Optimizing Participating Life Insurance Product Designs for both, Policyholders and Insurers, under Risk Based Solvency Frameworks

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Motivation

- **Participating life insurance products** play a major role in old-age provision.

- **Key problem**: significant financial risk due to cliquet-style guarantees
  - impact of low interest rates and volatile asset returns
  - market-consistent valuation
  - capital requirements under risk based solvency frameworks (e.g. **Solvency II**)

- Reuss et al. (2014) “Participating Life Insurance Contracts under Risk Based Solvency Frameworks: How to increase **Capital Efficiency** by Product Design”
  - proposed **product modifications** significantly **enhance** “**Capital Efficiency**”
  - reduce the insurer’s risk and increase profitability

**Focus of this presentation**: optimized designs for insurers and policyholders by
1. adjustment of the strategic asset allocation, or
2. additional participation of policyholders in benefits from **reduced capital requirements**
Considered products
3 product designs

- **Considered products** with identical **guaranteed benefit** $G$ at maturity:
  - annual premium payments (based on a constant interest rate $i = 1.75\%$)
  - **prospective actuarial reserves** for guaranteed benefit $G$ (also based on $i = 1.75\%$)
  - **yearly surplus** (e.g. 90% of book value returns), credited to a bonus reserve
  - (policyholder’s) **account value** consisting of **actuarial reserve** and **bonus reserve**

- Products come with the **same guarantee at maturity**, but **different year-to-year guarantee**:
  - **Traditional product**: $i = 1.75\%$ is also a **year-to-year minimum guaranteed interest rate** (cliquet-style guarantee)
    - at least this rate has to be earned each year on the assets backing the account value
  - **Alternative I product**: **year-to-year minimum guaranteed interest rate** $= 0\%$
    - only guarantee that account value cannot decrease
  - **Alternative II product**: no additional guarantee on the account value

- For the **alternative** products: minimum required yield can be **lower than $i = 1.75\%$** (in case of previously earned surpluses)
- Reuss et al. (2014) show that the **modified products** c.p. result in a **significantly reduced risk** and hence capital requirement from an insurer’s perspective
Stochastic modeling and key questions

The financial market model

- Insurer’s assets are invested in a portfolio consisting of **stocks** and **coupon bonds**.
- Short rate process follows a classical Vasicek model, stock market index follows a geometric Brownian motion.
- Risk-neutral (\(\mathbb{Q}\)) valuation framework and real-world (\(\mathbb{P}\)) projections.

<table>
<thead>
<tr>
<th></th>
<th>risk-neutral ((\mathbb{Q}))</th>
<th>real-world ((\mathbb{P}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>short rate process</td>
<td>(dr_t = \kappa (\theta - r_t)dt + \sigma_r dW_t^{(1)})</td>
<td>(dr_t = \kappa (\theta^* - r_t)dt + \sigma_r dW_t^{* (1)}); (\theta^* = \theta + \lambda \frac{\sigma_r}{\kappa})</td>
</tr>
<tr>
<td>stock market process</td>
<td>(\frac{ds_t}{s_t} = r_t dt + \rho \sigma_s dW_t^{(1)} + \sqrt{1 - \rho^2} \sigma_s dW_t^{(2)})</td>
<td>(\frac{ds_t}{s_t} = \mu dt + \rho \sigma_s dW_t^{* (1)} + \sqrt{1 - \rho^2} \sigma_s dW_t^{* (2)})</td>
</tr>
</tbody>
</table>

- Bank account given by \(B_t = \exp \left( \int_0^t r_u du \right)\), and used for investment of cash flows during the year.
- analyses using **Monte Carlo methods**
- parameter values:

<table>
<thead>
<tr>
<th></th>
<th>(r_0)</th>
<th>(\theta)</th>
<th>(\kappa)</th>
<th>(\sigma_r)</th>
<th>(\sigma_s)</th>
<th>(\rho)</th>
<th>(\lambda)</th>
<th>(\mu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values</td>
<td>2.5%</td>
<td>3.0%</td>
<td>30.0%</td>
<td>2.0%</td>
<td>20.0%</td>
<td>15.0%</td>
<td>-23.0%</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

- (Source of parameters: Graf et al. [2011]; \(r_0, \theta, \mu\) modified to take into account interest rate level)
Stochastic modeling and key questions
The asset-liability model

- simplified balance sheet:

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>book value of stocks $BV_t^S$</td>
<td>shareholders’ profit or loss $X_t$</td>
</tr>
<tr>
<td>book value of coupon bonds $BV_t^B$</td>
<td>sum of actuarial and bonus reserves $AV_t$</td>
</tr>
</tbody>
</table>

- **book-value accounting rules** following German GAAP are applied.

- **rebalancing** strategy with a **constant equity ratio** $q$

- **portion of total asset return credited to the policyholders**: participation rate $p$
  - surplus distribution such that total yield is the same for all policyholders
  - but at least the required yield

- further management rules regarding asset allocation (reinvestment, rebalancing) and handling of **unrealized gains or losses** etc.

