

Intertemporal smoothing and intergenerational risk sharing: The effects on risk-neutral value and risk of guarantees of traditional life insurance products

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Introduction

Motivation and Objective of this Paper

■ Starting point:

- In traditional life insurance, policyholders participate in the same pool of assets.
- Enables the implementation of various **return smoothing mechanisms**.
 - Goal: Reduction of the volatility of the policyholders' return.
- Concrete type of smoothing mechanism can have a significant effect on **risk-return-characteristics** cf. Kling et al. (2025).
 - Intertemporal smoothing reduces pathwise volatility.
 - Intergenerational risk sharing reduces uncertainty of terminal value.
- Alongside smoothing mechanisms, products often include a guarantee, e.g., terminal guarantee.
- Guarantees are well researched, however, not in combination with different types of return smoothing mechanisms.

■ In this Paper:

- We argue that the concrete design of smoothing mechanisms can have a significant impact on the value of a guarantee.
- We analyze return smoothing mechanisms based on Kling et al. (2024, 2025) combined with a terminal guarantee and different underlying funds.
- By considering two fairness conditions for the products, we illustrate that policyholders benefit from products that can only be provided by insurance companies.

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Capital Market and Products

The Capital Market Model and the Book Of Business (Kling et al. 2025)

Capital Market Model:

- On a finite time horizon $\mathbb{T} = [-T, T]$ and under the real-world measure \mathbb{P} , our model consists of

- a **risky asset** $(S_t)_{t \in \mathbb{T}}$ following a geometric Brownian motion

$$dS_t = S_t(\mu dt + \sigma dW_t)$$

with constant drift μ and volatility σ .

- a **risk-free asset** given by

$$\beta_t = e^{r(t - (-T))}$$

- From these we derive a fund process F^δ

$$dF_t^\delta = F_t^\delta \left(\delta \frac{dS_t}{S_t} + (1 - \delta) \frac{d\beta_t}{\beta_t} \right), \text{ with } \delta \in [0, 1].$$

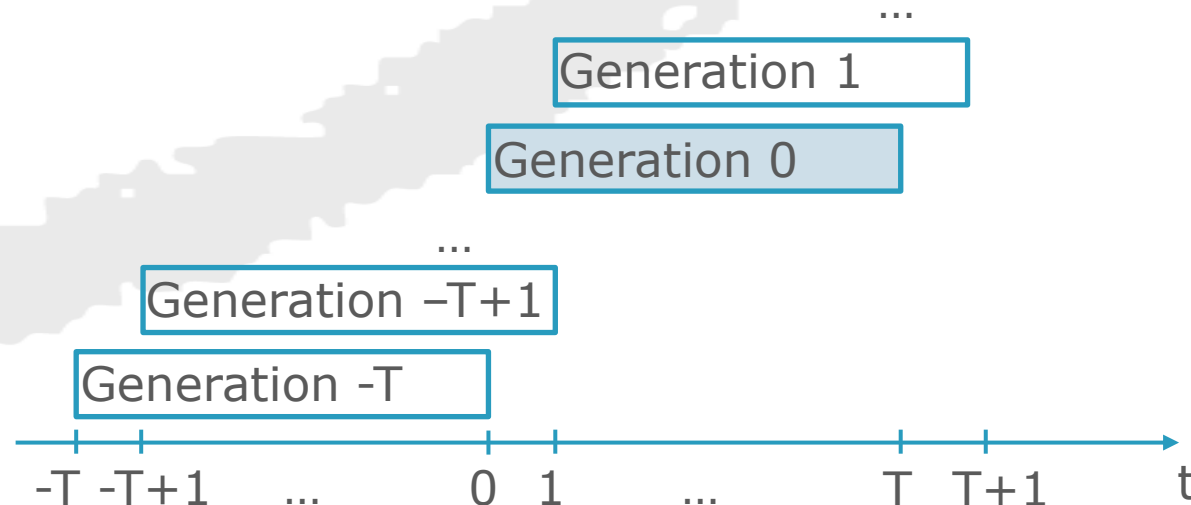
- Under the risk-neutral measure \mathbb{Q} , we receive

$$dS_t = S_t (r dt + \sigma dW_t^\mathbb{Q})$$

$$dF_t^\delta = F_t^\delta (r dt + \delta \sigma dW_t^\mathbb{Q}), \forall t \in \mathbb{T}$$

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.



