# Big Data ja vakuutustoiminta

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# Agenda

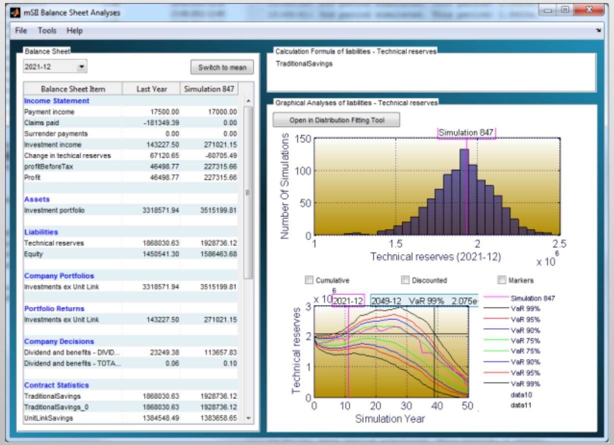
- **Model IT**

- **The age of Big Data**
  - Not generally accepted definition
  - <u>Important</u> phenomena
  - But also <u>hype</u>

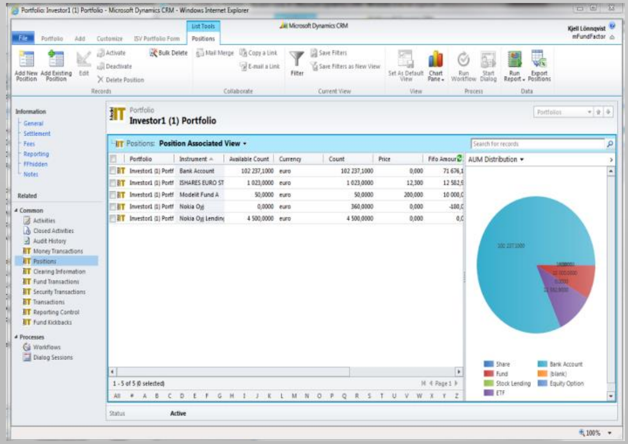
- **Case study / Example** – Life Company Modelling

# Model IT – Core Products

## **cFrame** insurance Analysis

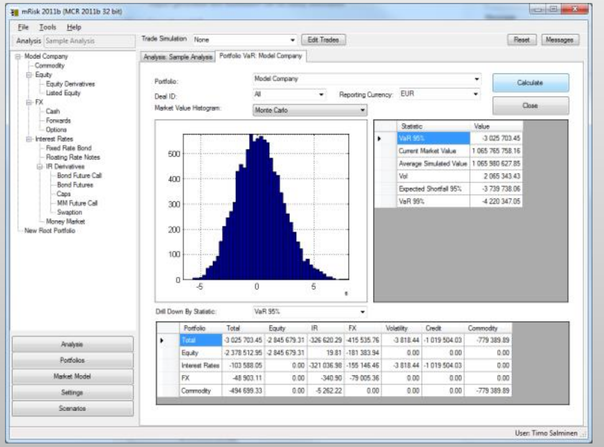


## **OneFactor** asset management



## **mProfit** performance analysis

## **mRisk** market risk management



# Big Data Creates Value

- The use of big data offers tremendous **potential** for creating value
- **McKinsey Global Institute**: “Big Data: The next frontier for innovation, competition and productivity,” June 2011:
  - “Our research suggests that we are on the cusp of a tremendous wave of innovation, productivity, and growth, as well as new modes of competition and value capture — all driven by big data as consumers, companies, and economic sectors exploit its potential. “
  - “Many pioneering companies are already using big data to create value, and others need to explore how they can do the same if they are to compete.”

# Data-driven Decisions (1/2)

- **McKinsey Global Institute**: "Big Data: The next frontier for innovation, competition and productivity," June 2011:
  - **Visualization**, a key tool for understanding very large-scale data and complex analyses in order to make better decisions.
  - **Presenting information** in such a way that people can consume it effectively is a key challenge that needs to be met if analyzing data is to lead to concrete action.

# Data-driven Decisions (2/2)

- A data-driven organization makes decisions on the basis of the empirical results, and the benefits of such an approach toward data have been demonstrated by academic research

  - Erik Brynjolfsson etc.: “Strength in Numbers: How Does Data-Driven Decision making Affect Firm Performance? 2011:

    “Case literature and economic theory suggest a potential connection between data driven decision making and productivity. By analyzing a larger sample of firms, we find that data driven decision making is indeed associated with higher productivity.”

# Finnish traditionally good at utilizing new technology - Many papers!

**Research on individual actuarial modelling. Examples:**

- Antonio K. and Plat R.: “*Micro-level stochastic loss reserving*”, SAJ, 2013 (Non-life real case study)
- Gustafsson, E. et al : “*Simulation based claim reserving in general insurance*”, Univ. of Stockholm, Research Report 2012:9
- Arjas, E., : “*The claims reserving problem in non-life insurance: Some structural ideas*”, ASTIN BULLETIN 1989.
- Rantala, J.: ”*Estimation of IBRN claims”,* 1983 (Early ideas)
- Leppisaari, M.: “*Modeling catastrophic deaths using EVT with a micro-simulation approach to reinsurance pricing*”, Manuscript

