The Cost of Financial Frictions for Life Insurers

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[1]The views expressed herein are not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

Theories of insurance markets

- Traditional theories: Market equilibrium determined by the demand side.
    - Life-cycle demand (Yaari 1965).
    - Informational frictions (Rothschild and Stiglitz 1976).
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  - Assumes efficient capital markets on the supply side.
- Modern view: Insurance companies are financial institutions.
  - Vulnerable to balance sheet shocks.
  - Pricing affected by financial frictions and statutory reserve regulation.

Evidence on individual annuities and life insurance

1. Firesale of policies in January 2009.
   - Term and life annuities: Average markup of -25%.
   - Universal life insurance: Average markup of -52%.
2. Larger price reductions for
   - Policies with looser statutory reserve requirements.
   - Insurance companies with more adverse balance sheet shocks.
3. Firesale of policies complements conventional channels of recapitalization:
   - Direct capital injection from the holding company.
   - Reduction of required capital by shifting to safer assets.

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   - Direct capital injection from the holding company.
   - Reduction of required capital by shifting to safer assets.
4. Exploit exogenous variation in required reserves across policies to identify the shadow cost of financial frictions.
   - Nearly \$5 per dollar of excess reserve in January 2009.

Example: Allianz Life Insurance Company

- 20-year term annuity: Guaranteed payment of $1 for 20 years.
- Allianz priced it at
  - $14.37 in July 2007.
  - $11.84 in January 2009.
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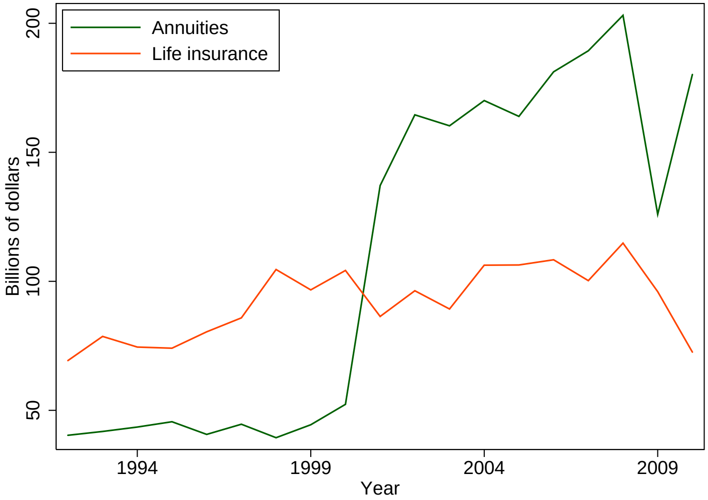
- Sale creates statutory capital: $\$11.84 - \$11.47 = \$0.37$
- Cost of statutory capital: $\$2.72/\$0.37 = \$7.35$

