 - Pro-rata in reduction: $20 * 50 / 110 = 9.1$, $20 * 60 / 110 = 10.9$
 - A: 40.9, B: 48.1
 - Marginal capital
 - A: $90 - 60 = 30$
 - B: $90 - 50 = 40$
 - In total: $30 + 40 = 70$

Capital Frameworks

- Risk measures
 - STD (not monotonicity), VaR (not subadditive), ERS, spectral
- Risk aggregation
 - Factors
 - Risk metric
 - Confidence level
 - Time horizon
 - Methods
 - Simple summation
 - Constant diversification
 - Variance-covariance matrix: by banks
 - Copulas
 - Full modelling/simulation
- Validation
 - Qualitative

- Use test
 - Qualitative review
 - System implementation
 - Management oversight
 - Data quality checks
 - Examination of assumptions – sensitivity testing
 - Correlation, recovery rates, shape of tail distribution
- Quantitative
 - Inputs and parameters
 - Model replication
 - Benchmarking and hypothetical portfolio testing
 - Backtesting
 - Profit and loss attribution
 - Stress testing
- Dependency Modeling in credit risk
- Evaluating CCP
 - Market risk: EAD
 - Credit risk: PD and LGD
 - Interaction – WWR
 - Operational risk
 - Margined and non-margined counterparties
 - Challenge
 - Derivative and securities
- Interest Rate Risk in banking book
- BIS
 - Economic capital -> capital adequacy
 - Senior mgt
 - Transparency and integration into decision-making
 - Risk identification
 - Risk measure
 - Risk aggregation
 - Validation
 - Dependency modelling in credit risk
 - Counterparty credit risk
 - Interest rate risk in banking book
- Constraints and Opportunities

BHC

- Capital plan rule
 - BHC \geq 50billion
- Governance policy: SM furnish the BOD with sufficient information to comprehend the risk exposure
- Capital policy: capital issuance, use, distribution, planning
- Capital contingency plan: suspension or reduction in dividend or repurchase

Repurchase

- Repo: borrower side, reverse repo: lender side

- Overnight repo: daily, term repo: >1 day
- Repo rate: annualized repurchase rate
- Settlement calculation
 - Repurchase price = contract price * (1 + repo rate/360*maturity)
- Repo rate
 - $FV = PV(1+r / 365 *days)$
- Borrowers
 - Lend at a lower rate
 - Bond financing
 - **Liquidity management**
 - Repo: short-term secured financing
 - **Cheaper** but **less stable**
 - Subject to **swings** in market conditions
 - Equity financing
 - **Stable but expensive**, require highest expected return
- Lenders
 - Investing or cash management
 - **Cash management**
 - Short-term investing: mutual funds, municipal (tax save)
 - **Overnight** repo: daily
 - Open repo: lend until cancelled
 - High **quality collateral**: Haircut
 - Margining and daily **margin** calls
 - Post additional or withdraw excess collateral
 - **Short** position **financing** (repos as financing vehicles) 空头
 - If bond price decrease
 - Lend bond for cash, sell it, buy it back later on
- **Counterparty risk**
 - Borrow default, has collateral, less a concern
- **liquidity risk**
 - collateral illiquidity
 - haircuts, margin calls, reducing the terms, only high-quality collateral
- repos during the credit crisis
 - weaker quality
- collateral in repo
 - general collateral
 - **GC rate**
 - General collateral rate, **overnight rate** for US Treasury collateral
 - **Fed funds rate**
 - depository institution in US charge **each other** for lending funds maintained at the federal **reserve**
 - **Fed-fund - GC spread**
 - Widen when treasuries become **scarcer** (GC fall) or during stress time
 - special collateral
 - repo trade -> special trade -> special collateral -> special rate

- special rate < general rate (demand for the collateral)
 - by demand and supply of the special trade not the security
- special spread and **Auction**
 - **special spread = GC rate – special rate**
 - on-the-run (OTR) and off-the-run (OFR)
 - OTR more liquid, lower bid-ask spread,
 - Favour OTR, lower repo rate and **widen special spread**
 - Special spread 抛物线
 - **Decrease** after auction (due to supply)
 - **Increase** close to the next auction (demand for new OTR)
- special spread and **Rate level**
 - $0 < \text{spread} < \text{GC rate}$
 - After 2009, penalty for failed trades,
 - penalty rate = $\max(3\% - \text{fed-fund rate}, 0)$
 - $0 < \text{spread} < \text{penalty rate}$
- Trade special spread
 - Own OTR, borrow cash at special rate, lend cash at general rate, and earn the spread

