The Liability Regime of Insurance Pools and Its Impact on Pricing

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WRIEC 2015
Munich, August 4, 2015
The Idea of Insurance Pools and Different Liability Regimes

- Insurance pools use to fill gap of coverage on traditional insurance markets
- Gaps occur due to heaviness of corresponding risks (e.g. nuclear risks, pharma risks, natural perils, terror risks)
- Idea of risk and premium sharing among several insurance companies
- Beneficial effects from insurance pools resemble effects from co-insurance and reinsurance, i.e. capacity enlargement, pooling of knowledge and information, diversification, control of accumulation risk
- As opposed to co-insurance/reinsurance agreements pools are (mostly) own legal entities that are founded for a long-lasting time horizon

Example of pools
- German Nuclear Reactor Insurance Association
- German Pharma Pool
- Austrian Insurance Pool for Terror Risks
- Nuclear Insurance Association of Canada

Premium payment and claims indemnification
Premium and claims are shared via pool

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The Idea of Insurance Pools and Different Liability Regimes

保险池的使用是为了填补传统保险市场上的覆盖空白。

由于对应风险的严重性（如核风险、制药风险、自然灾害、恐怖主义风险），这些空白会引发。

风险和保费的分享理念是保险池的主要特点。

保险池的优点类似于共同保险和再保险，即容量扩大、知识和信息的汇集、风险的分散、积累风险的控制。

与共同保险和再保险协议不同，保险池通常是一个（通常是）独立的法律实体，且成立时间较长。

如果一个或多个保险公司部分或全部违约，将如何影响政策持有者？

- **联合责任制度**：IC 2 和 IC 3 有义务承担 IC 1 的支付义务。
  - 违约风险仅限于所有保险公司均无法履行义务时。
  - 如德国核反应堆保险协会。

- **多个责任制度**：IC 2 和 IC 3 不需要承担 IC 1 的支付义务。
  - 违约将影响每一方。
  - 如奥地利恐怖主义保险池。

例子

- 德国核反应堆保险协会
- 德国制药池
- 奥地利恐怖主义保险池
- 加拿大核保险协会

What happens if one or more insurance companies default (partially) on their obligation from the pool business?

Regime of Joint Liability
IC 2 and IC 3 are committed to assume the payment obligation of IC 1
→ Default risk for policyholder limited to case where all insurers fail
   e.g. German Nuclear Reactor Insurance Association

Regime of Several Liability
IC 2 and IC 3 do not have to assume the payment obligation of IC 1
→ Any default effects policyholder
   e.g. Austrian Insurance Pool for Terror Risks

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A contingent claims model based on Doherty and Garven (1986)

approach is similarly used in, e.g. Cummins (JF, 1988), Cummins and Sommer (JBF, 1996), Sherris (JRI 2006), Gatzert and Kling (JRI, 2007), Schmeiser and Wagner (JRI, 2013)

At time $t = 0$ insurance company $i$ has assets available amounting to

$$A^i_0 = E^i_0 + \beta^i_0 P_0$$

Fair positions of policyholders and equity holders

In the context of risk-neutral pricing we presume fairness for policyholders and equity holders if their positions at time $t = 0$ equals the present values of the payoffs at time $t = 1$, i.e.

$$\left( P_0, E^1_0, \ldots, E^n_0 \right) = \left( PV(P_1), PV(E^1_1), \ldots, PV(E^n_1) \right)$$

→ Net present value of zero for all stakeholders
→ Equilibrium: no wealth transfer between stakeholders
Our Model – Payoffs at Time $t = 1$

A contingent claims model based on *Doherty and Garven (1986)*

Our model is based on the idea of contingent claims. The payoffs at time $t = 1$ are as follows:

- **Policyholders (PH)**
  - **Aggregated Market**
  - **Claims Indemnification $P_1 = C_1 - D_1$**
  - $D_1$ is the pool’s default put option. Its size depends on the liability regime at hand:
    - **Several Liability**
    - **Joint Liability**

- **Pool Organization (IC)**
  - **Equity Holders (EH)**
    - **Investment Return $E_1^i$**
    - $E_1^i = [A_i - \alpha_i C_1]^+$

