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From Intertemporal Smoothing to Intergenerational Risk Sharing: The Effects of Different Return Smoothing Mechanisms in Life Insurance

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Agenda

Introduction

Motivation of the Topic and Main Result

- In traditional life insurance, policyholder participate in the same pool of assets.
- Individual policyholder‘s return depend on the return of the total asset pool.
- Certain mechanisms are implemented to reduce the volatility of the individual policyholder‘s return.
- These mechanisms vary heavily between different countries, e.g.,
  - In Germany, „buffers“ exist on both sides of the balance sheet (cf. Alexandrova et al. 2017).
  - In UK-with-profit products, return credited depends on some average performance (cf. Haberman et al., 2003).
- There exists a large variety of different return smoothing mechanisms.

Introduction

Motivation of the Topic and Main Result

- We argue in this paper:
  - The concrete design of a smoothing mechanism can have a significant effect on the resulting product.
- This is illustrated by analyzing two examples of return smoothing mechanisms:
  - Mechanism purely based on crediting average historical returns
    - primarily "intertemporal" smoothing, i.e., between calendar years
  - Mechanism utilizing a buffer account
    - higher degree of "intergenerational" risk sharing, i.e., over longer time horizons and between different generations of policyholders
- We consider the effects of the mechanisms on
  - Annual returns and pathwise volatility
  - Contract value over time
- By this, we demonstrate how different smoothing mechanisms lead to different effects from the policyholder's perspective.

Introduction

Literature Overview

Existing Literature:

- Smoothing mechanisms based on average return over the last three years:
  - E.g., Haberman et al. (2003), Korn and Wagner (2019), and Ruß et al. (2024)
- Smoothing mechanisms using buffer accounts:
  - E.g., Grosen and Jørgensen (2000), Hansen and Miltersen (2002), Hieber et al. (2015), Kling et al. (2007), and Ruß and Schelling (2021)
- Smoothing mechanisms as an alternative to formal guarantees:
  - E.g., Goecke (2013), Guillen et al. (2006), and Boado-Penas et al. (2020)
- Comparing different smoothing mechanisms:
  - E.g., Zemp (2011), and Cummins et al. (2004)

Our Contribution:

- Comparison of two different smoothing mechanisms without interest rate guarantees
- Perspective of the policyholder
- By using a pool of contracts starting at different points in time, intergenerational risk sharing can be studied.
- The two smoothing mechanisms are based on
  - Korn and Wagner (2019)
  - an adaptation of the mechanism from Boado-Penas et al. (2020)

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The Model

The Capital Market Model and the Book Of Business

Capital Market Model:

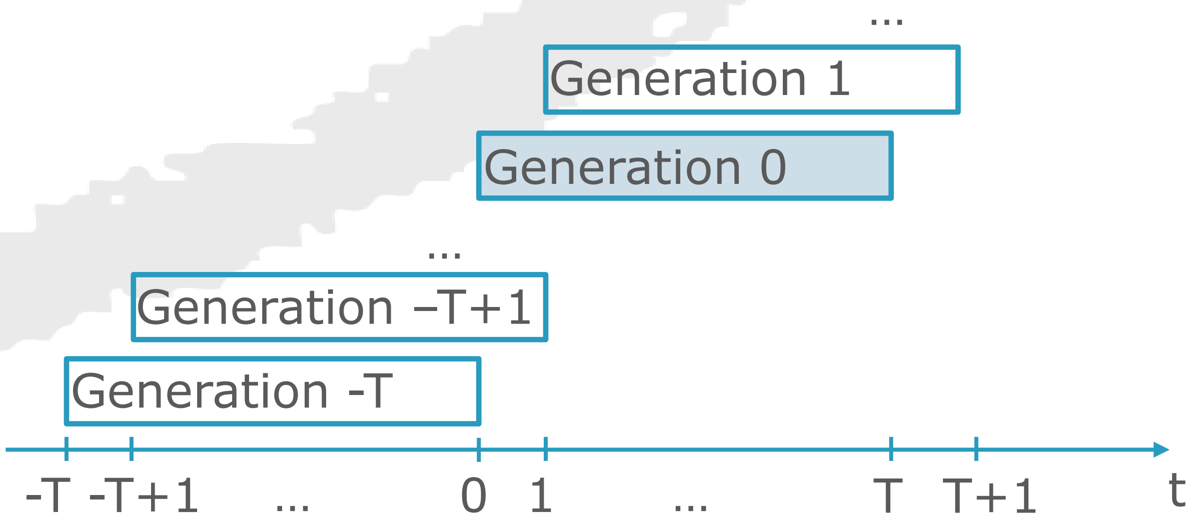
- Our model consists of one risky asset, a fund F.
- The fund process $F = (F_t)_{t\in\mathbb{T}}$ follows a geometric Brownian motion

