Workshop on the Financial Economics of Insurance
Pricing of Insurance Liabilities

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Theories of insurance markets

- Traditional theories: Market equilibrium determined by the demand side.
  - Life-cycle demand (Yaari 1965).
  - Informational frictions (Rothschild and Stiglitz 1976).
  - Assumes efficient capital markets on the supply side.

- Modern view: Insurers are financial institutions.
  - Rated and regulated because of the potential for excessive risk taking (e.g., state guaranty funds or agency problems).
  - Pricing of liabilities depend on financial and regulatory frictions.
  - Market dominated by a few large insurers.
Evidence on individual annuities and life insurance

1. Fire sale of policies from November 2008 to February 2009.
   - Average markup on annuities: $-19\%$
   - Average markup on life insurance: $-57\%$

2. Larger price reductions for
   - Policies with lower statutory reserve requirements.
   - Insurance companies with worse balance sheet shocks (especially from variable annuities).

3. More constrained companies also received capital from their holding companies and reduced dividends.
   - Evidence of frictions in both external and internal capital markets.

4. Exploit exogenous variation in statutory reserves across policies to identify the shadow cost of capital.
   - $0.96$ per dollar of statutory capital.
Example: MetLife Investors USA Insurance Company

- 10-year term annuity: Guaranteed payment of $1 for 10 years.
- MetLife priced it at
  - $8.60 in May 2009.
- Economic profit: $7.74 – $8.48 = –$0.74
- Liabilities recorded at accounting value.

\[
\begin{array}{c|c}
A & L \\
$7.74 & $7.54 \\
\end{array}
\]

- Sale creates statutory capital: $7.74 – $7.54 = $0.20
- Cost of statutory capital: $0.74/$0.20 = $3.70
Data on annuity and life insurance prices

  - 33,071 observations.
  - Covers 61% of market share in 2011.
  - Types of policies:
    1. Term annuities: 5- to 30-year maturities.
    2. Life annuities: Male and female, 50- to 85-years old, “life only” and 10- or 20-year guarantees.

- **Life insurance**: Compulife, January 2005–July 2011 (monthly).
  - 31,226 observations
  - Covers 42% of market share in 2011.
  - Universal life insurance: Male and female, 30- to 80-years old.

- Calculate the actuarial value for each type of policy.
  - Mortality tables from the American Society of Actuaries.
  - Zero-coupon Treasury yield curve.

- Merged with financial statements and A.M. Best ratings.
# Summary statistics for annuity and life insurance prices

<table>
<thead>
<tr>
<th>Type of policy</th>
<th>Sample begins</th>
<th>Frequency</th>
<th>Observations</th>
<th>Mean</th>
<th>Median</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Term annuities:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 years</td>
<td>December 1992</td>
<td>Semiannual</td>
<td>646</td>
<td>6.5</td>
<td>6.7</td>
<td>3.7</td>
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<tr>
<td>10 years</td>
<td>January 1989</td>
<td>Semiannual</td>
<td>870</td>
<td>7.0</td>
<td>7.2</td>
<td>4.2</td>
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<tr>
<td>15 years</td>
<td>May 1998</td>
<td>Semiannual</td>
<td>394</td>
<td>4.4</td>
<td>4.5</td>
<td>4.7</td>
</tr>
<tr>
<td>20 years</td>
<td>May 1998</td>
<td>Semiannual</td>
<td>390</td>
<td>4.1</td>
<td>4.0</td>
<td>5.7</td>
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<tr>
<td>25 years</td>
<td>May 1998</td>
<td>Semiannual</td>
<td>318</td>
<td>3.7</td>
<td>3.7</td>
<td>6.7</td>
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<tr>
<td>30 years</td>
<td>May 1998</td>
<td>Semiannual</td>
<td>309</td>
<td>3.1</td>
<td>3.2</td>
<td>7.9</td>
</tr>
<tr>
<td><strong>Life annuities:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Life only</td>
<td>January 1989</td>
<td>Monthly</td>
<td>13,675</td>
<td>7.9</td>
<td>8.4</td>
<td>7.6</td>
</tr>
<tr>
<td>10-year guarantee</td>
<td>May 1998</td>
<td>Monthly</td>
<td>10,221</td>
<td>4.2</td>
<td>4.9</td>
<td>6.7</td>
</tr>
<tr>
<td>20-year guarantee</td>
<td>May 1998</td>
<td>Semiannual</td>
<td>6,248</td>
<td>4.5</td>
<td>4.9</td>
<td>6.5</td>
</tr>
<tr>
<td>Universal life insurance</td>
<td>January 2005</td>
<td>Monthly</td>
<td>31,226</td>
<td>-5.8</td>
<td>-6.5</td>
<td>16.0</td>
</tr>
</tbody>
</table>
Average markup on term annuities
Average markup on life annuities

