Rising interest rates, lapse risk, and the stability of life insurers

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Motivation

- Since 2009 life insurers have been struggling with low interest rates
  $\Rightarrow$ Large annual guarantees vs. small return on assets
  $\Rightarrow$ Deteriorating solvency (Berdin and Gründl (2015))
  $\Rightarrow$ Rise in interest rates beneficial for solvency?
- 2016: Solvency II came into force
  $\Rightarrow$ Fair value-oriented valuation + risk-based capital

Impact of rising interest rates on life insurers' balance sheets?

Rise in interest rates

A) **Valuation benefit:**
Liabilities decrease faster than assets (duration gap)
$\Rightarrow$ Own funds increase ($\rightarrow$ *fair value BS*)

B) **Liquidity risk:**
90% of EU life contracts with lapse penalty $< 15\%$ (ESRB (2015))
$\Rightarrow$ Rise in interest rates $\Rightarrow$ High lapse rate
$\Rightarrow$ Large outflows (Recovery Value) but small inflows (RoA)
$\Rightarrow$ Negative free cash flow ($\rightarrow$ *book value BS*)
$\Rightarrow$ Own funds might decrease ($\rightarrow$ *fair value BS*)

C) **Lapse risk:**
Minimum return guarantee $\approx$ put option
$\Rightarrow$ Rise in interest rates $\Rightarrow$ Lapse if guarantee small
$\Rightarrow$ Policies with large guarantees remain in portfolio
$\Rightarrow$ Riskier contracts $\Rightarrow$ Capital requirement $\uparrow$

Overall effect?

Literature

- Berdin and Gründl (2015) and Berdin (2016) study the impact of low interest rates on life insurers' solvency
- Feodoria and Förstemann (2015) show that it is rational for policyholders to lapse if interest rates rise too much
- Positive interest rate shocks relate to larger empirical lapse probabilities (Dar and Dodds (1989), Kim (2005), Kuo et al. (2003), Kiesenbauer (2012), Russell et al. (2013), Russo et al. (2017))
- Albizzati and Geman (1994) price the surrender option in case of volatile interest rates
- Le Courtois and Nakagawa (2009) and Buchardt (2014) establish a link between an insurer's PD and lapse risk
- Barsotti et al. (2016) model lapse risk contagion

Gap: Impact of interest rate rise in combination with lapse risk on an insurer's balance sheet.

Liabilities

- Accumulation phase of endowment life contracts (*variable annuities*) with fixed annual premiums and lump-sum benefit upon maturity
- Upon lapse: recovery value $= \vartheta \times$ accumulated funds, $0 < \vartheta < 1$
- Initial back book with contracts that mature at times $t = 0, 1, ..., 29$ $\Rightarrow$ Liability duration $= 15$
- Each cohort h of contracts features guaranteed rate of return r_G^h and profit participation $r_{S,t}^h$ such that accumulated funds are $V_t^h = V_{t-1}^h \max\left(1 + r_G^h,\, 1 + r_{S,t}^h\right)$
- r_G^h follows reference rate $(= 0.6 \times MA_{10}(r_{rf}))$ in 0.5% steps
- $r_{S,t}^h \approx 90\% \times RoA_t$ ($\Leftrightarrow$ German legislation)

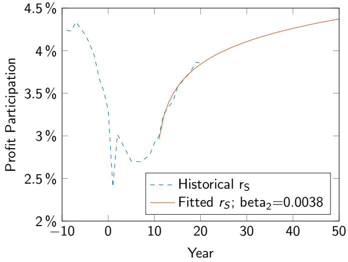
Liabilities: Market-consistent valuation

- Market consistent (fair) contract value:

$$PV(Liabilities) = V_t \times PV(\text{future guarantee} + \text{profit participation})$$

