The Actuarial Profession
making financial sense of the future

CILA
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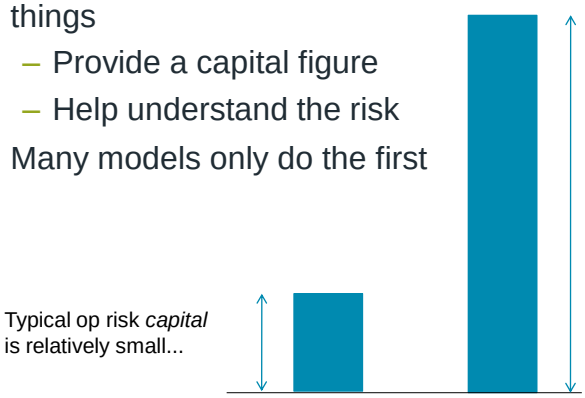
Operational Risk

What is Operational Risk?

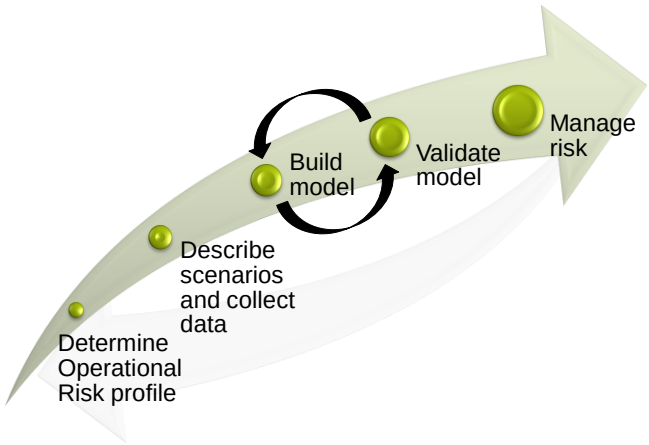
- Solvency II – Article 13 (27)
  - "the risk of loss arising from inadequate or failed internal processes, or from personnel and systems, or from external events"
- But, this is only the definition for SCR
- In the wider use of operational risk (e.g. ORSA) you need to consider other things like:
  - Legal
  - Strategic
  - Reputation
- Also need to consider that "modelling" is not always about capital

Perception Gap

- To be useful, modelling needs to achieve two different things
  - Provide a capital figure
  - Help understand the risk
- Many models only do the first



Concept



Risk Profile

- Describe how operational activity impacts goals
- Look at issues identified previously on risk register
- Consider each of the op risk categories for ideas
- Describe different types of outcome
- Describe how outcomes occur
- Understand what actions management can/would take

Unacceptable business practices
Internal control violations
Project failures
Communication failure
Brand abuse
Violation of reporting regulations
Solvency
Violation of disclosure requirements
Customer due-diligence
Product compliance
Mis-selling
Mishandling data
Incomplete documentation
Systemic reporting error
Mishandling of complaints
Mishandling of investment transactions
Mispricing/design of products
Mishandling of underwriting
Inadequate reinsurance
Inadequate claims management
IT systems failure
Unauthorized access to data
Inadequate functionality
Inappropriate skills
Staff act outside authority/competence
Business interruption
Adverse legal/regulatory change

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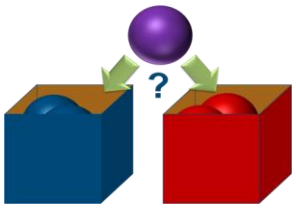
Risk Profile

- Operational risk is generally complex and adaptive
- Think about how drivers change over time and interact
- Typical risk register information is oversimplified
- Using multiple characteristics gives more realistic view of risks



Typically "gloss" over heterogeneity by labelling operational risk data with a single label per scenario. Tends to make scenarios unbelievable and disconnected from reality.

