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Section AFIR ERM

Analysis Threshold Portfolio Return of Swiss Pension Funds based on Nested Simulation Engine

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About the Speaker

Mauro Triulzi, Dr. math ETH, Actuary SAA

- Head of IT & Software Tools
- Developer of actuarial tools for ALM studies, local and international accounting valuations
- Software development for pension fund administration services
- Prepared several publications and presentations for actuarial journals and conferences

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Threshold Portfolio Return

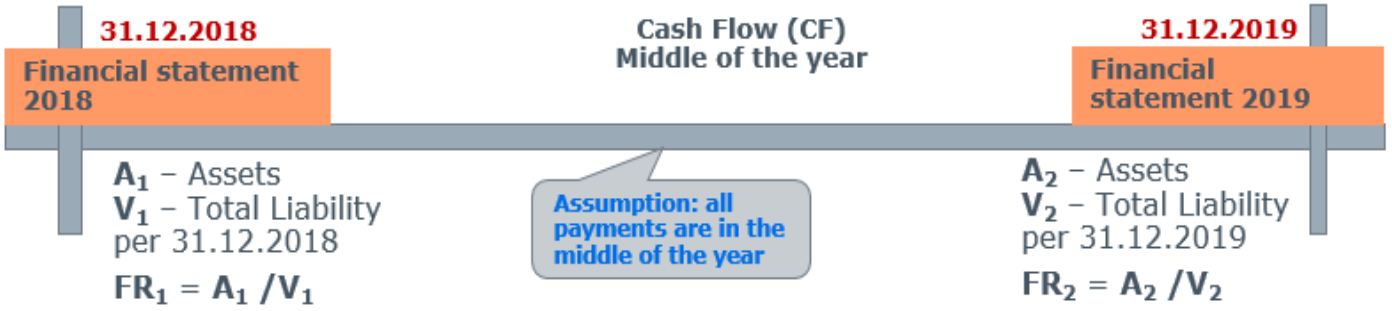
Definition ***Threshold Portfolio Return***

Guidelines **FRP5** of Swiss Chamber Pension Fund Experts (SKPE)

- **SKPE** - Swiss Chamber of Pension Fund Experts is an actuarial society of pension fund actuaries in Switzerland doing consulting and financial accounting for independent pension funds as well as for collective multi-employer foundations
  - Home page ***www.skpe.ch***
- Swiss Chamber of Pension Fund Experts sets up minimum requirements for the verification of a pension fund according to Art. 52e Abs. 1 BVG/LPP (the law of the second pillar in Switzerland)
  - The definition of the threshold portfolio return, **TPR** (*Sollrendite* in German and *rendement nécessaire* in French), belongs to the Guidelines **FRP5**
  - Guidelines **FRP5** request:
    - The pension fund expert gives a feedback to the necessary Threshold Portfolio Return compared to the expected/ potential portfolio return
    - If the level of the Threshold Portfolio Return is higher compared to the expected portfolio return the adjustments (reduction) of the occupational benefits could be requested/ suggested

Definition of Threshold Portfolio Return

Based on the Guidelines FRP5



To ensure that the funding ratio (FR) over one year stay constant **(i.e. $FR_1 = FR_2$)** it is necessary that the asset value at the year end (A_2) amounts to **$A_2 = A_1 * (V_2 / V_1)$**

$$A_2 = A_1 * (V_2 / V_1) = A_1 * (1 + R^{Liab})$$
$$= A_1 * (1+R^{TPR}) + CF * (1+ R^{TPR} / 2)$$

CF = Cash-In – Cash-out; **$CF^{\%(A1)} = CF/A_1$** (i.e. Cash flow divided by the asset value at the former year)
R^{TPR} -> Threshold Portfolio Return; **R^{Liab} - > Total liability change rate = $V_2 / V_1 - 1$**

$$R^{TPR} \approx R^{Liab} - CF^{\%(A1)} + \ldots$$

- **TPR** is a portfolio return necessary to keep the funding ratio on the same level like at the last Measurement Date (MD): ***here Dec 31, 2019 vs. Dec 31, 2018***
  - Funding ratio = Assets/ Total Liability

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Threshold Portfolio Return Role in Risk Management:

„rule of thumb with TPR"

$$R^{TPR} \approx R^{Liab} - CF\ \%^{(A1)} + \ldots$$

Increase (or decrease) of the funding ratio between two measurement dates (EoY and BoY)

Portfolio return - $R^{TPR} \approx$ FR (EoY)/FR (BoY) -1

(Portfolio return - R^{TPR}) * FR(BoY) ≈ FR (EoY) - FR (BoY)

- **If the funding ratio at the beginning of the year FR(BoY) is ca. 100% then the change of the funding ratio over the year is ca. the difference between the portfolio performance and the TPR for this year**
- **If the FR(BoY) < 100% (>100%) then the funding ratio change is smaller (bigger) than the difference between the portfolio return and TPR**

- The difference between the portfolio return and the Threshold Portfolio Return explains the increase (or decrease) of the funding ratio over the year
- The dynamic funding ratio forecasting could be implemented with the future TPR

Comments/ Explanations:
BoY – Begin of the Year, **EoY** – End of the Year, R^{Liab} – Liability Return (Increase or reduction rate of the total liability between two measurement dates), **CF** $\%^{(A1)}$ –total cash flow over the year (between **EoY** and **BoY**) % of the asset value of the first measurement date (**BoY**).

Useful key figures based on threshold portfolio return

They fit into "ex-post" and "ex-ante" risk management

Liability Sharpe Ratio, LSR

$$LSR = \frac{R - R^{TPR}}{\sigma}$$

Liability Sharpe Ratio (LSR)

- corresponds to the difference between the portfolio return and the threshold portfolio return (TPR) divided by the portfolio volatility
- shows the increase (or decrease if $R^{TPR} > R$) of the funding ratio normalised by portfolio volatility
- The larger the ***LSR*** is, the faster the funding ratio can increase.
- **For the same difference (R-R^{TPR}), the pension fund's ability to implement the re-development measures in case of underfunding will be lower with greater volatility, σ**

Liability Information Ratio, LIR, over Threshold Portfolio Return (TPR)

$$LIR\left(R - R^{TPR}\right) = \frac{R - R^{TPR}}{TE(R - R^{TPR})} = \frac{R - R^{TPR}}{\sigma(R - R^{TPR})}$$

- **Liability Information Ratio (LIR)** equals the difference between the portfolio return and the threshold portfolio return divided by the volatility of the difference between the portfolio return and threshold portfolio return (i.e. TE, tracking error)

- If the difference between the portfolio return and the target return is relatively stable, then their volatility is smaller compared to pension funds with more volatile differences
- **The larger this ratio is, the faster the funding ratio (FR) can increase**

TE – Tracking Error, i.e. the volatility of the difference between portfolio return and threshold portfolio return

Objectives of this study

Objectives of this study

Approach and Scope of the Analysis

- New approach to forecast the Threshold Portfolio Return (**TPR**)
  - Based on nested stochastic simulations of liabilities