- Future profit participation, $r_{S,t+s}$, is predicted by linear model estimated with average profit participation in previous 10 years:

$$\hat{r}_{S,t+s} = \hat{\beta}_{t,1} + \hat{\beta}_{t,2} \log(s)$$



Liabilities: Lapse Risk

Benchmark: $\lambda \equiv 2.86\%$ (average German lapse rate in 2015)

Interest-Rate Sensitive (IRS) Lapse:

$$\lambda_t^h(\Delta r_t^h, \Delta T_t^h) = a + e^{c - e^{d_1 \Delta r_t^h + d_2 \Delta T_t^h}},$$

where

- $\Delta r_t^h = r_G^h - r_{rf}(t)$: excess guaranteed rate with sensitivity $d_1 > 0$
  $\Rightarrow$ Higher guarantee $\Rightarrow$ Smaller lapse rate
- ΔT_t^h : current contract age with sensitivity $d_2 > 0$
  $\Rightarrow$ Older contracts $\Rightarrow$ Smaller lapse rate
- $a = 1\%$: minimum lapse rate
- $c \sim \mathcal{N}(\mu_c, \sigma_c^2)$: random effect across PH within cohort
- *Calibration* based on average lapse rates for 2005-2015 in German endowment life business

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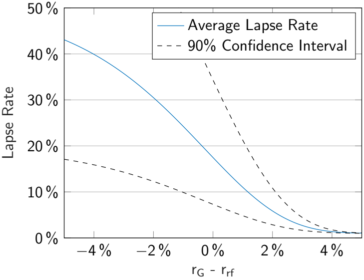
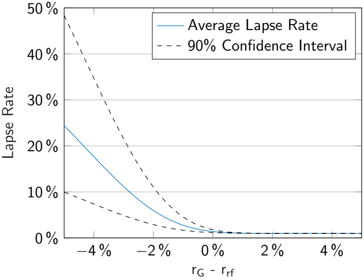
Liabilities: Lapse Risk Calibration



(a) $\Delta T_t^h = 1$



(b) $\Delta T_t^h = 15$

Asset Allocation

- Risk-free rate a la Hull and White (1990) with mean reversion level

$$\theta_r(t) = \gamma + (\beta - \gamma)\left(1 - \frac{1}{1 + e^{-b(t-h)}}\right)$$

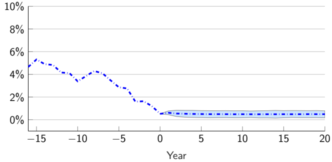
$$\Rightarrow \quad dr(t) = \alpha_r(\theta_r(t) - r(t))dt + \sigma_r dW_r(t)$$

- *Calibration* of initial yield curve: German bond yields in 2015
- Assets with aggregate duration 8.26 years and initial weights based on average German insurer in 2015:

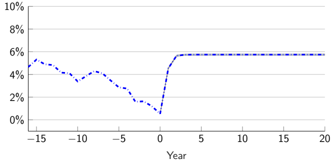
Asset Portfolio Weights	
Sovereigns w_{sov}	56.7%
Corporate w_{corp}	34.3%
Stocks w_{stocks}	5.6%
Real Estate $w_{\text{real estate}}$	3.4%

- Revolving portfolio with 20 sovereign bonds, 10 corporate bonds that mature in $t = 0, 1, 2, \ldots$.

