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

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Abstract According to the FRP5 Guidelines of the Swiss Chamber of pension fund experts (SKPE) the threshold portfolio return (TPR) corresponds to the annual portfolio return which the pension fund requires to keep the funding ratio constant. The difference between the expected return on assets and the threshold portfolio return plays a key role in determining whether the current benefits can be financed and in establishing and assessing recovery measures in cases of underfunding. The threshold portfolio return for the coming financial year depends mostly on expected interest credits, reserving and benefit policies as well as on the level of the funding ratio at the beginning of the financial year and the level and sign of cashflows. The investment strategy has no impact on the threshold portfolio return for the coming financial year. Over a longer period, it has an impact on the threshold portfolio return because the investment strategy has an impact on the level of funding ratio and future interest credits.

In our forecasting approach, the future threshold portfolio return is determined over several years based on the nested simulation engine for pension fund liabilities. This approach allows a realistic modelling of the pension fund development based on its human resource, benefit and reserving policies. The distribution of the future threshold portfolio return helps to verify the current investment strategy and prove if the current strategy should be adjusted. Based on the threshold portfolio return we developed two new parameters: Liability Sharpe Ratio and Liability Information Ratio that additionally help to prove why the portfolio strategy should be adjusted.

For Swiss pension funds the threshold portfolio return has become one of the most important metrics used in risk management and has a significant impact on the investment strategy.

Keywords Pension fund, threshold portfolio return, Sollrendite, nested stochastic modelling, neural network autoregression, pension fund liabilities, Swiss pension system, risk management, regime-switching model, funding ratio.

1 Introduction

The Swiss social security system is based on three pillars. The first pillar is managed by the government and is the same for all citizens like in other European countries. The second pillar defines the mandatory second pillar pension system (BVG/LPP) with its level of occupational provisions compulsory for all employees. The third pillar is based on private savings. In this publication we focus only on the second pillar and make a deeper insight into a pension fund specific situation in relation to the threshold portfolio return. This key metric is used by all pension funds as a parameter to verify if its asset allocation strategy could finance future statutory benefits and even improve them.

The FRP5 Guidelines of the Swiss Chamber of pension fund experts (SKPE) set out the definition of the threshold portfolio return in the framework of minimum requirements according to the Art. 52e Abs. 1 BVG/LPP. These guidelines explicitly require the pension fund expert to compare the threshold portfolio return with the expected portfolio return and to judge whether the difference is appropriate.

According to FRP5, the threshold portfolio return corresponds to the annual portfolio return which the pension fund requires to keep the funding ratio constant. The threshold portfolio return depends on the rate of change of the total pension fund liabilities (hereafter denoted by Liability Return) and the cash flow over the financial year.

The difference between the expected return on assets and the threshold portfolio return allows one to forecast the potential development of the funding ratio. It therefore plays a key role in determining
whether the current benefits can be financed, as well as in establishing and assessing recovery measures in cases of underfunding.

For this reason, the threshold of portfolio return has become one of the most important key metrics used in risk management for pension funds and has a significant impact on investment strategy.

It is very important to thoroughly forecast the future development of the threshold portfolio return because an overestimated threshold portfolio return can force the pension fund board of trustee to decide on reducing benefits and potentially on increasing the contribution level.

2 Threshold portfolio return

2.1 The second pillar occupational provisions in Switzerland

The majority of pension funds in Switzerland offer higher benefits compared to the mandatory level formulated in the Swiss pension law BVG/LPP and its ordinance. To ensure that the mandatory level of benefits is fully guaranteed for each pension fund member the so called “shadow account” is created and monitored in the pension fund administration system.

Typical Swiss pension plans offer accumulation phase for retirement benefits (retirement annuity and capital) in form of a cash balance plan. Many defined benefit plans for retirement benefits were closed during the last 15 years and converted into a cash balance plan. The reason for this decision were not only reserving costs for pension funds but as well the impact on the employer balance sheet and P&L in international accounting due to very low level of interest rates in Switzerland.

Typical cash balance plans in Switzerland look very similar to define contribution (DC) plans but they are not a DC plan in the Anglo-Saxon sense of the word. Very often in the translation from German to English the definition “DC plan” is used in international accounting for Swiss cash balance plans.

