The Low Rate Environment and the Fragility of Market Risk Insurance

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Liabilities of U.S. financial institutions in 2019.Q2

Liability	Trillion $
Mutual funds	16.7
Savings deposits	10.5
Life insurance	7.5
Private DC plans	6.9
Private DB plans	3.5

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- Most of the insurance literature about demand side.
  - Yaari (1965) and Rothschild and Stiglitz (1976).
- Less work on supply-side frictions.
  - Financial/regulatory frictions (corporate finance) and market power (IO).

Composition of life insurance liabilities in 2015

Liability	Trillion $
Variable annuities (separate accounts)	1.8
Life insurance	1.5
Traditional annuities	1.0
Pension fund liabilities	0.7
Other reserves (accident & health)	0.3

Risk-sharing functions of life insurers:

1. Diversify idiosyncratic risk: Traditional life/health products.
2. Market risk insurance: Reallocate aggregate risk across
   - Investors with heterogeneous risk preferences (Dumas 1989).
   - Generations, taking on the traditional role of pension plans and Social Security (Allen and Gale 1997).

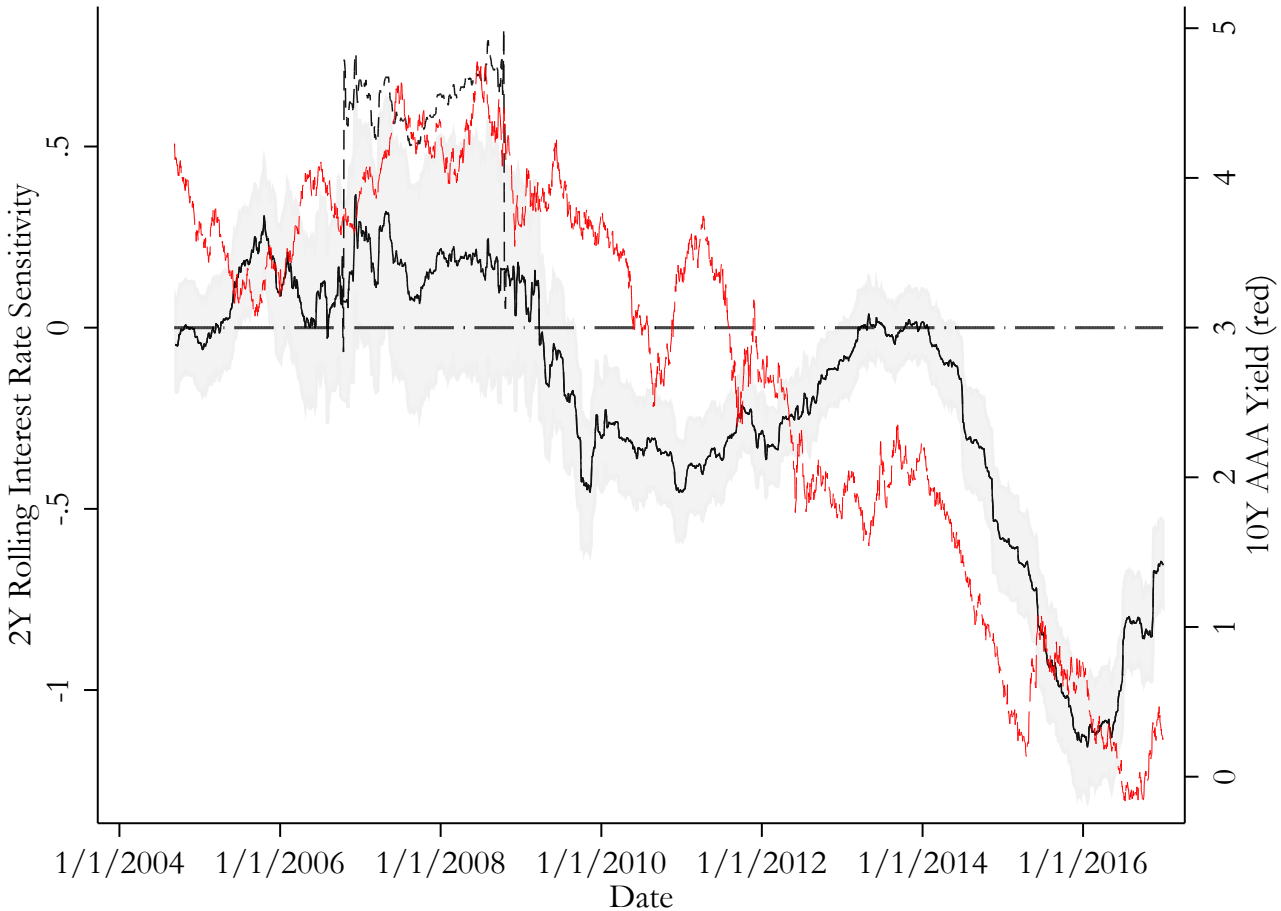
The changing risk exposures in the life insurance sector

$$r^e_{Insurance,t} = \alpha + \beta_m r^e_{mt} - \rho_y 10 \Delta y^{(10)}_t + \epsilon_t.$$

Sample	'00-'07	'10-'18	'00-'07	'10-'18	'15-'18
β_m	0.60	1.43	0.54	1.17	1.00
	(4.90)	(15.95)	(4.21)	(12.84)	(7.13)
ρ_y			-0.27	-0.81	-1.09
			(1.33)	(5.48)	(4.90)
α (%)	0.21	-0.55	0.28	-0.15	-0.37
	(0.42)	(-1.65)	(0.56)	(-0.49)	(-0.92)
T	96	99	96	99	39
R^2	0.203	0.724	0.218	0.790	0.781

1. CAPM: The market beta increased and the alpha declined since the financial crisis.
2. The equity of life insurers is becoming increasingly sensitive to changes in long-term interest rates.

Interest rate exposure of life insurers in the EU



- Magnitude similar as in the US: a 1% decline in 10-year rates corresponds to a 10% decline in insurers' equity prices.

Based on Barbu, Koijen, and Yogo (in progress).

Questions

1. What do life insurers insure?
   - Market risk through minimum return guarantees.
   - Variable annuity = Mutual fund + Long-dated put option
   - $1.5 trillion or 34% of U.S. life insurer liabilities in 2015.

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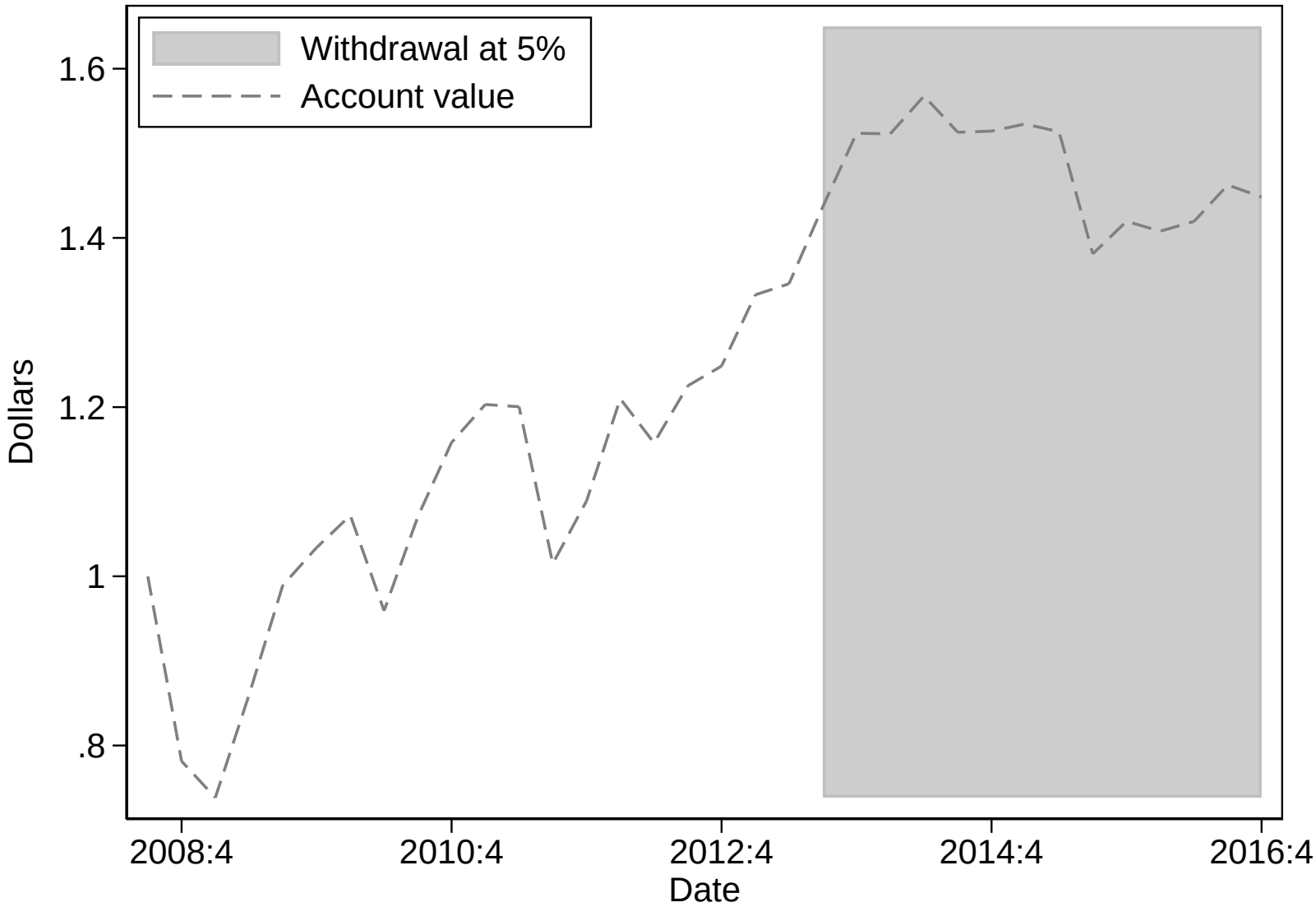
1. What do life insurers insure?
   - Market risk through minimum return guarantees.
   - Variable annuity = Mutual fund + Long-dated put option
   - $1.5 trillion or 34% of U.S. life insurer liabilities in 2015.
2. How do they insure market risk?
   - Financial frictions and market power interact with aggregate shocks.
   - After the 2008 financial crisis,
     - Pricing: Fees increased and sales fell.
     - Contract characteristics: Insurers made guarantees less generous or exited to limit risk exposure.
     - Moved liabilities off balance sheet through reinsurance.

Example: MetLife Series VA

- Sold by MetLife Insurance Company USA.
- American Funds Growth Allocation Portfolio: Mutual fund with a target equity allocation of 70–85%.
- Annual base contract expense of 1.3%.
- Guaranteed Lifetime Withdrawal Benefit: Optional minimum return guarantee with
  - Annual fee of 0.5%.
  - Rollup rate (guaranteed return) of 5%.
  - Withdrawal rate of 5%.

Example of a guaranteed living withdrawal benefit



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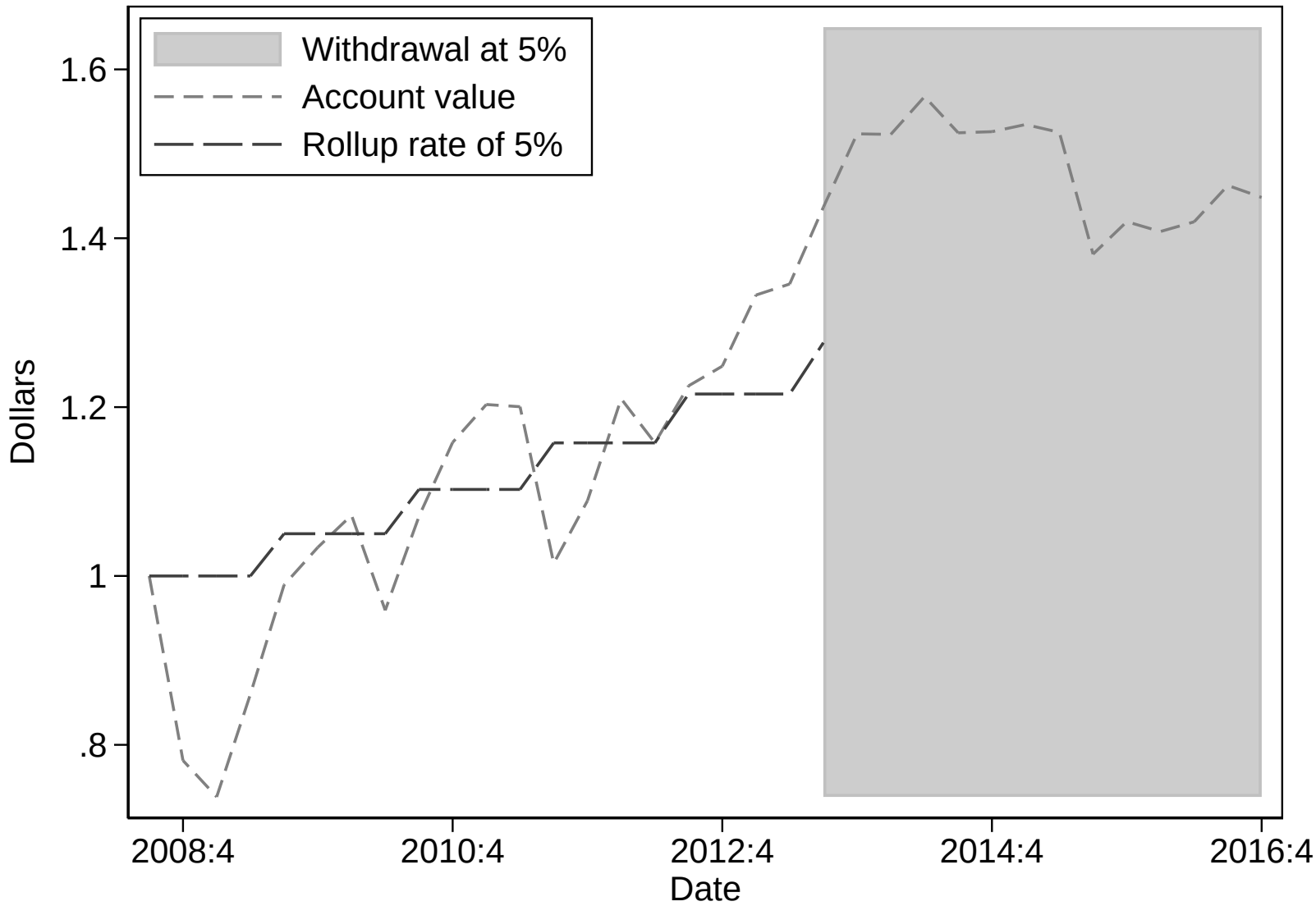

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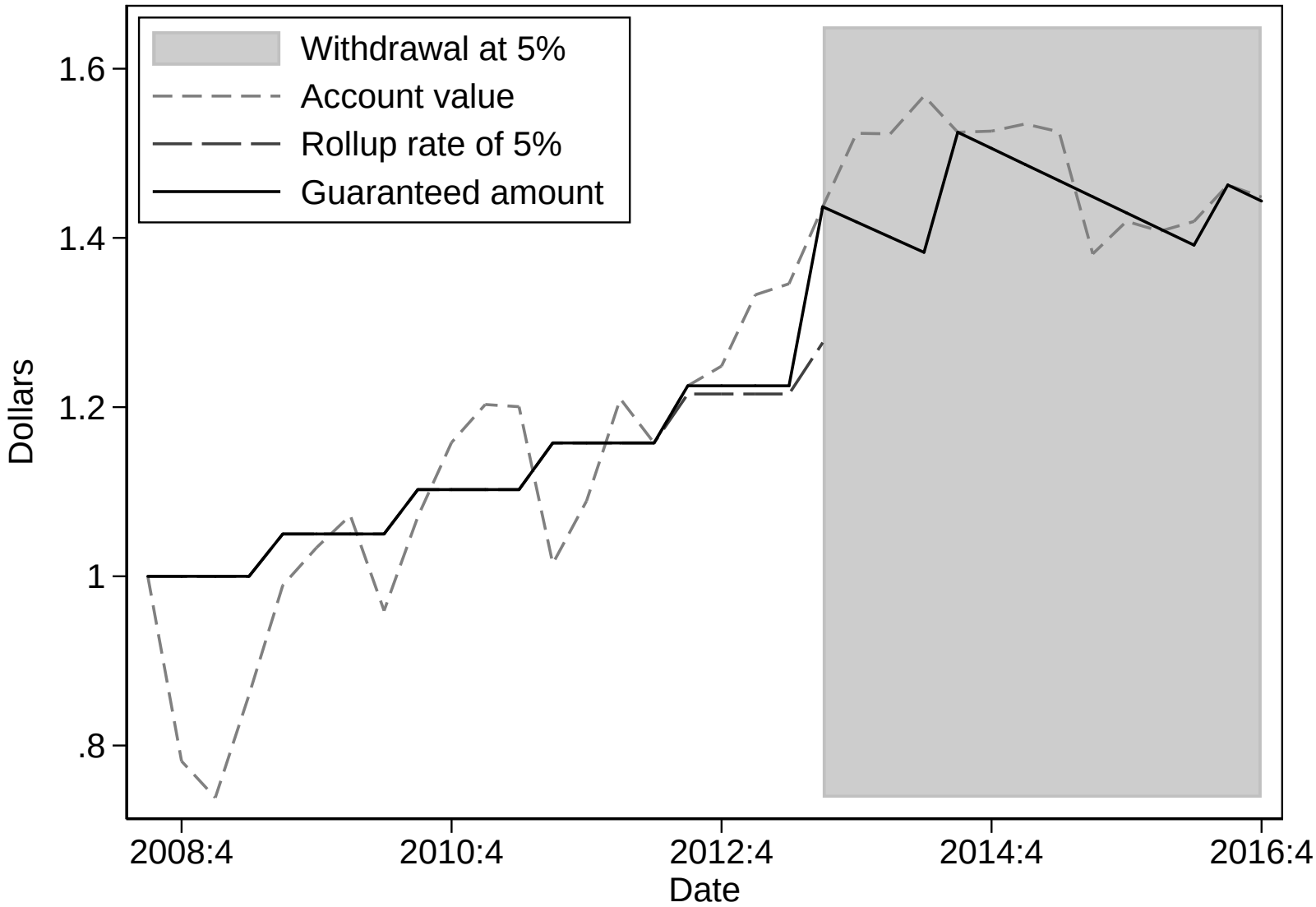


How are variable annuities regulated?

- Insurance regulators and rating agencies use the risk-based capital ratio:

$$\text{RBC} = \frac{\text{Assets} - \text{Reserves}}{\text{Required capital}}$$

- The value of VA guarantee (put option) increases with lower stock prices, lower interest rates, and higher volatility.
  1. Reserves increase because of revaluation.
  2. Required capital increases through risk exposure.
- An empirical measure of the value of VA guarantees:

$$\text{Reserve valuation} = \frac{\text{Reserves}}{\text{Account value}}$$

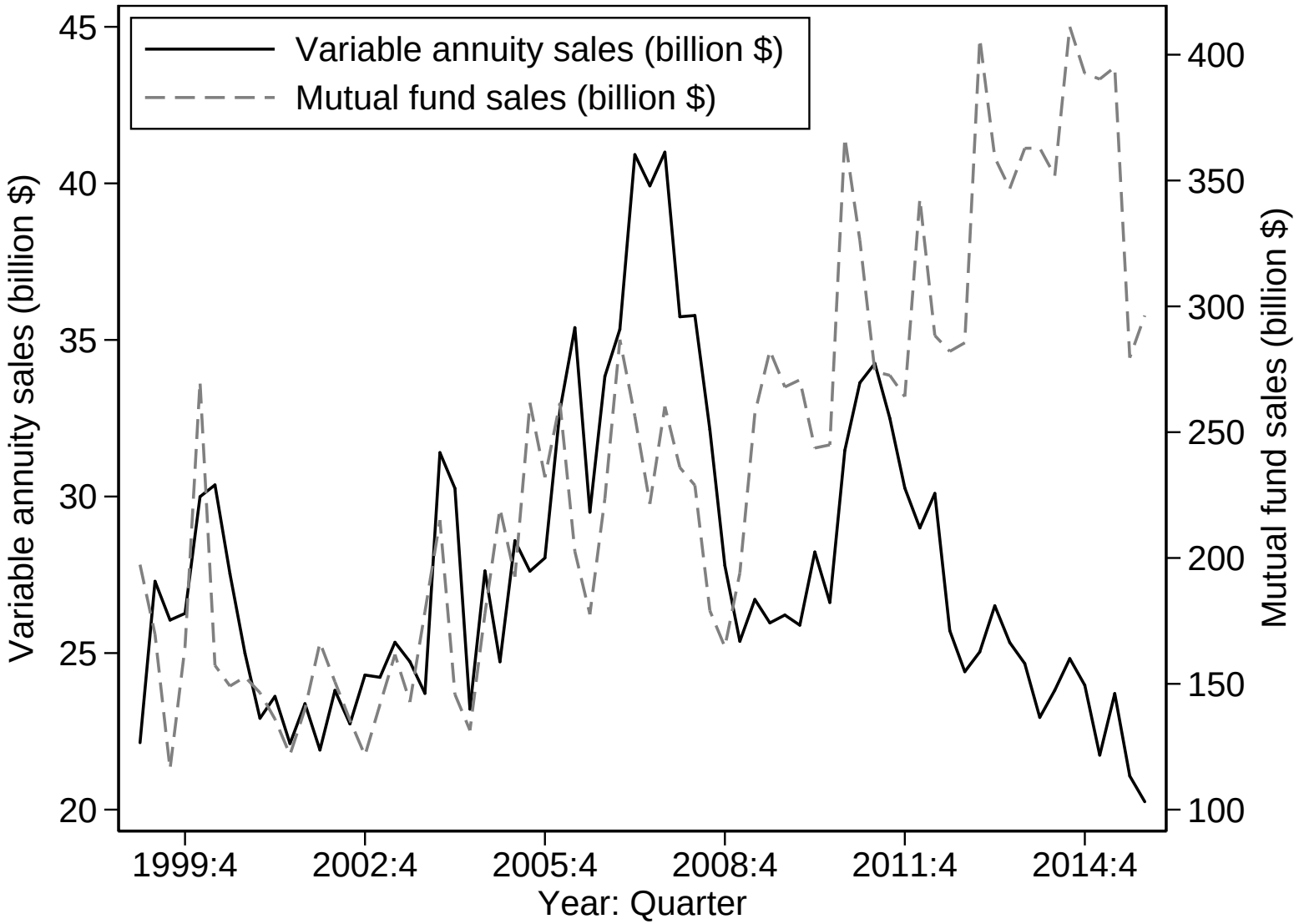
Data on the variable annuity market

- Morningstar (1999:1–2015:4):
  - Quarterly contract-level data on sales, fees, and characteristics.
- NAIC General Interrogatories Part 2 Table 9.2 (2005–2015):
  - Annual data on VA account value, reserve value, and amount of reserves reinsured.
- A.M. Best Company (2005–2015):
  - Annual financial statements.
  - A.M. Best rating.

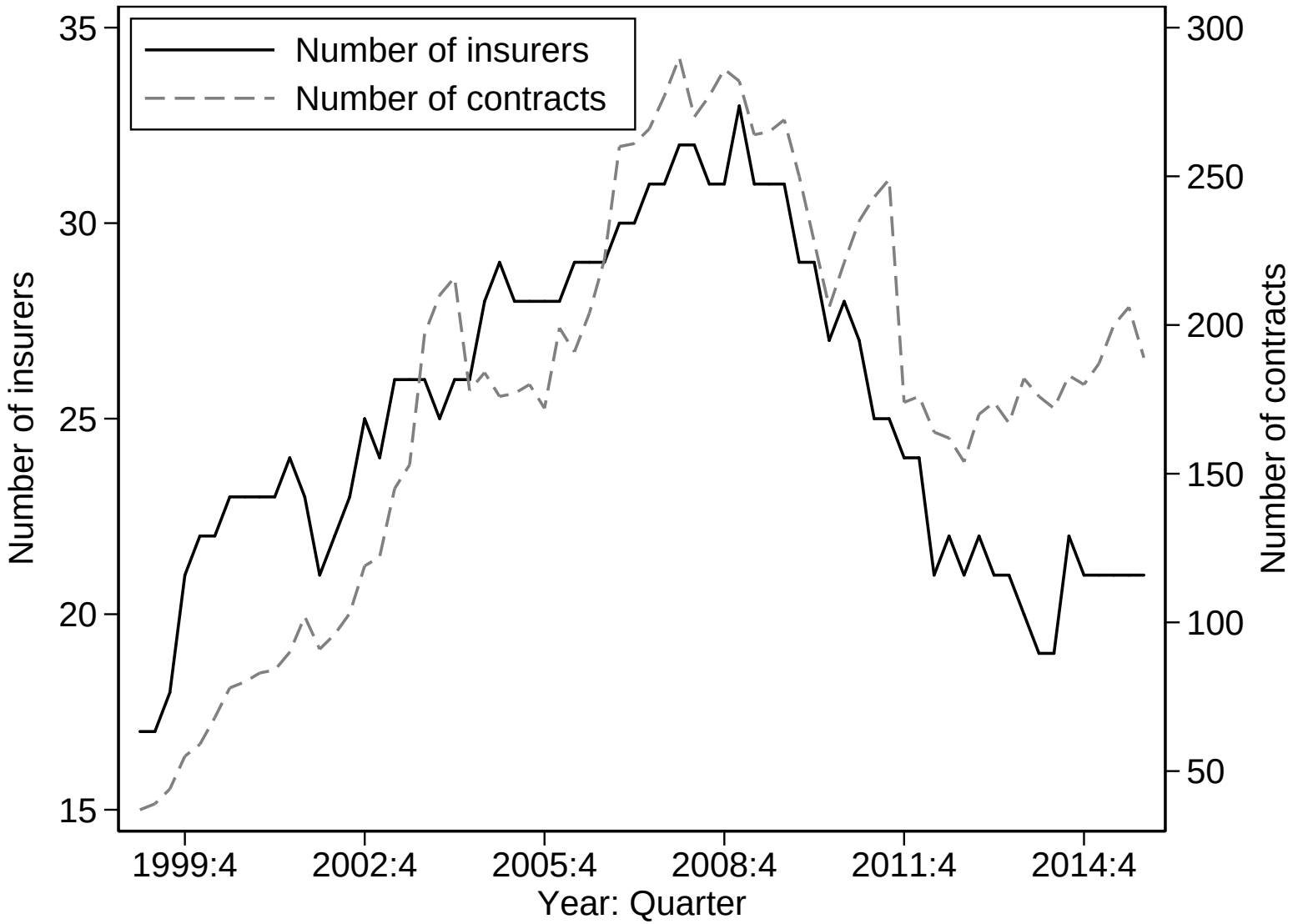
Summary statistics for the variable annuity market

	VA liabilities			
Year	Billion $	Percent of total liabilities	Number of insurers	Reserve valuation (percent)
2005	1,071	35	45	0.9
2006	1,276	38	47	0.8
2007	1,435	41	46	0.8
2008	1,068	34	44	4.1
2009	1,195	35	43	3.4
2010	1,344	36	43	2.5
2011	1,358	35	42	4.9
2012	1,434	36	39	3.9
2013	1,606	37	40	1.8
2014	1,599	37	38	2.3
2015	1,499	35	38	2.9

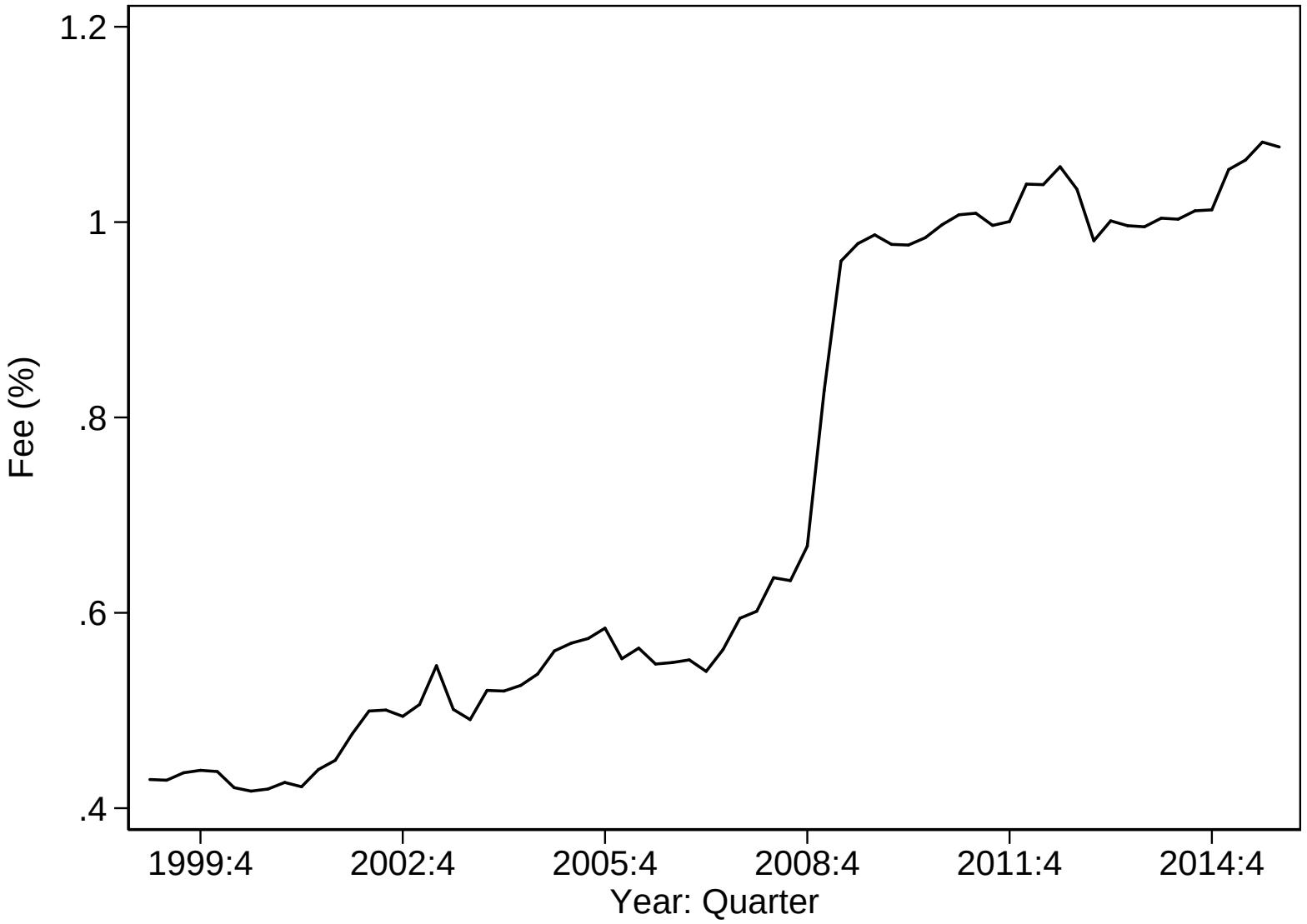
Variable annuity sales



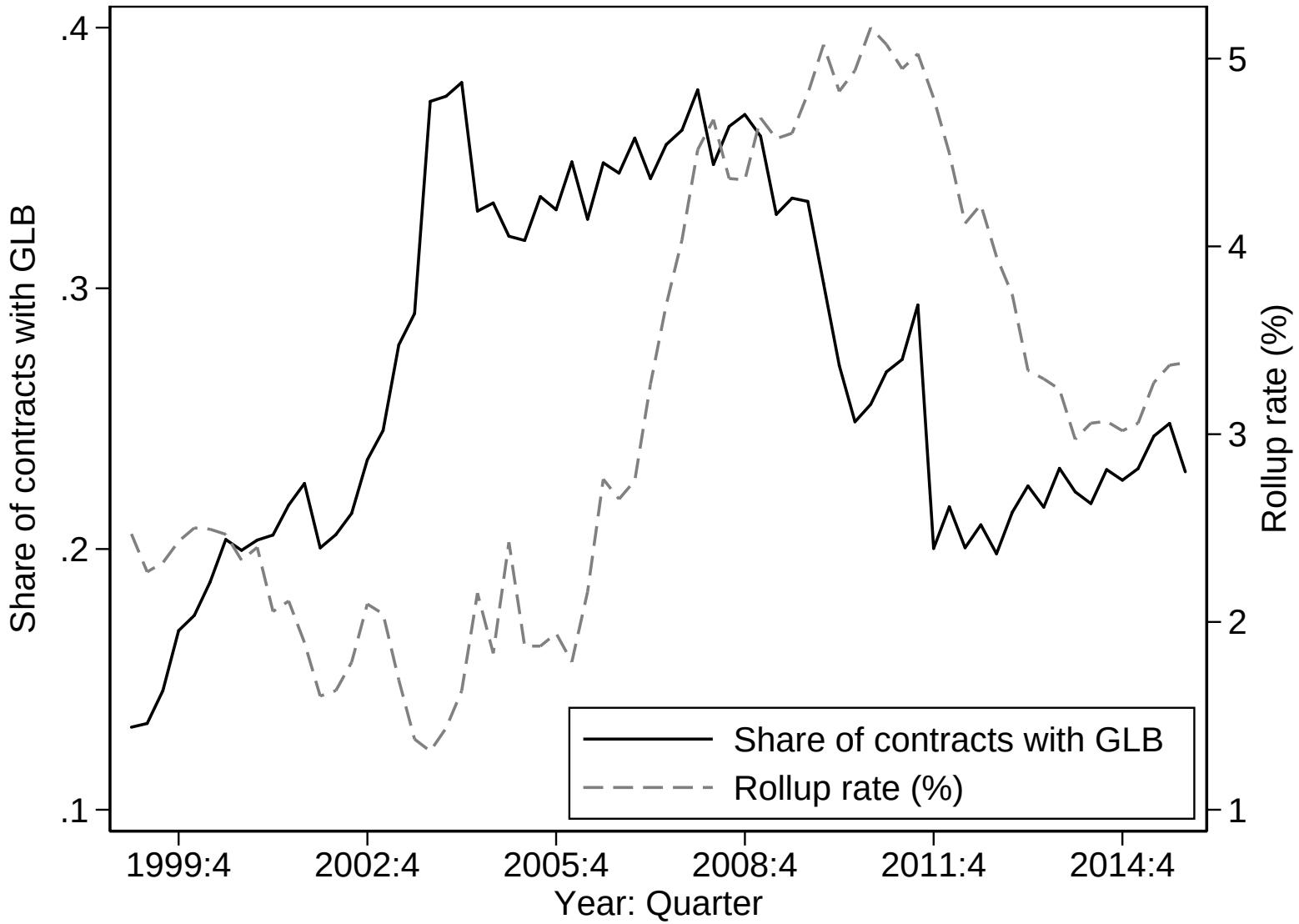
Number of insurers and contracts offering VA guarantees



Fees on variable annuity guarantees



Rollup rates on variable annuity guarantees



Evidence for supply-side fragility

- Fees increased and sales fell.
- Changing contract characteristics: Insurers made guarantees less generous to limit risk exposure.
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- Supply-side hypotheses:
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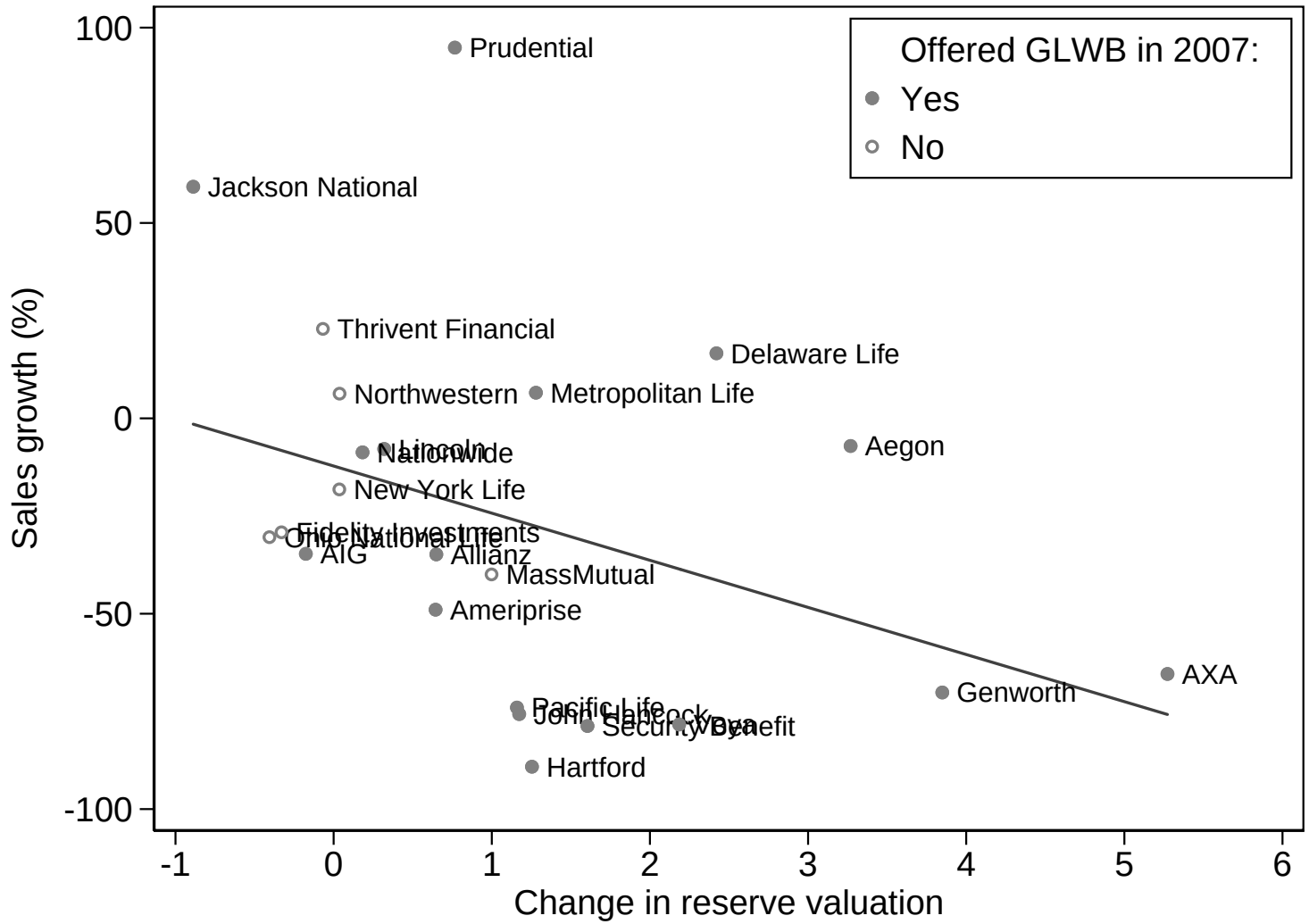
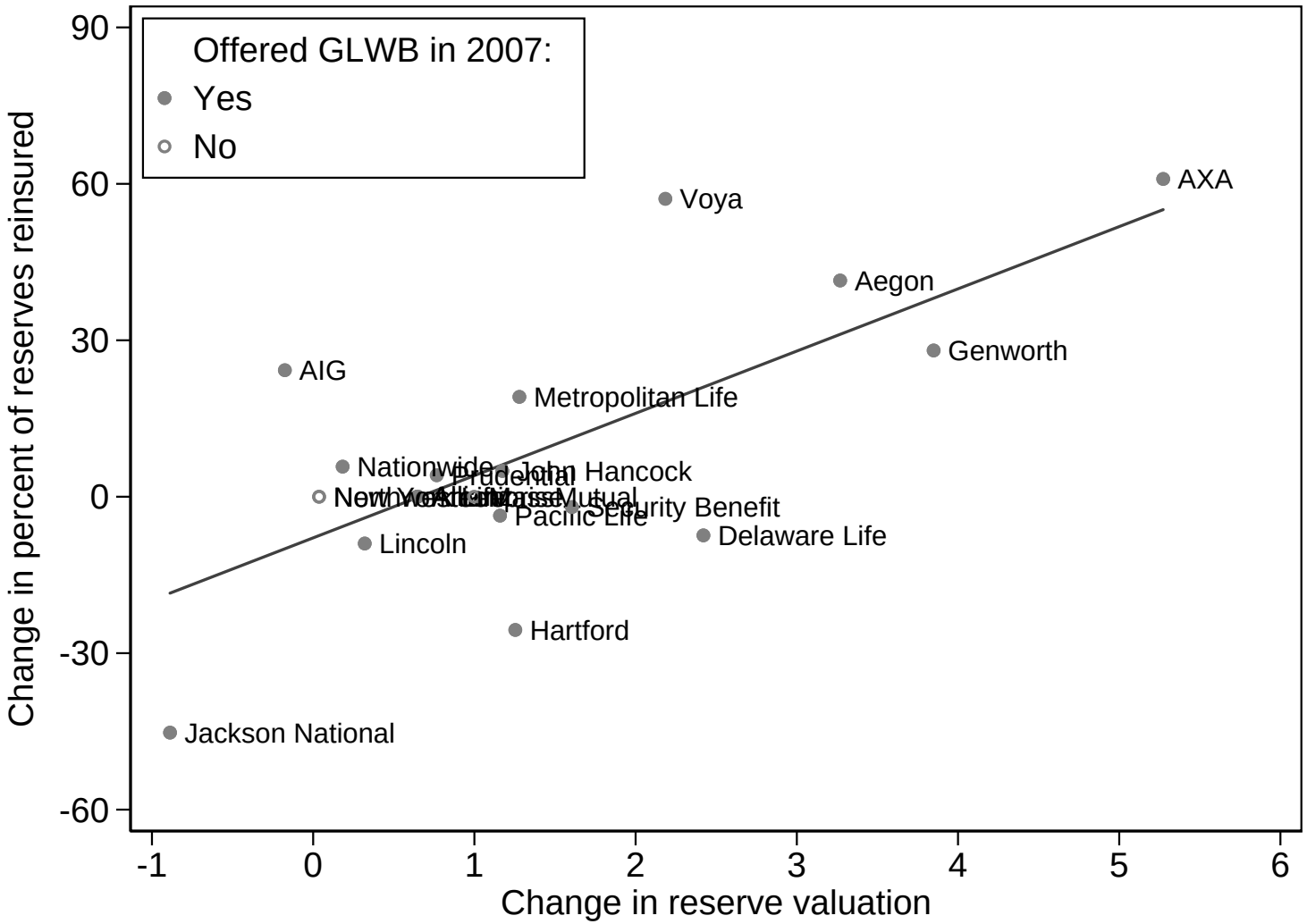
  2. Higher valuation of existing liabilities lowers risk-based capital.
- In the cross section, insurers that experienced larger increases in reserve valuation should
  1. Reduce sales more.
  2. Move liabilities off balance sheet through reinsurance.

Sales growth versus change in reserve valuation



Change in percent of reserves reinsured versus change in reserve valuation



A model of variable annuity supply

- Key frictions:
  1. Financial frictions: Issuance of new contracts increases required capital.
  2. Market power: Insurers compete by Bertrand pricing in an oligopolistic market.
- In response to an adverse shock to risk-based capital, insurer
  1. Increases prices.
  2. Changes contract characteristics (or exits entirely) to limit risk exposure.

Variable annuity market

- Financial market:
  - Asset price S_t evolves exogenously.
  - SDF that prices all assets: $S_t = \mathbb{E}_t[M_{t,t+1} S_{t+1}]$.
- VA issued in period t matures in period $t+2$.
  - Price P_t (account value 1 plus fee $P_t - 1$).
  - Rollup rate r_t.
  - Payoff:

$$X_{t,t+2} = \max\left\{(1+r_t)^2, \frac{S_{t+2}}{S_t}\right\} = \frac{S_{t+2}}{S_t} + \underbrace{\max\left\{(1+r_t)^2 - \frac{S_{t+2}}{S_t}, 0\right\}}_{\text{put option}}$$

  - Option value: $V_{t,t} = \mathbb{E}_t[M_{t,t+2} X_{t,t+2}]$.
- VA is a mutual fund when $r_t = -1$ (i.e., insurer exits the market for guarantees).

Risk-based capital

- Risk-based capital:

$$K_t = \underbrace{A_t - L_t}_{\text{equity}} - \underbrace{\phi_t L_t}_{\text{required capital}}$$

- Risk weight $\phi_t > 0$ on liabilities.
- Cost of a rating downgrade or regulatory action:

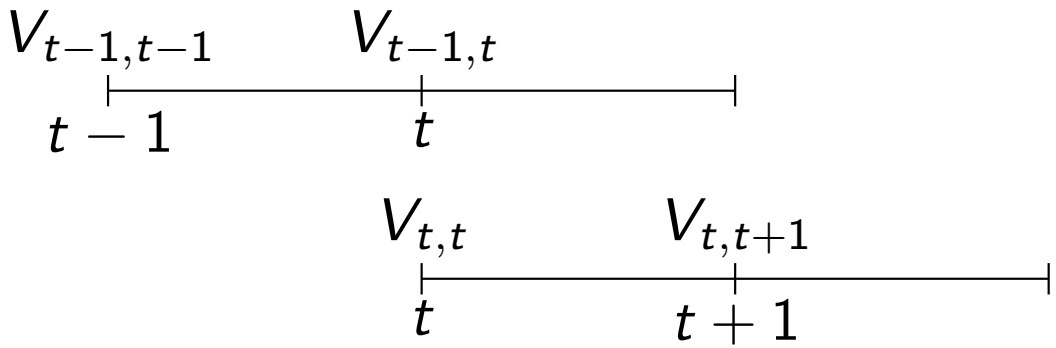
$$C_t = C(K_t)$$

where $C' < 0$ and $C'' > 0$.

- Define shadow cost of capital as

$$c_t = -\frac{\partial C_t}{\partial K_t} > 0$$

Shocks to risk-based capital



- Adverse shock at t (i.e., lower stock prices, lower interest rates, or higher volatility).
  1. Value of existing liabilities $V_{t-1,t}$ rises, lowering risk-based capital.
  2. Marginal cost $V_{t,t}$ increases on new contracts.
- Shadow cost of capital c_t rises through $V_{t-1,t-1}$.

Insurer's maximization problem

- Demand: $Q_t = Q_t(P_t, r_t)$.
  - Decreasing in price: $\partial Q_t / \partial P_t < 0$.
  - Increasing in the rollup rate: $\partial Q_t / \partial r_t > 0$.
- Insurer cannot offer negative rollup rates: $r_t \in \{-1\} \bigcup [0, \infty)$.
- Insurer maximizes firm value:

$$\max_{P_t, r_t} (P_t - V_{t,t}) Q_t - C_t.$$

Result 1: Optimal pricing

- Optimal price is

$$P_t = \left(1 - \frac{1}{\epsilon_{P,t}}\right)^{-1} \underbrace{\left(V_{t,t} + \frac{c_t \phi_t (V_{t,t} - 1)}{1 + c_t}\right)}_{\text{marginal cost}}$$

  1. Decreases in demand elasticity $\epsilon_{P,t}$.
  2. Increases in frictionless option value $V_{t,t}$.
  3. Increases in shadow cost of capital c_t and capital requirement ϕ_t.

- Adverse shock increases price through
  1. Higher $V_{t,t}$.
  2. Higher c_t through revaluation of existing liabilities.

Result 2: Optimal contract characteristics

- Optimal rollup rate is

$$r_t = \left(\frac{\partial V_{t,t}}{\partial r_t}\right)^{-1} \frac{\epsilon_{r,t}}{\epsilon_{P,t} - 1} \left(V_{t,t} - \frac{c_t \phi_t}{1 + (1 + \phi_t) c_t}\right) - 1 > 0$$

  if interior. Otherwise, corner solution $r_t \in \{-1, 0\}$.

- Insurer exits the market for guarantees (i.e., $r_t = -1$) when
  1. Demand is inelastic to the rollup rate (i.e., low $\epsilon_{r,t}$).
  2. Demand is price elastic (i.e., high $\epsilon_{P,t}$).
  3. Shadow cost of capital c_t or capital requirement ϕ_t is high.

- Key insight: Contract characteristics respond to risk-based capital and can lead to market incompleteness.

Estimation of variable annuity demand

- Decompose fee into markup vs. cost using a differentiated product demand system.
- Random-coefficients logit model implies market share for contract i in period t:

$$Q_{i,t} = \int \frac{\exp\{\alpha P_{i,t} + \beta' \mathbf{x}_{i,t} + \xi_{i,t}\}}{1 + \sum_{j=1}^{J} \exp\{\alpha P_{j,t} + \beta' \mathbf{x}_{j,t} + \xi_{j,t}\}} \, dF(\alpha, \beta).$$

  - Contract characteristics: Fee, rollup rate, number of investment options, and guaranteed death benefit.
  - Insurer characteristics: A.M. Best rating and fixed effects.
- Instruments that capture cost shocks:
  1. Reserve valuation: Value of existing liabilities.
  2. Share of reserves reinsured: Constrained insurers use reinsurance.

Estimated model of variable annuity demand

Variable	Mean	Standard deviation
Fee	-3.29	0.26
	(0.14)	(0.07)
Rollup rate	0.25	
	(0.04)	
Investment options	0.09	
	(0.01)	
Guaranteed death benefit	-5.25	
	(2.90)	
A.M. Best rating	0.73	
	(0.20)	
Observations	32,419	

Decomposing marginal costs

- Marginal cost for contract i sold by insurer n:

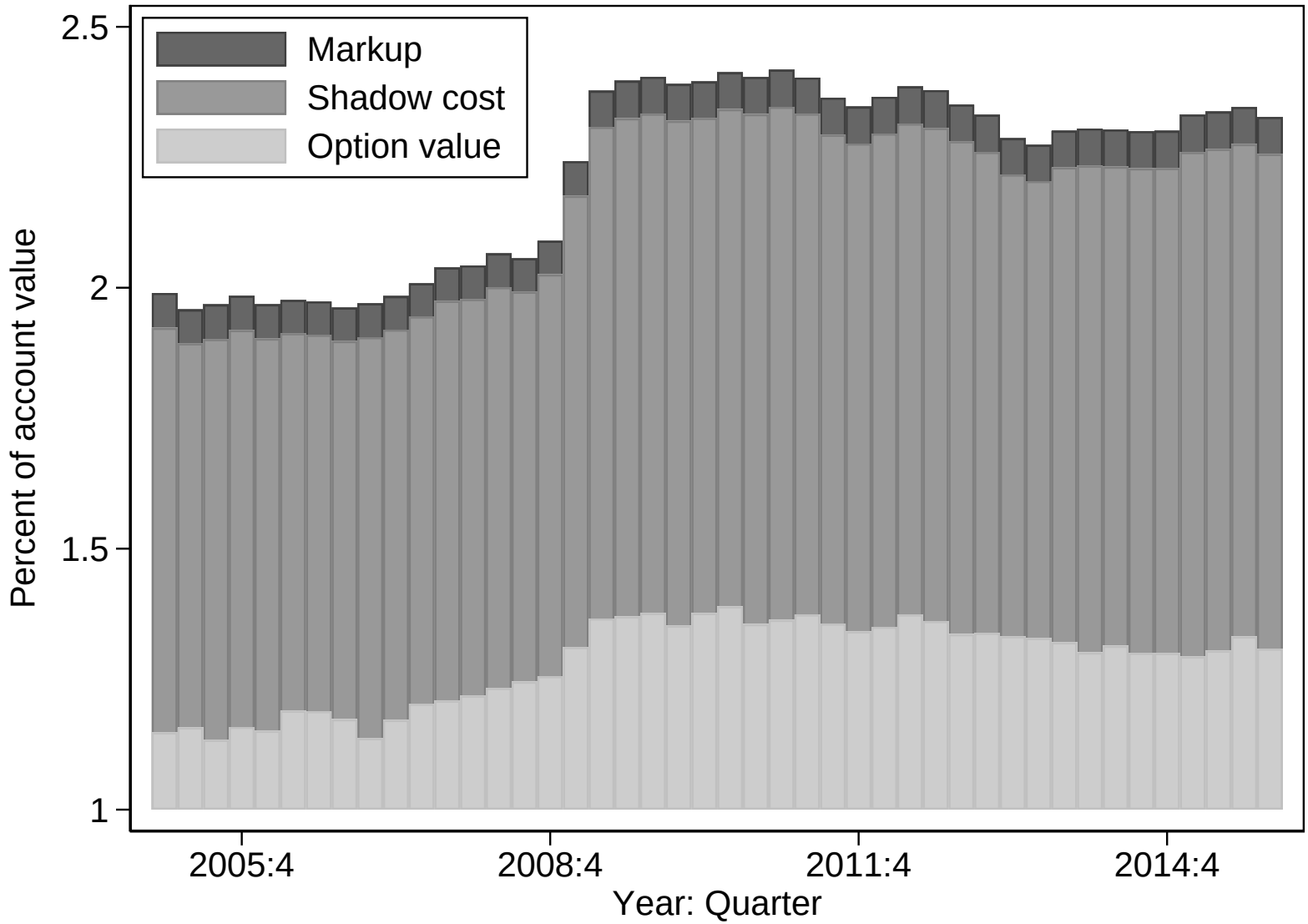
$$\log(\text{MC}_{i,n} - 1) = \underbrace{\log(V_{i,n} - 1)}_{\text{option value}} + \underbrace{\log\left(1 + \frac{c_n \phi_n}{1 + c_n}\right)}_{\text{frictions}}$$

- Cross-sectional regression:

$$\log(\text{MC}_{i,n} - 1) = \beta' \mathbf{x}_{i,n} + \nu_{i,n} + \gamma_n,$$

  - $\mathbf{x}_{i,n}$: Contract characteristics (rollup rate, number of investment options, and guaranteed death benefit).
  - γ_n: Insurer fixed effects identifies shadow cost.

Decomposing variable annuity fees



Supply-side theory of insurance

	Traditional view	Supply-side view
Products	Life/health insurance & traditional annuities	Guaranteed return products
Insures	Idiosyncratic risk across states	Market risk across investors
Frictions	Informational	Financial/regulatory & market power
Consequences	Variation in prices, contract characteristics & degree of market incompleteness	

Broader issues

- Mutual funds traditionally pure pass-through institutions with no risk mismatch.
- Growing part of the mutual fund sector sold through life insurers is subject to risk mismatch.
- Similar problem to persistent under-funding of pension funds, but with additional market discipline for publicly traded companies.
- Guaranteed return products are a significant share of life insurer liabilities in Austria, Denmark, France, Germany, Netherlands, and Sweden (ESRB 2015).
- A potential issue to monitor for financial stability.