Quantifying operational risk in life insurance companies

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Context
- GIRO working party on quantifying operational risk in general insurance companies
  - Michael Tripp (chair), Helen Bradley, Russell Devitt, George Orris, Gregory Overton, Louise Pryor, Richard Shaw
  - Report at GIRO followed by paper at Institute sessional meeting
  - Very little that was specific to general insurance companies

Paper includes
- Case study
- Risk management framework
- Stress and scenario testing
- Frequency and severity analysis (including EVT)
- Causal modelling and Bayesian methods
- DFA and overall risk modelling
- Pitfalls and consideration of soft issues
- Reporting and pulling the threads together

Outline
- Risk management framework
- Causal analysis
- EVT for operational risk
- Risk indicators
- Data and other pitfalls
- Conclusions

A basic risk management control cycle

Evolution of operational risk practices
Leaping ahead?

- Don’t run before you can walk
  - Awareness: realise the need for explicit management of operational risk
  - Monitor: effective risk reporting, risk indicators with escalation triggers
  - Quantify: loss database, quantitative targets, analysis techniques
  - Integration: correlations between risk indicators, compensation linked to risk adjusted returns
- Integration may not be an appropriate long term goal

Classifying risk

- Often difficult to assign a loss to a risk category
- Eg, is reputational risk a form of operational risk?
  - Systems failure → poor customer service → poor reputation → lower sales
  - Strategic decision → failure → poor reputation → lower sales
- Eg, bad underwriting strategy or poor implementation of good strategy

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Cause and consequence

- Analyse risk by cause and consequence
- A single consequence may have more than one cause
- A single cause may have many consequences

Causal risk mapping

- Analyse known losses to learn about risks
  - Document causal chain and make it explicit
  - Look at the effect of the outcome

Bayesian modelling

- Use conditional probabilities
  - Either earthquake or burglary may make alarm go off
  - 1.15% chance of hearing alarm
  - What if alarm but no radio?
  - 88.3% chance of burglary

<table>
<thead>
<tr>
<th>Causes</th>
<th>Consequences</th>
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<tbody>
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- Underlying internal causes
- Underlying external causes
- Failed processes
- Risk decisions
- Financial outcomes

- Earthquake
- Earthquake
- Earthquake
# Simple Bayesian model

![Bayesian model diagram]

# Results from Bayesian model

<table>
<thead>
<tr>
<th>Failed internal process</th>
<th>External trigger cause</th>
<th>Outcome evaluation</th>
<th>Individual risks</th>
<th>Prob/holder harm/benefit</th>
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</thead>
<tbody>
<tr>
<td>Weak</td>
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<td>-</td>
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<tr>
<td>Weak</td>
<td>-</td>
<td>-</td>
<td>Weak</td>
<td>99.8%</td>
</tr>
</tbody>
</table>

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# Modelling operational risk

- Traditional frequency and severity analysis
  - Fit distributions to historical loss data
  - Frequency: Poisson, negative binomial, binomial
  - Severity: Lognormal, weibull, gamma
- May want to modify historical data first
  - Known changes in controls and procedures may affect future numbers of losses
- Curve fitting
  - Maximum likelihood, other goodness of fit
  - Criteria may depend on which is the important part of the curve

# Skew distributions

- Some operational losses have extremely skew distributions
- Low frequency, high impact means little data available
- Traditional statistical methods emphasise the area around the mean of the distribution
- Extreme value theory (EVT) concentrates on tails
  - Pick a threshold
  - Use generalised pareto distribution to determine severity given that it exceeds threshold

# EVT

- Cumulative distribution function $1 - \lambda(1 + \xi(x-u)/\sigma)^{-\xi}$
  - $\lambda$: threshold (large)
  - $\lambda = \Pr(X > x)$
  - $\xi$, $\sigma$ shape and scale parameters
- First determine threshold $u$
- Then fit $\xi$ and $\sigma$
- Have distribution for losses above $u$ in size
- Use normal curve fitting for smaller losses, scale so that distributions meet smoothly
Determining threshold

- Plot mean excess above threshold against threshold
- Becomes linear at \( \lambda \)
- \( \lambda \) is number of losses above threshold divided by total number of losses

\[
\text{Mean Excess Plot}
\]

Shape and scale parameters

- Maximise log likelihood function for
\[
\text{maximize } \log \left( -\sigma \sum \frac{1}{\xi + 1} \log \left( 1 + \frac{\xi (x_i - \theta)}{\sigma} \right) \right)
\]
for \( i=1 \) to \( r \) (number of observations larger than \( u \))

Comparison

- Used poisson for loss frequency
- Compared EVT, lognormal, weibull, gamma for loss amount

Fitted distributions

\[
\text{CDF of Annual Losses}
\]

Percentile comparison

- Large variation in results at higher percentiles
- Tails have very different shapes
- Small number of large losses
- Choice of threshold not always obvious
- Especially with small data set
- Linearity may be a matter of interpretation
- EVT gave less extreme results at less extreme percentiles
- Gamma worse fit than weibull or lognormal
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Risk indicators

- Help with qualitative assessment of risk
  - Can indicate that subjective assessments should be updated
  - Can be used even if there have been no losses so far
  - Help gauge effectiveness of systems and controls
  - Tie in with management incentives (and penalties)
  - Can only be used within a more general risk management framework

Risk indicators should be

- Easy to calculate
- Predictive (leading rather than lagging)
- And so based on causal analysis

Categories

- Exposure-related
- Loss-related
- Cause-related

Exposure-related

- Typically measure the throughput of processes with the potential for operational failure
- Don’t pick up changes in loss rate or size

Examples

- Number of claims handled
- Sales volume
- Sizes of outsourcing contracts
- Numbers of IT projects under way
- Percentage of business given to each supplier

Loss-related

- Measure outcomes, so lagging

Examples

- Number of customer complaints
- Budget overruns

Cause-related

- Measure factors identified as drivers (so leading)
- Difficult to identify
- More complex than others

Examples

- Number of unresolved “severe” internal audit issues
- Staff turnover
- Training hours (or £) per staff member
- Number of un/dertrained staff members
- Number of different desktop computer configurations in use
- Hours of paid overtime per staff member
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Data collection

- Accuracy of quantitative results depends on
  - Appropriateness of model
  - Availability of data
- Need to understand the connection between causes and consequences
- Data collection driven by needs of models
  - Or models driven by available data?
- Need losses and exposure

Loss database

- Events
  - Data incurred, reported
  - Development of loss amount
  - Cause (consistent with firm-wide risk matrix)
  - Consequence (how the loss manifested)
- Losses due to more than one cause
  - Split amounts between causes, or whole amount to each
- Near misses
  - Blame-free procedures
  - Avoid underreporting

Exposure

- Often no commonly agreed measures
- May be able to use some of the data collected for risk indicators
- May be able to use data used for activity-based costing
  - In general, exposure data likely to encounter all the same problems as activity-based costing

Double counting

- Some operational risk probably already modelled implicitly
- Don’t model it explicitly too!

Conclusions

- Don’t run before you can walk
  - Start with identifying, assessing, understanding, controls...
  - Statistical techniques come later
- Operational risk management should be driven by value creation
- How important is operational risk compared to other risks?
  - But much that is currently considered insurance risk has its root cause in poor operational practices