# Oulun tutkimusta

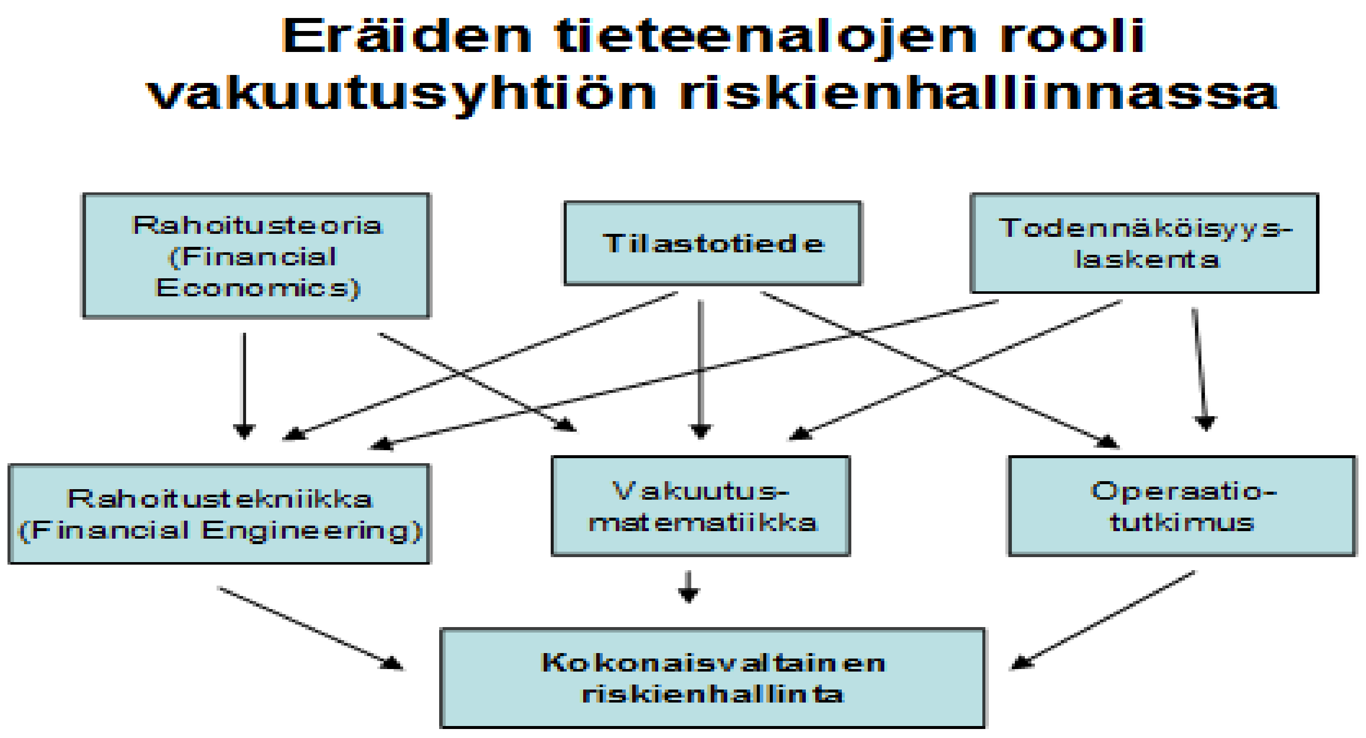
**Kaksi esimerkkiä:**

- Jussi Klemelä: Datan visualisointi
    - Juhan kommentti?
- Juha Joenväärä: Hedge-rahastojen analyysi
    - Jussin kommnetti?