$$dF_t = F_t\mu dt + \sigma dW_t$$

with constant drift μ and volatility σ.

Book Of Business:

- Policyholder pays a single premium at the start of the contract.
- After T years policyholder's account is paid out.
- Based on different generations buying the same contract at different points in time.
- The set of all generations is $\mathcal{H} = \{-T, \dots, T\}$.
- Analysis focuses on the generation entering at time $t = 0$ while the company is in a going-concern state.



The Model

The Insurance Company

- The insurance company is considered at each annual point in time $t \in \mathcal{T} = \{-T, \dots, T\}$ before and after payments are settled (indicated with superscript – and +, respectively)
- The notation with respect to the insurance company is in style of Døskeland and Nordahl (2008).
- The corresponding balance sheet is given by

Assets	Liabilities
$A_t^{-/+}$	$E_t^{-/+}$
	$B_t^{-/+}$
	$L_t^{-/+}$

- All assets are combined in one asset account $A_t^{-/+}$ and are invested into the fund F.
- The company's equity is labelled with $E_t^{-/+}$.
- The collective buffer account is labelled with $B_t^{-/+}$.
- The sum of the individual technical reserve accounts is called the technical reserve $L_t^{-/+}$.
  - Each generation h has their specific individually allocated technical reserve account $L_t^{h,-/+}$.

The Model

Smoothing Mechanisms

No Smoothing (nS)

- The policyholder receives the fund return.
- The payoff at maturity is given by

$$I_t^h = L_t^{h,-} = P \cdot \frac{F_t}{F_{t-T}}$$

- The distribution of the overall return of generation 0 conditional on $\mathcal{F}_{-T}$ is

$$ln(\frac{I_T^0}{P})|_{\mathcal{F}_{-T}} \sim N(T(\mu - \frac{\sigma^2}{2}), T\,\sigma^2), \text{ for } T > 0$$

Return Averaging (RA)

- The smoothed return is the average over the last $n \in \mathbb{N}$, i.e.,

$$r_t^{h,smooth} = \frac{1}{n}\sum_{i=0}^{n-1} r_{t-i}^F$$

- Each year the smoothed return is credited to the individually allocated technical reserve account

$$L_t^{h,-} = L_{t-1}^{h,+} exp(r_t^{h,smooth})$$

- The payoff at maturity is given by

$$I_t^h = L_t^{h,-}$$

- The distribution of the overall return of generation 0 conditional on $\mathcal{F}_{-T}$ is

$$ln\left(\frac{I_T^0}{P}\right)|_{\mathcal{F}_{-T}} \sim N\left(T\left(\mu - \frac{\sigma^2}{2}\right), \left(T - \frac{1}{3}\left(n - \frac{1}{n}\right)\right)\sigma^2\right),$$

for $T \geq n-1$

The Model

Smoothing Mechanisms

Collective Buffer Smoothing (CBS)