- Threshold Portfolio Return depends on:
  - Pension fund size,
  - Total pensioner liability vs. Active Membership Liability
  - Development of active membership (growth of salary and head count) and their benefits

- Threshold Portfolio Return depends on as well:
  - The total cash flow sign, CF (i.e. if it is negative or positive)
  - The level of the funding ratio at BoY, FR(BoY)

- To show the value added of this approach
  - The comparison with the Threshold Portfolio Return forecasted based on the widely used simple approach will be done

Forecast of Threshold Portfolio Return (TPR)

Important parameters for TPR forecasting

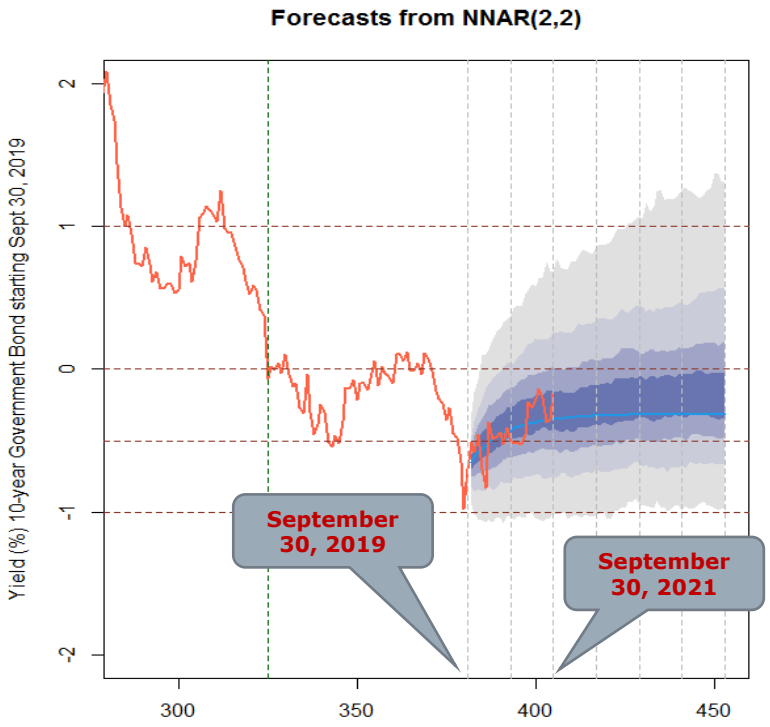
- **TPR** does not depend on the portfolio return (for the current year)
  - *Explanation:*
    - Formally the interest credit for the saving capital confirmed by the board of trustees for each year (compared to its mandatory level currently 1% 2019-2023) depends on the level of the funded ratio as well as the level and sign of the portfolio return
    - The level of funding ratio and the sign of the total cash flow has an impact on the TPR (slide 13)

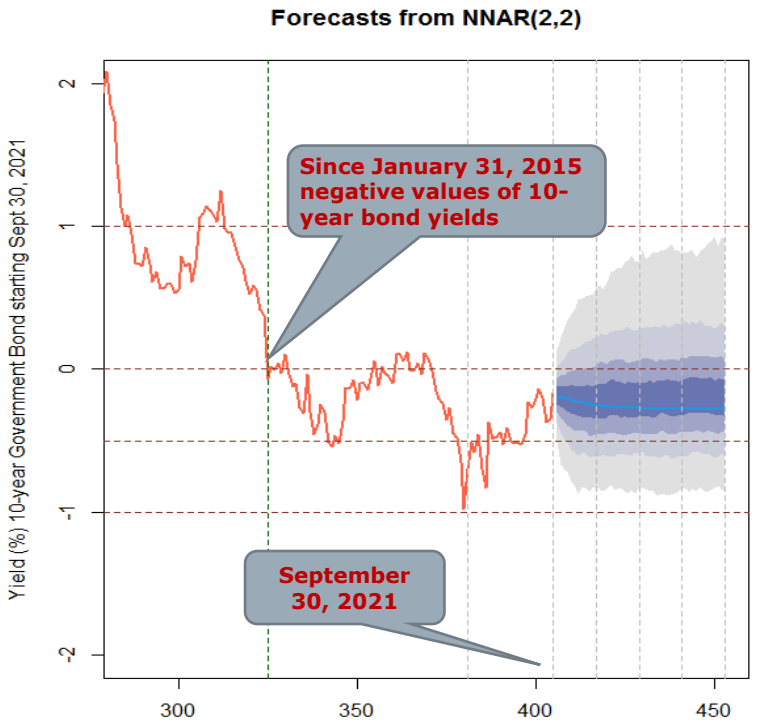
- Due to this fact this analysis is done with our ESG (Economic Scenario Generator) – for future portfolio returns
  - To project the asset value and
  - Compare the TRP with the portfolio return to understand the development of the funding ratio

- The technical interest rate is 1.5% and it is below the FRP4 Upper limit (2.13% per Sept 30, 2019)
  - FRP4 Upper Limit is defined per Sept 30, 20XX for the next year based on the average value of the monthly 10-year government bond yields of the period (Oct 1, 20X(X-1) – Sept 30, 20XX) *plus 2.5%*

The forecast of 10-year government bond yield (NNAR)

Starting from Sept 30, 2019 and from Sept 30, 2021

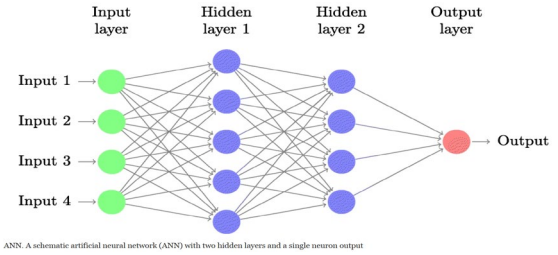




Explanation to x-axis:

- The values on the x-axis corresponds to the month number starting from Jan 31, 1998
- The historical data of 10-year government bond yield are down-loaded from the Home Page Swiss National Bank (SNB) over the Period [Jan 1988 – March 2022]
- The valuation of FRP 4 Upper Limit should be done per Sept 30, 20XX

- Comparison of the historical development (red line) on the left figure shows that the forecasted 10-year government bond yield per Sept 30, 2019 complies with the historical development between Sept 30, 2019 and Sept 30, 2021
- It means that the Neural Network Autoregression (NNAR) approach is useful for the forecasting 10-year government bond yields