# ERM

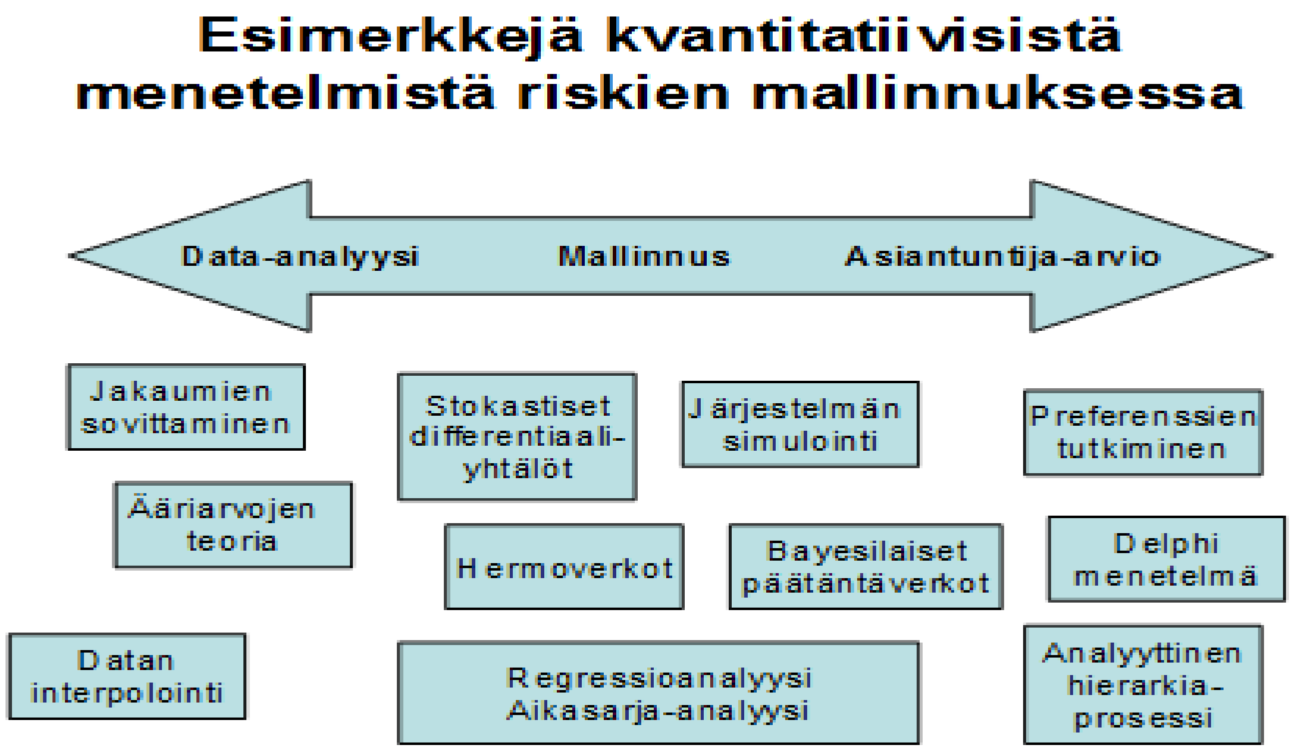
- Enterprise (Wide) Risk Management

**Risk also an opportunity!**



# Spectrum of Methods

- An example



# Insurance modelling (1/3)

- Background
  - Quoting England and Verrall, **2002**: "*With the continuing increase in computer power, it has to be questioned whether it would not be better to examine individual claims rather than use aggregate data.*"
  - Here we utilize micro-level insurance data for better informed decisions by performing large simulations
- **Example:** Standard PC + Graphic Cards => Tens of Billions ($10^9$) Black Scholes per Second
- *Now it is **2013**!* Individual simulation is feasible, but fast computers, large memories and efficient algorithms are still crucial
- Fast development each year: Both algorithms and hardware. **Future** looks **even better**!

# Insurance modelling (2/3)

- When micro-level information leads to better decisions?
  - Causal information is available
  - Causal information is correct
  - Information can be communicated
- A heavy computational application that actuaries encounter nowadays is the use of economic scenario generator (ESG). A key element of :
  - Market consistent valuation for insurance businesses
  - Business modeling and ORSA
- Available computational power can be used several purposes: ESG, Individual Simulation, Extreme Value estimation  etc.

# Insurance modelling (3/3)

**Big data analysis:**

- Familiarizing oneself with data is rather difficult

  => good graphical tools needed; Data visualization central
- Aim may be to detect peculiarities, anomalies, or unusual patterns with repeat.
- Often the entire population is stored in the database

  => description instead of inference is the aim.
- Data quality (as always) is central
- Used dataset is often originally collected for other purposes