- The policyholder's initial payment P is allocated between $L_t^{h,-}$ and B_t^- using $\alpha \in [0,1]$.
- Let $l_\tau, u_\tau \in [-1,1]$ denote the lower and upper bound for the contract year $\tau = t - h \in \{1, \dots, T\}$.
- The intended payment IP_t^h received from or paid to the collective buffer is

$$IP_t^h = \begin{cases} p\left(P\alpha exp(u_\tau)^\tau - L_{t-1}^{h,+} exp(r_t^F)\right), & ln\left(\frac{L_{t-1}^{h,+} exp(r_t^F)}{P\alpha}\right)^{\frac{1}{\tau}} > u_\tau \\ 0, & ln\left(\frac{L_{t-1}^{h,+} exp(r_t^F)}{P\alpha}\right)^{\frac{1}{\tau}} \in [l_\tau, u_\tau] \\ q\left(P\alpha exp(l_\tau)^\tau - L_{t-1}^{h,+} exp(r_t^F)\right), & ln\left(\frac{L_{t-1}^{h,+} exp(r_t^F)}{P\alpha}\right)^{\frac{1}{\tau}} < l_\tau \end{cases}$$

If annualized return lies within the "desired range", no payments are made

If annualized return lies above the desired range, a share $p \in [0,1]$ of the excess is paid to the buffer.

If annualized return lies below the desired range, a share $q \in [0,1]$ of the shortfall is paid by the buffer.

- The policyholder's account receives the fund return and a payment

$$L_t^{h,-} = L_{t-1}^{h,+} exp(r_t^F) + P_t^h$$

P_t^h is the share of IP_t^h that can be afforded.

- The payoff at maturity is

$$I_t^h = L_t^{h,-} + \frac{L_t^{h,-}}{L_t^-} \vartheta B_t^-$$

At expiry, the generation receives a share of the collective buffer.

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Analysis and Results

Parameter in the Base Case

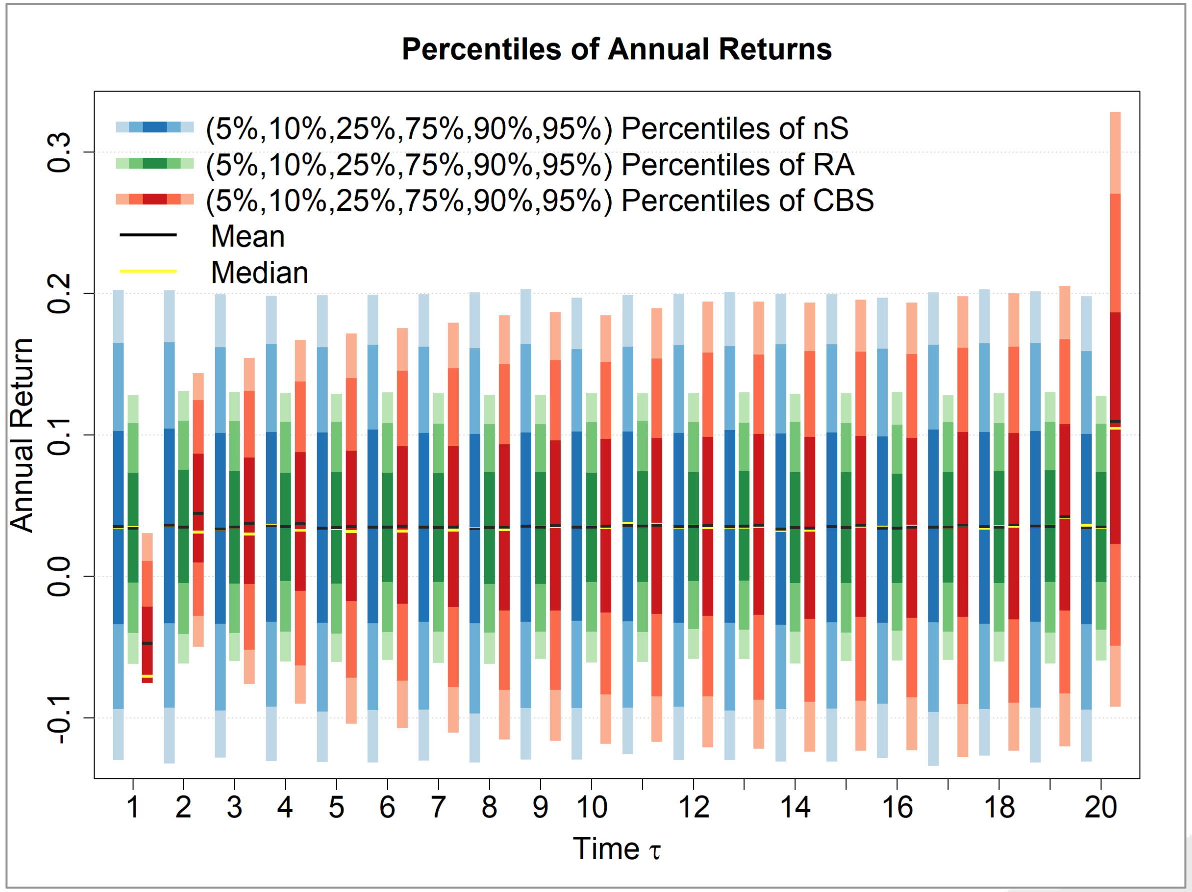
- For the model we use the following parameters:
  - $T = 20$, $P = 10{,}000$, $E_{Start} = 10{,}000$, $\mu = 4\%$, and $\sigma = 10\%$
- For the product with return averaging:
  - Smoothing over the last three years, i.e., $n = 3$
- For the product with collective buffer smoothing:
  - The parameters are

