Operational Risk Quantification at
Bank of America

University of Toronto – Fields Institute
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Agenda

- **ORX**
  - Overview
  - The Analytics Agent
  - Characteristics of the Loss Data

- **Bank of America Operational Risk Capital**
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  - Data Collection
  - Risk Identification & Measurement
  - Operational Risk AMA Framework

- **Value Proposition**
  - Value of Insurance
  - Value of Diversification
  - Value of Loss Event Scaling

- **Performance Measurement**

- **Capital Management**
ORX: an overview

• The core purpose of ORX is to advance the measurement and management of operational risk in the global financial services industry.

• ORX operates the world’s leading operational risk loss data consortium for the financial services industry.

• The ORX Global Loss Database contains 135,000 operational risk loss events, each event over €20,000 in value, with a total value of €42 billion.

• ORX is owned and controlled, on an equal basis, by its member firms. Currently the membership includes 52 banks from 18 countries, including:

  ▶ ABN AMRO
  ▶ Banc Sabadell
  ▶ Banco Bilbao Vizcaya Argentaria
  ▶ Banco Pastor
  ▶ Banco Português de Negócios
  ▶ Bank Austria – Creditanstalt
  ▶ Bank of America
  ▶ Bank of Nova Scotia
  ▶ Barclays Bank
  ▶ BMO Financial Group
  ▶ BNP Paribas
  ▶ Caixa Catalunya
  ▶ Caja Laboral
  ▶ Cajamar
  ▶ Commerzbank AG
  ▶ Credit Agricole
  ▶ Danske Bank A/S
  ▶ Deutsche Bank AG
  ▶ Dresdner Bank AG
  ▶ Erste Group Bank AG
  ▶ Euroclear Bank
  ▶ Fortis
  ▶ Grupo Banco Popular
  ▶ Grupo Banesto
  ▶ Grupo Santander
  ▶ HBOS plc
  ▶ Hana Bank
  ▶ HSBC
  ▶ ING
  ▶ Intesa Sanpaolo
  ▶ JPMorganChase
  ▶ Lloyds TSB
  ▶ National City Corporation
  ▶ Northern Trust
  ▶ Rabobank
  ▶ RBC Financial Group
  ▶ Royal Bank of Scotland
  ▶ Skandinaviska Enskilda Banken AB
  ▶ State Street
  ▶ TD Bank Financial Group
  ▶ US Bancorp
  ▶ Wachovia Corporation
  ▶ Washington Mutual
  ▶ WestLB
The ORX Analytics Working Group

- ORX supports research into operational risk through analysis of the ORX Global Database
  - Increase member understanding of the use and utility of the ORX database
  - Develop common analytical tools
  - Propose amendments to ORX data standards or practices

- The ORX Analytics Working Group is responsible for oversight and delivery of ORX research program and taking forward the use of ORX data

- In May 2007, ORX appointed IBM Research Laboratory (Zurich) as ORX Analytic Agent to fully leverage and exploit the analytic value of this unique data pool
  - Tackle industry level problems that no individual institution can tackle alone
  - Establish the feasibility and the appropriate methods for using pooled loss data
  - Advance the measurement of operational risk
Distribution of Loss Counts by Business Line/Event Type

The data is unevenly distributed over the 80 primary business line/event type combinations, both in terms of loss count. Retail Banking losses dominate with Trading and Sales and Commercial Banking a distant 2nd and 3rd respectively. External Fraud and Execution, Delivery and Process Management losses account for more than two-thirds of the loss count.
...and in terms of gross loss.