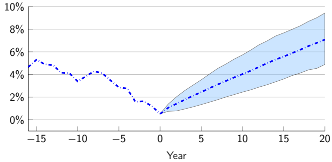
Interest Rate Environments



Low Interest Rates



Sudden Upward Shock

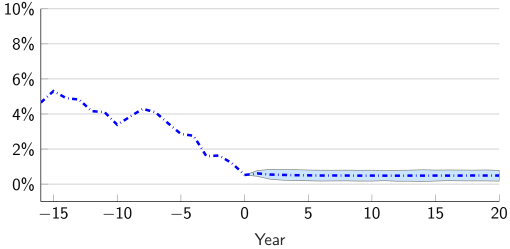


Gradual Increase

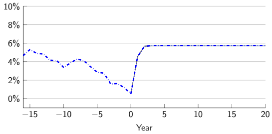
Solvency Capital Requirements

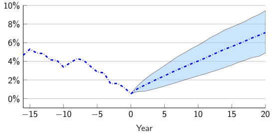
- Capital requirements based on standard model of Solvency II
- Market risk: interest rate, equity, property, spread
- Lapse risk: down/up/mass shock of lapse rates
  - up/mass shock: if recovery value > PV(liabilities),
    e.g. in times of small predicted profit participation
  - down shock: if recovery value < PV(liabilities)
    e.g. in times of large predicted profit participation
- Solvency ratio: Own Funds/SCR

Environment (1): Interest Rates

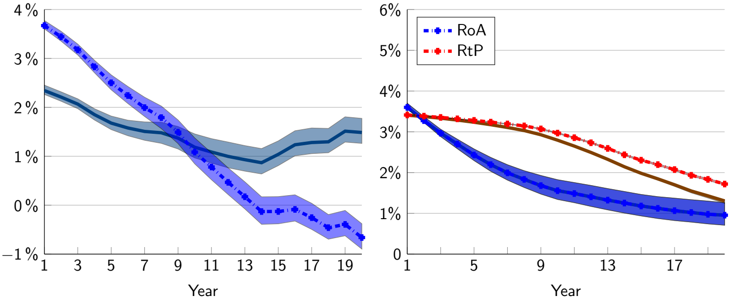


Low Interest Rates





Environment (1): Liquidity

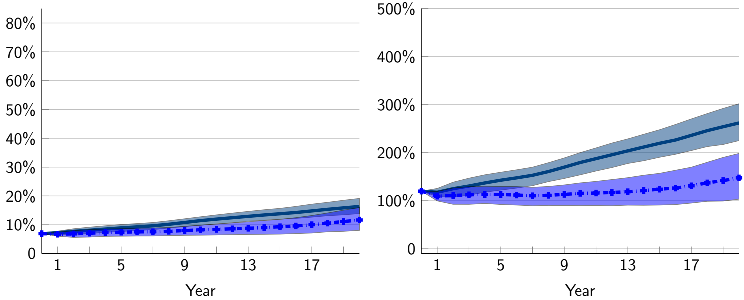


(a) Free Cash Flow / BV(Assets) (b) Return on Assets & to PH

With interest rate sensitive lapses (dashed):

- Large guarantee contracts mature ↓ ⇒ lapse rate ↑ ⇒ FCF ↓
- Large guarantee contracts lapse less ⇒ average guarantee ↑
- Low interest rates ⇒ RoA declines

Environment (1): Solvency

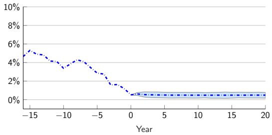


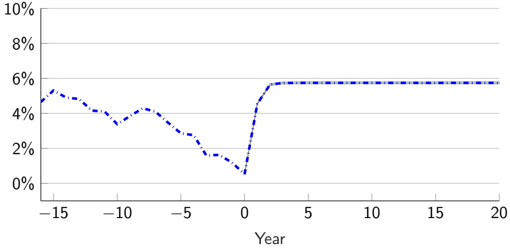
(a) Own Funds / MV(Assets) (b) Solvency Ratio

With interest rate sensitive (IRS) lapses (dashed):

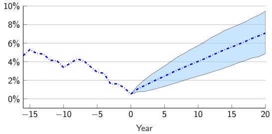
- Recovery values > PV(Liabilities) $\Rightarrow$ Own funds $\downarrow$
- Average guarantee $\uparrow \Rightarrow SCR \uparrow \Rightarrow$ Solvency ratio $\downarrow$