l_τ, $\tau \in \{1, \dots, 18\}$	l_{19}	l_{20}	$u_\tau, \tau \in \{1, \dots, 20\}$	α	ϑ	p	q
0.03	0.035	0.04	0.065	0.9	0.703	0.5	1

  - The terminal bonus parameter ϑ has been chosen such that $E(B_0^+) = E(B_{20}^+)$.

Analysis and Results

Annual Returns and Pathwise Volatility



Return Averaging:

- Strong effect on annual return, reduction of standard deviation from 9.9% to 5.8%.
- Pathwise volatility is reduced from 10.3% to 5.6%.
- Expected return does not change.

Collective Buffer Smoothing:

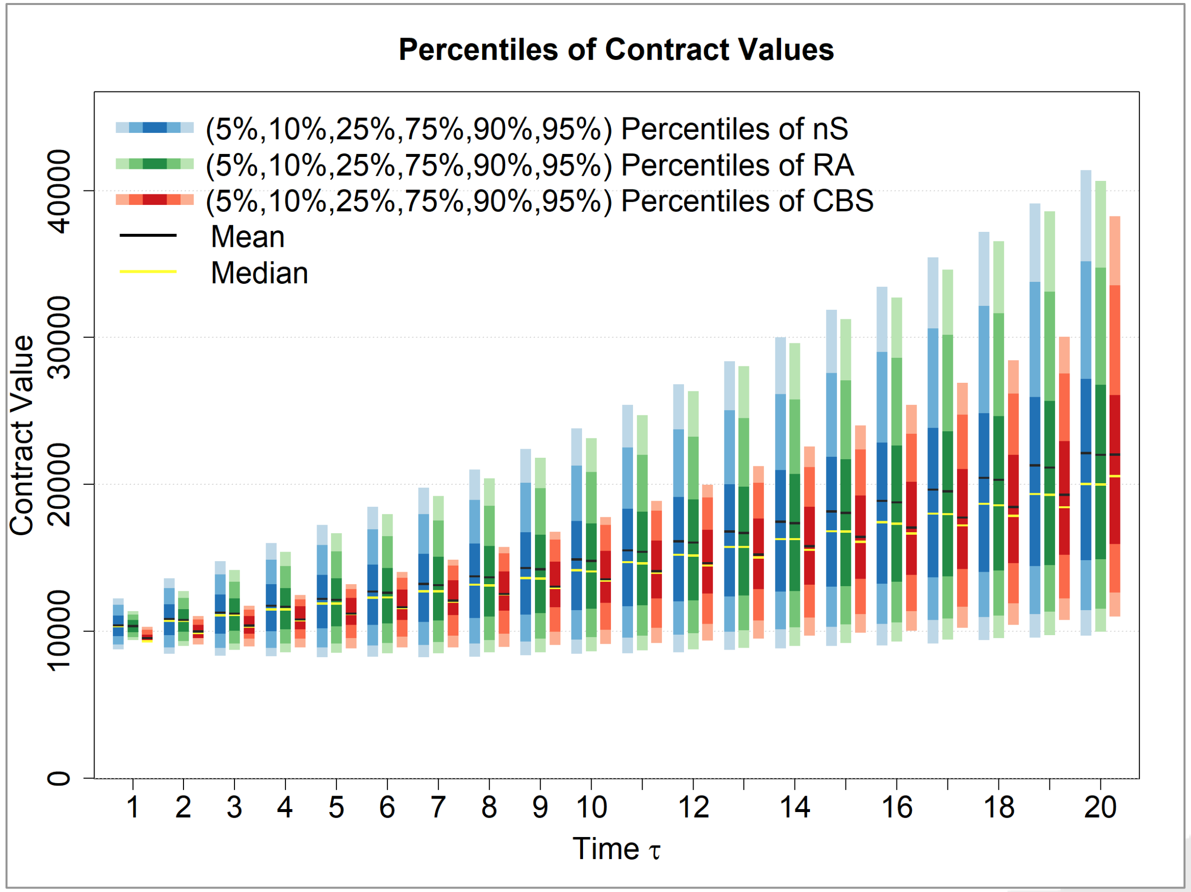
- Low annual return in the first year
- Reduction of variance in the first years. Effect diminishes over time.
- Pathwise volatility of 9.6%
- Return in the last year comes with a high upside potential.