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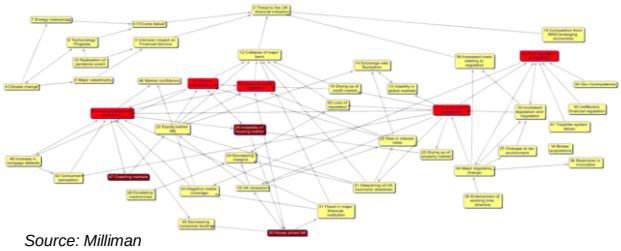
Risk Profile

- Capture knowledge of business experts including drivers
- Rationalise combined insight using cognitive tools (removes bias)
- Gain understanding of risk factor relationships and dependencies



Source: Milliman

Techniques like cognitive mapping very quick to do and provide rigorous underpin to scenario creation

Operational Risk Scenarios

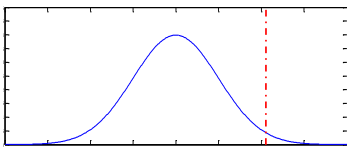
- Describe outcomes of scenario
- Describe build up to scenario outcome
  - What happened?
  - What didn't happen which let scenario occur?
- Estimate frequency of scenario occurrence
  - Need to separate high freq / low impact from low freq / high impact
  - Identify evidence to support frequency estimates
- Consider interaction with factors present in other scenarios
- Logical basis for scenario development permits sensible future evolution of scenarios linked to business risk profile
- Important that business people can explain how risk occurs so they feel ownership of scenario

Operational Risk Scenarios

- Simple example:
  - Transaction error leading to financial loss
  - Key features of scenario:
    - Staff error
    - System failure
  - Two types of process:
    - Regular minor errors
    - Infrequent large losses

High Frequency / Low Impact Scenarios

- Largely independent from low freq/high impact events
  - Set frequency threshold (e.g. Monthly)
  - Collect loss information
  - Annual data = S(monthly) ~ N(m,s) by Central Limit Theorem
  - m = 12*monthly mean, s= √12*monthly s.d.
  - Fit distribution and calculate required risk metric (e.g. VaR)



High frequency minor losses

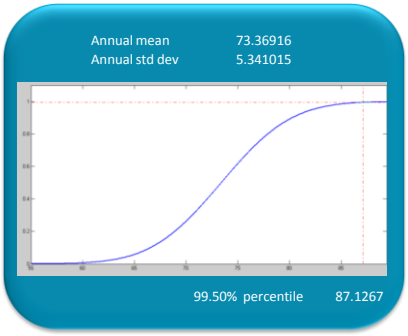
Collect loss information...

Date	Pricing errors
02/01/2008	0.0298128
03/01/2008	0.3203638
06/01/2008	0.4825977
10/01/2008	0.1650368
13/01/2008	0.6731923
17/01/2008	0.4217209
22/01/2008	0.0054239
23/01/2008	0.7367344
27/01/2008	0.1480485
27/01/2008	0.5703431
01/02/2008	0.0655102
06/02/2008	0.6562326
11/02/2008	0.8949479
14/02/2008	0.6396907
16/02/2008	0.4036177
18/02/2008	0.1826323
19/02/2008	0.9487514
22/02/2008	0.8083784
25/02/2008	0.2078895
29/02/2008	0.4457402

Calculate monthly losses...

Month	Loss
200801	3.5533
200802	5.2534
200803	5.0727
200804	6.7640
200805	5.7663
200806	7.3745
200807	7.6800
200808	4.6496
200809	9.1943
200810	6.5751
200811	6.3511
200812	4.7540
200901	6.8228
200902	4.3650
200903	6.6257
200904	5.9123
200905	7.4273
200906	6.6181
200907	8.2468
200908	3.2756

Fit normal distribution and compute risk metric

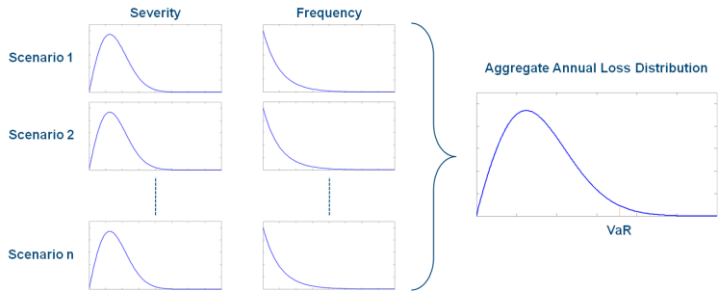


Low Frequency / High Impact Scenarios

- (Actually useful to bring med freq into this category)
- Has the scenario ever occurred in company?
- ...what evidence/records exist?
  - Audit reports
  - Compliance reports
  - Event logs
- Has it ever happened elsewhere?
- What controls would have to fail for scenario to occur?
- Evidence of controls failing/nearly failing from logs/industry