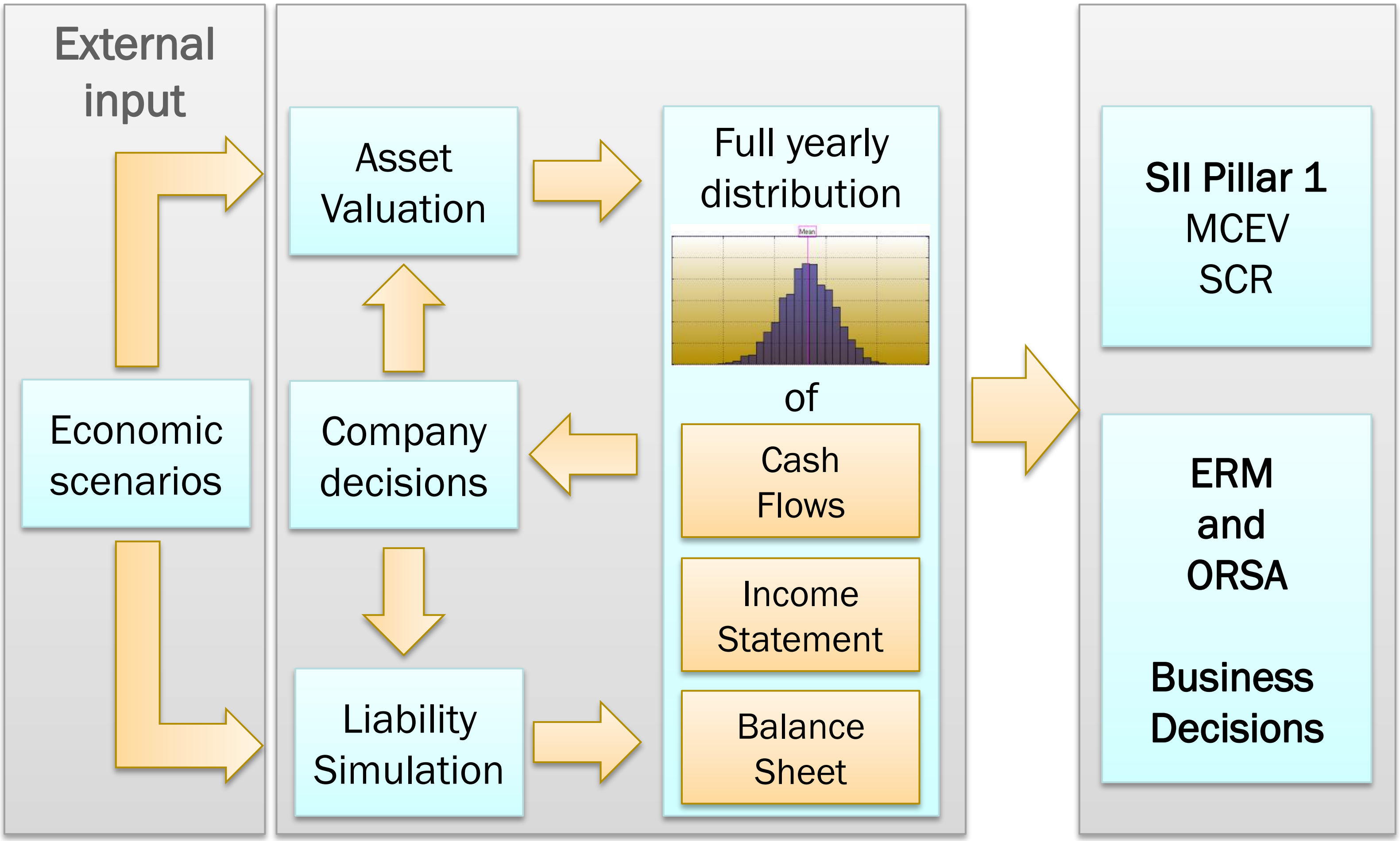
# Henkivakuutus

- **Henkivakuutus** on vakuutus, jossa riski liittyy vakuutetun elämään ja kuolemaan. Markkinoilla on useita erilaisia henkivakuutustuotteita, mutta yksinkertaistettuna puhtaat henkivakuutukset voidaan jakaa kahteen luokkaan:
- ***Kuolemanvaravakuutus*** on sopimus, jossa vakuutusyhtiö suorittaa vakuutetun edunsaajille korvausta, mikäli vakuutettu kuolee vakuutusaikana.
- ***Elämänvaravakuutu***s on sopimus, jossa vakuutettu saa korvausta, jos hän on sovittuna aikana hengissä. Elämänvaravakuutuksen korvaus voidaan suorittaa kerralla, tai osissa pidemmällä aikavälillä, jolloin kyseessä on usein eläke
- Osassa tuotteista keskeisenä elementtinä säästäminen.

# LIFE INSURANCE
# Modelling Framework

## Computations performed
## by Matlab (MathWorks) and cFrame (Model IT)

# Model Overview



# Balance Sheet Modeling

| Description | Assets | Liabilities | Description |
| --- | --- | --- | --- |
| Priced with current* yield curve | Fixed income investments | Equity | Based on policy-level SCR attribution and current* investment risk |
| | | SCR | |
| | | MCR | |
| Modeled as a basket of ESG indices | Equity and other investments | Technical reserves | Expected value of future cash flows<br>• For policies still active in current* simulation<br>• Discounted with current* yield curve |
| Sum of current* unit link policy savings | Unit Link investments | | |

* Current = current simulation path and current time step

# Simulation

- Task 1: Measuring the effect of management policies on profitability and solvency (under Solvency II)
  - Full stochastic real world policy-by-policy simulation
  - Customer behavior modeling
  - Multiple policy types with embedded options
  - Path-dependent mark-to-market balance sheet simulation

- Task 2: Dynamic management actions
  - Profit sharing between dividends, customer benefits, equity
  - Investment strategy changes based on financial position and expected liability cash flows
  - New sales policy (run-off → going concern)

# Simulation cycle & High performance computing

1. Simulate or import economic scenarios
2. Go through all years T
    1. **Go through all customers N**
        1. Simulate customer's random events (death, disability ...)
        2. Go through all customer's contracts (usually 1)
            1. Simulate contract's random events (surrender, payment, ...)
            2. Go through all time steps in a year (1-12)
                1. Calculate contract's cash flows for M simulations
                2. Terminate contracts that have encountered a termination condition for M simulations
    2. Generate company balance sheet and make company decisions for D simulations

- The biggest loop (customers, N) can be distributed to a computing cluster
    - Local multicore, Computing cluster, Cloud computing