We have formally defined $G_1^i$ to be in line with joint liability’s default mechanism in practice.
### Setting and Approach

**Setting & Parameters**

- Pool claims are modelled as jump-diffusion process (GBM & Poisson Process, Merton (1976))
- Constant process parameters for all applications
- The claims’ face value at time \( t = 0 \) is fixed at \( PV(C_1) = 100 \) (independent of regime)
- Asset returns are modelled as ordinary GBMs – volatility parameter at first constant and identical for both insurers (\( \sigma = 20\% \), no information asymmetry)
- Pool size: \( n = 2 \)
- Risk-free interest rate \( r = 3.00\% \)

**Two approaches**

1. Fix equity \( E_0^{*,i} \) for both insurers and calculate fair premiums \( P_0^* \) that ensure market equilibrium in both regimes \((* = J, S)\)
   - What are justified premium differences between both regimes if policyholder can choose between both regimes?

2. Fix premium for both regimes at same safety level and calculate fair equity amounts \( E_0^{*,i} \) for both insurers that ensure market equilibrium
   - What are different equity needs for reaching same (regulatory required) safety level in both regimes?
   - What is the value for equity holders investing in insurance companies in different regimes?
   - What are tax-adjusted prices in both regimes?

In approach 2 same premium means same safety level, since

\[
P_0^J = PV(P_1^J) = PV(P_1^S) = P_0^S
\]

\[
\Leftrightarrow PV(C_1) - PV(D_1^J) = PV(C_1) - PV(D_1^S)
\]

\[
\Leftrightarrow PV(D_1^J) = PV(D_1^S)
\]

i.e. present value of DPO is the same for both regimes.

Since \( G_1^J > 0 \), it becomes clear from

\[
E_1^{S,i} = [A_i^1 - \alpha_i C_1]^+ = [(P_1^S + E_0^{S,i})(1 + r) - \alpha_i C_1]^+
\]

\[
E_1^{J,i} = [A_i^1 - \alpha_i C_1 - G_i^J]^+ = [(P_1^J + E_0^{J,i})(1 + r) - \alpha_i C_1 - G_i^J]^+
\]

that \( E_0^{S,i} = PV(E_1^{S,i}) > PV(E_1^{J,i}) = E_0^{J,i} \) must hold true for \( P_0^S = P_0^J \).
# Equity Requirements in Different Regimes

## DPO-Equity-Combinations

\[
(\alpha_1, \alpha_2) = (0.5, 0.5) \\
(\beta_1, \beta_2) = (0.5, 0.5) \\
\rho = 0.0
\]

## Given Input Parameters

<table>
<thead>
<tr>
<th>$\rho$</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$PV(D_1^J)$</th>
<th>$PV(D_1^L)$</th>
<th>$E_0^{-S,1} + E_0^{-S,2}$</th>
<th>$E_0^{-J} + E_0^{-L}$</th>
<th>$\Delta$</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.50</td>
<td>0.50</td>
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<td>0.4</td>
<td>92.47</td>
<td>73.91</td>
<td>25%</td>
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<td></td>
<td>0.80</td>
<td>0.20</td>
<td>0.4</td>
<td>0.4</td>
<td>92.47</td>
<td>80.80</td>
<td>14%</td>
</tr>
<tr>
<td></td>
<td>0.95</td>
<td>0.05</td>
<td>0.4</td>
<td>0.4</td>
<td>92.47</td>
<td>89.15</td>
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<td>0.50</td>
<td>0.4</td>
<td>0.4</td>
<td>92.47</td>
<td>79.88</td>
<td>16%</td>
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<td>0.80</td>
<td>0.20</td>
<td>0.4</td>
<td>0.4</td>
<td>92.47</td>
<td>84.70</td>
<td>9%</td>
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<td>0.4</td>
<td>92.47</td>
<td>90.32</td>
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<td>0.50</td>
<td>0.4</td>
<td>0.4</td>
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<td>86.13</td>
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<td>88.75</td>
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<tr>
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<td>0.4</td>
<td>92.47</td>
<td>91.49</td>
<td>1%</td>
</tr>
</tbody>
</table>