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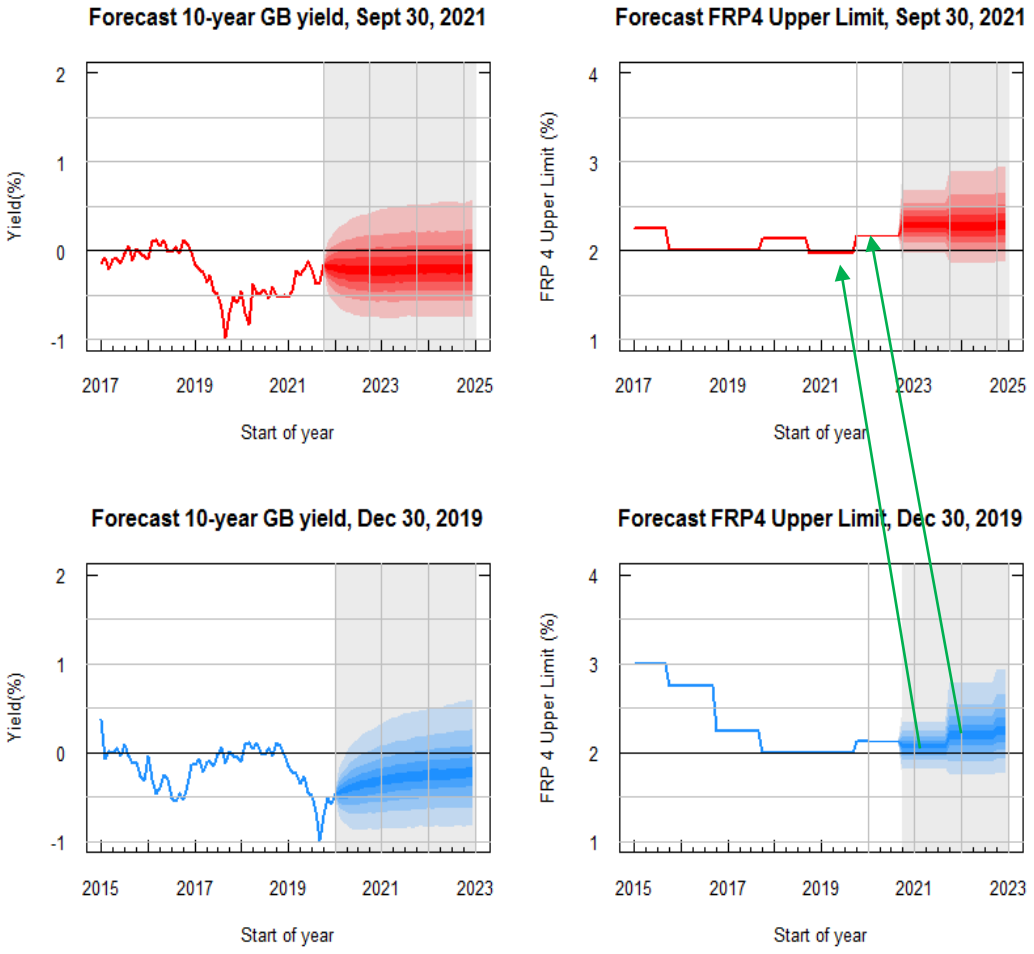
Example: Nested stochastic Liability Forecasting

Forecast over the next three years: Starting per Dec 31, 2019



- The FRP4 Upper Limit for the technical interest rate is estimated each year per Sept 30:
  For example:
  - The estimate per Sept 30, 2019 is done for the year [Oct 1, 2019 - Sept 30, 2020] based on historical data over the last year [Oct 1, 2018 - Sept 30, 2019]
- The FRP 4 Upper limit for the technical interest rate (for local liabilities):
  - The average value of the monthly 10-year government bond yield over this period plus 2.5%
- The forecast for the FRP4 Upper Limit in 2019 complies with their values calculated per Sept 30, 2020 and per Sept 30, 2021
- *The total bandwidth is 90% (between 5- and 95-percentiles) and step is 10%*

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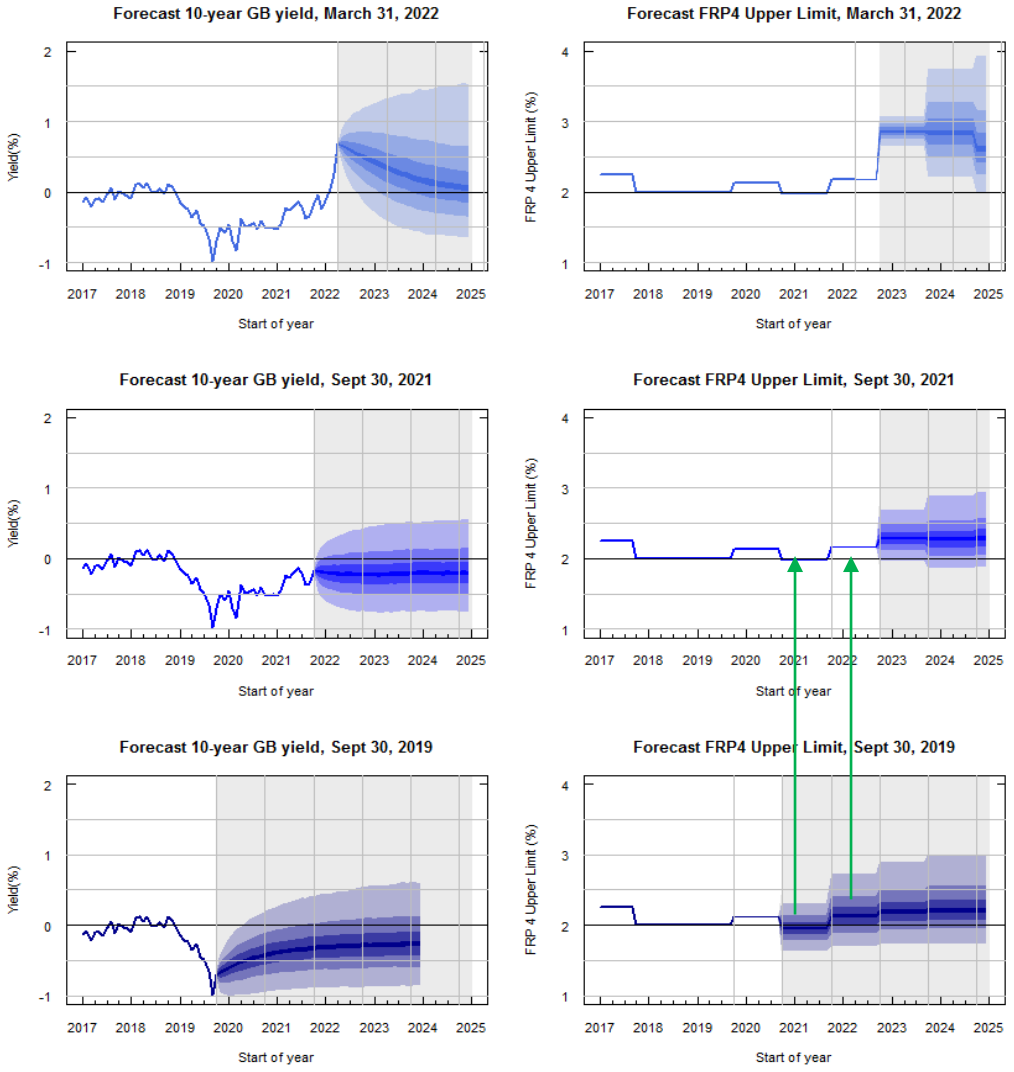