Annual premiums for individual annuities and life insurance



Data on annuity and life insurance prices

- Annuities: January 1989–July 2011 (semiannual)
  - Over 30,000 observations
  - Over 100 insurance companies.
  - Types of policies:
    1. Term annuities: 5- to 30-year maturities.
    2. Life annuities: Male and female, 50- to 90-years old.
    3. Guaranteed annuities: Male and female, 50- to 90-years old, 10- or 20-year guarantees.
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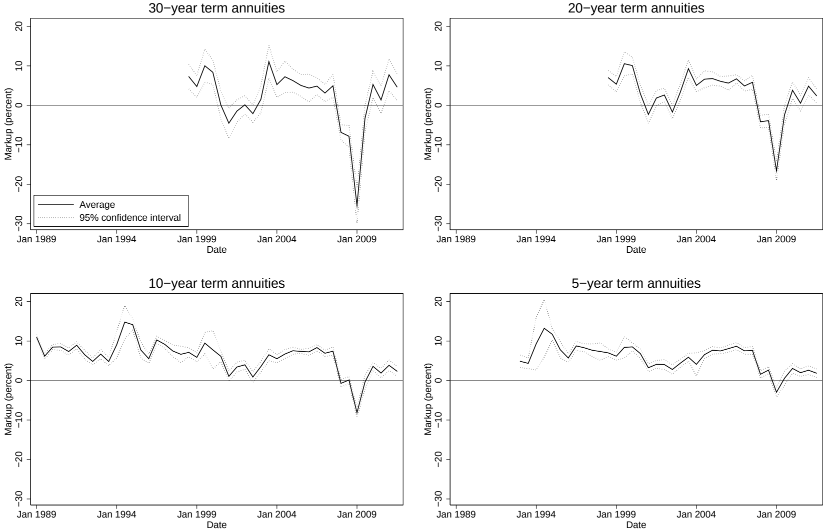
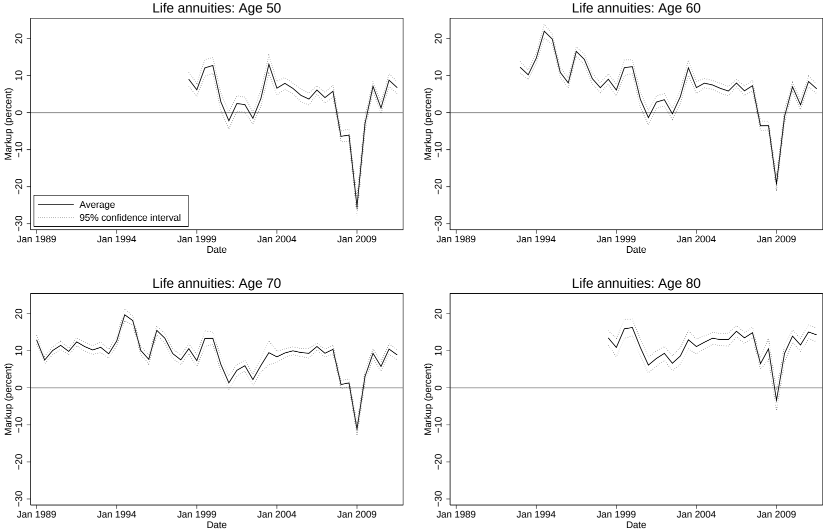
- Universal life insurance: January 2005–July 2011 (semiannual)
  - Nearly 4,000 observations
  - Over 50 insurance companies.
- Calculate the actuarial value for each type of policy.
  - Mortality tables from the American Society of Actuaries.
  - Zero-coupon Treasury yield curve.
- Merged with A.M. Best data on balance sheets and ratings.

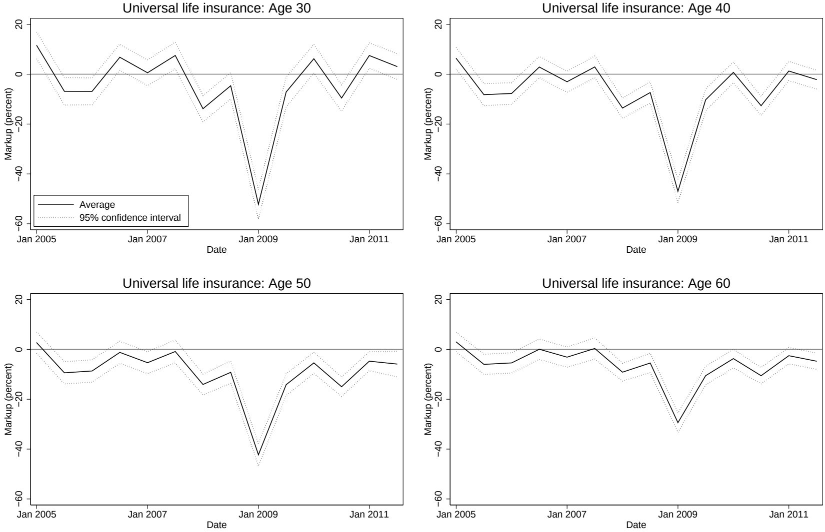
Average markup on term annuities



Average markup on life annuities



Average markup on universal life insurance



Default risk

1. Policies backed by the state guaranty fund.
   What if it fails?
   - Lower bound on the recovery rate: 84%.
     - Only 16% of life insurers' assets are risky.
     - Asset deficit of 5–10% in past cases of insolvency.

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     - Inconsistent with default probabilities implied by CDS.
2. No discounts on life annuities during the Great Depression.
   - Inconsistent with default story.
   - Consistent with our explanation based on statutory reserve regulation.

