Optimisation and automation of capital projections in insurance

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A FRESH TAKE ON RISK AND VALUATION

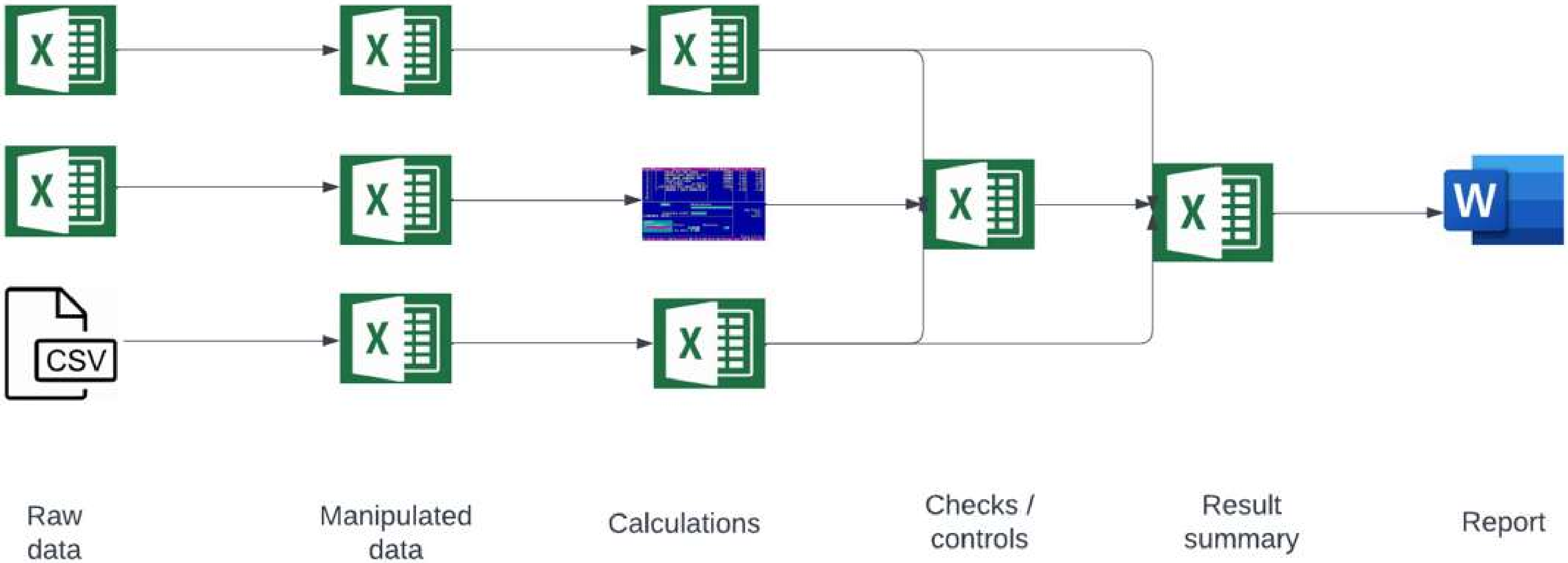
Agenda

1. Automation of financial reporting processes
2. Portfolio optimisation overview
3. Adaptation for insurance capital optimisation
4. Interactive decision making
5. Conclusion and future plans