- **Life annuities: Male aged 60**
- **Life annuities: Male aged 65**
- **Life annuities: Male aged 70**
- **Life annuities: Male aged 75**

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<thead>
<tr>
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<tbody>
<tr>
<td>Average</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>95% CI</td>
<td></td>
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</tr>
</tbody>
</table>

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Average markup on life insurance

Universal life insurance: Male aged 30

Universal life insurance: Male aged 40

Universal life insurance: Male aged 50

Universal life insurance: Male aged 60
Relation between price changes and balance sheet shocks

**Asset growth**

- Price change (percent) vs Percent
- Data points represent 20-year term annuities and Life annuities: Male aged 60

**Leverage ratio**

- Price change (percent) vs Percent
- Data points show trends in leverage ratios

**Risk-based capital relative to guideline**

- Price change (percent) vs Percent
- Data points illustrate risk-based capital relative to guidelines

**Deferred annuity liabilities**

- Price change (percent) vs Share of capital and surplus
- Data points demonstrate trends in deferred annuity liabilities
Statutory reserve regulation

- **Standard Valuation Law**: “Present value” formula for calculating statutory 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.

- **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 term annuities
Risk-based capital regulation

▶ Insurance regulators use the risk-based capital ratio:

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

▶ Low RBC leads in regulatory action.
▶ Required capital determined by a complicated formula, but a simple way to think about it is

\[
\text{Required capital} = \phi \text{Reserves}
\]

▶ Riskier liabilities have higher \( \phi \).
▶ A.M. Best bases ratings on a version of RBC called Best’s Capital Adequacy Ratio.
Optimal pricing model

- Insurance company sells $i = 1, \ldots, I$ different types of policies:
  - $P_{i,t}$: Price.
  - $V_{i,t}$: Actuarial (market) value.
  - $\hat{V}_{i,t}$: Reserve (accounting) value.
  - $Q_{i,t}(P)$: Downward-sloping demand.

- Profit:
  \[ Y_t = \sum_{i=1}^{I} (P_{i,t} - V_{i,t}) Q_{i,t} \]

- Firm value:
  \[ J_t = Y_t + \mathbb{E}_t[M_{t+1}J_{t+1}] \]
Balance sheet dynamics

- Assets:
  \[ A_t = R_{A,t} A_{t-1} + \sum_{i=1}^{l} P_{i,t} Q_{i,t} \]

- Statutory reserves:
  \[ L_t = R_{L,t} L_{t-1} + \sum_{i=1}^{l} \hat{V}_{i,t} Q_{i,t} \]

- Risk-based capital constraint:
  \[ \frac{A_t - L_t}{\phi L_t} \geq 1 \iff \frac{L_t}{A_t} \leq \frac{1}{1 + \phi} \]

  or
  \[ K_t = A_t - (1 + \phi) L_t \geq 0 \]
Optimal pricing equation

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

$$L_t = J_t + \lambda_t K_t = Y_t + \mathbb{E}_t [M_{t+1} J_{t+1}] + \lambda_t K_t.$$
Optimal pricing equation

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

\[ L_t = J_t + \lambda_t K_t = Y_t + \mathbb{E}_t [M_{t+1} J_{t+1}] + \lambda_t K_t. \]