Default probabilities implied by term annuities in January 2009

	Maturity (years)					
Insurance company	5	10	15	20	25	30
Panel A: Markup (percent)						
Allianz Life Insurance of North America	-1.1	-7.2	-14.2	-20.7	-27.3	-31.9
American General Life Insurance	-4.0	-7.6	-11.0	-15.7	-19.6	-24.3
Aviva Life and Annuity	-1.4	-5.8	-8.5	-12.2	-16.9	-22.0
Genworth Life Insurance	-1.6	-6.9	-10.5	-13.8	-17.8	-22.5
Lincoln Benefit Life	-3.0	-8.9	-12.8	-15.7	-18.9	-22.7
MetLife Investors USA Insurance		-13.4	-18.6	-22.4	-26.3	-31.0
Panel B: Default probabilities implied by term annuities (annual percent)						
Allianz Life Insurance of North America	2.5	58.5	100	100	100	100
American General Life Insurance	9.2	25.3	100	100	100	100
Aviva Life and Annuity	3.1	30.9	100	100	100	100
Genworth Life Insurance	3.5	45.1	100	100	100	100
Lincoln Benefit Life	6.8	72.5	100	100	100	100
MetLife Investors USA Insurance	33.1	33.1	100	100	100	100
Panel C: Default probabilities implied by credit default swaps (annual percent)						
Allianz Life Insurance of North America	1.6	1.5				
American General Life Insurance	6.9	4.3				
Aviva Life and Annuity	3.3	3.1				
Genworth Life Insurance	28.7	5.0				
Lincoln Benefit Life	3.1	2.5				
MetLife Investors USA Insurance	7.9	4.9				

Statutory reserve regulation

- Standard Valuation Law: "Present value" formula for calculating required reserves for each type of policy.
- Discount rate for annuities:

$$0.03 + 0.8(y_t - 0.03)$$

where y_t is a moving average of the Moody's composite bond yield.

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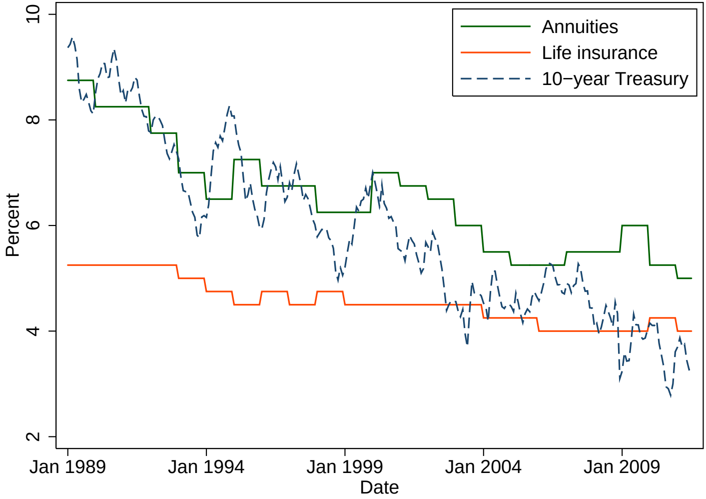
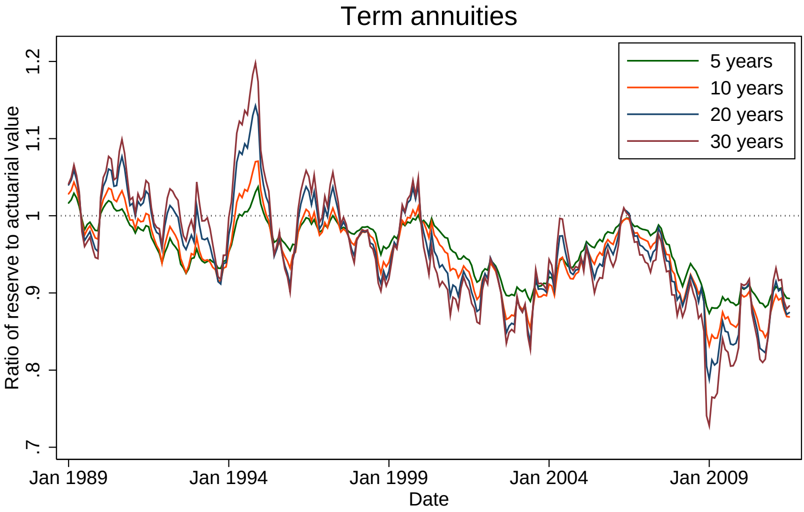
- Discount rate for life insurance:

$$0.03 + 0.35(\min\{y_t, 0.09\} - 0.03) + 0.175(\max\{y_t, 0.09\} - 0.09)$$

Discount rates for annuities and life insurance



Reserve to actuarial value for annuities



Structural model of insurance pricing

- Insurance company sells $i = 1, \ldots, I$ different types of policies:
  - $P_{i,t}$: Price
  - $V_{i,t}$: Actuarial value
  - $\widehat{V}_{i,t}$: Reserve value
  - $Q_{i,t}(P)$: Demand function with $Q'_{i,t}(P) < 0$
  - C_t: Fixed cost