Capital Market and Products

Smoothing Mechanisms (Kling et al. 2024, 2025)

- Intertemporal Smoothing: **Return Averaging (RA)**
 - Return = average return of the past 3 years
- Intergenerational Risk Sharing: **Collective Buffer Smoothing (CBS)**
 - Policyholders pay a share $(1 - \alpha)$ of their premium into a buffer account.
 - The buffer account is used to keep the annualized return of the policyholders' account within some target range.
 - Payment of a terminal bonus.
- Combination of the approaches: **Collective Buffer Smoothing and Return Averaging (CBS RA)**
- Additionally: **Product with no smoothing (nS)**

Capital Market and Products

Fairness conditions and Guarantee

Fairness of the Products:

- The products with smoothing mechanisms are parametrized consistently to allow for comparisons.
- For fairness under the real-world measure \mathbb{P} , we follow Kling et al. (2024, 2025).
- For fairness under the risk-neutral measure \mathbb{Q} , the condition $\mathbb{E}_{\mathbb{Q}}(I_t^h) = P_h$ for generation $h = 0$ should be held.
- Comparison between
 - products offered by an insurance company with a pool of generations
 - products replicable on the capital market.

Pricing of the Guarantee:

- A terminal money back guarantee for the contract of generation $h = 0$ is added.
- The price for the guarantee P_g is paid upfront and included in the total premium TP_0 of generation $h = 0$, i.e., $TP_0 = P_g + P_0$.
- The price of the guarantee is given by the risk-neutral expected value of the discounted payoff, i.e.,

$$P_g = \mathbb{E}_{\mathbb{Q}} \left(\exp(-Tr) \max(TP_0 - I_t^h, 0) \right)$$

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Choice of Parameters

- For the model we use the following parameters: $T = 20$, $P = 10,000$, $r = 2\%$, $\mu = 6\%$, and $\sigma = 20\%$.
- For the fund process, we consider different levels of $\delta \in \{0.25, 0.3, \dots, 0.95, 1.0\}$.
- Each product is modelled with fairness conditions under the real-world measure \mathbb{P} and under the risk-neutral measure \mathbb{Q} .
- Leading to 16 products for each smoothing mechanism and fairness condition.