- The first-order condition for the price of policy $i$ in period $t$ is

\[
\frac{\partial L_t}{\partial P_{i,t}} = \frac{\partial J_t}{\partial P_{i,t}} + \lambda_t \frac{\partial K_t}{\partial P_{i,t}} = \frac{\partial Y_t}{\partial P_{i,t}} + \lambda_t \frac{\partial K_t}{\partial P_{i,t}}
\]

\[ = Q_{i,t} + (P_{i,t} - V_{i,t}) \frac{\partial Q_{i,t}}{\partial P_{i,t}} \]

\[ + \bar{\lambda}_t \left[ Q_{i,t} + (P_{i,t} - (1 + \phi) \hat{V}_{i,t}) \frac{\partial Q_{i,t}}{\partial P_{i,t}} \right] = 0, \]

where we refer to

\[
\bar{\lambda}_t = \lambda_t + \mathbb{E}_t \left[ M_{t+1} \frac{\partial J_{t+1}}{\partial K_t} \right] = -\frac{\partial Y_t}{\partial P_{i,t}} \left( \frac{\partial K_t}{\partial P_{i,t}} \right)^{-1}
\]

as the shadow cost of capital.
Optimal pricing equation

- Price of policy $i$:

\[
P_{i,t} = V_{i,t} \left(1 - \frac{1}{\epsilon_{i,t}} \right)^{-1} \left( \frac{1 + \lambda_t (1 + \phi) \hat{V}_{i,t}/V_{i,t}}{1 + \lambda_t} \right)
\]

where

\[
\epsilon_{i,t} = -\frac{\partial \log Q_{i,t}}{\partial \log P_{i,t}} > 1,
\]

is the elasticity of demand.

- Without constraints, $\lambda_t = 0$, we obtain the Bertrand price

\[
P_{i,t} = V_{i,t} \left(1 - \frac{1}{\epsilon_{i,t}} \right)^{-1}
\]
Predictions

1. Price depends on statutory reserve requirements:

\[
\frac{\hat{V}_{i,t}}{V_{i,t}} \leq \frac{1}{1 + \phi} \iff P_{i,t} \leq \text{Bertrand price}
\]

- **Intuition**: Insurance company eager to sell policies with low statutory reserve requirements that loosen the constraint.
- Literature on banking (Peek and Rosengren 2000) and P-C insurance (Froot and O’Connell 1999) suggest that supply shifts in, but that’s because \( \hat{V}_{i,t}/V_{i,t} \geq 1 \) in these contexts.

2. Price reductions are larger for more constrained companies (i.e., higher \( \bar{\lambda}_t \)).
Empirical specification

- Policy \( i \), company \( j \), and time \( t \):
  \[
  \log \left( \frac{P_{i,j,t}}{V_{i,t}} \right) = -\log \left( 1 - \frac{1}{\epsilon_{i,j,t}} \right) \\
  + \log \left( \frac{1 + \bar{\lambda}_{j,t}(L_{j,t}/A_{j,t})^{-1}\hat{V}_{i,t}/V_{i,t}}{1 + \bar{\lambda}_{j,t}} \right) + e_{i,j,t}
  \]

- Elasticity of demand:
  \[
  \epsilon_{i,j,t} = 1 + \exp\{-\beta' y_{i,j,t}\}
  \]

- Shadow cost:
  \[
  \bar{\lambda}_{j,t} = \exp\{\gamma' z_{j,t}\}
  \]

- Explanatory variables:
  - A.M. Best rating, log assets, asset growth, leverage ratio, RBC, current liquidity, and ROE.
  - Dummies for time and domiciliary state.
Identifying assumptions

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:
     \[
     \log \left( \frac{P_i}{V_i} \right) \approx \alpha + \frac{\lambda}{1 + \lambda} \left( \frac{L}{A} \right)^{-1} \frac{\hat{V}_i}{V_i} + u_i,
     \]
   - Standard Valuation Law generates relative shifts in supply that are orthogonal to demand:
     \[
     \text{Cov} \left( \frac{\hat{V}_i}{V_i}, u_i \right) = 0
     \]
   - Exploits exogenous variation in capital requirements across policies.
Estimated model of insurance pricing