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  - $Q_{i,t}(P)$: Demand function with $Q'_{i,t}(P) < 0$
  - C_t: Fixed cost
- Profit:

$$\Pi_t = \sum_{i=1}^{I} (P_{i,t} - V_{i,t}) Q_{i,t} - C_t$$

- Firm value:

$$J_t = \Pi_t + \frac{1}{R} \mathbf{E}_t [J_{t+1}]$$

- Assets:

$$A_t = R_{A,t} A_{t-1} + \sum_{i=1}^{I} P_{i,t} Q_{i,t} - C_t$$

- Statutory reserves:

$$L_t = R_{L,t} L_{t-1} + \sum_{i=1}^{I} \widehat{V}_{i,t} Q_{i,t}$$

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- Leverage constraint:

$$\frac{L_t}{A_t} \leq \phi$$

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- Leverage constraint:

$$\frac{L_t}{A_t} \leq \phi \Leftrightarrow K_t = \phi A_t - L_t \geq 0$$

- Choose $P_{i,t}$ to maximize

$$\mathcal{L}_t = J_t + \lambda_t K_t$$

Optimal insurance pricing

- Price of policy i:

$$P_{i,t} = \underbrace{V_{i,t}\left(1 - \frac{1}{\epsilon_{i,t}}\right)^{-1}}_{\text{Bertrand price}} \underbrace{\left(\frac{1 + \overline{\lambda}_t \widehat{V}_{i,t}/V_{i,t}}{1 + \overline{\lambda}_t \phi}\right)}_{\text{Financial frictions}}$$

where $\epsilon_{i,t}$ is the elasticity of demand.

- Shadow cost of financial frictions:

$$\overline{\lambda}_t = \lambda_t + \frac{1}{R}\mathbf{E}_t\left[\frac{\partial J_{t+1}}{\partial K_t}\right] = -\frac{\partial \Pi_t}{\partial K_t}$$

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- Model predicts deeper discounts for
  1. Policies with looser statutory reserve requirements (i.e., lower $\widehat{V}_{i,t}/V_{i,t}$).
  2. Insurance companies that are more constrained (i.e., higher $\overline{\lambda}_t \phi$).

Empirical specification

- Policy i, firm j, and time t:

$$\log\left(\frac{P_{i,j,t}}{V_{i,t}}\right) = -\log\left(1-\frac{1}{\epsilon_{i,j,t}}\right) + \log\left(\frac{1+\overline{\lambda}_{j,t}\widehat{V}_{i,t}/V_{i,t}}{1+\overline{\lambda}_{j,t}L_{j,t}/A_{j,t}}\right) + e_{i,j,t}$$

- Elasticity of demand:

$$\epsilon_{i,j,t} = 1+\exp\{-\beta'\mathbf{y}_{i,j,t}\}$$

- Shadow cost:

$$\overline{\lambda}_{j,t} = \exp\{\gamma'\mathbf{z}_{j,t}\}$$

- Explanatory variables:
  - Insurance company: AMB rating, leverage ratio, asset growth, and log assets.
  - Dummies and interactions for policy type and date.

Identifying assumptions

1. Identification if demand is correctly specified.
   - Average markup must be nonnegative in the absence of financial frictions.

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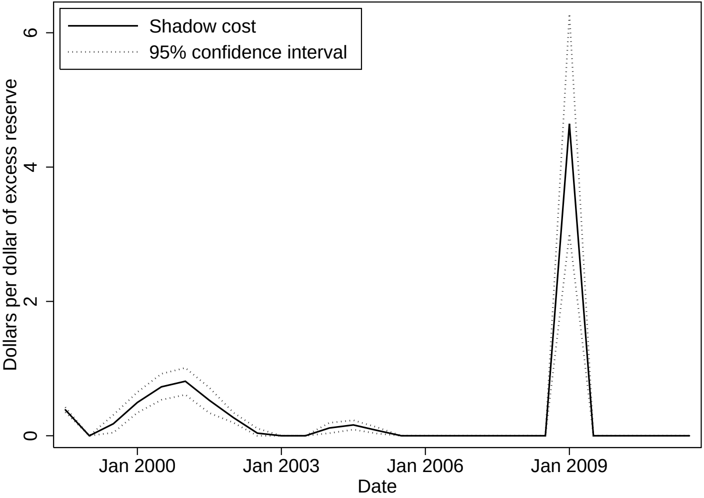
1. Identification if demand is correctly specified.
   - Average markup must be nonnegative in the absence of financial frictions.
2. Identification even if demand is potentially misspecified.
   - Linear approximation to the pricing model:

$$\log\left(\frac{P_{i,j,t}}{V_{i,t}}\right) \approx \alpha_{j,t} + \frac{1}{1/\overline{\lambda}_{j,t} + L_{j,t}/A_{j,t}}\left(\frac{\widehat{V}_{i,t}}{V_{i,t}} - \frac{L_{j,t}}{A_{j,t}}\right) + u_{i,j,t}$$

   - Standard Valuation Law generates relative shifts in supply that are orthogonal to demand:

$$\mathrm{Cov}\left(\frac{\widehat{V}_{i,t}}{V_{i,t}}, u_{i,j,t}\right) = 0$$

Shadow cost of financial frictions

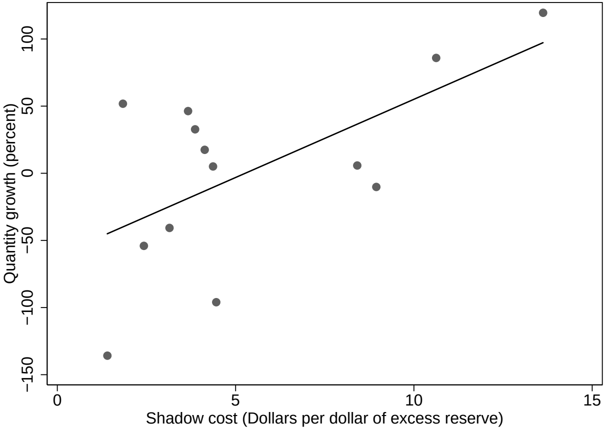


Shadow cost of financial frictions in January 2009

Insurance company	A.M. Best rating	Leverage ratio	Asset growth (percent)	Shadow cost
MetLife Investors USA Insurance	A+	0.97	-10	13.62
Allianz Life Insurance of North America	A	0.97	-3	10.62
Lincoln Benefit Life	A+	0.87	-45	8.95
OM Financial Life Insurance	A-	0.95	-4	8.41
Aviva Life and Annuity	A	0.95	12	4.46
Presidential Life Insurance	B+	0.91	-6	4.37
EquiTrust Life Insurance	B+	0.95	13	4.13
Integrity Life Insurance	A+	0.92	3	3.86
United of Omaha Life Insurance	A+	0.91	-3	3.67
Genworth Life Insurance	A	0.90	0	3.14
North American for Life and Health Insurance	A+	0.94	24	2.43
American National Insurance	A	0.87	-2	1.84
American General Life Insurance	A	0.87	5	1.40

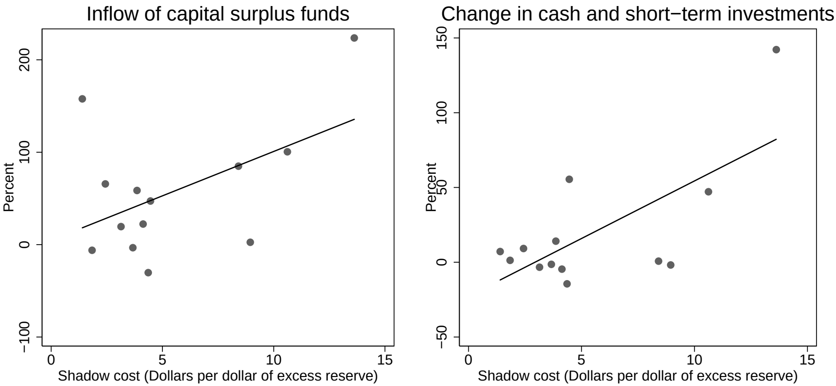
Change in Annuity Policies Issued from 2007 to 2009

- Financially constrained companies that lowered prices also sold more policies.
- Consistent with supply curve shifting down.



Conventional channels of recapitalization in 2008–2009

- Financially constrained companies also
  1. Received large capital injection from their holding company:
     - Issuance of surplus notes.
     - Reduction of stockholder dividends.
  2. Reduced required risk-based capital by shifting to safer assets.