Environment (2): Interest Rates

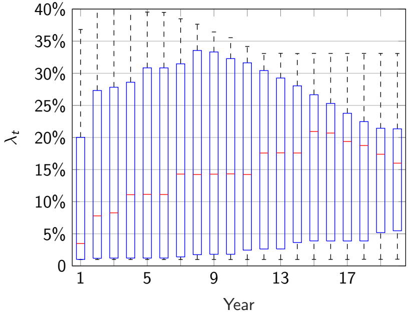




Sudden Upward Shock

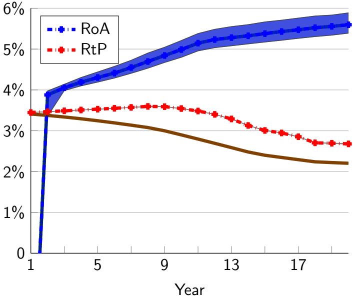


Environment (2): Lapse Rates

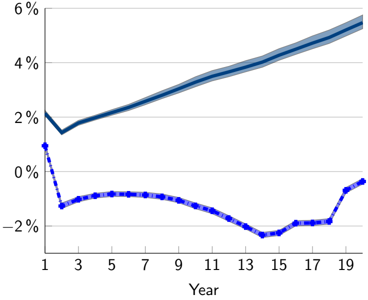


- Sharp increase in lapse rates
- Guarantees adjust very slowly ⇒ Lapse rates high for long time

Environment (2): Liquidity



(a) Return on Assets & to PH



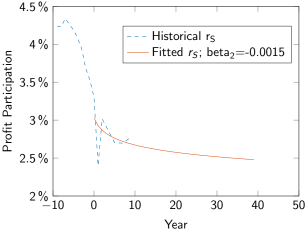
(b) Free Cash Flow / BV(Assets)

- 1^{st} year: enormous asset depreciations
- Steady increase in RoA
- Decline in RtP due to slow adjustment of guarantees

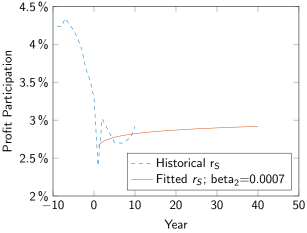
With IRS lapses (dashed):

- Substantial lapse rate of low-guarantee contracts ⇒ RtP ↑
- Enormous cash outflows

Environment (2): Liability Valuation



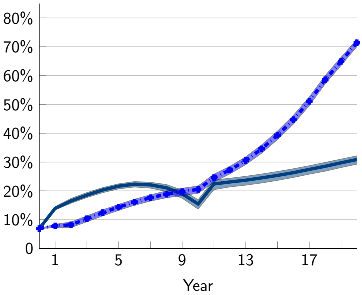
(a) $t = 9$.



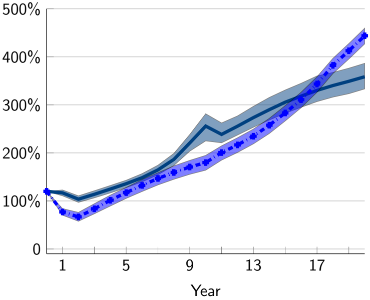
(b) $t = 20$.

- $t = 10$: Profit participation is predicted to increase for the first time
- PV(future benefits) substantially increases
- Recovery value << PV(liabilities)
  $\Rightarrow$ Own funds increase with lapse
  $\Rightarrow$ Sensitivity towards lapse changing from up- to down-shock

Environment (2): Solvency



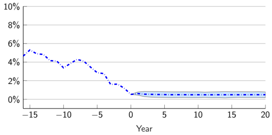
(a) Own Funds / MV(Assets)

