



Operational Risk Modeling

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About the Speaker




- Senior Expert – McKinsey & Co
- Implemented Operational Risk Quantification Methodology for Multiple Clients
- 10 years of risk quantification experience in Credit and Operational Risk
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Contents


Part I & 2

- Background
- AMA and Frequency Severity Framework
 - Frequency
 - Severity
 - Aggregation
 - Scenario Analysis
 - Capital Calculation
- Case Study





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Background

- Operational Risk may pose serious threats to investors, shareholders and general public
 - Madoff (50 billion estimated losses) (2008)
 - Société Générale (€ 4.9 billion) (2008)
 - Enron (largest US bankruptcy so far) (2001)
 - Nick Leeson/Barings Bank, £1.3b (1995)
- Basel II requires reserving capital for Operational Risk losses
 - Basic Indicators Approach
 - Standardized Approach
 - Advanced Measurement Approach



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Basel II Approaches

- Basic Indicator Approach
 - $C_{BIA} = \alpha \times GI$
 - *GI*: average annual gross income over the previous three years
 - $\alpha = 15\%$ (set by the Committee)
- Standardized Approach
 - $C_{SA} = \sum_{i=1}^8 \beta_i \times GI_i$, $\beta_i \in [2\%, 18\%]$, $i = 1, 2, \dots, 8$
 - *GI*: average annual gross income over the previous three years per business line
 - Eight business lines

• Corporate finance 18%	• Retail banking 12%
• Payment & Settlement 18%	• Asset management 12%
• Trading & sales 18%	• Commercial banking 15%
• Agency Services 15%	• Retail brokerage 12%






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Advanced Measurement Approach

- Requires quantitative modeling of operational loss data, but does not prescribe any particular methodology or formula
- Lists set of criteria and conditions for regulatory approval
 - Quantitative
 - Qualitative
- Requires capture of tail losses
- Requires at least 3 years of data





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Components of AMA modeling

- Internal loss data (ILD)
 - Losses realized in the bank
- External data (ED)
 - Losses realized in peer institutions
- Scenario analysis (SBA)
 - Forward looking potential loss scenarios created by business line managers
- Business environment and internal control factors (BEICFs)
 - Factors that may affect the capital




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AMA Challenges

- Limited data on operational losses
- Not very developed academic literature specific to operational losses
- Models and results from modeling are different from those of market risk
- The techniques used in insurance and credit modeling are applied
- **Scenario based techniques can be used in absence of data**




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Event Types



- Internal Fraud
 - Losses due to acts of a type intended to defraud, misappropriate property or circumvent regulations, the law or company policy, excluding diversity/discrimination events, which involves at least one internal party.
- External Fraud
 - Losses due to acts of a type intended to defraud, misappropriate property or circumvent the law, by a third party.
- Employment Practices and Workplace Safety
 - Losses arising from acts inconsistent with employment, health or safety laws or agreements, from payment of personal injury claims, or from diversity / discrimination events.
- Clients, Products & Business Practices
 - Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements), or from the nature or design of a product.
- Damage to Physical Assets
 - Losses arising from loss or damage to physical assets from natural disaster or other events.
- Business Disruption and System Failures
 - Losses arising from disruption of business or system failures
- Execution, Delivery & Process Management
 - Losses from failed transaction processing or process management, from relations with trade counterparties and vendors.