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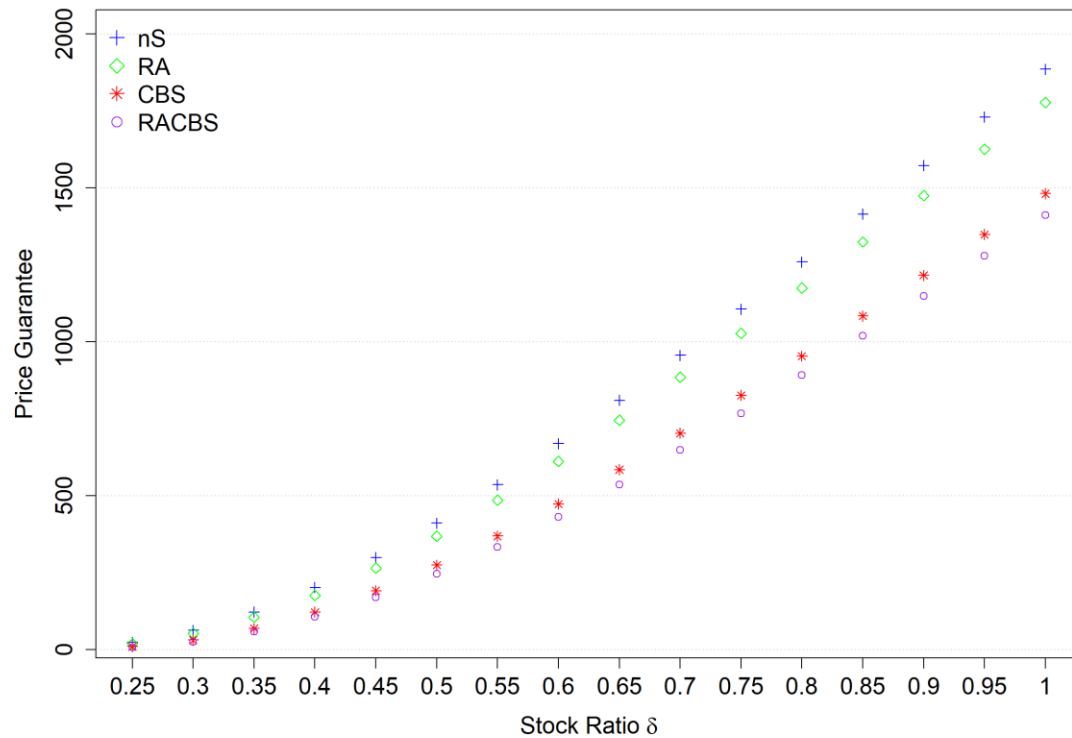
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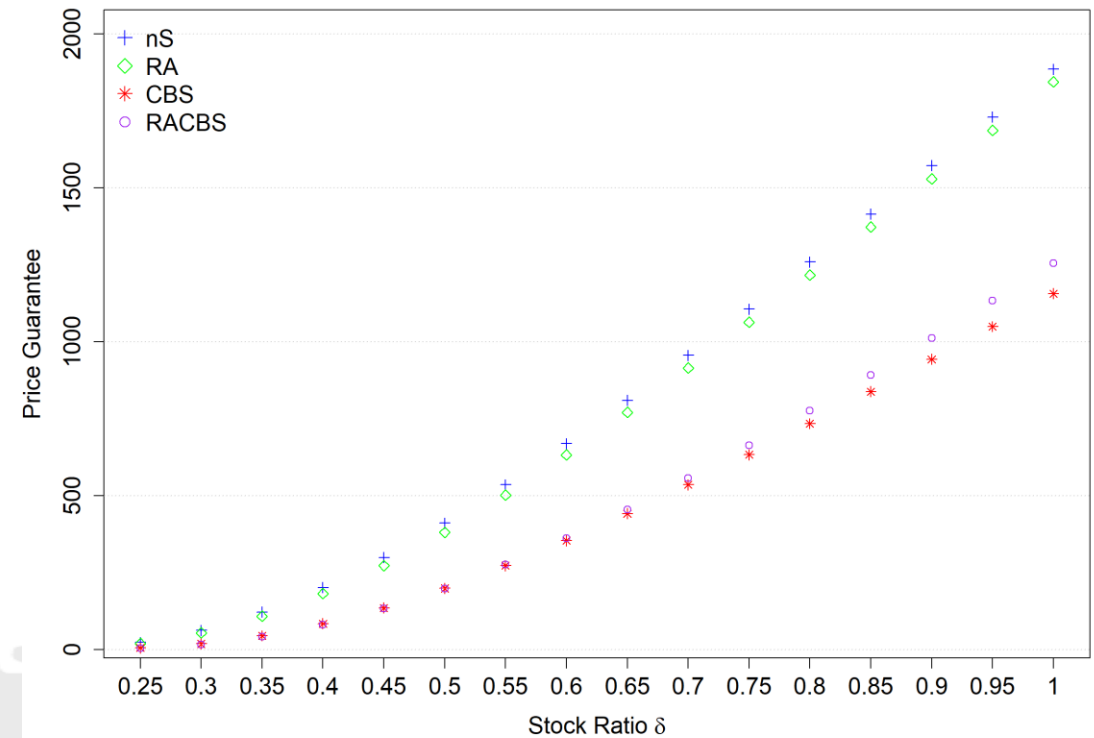
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Guarantee Prices