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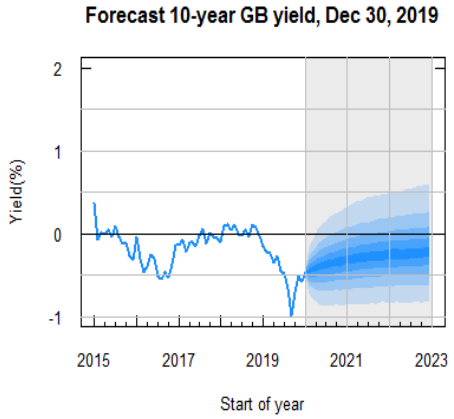
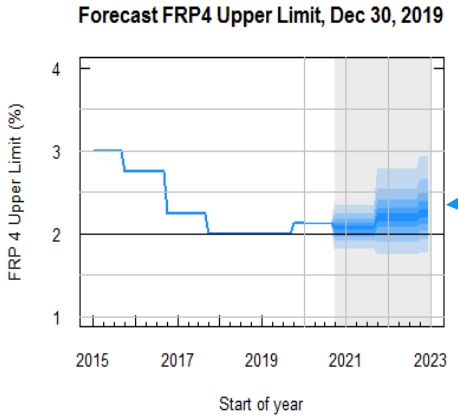
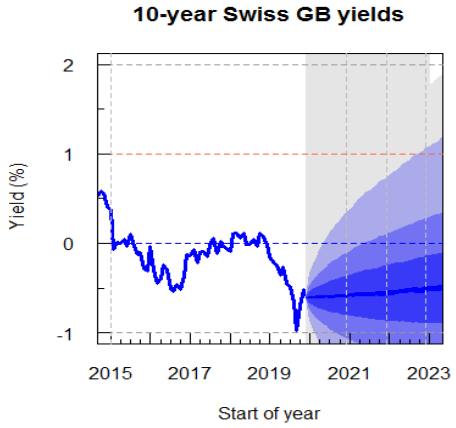
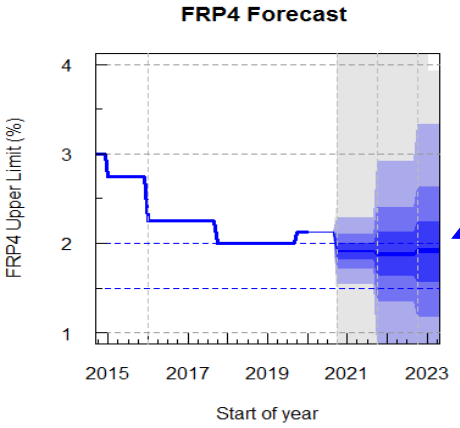
Example: Nested stochastic Liability Forecasting

Comparison: Forecast with NNAR and based on the affine model









- The forecast of the 10-year government bond yield per Dec 30, 2019 (here on figures "Start of year 2020") with two different approaches (NNAR and affine model) based on the same historical data
- The median FRP 4 Upper Limit forecasted based on the NNAR Approach is over 2% and complies with the estimation made per Sept 30, 2020 and per Sept 30, 2021
- The forecast based on the affine model produces higher bandwidth of 10-year government bond yield and that is why much wider bandwidth for the FRP 4 Upper Limit
  - *Our analysis of the forecasting TPR war made based on the affine model and presented in AFIR Paris 2020 Colloquium*

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Impact of Fund membership and its development

Active membership vs. Pensioners

- Modelling of active membership
  - Stochastic simulations of leavers, death and disability cases, retirement and new enters
  - The impact of light growing population (ca. 1.5%) is investigated

- Modelling of pensioner population
  - The pensioner population is open due to the fact that every year new potential retirees, spouses and disabled could enter into the pensioner population
  - Only in case of death all kind of pensioners will quit from the pensioner population
  - Disability annuity is paid up to the retirement age and after the retirement age the disabled will be converted into the retiree state

- Child pensions (orphan, child pension for disabled and child pension for retiree if child younger than 25) will be modelled as a capital payment

Impact of cash flow sign and FR level

Negative cash flows in pension funds with small active membership vs. pensions in payment

- Based on **TPR** definition the level of the funding ratio, **FR**, has an impact on **TPR** depending on the sign of the total cash flow
  - Total Cash Flow = *Cash-Inflow – Cash-Outflow*

- The total cash flow is ***negative***
  - TPR (FR < 100%) > TPR (FR = 100%)
  - TPR (FR > 100%) < TPR (FR = 100%)
  - This is the case of pension funds with a big pensioner liability

- The total cash flow is ***positive***
  - TPR (FR < 100%) < TPR (FR = 100%)
  - TPR (FR > 100%) > TPR (FR = 100%)
  - This is the case of growing pension funds with smaller part of pensioner liability

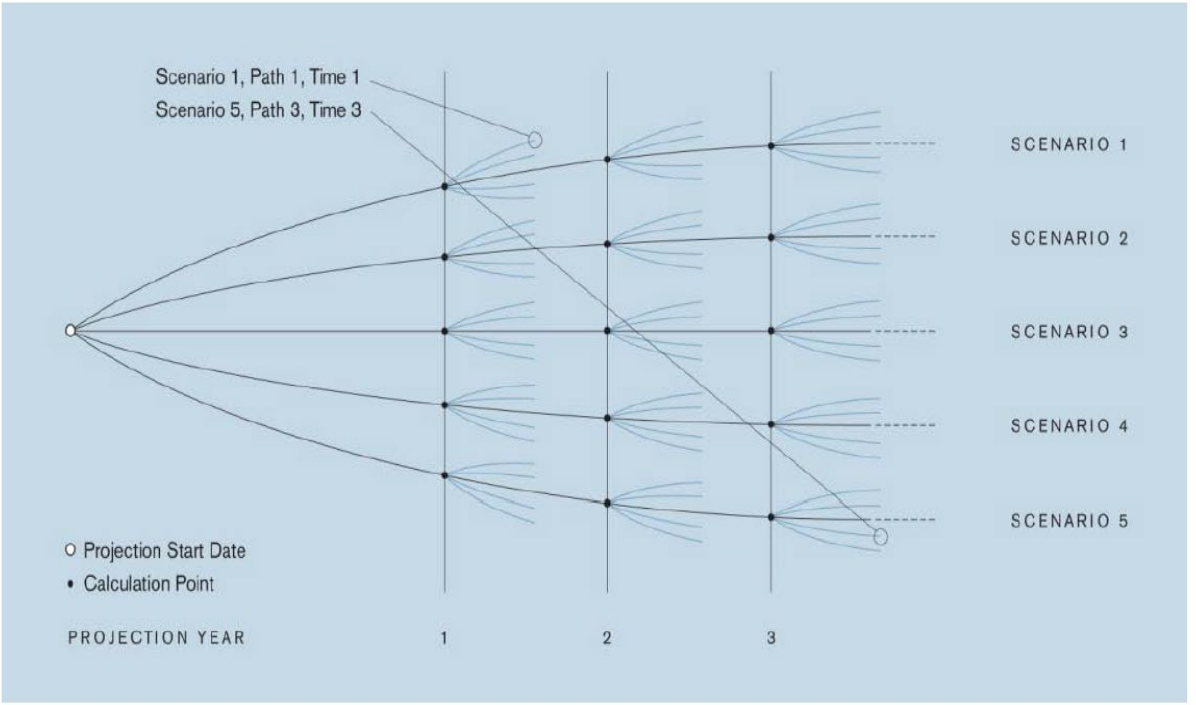
Approach & Results

Nested stochastic simulations of pension fund memberhsip mutations and future discount rates

Liability Stochastic Simulations

Based on Nested Stochastic Projections

- Useful book



Excerpted from "The Future of Capital Modeling," by Pat Renzi, Milliman Insight, Issue 2, 2006.