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AMA Modeling

1. Data analysis
 - By business line, event type, event/business line.
 - Split data according to data generating process (hopefully)
 - Model frequency and severity for each business line, event type separately
 - Model correlation between business lines /events
 - Simulate and aggregate taking into account correlation
 - **Modeling Top of the House**
 - Do not separate losses by business lines/ event types
 - Apply Extreme Value Theory to fit combined data
 - Simulate on Company wide level
2. Scenario analysis
 - To help management to understand underlying risks and to translate business processes into capital calculation
 - To reflect the changes in loss generating process
3. Combination of data and scenario analysis



AMA Modeling Choice: Unit of Measure

Business Line	
BL.1	650
BL.2	95
BL.3	502

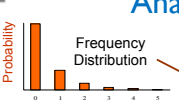
Joint Table/Modeling Decision Option 1			
	BL.1	BL.2	BL.3
ET1	308	30	44
ET2	192	37	456
ET3	150	28	2
Total	650	95	502

Joint Table/Modeling Decision Option 2				
	BL.1	BL.2	BL.3	Total
ET1	308	30	44	381
ET2	192	37	456	686
ET3	150	28	2	180

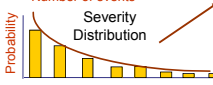
Event Type	
ET1	381
ET2	686
ET3	180

Analytical Framework




Frequency Distribution





Severity Distribution

Monte Carlo Engine Or Analytical Approximation



Annual aggregate loss (\$)



- Estimate Frequency Distribution
- Estimate Severity Distribution
- Draw Number Of Losses (N) From Frequency Distribution
- Draw N Times From Severity Distribution and sum

Frequency Distribution

What is the number of losses that will happen in a given year, quarter?

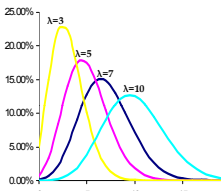


- Describes number of losses for a given time period
- Usually is not a huge contributor to capital number, but may have a significant impact for severe UoM
- Correct choice is important for business lines or event types that have many small losses
- Can be modeled by several distribution types
 - Poisson
 - Negative binomial
 - Discrete Uniform
 - Other

Frequency Distribution: Poisson

- The most frequently used distribution type
- Density Function is described as

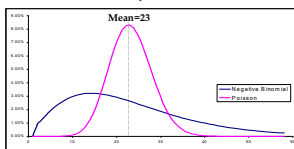


$$P_x(n) = \frac{\lambda^n e^{-\lambda}}{n!}, \quad \text{mean} = \lambda, \quad \sigma = \sqrt{\lambda}$$
- Easy to estimate since one parameter
- Although may deviate from data generating process, works in most cases
- Approaches normal distribution when λ increases






Frequency Distribution: High Volatility

- Negative Binomial Distribution
- Used to model lines with high volatility of number of losses
- Density Function is described as

$$p(n) = \frac{\Gamma(r+n)}{\Gamma(r)\Gamma(n)} \left(\frac{1}{1+\beta}\right)^r \left(\frac{\beta}{1+\beta}\right)^n$$
- Complicated distribution function
- Mixture of Poisson distributions
- Very flexible, but not easily tractable










Severity distribution

How large is the loss, given that the loss happened ?



- Describes the magnitude of the losses
- For most of the institutions severity distribution of few business lines determines the capital number
- No sound theory on distribution choice
- Can be modeled by large number of theoretical distributions
 - Empirical
 - Weibull
 - Lognormal
 - Generalized Pareto
 - Inverse Gaussian
 - Transformed Beta
 - Others
- Typically has fat or very fat tails
- Data typically is insufficient to correctly estimate tails
- **May require scenario analysis to limit the maximum loss**







Severity distribution: Key Issues



- Distribution Choice
 - Data exploration and fitting
- Data sufficiency
 - Scenario Analysis
 - External Data
- Recording threshold
 - **Fit shifted data**
 - Fit truncated distribution
- Maximum
 - Scenario Analysis, EVT analysis
 - Mixture distribution model
- Multimodal Distribution
 - Separate by data generating process