Fairness under \mathbb{Q}



Fairness under \mathbb{P}

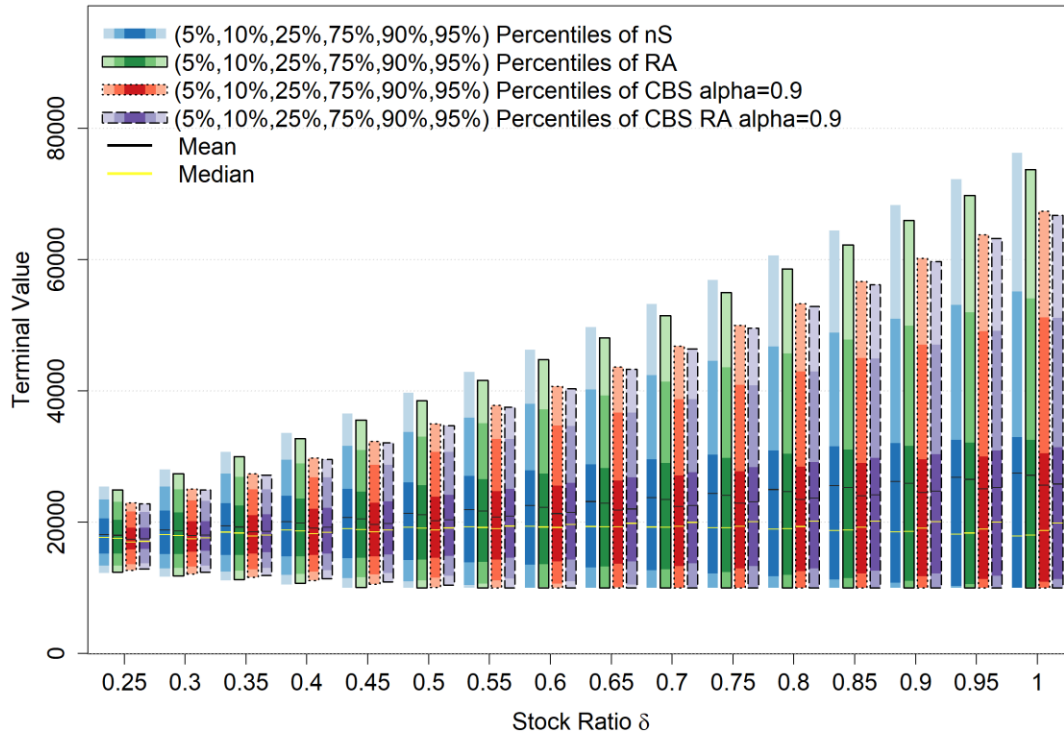


- Return smoothing mechanisms decrease the guarantee prices.
- Intergenerational risk sharing has a greater effect than intertemporal smoothing.
- The effect is even greater when the products are fair under \mathbb{P} .

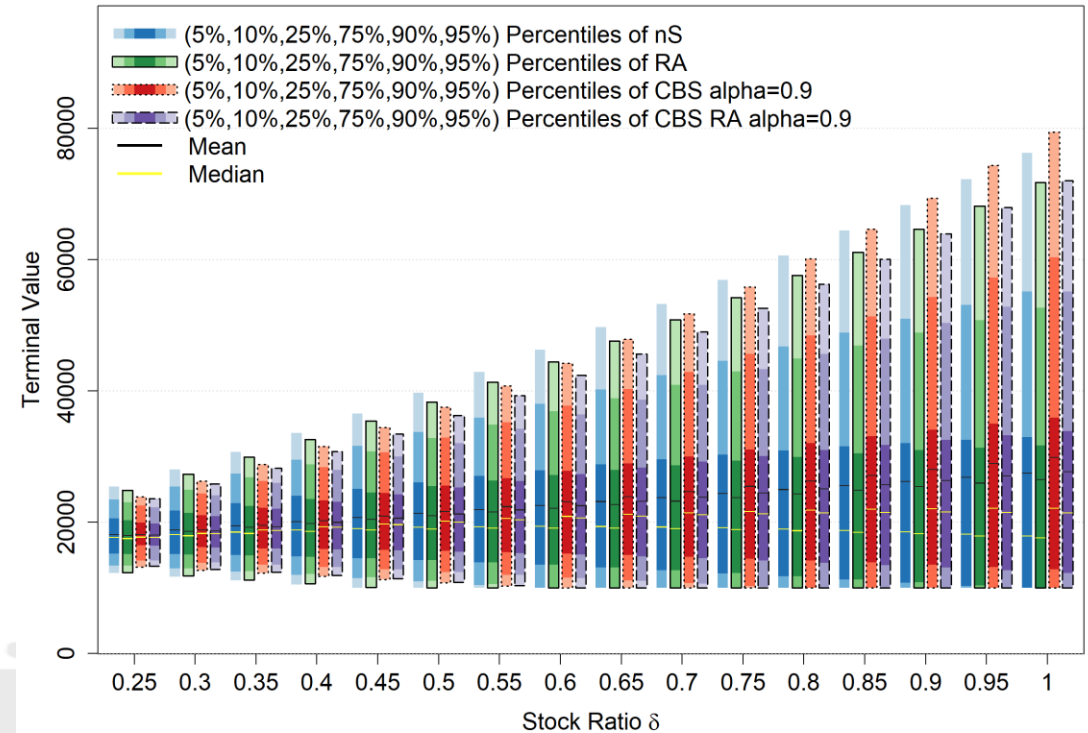
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Payoff of the Products – Fixed Stock Ratio