- Book „Stochastic Modeling: Theory and Reality from an Actuarial Perspective", ISBN 978-0-9813968-2-8, ***www.actuaries.org*** (Milliman)

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General Information on Pension Fund

Membership & plan scope

Information per December 31, 2021	Number	Average age	Liabilities *) (local accounting) CHF Mio.	Average insured salary and Average pensions (in CHF)
Active membership	**814**	**44.3**	**332.4**	**110'750**
Pensioners	**195**	**69.1**	**217.9**	**52'780**

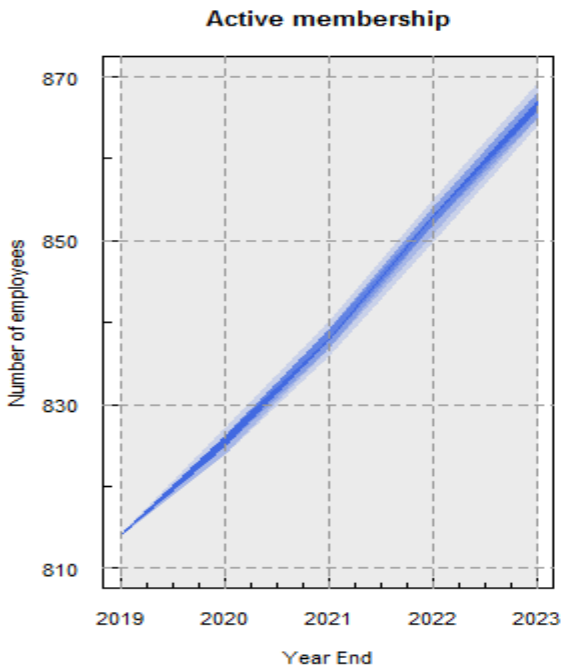
- Open autonomous pension fund with active membership and pensioners
- Cash Balance plan for saving accounts with the guaranteed interest credits of 1%
- The size of this pension fund is middle compared to other Swiss pension funds
- The retirement age is 65 for males and 64 for females
  - At retirement the retirement pension is based on the individual saving account and conversion rate
    - Annual retirement pension = conversion rate * saving account

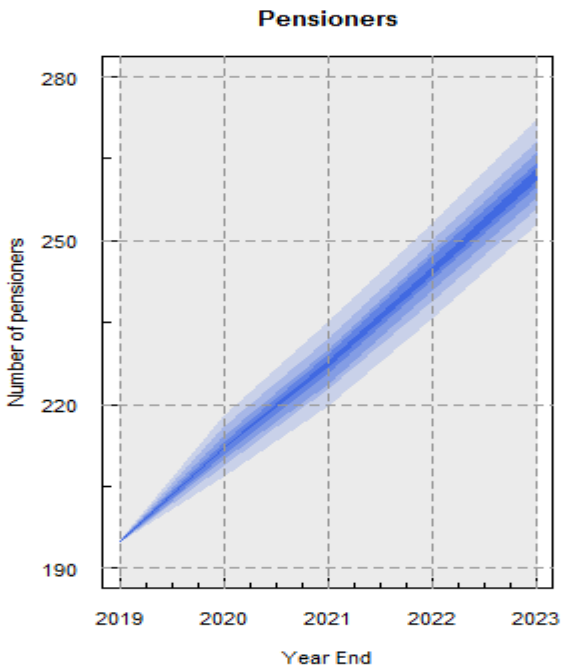
*) Local liabilities for:

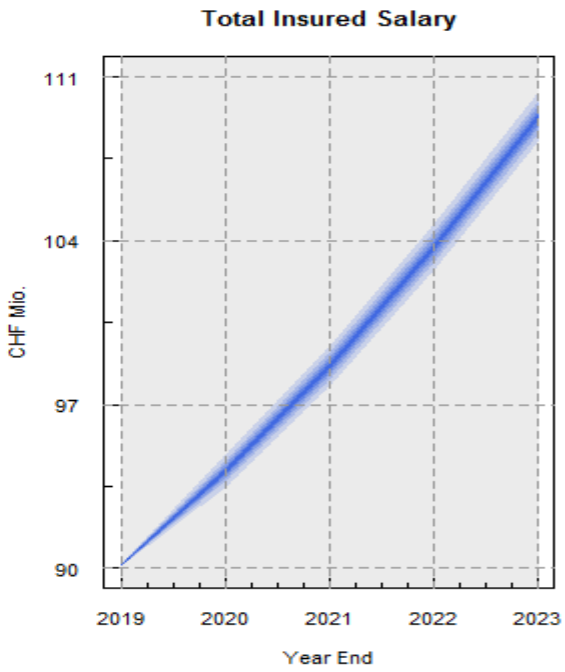
- Active membership – vested benefits (i.e. individual saving accounts);
- for pensioners – the DBO pensions in payment with the local discount rate (1.5%)
  - The local discount rate has an upper limit based on the Guidelines FRP4 (now 2.17%) which depends on the average level of the 10-year government bond yield over the last 12 months (per September 30, 20XX)

Example: Nested stochastic Liability Forecasting

Forecast over the next four years: Starting per Dec 31, 2019







- Per Dec 31, 2019
  - Number of employees 814
  - Number of pensioners 195
- On average over 2019-2023:
  - Number of employees increases by ca. 1.6% per year
  - Number of pensioners increases by ca. 7.5% per year
  - The sum of insured salary increases by ca. 4.9% per year
- Only membership mutations have an impact on the liability forecasting in this study

