# Regulation-induced Interest Rate Risk Exposure

Maximilian Huber

NYU Student Macro Lunch

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# Research Question

- How exposed are life insurers to interest rate risk?
- Naturally exposed through their business:
  - Liabilities: long-term mortality insurance policies and retirement savings vehicles $\Rightarrow$ 7% of household financial assets
  - Assets: bonds and mortgages $\Rightarrow$ more than 25% of corporate bonds
- Maturity matching? Potential for risk-shifting $\Rightarrow$ statutory regulation

# Findings

- Quantification: when interest rates fall by one-percentage-point...
    1. life insurers realize a capital loss of \$121 billion or 26% of capital in 2019.

       Regulatory micro data $\Rightarrow$ how long-term are the liabilities compared to assets?
    2. life insurers earn a half percentage point lower spread on newly issued policies.

       Incomplete pass-through from bond market interest rates to annuity interest rates
- Two exposures do not offset each other! Explanation:
    3. Model of a life insurer featuring statutory regulation $\Rightarrow$ statutory hedging motives overpower economic hedging motives!

       Empirical evidence, policy recommendations, learnings

# 0. Preliminaries

# Interest Rate Sensitivity

- Value $V$ of a risk-free bond: $$V = \sum_{h=1}^{\infty} e^{-h \cdot r_h} \cdot b_h$$

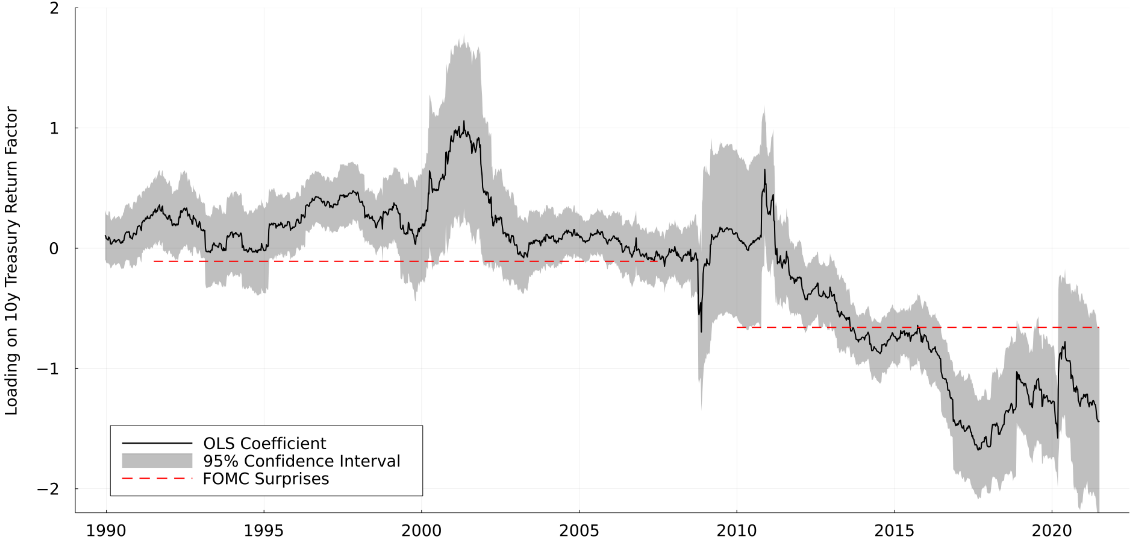
  where $b_h$ is the cash flows in $h$ years and $r_h$ is the corresponding Treasury yield.

- Contemplate a level shift $\Rightarrow$ Duration:

$$D_V = -\frac{1}{V}\frac{\partial V}{\partial r} = \frac{1}{V}\sum_{h=1}^{\infty} h \cdot e^{-h \cdot r_h} \cdot b_h$$

- Duration of a 10-year zero-coupon bond? 10 years.
- Value $E$ of a life insurer: $$E = \underbrace{A - L}_{\text{net assets}} + \underbrace{F}_{\text{franchise}}$$
- Duration:

$$D_E = \frac{A-L}{E} D_{A-L} + \frac{F}{E} D_F$$




Duration of Market Equity $D_E = 10 \cdot \beta^T$ in $rx_t^{\mathrm{L}} = \alpha + \beta^{\mathrm{M}} \cdot rx_t^{\mathrm{M}} + \beta^T \cdot rx_t^{\mathrm{T}} + \epsilon_t$

▸ $D_{A-L}$ ▸ FOMC Table ▸ FOMC w/o outliers ▸ FOMC timing ▸ FOMC Swanson ▸ Banks

# 1. Net Assets $A - L$

# Duration of Net Assets

- Duration of net assets $D_{A-L}$ and duration gap $G$:

$$D_{A-L} = -\frac{1}{A-L}\frac{\partial(A-L)}{\partial r} = \frac{A}{A-L}\underbrace{\left(D_A - \frac{L}{A}D_L\right)}_{=G} \gtrless 0$$

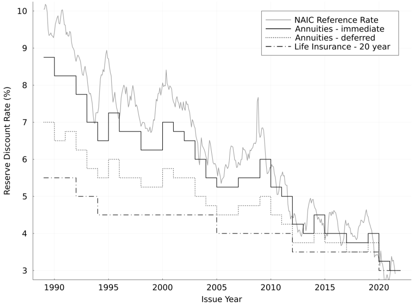
- Estimate $D_A$ from the transparent data on the assets.
- Estimate $D_L$ from the statutory accounting data on the liabilities.

# Actuarial and Reserve Value of a Liability

- Actuarial (fair) $V$ and reserve value $\hat{V}$ of a liability:

$$V_t = \sum_{h=1}^{\infty} e^{-h \cdot r_{t,h}} \cdot \mathbb{E}_t \left[ b_{t+h} \right] \qquad \hat{V}_t = \sum_{h=1}^{\infty} \left(1 + \hat{r}_S\right)^{-h} \cdot \hat{b}_{t+h}$$

where $\hat{r}_s$ is the reserve discount rate and $\hat{b}$ are reserve cash flows specific to a valuation standard $S$ prescribed by regulation.




