Risk Modelling Using Monte Carlo Methods

Design and Validation of an Insurance Model

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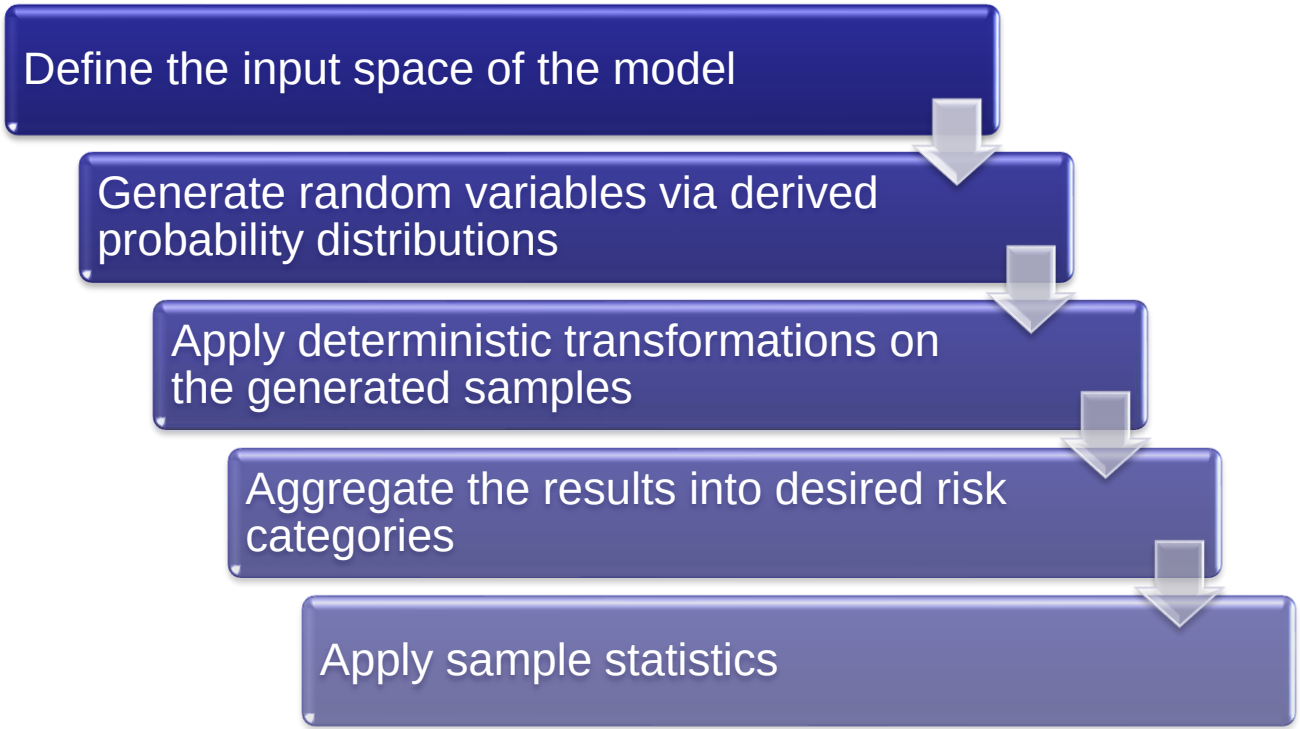
Reasons for using a Monte Carlo model