1 Automation of financial reporting processes

Manual or semi-automated reporting processes

An operational burden

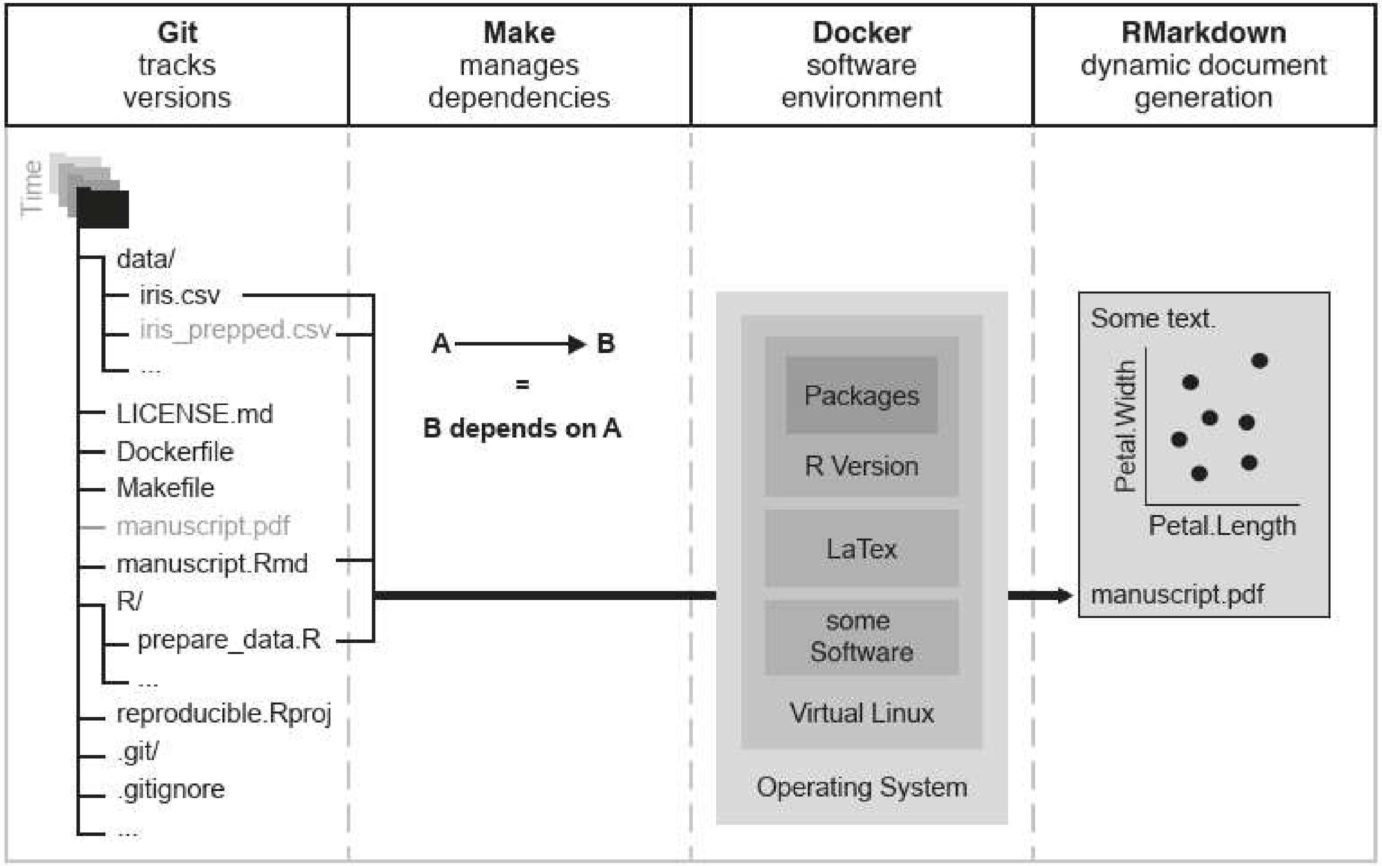


Manual or semi-automated financial reporting processes cause an operational burden:

- High risk of error due to manual imports, calculations, exports
- Whole process has to be repeated / cloned to assess impact of changes in input parameters
- Checks performed in separate spreadsheets manually due to lack of workflow controls
- Report writing involves multiples versions (with track changes) and manual import of results
- Reviewer and auditor has to go through the whole process to get comfort over accuracy

Tool	Description
R	Data cleaning, valuations, optimisation
git	Version control
docker	Reproducible code
make	Dependency management
M↓	Automated reports
Shiny	Interactive apps to support decision making