# Company overview

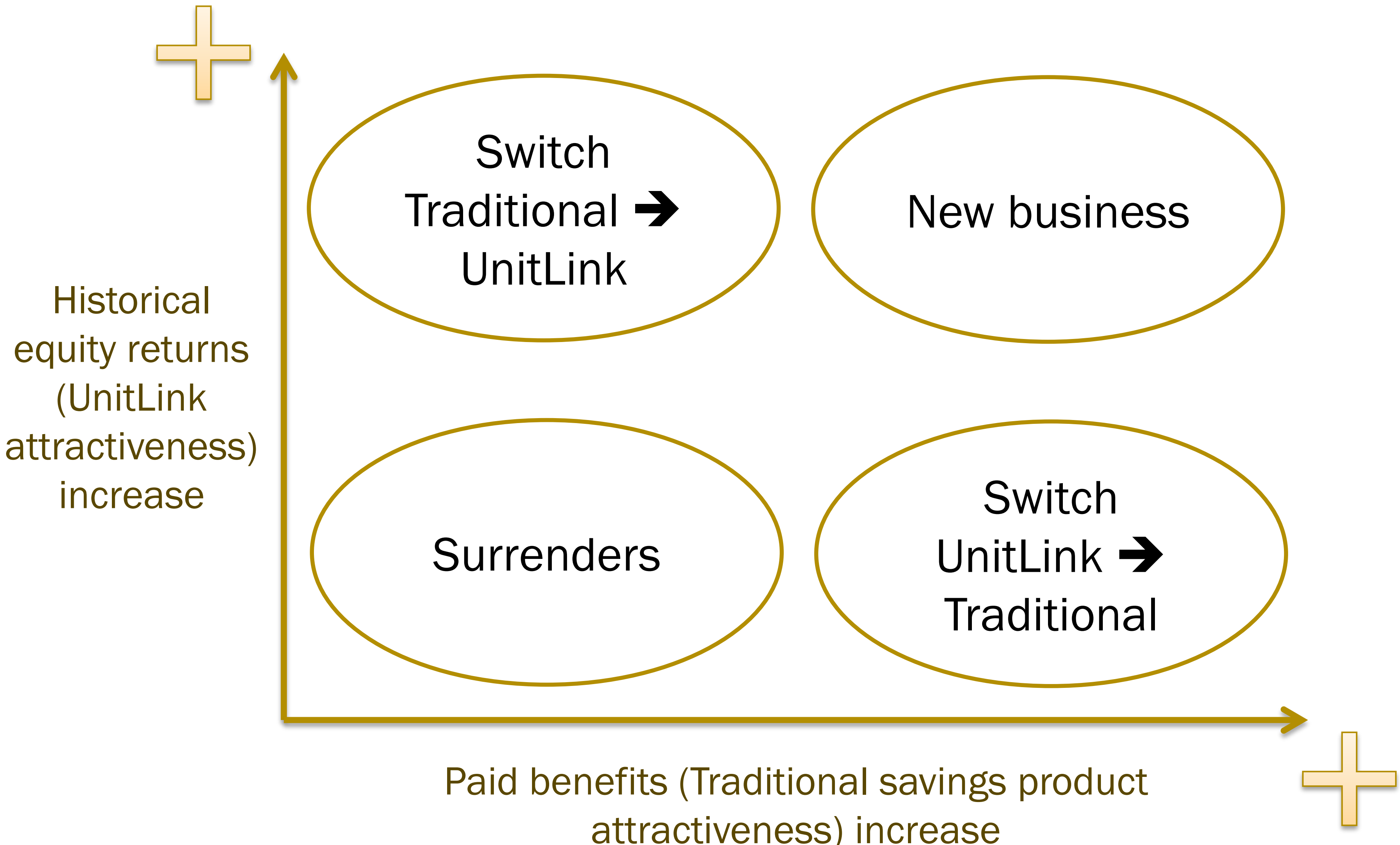
- A publicly listed (hypothetical) life insurance company
- Solo structure with policyholders and investors as the main interest group
- All liabilities are euro denominated
- Solvency II and MCEV are closely followed
- Policy groups are:
  - Pure risk policies
  - 0% and 4% guaranteed rate savings products with all life pension payments and options to switch between guaranteed fund and unit linked funds
- All three policy groups have 100 000 policyholders each
- Estimated year premium from the insurance portfolio including new sales is around 500 million euro

# Company policies

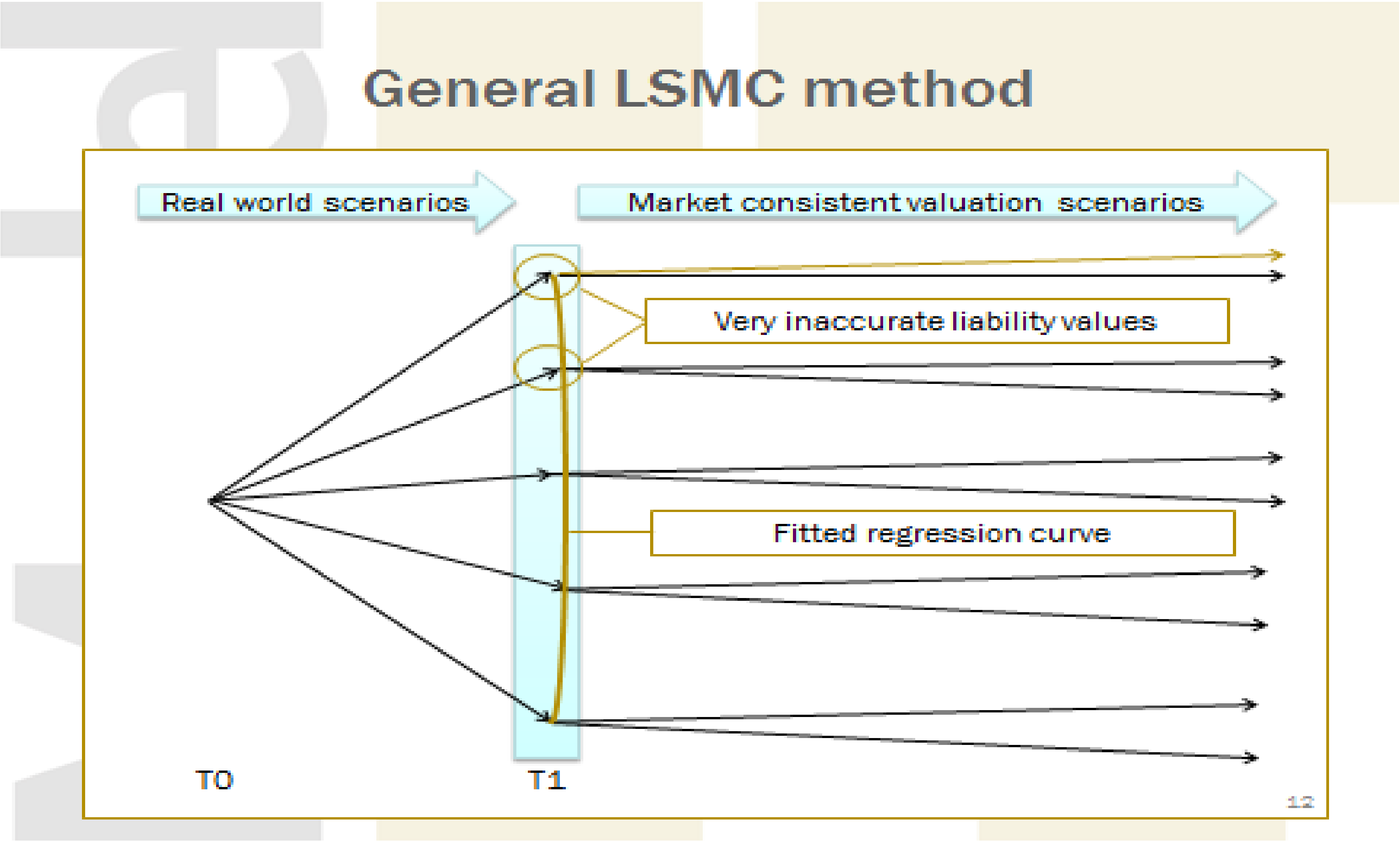
Company decision making - binding together all the policies

