Regulation-Induced Interest Rate Risk Exposure

Maximilian Huber

January 2022

Interest Rate Sensitivity of Life Insurers' Stock Prices has increased

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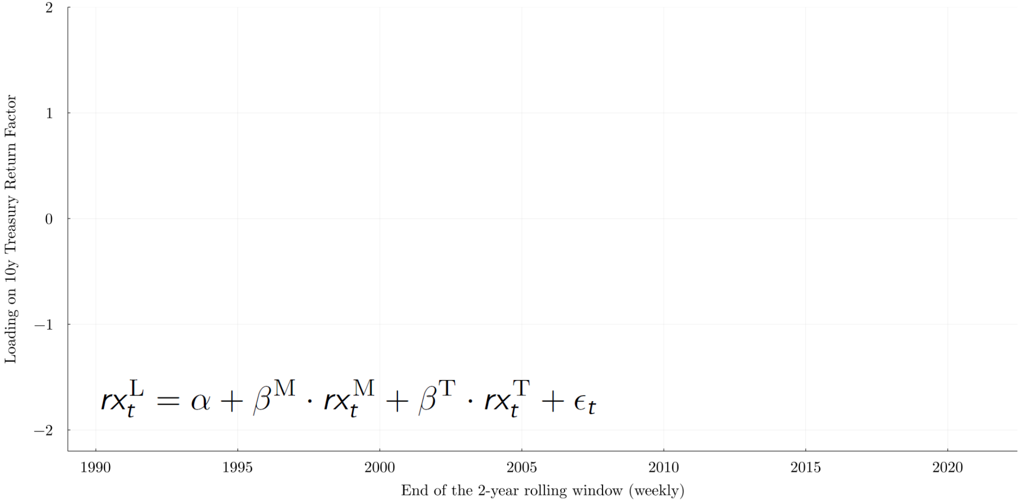

$$rx_t^{\mathrm{L}} = \alpha + \beta^{\mathrm{M}} \cdot rx_t^{\mathrm{M}} + \beta^{\mathrm{T}} \cdot rx_t^{\mathrm{T}} + \epsilon_t$$

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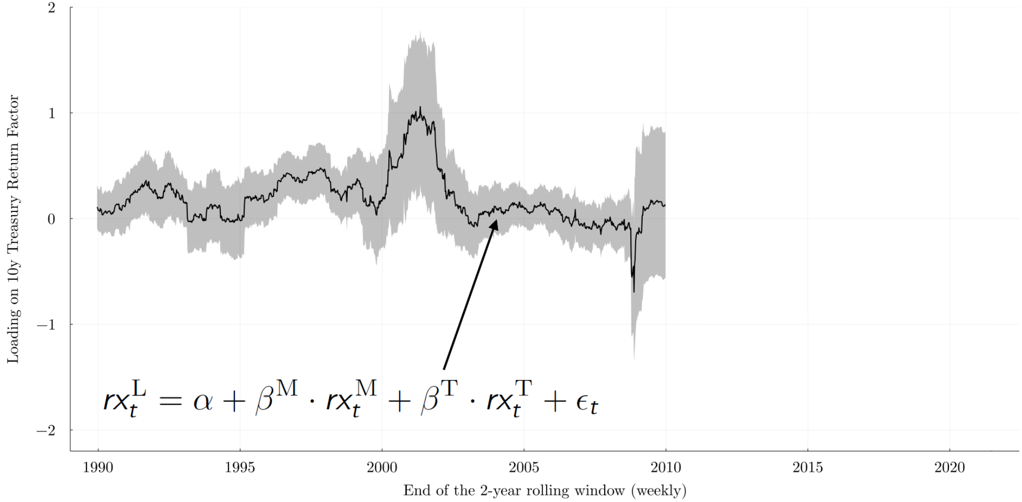

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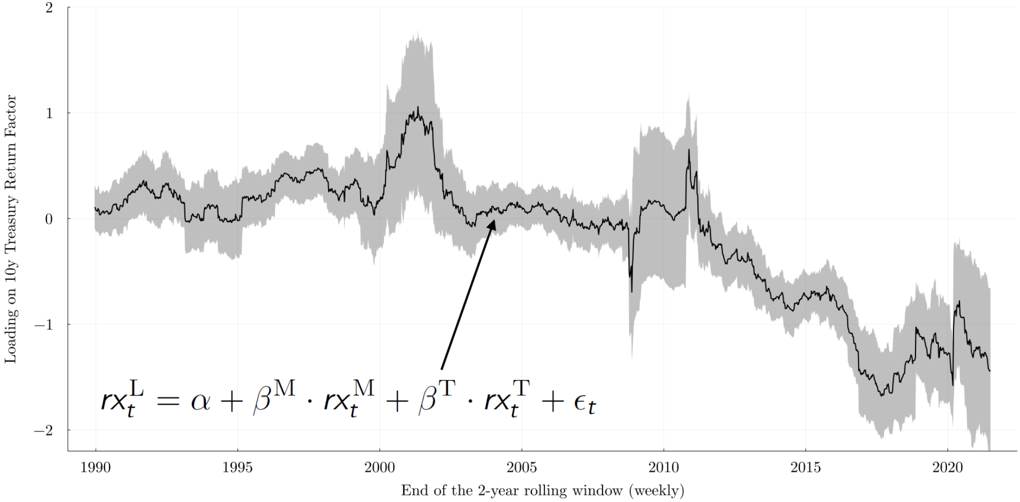

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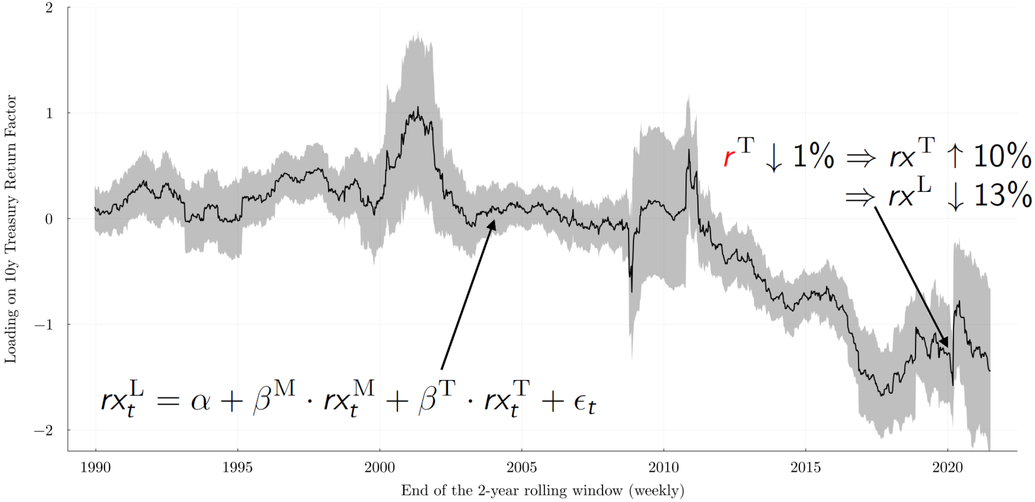

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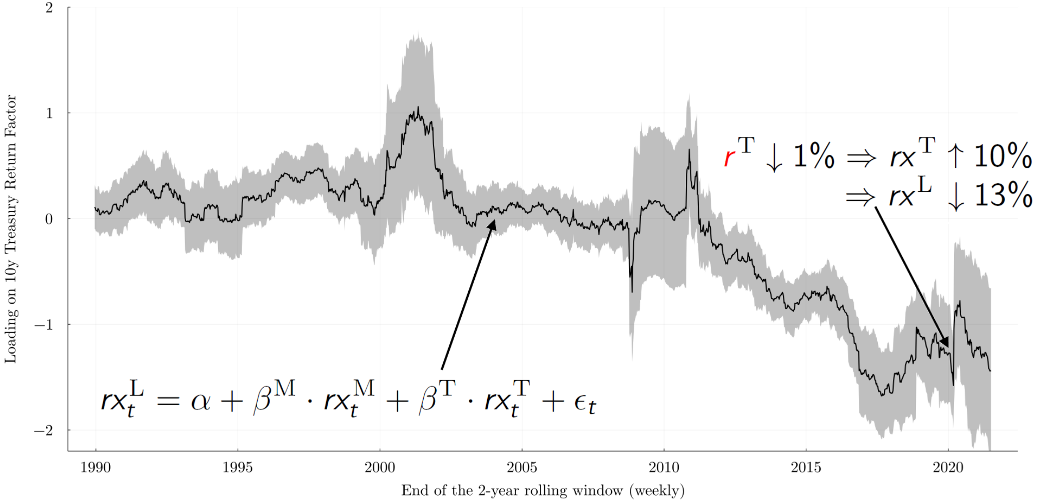

FOMC scatter | FOMC table | FOMC w/o outliers | FOMC timing | FOMC Swanson | Banks

Interest Rate Sensitivity: Concepts and Notation

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       Empirical evidence, policy recommendations, broader implications

Contributions to the Literature

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- Risk management and regulation: Sen (2021)
  ⇒ regulatory treatment of franchise

1. Net Assets $A - L$

Duration of Net Assets

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

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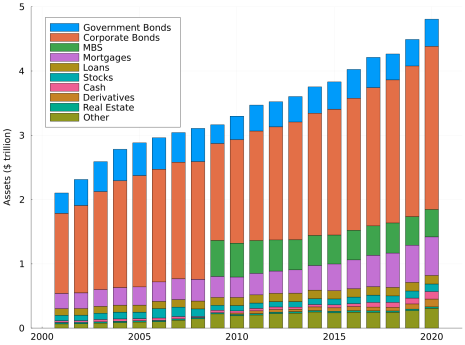
- Estimate D_L from the opaque statutory accounting data on the liabilities

Duration of Assets



Asset allocation (*Source: ACLI*)

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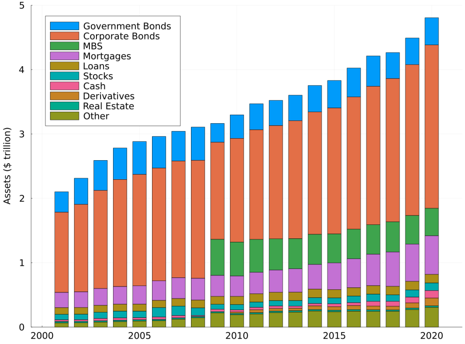

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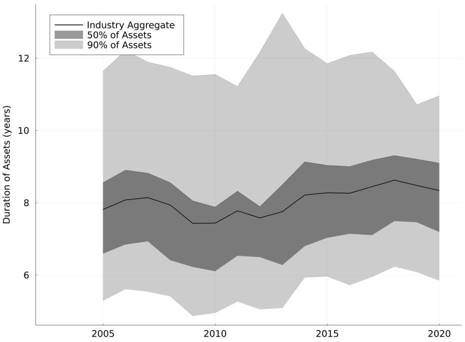

Duration of assets

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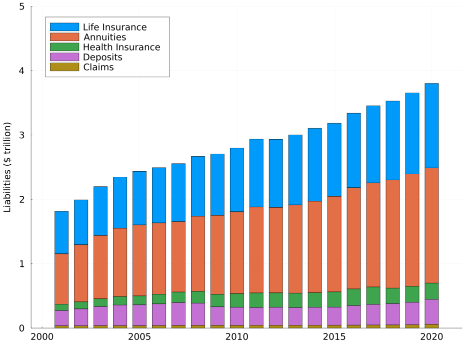

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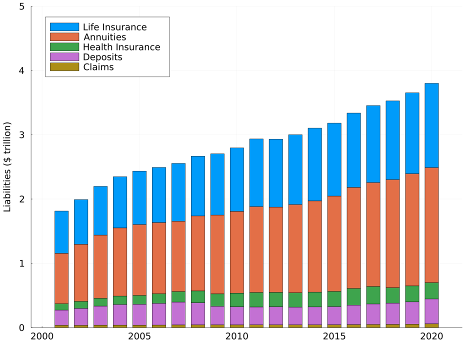

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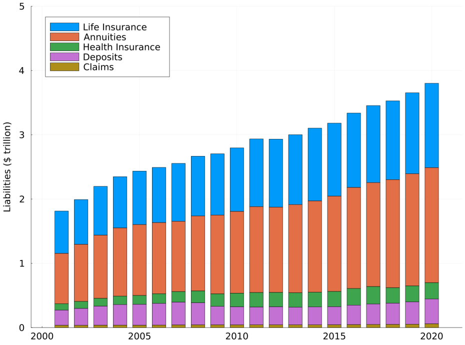

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  - at the end of year t from 2001 to 2020
  - for each life insurer i out of 900

1 Valuation Standard	2 Total
Life Insurance:	
0100001. 58 CSO - NL 2.50% 1961-1969	243,737
⋮	⋮
0100025. 80 CSO - CRVM 4.50% 1998-2004	306,242,662
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0100037. 01CSO CRVM - ANB 4.00% 2009	869,698
0199997. Totals (Gross)	466,142,285
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Annuities (excluding supplementary contracts with life contingencies):	
0200001. 71 IAM 6.00% 1975-1982 (Imm)	359,802
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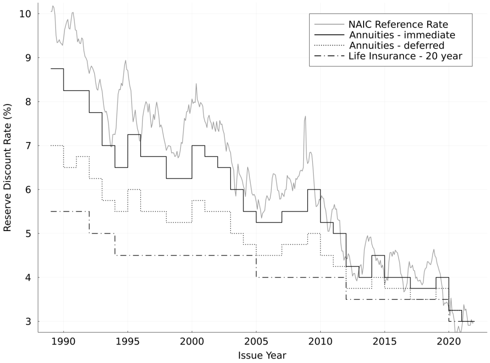

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with *reserve disount rate* $\hat{r}$ constant after issuance

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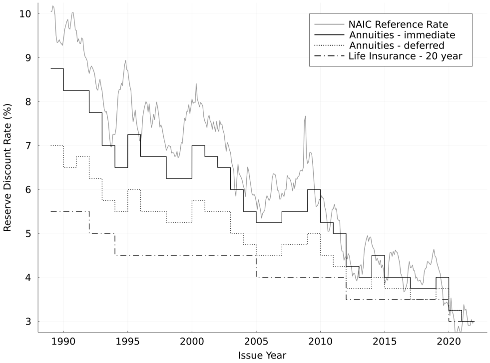

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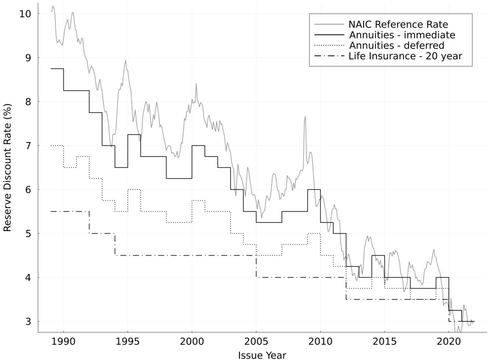

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Duration of Liabilities: Reserve Evolution

- Need $\hat{b}$ to calculate $\tilde{V}$ and $\tilde{D}$

1 Valuation Standard	2 Total
Life Insurance:	
0100001. 58 CSO - NL 2.50% 1961-1969	243,737
⋮	⋮
0100025. 80 CSO - CRVM 4.50% 1998-2004	306,242,662
⋮	⋮
0100037. 01CSO CRVM - ANB 4.00% 2009	869,698
0199997. Totals (Gross)	466,142,285
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9999999. Totals (Net) - Page 3, Line 1	9,804,893,998

Exhibit 5 of the Great American Life Insurance Company in 2010

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- Back out from reserve values $\hat{V}$:

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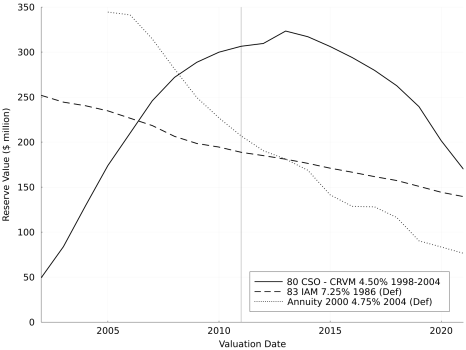

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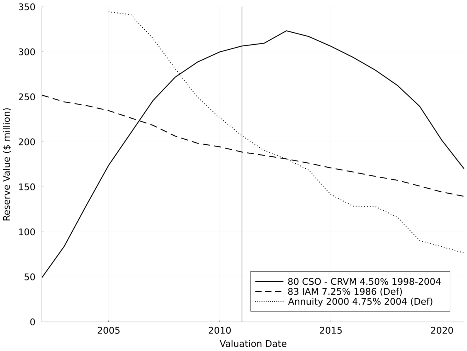

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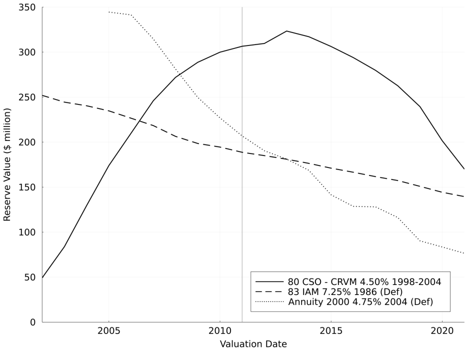

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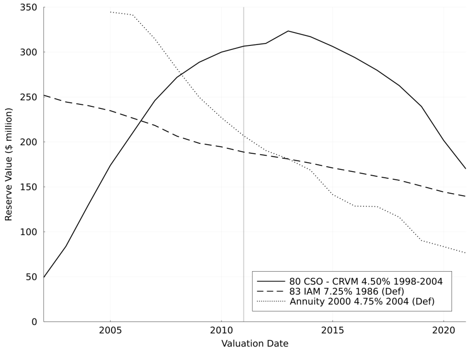

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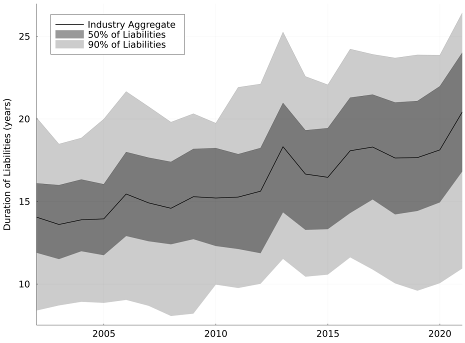
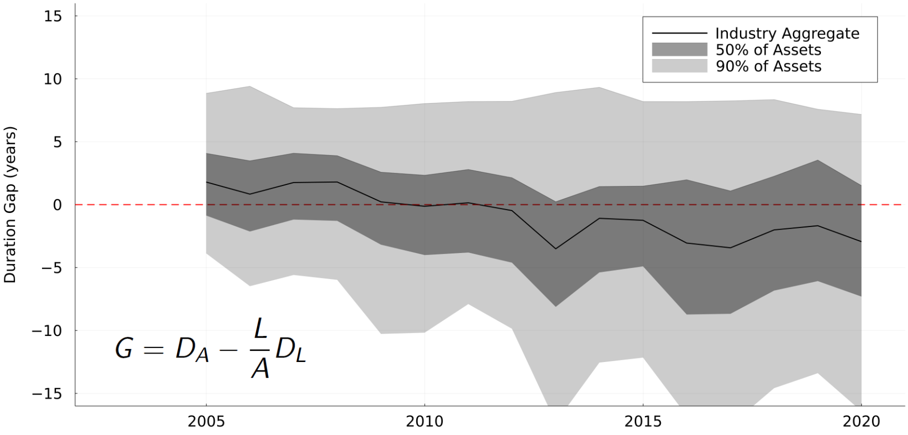


Duration of liabilities

Duration Gap



Duration of net assets in 2019: $D_{A-L} = \frac{A}{A-L} G = -26$ with $A = \$4.24tn$, and $L = \$3.77tn$

2. Franchise

Annuity Yield Curve: Data & Estimation

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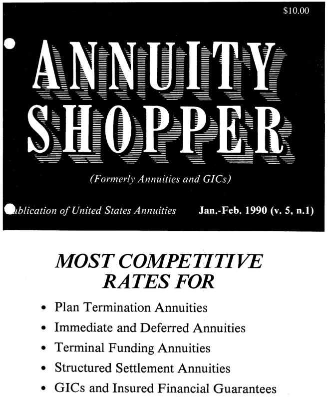

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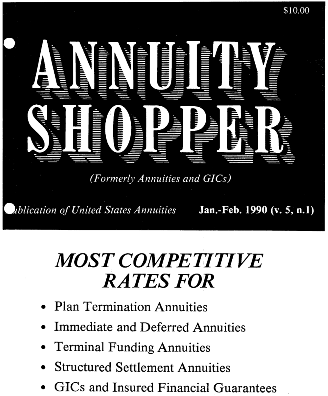
$10.00

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(Formerly Annuities and GICs)

ublication of United States Annuities Jan.-Feb. 1990 (v. 5, n.1)

MOST COMPETITIVE RATES FOR

- Plan Termination Annuities
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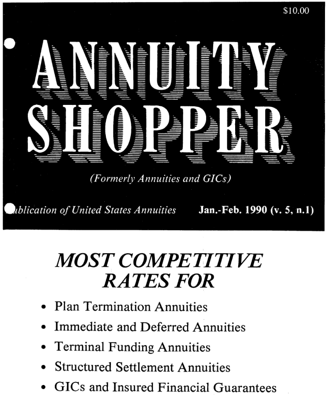
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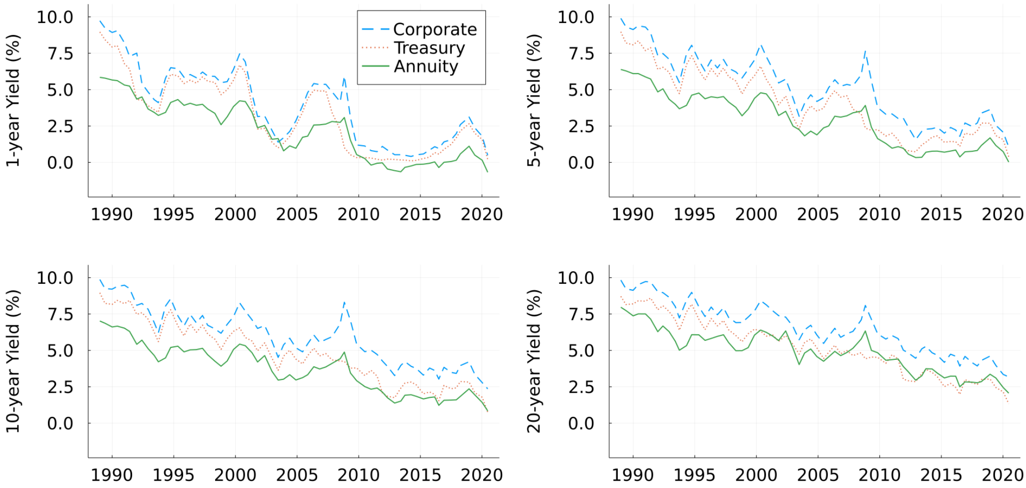

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3. Regulatory Hedging

Model: Setup

- Static model of a life insurer issuing one new policy

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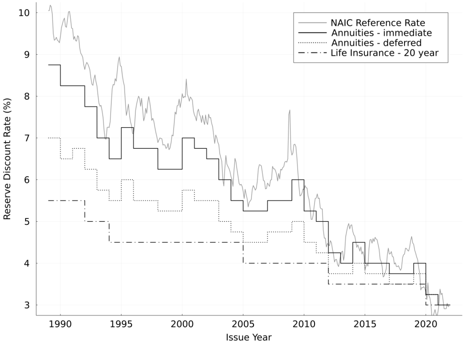

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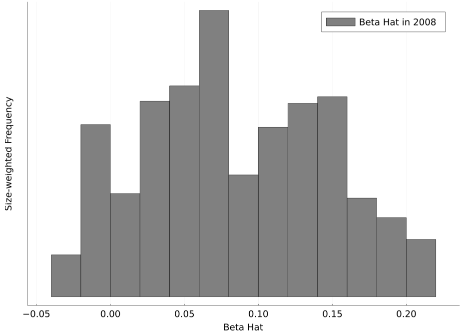

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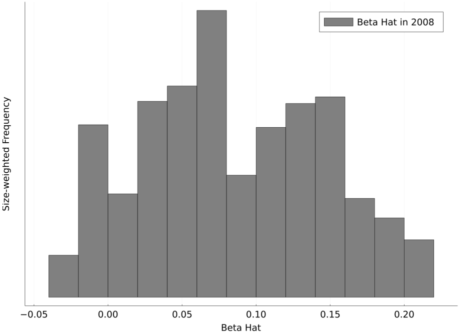
- Effect on duration gap G:

$$G_{i,t} = \gamma_{\hat{\beta}} \hat{\beta}_{i,2008} \times Post_t + \gamma X_{i,t} + \alpha_i + \alpha_t + \epsilon_{i,t}$$

with $Post_t = 1$ starting 2012.



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	(5.628)
Controls	Yes
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Summary

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- Stability of life insurers' liabilities as source of funding

Thank you!

mjh635@nyu.edu

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back

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

Evidence: Ex-ante Exposure to $\hat{\beta}$

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

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$$G_{i,t} = \alpha_i + \alpha_t + \gamma_{FL} FL_{i,2008} \times Post_t + \gamma \cdot X_t + \epsilon_{i,t}$$

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	(1)
$FL \times Post$	-3.670**
Controls	Yes
Life Insurer FE	Yes
Year FE	Yes
N	3,839
R^2	0.751

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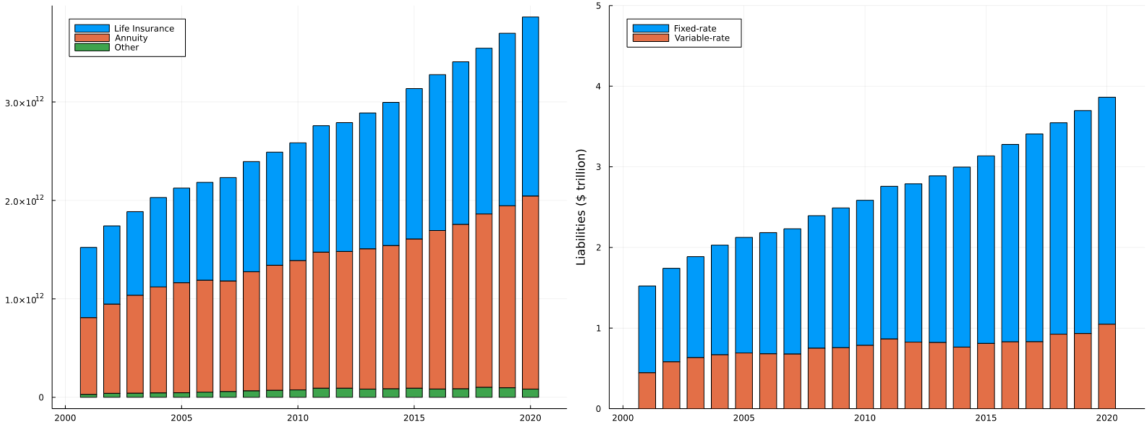
- Equity: many public/private stock companies, few large mutual companies

back

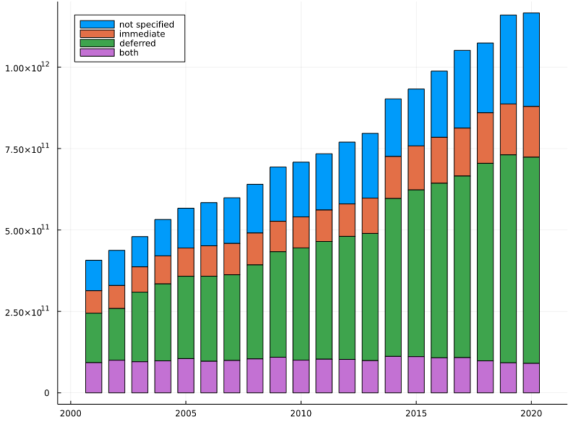
Reserves

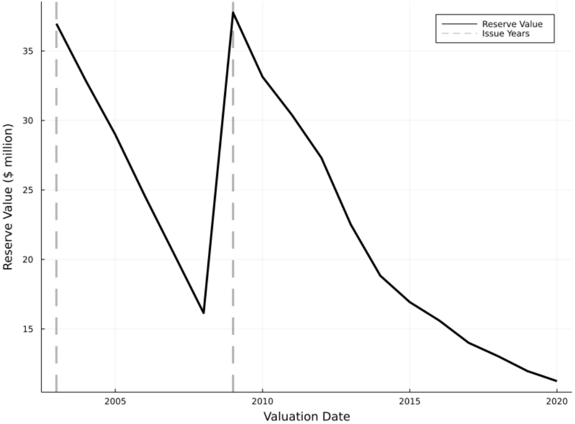


Composition of reserves

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 $\hat{\lambda}_{i,t,S} = \frac{\hat{b}_{i,t,S}}{\hat{V}_{i,t-1,S}}$:

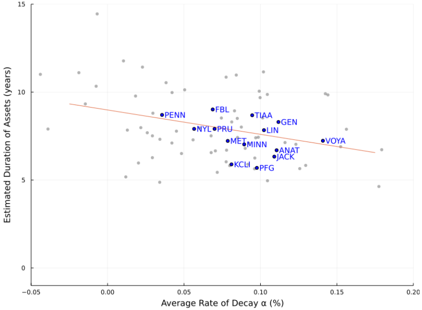
$$\hat{\lambda}_{i,t,S} = \alpha_i + \epsilon_{i,t,S}$$

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 Ψ 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

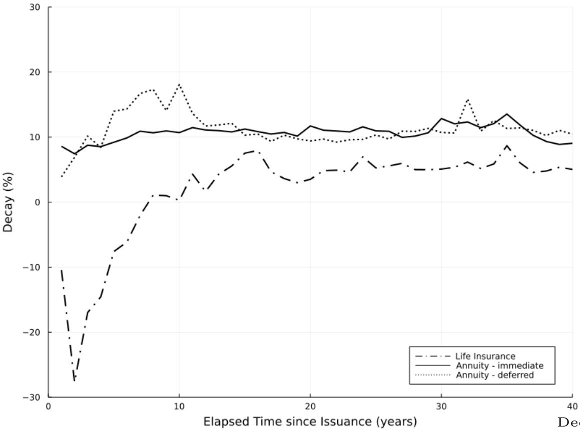
Life-Cycle Reserve Decay

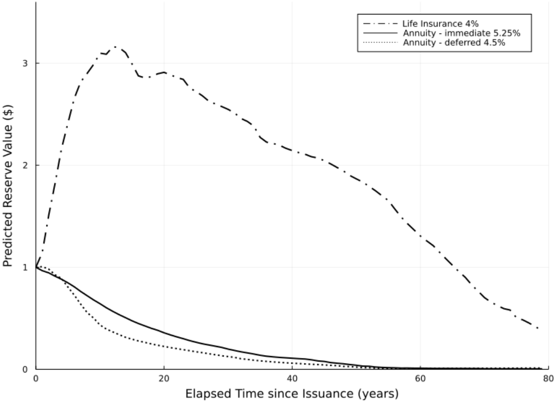
	Rate of Decay $\lambda_{i,t,S,\tau}$					
Decade		0.000	-0.001	-0.010***	-0.000	-0.007***
$\Delta r^T_{t,\tau,10}$			0.171***	0.227***		
$\Delta r^T_{t,t-1,10}$					-0.147***	-0.113***
Life-cycle FE	Yes	Yes	Yes		Yes	
Finer Life-cycle FE				Yes		Yes
N	97,712	97,712	94,707	94,227	97,712	97,120
R^2	0.286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

Decay

back

Life-Cycle Reserve Decay

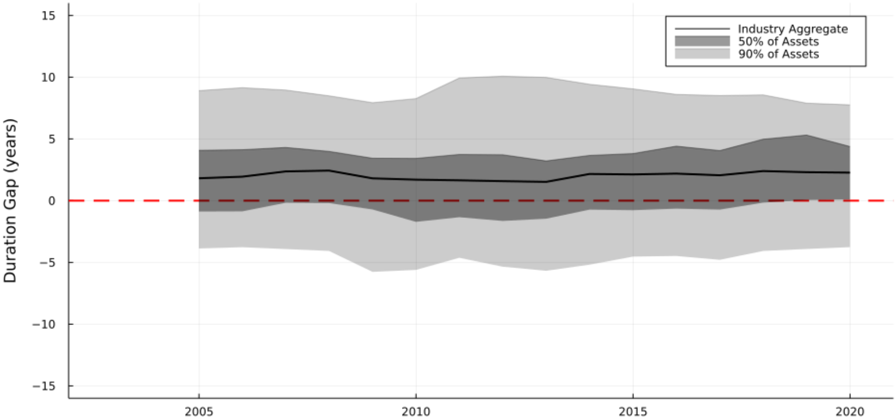




Decay

back

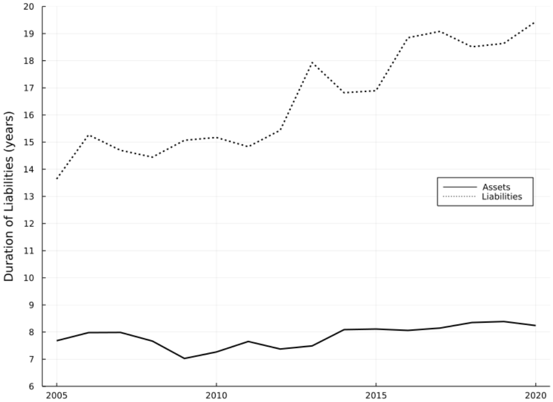
Duration Gap under constant Interest Rates



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

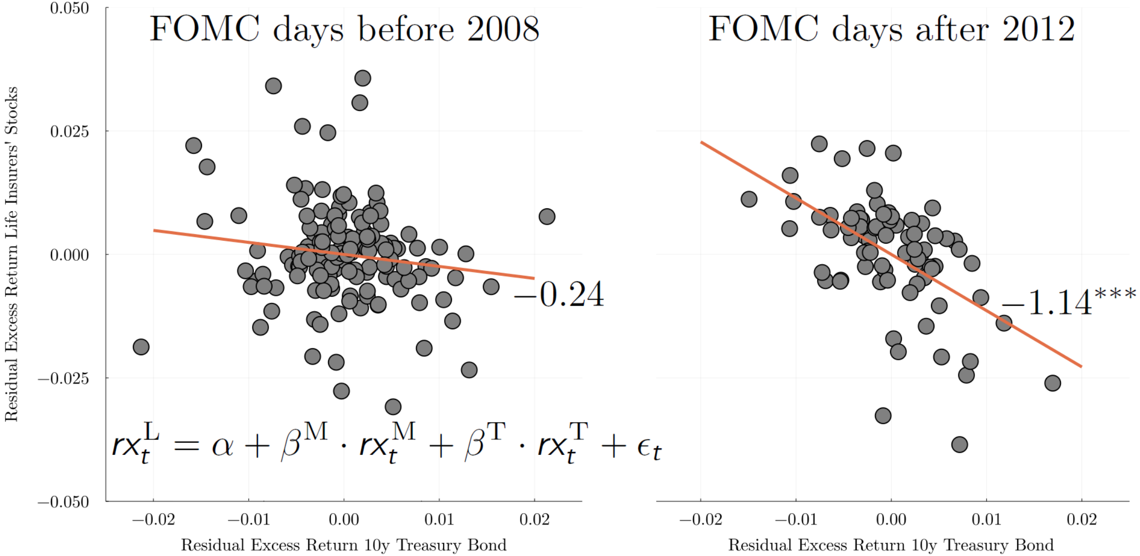
return

Net Assets of publicly-traded Life Insurers

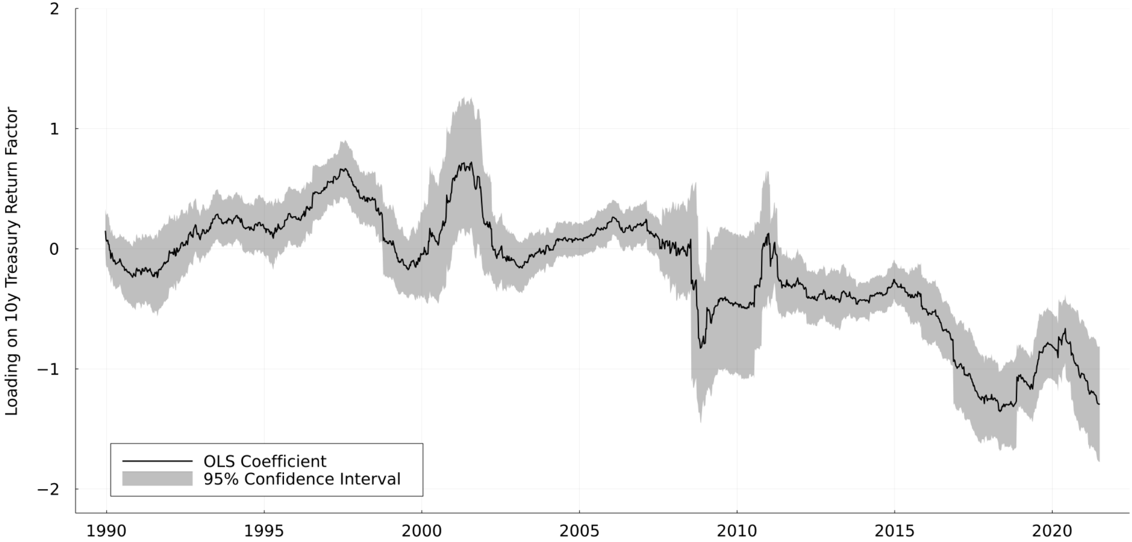


Duration of assets and liabilities of a set of publicly-traded life insurers

return


FOMC days before 2008
FOMC days after 2012
Residual Excess Return Life Insurers' Stocks
0.050
0.025
0.000
−0.025
−0.050
−0.02
−0.01
0.00
0.01
0.02
Residual Excess Return 10y Treasury Bond
−0.24
−1.14***
$$rx_t^{\mathrm{L}} = \alpha + \beta^{\mathrm{M}} \cdot rx_t^{\mathrm{M}} + \beta^{\mathrm{T}} \cdot rx_t^{\mathrm{T}} + \epsilon_t$$

▸ return



Interest rate sensitivity of life insurers' stock prices: β^T in 2-year rolling-window regression of weekly $rx_t^{\mathrm{B}} = \alpha + \beta^{\mathrm{M}} \cdot rx_t^{\mathrm{M}} + \beta^T \cdot rx_t^{\mathrm{T}} + \epsilon_t$

return begin   return end

	rx_t^L					
	Full	Before	After	Full	Before	After
rx_t^{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^{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^{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^{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^{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^{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^{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^{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

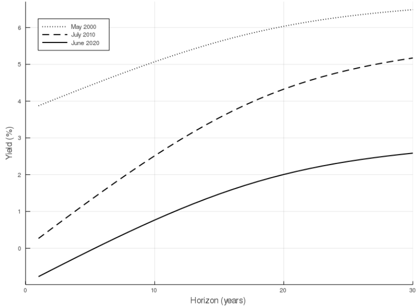
Calculating the Yield Curve

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

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

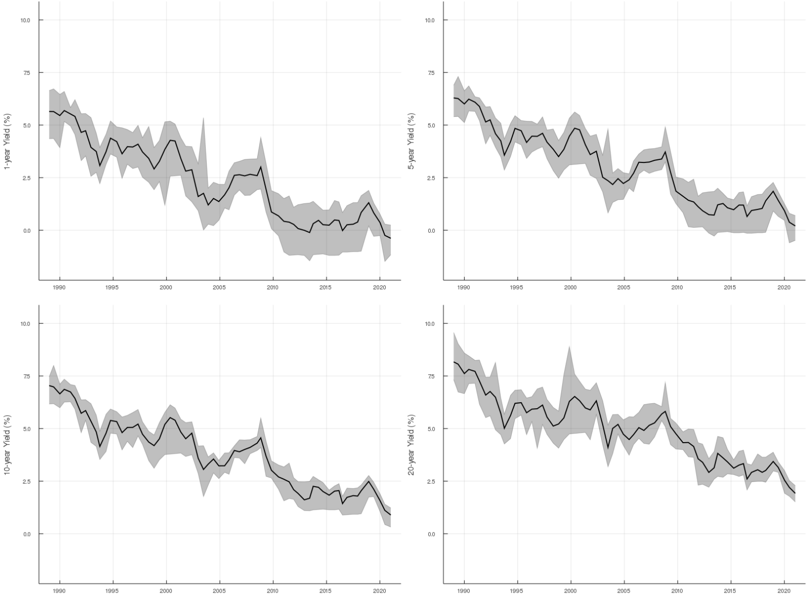
- Parametrize $r_{i,t,h}$ by imposing a B-spline on the forward rates for every insurer i, time t, and policy j:

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



Annuity yield curves

back


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

return

Incomplete Pass-Through: Reserve Interest Rate

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

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

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- Changes over the 1-year time interval:

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

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

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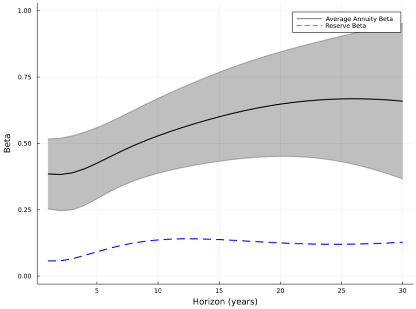


Pass-through to reserve discount rates

return

Incomplete Pass-Through: Reserve Interest Rate

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

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

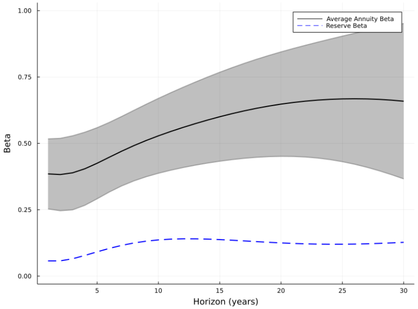
- Changes over the 1-year time interval:

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

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

- Annuities:

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



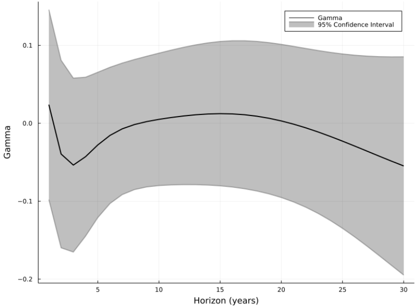
Pass-through to reserve discount rates

return

Incomplete Pass-Through: lower at lower rates?

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

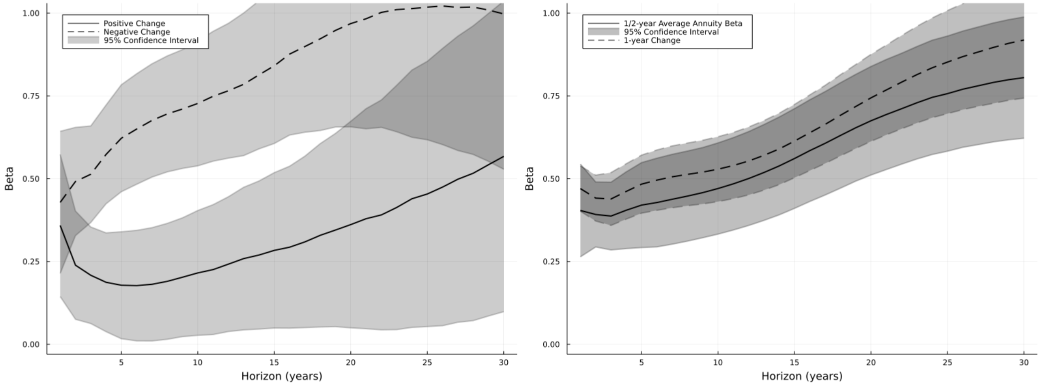
$$\Delta r^{a}_{t,h} = \alpha_h + \beta_h \cdot \Delta r^{b}_{t,h} + \gamma_h \cdot \Delta r^{b}_{t,h} \cdot r^{b}_{t,h} + \epsilon_{h,t}$$



Pass-through to annuity rates at higher interest rates

return

Incomplete Pass-Through



return

Market Concentration and Pass-Through

	Annuity Spread			
	Levels s		Changes Δs	
$r \cdot$ 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: $s_{i,t,h} = \gamma \cdot r_{t,h}\mathrm{HHI}_{i,t-1} + \beta_h \cdot r_{t,h} + Rating_{i,t} \cdot r_{t,h} + \epsilon_{i,t,h}$

return

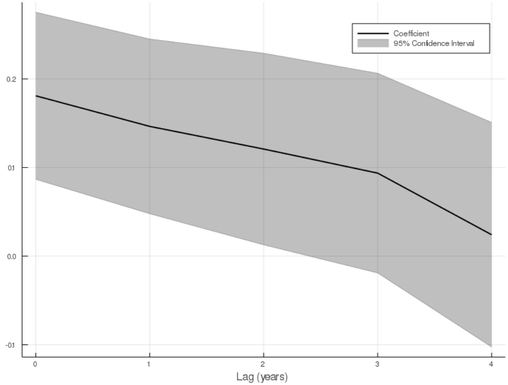
Spread affects future Net Gain from Operations

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

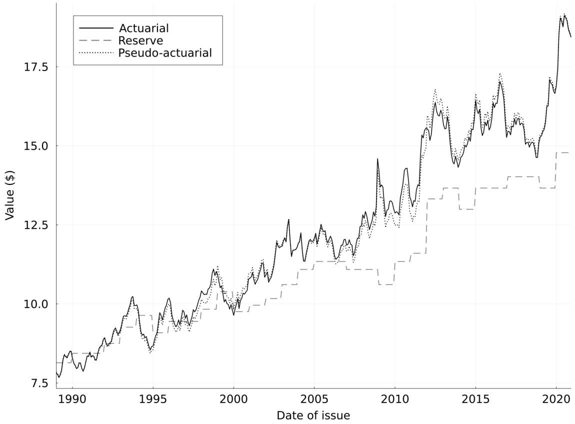
$$NetGain_{i,t+h} = Spread_{i,t} + \epsilon_{i,t}$$

A higher annuity spread implies larger future profits!

return



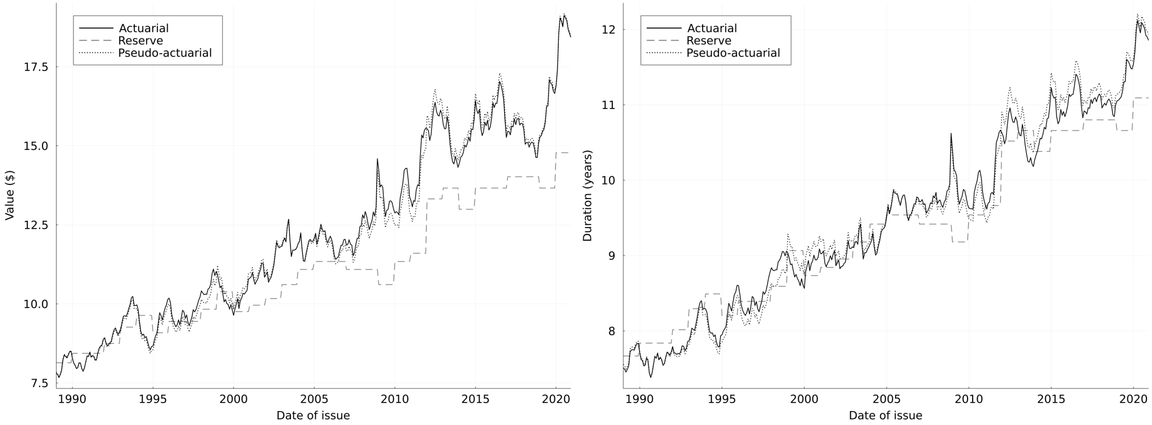
Example: Life annuity for 65-year-old male paying 1$ annually



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

▸ return

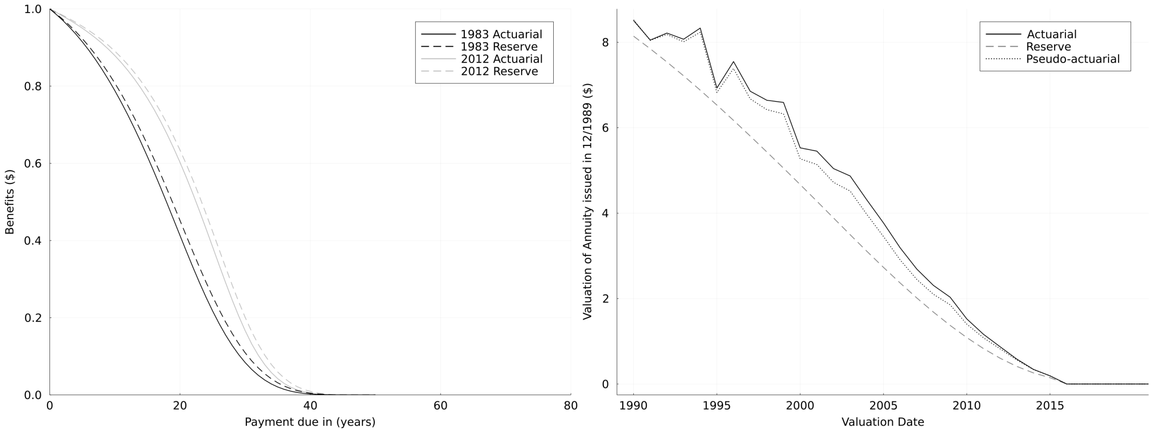
Example: Life annuity for 65-year-old male paying 1$ annually



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

▸ return

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?

VALUATION STANDARD	Location in last year's analysis of valuation reserves Line No.	Total	
		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.

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

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

return

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	(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