<table>
<thead>
<tr>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate Finance</td>
<td>0.08%</td>
<td>0.42%</td>
<td>0.18%</td>
<td>24.79%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>1.24%</td>
<td>0.00%</td>
<td>26.71%</td>
</tr>
<tr>
<td>Trading &amp; Sales</td>
<td>1.34%</td>
<td>0.69%</td>
<td>0.30%</td>
<td>4.74%</td>
<td>0.00%</td>
<td>0.28%</td>
<td>7.00%</td>
<td>0.00%</td>
<td>14.35%</td>
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<tr>
<td>Retail Banking</td>
<td>1.97%</td>
<td>7.13%</td>
<td>2.12%</td>
<td>8.51%</td>
<td>0.33%</td>
<td>0.61%</td>
<td>7.46%</td>
<td>0.02%</td>
<td>28.17%</td>
</tr>
<tr>
<td>Commercial Banking</td>
<td>1.04%</td>
<td>2.10%</td>
<td>0.28%</td>
<td>3.35%</td>
<td>0.01%</td>
<td>0.09%</td>
<td>5.08%</td>
<td>0.00%</td>
<td>11.97%</td>
</tr>
<tr>
<td>Clearing</td>
<td>0.11%</td>
<td>0.26%</td>
<td>0.03%</td>
<td>0.31%</td>
<td>0.00%</td>
<td>0.08%</td>
<td>0.63%</td>
<td>0.00%</td>
<td>1.42%</td>
</tr>
<tr>
<td>Agency Services</td>
<td>0.02%</td>
<td>0.03%</td>
<td>0.04%</td>
<td>2.03%</td>
<td>0.00%</td>
<td>0.02%</td>
<td>0.69%</td>
<td>0.00%</td>
<td>2.84%</td>
</tr>
<tr>
<td>Asset Management</td>
<td>0.06%</td>
<td>0.05%</td>
<td>0.17%</td>
<td>3.11%</td>
<td>0.00%</td>
<td>0.02%</td>
<td>0.89%</td>
<td>0.00%</td>
<td>4.30%</td>
</tr>
<tr>
<td>Retail Brokerage</td>
<td>0.14%</td>
<td>0.09%</td>
<td>0.26%</td>
<td>1.57%</td>
<td>0.01%</td>
<td>0.01%</td>
<td>0.30%</td>
<td>0.00%</td>
<td>2.38%</td>
</tr>
<tr>
<td>Private Banking</td>
<td>0.55%</td>
<td>0.20%</td>
<td>0.11%</td>
<td>2.44%</td>
<td>0.00%</td>
<td>0.01%</td>
<td>0.65%</td>
<td>0.00%</td>
<td>3.96%</td>
</tr>
<tr>
<td>Corporate Items</td>
<td>0.10%</td>
<td>0.07%</td>
<td>0.33%</td>
<td>1.28%</td>
<td>1.12%</td>
<td>0.03%</td>
<td>0.97%</td>
<td>0.01%</td>
<td>3.90%</td>
</tr>
<tr>
<td><strong>Total % by Event Type</strong></td>
<td><strong>5.42%</strong></td>
<td><strong>11.04%</strong></td>
<td><strong>3.84%</strong></td>
<td><strong>52.14%</strong></td>
<td><strong>1.48%</strong></td>
<td><strong>1.15%</strong></td>
<td><strong>24.90%</strong></td>
<td><strong>0.03%</strong></td>
<td><strong>100.00%</strong></td>
</tr>
</tbody>
</table>

- Retail Banking and Corporate Finance losses combine to account for more than 50% of the total gross losses, with Trading and Sales and Commercial Banking combining for another 25%
- In gross amount terms Clients, Products and Business Practices is by far the largest event type category
**Bank of America Operational Risk Capital — A Short History**

<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Began data collection with 2 years of history (beg. 1999)</td>
</tr>
<tr>
<td>2002</td>
<td>Developed statistical model</td>
</tr>
<tr>
<td>2003</td>
<td>Key stakeholder reviews</td>
</tr>
<tr>
<td>2004</td>
<td>Parallel economic capital calculation/ comment period</td>
</tr>
<tr>
<td>2005</td>
<td>Implemented Basel II taxonomy</td>
</tr>
<tr>
<td>2006</td>
<td>Developed internal reporting framework</td>
</tr>
<tr>
<td>2007</td>
<td>No explicit minimum data req.</td>
</tr>
<tr>
<td>2008</td>
<td>Adjusted model for parallel run feedback</td>
</tr>
<tr>
<td>2009-10</td>
<td>Introduced direct modeling of external data using joint MLE</td>
</tr>
</tbody>
</table>

- **2001 - 2002**
  - Began data collection with 2 years of history (beg. 1999)
  - Proof of concept

- **2003 - 2004**
  - Developed statistical model
  - Implemented insurance modeling
  - Key stakeholder reviews
  - Initial presentation to regulators

- **2005 - 2006**
  - Parallel economic capital calculation/comment period
  - Implemented Basel II taxonomy
  - Developed internal reporting framework
  - No explicit minimum data req.

- **2007 - 2008**
  - Adjusted model for parallel run feedback
  - Adopted in economic capital framework
  -Joined ORX
  - Introduced v.1 scenario analysis
  - Minimum data req. = 50/UOM

- **2009-10**
  - Introduced direct modeling of external data using joint MLE
  - Implemented a constrained MLE approach
  - Introduced an OLS regression based frequency model
  - Incorporated Fleet Boston data
  - Minimum data req. = 100/UOM

- **2009-10**
  - Introduced accelerated Monte Carlo approach
  - Added MBNA data
  - Minimum data req. = 150/UOM

- **2009-10**
  - Introduced copula based loss aggregation approach
  - Implemented Poisson regression model for frequency distribution
  - Enhanced insurance counterparty risk treatment
  - Added US Trust data
  - Minimum data req. = 200/UOM