| No | Solvency & business trigger | Profit sharing | Risk tolerance | Capital management |
|---|---|---|---|---|
| 1. | (EOF/SCR > 300%) | Benefits are granted amount of 30% of positive profit. Shares are payed amount that cuts the over capitalization into 300% | Since the amount of (Assets - liabilities - 2/3*SCR) is invested in equitys, this increases the company risk position quite much | Over capitalization is taken care in profit sharing part |
| 2. | (140% < EOF/SCR) && dMCEV > 1.1 | Benefits are granted 30% of the positive profit. Shares on the other hand are granted 50% of positive profit in case of substantial increase in MCEV | - | - |
| 3. | (140% < EOF/SCR) | Benefits and Shares are granted both 30% of the positive profit | - | - |
| 4. | 100% < EOF/SCR < 140% | Benefits are halved (if positive profit) and shares are set at zero | Equity proportion is redused as EOF diminishes | - |
| 5. | 2/3 < EOF/SCR < 100% | - | Equity proportion of the portfolio is minimized now. Also worst rating class of bond holdings is lifted up into A or less risky. | Sub-ordinated loan is raised with spread equal to A + alpha. This amounts up to (1.1xSCR - EOF) but makes only Tier 2 type of capital (and max is 50% of Tier 1 EOF) |
| 6. | MCR < EOF/SCR < 2/3 | - | No new policies will be accepted. All assets are re-allocated into A or less risky bonds. | New share capital will be collected, total value an amount up to (SCR - EOF) |
| 7. | EOF/SCR < MCR | Bankruptcy | Bankruptcy | Bankruptcy |