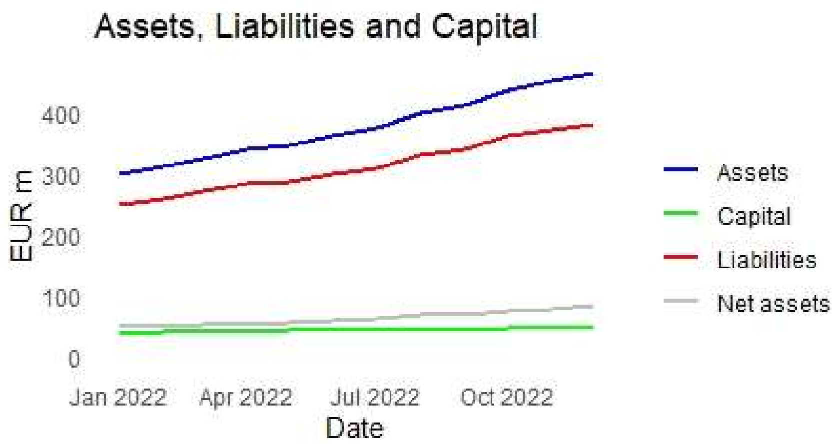
Components of a robust, streamlined financial reporting process (details in article [1], see References):



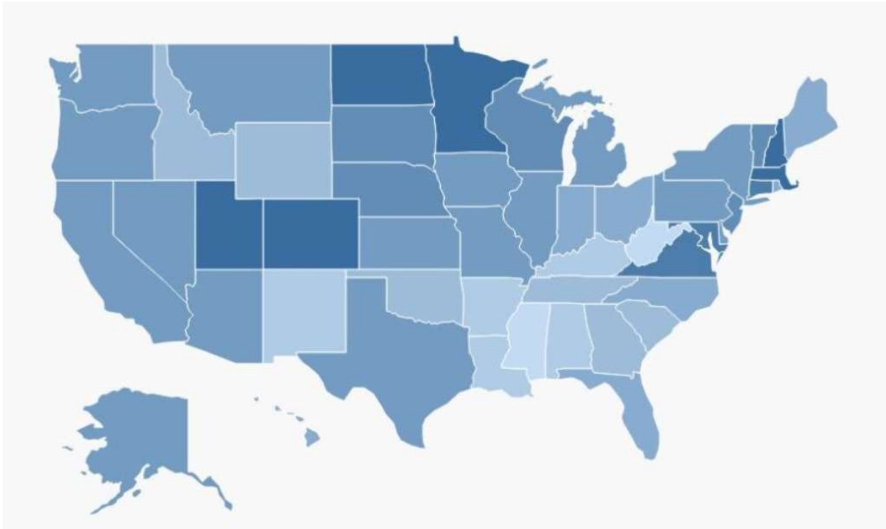
Visualisation of results

2D, 3D and geospatial plots

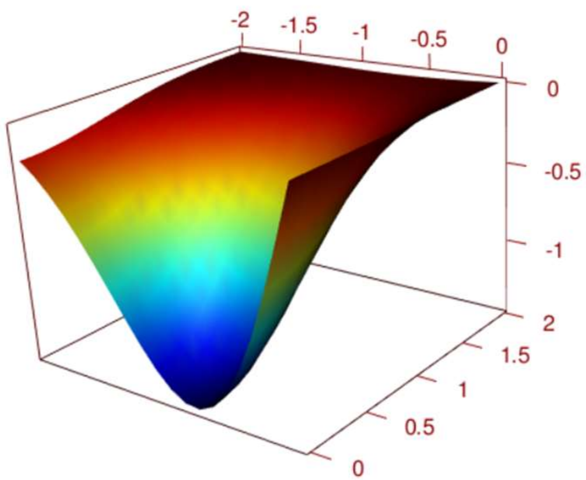
2D plots (ggplot2):