Typical Modelling Approach

- Objective is to “understand” the annual aggregate loss from operational risk events
- Consider the loss at the risk tolerance level required e.g. 99.5% point for one year loss

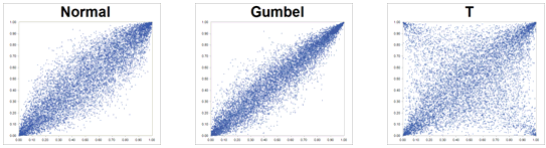


Typical Modelling Approach

- Assume frequency follows Poisson distribution
- Assume outcome can be approximated by a fat-tailed loss distribution
  - Lognormal
  - Weibull
  - PERT/Beta
  - (if you had a lot of data you could go non-parametric)
- Experts typically asked to estimate a median and tail loss to fit distribution

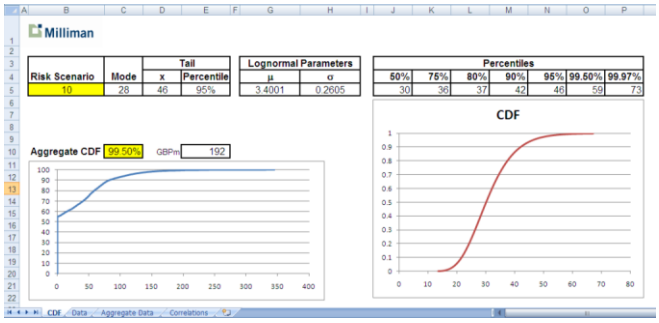
Typical Modelling Approach

- Approximate dependency between scenarios
  - Correlation
  - Copula (Gaussian, Gumbel, T)



Modelling

- Check models actually make sense
- Iterate with experts, consider interactions, etc.
- Use time series of indicator data to validate assumptions



Ask experts to confirm that they are happy with the model implications:
£30m impact for half of the occurrences
£37m impact for 1:20 occurrences
Etc.

Does the interaction between scenarios seem to make sense? Try different correlations, copula, d.o.f, etc.

Risk Management

- For modelling to mean anything it has to feed back into risk management
- Choosing scenarios carefully means outputs apply to real world
- Risk indicators relevant to each scenario need to be regularly monitored to feed parameterisation
- Knowledge of scenario dynamics should inform design of risk controls

- But...

Challenges

- Experts find it hard to relate to a loss distribution – too abstract
- Risk indicators separate from model of loss
- Many operational risks are adaptive – indicators change!
- Hard to project a loss distribution

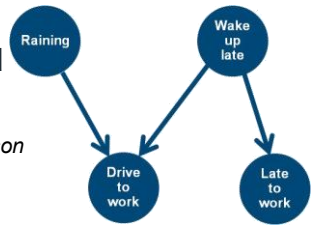
Alternative approach

- Build-up the loss distribution by its contributing factors
- Explicitly capture the dynamics known by experts
- Keep the model in a form that the experts recognise
- Embed the indicators of risk into the model so that observations update the model estimates

- Bayesian Networks

Bayesian Networks

- Bayesian Networks are probabilistic graphical models
- Show the conditional dependence of factors relevant to outcome
- Monte Carlo not required – loss distribution specified exactly
- Expert judgement and data combined



BN's enable us to propagate evidence. If we know this person was late, the chance of them having overslept increases.