Liquidity Risk

- Risk
 - Standard -> less risk
 - OTC -> more risk
 - Size & frequency of trade
 - #traders
 - Trader decrease and size increase -> liquidity risk
- Types
 - Transaction liquidity
 - Balance sheet risk or funding liquidity risk
 - Cannot meet payment obligations
- Endogenous or exogenous risk
 - endogenous: size of trade/size of market, price elasticity of demand
 - exogenous: bid-ask spread
- **Liquidity Adjusted VaR**
 - $LVaR = VaR + LC$
 - Normal $VaR = V \times (Z \times \sigma - u)$
 - Lognormal: $VaR = V \times (1 - \exp(u - Z \times \sigma))$
 - Usually assume u is zero
- Spread
 - $\text{spread} = \frac{\text{ask} - \text{bid}}{(\text{ask} + \text{bid})/2}$
 - $(\text{ask} + \text{bid})/2$: middle point of bid-ask spread
 - $\text{ask} - \text{bid}$ is the full round trip, buy and then sell cost
 - liquidity cost: half of the spread, selling cost
- Constant Spread
 - $LC = V \times 0.5 \times \text{spread}$
 - Liquidity adjustment ratio (Lognormal)

- $\frac{LVaR}{VaR} = 1 + \frac{0.5 \times \text{spread}}{1 - \exp(-z \times \sigma)}$
- Adjustment **increase** when spread **increase**, confidence level and holding period **decrease**
- Exogenous Spread Approach (stochastic spread is a distribution)
 - $LC = V \times 0.5 \times (\mu_s + z_s \times \sigma_s)$
 - $\frac{LVaR}{VaR} = 1 + \frac{0.5 \times (\mu_s + z_s \times \sigma_s)}{1 - \exp(-z \times \sigma)}$
- Endogenous (Elastic)
 - Price will be changed, previous methods assume price won't change
 - $E = \frac{\Delta P/P}{\Delta N/N} < 0$ 交易影响价格
 - $LVaR = VaR \times \left(1 - \frac{\Delta P}{P}\right) = VaR \times \left(1 - E \times \frac{\Delta N}{N}\right)$
 - Ignore bid-ask spread and transaction cost
- Combination
 - $\frac{LVaR}{VaR} |_{combined} = \frac{LVaR}{VaR} |_{exogenous} \times \frac{LVaR}{VaR} |_{endogenous}$
- Liquidation, transaction cost and market price impact
 - Execute
 - Quickly: increase transaction cost (endogenous)
 - Slowly: exogenous, more price uncertainty
 - Risk
 - More averse: quickly, high cost, less price uncertainty
- Liquidity-at-Risk (LaR/CFaR)
 - Cash flow (positive for outflow)
 - Hedge with Future
 - Basis risk is small -> small VaR
 - Due to margin call -> high LaR
 - Hedge with European options
 - Zero LaR but large VaR prior to maturity
 - Factors
 - Borrowing/lending
 - Margin requirements
 - Collateral obligation, swap
 - LaR increase for hard times
 - Estimation: variance-covariance, simulation
 - Ways
 - Delta-gamma approximation, margin * max loss
 - Margin * ES
 - Crisis-scenario analysis: probabilistic consider interaction and complication, but subjectivity
- Cases
 - Yield between on-the-run and off-the-run only reflects a liquidity premium
 - Flight-to-quality reflects the **increase** in spread between corporate and government issues
 - Asset liquidity risk can be managed by setting limits on certain asset markets or products and by means of diversification.