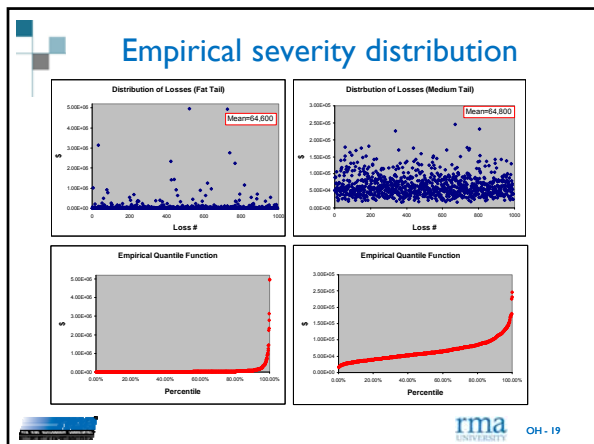



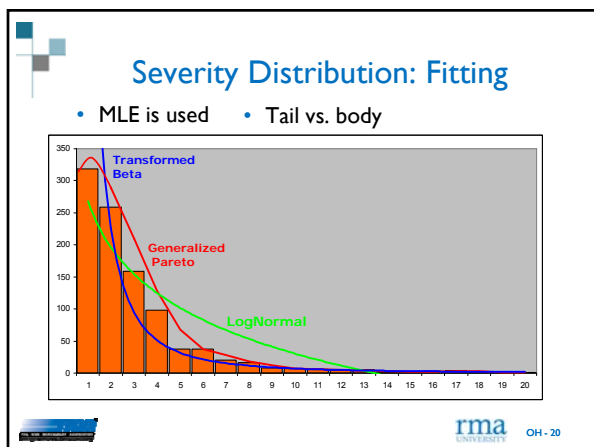


Severity Distribution: Fitting

- Empirical Distribution/ No Fitting
 - Large number of losses
 - Stable distribution
 - Limited threat of large losses
 - Empirical distribution function
 - Some smoothing algorithm
- Analytical Fitting
 - Full distribution to be derived from few losses
 - MLE
 - Bayesian Methods
 - Nonparametric Methods
 - Truncated or **shifted** distributions may be used





Severity Distribution: Truncated Distributions

- Small losses rarely get into operational risk databases
- Most of the theoretical distributions have minimum zero
- Conditional fitting may be used to combine body and tail of distribution
- Maximums from scenario analysis may be incorporated into simulation
- $f_{truncated}(x) = \frac{f_{fit}(x)}{F_{fit}(max) - F_{fit}(min)}$
- MLE can be used to fit truncated distribution

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Modeling Severity Distribution: Truncation

- Truncation point may influence the final capital number
- Errors may be very large for fat-tailed distributions
- Fitting may be very unstable if $F(\max) - F(\min)$ is small

Severity Distribution: Validation of Fit

- Statistical tests can be used to validate goodness of fit between the empirical and theoretical distribution
- Kolmogorov-Smirnov is the most popular test

$$D_i = F_i^{emp} - F_i^{theor}$$

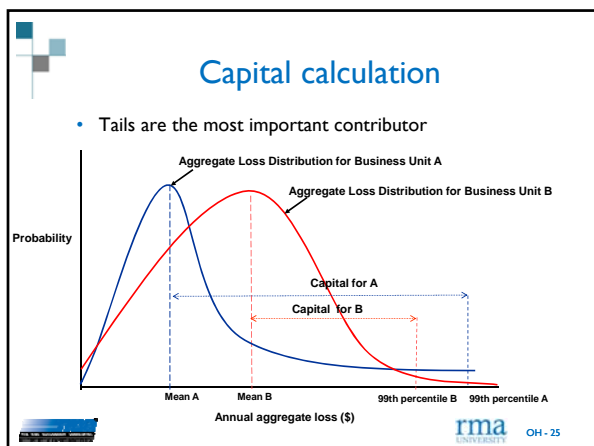
$$D_n = \max(D_1, D_2, \dots, D_n)$$

$$\sqrt{n}D_n > K_\alpha$$

$$\Pr(K < K_\alpha) = 1 - \alpha$$
- Other tests
 - Anderson Darling
 - Chi Square

Capital calculation

- Capital is a sum of expected and unexpected losses unless special reserves are made for Expected loss



Thank You

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