Due to the mandatory level of occupational provisions Swiss cash balance plans should guarantee at least the mandatory BVG/LPP interest credit to mandatory vested benefits and could grant a zero-interest credit to the over-mandatory vested benefits (i.e. saving account). Negative interest credits cannot be done even if the portfolio performance was deeply negative. The current guaranteed rate of interest amounts to 1%. The pension fund board of trustees decide each year based on the funding ratio and the earned portfolio return which interest credit should be credited. If an employee leaves the company and starts working in another firm the vested benefits should be transferred to the pension fund of his/her new employer.

The annuity at retirement is defined based on the individual vested benefits multiplied by a conversion ratio stipulated in the plan rules. In this case there is a mandatory level of retirement annuity as well based on the mandatory BVG/LPP conversion ratio (6.8% at age 65/64 for male and female) applied to the mandatory vested benefits at retirement. The majority of pension funds have a part of their mandatory BVG/LPP vested benefits on the level of 40%-70% of the total vested benefits. If in an individual case the plan rule retirement annuity is smaller than the mandatory level of retirement annuity then the pension fund should pay the annuity of the mandatory level.

Due to the fact that the interest rates are very low now in Switzerland and the plan rule conversion ratio cannot be spontaneously reduced the so-called pension losses arise because normally the vested benefits at retirement are not sufficient to finance the retirement annuity and this difference if financed by the pension fund.

The reserving process for Swiss pension funds is formulated in a Guidance FRP 5 of the Swiss Chamber of pension fund experts (SKPE). Additionally, to the vested benefits and the net pensioner liability additional actuarial provisions should be set up to cover pension fund specific actuarial risks. One of these provisions is an actuarial provision to mitigate the pension losses as a rule for active membership older than 50 or 55 (i.e. 15 or 10 years before retirement).

The plan rules for additional actuarial provisions describe all necessary pension fund specific actuarial provisions as well as the approach of their setting.
The benefits in case of death and disability could be arranged in form of a defined benefit plan, i.e. the level of these benefits depends on the insured salary. The mandatory benefits in case of death and disability are calculated based on the projected vested benefits up to the retirement timepoint without future interest credits (or with zero interest credits).

As a rule, the so-called risk profits arise in such cases due to the fact that the pension plan risk contributions are sufficient. To avoid any big risk losses in case of death and disability the risk fluctuation reserve should be set up with the probability at least 99%.

2.2 Factors which affect the threshold portfolio return

The threshold portfolio return reflects the costs of occupational provisions which are not financed via contributions: for example, interest credits and discount rates.

The following factors affect the pension fund’s specific threshold portfolio return and the extent of their impacts is very pension fund specific:

- Interest credit to vested benefit saving accounts,
- Discount rate or technical interest rate for pensioner liabilities provisions,
- Annual increase or decrease of additional actuarial provisions based on their definition in the plan rules,
- Plan amendment or change in provision parameters: e.g. decrease in technical interest rate or decrease in conversion rate,
- Actuarial gains and losses (gains reduce the threshold portfolio return and losses increase it)
- Administration costs (small and medium pension funds might be affected by this item, for large pension funds the impact of this part is not significant)

Since the components of the threshold portfolio return are differently affected by macroeconomic parameters, the analysis presented below in this article is very useful for risk budgeting purposes and supports the pension fund board in developing optimization strategies. This is due to the fact that the future development of the funding ratio depends on the difference between the expected portfolio return and the threshold portfolio return.

2.3 Legal requirements which could affect the threshold portfolio return

The FRP 4 Guidelines of the Swiss Chamber of Pension fund experts (SKPE) set up rules for the upper limit of the technical interest rate (discount rate):

- the average value of monthly 10-year government bond yields over the last 12 months measured at September 30 plus 2.5%; the maximum value of the upper limit is 4.5%.
- The upper limit FRP 4 is up-dated every year at the end of September and is valid for a year and especially for the local actuarial valuation per December 31.
- For example, the upper limit FRP 4 valuated per September 30, 2021 amounts to 2.17% and this upper limit holds from October 1, 2021 to September 30, 2022. Swiss pension funds use generational and periodical mortality tables. In case of periodical tables, the upper limit should be additionally reduced by 0.3%. The upper limit 2.17% per September 30, 2021 is valid for generational mortality tables and for pension funds with periodical tables it is 1.87%.