<table>
<thead>
<tr>
<th>Explanatory variable</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel B. Shadow cost of capital</strong></td>
<td></td>
</tr>
<tr>
<td>Corporate yield spread</td>
<td>0.660</td>
</tr>
<tr>
<td>Log assets</td>
<td>-0.240</td>
</tr>
<tr>
<td>Asset growth</td>
<td>-0.255</td>
</tr>
<tr>
<td>Leverage ratio</td>
<td>1.545</td>
</tr>
<tr>
<td>Risk-based capital relative to guideline</td>
<td>0.393</td>
</tr>
<tr>
<td>Net equity inflow</td>
<td>0.085</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.232</td>
</tr>
<tr>
<td>Observations</td>
<td>45,430</td>
</tr>
</tbody>
</table>
Shadow cost of capital

[Graph showing the shadow cost of capital from Dec 1999 to Dec 2011 with 95% confidence intervals]

<table>
<thead>
<tr>
<th>Date</th>
<th>Shadow cost</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 2002</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 2005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dec 2011</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Shadow cost of capital in November 2008

<table>
<thead>
<tr>
<th>Insurance company</th>
<th>Shadow cost (dollars)</th>
<th>Asset growth (percent)</th>
<th>Leverage ratio (percent)</th>
<th>Net equity inflow (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MetLife Investors USA Insurance</td>
<td>5.53</td>
<td>(1.52)</td>
<td>-9</td>
<td>97</td>
</tr>
<tr>
<td>Pruco Life Insurance</td>
<td>5.38</td>
<td>(1.39)</td>
<td>-19</td>
<td>97</td>
</tr>
<tr>
<td>National Integrity Life Insurance</td>
<td>5.37</td>
<td>(1.20)</td>
<td>10</td>
<td>95</td>
</tr>
<tr>
<td>John Hancock Life Insurance of New York</td>
<td>5.02</td>
<td>(1.39)</td>
<td>-15</td>
<td>96</td>
</tr>
<tr>
<td>Pruco Life Insurance of New Jersey</td>
<td>4.97</td>
<td>(1.26)</td>
<td>-13</td>
<td>97</td>
</tr>
<tr>
<td>AXA Equitable Life Insurance</td>
<td>4.52</td>
<td>(1.12)</td>
<td>-22</td>
<td>97</td>
</tr>
<tr>
<td>John Hancock Life Insurance (USA)</td>
<td>3.87</td>
<td>(1.09)</td>
<td>-18</td>
<td>98</td>
</tr>
<tr>
<td>Lincoln National Life Insurance</td>
<td>3.50</td>
<td>(0.82)</td>
<td>-17</td>
<td>96</td>
</tr>
<tr>
<td>Sun Life Assurance of Canada (US)</td>
<td>3.31</td>
<td>(0.88)</td>
<td>-11</td>
<td>97</td>
</tr>
<tr>
<td>Phoenix Life Insurance</td>
<td>3.06</td>
<td>(0.64)</td>
<td>-8</td>
<td>94</td>
</tr>
<tr>
<td>OM Financial Life Insurance</td>
<td>2.88</td>
<td>(0.66)</td>
<td>-4</td>
<td>95</td>
</tr>
<tr>
<td>Aviva Life and Annuity of New York</td>
<td>2.75</td>
<td>(0.61)</td>
<td>4</td>
<td>94</td>
</tr>
<tr>
<td>Allianz Life Insurance of North America</td>
<td>2.75</td>
<td>(0.70)</td>
<td>-3</td>
<td>97</td>
</tr>
<tr>
<td>Texas Life Insurance</td>
<td>2.44</td>
<td>(0.51)</td>
<td>5</td>
<td>93</td>
</tr>
<tr>
<td>United States Life Insurance in City of New York</td>
<td>2.19</td>
<td>(0.51)</td>
<td>0</td>
<td>94</td>
</tr>
<tr>
<td>EquiTrust Life Insurance</td>
<td>2.18</td>
<td>(0.47)</td>
<td>14</td>
<td>95</td>
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<tr>
<td>Integrity Life Insurance</td>
<td>2.07</td>
<td>(0.40)</td>
<td>3</td>
<td>92</td>
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<tr>
<td>OM Financial Life Insurance of New York</td>
<td>1.96</td>
<td>(0.42)</td>
<td>-2</td>
<td>93</td>
</tr>
<tr>
<td>Companion Life Insurance</td>
<td>1.92</td>
<td>(0.39)</td>
<td>4</td>
<td>91</td>
</tr>
<tr>
<td>Sun Life Insurance and Annuity of New York</td>
<td>1.85</td>
<td>(0.37)</td>
<td>-2</td>
<td>92</td>
</tr>
</tbody>
</table>
Additional evidence on financial frictions