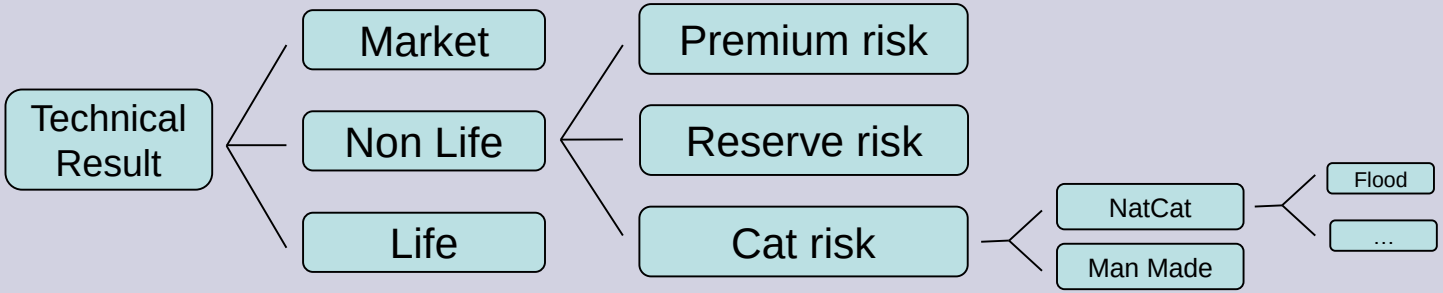
Basic principle is easy to understand:



Reasons for using a Monte Carlo model

Granularity, Key Figures:

The total risk can be split into key risk drivers



Multiple statistical measures can be applied to the results

- Location: expected value, median, mode
- Deviation: variance, standard deviation
- Tail: quantiles, VaR, TVaR

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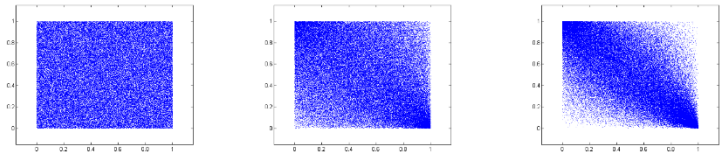
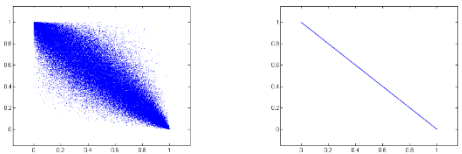
Reasons for using a Monte Carlo model

Correlations

- Possibility to model different kinds of correlation structures
  - Linear, non-linear
  - Hierarchical, elliptical



(a) $\tau = 0\%$ (b) $\tau = 25\%$ (c) $\tau = 50\%$



(d) $\tau = 75\%$ (e) $\tau = 100\%$

Figure: Gumbel copula neg. mirrored with different τ

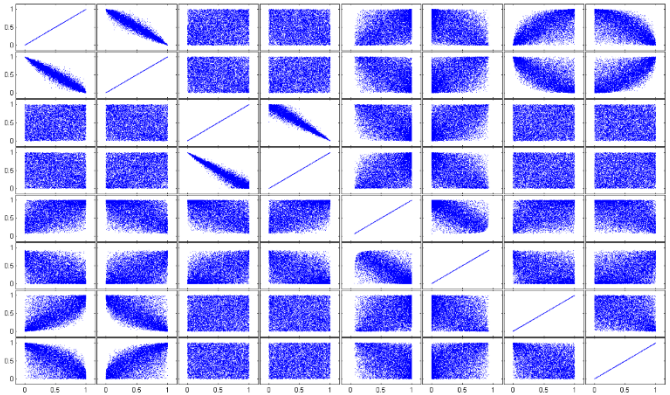


Figure: Scatter Matrix with 4 LoBs

Scope and use cases of Monte Carlo models

Simulation of future premium and claims

- Portfolio optimization
- Planning of future business
- Impact of trends and management decisions

Calculating regulatory risk capital requirements

- Solvency II capital requirements & ORSA models

Simulation of natural catastrophes

- Tail risk is of special interest in this area

Reinsurance

- Challenge current reinsurance structure against simulated average and extreme events
- Backtest current reinsurance structure against historical events
- Plan future reinsurance
- Profitability and risk transfer testing

Calculating best estimates

- Claims and premium best estimates
- Annuities (IBNR and RBNS)

Design decisions – involved stakeholders

Model user(s)

- Is the model used solely by the developers or other non-technical users?
- Scripting tool vs. full solution with GUI