Figure 1 shows the historical development and forecast for the upper limit FRP 4 based on the Swiss 10-year government bond yield per September 30, 2019 and per September 30, 2021.
Figure 1. The historical development of Swiss 10-year government bond yield ("10-year GB yield") and the upper level of the technical interest rate ("Forecast FRP4 Upper Limit") according to FRP 4 Guidelines. The bandwidths are 30%, 60% and 90% and the median is shown between percentiles [48%,52%]. The forecasts of the 10-year government bond yield and the FRP4 Upper Limit per September 30, 2019 comply very well with the historical development of these key metrics between September 30, 2019 and September 30, 2021. The median of FRP 4 Upper Limit per September 30, 2022 is 2.25%. The approach used for the forecast of the 10-year government bond yield is NNAR (neural network autoregression).

Due to the very strong increase of the Swiss 10-year government bond yield since January 2022 the forecast based on the data per March 31, 2022 was done as well.
Figure 2. The forecast of the 10-year GB yield is based on historical data over the period [January 31, 1988 to March 31, 2022]. The forecast of FRP4 Upper Limit per March 31, 2022 uses historical values of the 10-year government bond yield over the period [October 1, 2021 to March 31, 2022] and the stochastically forecasted 10-year government bond yield for the period [April 1, 2022 to September 30, 2022] to determine the FRP4 Upper Limit per September 30, 2022. The median of FRP 4 Upper Limit per September 30, 2022 is 2.9% based on the yield data up the end of March 2022.

According to the FRP4 Guideline pension funds should do their reserving for pensions in payment with technical interest rates lower than the FRP4 Upper Limit. If the FRP 4 Upper Limit is increasing the regulatory authority advises pension funds not to increase their technical interest rates and keep them on the low level. However, in case of international accounting the adjustment of discount rates should be applied immediately.

Many pension funds reduced their technical interest rates in advance based on the strongly sinking FRP 4 Upper Limit over 2012-2019. Now the typical interest rate is between 1.0% and 1.5%, i.e. substantially lower compared to the Upper Limit 2.17% per September 30, 2021 and the expected value per September 30, 2022 (2.9%).

The very low level of technical interest rate as soon as it sufficiently financed helps to keep the threshold portfolio return (TPR) on very low level as well.

2.4 The formula used to define the threshold portfolio return according to Guidelines FRP 5

The formula to calculate the threshold portfolio return is shown below based on the definition in FRP 5 Guidelines of Swiss Chamber of Pension Fund Experts (SKPE):

\[
R_{TPR} = \frac{R^L - CF\%A}{1 + 0.5 \times CF\%A},
\]

Where \( R_{TPR} \) is the threshold portfolio return, \( R^L \) – liability return, \( CF \) – total cash flows, \( CF\%A \) – total cash flows in % of assets under management at the beginning of the year.

The liability return, \( R^L \), is the rate of change of the total liability value between two measurement dates (for example, \( V_1 \) per December 31, 2020 and \( V_2 \) per December 31, 2021, then \( R^L = V_2 / V_1 - 1 \)). The total liability value includes the liability for active membership, for pensioners and additional actuarial provisions based on the plan rules, reserving parameters and actuarial bases. If the total cash flow is zero than the TPR is equal to the liability return. The positive (negative) cash flow reduces (increases) the TPR compared to the liability return.

The funding ratio (here per December 31, 2020) \( FR_1 = A/V_1 \), the funding ratio \( FR_2 \) (here per December 31, 2021) should be the same as \( FR_1 \) based on the definition of the TPR to calculate the TPR for the year 2021. The corresponding asset value of \( FR_2 \) is \( A^*(1+R_{TPR}) + CF^*(1 + 0.5 \times R_{TPR}) \), based on the typical assumption that the total cash flow is paid in the middle of the year.

Taking into account that many payments are monthly like contributions and annuities this assumption is reasonable especially for big pension funds. In a small pension fund, it could happen that a person with a big vested benefit leaves the pension fund and the weighted total cash flow will be not positioned in the middle of the year but skewed to the month of the paid-out of this vested benefit. Analysis of historical threshold portfolio returns based on the local pension fund financial statements can help to verify if such cases are regular to improve the forecasting.