# Customer behavior

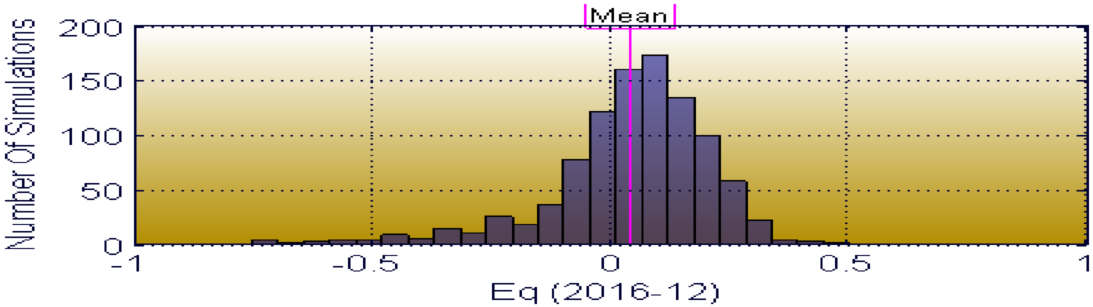


# Approximating market consistent technical reserves <u>without</u> nested stochastic simulation

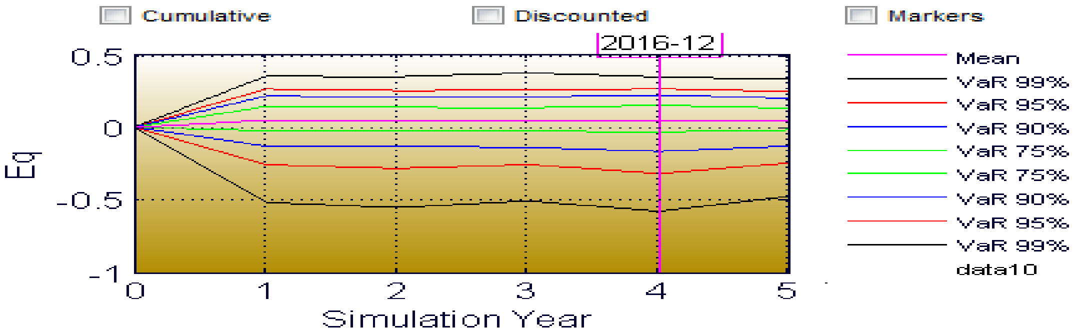


# Simulation results – ESG

- Stock returns

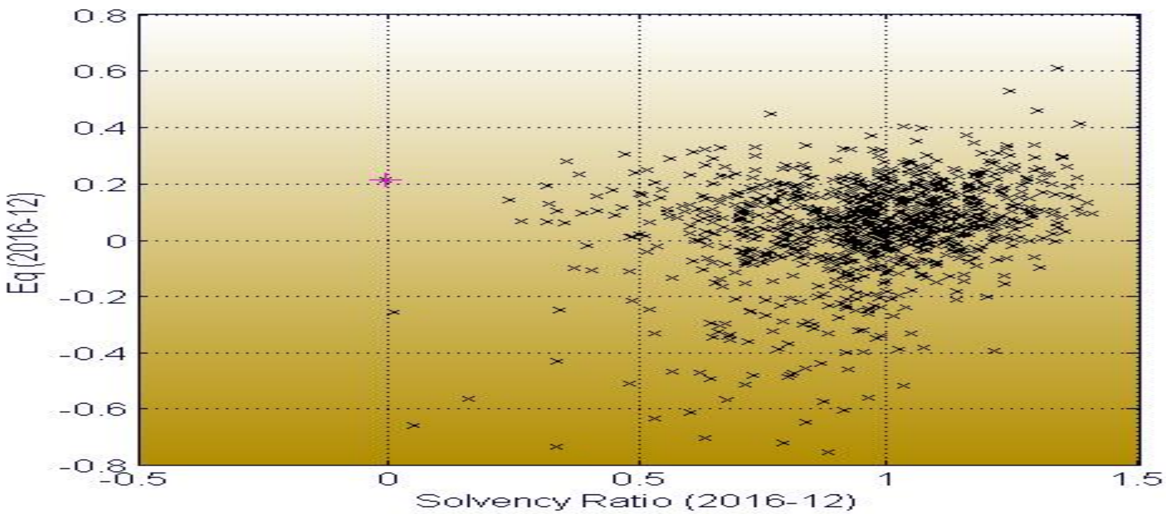



- Probabilty intervals



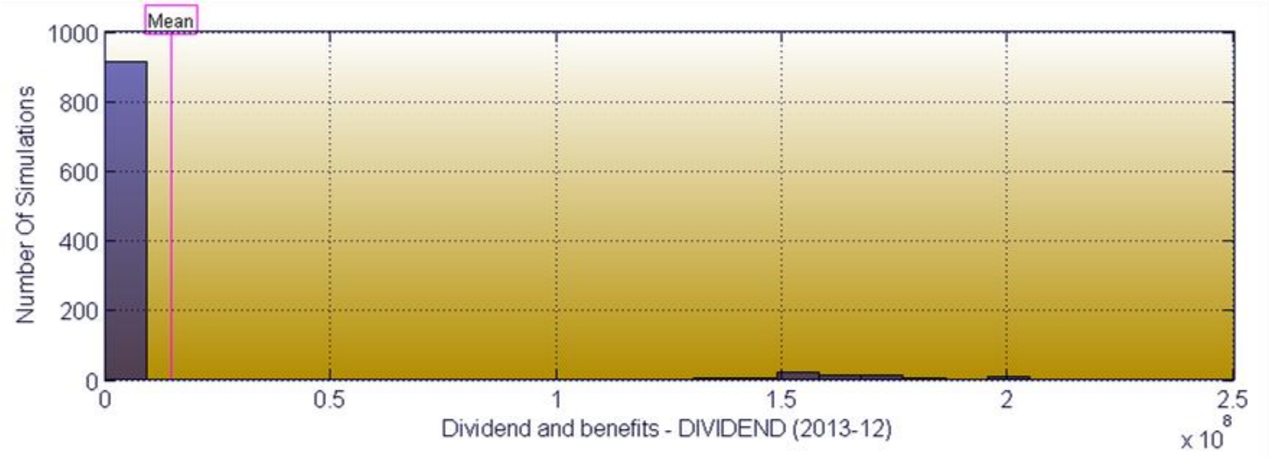

- Correlation: Solvency ratio vs. Stock return

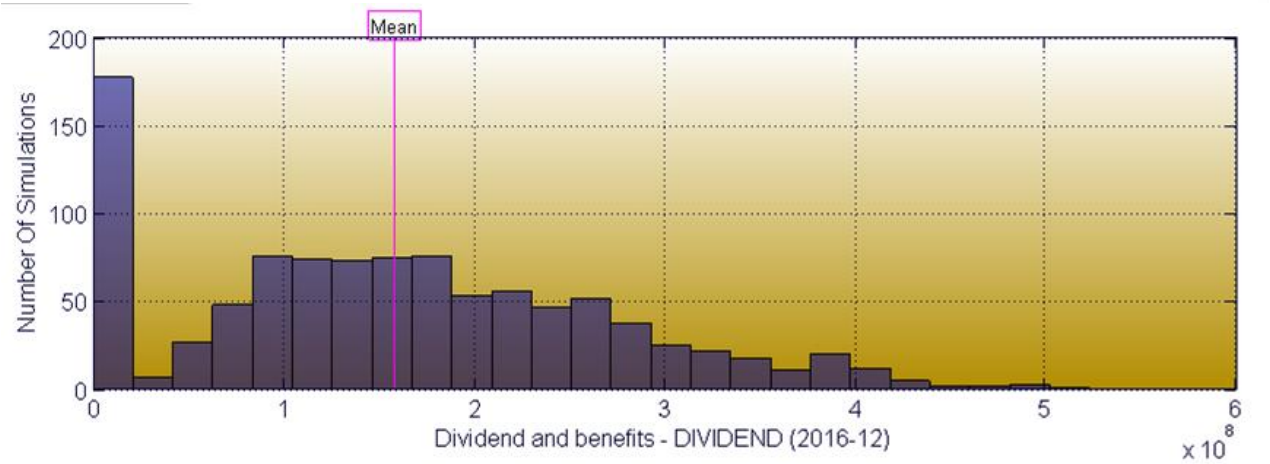
- Outliers?