Stakeholders

- Internal tool
  - ➢Planning of results, pricing, reinsurance
- Tool to satisfy regulatory requirements
  - ➢E.g. Solvency II, IFRS 17, Basel III

Output

- Are results interpreted by actuaries / technical experts or business experts?
- Standardized reporting for supervisors
- Executive summaries for management

Completely different requirements

- For documentation
- For UI
- For output reports

Design decisions – target key figures

Average or extreme scenarios

- Influences required number of simulations to gain trustworthy stability
- Influences the parametrization of input parameters
  - ➢ Average scenarios: Method of moments, Maximum Likelihood
  - ➢ Extreme scenarios:
    - ○ Anderson-Darling statistic, quantile fits
    - ○ Using higher order moments and fitting to distribution systems (e.g. Pearson, Johnson)

Complexity

- Simulation over multiple years vs. detailed one year simulation
- Choosing the right framework and programming environment for the task

Design decisions – underlying methodology

Sources of risk

- Model risk: Choosing the right model
- Chance risk: Inherent randomness of underlying process
- Estimation risk / error: Variation in setting the model parameters
- Change risk: How stable are the underlying assumptions over time

Random number generation

- Do not roll your own algorithms, unless you really know what you‘re doing
- Use vetted and trusted systems
- Single- vs. multi-threaded
  - ➢For multi-threaded simulation the RNG should support multiple streams to avoid collisions

Correlation approach

- Direct modelling of correlations via copulas
- Independent sub models and aggregation of results via „root formula“

Model validation

Validation of inputs

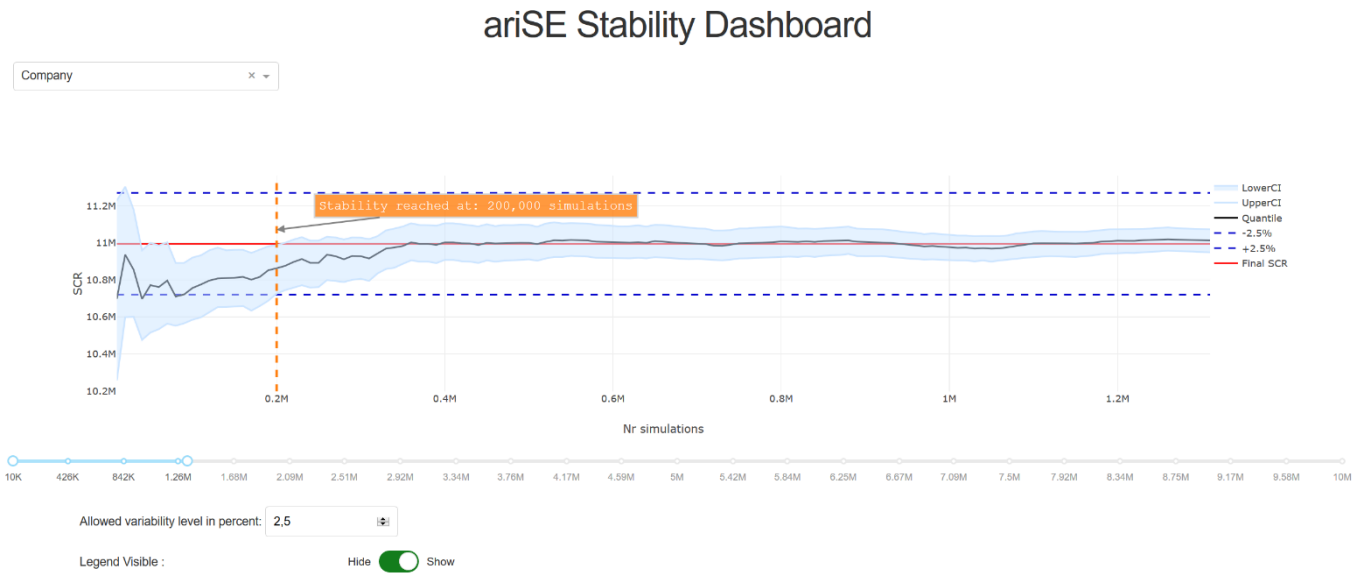
Sensitivities & Parameter Uncertainty	Input Plausibility & Consistency	Assumptions & Limitations	Scenario and Stress Test
Profit & Loss Attribution	Backtest	Stability	Reverse Stress Test