An isolated look at annual returns suggests that return averaging is extremely effective in reducing risk without reducing expected return.

Collective buffer smoothing appears to have a much smaller and erratic effect on returns.

Analysis and Results

Contract Value



Return Averaging:

- Very effective in reducing risk in the first years with similar expected contract value.
- Over time, distribution converges to the distribution of the unsmoothed product.

Collective Buffer Smoothing:

- Initial payment leads to lower contract values in the first years.
- Terminal bonus compensates for this, leading to similar expected value and median at maturity.
- At maturity, risk of the product is considerably reduced.

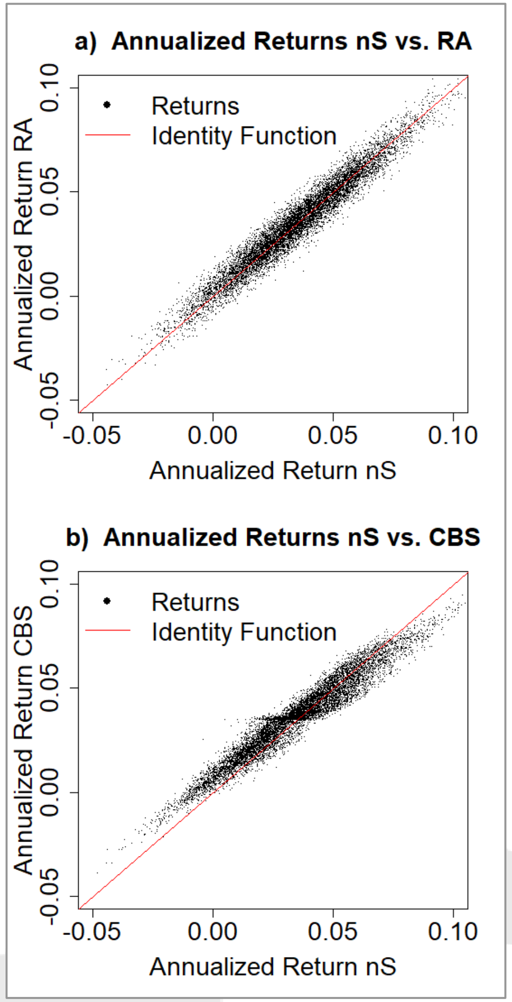
Return averaging has almost no effect on risk and return profile of the whole contract.

Collective buffer smoothing reduces the uncertainty of terminal value without reducing expected performance over the whole contract term.

