Modelling Operational Risk

Lucie Mazurová

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Operational Risk Definition

Operational Risk in Banks

Operational Risk Management

Capital Requirement for Operational Risk
  - Basic Indicator Approach
  - The Standardized Approach
  - Advanced Measurement Approach
  - Further Development

Loss Distribution Approach
  - Probability Distributions
  - Modelling Large Losses
  - Modelling Dependence
1. **Operational Risk Definition**

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Operational Risk Definition

**Operational risk** - risk of losses arising from operation of a company, it does not concern the production or services provided by the company (i.e. losses from an insurance portfolio or from a portfolio of bank loans).

**OR according to Basel 2**
Operational risk is defined as the risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk.

**OR according to Solvency 2**
Operational risk means the risk of loss arising from inadequate or failed internal processes, personnel or systems, or from external events. Operational risk...shall include legal risks, and exclude risks arising from strategic decisions, as well as reputation risks.

*legal risk* - includes exposure to fines, penalties or punitive damages resulting from supervisory actions, as well as private settlements.
Operational Loss Event Type Classification

Basel 2:

- **Internal fraud**
  (Losses due to acts of a type intended to defraud, misappropriate property or circumvent regulations, the law or company policy, which involves at least one internal party)
  → Unauthorised Activity, Theft and Fraud

- **External Fraud**
  (Losses due to acts of a type intended to defraud, misappropriate property or circumvent the law, by a third party)
  → Theft and Fraud, Systems Security
Operational Loss Event Type Classification

- **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)
  → Employee Relations, Safe Environment, Diversity and Discrimination

- **Clients, Products and Business Practices**
  (Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients, or from the nature or design of a product)
  → Suitability, Disclosure and Fiduciary, Improper Business or Market Practices, Product Flaws, Selection, Sponsorship and Exposure, Advisory Activities
Operational Loss Event Type Classification

- **Damage to Physical Assets**
  (Losses arising from loss or damage to physical assets from natural disaster or other events)
  → Disasters and other events

- **Business disruption and system failures**
  (Losses arising from disruption of business or system failures)
  → Systems

- **Execution, Delivery and Process Management**
  (Losses from failed transaction processing or process management, from relations with trade counterparties and vendors)
  → Transaction Capture, Execution Maintenance, Monitoring and Reporting, Customer Intake and Documentation, Customer / Client Account Management, Trade Counterparties, Vendors and Suppliers
Examples from history

- 1995 bankruptcy of Barings Bank (founded 1762)
  - due to unauthorized trading by its head derivatives trader in Singapore, Nick Leeson
  - failure of internal control, unauthorized trading, internal fraud, external factors (earthquake in Japan)
  - loss US$1.3 billion - twice the bank’s available trading capital

- September 11, 2001 terrorist attack
  - damage to physical assets, business disruption, dead employees
  - Bank of New York - loss US$ 140 million
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Operational Risk in Banks

Basel Committee for Bank Supervision

The Basel Committee is the primary global standard-setter for the prudential regulation of banks and provides a forum for cooperation on banking supervisory matters.

- established in 1974 by the central bank governors of the G10 countries
- Secretariat is located at the Bank for International Settlements in Basel, Switzerland
- 28 members (countries represented by their central banks, EU)
- publishes:
  - standards (BCBS expects full implementation of its standards by BCBS members and their internationally active banks)
  - guidelines (elaborate the standards)
  - sound practices (describe actual observed practices)
3 generations of standards

- **Basel I: the Basel Capital Accord**
  - released 1988
  - a minimum ratio of capital to risk-weighted assets

- **Basel II: the New Capital Framework**
  - released 2004, comprehensive document 2006
  - 3 pillars: minimum capital requirements, supervisory review of an institution’s capital adequacy and internal assessment process, effective use of disclosure

- **Basel III**
  - reacts to financial crisis
  - enhanced capital requirements, liquidity risk management, systemically important banks, ...
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- Strong risk management culture
- Framework fully integrated into the bank’s overall risk management processes
- Governance structure with well defined, transparent and consistent lines of responsibility
- Identification and assessment of the operational risk inherent in all material products, activities, processes and systems
- Monitoring and reporting
- Control and mitigation
- Business resiliency and continuity plans
- Disclosure
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Under the Basel II framework, three approaches can be used to quantify the operational risk annual capital charge.