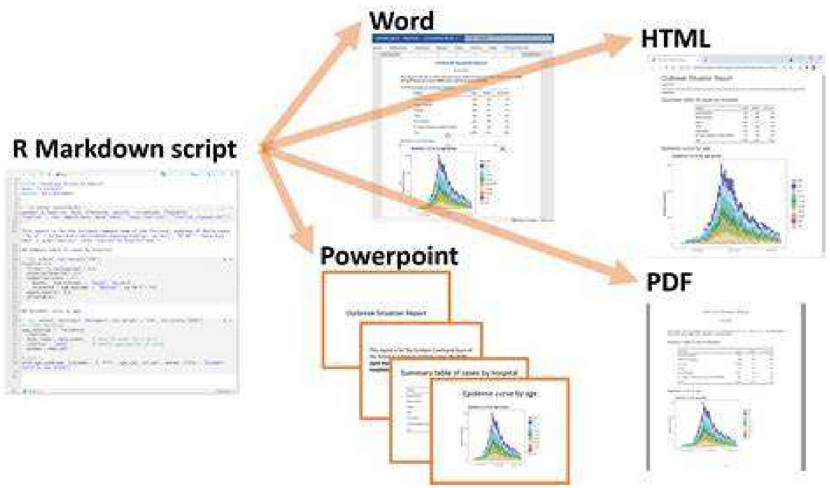
Geospatial plots (leaflet):



3D plots (rgl):



Plots and code feed into automated reports:



2 Portfolio optimisation overview

Portfolio optimisation problem:

- Portfolio optimisation is an important process in finance that consists in finding the optimal asset allocation that maximises expected returns while minimising risk.
- Statistical methods for portfolio optimisation and their implementation in R are covered in book [2] (see in References).

Timeframe:

- Static – point in time
- Dynamic – portfolio rebalancing over a period of time (projection)

- The PortfolioAnalytics R package provides a numerical solution to the portfolio optimisation problem for both static and dynamic cases (note that alternative portfolio optimisation methods are available via the FRAPO package – not covered here).
- The algorithm (solver) finds the optimal asset weights according to the objective and has the following components:

Component	Options
Assets	Asset universe (any assets with historical return data)
Expected return	Estimated using statistical methods
Moments	
Constraints	Long only vs. short selling allowed Min/max limits for individual asset weights Min/max limits for grouped weights (e.g. corporate bonds in total)
Objective	Maximise return Minimise risk (e.g. standard deviation, variance or expected shortfall) **Maximise risk adjusted return**
Optimisation method	ROI – suitable for linear and quadratic programming

Risk adjusted return as objective is based on:

- Modern Portfolio Theory introduced by Harry Markowitz in 1952

Objective is to find the optimal asset weights ω to maximise: $\omega^T \mu \; - \; \lambda \, \omega^T \, \Sigma \, \omega$

Subject to: $\sum \omega_i$ = 1 (plus $\omega_i \geqq$ 0 if the long only constraint applies)

Where:
μ expected return
Σ variance – covariance matrix
λ risk aversion parameter

Notes:
μ and Σ are estimated using appropriate statistical methods
λ is user input and reflects risk aversion attitude

3 Adaptation for insurance capital optimisation

Why are capital projections important?

- Key component of risk management framework and financial planning
- Regulatory requirement
- Key driver of dividend payment capacity

Definition of capital requirements:

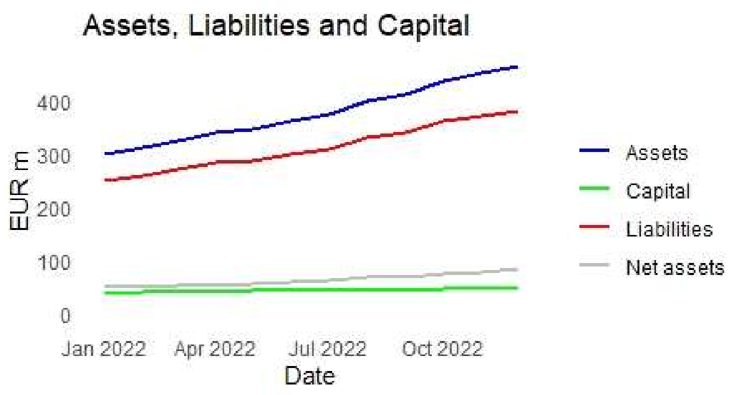
- The amount of financial resources held by insurance companies to withstand the risks they are exposed to, such as falling asset prices or increased liabilities.