Based on this definition of the threshold portfolio return and assumptions that the total cash flow in % of assets under management, the difference between the portfolio performance and the threshold portfolio return as well as the liability return are not very big (ca. below 10%), then the rule of thumb used by Swiss pension fund board of trustees works:

\[
FR_2 = FR_1 \times (1 + R - R_{TPR}) + \cdots
\]
Many pension fund trustees simply say that the increase of the funding ratio corresponds to the positive difference between the portfolio performance, $R$, and the threshold portfolio return, $R_{TPR}$. If this difference is negative, then the funding ratio decreases:

$$FR_2 - FR_1 \cong FR_1 \cdot (R - R_{TPR})$$  \hspace{1cm} (3)$$

It means that if the funding ratio $FR_1$ is close to 100% then the funding ratio $FR_2$ will be increased or decreased by the difference between the portfolio return and the threshold portfolio return. If the funding ratio $FR_1$ is higher than 100% (lower than 100%) the impact of the difference between the portfolio return and the threshold portfolio return will be increased (decreased).

The total cash flow $CF = \text{cash inflow} - \text{cash outflow}$. In a pension fund the cash inflow consists of all types of contributions paid by employees and the plan sponsor, vested benefits transferred by new entrants, voluntary purchases of service years made by employees and back-payments due to divorces and other cases.

The cash outflow consists of vested benefits paid out/transferred with leavers; other benefits like annuities, death or disability capital as well as capital payments at retirement etc. Additionally, cash outflow includes the administration costs and different payments to the third parties like consultants, auditor and insurance premiums for pension fund insurance contracts (like stop loss contract).

To produce any forecasts for the future threshold portfolio return it is necessary to project liabilities and cash flows over future years. Taking into account that normally a pension fund is an open pension fund and the structure of active membership as well as the development of active membership population depends on the HR-policy of the employer firm it is necessary to implement active membership development strategies. The pensioner population is an open population as well because new entrants into pensioner population every year are new retirees, disabled and spouses (only from the pension fund).

3 Stochastic approach to project liabilities

3.1 Nested simulation engine


The implementation of this approach is made by us for each person (active membership and pensioners in the sample pension fund) and the results are aggregated. The total number of scenarios is 80'000 realistically implemented for mutations and turnovers.

To understand the impact of different parameters on stochastic simulated membership and their liabilities at the first step only the mutations in the pension fund population will be implemented, i.e. leaving with transferred vested benefits to an external pension fund; death and disability cases with corresponding benefits based on the plan rules; retirement with annuity and capital payments depending on decisions. The pension fund leavers will be exchanged with new entrants based on scenarios for head counts of employees (it depends on the firm specific HR-policy).

The reason for this is the habit of estimating the threshold portfolio return as a constant for the future period based on a simple approach. In many cases this estimate is not sufficient and cannot reflect the real development. Our analysis will show the difference between the threshold portfolio return estimated based on this simple approach and based on stochastic simulations of membership, their liabilities and cash flows.

3.2 Sample Pension Fund
The sample pension fund (hereafter PF) is a medium pension fund in Switzerland and has a relatively small pensioner population (24% of active membership) with substantial level of their reserves (65.4% of the total active membership liability) due to the technical interest rate 1.5%. In Switzerland is not possible now to make a “buy-out” for pensions in payment (“buy-in” it was never possible).

<table>
<thead>
<tr>
<th>December 31, 2019</th>
<th>Membership</th>
<th>Average age</th>
<th>Liabilities CHF Mio.</th>
<th>Average Insured Salary Average Annuity (in CHF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active membership</td>
<td>814</td>
<td>44.3</td>
<td>332.4</td>
<td>110'750</td>
</tr>
<tr>
<td>Pensioners</td>
<td>195</td>
<td>69.1</td>
<td>217.9</td>
<td>52'780</td>
</tr>
</tbody>
</table>

The sample pension fund is a cash balance plan. Each active member has an individual saving account with a guaranteed interest credit (there is a mandatory level, now 1%, for the mandatory saving capital). As a rule, all individual saving accounts have more money compared to the mandatory level and pension funds try to guarantee the mandatory interest credit for the whole saving account. In this sample pension fund the interest credit is 1% and the technical interest rate for reserving pensioner liabilities is 1.5%. As a rule, the interest credit could be increased if the funding ratio is higher than ca. 110%-115% – such decisions are made annually by members of the board of trustees.