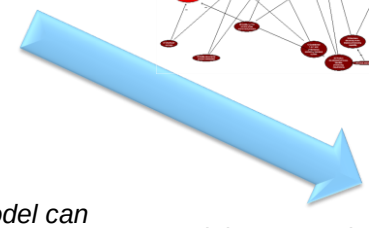
$$P(\text{o'sleep} \mid \text{late}) = P(\text{late} \mid \text{o'sleep})\,P(\text{o'sleep}) / P(\text{late})$$

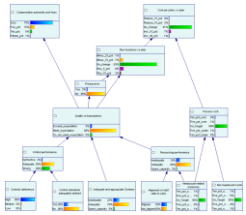
$$= \frac{P(\text{late} \mid \text{o'sleep})\,P(\text{o'sleep})}{P(\text{late}|\text{o'sleep})P(\text{o'sleep})+P(\text{late}|\textit{not}\ \text{o'sleep})P(\textit{not}\ \text{o'sleep})}$$

Example

Experts describe risk scenario

Analysis determines key features



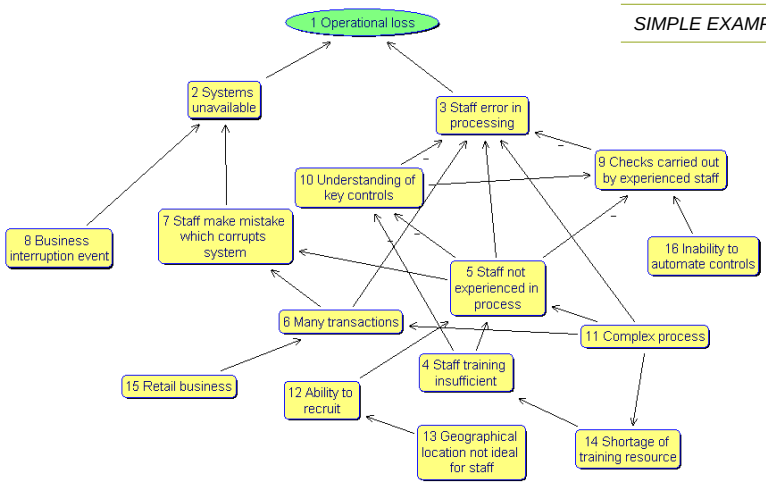


Note that the model can simultaneously capture capital outcomes as well as other outcomes

Model captures key features of scenario explicitly

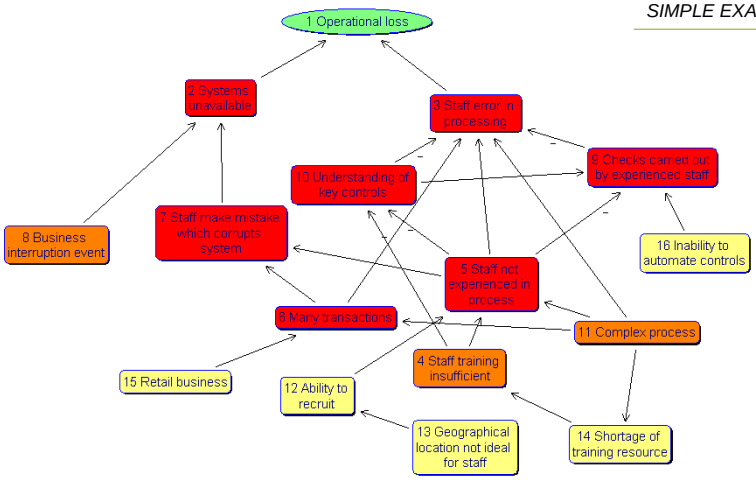
Describe the scenario

SIMPLE EXAMPLE



Analyse Scenario

SIMPLE EXAMPLE



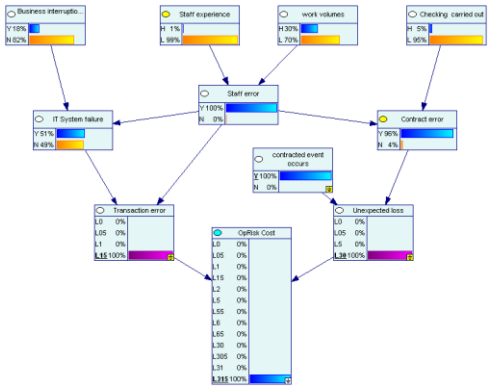
Example

- Two operational scenarios

Model combines two scenarios. Both exposed to mistakes by staff. Explicit dependence.