# Simulation results – future dividends

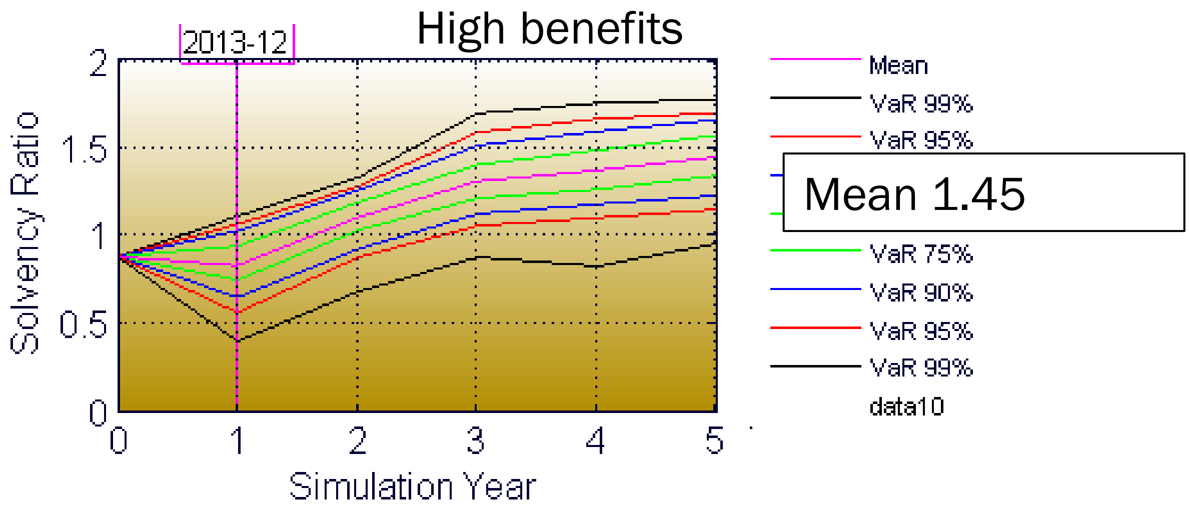
- The amount company is able to pay dividends (according to its policy)
- Neglible in 2013
- Grows as its solvency position recovers

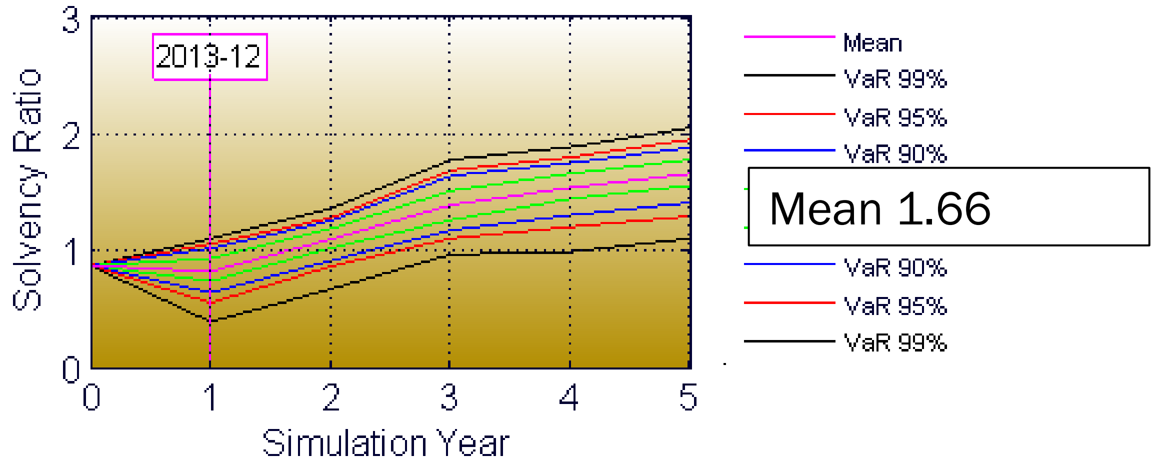


# Results: Achieving solvency target

- The target for future benefits on the profit sharing policy has a key impact on solvency position



# Conclusions I

- Individual level simulation is feasible computational tool for life insurance modeling
  - Flexibility to model the future cash flows realistically
  - Better information can potentially lead to better decisions
    - Effective communication critical!
- Computational power needs to be focused on essential tasks: most demanding or frequent; Full data or small sample?
- <u>Specific / tailored </u>algorithms needs to be developed for (e.g.):
  - Contract level cash-flows
  - Avoiding nested simulations in ERM/ORSA

  ➔ Parallel algorithms

  Fast data structures

  Tailored versions of known computational

  statistics / finance algorithms + know new methods
- Interactive tools needed for interactive model development / use

# Conclusions II

- For business decisions
  - It should be clarified which metrics to follow (here SII and MCEV levels)
  - well-defined strategy and harmony between sub strategies appropriately taken into account in the model will help
- Causality structure drives results
  - Interactive modeling a tool for scrutinizing stochastic causality
  - Stochastic sensitivity analysis
- All model components need to be realistic enough so that the overall process complexity can be separated into understandable parts.
- The link between policyholder behavior and company was here approached via economic scenarios resulting lapses → more interrelationships (like other events that cause lapses) could have also been needed
- For Solvency II purposes this kind of modeling would probably cover many of the ORSA requirements.

# Thank You!

**Teivo Pentikäinen** (1975):

- *The strategy of 'practical men' can be a random product of old traditions, more or less reliable institutions.*

- *A discussion on theoretical aspects and on the theoretical point of view, even if the direct numerical results are of little value, may anyway direct attention to the statement and restatement of problems and to a conscious analysis of the facts and possibilities*.