- In order for the subsidiary to be constrained, you need frictions in either
  - External capital markets: Holding company doesn’t have capital to inject into the subsidiary.
  - Internal capital markets: Holding company doesn’t have proper incentives to inject capital into the subsidiary.
- Evidence that external capital was costly during the financial crisis.
- Insurance Holding Company System Regulatory Act may have led to frictions in internal capital markets.
Cost of external equity issuance: MetLife

- October 7, 2008: Announced issuance of 86.25 million shares.
- October 8: Abnormal return of $-24\%$.
  - Its market cap was $26.170$ billion.
  - Announcement effect: $0.24 \times 26.170 = 6.370$ billion
- Raised $2.329$ billion in new equity.
- Average cost of
  \[
  \frac{6.370}{2.286} = 2.79 \text{ per dollar of capital}
  \]
- Marginal cost (i.e., shadow cost of capital) is
  - $0.96$ for the average company.
  - $5.53$ for MetLife.
Significant activity to recapitalize by the holding companies

<table>
<thead>
<tr>
<th>Holding company</th>
<th>Date</th>
<th>Significant activity</th>
<th>Announcement effect (dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Panel A. Applied for government assistance</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Allstate</td>
<td>11/14/2008</td>
<td>Applies for TARP.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/25/2009</td>
<td>Reduces quarterly dividend from $0.41 to $0.20 per share.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5/15/2009</td>
<td>Receives approval for TARP.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5/19/2009</td>
<td>Withdraws application for TARP.</td>
<td></td>
</tr>
<tr>
<td>American International Group</td>
<td>9/22/2008</td>
<td>Suspends dividends under an $85 billion credit agreement with the New York Fed.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11/25/2008</td>
<td>Issues $40 billion of preferred equity to the US Treasury under TARP.</td>
<td></td>
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<tr>
<td></td>
<td>11/16/2008</td>
<td>Applies for TARP with plans to acquire InterBank, FSB.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4/9/2009</td>
<td>Is rejected for TARP and cancels the acquisition of InterBank, FSB.</td>
<td></td>
</tr>
<tr>
<td>ING Group</td>
<td>10/19/2008</td>
<td>Issues 10 billion euros of preferred equity to the Dutch government.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10/19/2008</td>
<td>Suspends dividends.</td>
<td></td>
</tr>
<tr>
<td>Lincoln National</td>
<td>10/10/2008</td>
<td>Reduces quarterly dividend from $0.415 to $0.21 per share.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11/13/2008</td>
<td>Applies for TARP with plans to acquire Newton County Loan and Savings, FSB.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/24/2009</td>
<td>Reduces quarterly dividend from $0.21 to $0.01 per share.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7/10/2009</td>
<td>Issues $950 million of preferred equity to the US Treasury under TARP.</td>
<td></td>
</tr>
<tr>
<td>Phoenix Companies</td>
<td>1/15/2009</td>
<td>Applies for TARP with plans to acquire American Sterling Bank.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2/7/2009</td>
<td>Suspends dividends.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4/20/2009</td>
<td>Withdraws application for TARP after failing to acquire American Sterling Bank.</td>
<td></td>
</tr>
<tr>
<td>Protective Life</td>
<td>11/3/2008</td>
<td>Reduces quarterly dividend from $0.235 to $0.12 per share.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1/15/2009</td>
<td>Applies for TARP with plans to acquire Bonifay Holding Company.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4/1/2009</td>
<td>Withdraws application for TARP after failing to acquire Bonifay Holding Company.</td>
<td></td>
</tr>
<tr>
<td>Prudential Financial</td>
<td>10/1/2008</td>
<td>Applies for TARP.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11/11/2008</td>
<td>Reduces annual dividend from $1.15 to $0.58 per share.</td>
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</tr>
<tr>
<td></td>
<td>5/14/2009</td>
<td>Receives approval for TARP.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6/1/2009</td>
<td>Withdraws application for TARP.</td>
<td></td>
</tr>
<tr>
<td><strong>Panel B. Issued public equity</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manulife Financial</td>
<td>12/11/2008</td>
<td>Issues $2,275 million of common equity.</td>
<td>0.72</td>
</tr>
<tr>
<td></td>
<td>8/6/2009</td>
<td>Reduces quarterly dividend from $0.26 to $0.13 per share.</td>
<td></td>
</tr>
<tr>
<td>MetLife</td>
<td>10/15/2008</td>
<td>Issues $2,286 million of common equity.</td>
<td>2.79</td>
</tr>
<tr>
<td><strong>Panel C. Reduced or suspended dividends</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Allianz Group</td>
<td>2/26/2009</td>
<td>Reduces annual dividend from 5.50 to 3.50 euros per share.</td>
<td></td>
</tr>
<tr>
<td>AXA</td>
<td>4/30/2009</td>
<td>Reduces annual dividend from 1.20 to 0.40 euros per share.</td>
<td></td>
</tr>
<tr>
<td>FBL Financial Group</td>
<td>5/21/2009</td>
<td>Reduces quarterly dividend from $0.125 to $0.0625 per share.</td>
<td></td>
</tr>
<tr>
<td>Legal and General Group</td>
<td>3/25/2009</td>
<td>Reduces final dividend from 4.10 to 2.05 pence per share.</td>
<td></td>
</tr>
</tbody>
</table>
Frictions in internal capital markets