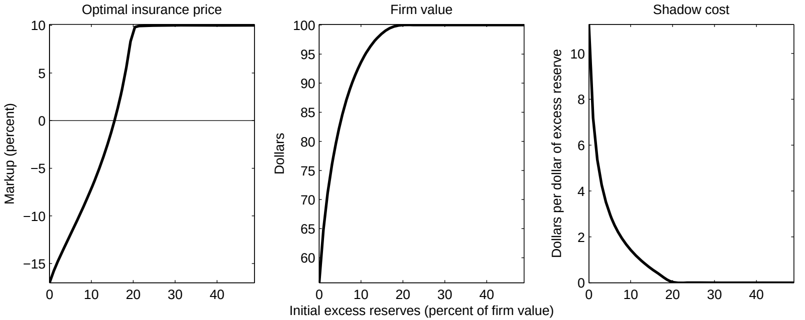
Fully specified model for welfare analysis

- Continuum of one-period consumers:
  1. Has quasi-linear utility over life annuities and wealth.
  2. Implies constant-elasticity demand for life annuities:

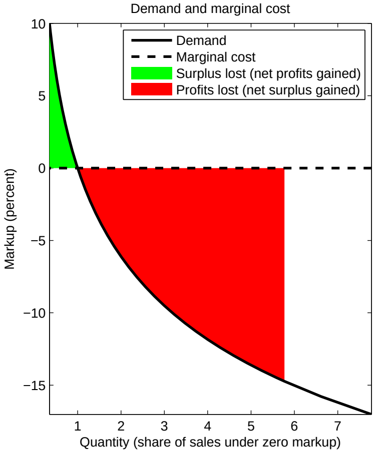
$$Q_t = X_t P_t^{-\epsilon}$$

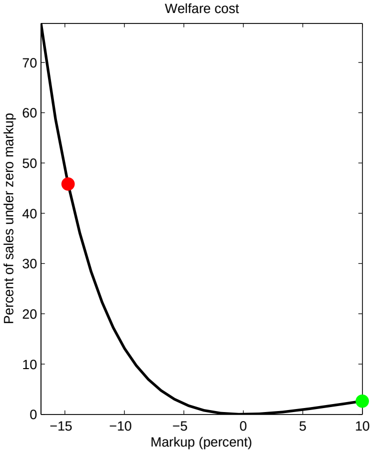
     where X_t is a stochastic demand shock.
  3. Faces a search cost to be matched with an insurance company.
- Continuum of insurance companies:
  1. Constant returns on assets and liabilities, equal to the riskless interest rate.
  2. Fixed cost creates operating leverage.
  3. Heterogeneity in initial excess reserves, and therefore, financial constraints.
- Equilibrium price dispersion: Lucky consumers get matched with a financially constrained company and pay a lower price.

Optimal insurance price and firm value in the calibrated model



Welfare cost of deviations from actuarially fair pricing





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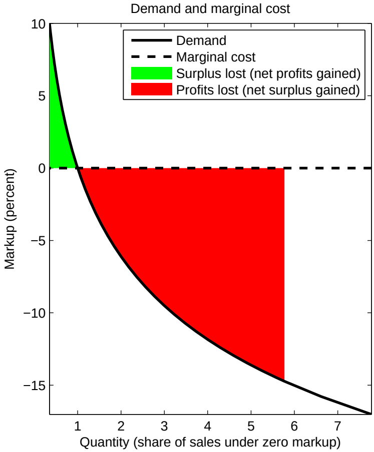

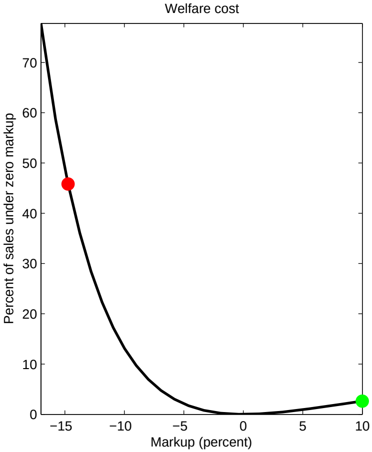

- A simple modification to statutory reserve regulation (i.e., $\widehat{V} = \phi V$) can eliminate firesales.

Broader implications

1. Household finance:
   - Literature mostly about frictions on the demand side.
     - Household borrowing constraints, asymmetric information, moral hazard, and near rationality.
   - Financial and regulatory frictions on the supply side are also important for market equilibrium and social welfare.