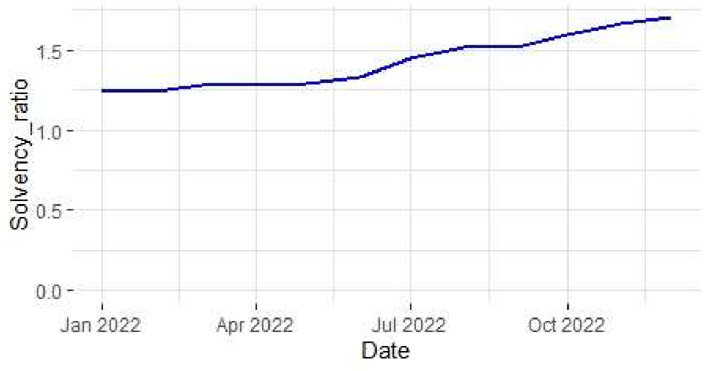
Types of capital:

- Regulatory capital – minimum amount insurers are required to hold as required by the regulator
- Economic capital – amount of risk capital assessed on a realistic basis by the firm itself to cover its risks

Key metric – solvency ratio

- Solvency ratio = Net Assets / Capital = (Assets – Liabilities) / Capital
- Restrictions apply on net assets based on availability and quality
- Meaning: available funds as % of capital –> should exceed 100% to comply