Validation of results

Selected validation tests

Stability

- Aim is to separate process variance from simulation variance
- A stable result is achieved when simulation variance is minimized to an acceptable level
- Multiple runs with the same input, but different random number seed, should yield consistent outputs
- Nr. of simulations for stability highly depedent on target key variable and statistic



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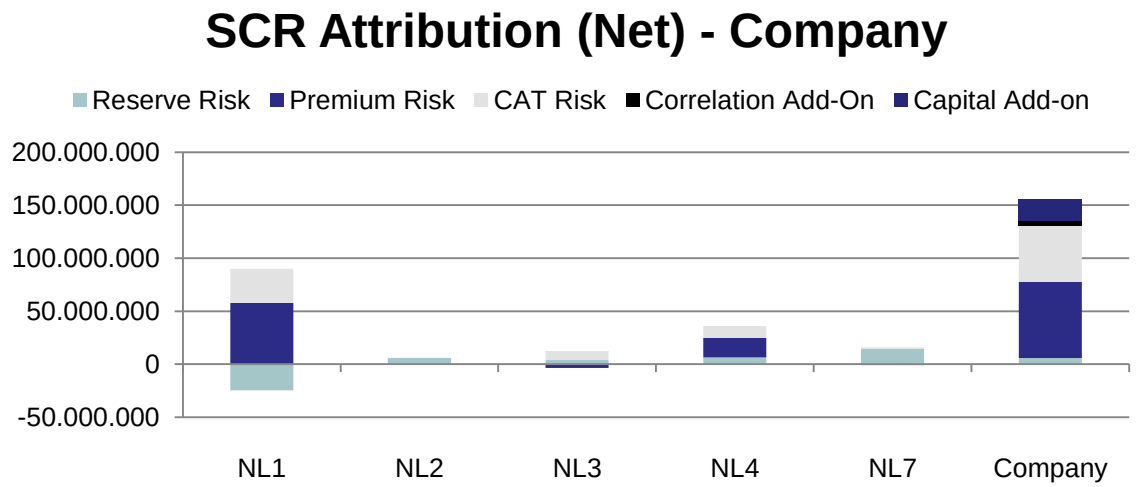
Selected validation tests

Profit & Loss Attribution

- Target is to assess the sources of profits and losses per risk unit to
  - ➢ rank risks factors after their origin
  - ➢ assess profitability versus risk of a business line
- Capital allocation to business units: Euler allocation, Shapley value, …



Validation tests – what to consider

Timing of validation

- Static validation after running the model
  - ➢All information is available (inputs, simulated variables, statistics) and can be incorporated into validation
- Live validation while filling out the input or setting parameters and options
  - ➢Allows for much faster feedback loops

Requirements

- Internal policies (especially regarding documentation)
- Regulatory framework may prescribe some validation tests

Frequency

- Initial versus ongoing validation

Validation tests – user experience

Live user interfaces

- ✓ User can set and change variables on the go
- ✓ Allows deeper insights into business and data structure
- ✓ Especially useful if model is new and experience level is low
- – Can be time consuming and requires a lot of model knowledge

Static, pre-compiled validation reports

- ✓ All information at a glance
- ✓ Can be quickly transformed into management reports
- ✓ Outputs can already be in desired form and format (pdf, pptx, docx, xlsx, xml)
- – To change parameters, the whole model must be re-run

Thank you for listening!

For further information, please visit our website
https://www.arithmetica.at/

or contact me directly

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