The pension annuity is long-life and its value corresponds to the saving capital at retirement multiplied by the conversion ratio (here 5.8%). Normally, depending on the technical interest rate and actuarial basis used for reserving the so-called pension losses could arise. For example, the conversion ratio 5.8% was produced based on actuarial basis tables BVG2015 (used per December 31, 2019) with technical interest rate 3.15% for females and 3.30% for males. If the technical interest rate is lower (like here 1.5%) then the pension losses are not small (here ca. 26%-29% based on the saving capital at retirement which converted into retirement pension) and they are financed by the pension fund. Such losses increase the TPR. The forecasting over the next four years starts on December 31, 2019. The HR-policy planned that the active membership would be increasing by ca. 1.6% and the insured salary on average per person would be growing by ca. 3.0% per annum. Due to restructuring of business, many employees over the year 2018 left the employer 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 – Figure 4.

### 3.3 Simulation of pension fund population and their liabilities

The development of active membership, pensioner population and the aggregated insured salary of the pension fund PF is shown below.
Figure 3. The head count of active membership is growing by ca. 1.6%, the pensioner population is growing by ca. 7.5% and the insured salary sum by ca. 4.9% on average per annum. The strong salary increase for the whole active membership is due to the growing active membership as well. Only mutations and turnovers are implemented with nested stochastic simulation engine to understand their impact on results. The total bandwidth of simulated results is 90% (between 5- and 95- percentiles) with the step 15%, i.e. the widths depending on the colour intensity are 30%, 60% and 90%.

The impact of mutations on liabilities of active membership (vested benefits) and the total pensioner liability is shown below (Figure 4).

![Graphs showing the impact of mutations on liabilities](image)

Figure 4. The impact of pension fund membership mutations on the corresponding liabilities are shown at lower level. The pensioner population is smaller than the active membership that is why the bandwidth of the stochastic simulated pension liabilities is wider compared to the vested benefits of active membership. The total bandwidth of simulated results is 90% (between 5- and 95- percentiles) with the step 15%, i.e. the widths depending on the colour intensity are 30%, 60% and 90%.

The forecast of liabilities as well as assets needs the forecast of total cash flow.
Figure 5. The total cash flow (Total CF) forecast starts per December 31, 2019 and is over four years, i.e. up to December 31, 2023 (shown in the grey area). The historical development of the cash flow over the last two years (between December 2017 up to December 2019) is shown in the white area.

Below Figure 6 presents the forecast of the total liability FER 26, the liability return, $R_L$, plan assets as well as the local funding ratio (based on Swiss GAAP FER 26).

The asset allocation of the sample pension fund corresponds to the Pictet Index 2015 40 (50% bonds, 40% equities, 5% Swiss real estate and 5% hedge funds). The forecast of portfolio return is prepared with a regime-switching model by our consulting firm allea Ltd.

The funding ratio is equal to the asset value per end of the year divided by the total liability. It is necessary to keep the funding ratio higher than 100%.
Figure 6. Total Liability (Swiss GAAP FER 26) is the total local liability value of the pension fund (based on accounting guidelines Swiss GAAP FER 26). Here Liability FER 26 is the sum of the vested benefits, pensioners liability and additional actuarial provisions. The liability return, $R$, represents a change rate of the total liability over each year and has a strong impact on the TPR. The median of the liability return has a level of ca. 5.0%. The funding ratio per December 31, 2019 111% and its median remains approximately on this level over the next four years. The underfunding is possible at the end of the year 2020 (the percentile 5% is on the level 100%), at the end of the year 2023 the probability of underfunding is ca. 20%.

3.4 Threshold Portfolio Return and the Liability Sharpe Ratio

The development of the funding ratio could be explained based on the forecast of the TPR and its components. The median of the liability return is ca. 5.0% (Figure 6). The total cash flow value in percent of assets (Cash Flow % Assets Figure 5) is necessary to evaluate the threshold portfolio return. The total cash flow of the sample pension fund is positive and its median value (% of assets) per December 31, 2019 ca. 1.7%. Over the next four years it is slightly decreasing to ca. 1.3%.