Analysis and Results

Additional Results

Pathwise Comparison of Smoothing Mechanisms



Sensitivity Analysis:

- Collective buffer smoothing with respect to
  - Share α allocated to the individual policyholder account

  → The lower the investment into the individual reserve account, the more effective the collective buffer smoothing at maturity
  - Size of the collective buffer at $t = 0$

  → A higher initial buffer increases return potential and reduces the risk of the product
- Further sensitivities performed with respect to:
  - Capital market parameters
  - Time to maturity T
  - Number of years n for return averaging

  → These did not show any additional insights.

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Summary and Outlook

Our main results:

- Mechanisms that are purely based on crediting average historical returns are good in reducing pathwise volatility but have hardly any effect on the contract value at maturity
- Mechanisms using buffers can be designed in a way that money is transferred from “good states” to “bad states” not only intertemporally but also intergenerationally

Consequences:

- “Real” smoothing mechanisms typically have elements of both, intertemporal smoothing and intergenerational risk sharing. Concrete design may vary heavily from country to country.
- Simple generic mechanism used in academics may not fully cover the effect from return smoothing in practice

Outlook:

- Which smoothing mechanism result in high (objective) utility?
- Which smoothing mechanism result in high subjective attractiveness for consumers that behave according to theories of behavioral economics, e.g., Cumulative Prospect Theory (cf. Tversky and Kahneman, 1992) or Multi Cumulative Prospect Theory (cf. Ruß and Schelling, 2018) ?

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Appendix

Distribution of the Overall Return for nS and RA

In the model, the distribution of the annual fund return is given by

$$r_t^F \sim N\left(\mu - \frac{\sigma^2}{2}, \sigma^2\right) i.i.d. \forall t \in \{T-1, \dots, T\}$$

For the overall return of the unsmoothed product of generation 0 conditional on F_{-T} we get

$$\ln\left(\frac{I_T^h}{P}\right) = r_{h+1}^F + \dots + r_{h+T}^F \sim N\left(T\left(\mu - \frac{\sigma^2}{2}\right), T\sigma^2\right), for\ T > 0$$

For the product with return averaging of generation 0 conditional on F_{-T} we get (for $T \geq n-1$)

$$\ln\left(\frac{I_T^h}{P}\right) = r_{h+1}^{h,smooth} + \dots + r_{h+T}^{h,smooth} = \frac{1}{n}\left(\sum_{i=0}^{n-1} r_{h+1-i}^F + \dots + \sum_{i=0}^{n-1} r_{h+T-i}^F\right)$$

$$= \frac{1}{n}\left(1\, r_{h+1-(n-1)}^F + 2\, r_{h+1-(n-2)}^F + \dots + (n-1) r_h^F\right) + \sum_{i=1}^{T-(n-1)} r_{h+i}^F$$

$$+ \frac{1}{n}\left((n-1) r_{h+T-(n-1)+1}^F + \dots + 1\, r_{h+T}^F\right)$$

Appendix

Distribution of the Overall Return for nS and RA

Since, $\ln\left(\frac{I_T^h}{P}\right)$ is the sum of independent normally distributed random variables, it is also normally distributed with expected value

$$E\left(ln\left(\frac{I_T^h}{P}\right)\right) = \left(\mu - \frac{\sigma^2}{2}\right)\left(\frac{2}{n}(1 + 2 + \cdots + (n-1)) + T - (n-1)\right) = \left(\mu - \frac{\sigma^2}{2}\right)T$$

and variance

$$\begin{aligned} Var\left(ln\left(\frac{I_T^h}{P}\right)\right) &= \sigma^2 \tfrac{1}{n^2}\left(1^2 + \cdots + (n-1)^2 + n^2\big(T-(n-1)\big) + (n-1)^2 + \cdots + 1^2\right) \\ &= \sigma^2\left(T - (n-1) + \frac{2}{n^2}\left(1^2 + \cdots + (n-1)^2\right)\right) \\ &= \sigma^2\left(T - (n-1) + \frac{2}{n^2}\left(\frac{n^3}{3} - \frac{n^2}{2} + \frac{n}{6}\right)\right) \\ &= \sigma^2\left(T - \tfrac{1}{3}\left(n - \tfrac{1}{n}\right)\right) \end{aligned}$$