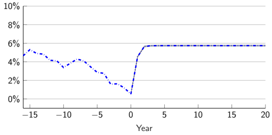


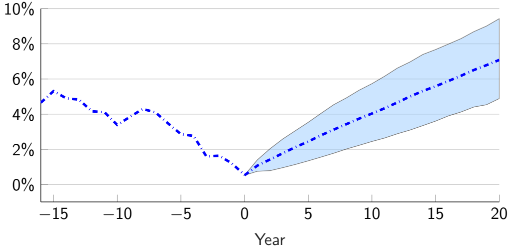
(b) Solvency Ratio

- Peak at $t = 10$: Change in extrapolation of r_S
- Less sensitive with IRS lapses (smaller $|r_S - r_G|$)
- Average guarantee larger with IRS lapses $\Rightarrow$ SCR $\uparrow$ $\Rightarrow$ smaller Solvency Ratio $\downarrow$
- In the long run: recovery values $<$ PV(liabilities) $\Rightarrow$ Own funds $\uparrow$ with more lapse $\Rightarrow$ Solvency Ratio $\uparrow$

Environment (3): Interest Rates

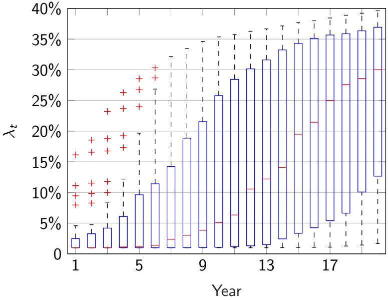




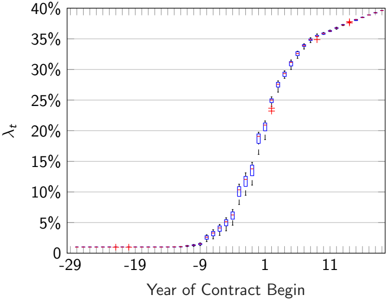


Gradual Increase

Environment (3): Lapse Rates



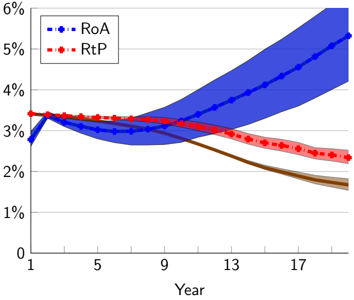
(a) Over time.



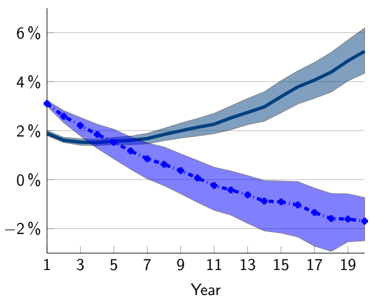
(b) Over cohorts.

- Gradual increase in average lapse rates over time
- Large variation across but not within cohorts
  $\Rightarrow$ Increase in interest rates (lapse $\uparrow$)
  sets off increase in contract age (lapse $\downarrow$)

Environment (3): Liquidity



(a) Return on Assets & to PH



(b) Free Cash Flow / BV(Assets)

With IRS lapse (dashed):

- $\approx$ 10 years until $RoA_t \geq RoA_0$ and $RoA_t \geq RtP_t$
  $\Rightarrow$ small profit participation for substantial time
- Substantial liquidity need with IRS lapse

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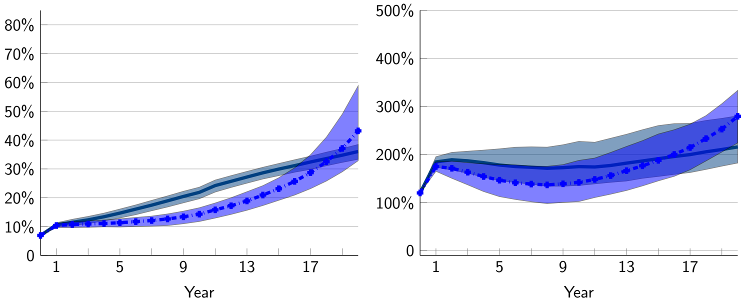
Environment (3): Solvency