Assessing the Quality of Risk Measures

- Model risk
 - Programming bugs, valuation and hedging, VaR, mapping factors
 - Use market prices can avoid errors, but not all market can due to infrequent trading
- Variability in VaR estimates
 - Data
 - Market data: missing, erroneous
 - Security master data:
 - Position data:
 - Variability of measure
 - No standardization: time horizon and confidence interval
 - Difference: length of time series, moments, mapping, risk factors, #simulation MC
 - Mapping
 - Cash flow, duration, principle-mapping
 - Compared with cash flow, Duration fewer risk factor,
 - reduce data errors and model risk
 - Incorrectly mapping -> liquidity and basis risk
 - Liquidity risk
 - divergences in **model and market** prices
 - **Basis risk**
 - Hedge does not provide expected protection
 - A position and its hedge is mapping to the same set of risk factors
 - Event-driven strategies
 - Binary, cannot use historical data
 - Dynamic strategies
 - Generated over time not a point in time
 - 2005 (correlation **decrease**)
 - Strategy
 - **Sell equity protection and buy protection junior tranche**
 - Assume a **constant** correlation
 - when correlation **decrease**, and spread not widen
 - initial default-risk neutral
 - **long** credit and credit **spread risk** on **equity** and **short** credit and credit spread on **mezzanine** tranche
 - benefit from **spread** volatility
 - positively **convex** payoff
 - risk in 2007-2009
 - assumption
 - house price appreciation
 - assumed low correlation

Liquidity and Leverage

- types

- transactions
 - financial **assets/markets**
 - buying/selling asset -> adverse price move
- funding/balance sheet
 - **individual** creditworthiness
 - maturity mismatch
 - long term with short-term: rollover risk
- systemic risk
 - overall
- leverage
- liquidity at banks
 - fractional-reserve bank
 - suspension of convertibility
- structured credit products and off-balance sheet
 - rely on short-term financing
 - ABCP (liquidity and credit support) and SIV
- Systematic funding liquidity risk
 - LBO
 - Merge arbitrage hedge
 - Convertible arbitrage hedge fund
- MMMF (money market mutual fund)
 - **Not** MtM daily
 - Amortized cost method
 - Breaking the buck: **NAV<1 -> liquidity problem**
 - Redeem in adverse market conditions
- Economic of the collateral market
 - Overnight loan extended automatically
 - Haircut
 - remargining, variation margin
 - **repledging**: collateral are pledged again, circulates
 - margin loan
 - repurchase
 - securities lending
 - rebate
 - lender: receive dividend and interest
 - held in street name accounts
 - Total return swaps
- Leverage ratio
 - $L = \frac{A}{E} = 1 + \frac{D}{E}$
 - Leverage effect
 - $ROE = \frac{NI}{E} = \frac{revenue}{E} - \frac{cost}{E} = \frac{revenue}{A} \times \frac{A}{E} - \frac{cost}{D} \times \frac{D}{E}$
 - $\rightarrow ROE = L \times R_A - (L - 1) \times R_D$
 - return on equity, return on asset, cost of debt
 - ROE is higher if the leverage increase
 - Increasing leverage
 - $\frac{\partial ROE}{\partial L} = R_A - R_D$

- Bank: book value
- Hedge fund: NAV
- **Explicit and implicit leverage**
 - Explicit: Purchase stock on margin
 - Implicit: short, derivative (options, swaps)
 - Margin loan
 - Haircut h is the borrower's equity and $1-h$ is loaned against the market value of the collateral
 - Short position
 - Gross leverage: value of all asset, cash generated by short sales
 - Net leverage: difference between long and short positions divided by capital
 - Derivative
 - Cash-equivalent market value
 - Future, forwards, swap
 - **Linear and symmetric**
 - Zero NPV at initiation
 - Option
 - Non-linear and asymmetric
 - Option **delta** equivalent
 - **Non-zero NPV**
 - **Value = Intrinsic value (can be zero) + time value**
- **Sources of transaction liquidity risk**
 - Cost of searching a counterparty
 - Trade processing cost
 - Inventory management
 - Adverse selection
 - Differences of opinion
- OTC and exchange
 - OTC: quote-driven,
 - Exchange: order-driven
- Liquidity risk
 - adverse price impact
 - slippage: price drop when it is sold
- **Transaction cost**
 - Assume spread is normally distributed
 - $\pm P \times 0.5 \times (s + z \times \sigma)$, 99% -> 2.33 单边
 - P : next day mid price
 - S : (ask-bid)/mid price
 - Spread risk factor: $0.5 \times (s + z \times \sigma)$
- **Adjusting VaR for position liquidity**
 - Consider number of days
 - T-day VaR is
 - $VaR \times \sqrt{T}$, **overstate**
 - Assume T days, equally liquidity