- Pseudo-actuarial value:

$$\tilde{V}_t = \sum_{h=1}^{\infty} e^{-h \cdot r_{t,h}} \cdot \hat{b}_{t+h}$$

- Popular policies: $\tilde{V}_t \approx V_t$ and $\tilde{D}_t \approx D_t$! Examples

# Data

- Need $\hat{b}$ for the pseudo-actuarial value and duration!
- Back out from reserve values $\hat{V}$:

$$\hat{V}_{i,t,S} = \left(1 + \hat{r}_S\right)^{-1} \hat{b}_{i,t+1,S} + \left(1 + \hat{r}_S\right)^{-1} \hat{V}_{i,t+1,S}$$

- "Exhibit 5 - Aggregate Reserves for Life Contracts":
  - at the end of year $t$ from 2001 to 2020
  - for each life insurer $i$ out of 900
  - aggregated to valuation standard $S$ (mortality table, reserve discount rate $\hat{r}$, issue years)

| 1<br>Valuation Standard | 2<br>Total | |
|---|---|---|
| **Life Insurance:** | | **Life Insu** |
| 0100001. 58 CSO - NL 2.50% 1961-1969 | 243,737 | 0100001 |
| ⋮ | ⋮ | |
| 0100025. 80 CSO - CRVM 4.50% 1998-2004 | 306,242,662 | 0100025 |
| ⋮ | ⋮ | |
| 0100037. 01CSO CRVM - ANB 4.00% 2009 | 869,698 | 0100037 |
| 0199997. Totals (Gross) | 466,142,285 | 0199997 |
| 0199998. Reinsurance ceded | 339,424,855 | 0199998 |
| 0199999. Totals (Net) | 126,717,430 | 0199999 |
| **Annuities (excluding supplementary contracts with life contingencies):** | | **Annuities** |
| 0200001. 71 IAM 6.00% 1975-1982 (Imm) | 359,802 | 0200001 |
| ⋮ | ⋮ | |
| 0200028. 83 IAM 7.25% 1986 (Def) | 188,675,689 | 0200028 |
| ⋮ | ⋮ | |
| 0200043. Annuity 2000 4.75% 2004 (Def) | 206,817,839 | 0200043 |
| ⋮ | ⋮ | |
| 0200047. Annuity 2000 4.50% 2010 (Def) | 1,731,459,797 | 0200047 |
| 0299997. Totals (Gross) | 9,676,901,276 | 0299997 |
| 0299998. Reinsurance ceded | 7,415,759 | 0299998 |
| 0299999. Totals (Net) | 9,669,485,517 | 0299999 |
| ⋮ | ⋮ | |
| 9999999. Totals (Net) - Page 3, Line 1 | 9,804,893,998 | 9999999 |

Exhibit 5 of the Great American Life Insurance Company in 2010

# Empirics of Reserve Decay

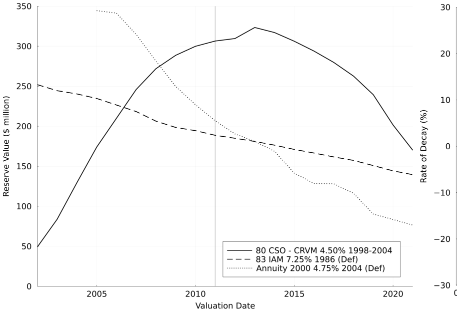
- Reserve decay has life-cycle pattern:

$$\frac{\hat{b}_{i,t,S}}{\hat{V}_{i,t-1,S}} = \Psi_{t-\tau,S} + \epsilon_{i,t,S}$$

  estimated by least squares weighted by $\hat{V}_{i,t-1,S}$.

- Estimated model yields predictions for $\hat{b}$. ▸ Richer Models
- Calculate pseudo-actuarial duration $D_L$.
- Duration gap:

$$G = D_A - \frac{L}{A} D_L$$

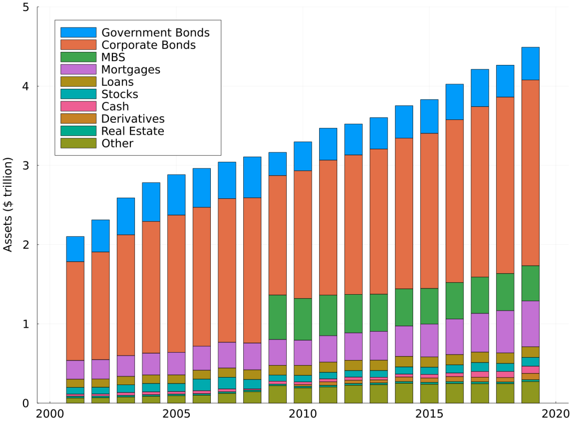



Evolution of selected reserve positions

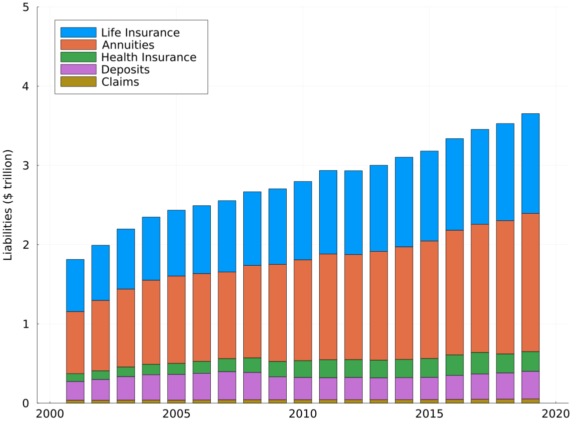
Estimated reserve decay

Duration of liabilities

# Net assets

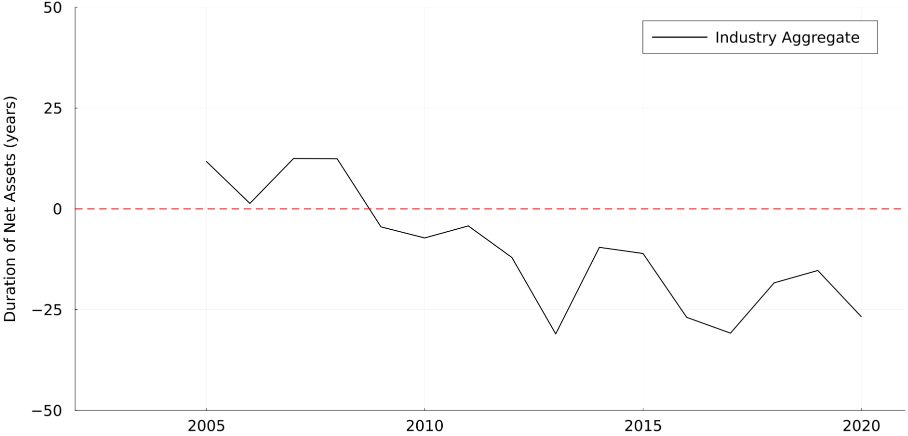


Assets ($ trillion)
Government Bonds
Corporate Bonds
MBS
Mortgages
Loans
Stocks
Cash
Derivatives
Real Estate
Other
0
1
2
3
4
5
2000
2005
2010
2015
2020

Liabilities ($ trillion)
Life Insurance
Annuities
Health Insurance
Deposits
Claims
0
1
2
3
4
5
2000
2005
2010
2015
2020

# Duration of Net Assets




Duration gap in 2019: $G = D_A - \frac{L}{A} D_L = -2.85$ implies $D_E = \frac{A}{E} G = -26$ with $A = \$4.24n$, and $E = \$0.47tn$

▸ Constant

# 2. Funding Franchise

# Incomplete Pass-Through: Annuity Rates

- How do the annuity interest rate react to a change of Treasury interest rates?

$$\Delta r^a_{t,h} = \alpha_h + \beta_h \cdot \Delta r^T_{t,h} + \epsilon_{t,h}$$

- How does the reserve discount rate react to a change of Treasury market interest rates?

$$\Delta \hat{r}^a_t = \alpha_h + \hat{\beta}_h \cdot \Delta r^T_{t,h} + \epsilon_{t,h}$$

Estimates $\hat{\beta} \approx 0.15$.