Fairness under \mathbb{Q}



Fairness under \mathbb{P}

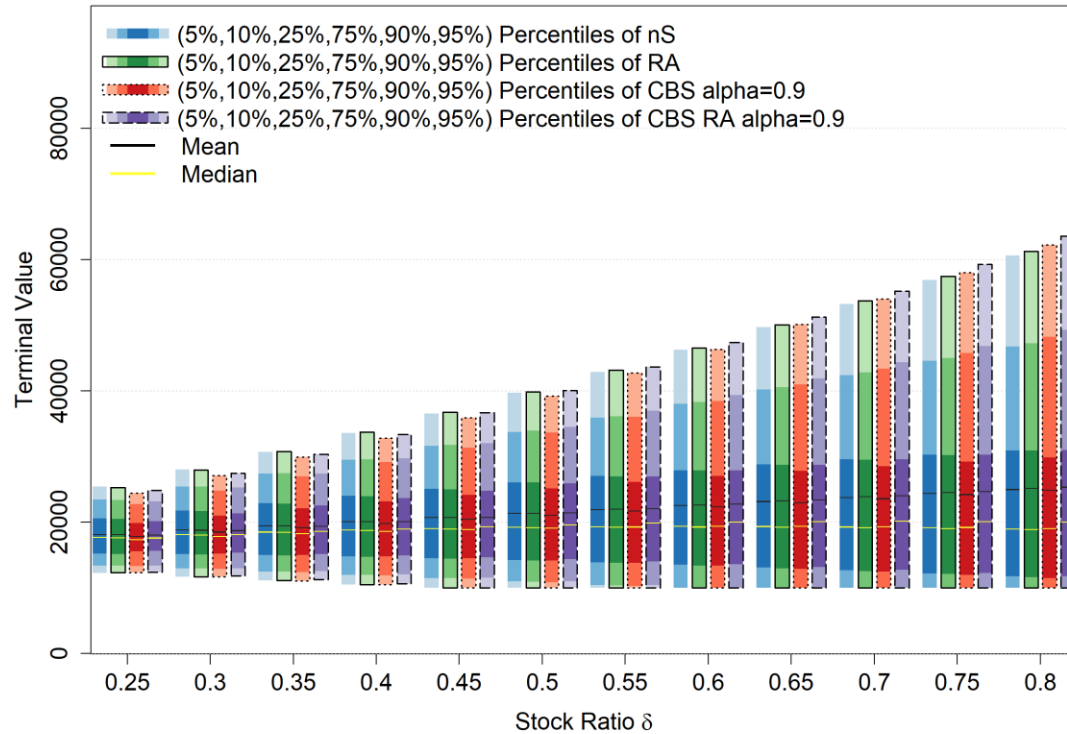


- Fairness under \mathbb{Q} : Return smoothing decreases the risk but also the chances.
- Fairness under \mathbb{P} : Intergenerational risk sharing leads to lower risk and higher chances for higher stock ratios.

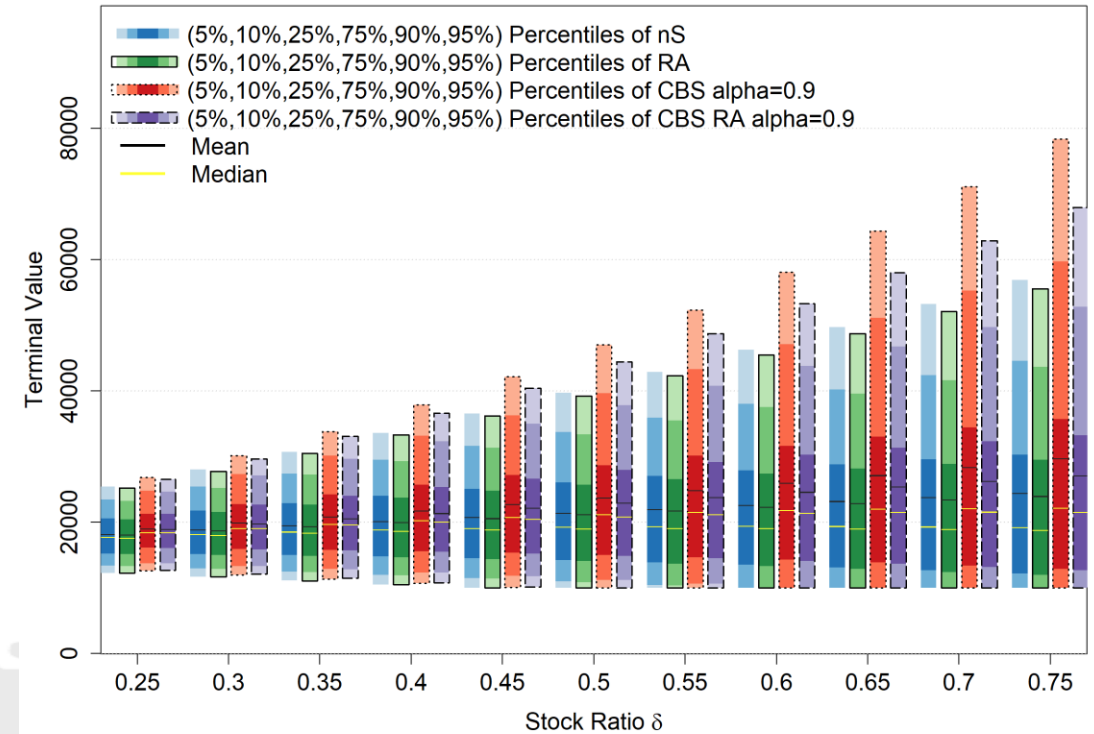
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Payoff of the Products – Fixed Guarantee Price