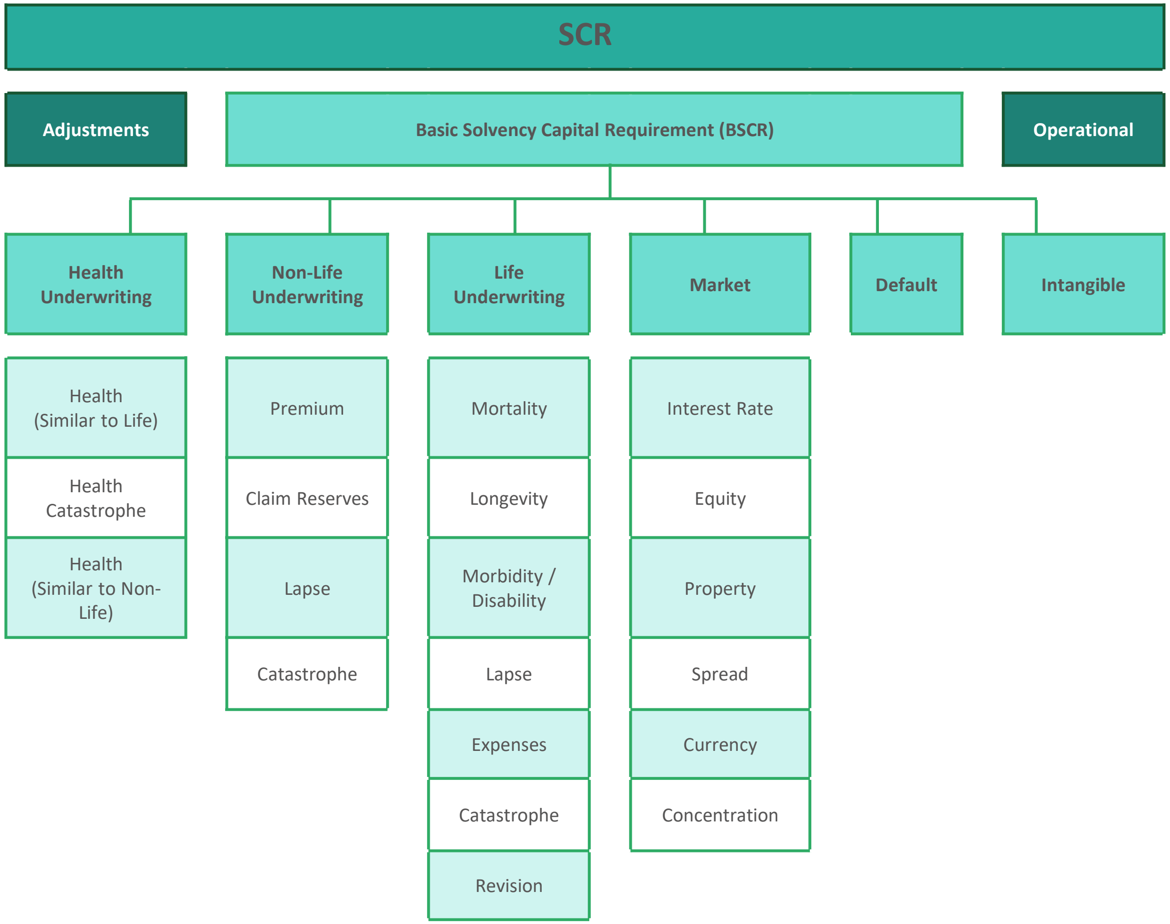


Calculation of regulatory capital

Example – Solvency II

As an example for regulatory capital calculation, the components of the Solvency II standard formula are shown below (harmonised requirements in the EU, still applicable in the UK until new regime introduced post Brexit):

- Solvency Capital Requirement (SCR) = Basic Solvency Capital Requirement (BSCR) + Operational Risk + Adjustments
- Aggregation of BSCR across submodules and modules allows for “diversification” via correlation matrices
- Each component (box) calculated as an asset and / or liability stress



In general, capital is a function of:

- Asset shocks = Market value of shocked assets – Market value of base assets; and
- Liability shocks = Shocked liabilities – base liabilities

As shock factors are fixed in the standard formula, ultimately:

- Capital = f (Assets, Liabilities)
  - where *f* is non-linear due to the combination of shock factors and the complex capital aggregation formulae

A simplified optimisation approach may be adopted by keeping liabilities unchanged (note that this assumption is hard to justify for certain products where liabilities depend on asset values e.g. products with guarantees):

- Capital = f (Assets)
  - Narrows down capital optimisation problem to asset portfolio optimisation

- Objective function in the PortolioAnalytics package can be any function in R
- Allowance can be made for (cost of holding) capital.
- Global solver instead of ROI as problem not linear / quadratic programming anymore.

Component	Portfolio optimisation	Capital optimisation – simplified (asset only)
Assets	Asset universe (any assets with historical return data)	
Expected return	Estimated using statistical methods	
Moments		
Constraints	Long only vs. short selling allowed Min/max limits for individual assets Min/max limits for grouped weights (e.g. corporate bonds in total)	
Objective	Maximise return Minimise risk (e.g. standard deviation, variance or expected shortfall) Maximise risk adjusted return	Maximise capital adjusted return Minimise capital Maximise risk and capital adjusted return Maximise solvency ratio
Optimisation method	ROI – suitable for linear and quadratic programming	Global solver – DEopt, random, GenSA, pso

Constraints

Driven by investment policy and risk appetite

The constraints of the optimisation problem can be derived directly from the risk management framework (investment policy and risk appetite statement):

- Individual constraints
  - Concentration risk mitigation (e.g. cap of 5% of total assets to be invested in single name exposure)
- Grouped constraints
  - Asset allocation limits (e.g. cap of 10% to be invested in corporate bonds or equities)
- Long vs. short selling
  - More common to allow long investments only in insurance

The capital optimisation problem can be extended to:

- Liabilities
  - Relax assumption that policyholder liabilities (cashflows) are unchanged
  - Optimisation extended to allow portfolio transfers, changes in reinsurance etc.
- Market risk management strategies
  - Options, swaps, hedges, derivatives etc.
- Group entities
  - Group capital optimisation
  - Transfers of assets and liabilities across entities

Implementation in R:

- ROI: Extensible optimisation infrastructure in R
- Covers broad range of solvers including non-linear and mixed integer optimisation:
  - *Non-linear*: Objective function becomes non-linear once capital component introduced
  - *Mixed integer*: Integer variables can be used to model decision on management actions (e.g. in case of portfolio transfer: 0 – no transfer, 1 - transfer)

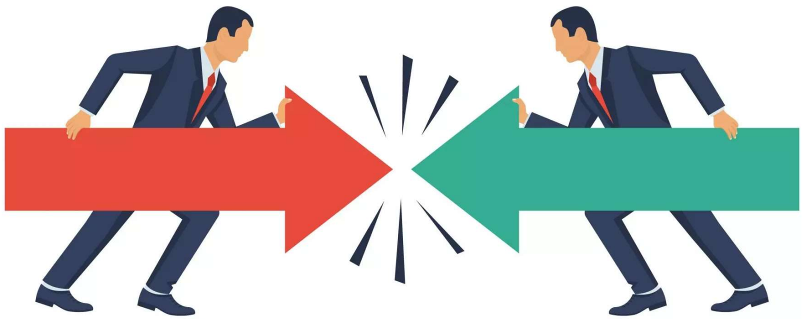
4 Interactive decision making

Capital projections involve stakeholders across departments:

- Risk
- Actuarial
- Finance
- Board etc.

Capital optimisation involves trade-offs and compromises. Examples:

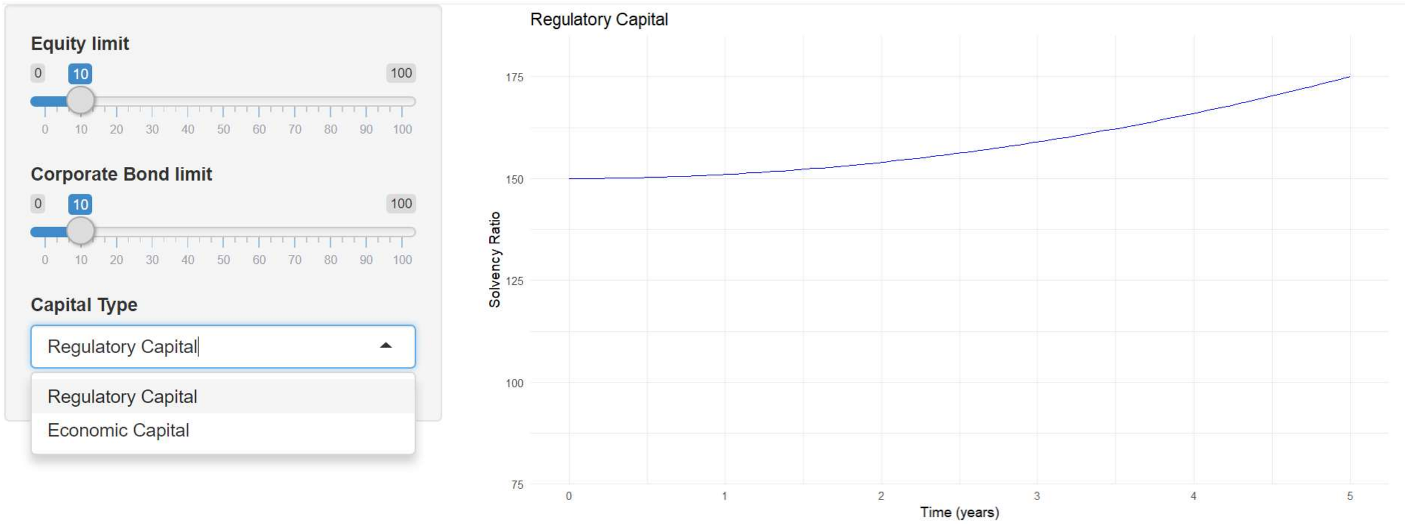
- Risk vs. return
- Objective for capital optimisation
- Policy decisions (e.g. investment limits)
- Scope of management actions (hedges, portfolio transfers, reinsurance etc.)