- **2009-10**
  - Enhanced insurance counterparty risk treatment
  - Added US Trust data
  - Minimum data req. = 250/UOM

- **2009-10**
  - Developed parallel Monte Carlo capability
  - Expanded library of frequency distributions
  - Enhanced insurance treatments
  - Implemented an MCMC severity dist. approach

- **2009-10**
  - Utilized scaled external loss data (ORX)
  - Expanded library of severity distributions
  - Added scenario analysis v.2
  - Minimum data req. = 250/UOM

- **2009-10**
  - Added Country-wide, LaSalle and Merrill Lynch data
  - Utilized scaled external loss data (ORX)
  - Expanded library of severity distributions
  - Added scenario analysis v.2
  - Minimum data req. = 250/UOM

- **2009-10**
  - Developed parallel Monte Carlo capability
  - Expanded library of frequency distributions
  - Enhanced insurance treatments
  - Implemented an MCMC severity dist. approach
Loss Data Collection Process – Key Features

Formal data collection policy first implemented in 2004

- 10+ years of loss data for legacy BAC including (Q1 1999 – Present)
  - Loss history includes legacy LaSalle (9 yrs), Merrill Lynch (8 yrs), FleetBoston (7 yrs), MBNA (7 yrs), Countrywide (5 yrs), and US Trust (3 yrs)

- More than 8.5 million loss events collected from approximately 25 source systems

- Policy is aligned with Basel II loss definition

- Opportunity costs and foregone revenue are collected where material and estimable

- Loss data collection threshold is $10,000

- Data includes descriptive information needed for transparency and root cause analysis
Risk Identification & Measurement

Robust and comprehensive data collection platforms provide several benefits (internal and external):

- Analysis of frequency and severity to identify trends by business and event type
- Root cause analysis for large losses to identify and correct control weaknesses
- Inform scenario analysis based on factual assessments of internal and external large events
- Inform risk control self-assessments
- Provide a feedback mechanism to validate scenarios and BEICF assessments
- Benchmarking vs. other banks to understand relative effectiveness of the control environment
Operational Risk AMA at Bank of America

![Diagram showing operational risk management at Bank of America](image)

- **Internal Loss Data (ORX)**
- **External Loss Data (ORX)**

**Conversion of Risk Points to Qualitative Adjustment Factor**

<table>
<thead>
<tr>
<th>Risk Points</th>
<th>QA Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>-15%</td>
<td>-25%</td>
</tr>
<tr>
<td>-10%</td>
<td>-20%</td>
</tr>
<tr>
<td>-5%</td>
<td>-15%</td>
</tr>
<tr>
<td>0%</td>
<td>0%</td>
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<tr>
<td>5%</td>
<td>5%</td>
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<tr>
<td>10%</td>
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<tr>
<td>15%</td>
<td>15%</td>
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<tr>
<td>20%</td>
<td>20%</td>
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<tr>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>30%</td>
<td>30%</td>
</tr>
</tbody>
</table>

**Loss Distributions**

- **Risk 1**
- **Risk 2**
- **Risk M**

**Correlation**

<table>
<thead>
<tr>
<th></th>
<th>$\rho_{12}$</th>
<th>$\ldots$</th>
<th>$\rho_{1n}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho_{21}$</td>
<td>1</td>
<td>$\ldots$</td>
<td>$\rho_{2n}$</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>$\ldots$</td>
<td>1</td>
</tr>
<tr>
<td>$\rho_{n1}$</td>
<td>$\ldots$</td>
<td>$\ldots$</td>
<td>1</td>
</tr>
</tbody>
</table>

**Probability of Payout**

- **Category**
- **Coverage**
- **Claim Acceptance**
- **Program Limit**

**Monte Carlo Simulation**

**Diversified Capital**

<table>
<thead>
<tr>
<th>Risk 1</th>
<th>Risk 2</th>
<th>$\ldots$</th>
<th>Risk M</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORC_{A1}</td>
<td>ORC_{A2}</td>
<td>$\ldots$</td>
<td>ORC_{AM}</td>
<td>ORC_{A}^*</td>
</tr>
<tr>
<td>ORC_{B1}</td>
<td>ORC_{B2}</td>
<td>$\ldots$</td>
<td>ORC_{BM}</td>
<td>ORC_{B}^*</td>
</tr>
<tr>
<td>$\vdots$</td>
<td>$\vdots$</td>
<td>$\ldots$</td>
<td>$\vdots$</td>
<td>$\vdots$</td>
</tr>
<tr>
<td>ORC_{N1}</td>
<td>ORC_{N2}</td>
<td>$\ldots$</td>
<td>ORC_{NM}</td>
<td>ORC_{B}^*</td>
</tr>
<tr>
<td>Total</td>
<td>ORC_{1}</td>
<td>ORC_{2}</td>
<td>$\ldots$</td>
<td>ORC_{M}</td>
</tr>
</tbody>
</table>
Estimation of the severity distribution uses a combination of joint MLE, MCMC, and minimum distance (CvM) approaches