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     - Household borrowing constraints, asymmetric information, moral hazard, and near rationality.
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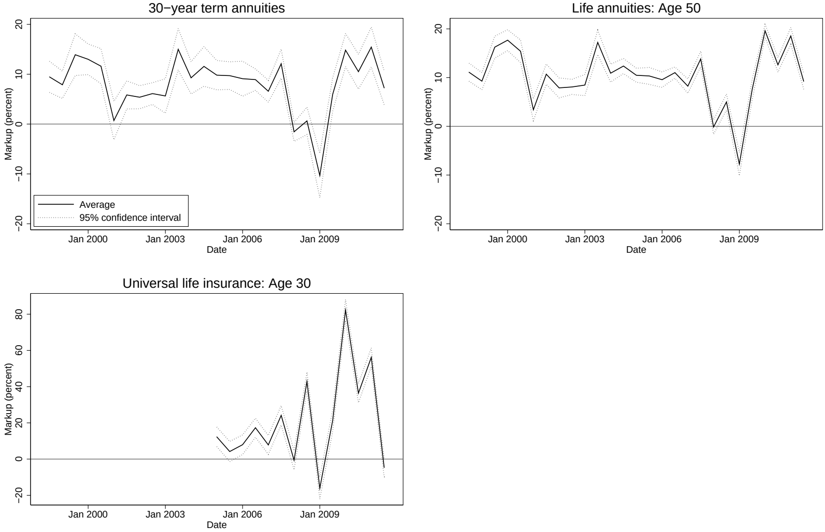
2. Macro models with financial frictions:
   - Micro evidence necessary.
   - We quantify the cost of financial frictions for life insurers.
   - Extend our empirical approach to other types of financial institutions.

Average markup under the U.S. agency yield curve



Summary statistics for annuity and life insurance prices

Type of policy	Sample begins	Number of: Observations	Number of: Insurance companies	Markup (percent): Mean	Markup (percent): Median	Markup (percent): Standard deviation
Term annuities:						
5 years	January 1993	762	83	6.7	6.5	8.2
10 years	January 1989	1,022	98	6.8	6.9	5.8
15 years	July 1998	452	62	4.2	4.8	5.7
20 years	July 1998	448	62	3.8	4.4	6.6
25 years	July 1998	368	53	3.4	3.6	7.6
30 years	July 1998	350	50	2.8	2.8	8.9
Life annuities:						
Life only	January 1989	11,879	106	9.8	9.8	8.2
10-year guaranteed	July 1998	7,885	66	5.5	6.1	7.0
20-year guaranteed	July 1998	7,518	66	4.2	4.8	7.5
Universal life insurance	January 2005	3,989	52	-4.2	-5.5	17.9