- Policyholders are senior to creditors of the holding company.
- State regulators severely restrict capital flow from the subsidiary to the holding company.
  - For example, dividends authorized under the Insurance Holding Company System Regulatory Act.
- Leads to “regulatory overhang”.
  - Regulatory uncertainty over the ability to move capital out reduces ex-ante incentives to inject capital.
Default risk

1. Policies backed by the state guaranty fund. What if it fails?
   - Lower bound on the recovery rate: 84%.
     - Capital regulation: Only 16% of assets are risky.
     - Asset deficit of 5–10% in past cases of insolvency.
   - Risk-neutral default probabilities implied by term annuities in November 2008:
     - 100% for maturity greater than 15 years.
     - Higher than default probabilities implied by CDS.
     - Upward sloping term structure inconsistent with CDS.

2. No discounts on life annuities during the Great Depression.
   - Inconsistent with default story.
   - Consistent with the explanation based on statutory reserve regulation.
Related evidence (Ge 2017)

- After a weather shock, P-C subsidiary loses capital.
- Holding company reallocates capital from the life subsidiary to the P-C subsidiary.
- Life subsidiary becomes constrained, and price changes consistent with optimal pricing equation.
  - Prices for universal life insurance go down because $\hat{V}/V < (1 + \phi)^{-1}$.
  - Prices for term life insurance go up because $\hat{V}/V > (1 + \phi)^{-1}$.
Next steps

- Clean evidence that financial frictions affect insurance prices.
- Is this isolated to the financial crisis? Or do supply-side frictions matter at lower frequencies?
- Questions to be addressed next:

  1. Why did insurers get constrained in the first place? For a traditional insurer, liability matching implies that overall balance sheet should be insensitive to market risk.
  2. Pricing is only one dimension of insurance policies. How do we extend the theory to other contract characteristics?
  3. Lack of detailed data on quantities prevents demand estimation.