- $\text{VaR} \times \sqrt{\frac{(T+1) \times (2T+1)}{6T}}$
- First day hold 1, 2-day hold 1-1/T, 3-day hold 1-2/T,
- last day hold 1/T
- **Market Liquidity**
 - **Tightness**/width: cost of a **round-trip** transaction, measured by bid-ask spread
 - **Depth**: how large an order must be to **move** the price adversely
 - **Resiliency**: length of **time** it takes 'lump orders' to move the market away from equilibrium price
 - **Both depth and resiliency affect execution speed**
- **Funding liquidity risk management**
 - **Cash**
 - **Unpledged** asset
 - **Unused borrowing** capacity
 - Unfettered source of liquidity,
 - Can be revoked by raising haircuts or declining

Failure of dealer bank

- Function
 - OTC derivative
 - Repo market
 - Prime broker – hedge fund
- Markets
 - Primary securities: underwriter
 - Secondary securities: provide liquidity
 - Repos
 - Off-balance sheet financing
- Diseconomies of scope
 - economies: in, marketing, financial innovation
 - diseconomies: **risk management**, corporate governance
- liquidity concerns
 - reduce exposure or
 - **novation**
 - reduce their exposure to a dealer to another dealer
 - CCP
 - Effective in Standard terms
 - Reduce exposure by entering new contracts
 - Dealer bank must settle with cash
 - Mitigate
 - Establish lines of bank credit, holding cash and liquid securities, laddering the maturities of its liabilities
 - Prime brokerage account
 - Source of cash inflow for dealer banks
- Policies to alleviate dealer bank risks
 - TARP
 - Effect of adverse selection for toxic assets

- Absorb losses beyond a pre-specified level
- Provide financing for toxic assets
- Tri-party clearing
- Emergency bank
- Central clearing
- Too-big-to-fail

Stress Testing banks

- Goal
 - How much **capital** and **liquidity** needs
 - Provides clarity about the true risk and **soundness** of banks
- Stresses
 - Scenarios: severe recession
 - Sensitivities: increase in interest rate
- **Supervisory Capital Assessment program (SCAP) 2009**
 - First **macro**-prudential stress test
 - **Soundness** of banking system as a **whole**
 - 19 banks needs 75 billion. They raised 77 billion of T1 common equity
 - **Macro**-scenarios and market wide vs single-shock
 - **Whole** firm vs. specific bank product or BU
 - **Capital** adequacy vs earning shocks
 - **Revenues, costs**, and projects losses vs losses
 - **Dynamic and path dependent** vs static
 - **One-size-fits all**

<i>Pre-SCAP</i>	<i>Post-SCAP</i>
Primarily assessed exposure to single-shocks (e.g., volatility increases OR interest rate increases OR increasing unemployment).	Considers broad macro-scenarios and market-wide stresses with multiple factors occurring/changing at once, as evidenced in the 2007–2009 financial crisis.
Focused on specific bank products or business units (e.g., lending or trust).	Focuses on the whole firm, a more comprehensive look at the effect of the stress scenarios on the institution.
Typically focused on earnings shocks (i.e., losses) but not on capital adequacy.	Explicitly focuses on capital adequacy. Considers the post-stress common equity threshold to ensure that a bank remains viable.
Focused exclusively on losses.	Focuses on revenues, costs, and projected losses.
Stress testing was static in nature.	Stress testing is now dynamic and path dependent.

- Challenge - Coherence
 - **Reasonable or possible**
 - Problems are multi-factored
 - Specific joint outcomes of all relevant risk factors
 - Flight to quality
 - Need to identify the risk-free asset
 - MtM portfolios of traded securities and derivatives
 - Volatility and correlation
 - Complex and multi-dimensional universe
 - Three variables: GDP growth, unemployment, HIP (house price index)
 - Prior to 2011, SCP2009