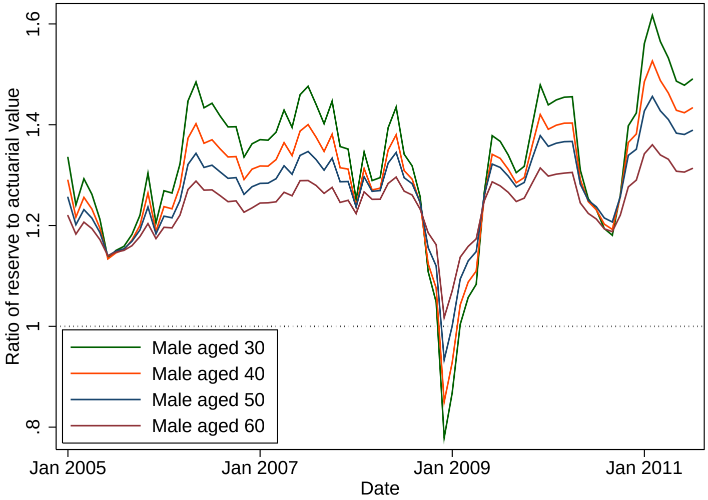
Estimated model of insurance pricing

Explanatory variable	Average marginal effect	
Rating: A to A−	3.26	(21.58)
Rating: B++ to B−	8.13	(10.70)
Leverage ratio	-2.14	(-24.43)
Asset growth	0.10	(0.00)
Log assets	1.88	(36.81)
Interaction effects for life annuities:		
Rating: A to A−	-2.37	(-19.96)
Rating: B++ to B−	-7.75	(-9.90)
Leverage ratio	26.84	(28.43)
Asset growth	-1.90	(-5.27)
Log assets	-1.46	(-28.59)
Female	0.28	(4.74)
Age 55	0.27	(1.10)
Age 60	0.61	(1.61)
Age 65	0.84	(9.28)
Age 70	1.15	(12.79)
Age 75	1.47	(5.05)
Age 80	1.82	(7.65)
Age 85	2.37	(8.36)
Age 90	3.30	(6.46)
Interaction effects for life insurance:		
Rating: A to A−	-23.69	(-5.15)
Leverage ratio	29.25	(4.15)
Asset growth	-25.93	(-5.22)
Log assets	-12.75	(-7.57)
Female	0.17	(0.00)
Age 30	2.43	(0.84)
Age 40	0.65	(0.00)
Age 60	0.20	(0.00)
Age 70	0.68	(0.00)
Age 80	0.78	(0.05)
Age 90	24.09	(6.27)
R^2 (percent)	48.53	
Observations	29,756	

Parameters in the calibrated model

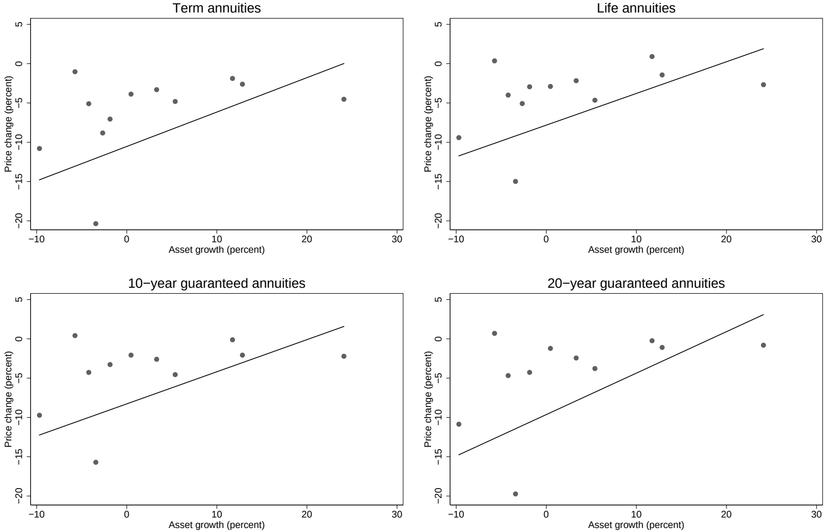
Parameter	Symbol	Value
Riskless interest rate	$R-1$	0.5%
Ratio of reserve to actuarial value	$\widehat{V}/V$	0.71
Elasticity of demand	ϵ	11
Standard deviation of demand shocks	σ	28%
Size of the fixed cost	c	1%
Sensitivity of the fixed cost to demand shocks	ω	4.02
Maximum leverage ratio	ϕ	0.97

Reserve to actuarial value for universal life insurance

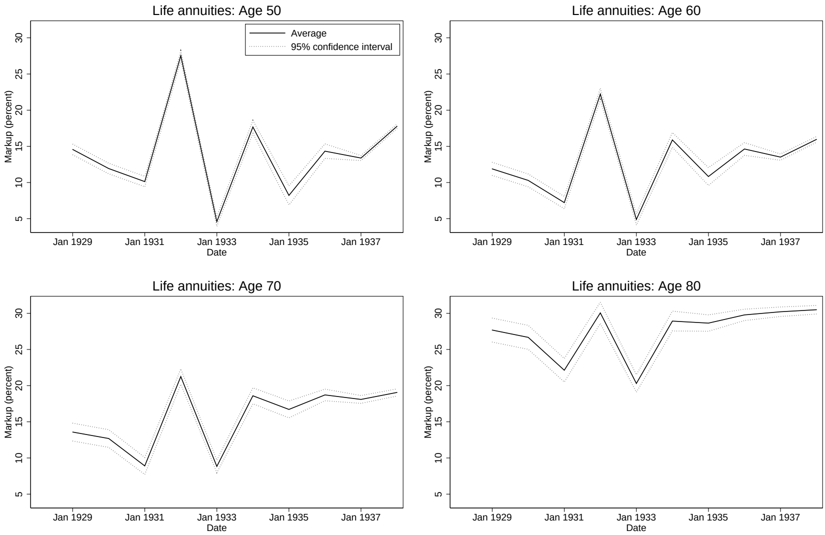


Asset growth and the leverage ratio for life insurers

Price change versus asset growth in January 2009



Average markup on life annuities in 1929–1938



Reserve to actuarial value for life annuities in 1929–1938