- Uses ORX scaled loss data attached at 90th percentile
- Jointly estimate severity parameters from internal and external data assuming events are drawn from the same distribution
- Distributional choices include Lognormal, Gamma−lognormal, and Generalized Pareto
- Most effective when the truncation point for the external data is known with certainty

Estimation of the frequency distribution uses a regression approach

- Adjusts for changes in size of the business by relating loss frequency to exposure indicators
- Distributional choices include Poisson, Negative Binomial, Zero−Inflated Poisson and Zero−Inflated Negative Binomial
The severity and frequency distributions are combined using Monte Carlo simulation.

The banks' insurance programs help mitigate the capital requirement.

- Insurance program deductibles and limits are mapped to operational loss event type sub-categories.
- Subject matter expert estimates of the probability of coverage are determined.
- A haircut for coverage dispute is applied.
- Risk of insurer default is explicitly considered.

The separate unit of measure marginal distributions are combined using conservative correlation assumptions and an elliptical copula (Gaussian and t).

Diversified results are adjusted for the quality of the current and near-term (expected) future control environment.
Value of Insurance

- A bank may take an offset to its risk-based capital requirement up to 20% if insurance.
- The bank’s methodology must account for:
  - Residual term and cancellation term of the policy if less than 1-year.
  - The credit rating of the insurer (top-3 category rating on claims paying ability from an NRSRO).
  - The policy’s timeliness of payment.
  - The uncertainty of payment and mismatches in coverage.
- The bank may not recognize a benefit if the residual term is 90 days or less.
- Significant benefits can be attained from mapping insurance policies to operational losses and collecting insurance recovery data.
- Approximate reduction is 8%.
Value of Diversification

• Banks may use internal estimates of dependence if they can satisfactorily demonstrate the estimation process is
  - Sound and robust to a variety of scenarios
  - Implemented with integrity
  - Allows for uncertainty in estimation

• ORX/IBM Research*
  - Correlations among quarterly aggregate losses are usually not greater than 0.2.
  - Correlations measures are generally homogeneous across banks
  - Only slight evidence of tail correlation is found (i.e., that extreme losses in one unit of measure occur simultaneously with extreme losses in another unit of measure)
  - ORX study suggests an industry average impact on regulatory capital of 39% for banks with 56 units-of-measure

Value of Scaling

• Basel II requires a bank to establish a process for incorporating external loss data
  - Particularly useful input when internal operational loss event data are limited
  - Provide a means for the bank to understand industry experience
  - Provide a means for the bank to assess the adequacy of its internal operational loss event data

• ORX/IBM Research*
  - The analysis identifies similarities in loss distributions and relationships between losses and gross income/region
  - Scaling analysis shows that errors in high quantile estimates can be greatly reduced through appropriate clustering
  - Value proposition is to simultaneously reduce sampling error at high quantiles while retaining the relevance of the data

Risk Management and Profitability Measurement

- Economic capital provides for integrated risk management and profitability measurement
  - Provides framework used to compare the risk-adjusted profitability and relative value of businesses with varying degrees of risk
  - Allows bank management and supervisors to evaluate overall capital adequacy in relation to the risk profile of the Bank
Value-Based Management

- A well developed operational risk framework is vital so that all forms of risk—credit, market, country, and operational—are quantified on a uniform scale.
- Risk-adjustment based on economic capital allows a common hurdle to be used to assess value creation or destruction.
- Businesses are assigned capital in proportion to the economic risk they contribute.
- Allows relative comparisons of returns between operational risk intensive and credit or market risk intensive businesses.
- Performance is expressed as an after-tax return on economic capital and as income after the cost of capital (SVA).
- The framework creates incentives to deploy capital toward activities with better risk-adjusted returns.
Capital Adequacy in Relation to Risk

- Economic capital is the basis for monitoring and managing overall capital levels in relation to risk.
- Economic capital represents the overall demand for capital and risk taken.
- Available financial resources represent the Bank’s capital supply and risk bearing capacity.
- Risk bearing capacity can include various elements of capital, reserves, trust-preferred securities and future margin income.
- Guidelines for economic capital coverage can be established to maintain a buffer at prudent levels.
- Minimum coverage guidelines should consider un-modeled risks, model uncertainty and changes in the economic environment over time.
Publications