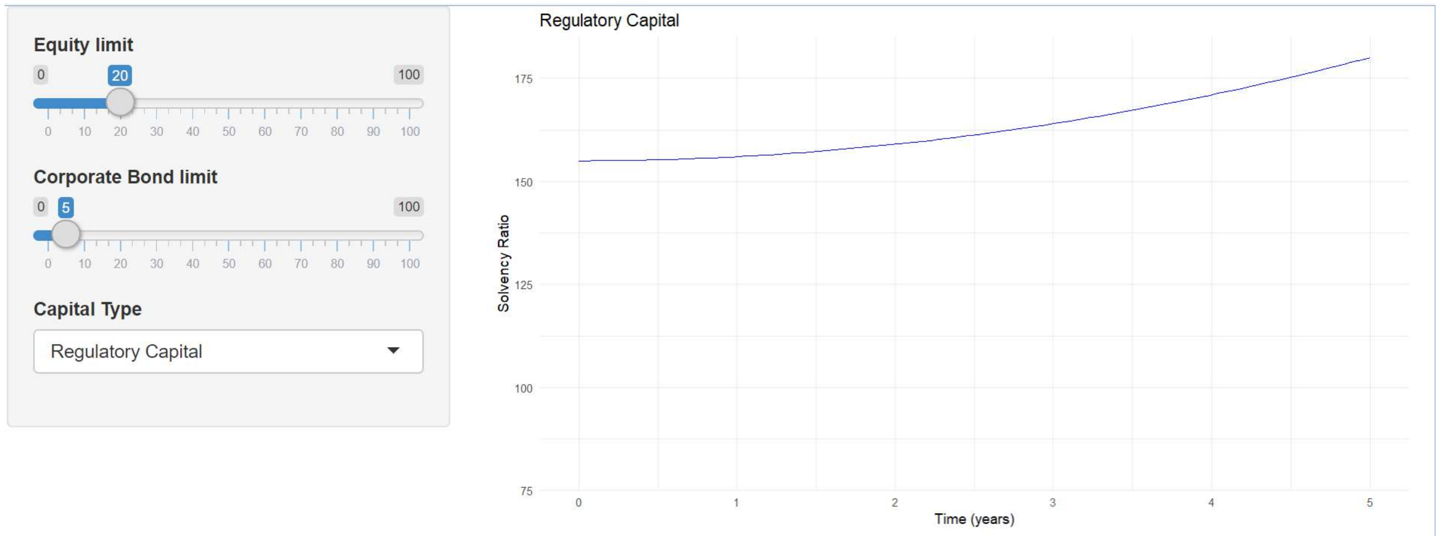
Interactive decision making – with R Shiny apps

Example – evaluate impact of investment policy limit

Equity and Corporate bond limits (%) - current investment policy



Equity and Corporate bond limits (%) - investment policy under consideration



5 Conclusions and future plans

- Automation of financial reporting processes may significantly reduce operational burden and free up resources for value-added analysis
- Open source toolkit is available to design robust, streamlined processes
- Portfolio optimisation problem can be adapted to an insurance context in the form of capital optimisation
- The optimum depends on the objective and ultimately on the risk appetite of the company
- Interactive apps are effective tools in supporting decision making involving multiple stakeholders (such as capital optimisation)

- Demos on automated financial reporting toolkit and workflows
- Case studies on capital optimisation across:
  - Objective functions
  - Type of entities (life, non-life and reinsurer)
  - Solo companies and groups
  - Simplified approach (asset only) vs. broader optimisation
- Back-testing of results of case studies to demonstrate potential impact

References

1.Peikert A, Brandmaier A. (2020). A Reproducible Data Analysis Workflow With R Markdown, Git, Make, and Docker

2.Pfaff B. (2013). *Financial Risk Modelling and Portfolio Optimization with R - Second edition.* Wiley.

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Demos and sample code to be uploaded to this repo – stay tuned:

https://github.com/bencezaupper

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Any questions?