**Elementary approaches**
- the basic indicator approach (BIA)
- the standardized approach (TSA)

- use gross income as a volume measure of the exposition to OR

**Internal risk measurement system**
- advanced measurement approach (AMA)

- mathematical modelling of OR losses based on internal and external data
Basic Indicator Approach

Banks using the Basic Indicator Approach must hold capital for operational risk equal to the average over the previous three years of a fixed percentage (denoted alpha) of positive annual gross income.

\[
C_{BI}^t = \frac{1}{Z_t} \sum_{i=1}^{3} \alpha \max(GI^{t-i}, 0),
\]

\[
Z_t = \sum_{i=1}^{3} \chi[GI^{t-i}>0]
\]

\(GI^j\) - gross income in year \(j\)

Based on QISs: \(\alpha = 0, 15\).

GI is net interest income plus net non-interest income (gross of any provisions (e.g. for unpaid interest), gross of operating expenses, excludes realised profits/losses from the sale of securities and extraordinary or irregular items as well as income derived from insurance).
In the Standardised Approach, banks’ activities are divided into eight business lines: corporate finance, trading & sales, retail banking, commercial banking, payment & settlement, agency services, asset management, and retail brokerage.

The capital charge for each business line is calculated by multiplying gross income by a factor (denoted $\beta_j$) assigned to that business line.

$$C_S^t = \frac{1}{3} \sum_{i=1}^{3} \max \left[ \sum_{j=1}^{8} \beta_j G_{j}^{t-i}, 0 \right]$$

Values of $\beta_j$: 0.12 - 0.18.
Under the ASA, the operational risk capital charge/methodology is the same as for the Standardised Approach except for two business lines — retail banking and commercial banking. For these business lines, loans and advances — multiplied by a fixed factor $m$ — replaces gross income as the exposure indicator. The betas for retail and commercial banking are unchanged from the Standardised Approach. The ASA operational risk capital charge for retail banking:

$$C_{rb} = \beta_{rb} m LA_{rb}$$

where $m = 0, 35$ and $LA_{rb}$ are total outstanding retail loans and advances.
Advanced Measurement Approach

Under the AMA, the regulatory capital requirement will equal the risk measure generated by the bank’s internal operational risk measurement system using prescribed quantitative and qualitative criteria. Use of the AMA is subject to supervisory approval.
- qualification criteria for AMA must be fulfilled

Use of data:

- \textit{internal data}
  - collected over a minimum five-year period
  - classified according to different business lines and loss-event types
  - usually truncated by a reporting threshold (e.g. 10000EUR)
  - for many risk cells contain few low-frequency/high-severity losses or none
**Advanced Measurement Approach**

- **external data**
  - public data and/or pooled industry data
  - industry data available through external databases from vendors and consortia of banks
  - difficult to use directly due to different volumes
  - survival bias as typically the data of all collapsed companies are not available

- **scenario analysis**
  - in conjunction with external data to evaluate the exposure to high-severity events
  - rough quantitative assessment of the risk frequency and severity distributions can be obtained
  - very subjective
Advanced Measurement Approach

- **business environment and internal control factors**
- **exposure indicators**
  - influence the frequency and severity of losses
  - e.g. gross income, number of transactions, number of staff and asset values
- **near-miss losses**
  - losses that could occur but were prevented
  - included in internal datasets to estimate severity of losses but excluded in the estimation of frequency
Further Development

Standardised Measurement Approach for operational risk
- consultative document issued in 2016

withdrawal of internal modelling for operational risk regulatory capital (AMA) from the Basel Framework

- for complexity of the AMA and the lack of comparability arising from a wide range of internal modelling practices

introduction of the Standardised Measurement Approach (SMA)