Fairness under \mathbb{Q}



Fairness under \mathbb{P}

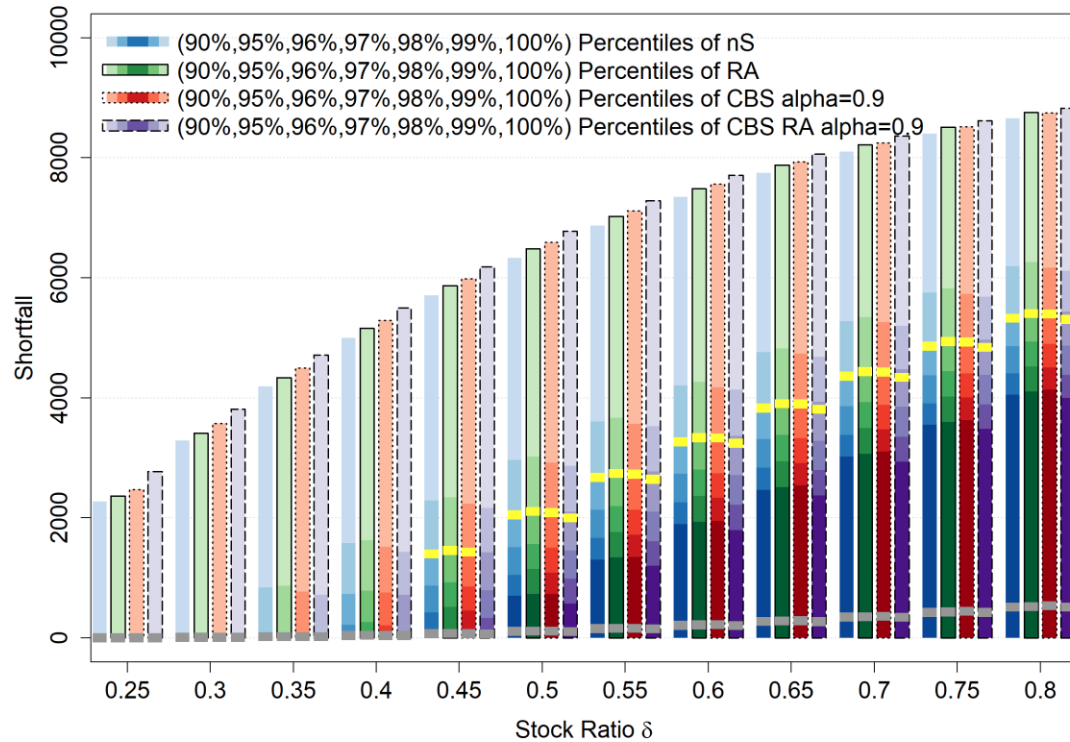


- Fairness under \mathbb{Q} : Slightly higher chances for the products with smoothing for higher stock ratios.
- Fairness under \mathbb{P} : Considerably higher chances for the products with intergenerational risk sharing.