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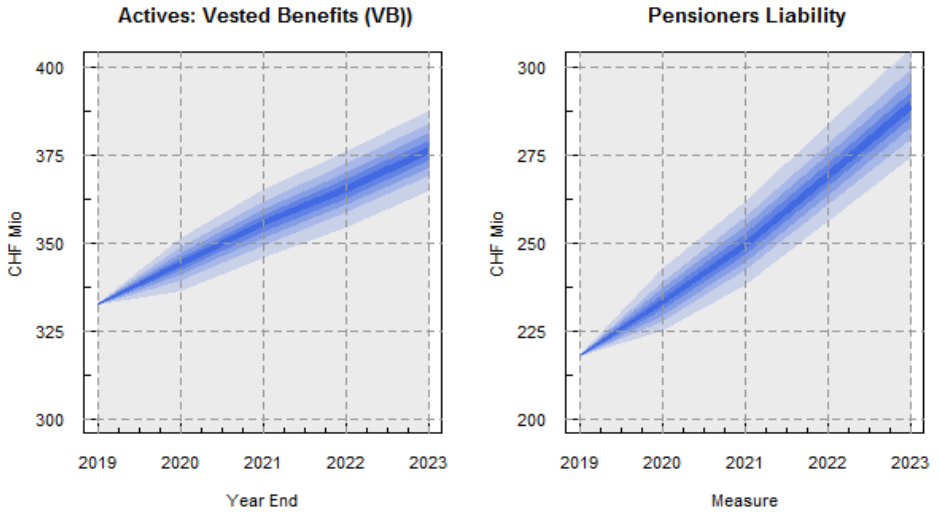
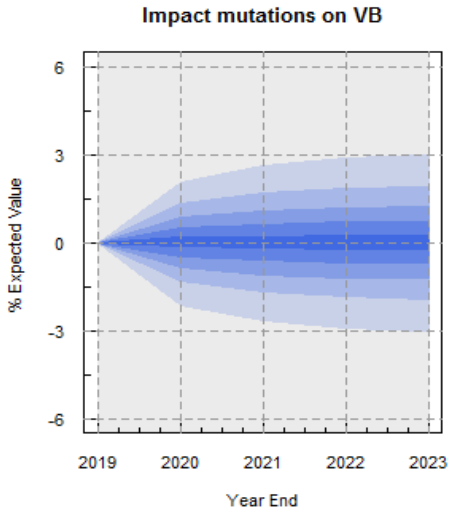
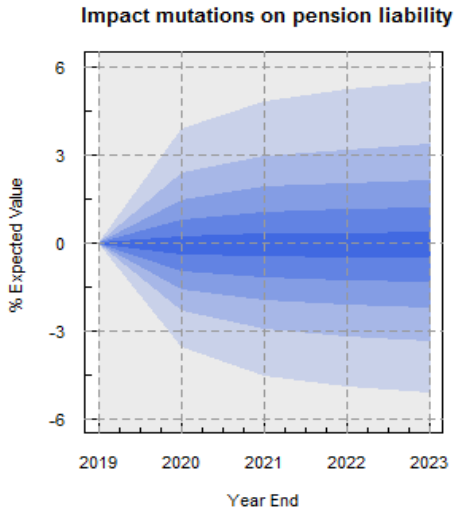
Example: Nested stochastic Liability Forecasting

The Impact of pension fund membership mutations on liabilities







- The vested benefits active membership correspond to the individual saving accounts
  - The level of such accounts has an impact on the future retirement pension level and on DBO
- Pensioners liability is a DBO valuated with the local technical interest rate (here 1.5%) instead of the discount rate in IAS19 (here start value 0.28%)
  - The lower the technical interest rate the stronger the impact of the membership mutations on the liability
- By this simulation
  - The technical interest rate is 1.5% and constant over 2019-2023
  - The interest credit for saving accounts is 1% and constant over 2019-2023
- The total bandwidth is 90% (between 5- and 95- percentiles) and step 10%

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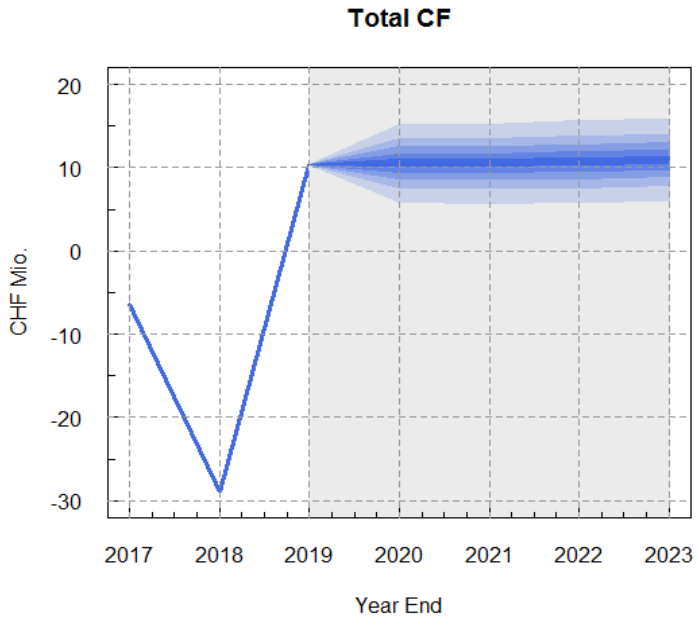
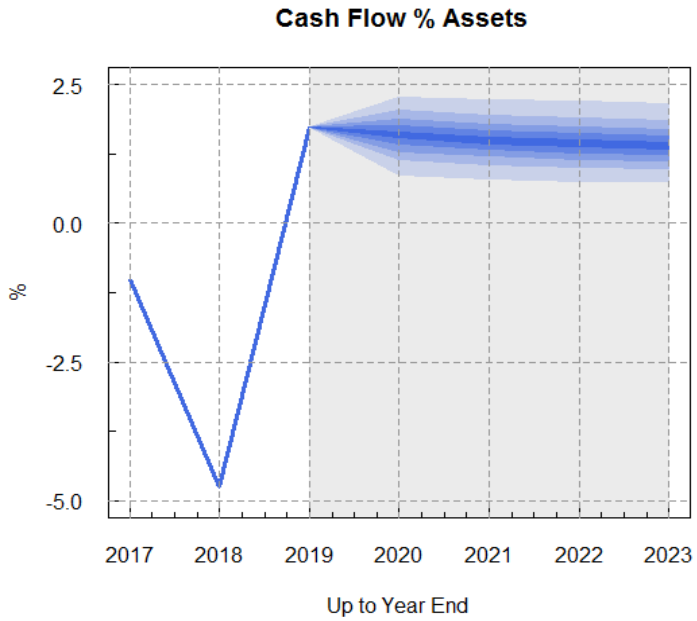
Example: Nested stochastic Liability Forecasting

Development Cash Flow and its historical values





- The total Cash Flow (CF) = Benefits paid in – Benefits paid out + total contributions
- Due to restructuring of business:
  - Many employees over the year 2018 left the firm and new hired employees were younger and with lower vested benefits – that is why the cash flow over 2018 was negative (ca. -5% assets) and very low
  - At the same time per end of 2018 the technical interest rate was reduced from 2.5% to 1.5%
    - ➢ The liability of pensions in payment was increased ca. by 10% and the TPR per Dec 31, 2018 was 5%
- Starting from the end of the year 2019 the active membership will be growing ca. by 1.6%