- Interest rates rise, economic spreads rise: $1 - \beta > 0$

▸ Term Structure ▸ Lower Rates ▸ Cross-section ▸ Concentration ▸ Net Gain ▸ More

# Recap

- When interest rates fall...
  1. life insurers realize a capital loss on their net assets.
  2. life insurers earn a lower spread on newly issued policies.

- What would make them to amplify rather than hedge these two exposures after 2010?
  - Towers Watson - Life Insurance CFO Survey #30 - June 2012
    - ★ "Almost all (97%) respondents consider interest rate risk a significant exposure for their company."
    - ★ "When considering interest rate exposure, respondents cited the level of statutory capital and earnings as the primary metrics for concern."

# Incomplete Pass-Through: Annuity Rates

- How do the annuity interest rate react to a change of Treasury interest rates?

$$\Delta r^A_{t,h} = \alpha_h + \beta_h \cdot \Delta r^T_{t,h} + \epsilon_{t,h}$$

  Estimates $\beta \approx 0.5$ are consistent with Charupat, Kamstra, and Milevsky (2016).

- How does the reserve discount rate react to a change of Treasury market interest rates?

$$\Delta \hat{r}^A_t = \alpha_h + \hat{\beta}_h \cdot \Delta r^T_{t,h} + \epsilon_{t,h}$$

  Estimates $\hat{\beta} \approx 0.15$.

- Interest rates rise, economic spreads rise: $1 - \beta > 0$, statutory spreads falls: $\hat{\beta} - \beta < 0$.

Term Structure | Lower Rates | Cross-section | Concentration | Net Gain | More

# 3. Model

# Model of a Life Insurer

- Partial equilibrium model of a life insurer:
  - chooses the duration of net assets
  - is subject to variation in economic earnings from issuing new policies
- Two reduced form financial frictions:
  - cost of operating with a volatile economic capital
  - cost of operating with a volatile statutory capital

# Model of a Life Insurer

- Static problem with exogenous, stochastic bond market interest rate $r$
- Life insurer issues annuity, pays interest rate $r^A$, and earns the spread $r - r^A$
- Life insurer chooses the duration of the legacy capital $D$:

$$\max_{D} \quad \mathbb{E}\left[r - r^A - C\left(R_K\right) - \hat{C}\left(R_{\hat{K}}\right)\right]$$

with reduced form costs $C(R_K) = \frac{\chi}{2} R_K^2$ and $\hat{C}(R_{\hat{K}}) = \frac{\hat{\chi}}{2} R_{\hat{K}}^2$.

- Economic capital return:

$$R_K = \underbrace{-D\left(r - \mathbb{E}\left[r\right]\right)}_{\text{return on legacy capital}} + \underbrace{r - r^A}_{\text{economic earnings}}$$

- Statutory capital return:

$$R_{\hat{K}} = \underbrace{-\psi D\left(r - \mathbb{E}\left[r\right]\right)}_{\text{return on legacy statutory capital}} + \underbrace{\hat{r} - r^A}_{\text{statutory earnings}}$$

# Duration of Net Assets

- First-order condition:

$$D = \frac{\chi(1-\beta) + \hat{\chi}\psi(\hat{\beta}-\beta)}{\chi + \psi^2\hat{\chi}}$$

- Without the regulatory friction $\hat{\chi} = 0$, the economic hedging motives prevail:

$$D = 1 - \beta > 0$$

- Without the economic friction $\chi = 0$, the statutory hedging motives prevail:

$$D = \frac{\hat{\beta} - \beta}{\psi} < 0$$

- The annuity interest rate reacts more to the bond market interest rate than the reserve discount rate does!

# Duration of Net Assets: Predictions

$$D = \frac{\chi(1-\beta) + \hat{\chi}\psi(\hat{\beta}-\beta)}{\chi + \psi^2\hat{\chi}}$$

- Reserve discount varies by policy type: $\hat{\beta}^{\text{life}} < \hat{\beta}^{\text{annuity}}$:

$$FL_{i,t} = \frac{(\text{Liabilities in Life Insurance Policies})_{i,t}}{(\text{Liabilities})_{i,t}}$$

- Higher statutory leverage increases $\hat{\chi}$.

$$Lev_{i,t} = \frac{(\text{Statutory Assets})_{i,t}}{(\text{Statutory Equity})_{i,t}}$$

- Larger life insurers have better access to capital and lower $\chi$:

$$LogA_{i,t} = \log\left((\text{Market Value of Assets})_{i,t}\right)$$

# Evidence

- What explains the cross section of the duration gaps?

$$G_{i,t} = \alpha_t + \gamma_{FL} FL_{i,t} + \gamma_{Lev} Lev_{i,t} + \gamma_{LogA} LogA_{i,t} + \gamma \cdot X_{i,t} + \epsilon_{i,t}$$

- What explains the panel of the duration gaps?

$$G_{i,t} = \alpha_i + \alpha_t + \gamma_{FL} FL_{i,t} + \gamma_{Lev} Lev_{i,t} + \gamma_{LogA} LogA_{i,t} + \gamma \cdot X_{i,t} + \epsilon_{i,t}$$

| | (1) | (2) |
|---|---|---|
| $FL$ | -12.323*** | -8.868*** |
| $Lev$ | -0.020*** | 0.002 |
| $LogA$ | -0.135*** | 0.826 |
| Mutual | -1.510*** | |
| $MktLev$ | -0.000 | -0.000 |
| Year FE | Yes | Yes |
| Life Insurer FE | | Yes |
| $N$ | 5,871 | 5,867 |
| $R^2$ | 0.332 | 0.804 |

Constant

# Evidence: Ex-ante Exposure

‘

- What explains the dynamics of the duration gaps?

$$
\begin{aligned}
G_{i,t} = & \alpha_i + \alpha_t + \\
& \gamma_{FL} FL_{i,2008} \times Post_t + \\
& \gamma_{Lev} Lev_{i,2008} \times Post_t + \\
& \gamma_{LogA} LogA_{i,2008} \times Post_t + \epsilon_{i,t}
\end{aligned}
$$

where $Post_t = 1$ after 2010.

| | (1) |
|---|---|
| $FL \times Post$ | -3.670** |
| $Lev \times Post$ | 0.004 |
| $LogA \times Post$ | 0.056 |
| *mutual* | -0.416 |
| *MktLev* | -0.003 |
| Life Insurer FE | Yes |
| Year FE | Yes |
| $N$ | 3,839 |
| $R^2$ | 0.751 |

# Recent Regulatory Reform

- Annuity reserve discount rate changed in 2018 with "VM-22":
  - replaced formula with 7 pages of text and formulas
  - based on the Treasury yields over previous quarter or even day $\Rightarrow$ higher $\hat{\beta}$!
- Life insurance policies reserve discount rate changed in 2020 with "VM-20":
  - based on yields on assets and prescribed mean reversion interest rate set by the state insurance commissioners
  - $\hat{\beta}$ depends on insurance commissioners $\Rightarrow$ make it responsive and be transparent about it!

# Literature Review

- Interest rate risk in banking: Begenau, Piazzesi, and Schneider (2020), Drechsler, Savov, and Schnabl (2017, 2021), Di Tella and Kurlat (forthcoming)
- Financial frictions and risk taking of life insurers: Becker and Ivashina (2015), Koijen and Yogo (2021)
- Risk management and accounting: DeMarzo and Duffie (1992), Heaton, Lucas, and McDonald (2010), Sen (2019)
- Overcoming balance sheet opacity: Gomez, Landier, Srear, and Thesmar (2021), Möhlmann (2021), Tsai (2009)
- Stability of life insurance liabilities: Chodorow-Reich, Ghent, and Haddad (2020), Ozdagli and Wang (2019)

# Conclusion

When interest rates fall:

1. life insurers realize a capital loss on their net assets
2. life insurers earn a lower spread on newly issued policies
3. life insurers want to hedge statutory earnings rather than economic earnings because of statutory regulation

Thank you!

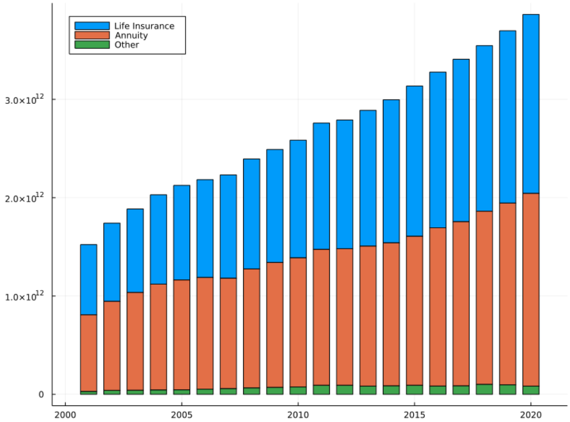
mjh635@nyu.edu

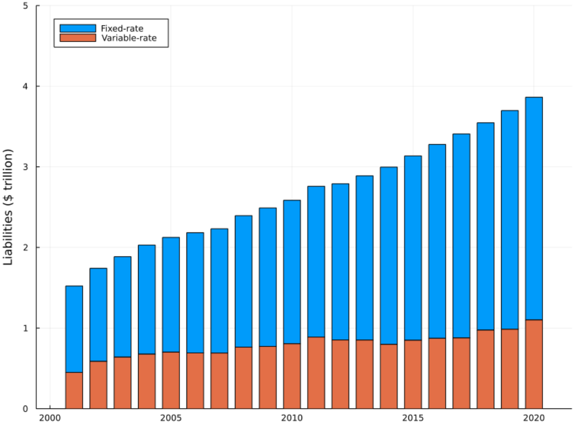
# Background

- Life insurers provide insurance against mortality and retirement saving vehicles.
- Assets: transparent!
  - Life insurance companies own assets of about \$7 trillion
  - 37% of life insurer's assets are invested in corporate and foreign bonds
  - Corporate and foreign bond debt \$15 trillion of which 22% are held by life insurers
- Liabilities: opaque!
  - Household financial assets of \$105 trillion: 13% deposits, 43% securities, 30% pension entitlements and life insurance
  - Guaranteed by state guaranty funds in the case of default
- Equity: many public/private stock companies, few large mutual companies

back

# Reserves

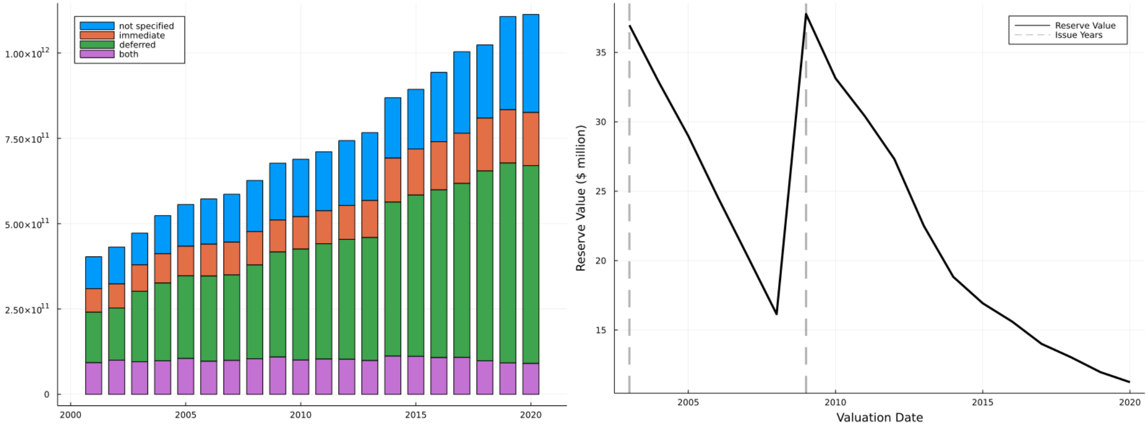



Composition of reserves

return

# Reserves




Composition of annuity reserves and the evolution of the A2000 6% Immediate reserve position of the Delaware Life Insurance Company

return

# Empirics of Reserve Decay

- Insurer-specific weighted-average decay $\hat{\lambda}_{i,t,S} = \frac{\hat{b}_{i,t,S}}{\hat{V}_{i,t-1,S}}$:

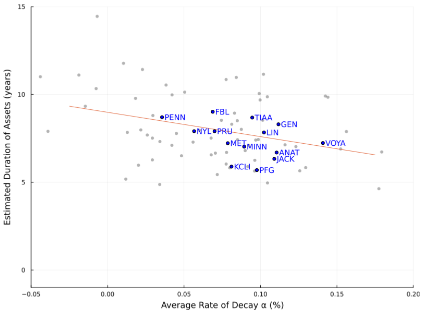
$$\hat{\lambda}_{i,t,S} = \alpha_i + \epsilon_{i,t,S}$$

weighted by the previous size of the reserve position.

- Life-cycle model of average reserve decay:

$$\hat{\lambda}_{i,t,S} = \Psi(t-\tau, S) + \epsilon_{i,t,S}$$

where $\Psi$ is as fixed effect which captures the average decay of a $t-\tau$ year old reserve position of type $S$.




Asset duration and average decay across life insurance companies

back

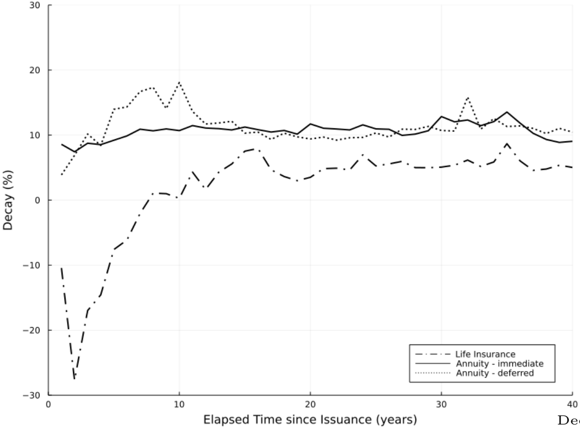
# Life-Cycle Reserve Decay

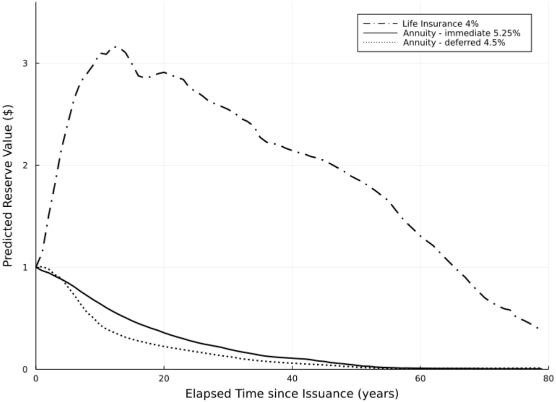
| | Rate of Decay $\lambda_{i,t,S,\tau}$ | | | | | |
|---|---|---|---|---|---|---|
| Decade | | 0.000 | -0.001 | -0.010*** | -0.000 | -0.007*** |
| $\Delta r^T_{t,\tau,10}$ | | | 0.171*** | 0.227*** | | |
| $\Delta r^T_{t,t-1,10}$ | | | | | -0.147*** | -0.113*** |
| Life-cycle FE | Yes | Yes | Yes | | Yes | |
| Finer Life-cycle FE | | | | Yes | | Yes |
| $N$ | 97,712 | 97,712 | 94,707 | 94,227 | 97,712 | 97,120 |
| $R^2$ | 0.286 | 0.286 | 0.286 | 0.350 | 0.286 | 0.349 |

Decay

back

# Life-Cycle Reserve Decay

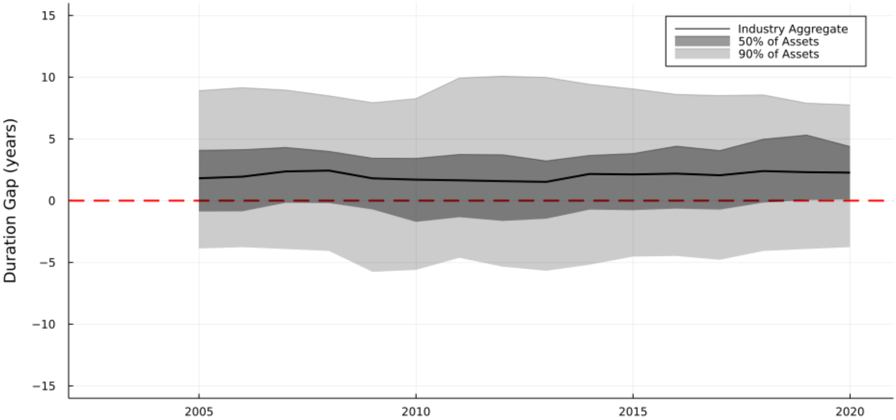



Decay

back

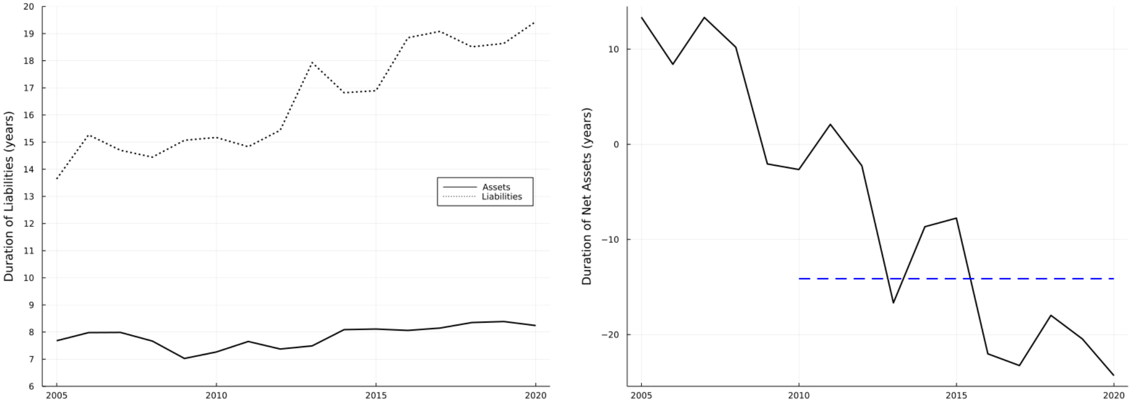
# Duration Gap under constant Interest Rates




Duration gap under constant 2004 interest rates $G = D_A - \frac{L}{A} D_L$

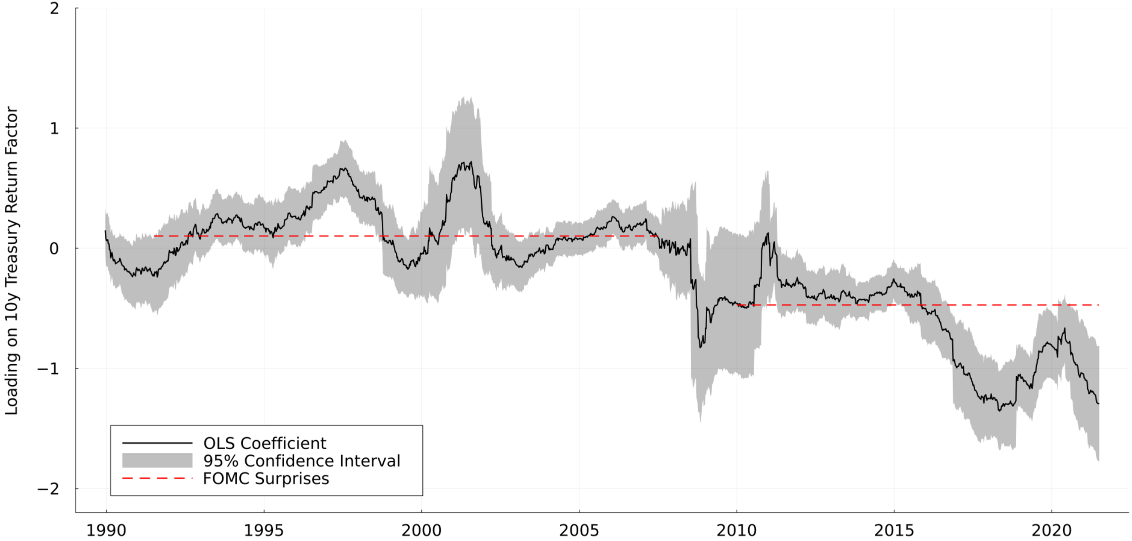
return

# Net Assets of publicly-traded Life Insurers




Duration of assets and liabilities of a set of publicly-traded life insurers

▸ return




Duration of Market Equity of Banks with FOMC Evidence

▸ return

| | $rx_t^L$ | | | | | |
|---|---|---|---|---|---|---|
| | Full | Before | After | Full | Before | After |
| $rx_t^{\mathrm{T}}$ | 0.492** | 0.017 | -0.672** | 0.407** | -0.109 | -0.658*** |
| | (0.234) | (0.176) | (0.336) | (0.163) | (0.132) | (0.170) |
| $rx_t^{\mathrm{M}}$ | | | | 1.588*** | 0.751*** | 1.543*** |
| | | | | (0.096) | (0.071) | (0.095) |
| Intercept | 0.004** | 0.002** | 0.001 | -0.001 | 0.000 | -0.000 |
| | (0.002) | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) |
| $N$ | 257 | 140 | 92 | 257 | 140 | 92 |
| $R^2$ | 0.017 | 0.000 | 0.042 | 0.525 | 0.447 | 0.757 |

Regressions on FOMC days

back

| | | | $rx_t^L$ | | | |
|---|---|---|---|---|---|---|
| | Full | Before | After | Full | Before | After |
| $rx_t^{\mathrm{T}}$ | -0.388** | 0.293 | -0.839** | -0.467*** | -0.155 | -0.677*** |
| | (0.178) | (0.207) | (0.329) | (0.120) | (0.156) | (0.191) |
| $rx_t^{\mathrm{M}}$ | | | | 1.332*** | 0.836*** | 1.491*** |
| | | | | (0.063) | (0.078) | (0.096) |
| Intercept | 0.003*** | 0.002** | 0.003* | -0.000 | 0.000 | 0.000 |
| | (0.001) | (0.001) | (0.002) | (0.001) | (0.001) | (0.001) |
| $N$ | 243 | 133 | 78 | 249 | 134 | 83 |
| $R^2$ | 0.019 | 0.015 | 0.079 | 0.660 | 0.467 | 0.787 |

Regressions on FOMC days excluding outliers

back

| | $rx_t^L$ | | | | | |
|---|---|---|---|---|---|---|
| | After 2009 | After 2010 | After 2011 | | After 2010 | |
| | | Until 2021 | | Until 2019 | Until 2020 | Until 2021 |
| $rx_t^{\mathrm{T}}$ | 0.307 | -0.658*** | -0.855*** | -0.526*** | -0.552*** | -0.658*** |
| | (0.256) | (0.170) | (0.186) | (0.165) | (0.165) | (0.170) |
| $rx_t^{\mathrm{M}}$ | 2.127*** | 1.543*** | 1.547*** | 1.520*** | 1.478*** | 1.543*** |
| | (0.177) | (0.095) | (0.095) | (0.107) | (0.105) | (0.095) |
| Intercept | 0.001 | -0.000 | -0.001 | -0.001 | -0.001 | -0.000 |
| | (0.002) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| $N$ | 100 | 92 | 84 | 72 | 80 | 92 |
| $R^2$ | 0.603 | 0.757 | 0.780 | 0.750 | 0.728 | 0.757 |

Regressions on FOMC days with different cut-off dates

back

| | $rx_t^L$ | | | | | |
|---|---|---|---|---|---|---|
| | Full | Before | After | Full | Before | After |
| $rx_t^{\mathrm{T}}$ | 1.044*** | 0.842** | -0.782* | 0.869*** | 0.262 | -1.048*** |
| | (0.349) | (0.347) | (0.463) | (0.329) | (0.286) | (0.302) |
| $rx_t^{\mathrm{M}}$ | | | | 0.504 | 0.689*** | 1.051*** |
| | | | | (0.400) | (0.169) | (0.395) |
| Intercept | 0.003* | 0.001 | 0.001 | 0.002 | -0.000 | -0.000 |
| | (0.002) | (0.001) | (0.002) | (0.002) | (0.001) | (0.001) |
| $N$ | 241 | 139 | 76 | 241 | 139 | 76 |
| $R^2$ | 0.008 | 0.016 | 0.011 | 0.277 | 0.414 | 0.630 |

Regressions on FOMC days with different cut-off dates

back

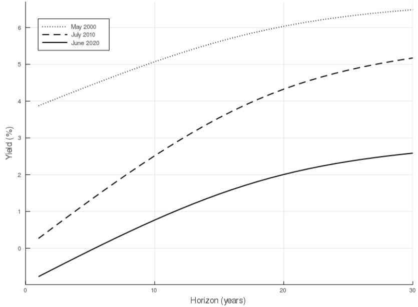
# Calculating the Yield Curve

- What term structure of interest rates $r$ rationalizes the observed prices of a menu of policies?

$$V_n^{term} = \sum_{h=1}^{n} e^{-h \cdot r_{t,h}} \cdot 1 \quad V_{age}^{life} = \sum_{h=1}^{\infty} e^{-h \cdot r_{t,h}} \cdot b_{age,h}$$

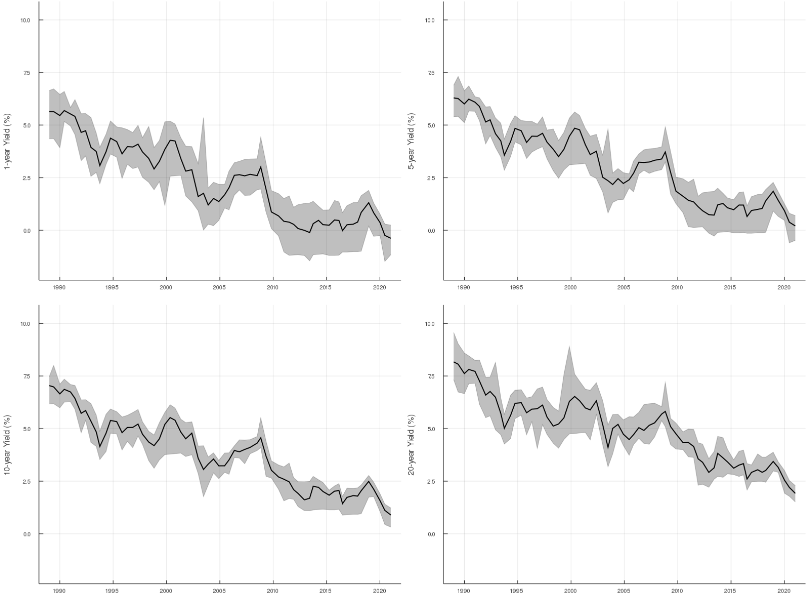
- Parametrize $r_{i,t,h}$ by imposing a B-spline on the forward rates for every insurer $i$, time $t$, and policy $j$:

$$P_{i,j,t} = V_{i,j,t} + \epsilon_{i,j,t}$$



Annuity yield curves

back


1-year Yield (%)
5-year Yield (%)
10-year Yield (%)
20-year Yield (%)
10.0
7.5
5.0
2.5
0.0
1990
1995
2000
2005
2010
2015
2020

return

# Incomplete Pass-Through: Reserve Interest Rate

- How does the reserve discount rate react to a change of bond market interest rates?

$$\hat{r}_t = 0.03 + 0.8 \cdot \left(\bar{r}^{\mathrm{NAIC}}_{June(t)-12,June(t)} - 0.03\right)$$

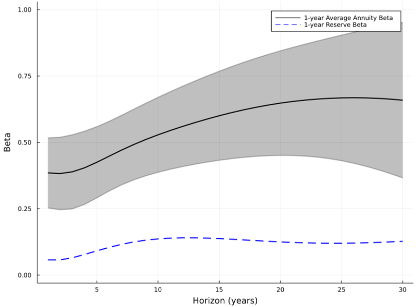
- Changes over the 1-year time interval:

$$\Delta r^a_{t,h} = \alpha_h + \beta_h \cdot \Delta r^b_{t,h} + \epsilon_{h,t}$$

$$\Delta \hat{r}_t = \alpha_h + \hat{\beta}_h \cdot \Delta r^b_{t,h} + \epsilon_{h,t}$$

- Annuities:

$$0.5 = \beta > \hat{\beta} = 0.13$$



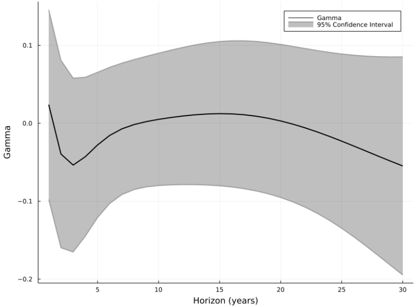

Pass-through to reserve discount rates

▸ return

# Incomplete Pass-Through: lower at lower rates?

- How does the annuity interest rate react to a change of bond market interest rates?

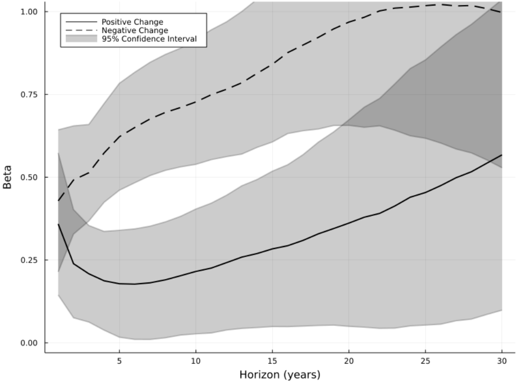
$$\Delta r^a_{t,h} = \alpha_h + \beta_h \cdot \Delta r^b_{t,h} + \gamma_h \cdot \Delta r^b_{t,h} \cdot r^b_{t,h} + \epsilon_{h,t}$$

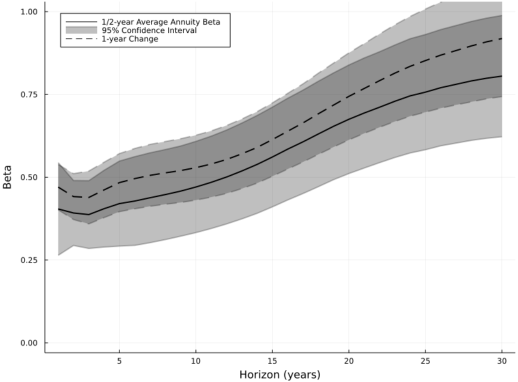



Pass-through to annuity rates at higher interest rates

return

# Incomplete Pass-Through

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# Market Concentration and Pass-Through

| | Annuity Spread | | | |
|---|---|---|---|---|
| | Levels $s$ | | Changes $\Delta s$ | |
| $r \cdot$ HHI | 0.022*** | 0.033*** | | |
| | (0.001) | (0.001) | | |
| $\Delta r \cdot$ HHI | | | 0.060*** | 0.082*** |
| | | | (0.006) | (0.006) |
| Horizon FE | Yes | Yes | Yes | Yes |
| Rating FE | | Yes | | Yes |
| $N$ | 13,290 | 13,290 | 13,290 | 13,290 |
| $R^2$ | 0.916 | 0.931 | 0.319 | 0.333 |

Cross-sectional pass-through related to a proxy for the insurance company specific market power: the average of Herfindahl-Hirschman indices of U.S. states weighted by the share of the collected premiums from a state to overall premiums. The regression specification is: $s_{i,t,h} = \gamma \cdot r_{t,h} \mathrm{HHI}_{i,t-1} + \beta_h \cdot r_{t,h} + Rating_{i,t} \cdot r_{t,h} + \epsilon_{i,t,h}$

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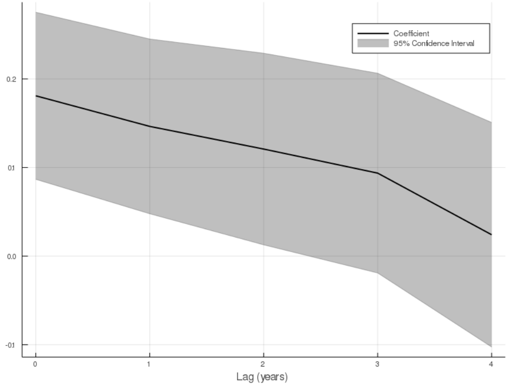
# Spread affects future Net Gain from Operations

The annuity spreads $s_{i,t,h}$ predicts the future net gain of operations:

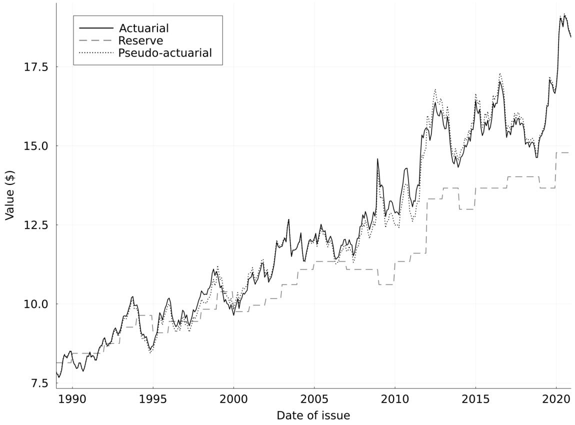
$$NetGain_{i,t+h} = Spread_{i,t} + \epsilon_{i,t}$$

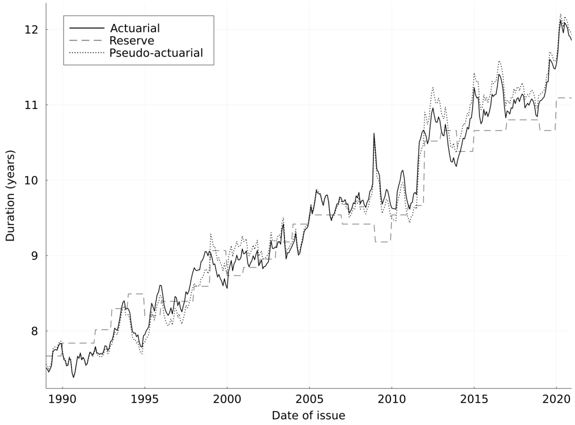
A higher annuity spread implies larger future profits!

◂ return



# Actuarial vs. Reserve vs. Pseudo-Actuarial

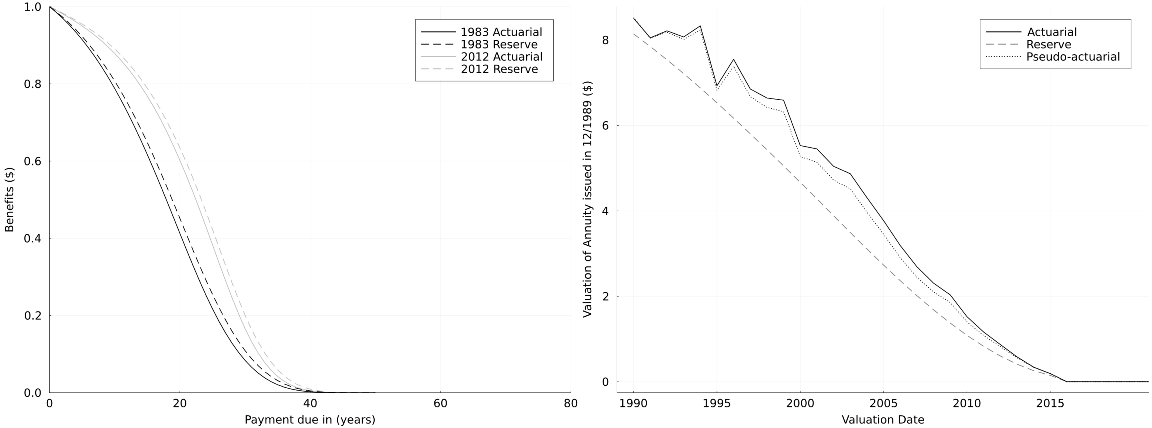



Valuation and duration at issuance for a life annuity for a 65-year-old male

▸ Cash flows and Life-cylce

# Actuarial vs. Reserve vs. Pseudo-Actuarial




Comparison of cash flows and and valuations after issuance in December 1989 for a life annuity for a 65-year-old male

return

# Indirect Evidence: Supplemental Information

- New York-based life insurance companies have to file the “Analysis of Valuation Reserves” supplement to the annual statement
  - How well does the annual income align with the predicted cash flow?

| | | | Total | |
|---|---|---|---|---|
| | VALUATION STANDARD | Location in last year's analysis of valuation reserves Line No. | Annual Income(a) (000 Omitted) | Reserve |
| 0200014. | 83 Table 'A'; 9.50%; Imm.; 1981 | 200015 | 56 | 106,355 |
| 0200015. | 83 Table 'A'; 7.65%; Imm.; 1984 | 200017 | 457 | 1,634,586 |
| 0200016. | 83 Table 'A'; 7.65%; Imm.; 1985 | 200018 | 1,850 | 10,263,129 |
| 0200017. | 83 Table 'A'; 7.65%; Imm.; 1986 | 200019 | 1,696 | 7,104,998 |
| 0200018. | 83 Table 'A'; 7.65%; Imm.; 1987 | 200020 | 2,307 | 9,379,066 |
| 0200019. | 83 Table 'A'; 7.65%; Imm.; 1988 | 200021 | 2,566 | 10,575,657 |
| 0200020. | 83 Table 'A'; 7.65%; Imm.; 1989 | 200022 | 3,913 | 16,526,073 |
| 0200021. | 83 Table 'A'; 7.65%; Imm.; 1990 | 200023 | 4,933 | 22,012,788 |
| 0200022. | 83 Table 'A'; 7.50%; Imm.; 1991 | 200024 | 2,169 | 10,523,236 |
| 0200023. | 83 Table 'A'; 7.00%; Imm.; 1992 | 200025 | 2,426 | 10,323,403 |
| 0200024. | 83 Table 'A'; 6.00%; Imm.; 1993 | 200026 | 2,559 | 10,382,114 |
| 0200025. | 83 Table 'A'; 6.50%; Imm.; 1994 | 200027 | 4,363 | 20,934,023 |
| 0200026. | 83 Table 'A'; 6.50%; Imm.; 1995 | 200028 | 5,904 | 32,589,468 |
| 0200027. | 83 Table 'A'; 6.00%; Imm.; 1996 | 200029 | 5,559 | 29,913,379 |

Supplement of the New York Life Insurance Company in 2011

return

# Effect of Market Rates on Policyholder Behaviour

- Model with policyholder behaviour:

$$\bar{b}_{i,t,S} = \Psi(t - \tau, S) + \delta \cdot \Delta r_{t,\tau,10} + \epsilon_{i,t,S}$$

- The change in the market interest rate since the issuance of the policy may make the outside option more or less attractive.
- A one-percent increase leads to a 0.16 percent higher rate of decay.
- The policyholder behavior has a marginal effect on the duration of the liabilities!

| | $\bar{b}$ | |
|---|---|---|
| | (1) | (2) |
| $t$ in decades | 0.003*** | 0.003*** |
| | (0.000) | (0.000) |
| $\Delta r^{Treasury}_{t,\tau,10}$ | -0.008 | |
| | (0.022) | |
| $\Delta r^{HQM}_{t,\tau,10}$ | | -0.017 |
| | | (0.024) |
| $N$ | 90,954 | 90,954 |
| $R^2$ | 0.355 | 0.355 |

return

# Evidence under Constant Interest Rates

- Omitted variable bias:
  falling interest rates mechanically increase the duration of life insurance policies!
- Evaluate all objects under constant 2004 interest rates.

$$G_{i,t} = \alpha_t + \gamma_{FL} FL_{i,t} + \gamma_{Lev} Lev_{i,t} + \gamma_{LogA} LogA_{i,t} + \gamma \cdot X_{i,t} + \epsilon_{i,t}$$

$$G_{i,t} = \alpha_i + \alpha_t + \gamma_{FL} FL_{i,2008} + \gamma_{Lev} Lev_{i,t} + \gamma_{LogA} LogA_{i,t} + \gamma \cdot X_{i,t} + \epsilon_{i,t}$$

| | (1) | (2) |
|---|---|---|
| *FL* | -6.260*** | -4.577** |
| *Lev* | -0.022*** | -0.005 |
| *LogA* | -0.057 | 1.002 |
| *mutual* | -1.356*** | |
| *MktLev* | -0.021** | -0.003 |
| Year FE | Yes | Yes |
| Life Insurer FE | | Yes |
| *N* | 5,868 | 5,864 |
| $R^2$ | 0.298 | 0.758 |

return