- projection of sample book of business over **20 years**
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Key questions and results

Key question 1

The **objective** of the present paper is to **share** the **insurer's benefits** from the alternative product designs **with the policyholders**.

1. In a **first** step, we consider the following question: How can the **alternative products be designed** to achieve the **same profitability** (“iso-profit”) as for a traditional portfolio in a base case?

- **Profit measure**: Present Value of Future Profits: 
  \[
  PVFP = \frac{1}{N} \sum_{n=1}^{N} \sum_{t=1}^{T} \frac{X_t^{(n)}}{B_t^{(n)}} = \frac{1}{N} \sum_{n=1}^{N} PVFP^{(n)} \]

  \(X_t^{(n)}, B_t^{(n)}, PVFP^{(n)}\) the realizations of \(X_t, B_t, PVFP\) in scenario \(n\)

- **variables**:
  - policyholders’ profit participation rate \(p\)
  - equity ratio \(q\)

- **Starting point** is the profitability of the traditional product in the **base case**, i.e. a \(PVFP\) of \(3.62\%\) with participation rate \(p = 90\%\) and equity ratio \(q = 5\%\)
Key questions and results

Iso-profit curves

For all products, with an increasing stock ratio the participation rate has to be reduced to preserve a constant PVFP of 3.62%.

The alternative products allow for a much higher stock ratio with the same participation rate for policyholders and the same PVFP for the insurer; more pronounced effect for alternative II.
Key questions and results

Key question 2

2. In a **second** step, we only look at product designs that result in the **same PVFP** of 3.62%, and analyze the **insurer’s risk** resulting from these iso-profit products. We focus on market risk and use the insurer’s **Solvency Capital Requirement** as a **measure**.

- **Solvency Capital Requirement for market risk** ($SCR_{mkt}$)
  - based on the Solvency II standard formula
  - interest rate risk: reduction of $r_0, \theta$ by 100 bps $\rightarrow PVFP_{int}$
    - $SCR_{int} = (PVFP - PVFP_{int})$
  - equity risk: reduction of initial market value of stocks by 39% $\rightarrow PVFP_{eq}$
    - $SCR_{eq} = (PVFP - PVFP_{eq})$
  - correlation $\rho_M = \frac{1}{2}$

$$SCR_{mkt} = \sqrt{(SCR_{int})^2 + (SCR_{eq})^2 + 2\rho_M \cdot SCR_{int} \cdot SCR_{eq}}$$
1. **same profit** and **same risk**: alternative products allow for a **significantly higher equity ratio**

2. **same profit** and **same equity ratio**: alternative products reduce the insurer’s risk
3. In a third step, we compare the different product designs from a **policyholder’s perspective** using **risk-return-profiles**.

1) ... if comparing products with the **same profitability** and the **same risk** for the insurer

2) ... if comparing products with the **same profitability**, but some **risk reduction** for the insurer

- policyholders’ return measured by the **internal rate of return (IRR)**
- policyholders’ risk measured by the **conditional tail expectation** on the **lowest 20% (CTE20)**
  - considering new business of the 1st year
Key questions and results
1) Same PVFP / same SCR

Compare products with same PVFP and same \( SCR_{mkt} \):

**equity ratios** of 5% / 10% / 13% for traditional / alternative 1 / alternative 2 product
Key questions and results
1) Same PVFP / same SCR: benefit distribution and risk-return profile

- Traditional product has a lower risk for the policyholder (CTE20 is larger), but the alternative products exhibit significantly higher expected returns.
- Additional expected return of alternative I/II product: 15 / 26 bps.
Key questions and results

2) Same PVFP / „50/50“ split SCR

Compare products with same PVFP and if SCR\textsubscript{mkt} reduction (between traditional and alternative product with same \( q \)) are split 50/50:

**equity ratio** increase from 5% to 8.25% / 10%, but SCR reduced from 3.4% to 2.5%
Key questions and results

2) Same PVFP / „50/50“ split SCR: benefit distribution and risk-return profile

- The alternative products still offer beneficial risk-return-profiles.
- Additional return of alternative I/II product: 10 / 16 bps.
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Importance of “risk management by product design” will increase

- **Advantages** of alternative product designs compared to traditional product design:
  - same profit for the insurer and same participation rate for policyholders: significantly higher stock ratio
  - same profit and same risk for the insurer: significantly higher stock ratio
  - same profit for the insurer and same stock ratio: significant reduction of insurer’s risk

- **Impact on risk-return profiles** for policyholders:
  - increase of expected return (but also higher tail risk for policyholders)
  - effect depends on amount of risk reduction for the insurer

→ Alternative guarantees allow to reconcile the interests of all stakeholders.
  → designs with significant increase of expected return and reduction of insurer’s risk are possible

- **Areas for additional research:**
  - analysis of a change in new business strategy (traditional product in the past, modified products in new business)
  - product modifications for the annuity payout phase
Thank you for your attention!