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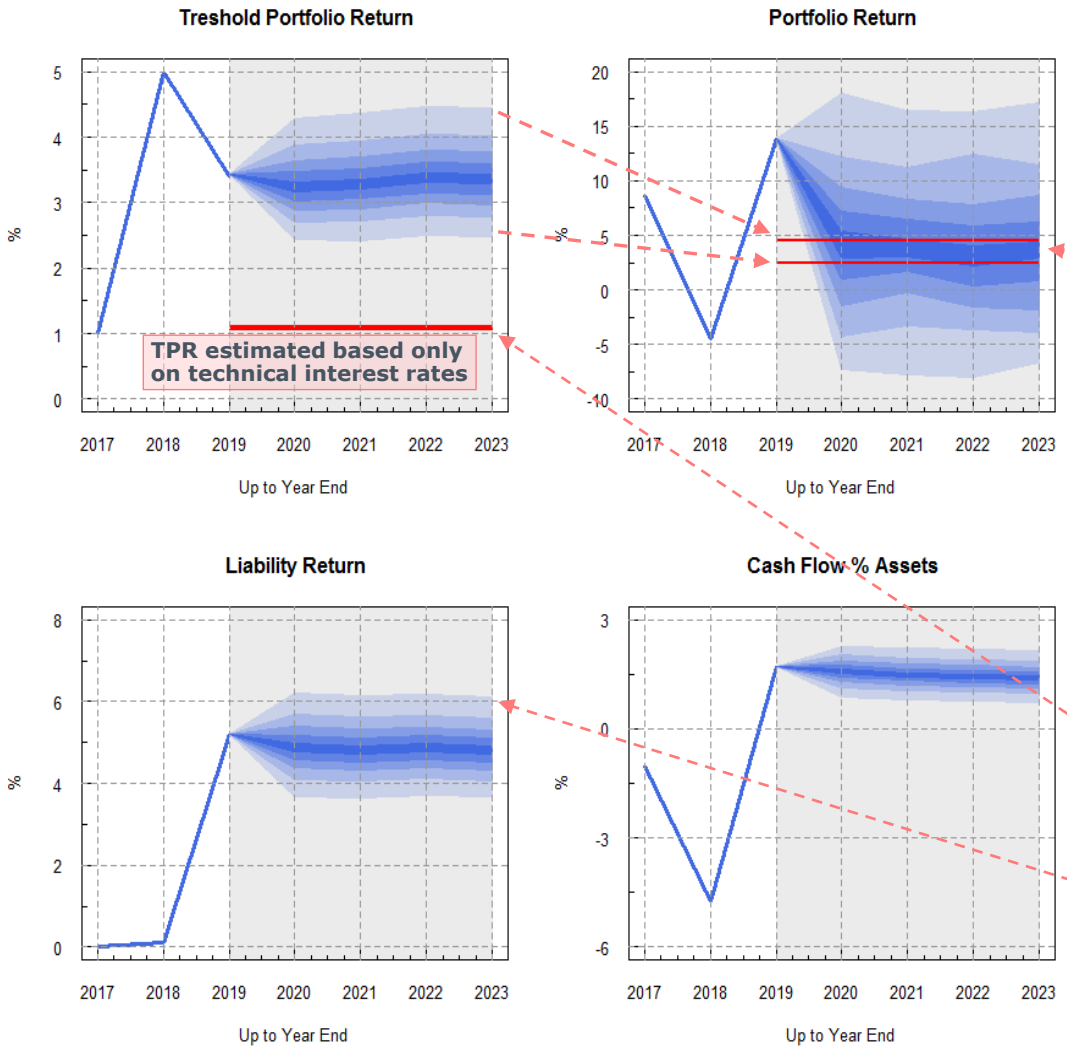
Example: Threshold Portfolio Return - 1

Forecast over the next four years: Starting per Dec 31, 2019



- **Results over period 2020-2023**:
  - The median of the TPR is 3.31% and the expected value 3.35%, StDev = 0.60%
    - ≈ **Liability Return – CF % Assets + … (slide 5)**
  - TPR's bandwidth (5%÷95%) is ca. (**2.5%÷4.5%**)
  - ---
  - The median of portfolio return 3.68% and its expected value 4.0%, StDev = 7.52%
  - Portfolio return bandwidth (5%÷95%) is ca. (-7.5%÷16.5%)
  - ---
  - As a rule the estimate of the TPR by pension fund board of trustees is done based on the technical interest rate (here 1.5%) and the expected interest credits (here 1.0%) plus administration costs
    - here it would be ca. 1.05%-1.1% (red line on TPR figure)
- The highest level (95%) of liability development (Liability Return) of ca. 6.0%

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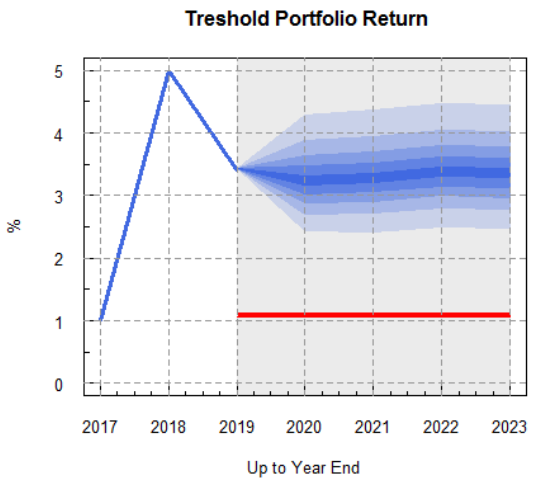
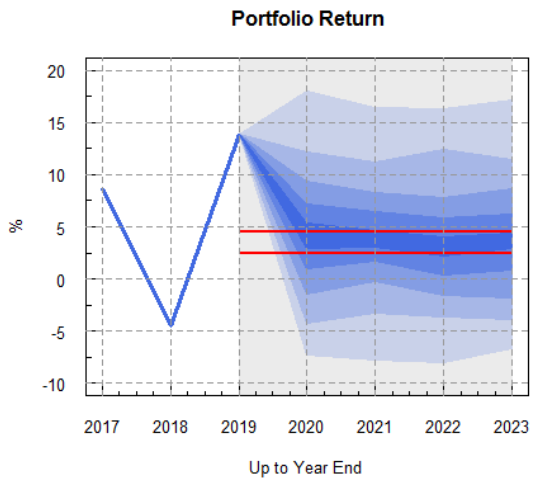
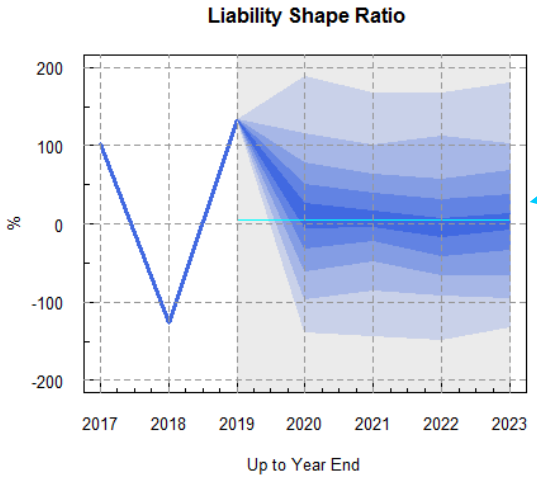
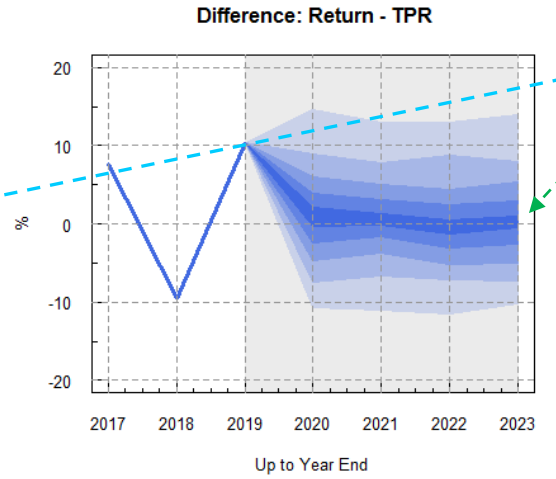
Example: Threshold Portfolio Return - 2