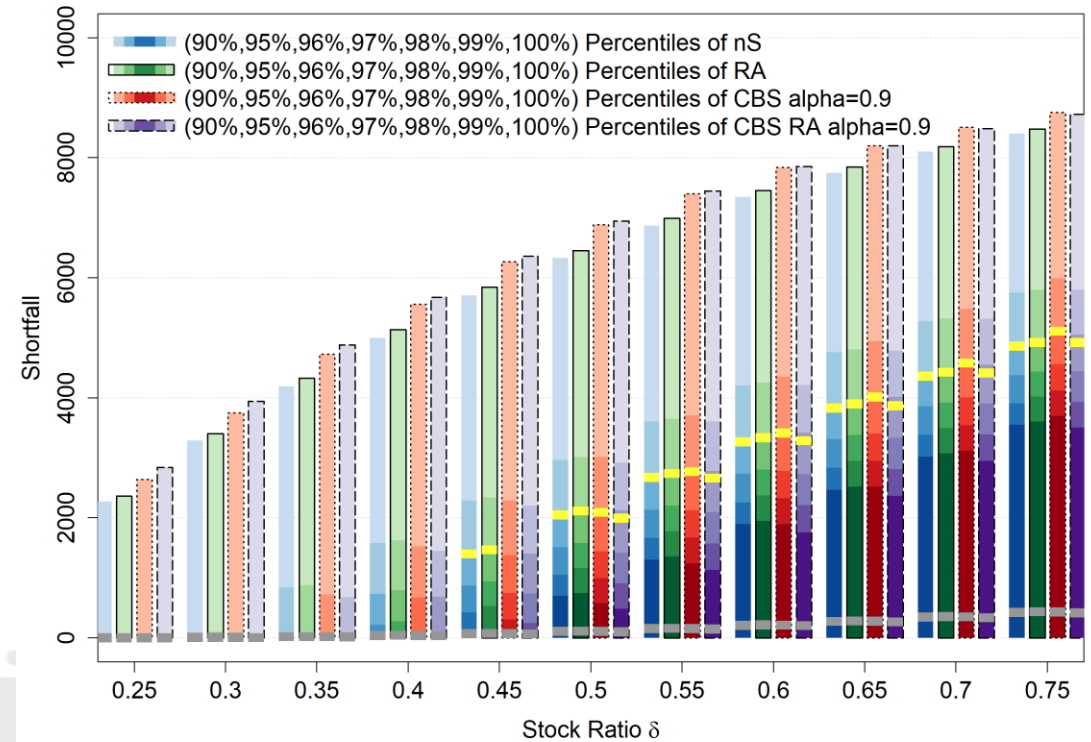
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Payoff from the Guarantee – Fixed Guarantee Price

Fairness under \mathbb{Q}



Fairness under \mathbb{P}



- The payout structure is very similar for the different products for a fixed guarantee price.
- The risk of providing a guarantee is mainly driven by the guarantee price.

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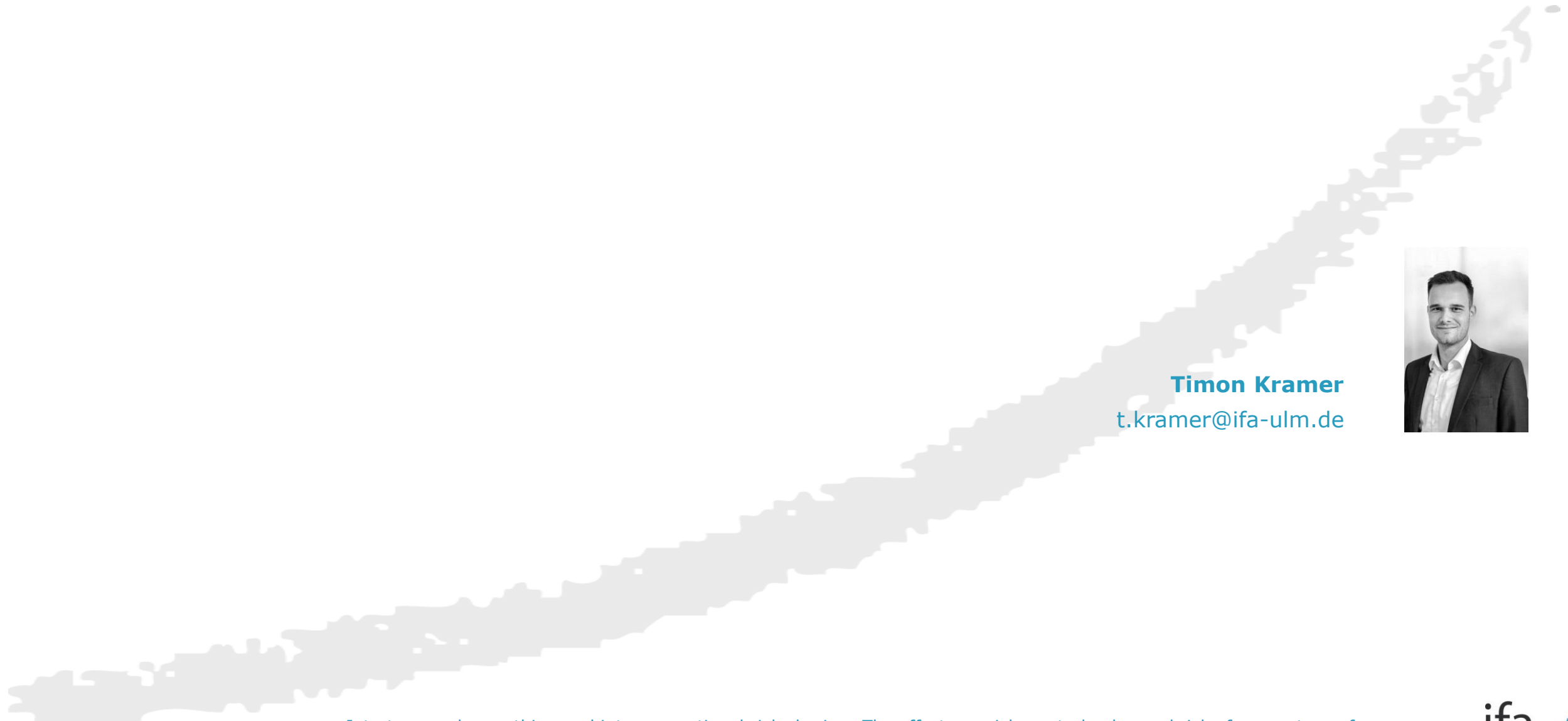
Our main results:

- Smoothing mechanisms lead to lower guarantee prices.
- Intergenerational risk sharing has a greater effect than intertemporal smoothing.
- For the same price, a higher stock ratio can be chosen for products with smoothing mechanisms leading to higher chances for the policyholder.
- These effects are especially strong for products with intergenerational risk sharing holding fairness conditions under \mathbb{P} .
- The risk for providing a guarantee is mainly driven by the price of the guarantee – a riskier underlying combined with a smoothing mechanism does not change the risk.

Consequences:

- Smoothing mechanisms are a useful tool on products with guarantees to decrease the guarantee price or to increase the chances for the policyholder.
- Intergenerational risk sharing can release its full potential when offered with a collective of policyholders from different generations.
- This can only be done by insurance companies that can mitigate the capital market risk over different generations. This gives products from insurance companies an advantage compared to a pure hedgeable investments on the capital market.

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Analysis of Objective Utility and Subjective Attractiveness

Finding Compromises

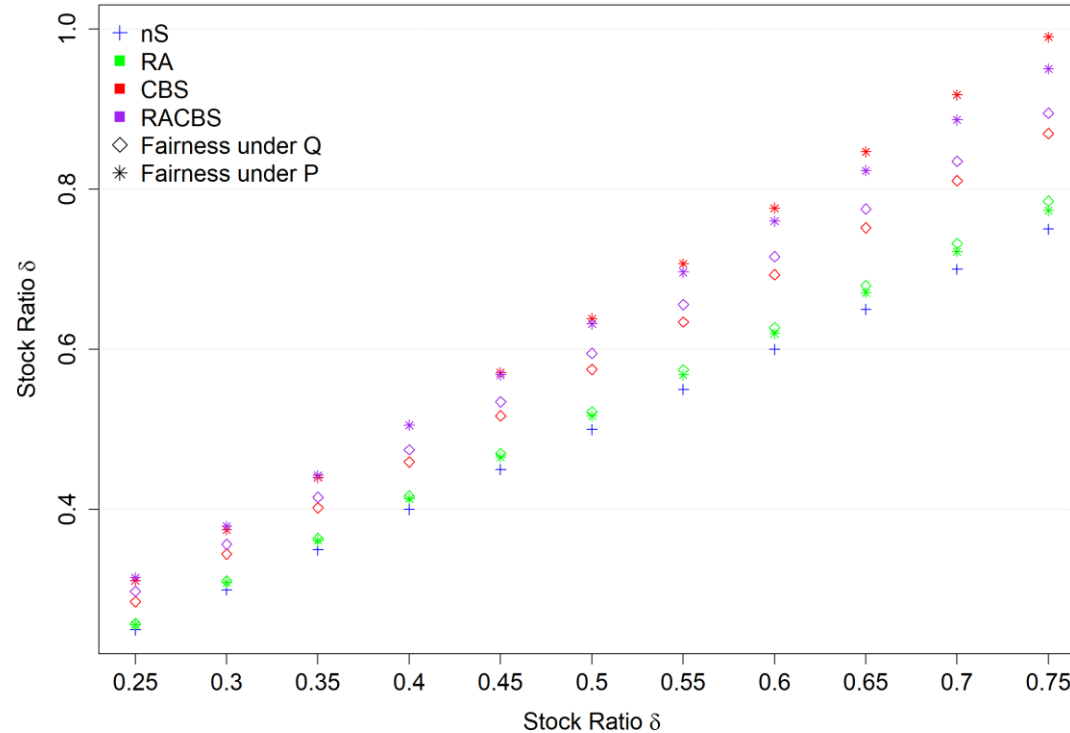
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Stock Ratio for Equal Guarantee Prices



- For the products with intergenerational risk sharing a significantly higher stock ratio can be chosen.
- Fairness under \mathbb{P} increases this effect.
- For the RA product, the stock ratio is only slightly higher.