- The same scenarios on all banks – one-size-fits-all
- 2011 CCAR
 - Submit **own** stress scenarios to reveal bank-specific vulnerabilities 提交自己的
 - Both bank-specific (**micro**-prudential) but also improves **macro**-prudential as it highlights common risk factors unnoticed before
- Challenge in modelling losses and revenues
 - How to map **macro**-risk factors into **micro** outcomes related to **revenue and losses**
 - Credit card losses -> unemployment figures
 - business cycle
 - modelling revenues less developed than modelling losses
 - income = **interest** income + **non-interest** income
 - yield curve -> interest income
 - non-interest income: **fees** and **service** charges
- challenges in modelling **balance sheet**
 - capital can be common equity, measured as capital-to-asset
 - Risk-weighted asset (RWA)
 - Usually two year, -> actually three-years
- Stress test comparisons
 - **2009 SCAP** 披露
 - **Disclosure** a major feature in 2009 SCAP
 - Transparency, disclosure resources, projected losses
 - 2011 CCAR
 - Macro-scenarios results be published, not bank level
 - No idea it passed the test or not
 - 2012 CCAR
 - Disclosed the same as 2009 SCAP
 - CCAR 提交自己的场景
 - Submit own **scenarios**, both baseline and stress
 - Trading book stress test
- 2011 EBA
 - Bank and third-party estimates of **losses**
 - EBA: electronic, downloadable form
 - EBA Europe: 8 macro-factors, 70 factors for trading book.
- Disclosure – transparency
 - Import in distress
 - Normal: costs outweighs benefits
- Compare
 - 2009 SCAP
 - **Macro**-prudential stress test 第一次宏观
 - GDP growth, unemployment, HPI
 - Disclosure – 披露
 - Projected revenue, costs, losses
 - One-size fit all
 - 2011 CCAR

- Macro-scenarios results are published, not bank level
- 2012
 - Disclosure – same with 2009
 - Electronic and downloadable
 - Submit **own** scenarios 自己的场景
- 2011 EBA
 - More macro factors
 - More disclosure

<i>Stress Test</i>	<i>Methodologies</i>	<i>Disclosure</i>	<i>Findings</i>
SCAP (2009). All banks with \$100 billion or more in assets as of 2008 year end were included.	Tested simple scenarios with three dimensions, GDP growth, unemployment, and the house price index (HPI). Historical experience was used for the market risk scenario (i.e., the financial crisis—a period of “flight to safety,” the failure of Lehman, and higher risk premia). A “one-size-fits-all” approach.	First to provide bank level projected losses and asset/product level loss rates.	19 SCAP banks were required to raise \$75 billion within six months. The undercapitalized banks actually raised \$77 billion of Tier 1 common equity and none of the banks were forced to use the Treasury’s Capital Assistance Program funds.
CCAR (2011)	In recognition of “one-size-fits-all” stress testing, CCAR asked banks to submit results from their own baseline and stress scenarios.	Only macro-scenario results were published.	
CCAR (2012)	Banks were again asked to submit their own baseline and stress test results.	Similar in detail to SCAP 2009— bank level and asset/product level loss rates disclosed.	
EBA Irish (2011)	Similar in design to EBA Europe 2011.	Comparison of bank and third party projected losses; comparison of exposures by asset class and geography. Data is electronic and downloadable.	After passing the 2010 stress tests, 2011 stress tests revealed Irish banks needed €24 billion. Greater disclosure in 2011 resulted in tightening credit spreads on Irish sovereign and individual bank debt.
EBA Europe (2011). [formerly the Committee of European Bank Supervisors (CEBS)] 90 European banks were stress tested.	Specified eight macro-factors (GDP growth, inflation, unemployment, commercial and residential real estate price indices, short and long-term government rates, and stock prices) for each of 21 countries. Specified over 70 risk factors for the trading book. It also imposed sovereign haircuts across seven maturity buckets.	Bank level projected losses. Comparisons of exposures by asset class and geography. Data is electronic and downloadable.	Eight banks were required to raise €2.5 billion.

Guidance on Managing outsourcing risk

- Outsourcing Risks
 - Compliance
 - Legal
 - Country
 - Economic and political risk in that country
 - Reputation
 - Concentration
 - Operational
- Core elements
 - Risk assessments
 - In-house or by a third party
 - Due diligence and selection of service providers
 - Business background, reputation, strategy
 - Financial performance
 - Operations and internal controls
 - Contract provisions and considerations
 - Incentive compensation review
 - Oversight and monitoring of service providers
 - Business continuity and contingency plans
- Focus more on business continuity and contingency plans
-

Stress Test

- Coherence
 - problems are multi-factored, making it difficult to design a coherent stress test.
 - One factor influences other factors in a logical manner.

The Failure Mechanics of Dealer Banks

- Failure
 - Reaction by OTC derivative counterparties: reduce exposure
 - Flight of short-term creditors
 - Flight of prime brokerage clients
 - Loss of cash settlement privileges: clearing bank
- Liquidity risk
 - Collateral / asset, lower less risk
- Early warning indicator
 - Rapid asset growth in leverage ratio with significant dependence on short-term repo financing