(a) Own Funds / MV(Assets) (b) Solvency Ratio

- PV(Liabilities) $\leq$ recovery values
  $\Rightarrow$ Own funds $\downarrow$ with IRS lapses (dashed)
- Average guarantee $\uparrow$ with IRS lapses
  $\Rightarrow$ SCR $\uparrow$ $\Rightarrow$ Solvency Ratio $\downarrow$
- Long run: recovery values $<$ PV(Liabilities)
  $\Rightarrow$ Own funds $\uparrow$ with lapse $\Rightarrow$ Solvency Ratio $\uparrow$

Conclusion

- A sudden upward shock in interest rates
  - jeopardizes a life insurer's liquidity for the next 20 years due to enormous recovery payments
  - endangers the solvency situation for the next 5 years due to expensive guarantees
- A gradual increase in interest rates
  - substantially worsens liquidity situation
  - slightly reduces solvency
  - cannot make up for small profit participation
- 2 main drivers:
  1. More expensive liability portfolio as low-guarantee contracts lapse
  2. PV(Liabilities) - Recovery Value $\gtrless 0$:
     - Increase vs. reduction in own funds upon lapse
     - Up- vs. down-shock capital requirement for lapse
     - Highly sensitive towards RoA forecast

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Thank you for your attention

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Backup

Calibration of lapse rates

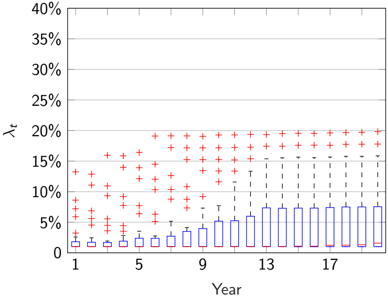
Average lapse rate in year t based on German environment:

$$\tilde{\lambda}_t = \log\left(\lambda_t - a\right)$$
$$= c + \log\left(\frac{1}{\sum_h n_t^h}\right) + \log\left(\sum_h n_t^h e^{-e^{d_1 \Delta r_t^h + d_2 \Delta T_t^h}}\right) \sim \mathcal{N}\left(\mu_t,\, \sigma_t^2\right)$$

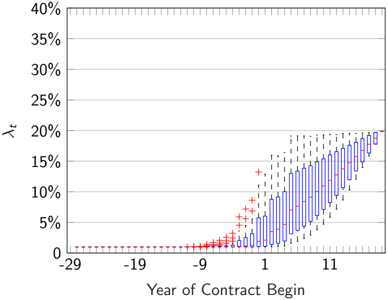
Observations: Log excess average German lapse rates $L_1, \ldots, L_n$.

1) Repeat until convergence of μ_c and σ_c ($c \sim \mathcal{N}(\mu_c, \sigma_c^2)$):
   a) $d_1 = \arg\min \sum_t \left(\tilde{\lambda}_t - L_t\right)^2$
   b) Update μ_c and σ_c via ML estimators
2) If $\tilde{\lambda}_{2015}(model) < 0.0286 - \varepsilon$, increase d_2 and go to 1).
   Else: Return.

Environment (1): Lapse



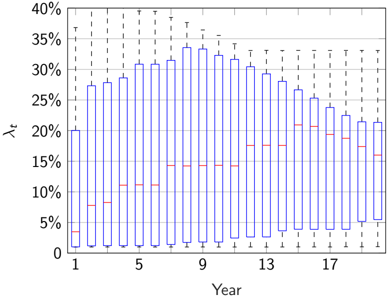
(a) Over time.



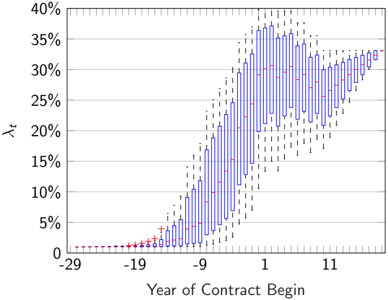
(b) Over cohorts.

- First: Large guarantee contract mature and lapse rates slightly increase
- Then: Lapse rates mainly depend on contract duration since $r_G \approx r_{rf}$

Environment (2): Lapse



(a) Over time.



(b) Over cohorts.