Below is the forecast of the TPR and the portfolio return over four years together with their historical value (Figure 7).

![Figure 7](image)

Figure 7. The median of the Threshold Portfolio Return (TPR) is slightly below 3.5% and its bandwidth between 2.5% and 4.5% (i.e. between 5% and 95% percentiles). The cyan line on the figure TPR (lefts) shows the estimate of the TPR based on the simply approach (interest credits and technical interest rates without any impact of membership mutations and pension fund development). Compared to the portfolio return (rights) the bandwidth of the TPR is shown with two cyan lines.

The TPR per Dec 31, 2018 was 5% because per end of 2018 the technical interest rate was reduced from 2.5% to 1.5% and additionally due to restructuring the total cash flow was negative (Figure 5). Taking into account that the level and bandwidth of the TPR forecasted over four years corresponds to the median level of the forecasted portfolio return, the growth of the funding ratio based on the median values is around zero.

The Liability Sharpe Ratio, LSR, as a parameter is equal to the difference between portfolio return and TPR divided by the portfolio volatility. Figure 8 shows the forecast of LSR and the difference between the portfolio return and the TPR.
The median of the Liability Sharpe Ratio (LSR) is over level 0%. It means that no increase of the median funding ratio could be expected. The bandwidth of the LSR is between [-150%, 150%], i.e. ±1.5 σ, portfolio volatility. The median of the difference between the portfolio return and the TPR is on the level 0%.

The LSR is very useful for benchmarking studies with other pension funds. It helps to compare the difference between the portfolio return and the TPR divided by the portfolio volatility. The higher the LSR the stronger the funding ratio could be increased. Due to the fact that the mean value of the LSR is on the level 0% (Figure 8), the median of the funding ratio (Figure 6) cannot increase.

5 Summary results

The realistic forecast of the threshold portfolio returns and the funding ratio development needs the nested simulation engine for the liability forecasting, an ESG model for the portfolio return forecast as well as the stochastic forecast of Swiss 10-year government bond yield to verify the FRP 4 Upper Limit for technical interest rates.

The forecast of the FRP 4 Upper Limit for technical interest rate is very important for the forecasting of the threshold portfolio return because the decrease of the Upper Limit has a very strong impact on the total liability and on the liability return. The forecast of the FRP 4 Upper Limit is based on the forecast of Swiss 10-year government bond yield (Figure 1 and Figure 2) prepared with the NNAR approach (Neural Network Autoregression). This approach is useful for the forecasting 10-year government bond yields. The situation over the first four months in the year 2022 is very difficult to forecast in advance. That is why it is worth verifying the forecasting monthly and quarterly.

Based on our forecasting of the FRP 4 Upper Limit it was clear that in the coming four years it is not expected that the Upper Limit could be strongly reduced. Due to the fact that the technical interest rate of the sample pension fund (1.5%) was lower than the Upper Limit (starting from December 31, 2019) it was not necessary in our forecasting of the threshold portfolio return to implement a potential decrease of the technical interest rate.

The threshold portfolio return analysis prepared based on stochastic simulations of pension fund membership, their liabilities and cash flows for the sample pension fund shows that:

- The bandwidth of the threshold portfolio return depends on the pension fund membership, their pension fund specific development and the art of mutations;
- The bigger the membership the smaller is the bandwidth of the threshold portfolio return (Figure 4); The bandwidth of pensioner liabilities is normally wider than the band width of vested benefits compared to their expected value;
- The simple approach (Figure 7, cyan line) used by pension fund trustees to estimate the future threshold portfolio return underestimates the potential threshold portfolio return values and is substantially below the median.
The parameter Liability Sharpe Ratio, LSR, determined based on the difference between the portfolio return and the threshold portfolio return divided by the portfolio volatility is very useful to understand if and how fast the funding ratio could be increased.

The development of the threshold portfolio return is very specific to each pension fund and depends on many factors. For this reason, it is not possible to apply the results presented above to other pension funds without analysis of their specific situations.