Liability Sharpe Ratio – this parameter helps to estimate financing









- **Liability Sharpe Ratio (LSR)**
  - = **(Portfolio Return – TPR)/σ**
  - **σ** - Portfolio volatility
- The higher the LSR value, the faster the funding ratio grows
  - The median of the difference (Portfolio Return – TPR) over 2020-2023 is **0.33%**
    - i.e. it is positive but small that is why the funding ratio could only slowly grow
  - The portfolio volatility **σ** over 2020-2023 is **7.52%**
  - The median LSR = **4.4%** (i.e. very low)
  - The volatility of the difference (Portfolio Return – TPR) is **7.55%**
    - i.e. slightly higher than **σ**
- **It is useful to reduce the volatility of this difference (Portfolio return – TPR) vs. portfolio volatility**
  - It means the benefits should be improved and additional actuarial provisions increased if the portfolio return would be enough high

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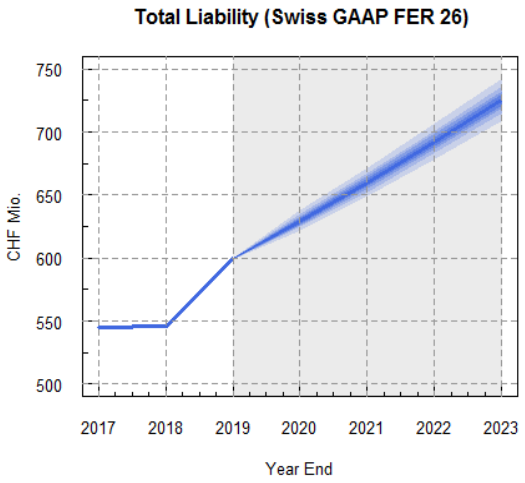
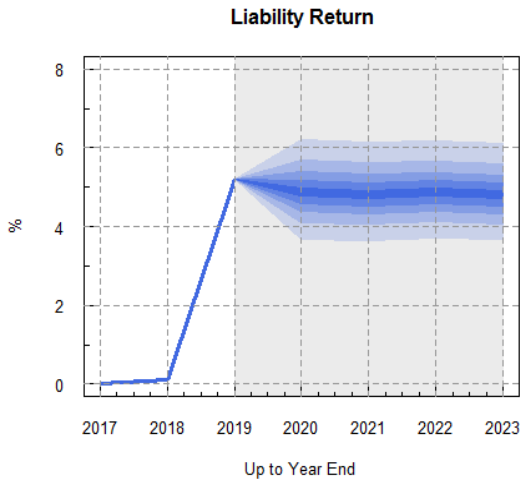
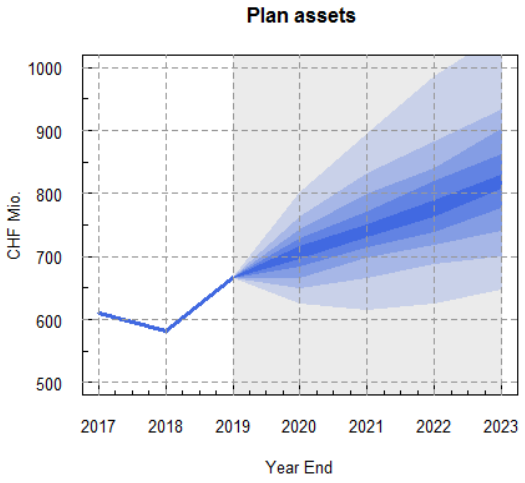
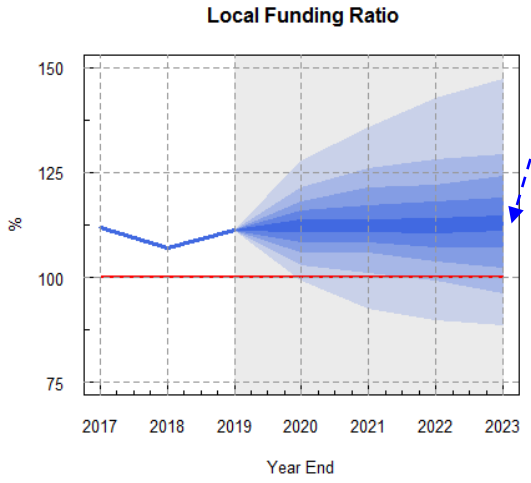
Example: Threshold Portfolio Return - 2

Forecasting funding ratio









- **<u>Results over Period 2020-2023</u>**
  - The Median of Liability Sharpe Ratio 4.4% over 2020-2023
  - **That is why the median of the (local) funding ratio is practically not growing**
- The local funding ratio definition is based on Guidelines Swiss GAAP FER 26
  - The local funding ratio = Plan assets / (Total Liability)
  - The local liability technical interest rate 1.5% and its interest credit 1.0% (of this pension fund)
  - The Liability Return shows the increase rate of the total local liability from year to year
    - ➢ Here on average ca. 5% in the bandwidth of ca. 4%-6%
- *The total bandwidth is 90% (between 5- and 95-percentiles) and step is 10%*

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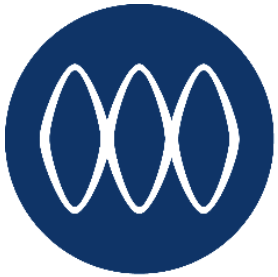
Summary

Value added by this approach

- The nested stochastic projections of liabilities produce more realistic forecast for liability developments and the threshold portfolio return
  - This approach is very important for the stochastic forecasting of the international accounting disclosures (IFRS, US GAAP and IPSAS) as well
- The results are pension fund specific and depend on
  - The size of active membership vs. pensioner population,
  - On development scenarios as well as on the scope of benefit plans
- Modelling liabilities based on nested stochastic approach could be used additionally for reserving and pricing of all types of actuarial products in pension funds and in insurance companies
- The forecast of the potential funding ratio development could be done based on this approach (for liability forecasting) together with the ESG for future portfolio returns



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