The Business Indicator (BI)
- similar to gross income, combines P&L items in different way
- multiplied by coefficient dependent on the size of BI (no segmentation into lines of business)
Further Development

The operational risk capital is determined as follows:

\[
SMA \text{ Capital} = \begin{cases} 
    \text{BI Component}, \text{ if Bucket 1} \\
    110\text{Mln} + (\text{BI Component} - 110\text{Mln}) \cdot \ln\left(\exp(1) - 1 + \frac{\text{Loss Component}}{\text{BI Component}}\right), \text{ if Buckets 2} - 5 
\end{cases}
\]

\[
\begin{align*}
\text{BI Component} &= \begin{cases} 
    0.11 \cdot \text{BI}, \text{ if Bucket 1} \\
    110\text{Mln} + 0.15(\text{BI} - 1\text{Bln}), \text{ if Bucket 2} \\
    410\text{Mln} + 0.19(\text{BI} - 3\text{Bln}), \text{ if Bucket 3} \\
    1.74\text{Bln} + 0.23(\text{BI} - 10\text{Bln}), \text{ if Bucket 4} \\
    6.34\text{Bln} + 0.29(\text{BI} - 30\text{Bln}), \text{ if Bucket 5} 
\end{cases}
\end{align*}
\]

And:

\[
\text{Loss Component} = 7 \times \text{Average Total Annual Loss} \\
+ 7 \times \text{Average Total Annual Loss only including loss events above €10 million} \\
+ 5 \times \text{Average Total Annual Loss only including loss events above €100 million}
\]
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Data on OR losses classified according to the above mentioned business lines and loss-event types.

For computing the capital requirement for year \( t \) based on the experience from the past \( T \) years (\( T \geq 5 \)) we have observations

\[
X^{t-i,b,l}_k, \quad i = 1, \ldots, T, \quad b = 1, \ldots, 8, \quad l = 1, \ldots, 7, \quad k = 1, \ldots, N^{t-i,b,l}
\]

where

\( X^{t-i,b,l}_k \) is the \( k \)-th loss of type \( l \) in business line \( b \) in year \( t - i \),

\( N^{t-i,b,l} \) is the number of losses of type \( l \) in business line \( b \) in year \( t - i \).
Loss Distribution Approach

For each category \((i, b, l)\) there can be a reporting threshold (typically of the order of 10000 EUR).

\[ \rightarrow X_{k}^{t-i,b,l} \text{ has a distribution truncated from the left (i.e. conditional distribution \((X|X > d)\)), where } X \geq 0 \text{ denotes the size of loss without reporting threshold).} \]

The aggregate loss in business line \(b\) in year \(t - i\) is

\[
L^{t-i,b} = \sum_{l=1}^{7} \sum_{k=1}^{N^{t-i,b,l}} X_{k}^{t-i,b,l}.
\]

and the aggregate loss in year \(t - i\) is

\[
L^{t-i} = \sum_{b=1}^{8} L^{t-i,b}.
\]
The aim is to estimate from data the distribution of total loss in year $t$, $L^t$, and to determine an appropriate risk measure for that distribution.

$\rho_\alpha$ - risk measure at confidence level $\alpha$ (typically $\alpha$ between 0.99 - 0.999)

Capital requirement: $C_{AM}^t = \rho_\alpha(L^t)$.

We need to know the dependence structure of losses in different cells defined by business lines and loss-event types. Simple aggregation of partial risk measures gives

$$C_{AM}^t = \sum_{b=1}^{8} \rho_\alpha(L^{t,b}).$$

It is correct for $\rho_\alpha = \text{Var}_\alpha$ in case of comonotonic losses. It does not take into account diversification effects.
Risk Measures

Value at risk

$$\rho_\alpha (L) = \text{VaR}_\alpha (L)$$

$$\text{VaR}_\alpha (L) = \inf \{ l \in \mathbb{R} | P(L > l) \leq 1 - \alpha \}$$

Conditional value at risk

$$\rho_\alpha (L) = \text{CVaR}_\alpha (L) = \mathbb{E} \left( L \mid L > \text{VaR}_\alpha (L) \right)$$

$$\text{CVaR}_\alpha (L) = \text{Var}_\alpha (L) + e \left( \text{VaR}_\alpha (L) \right),$$

where $$e(u) = \mathbb{E}(L - u \mid L > u)$$ is the mean excess value of the loss above the threshold $$u.$$
Probability Distributions

For modelling the sums

\[ \sum_{k=1}^{N_{t-i,b,l}} X_{t-i,b,l} \]

a compound distribution can be used. For computing its distribution function various recursive methods (e.g. Panjer formula, Fast Fourier transform), numerical methods or approximations are applicable.