What if

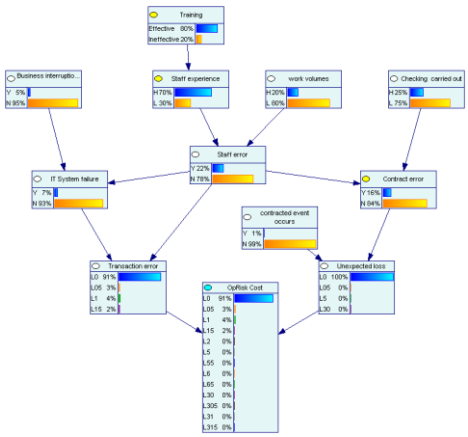
- Business experts can explicitly ask questions
- What would cause worst case outcome?



- Staff error is a key contributor
- Extreme outcome requires both scenarios

What if

- Model can be used to inform business case for control improvements
- Adding training reduces VaR by £60k
- Could project an improvement in training effectiveness and explicitly see the VaR impact



Solvency II

- Tests
  - Use
  - Statistical quality
  - Calibration
  - P&L attribution
  - Validation
  - Documentation

Article 120 – Use Test

- A BN method provides a strong level of engagement between risk management and the business by
  - Explaining how risks actually arise and behave
  - Providing a mechanism for understanding the capital consequences of adjusting risk mitigation activity
  - Providing an integration of financial and non-financial risk consequences
- Model therefore provides a key input for main “uses” such as planning, capital allocation, decision-making, system of governance, etc.
- Model can react to new information so provides a good basis for real-time risk management

Article 121 – Statistical Quality

- Very hard to “prove” statistical quality of loss distributions directly
- FSA will want to see a long history of KRI data
- Expressing final loss distribution via a series of conditional probability distributions captures interdependencies transparently and permits a hierarchy of evidence to be provided supporting the final distribution
- Can mathematically test dependencies in BN

Article 121 – Statistical Quality (2)

- The model explicitly incorporates the latest and most relevant data (current and credible)
- The model makes the assumptions about the risk scenario dynamics transparent so they can be evidenced, validated and understood (justification)
- Critical analysis and sensitivity testing is easy in BN
- Ability to measure the information content of model versions enables robust testing of the impact of model changes
- Straightforward for business people to assist in validating and challenging the model inputs and outputs
- The model clearly satisfies the relevance requirement by providing actionable risk information

Article 121 – Statistical Quality (3)

- It is completely transparent which data has been used in the model
- Reliance upon expert judgement is replaced over time by incorporating observations
- Where expert judgement is used, it is explicit in the model and sensitivity analysis can be used to quantify the impact of any uncertainty over that evidence
- The model explicitly allows for management actions now and in the future. Trends in these are linked directly to the business plan.

Article 122 – Calibration

- Model can generate multiple time periods and appropriate granularity of loss distribution so it is possible to obtain regulatory 99.5th percentile 1 year figure and any risk metric over other time horizons from the same model

Article 123 – P&L Attribution

- The granularity of the model enables us to determine which scenarios contribute to P&L effects and how
- For example, if a scenario leads to an impact on headcount costs, or expense on external resource, this is explicitly captured in the model and can therefore be reflected in the P&L attribution

Article 124 – Validation

- A prior distribution for each node is set with reference to expert opinion and internal and external reference data
- The initial model is tested to verify that its key dynamics, sensitivities and behaviours match those observed or expected by business experts
- This includes presenting experts with predictions from the model to ensure that these appear reasonable
- Information theory metrics are used to test whether the addition or omission of parameters make significant differences to the usefulness of the model
- Node distributions updated for new evidence so the model increasingly closely matches the reality of the scenario

Article 125 – Documentation

- The very nature of the model provides an instant description of the way in which the scenario is anticipated to develop
- Evidence to support the choices of nodes distributions is to be maintained

Summary

- Operational risk models have to cover capital ***and*** useful risk management information
- Few operational risks follow a statistical process so loss distributions hard to form
- Adaptive nature of risks means collating KRI data for statistical purposes is somewhat dubious
- Build a strong bridge between business, risk and modellers
- How to adapt to changing risk profile – projections?
- Consider ability to meet Solvency II tests

Questions or comments?

Expressions of individual views by members of the Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenter.