Workshop on the Financial Economics of Insurance

Modeling Supply[1]

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Composition of life insurer 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).

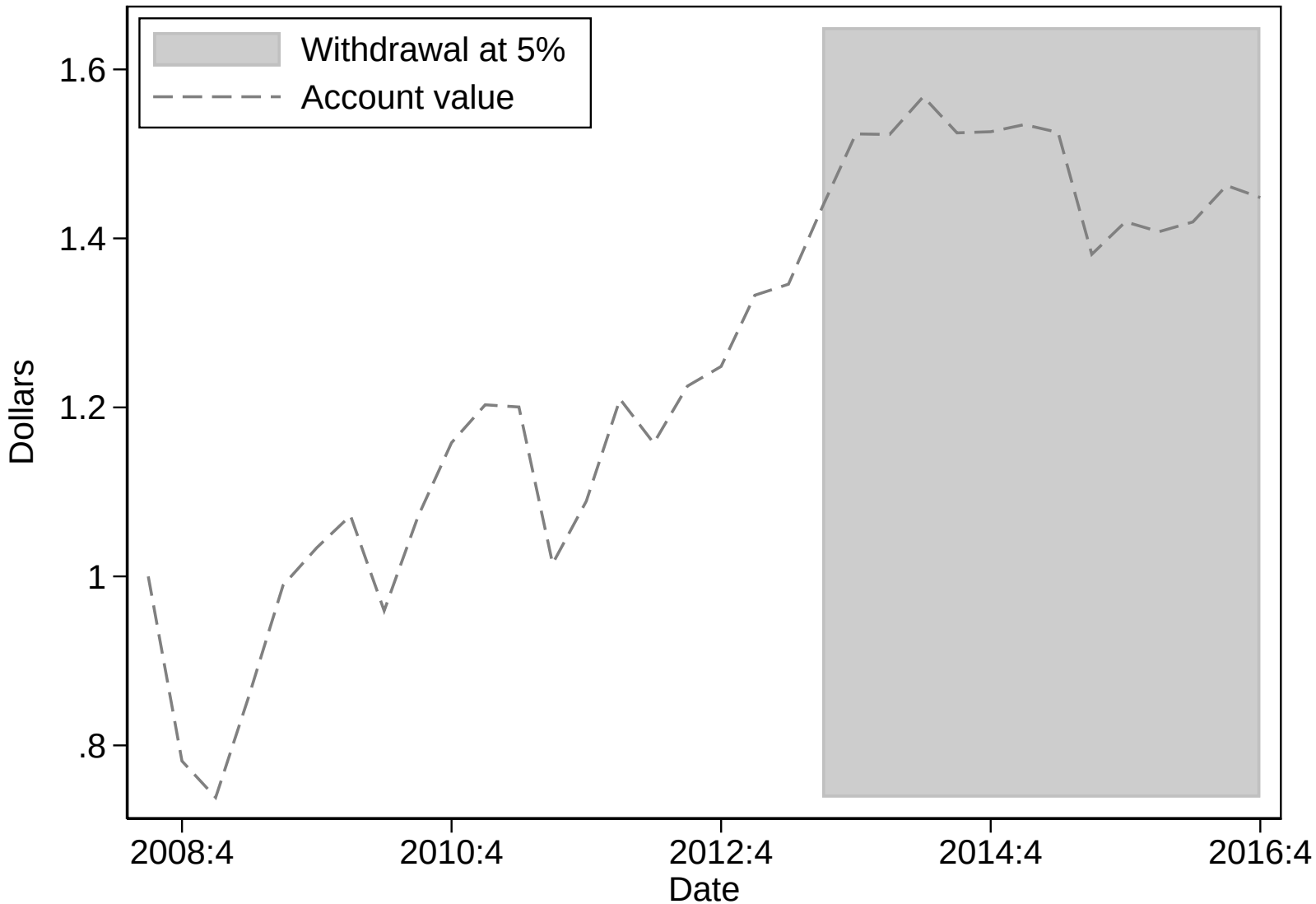
Questions

1. What do life insurers insure?
   - Market risk through minimum return guarantees.
   - Variable annuity = Mutual fund + Long-dated put option
   - $1.5 trillion or 35% 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 decreased.
     - Contract characteristics: Insurers made guarantees less generous or exited to limit risk exposure.
     - Moved liabilities off balance sheet through reinsurance.
   - Never fully recovered because of the low interest rate environment.
     - Negative duration and negative convexity.
     - During 2010–2017, insurance stocks have 10-year Treasury beta of -1.28 (0.16).

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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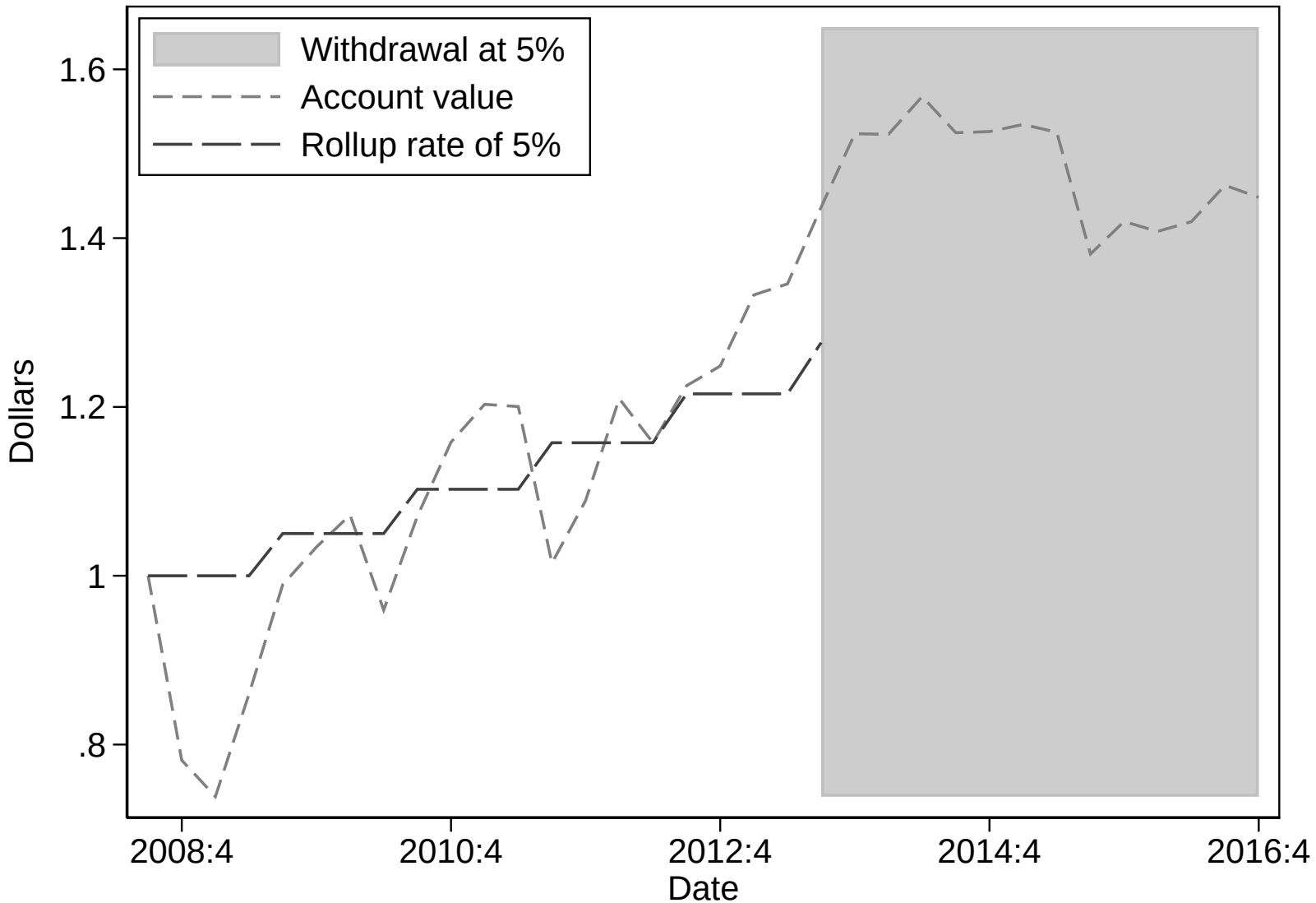

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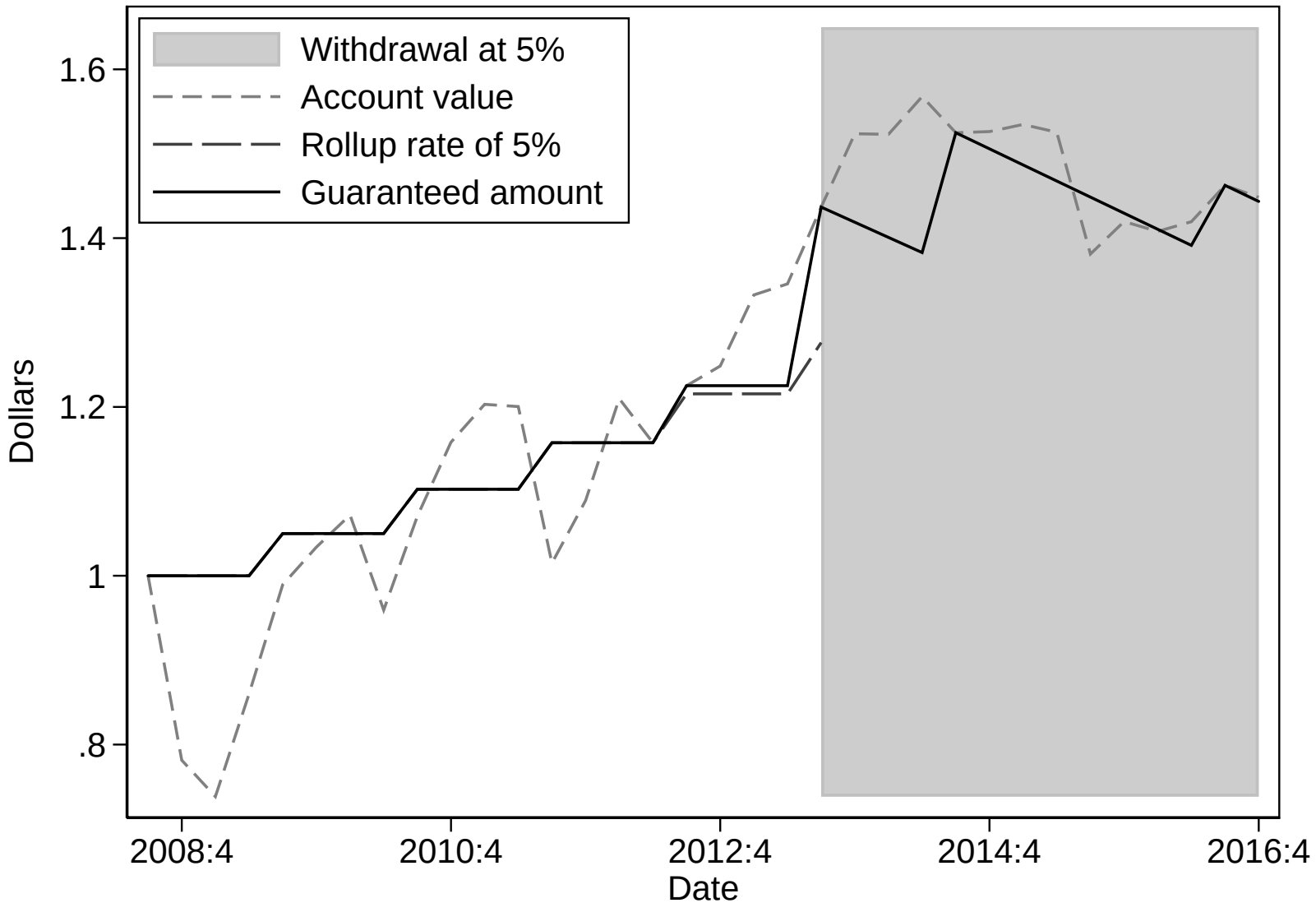


How are variable annuities regulated?

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

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

- Value of minimum return 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.
- Accounting value of minimum return guarantees:

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

Value-at-risk constraint

- The constraint that insurers faces may not be just regulatory, but also economic.
- Value-at-risk constraint:

$$\Pr\left(\frac{\text{Liabilities}}{\text{Assets}}\epsilon \leq 1\right) = F\left(\frac{\text{Assets}}{\text{Liabilities}}\right) \geq \kappa$$

- Rewrite as

$$\frac{\text{Assets} - \text{Liabilities}}{\phi\text{Liabilities}} \geq 1$$

  where $\phi = F^{-1}(\kappa) - 1$.
- Insurer with more conservative risk management chooses higher κ or lower variance.

Why do insurers not hedge variable annuity risk?

1. Insurers may not want to hedge.
   - Risk shifting under limited liability and guaranty funds.
   - Hedge positions differ depending on whether insurer targets economic, statutory, or GAAP capital.
2. Insurers cannot hedge perfectly because of model uncertainty.
3. Limited supply of long-dated puts.
   - Someone has to hold aggregate risk, and insurers may have comparative advantage over other institutions.

Risk exposure of U.S. life insurers

		By subsample		
Factor		1999–2007	2008–2009	2010–2017
Stock market	1.36	0.56	2.56	1.11
	(0.19)	(0.15)	(0.22)	(0.08)
10-year Treasury	-0.01	-0.38	1.14	-1.28
	(0.32)	(0.29)	(0.66)	(0.16)
Alpha (%)	-0.22	0.35	-1.14	0.41
	(0.46)	(0.47)	(1.70)	(0.29)
Observations	228	108	24	96

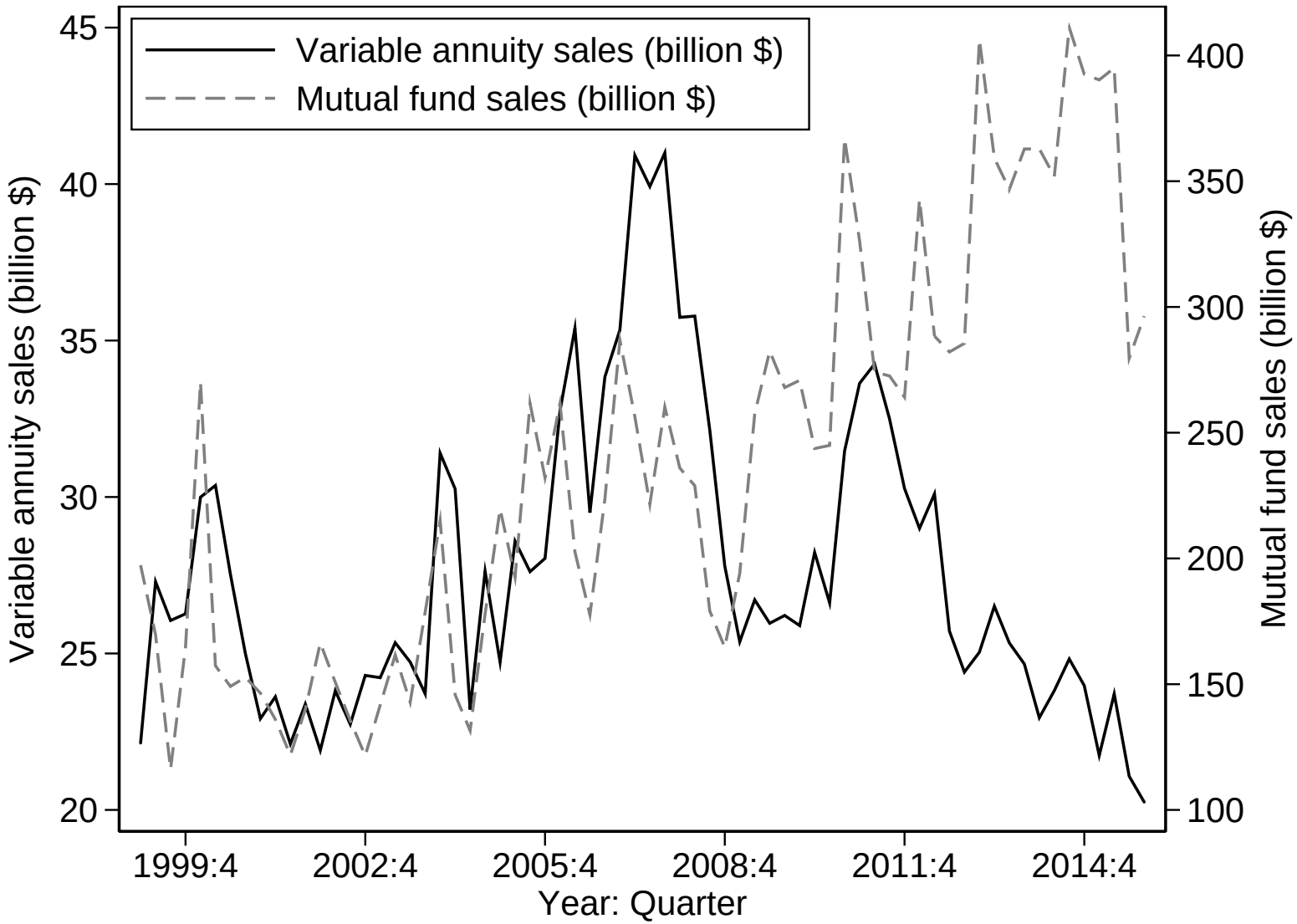
Data on the variable annuity market

- 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.

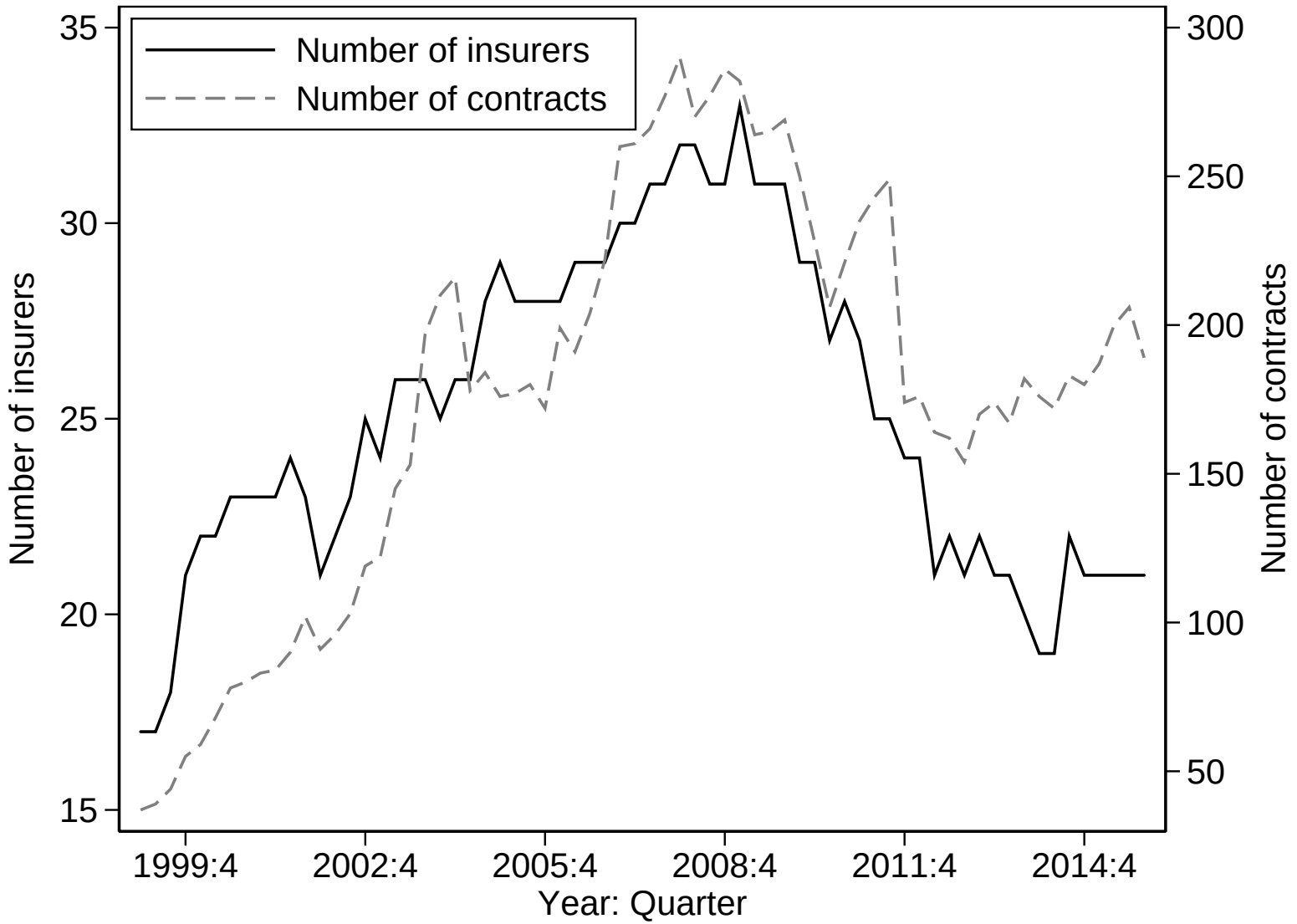
A summary of the variable annuity market

	VA liabilities			
Year	Billion $	% of total liabilities	Number of insurers	Reserve valuation (%)
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

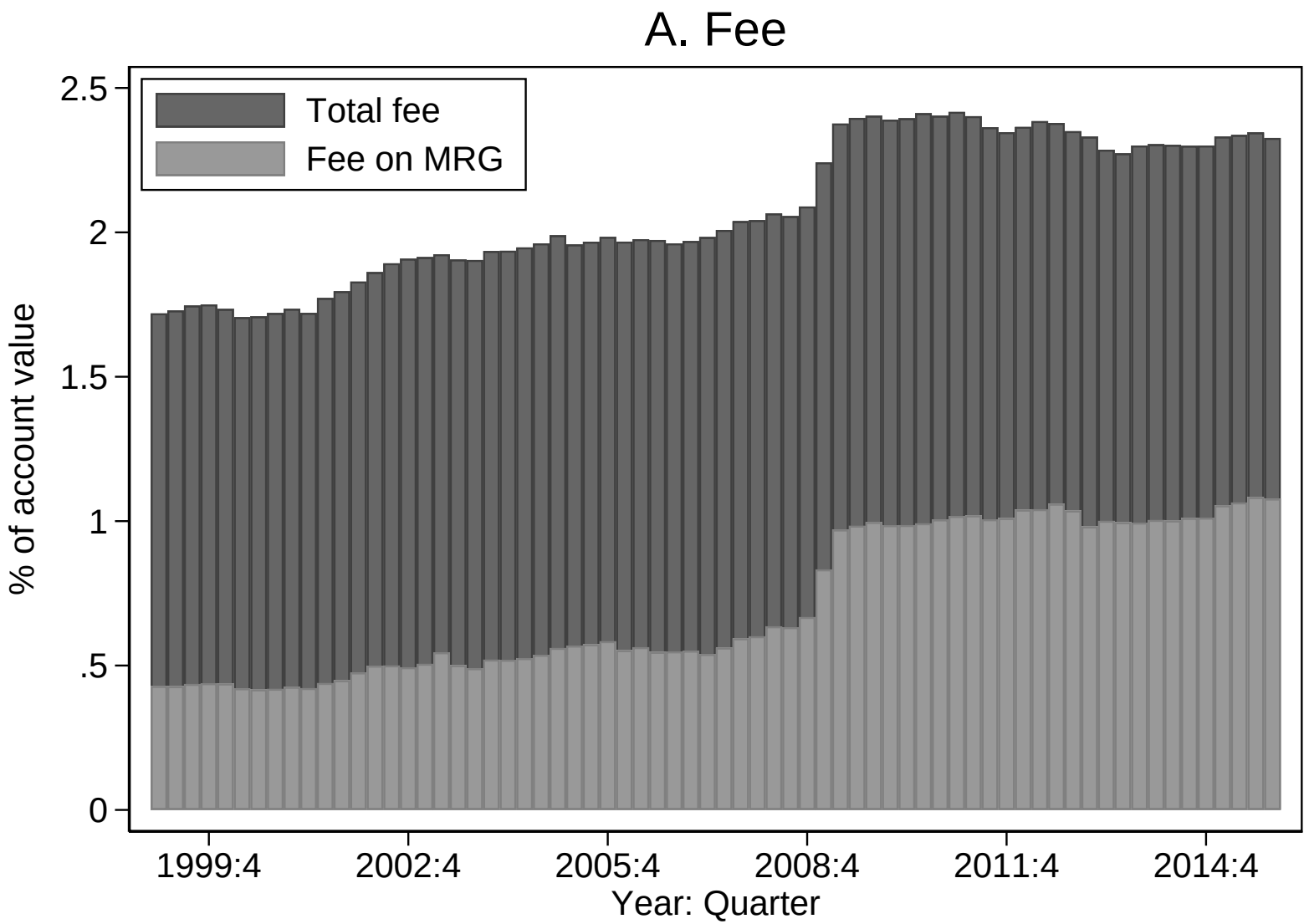
Variable annuity sales



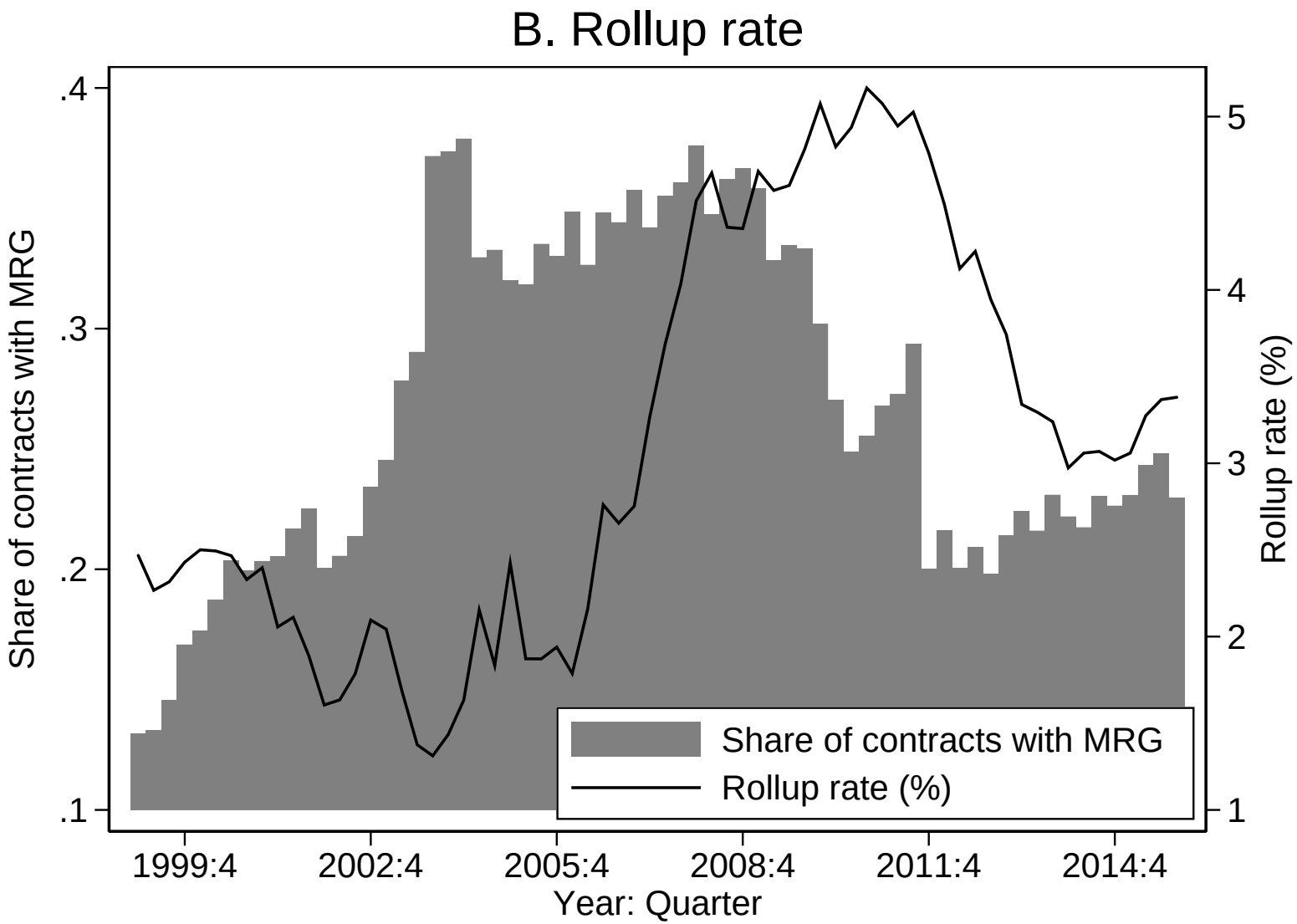
Number of insurers with minimum return guarantees



Fees on minimum return guarantees



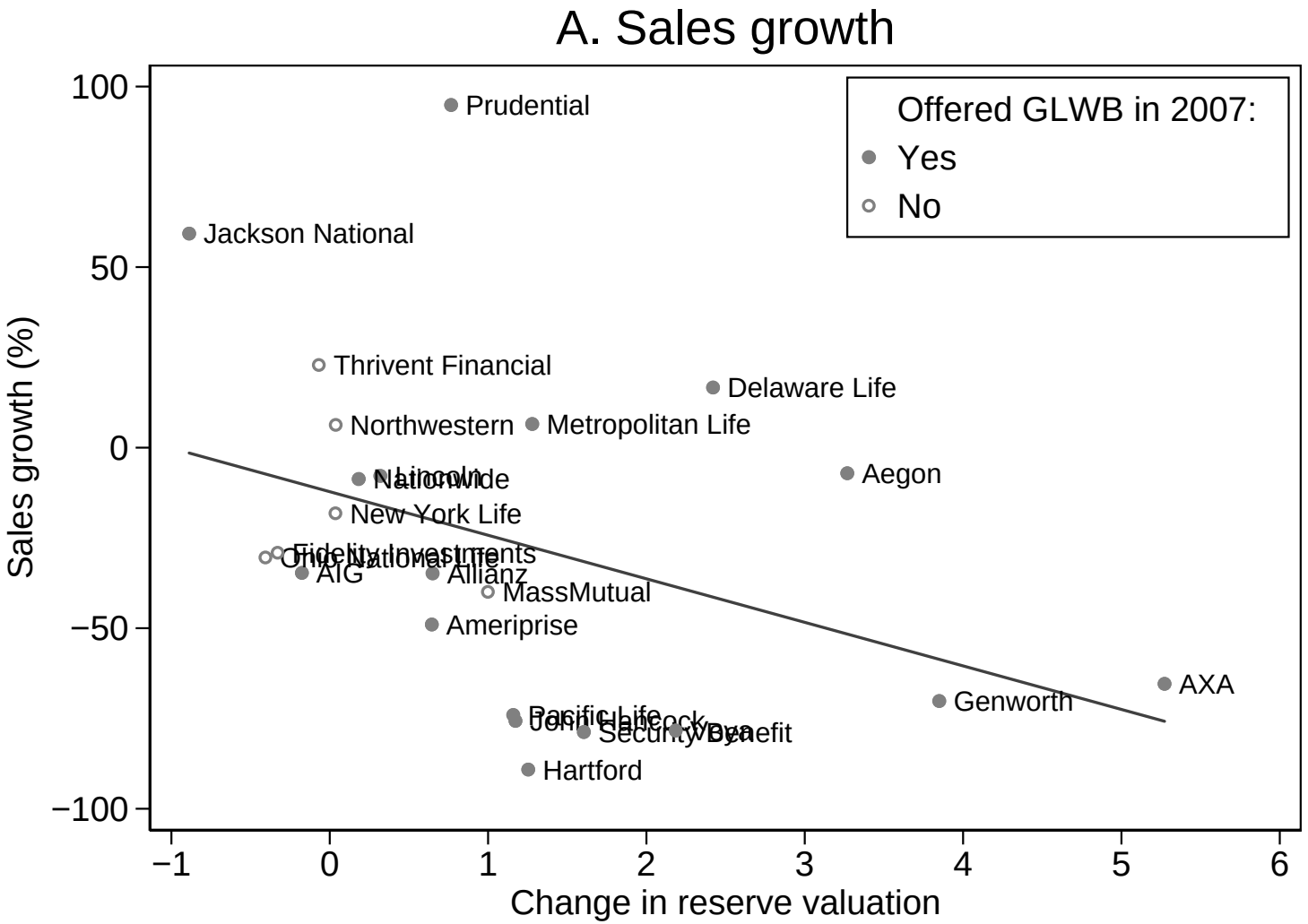
Rollup rates



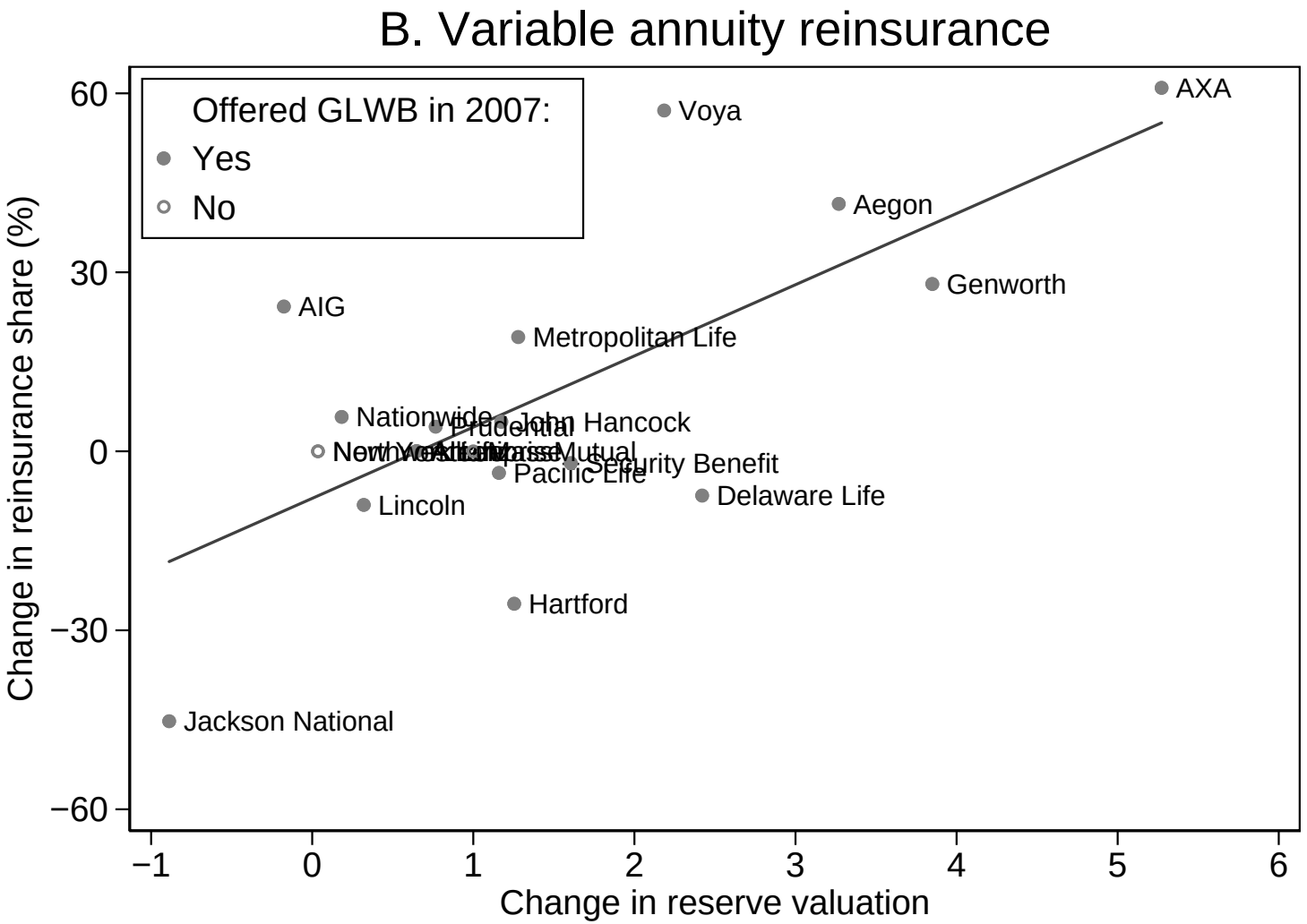
Evidence on supply-side fragility

- Fees increased and sales decreased.
- Changing contract characteristics: Insurers made guarantees less generous to limit risk exposure.
  - Lower rollup rates (intensive margin).
  - Exit the market for guarantees (extensive margin).
- Hypothesis: Higher valuation of existing liabilities lowers risk-based capital.
- In the cross section, insurers with larger increases in reserve valuation
  1. Reduce sales more.
  2. Move liabilities off balance sheet through reinsurance.

Sales growth vs. change in reserve valuation



Change in variable annuity reinsurance vs. 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 $t+2$.
  - Fee P_t (per \$1 account value).
  - Rollup rate r_t.
  - Payoff of minimum return guarantee:

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

  - 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:

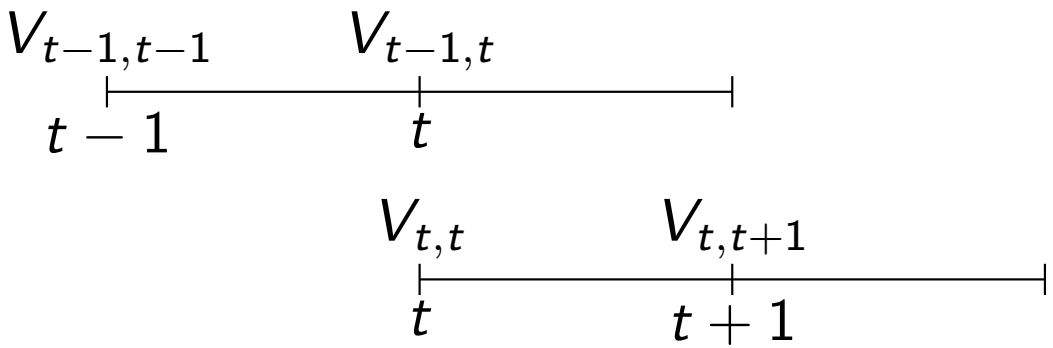
$$C_t = C(K_t)$$

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

- Define shadow cost of capital as

$$\lambda_t = \frac{1 - C_t'(1 + \phi_t)}{1 - C_t'} > 1$$

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 λ_t increases through $V_{t-1,t}$.

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 fee is

$$P_t = \frac{1}{\epsilon_{P,t}} + \underbrace{\lambda_t V_{t,t}}_{\text{marginal cost}}$$

1. Decreases in semi-elasticity $\epsilon_{P,t}$.
2. Increases in option value $V_{t,t}$.
3. Increases in shadow cost of capital λ_t.

- Adverse shock increases fee through

1. Higher $V_{t,t}$.
2. Higher λ_t through revaluation of existing liabilities.

Result 2: Optimal rollup rate

- At an interior optimum, rollup rate satisfies

$$\frac{\epsilon_{r,t}}{\epsilon_{P,t}} = \lambda_t \frac{\partial V_{t,t}}{\partial r_t}$$

  Otherwise, corner solution $r_t \in \{-1, 0\}$.
- When shadow cost of capital λ_t is high, insurer
  - Reduces the rollup rate.
  - Can exit the market for guarantees (i.e., $r_t = -1$).
- Key insight: Contract characteristics respond to risk-based capital and can lead to market incompleteness.

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.