Examples of the most commonly used probability distributions of loss sizes are

**Gamma:**

\[ f(x) = \left( \frac{x}{\theta} \right)^\alpha \frac{e^{-x/\theta}}{x \Gamma(\alpha)} , \alpha > 0, \theta > 0 \]

**Lognormal:**

\[ f(x) = \frac{1}{\sqrt{2\pi}\sigma x} \exp \left[ -\frac{1}{2} \left( \frac{\ln x - \mu}{\sigma} \right)^2 \right] , \mu \in \mathbb{R}, \sigma > 0 \]

**Pareto:**

\[ f(x) = \frac{\alpha \theta^\alpha}{(x+\theta)^{\alpha+1}} , \alpha > 0, \theta > 0. \]
- survey of practice of the banks using AMA approach (or candidates for approval of AMA approach)

Probability distributions used in OR losses:
Claim Severity Distributions

"body" - the part of distribution describing losses of common size

<table>
<thead>
<tr>
<th>Number of AMA banks</th>
<th>All Participating AMA Banks</th>
<th>Australia</th>
<th>Europe</th>
<th>Japan</th>
<th>North America</th>
</tr>
</thead>
<tbody>
<tr>
<td>Used for the Body</td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>#</td>
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</tr>
<tr>
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<tr>
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<td>3</td>
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<tr>
<td>g and h</td>
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<tr>
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</table>
"tail" - the part of distribution describing large losses

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</tr>
<tr>
<td>Gamma</td>
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<td>7%</td>
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<td>0%</td>
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<td>15%</td>
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</table>
Claim Severity Distributions

one distributional model for both common and large losses

<table>
<thead>
<tr>
<th>Number of AMA banks</th>
<th>All Participating AMA Banks</th>
<th>Australia</th>
<th>Europe</th>
<th>Japan</th>
<th>North America</th>
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## Claim Frequency Distributions

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<th>Number of AMA banks</th>
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<th>Japan</th>
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<td>29%</td>
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<tr>
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<td>10%</td>
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</tr>
</tbody>
</table>
Modelling Large Loses

For modelling the tail of the loss distribution (extreme losses) POT method based on data exceeding certain threshold is often used.

**Generalized Pareto distribution** d.f.

\[ W_{\gamma,\beta}(x) = 1 - (1 + \gamma x/\beta)^{-1/\gamma}, \quad \gamma \neq 0 \]
\[ W_{0,\beta}(x) = 1 - \exp(-x/\beta), \]

where \( \beta > 0; \)
\( x \geq 0 \) pro \( \gamma \geq 0, \)
\( 0 \leq x \leq -\beta/\gamma \) pro \( \gamma < 0. \)
For modelling the aggregate loss in year $t$

$$L^t = \sum_{b=1}^{8} L^{t,b}$$

the joint distribution of losses in different lines of business is needed. Simple aggregation

$$C_{AM}^t = \sum_{b=1}^{8} \rho_\alpha(L^{t,b})$$

in case of the risk measure represented by value at risk is correct only for comonotonic partial losses.

To allow for diversification effects, more realistic modelling of dependence by means of copulas is often used. In the BCBS document on the observed range of practice from 2009 the following use of copula models was recorded:
### Modelling Dependence

<table>
<thead>
<tr>
<th>Correlations are introduced into the modelling process by:</th>
<th>All Participating AMA Banks</th>
<th>Australia</th>
<th>Europe</th>
<th>Japan</th>
<th>North America</th>
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</table>
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