- For same safety level/insolvency costs, several liability requires overall more equity
- Equity spread depends on insurers’ asset correlation and the balance of risk sharing within the pool arrangement
- Framework ensures fair return on equity holders’ investment → risk-neutral stakeholders are indifferent with respect to regimes
Corporate Income Taxation in Different Regimes

Given Input Parameters

<table>
<thead>
<tr>
<th>$\rho$</th>
<th>$\alpha_1$</th>
<th>$\alpha_2$</th>
<th>$PV(D_t^I)$</th>
<th>$PV(D_t^J)$</th>
<th>$T_{0}^S$</th>
<th>$T_{0}^J$</th>
<th>$\Delta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.5</td>
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<td>0.50</td>
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<td>0.4</td>
<td>7.71</td>
<td>6.97</td>
<td>11%</td>
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<tr>
<td>-0.5</td>
<td>0.80</td>
<td>0.20</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.24</td>
<td>6%</td>
</tr>
<tr>
<td>0.0</td>
<td>0.95</td>
<td>0.05</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.57</td>
<td>2%</td>
</tr>
<tr>
<td>0.5</td>
<td>0.50</td>
<td>0.50</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.22</td>
<td>7%</td>
</tr>
<tr>
<td>0.0</td>
<td>0.80</td>
<td>0.20</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.41</td>
<td>4%</td>
</tr>
<tr>
<td>0.5</td>
<td>0.95</td>
<td>0.05</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.62</td>
<td>1%</td>
</tr>
<tr>
<td>0.5</td>
<td>0.50</td>
<td>0.50</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.46</td>
<td>3%</td>
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<td>0.20</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.57</td>
<td>2%</td>
</tr>
<tr>
<td>0.5</td>
<td>0.95</td>
<td>0.05</td>
<td>0.4</td>
<td>0.4</td>
<td>7.71</td>
<td>7.67</td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

- Reduced equity requirements in a regime of joint liability reduces the burden of income taxation
- If present value of tax is added as loading to the policyholders’ premium the regime of joint liability has cost reducing effect for policyholder
- Cost advantage vanishes as asset correlation is high and risk sharing unbalanced
Risk Shifting: Incentives and Effects

Risk Shifting
Insurer(s) have ability to invest in alternative project with higher volatility

- Discrepancy between pricing and actual parameters → Market disequilibrium (follows example of Jensen & Meckling (1976))
- Market disequilibrium results in non-zero net present values at time $t = 0$ → Measured by NPV ratios $\theta_p, \theta_{E,1}, \theta_{E,2}$

<table>
<thead>
<tr>
<th>Asset Volatility</th>
<th>Pricing Parameters</th>
<th>Actual Parameters</th>
<th>Risk Shifting of Insurer 2!</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\sigma_1$</td>
<td>$\sigma_2$</td>
<td>$\sigma_1$</td>
</tr>
<tr>
<td>Single Risk Shift</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
</tbody>
</table>

### Pricing Parameters

- **Joint Liability**
  - $\theta_p$: -0.18% to 0.00%
  - $\theta_{E,1}$: -3.24% to 2.39%
  - $\theta_{E,2}$: 3.98% to 2.40%

- **Several Liability**
  - $\theta_p$: -0.82% to 0.00%
  - $\theta_{E,1}$: -0.49% to 0.00%
  - $\theta_{E,2}$: 2.40% to 1.12%

### Regime of Several Liability
- Policyholder is adversely effected
- No effects on zero net present value of equity holders of Insurer 1
- Beneficial effects for equity holders of Insurer 2
→ Principal-agent-problem:
  - Principal = Policyholder
  - Agent = Insurer 2
  - Insurer 1 neutral position

### Regime of Joint Liability
- Policyholder is adversely effected
- Equity holders of Insurer 1 are adversely effected as well
- Beneficial effects for equity holders of Insurer 2
→ Principal-agent-problem:
  - Principals = Policyholder and Insurer 1
  - Agent = Insurer 2

- In general position of policyholder in a regime of several liability more vulnerable than in a regime of joint liability
- Group of principals in a regime of joint liability appears as more powerful than in a regime of several liability
## Risk Shifting: Incentives and Effects

<table>
<thead>
<tr>
<th>Insurer 1</th>
<th>Insurer 2</th>
<th>Policyholder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Joint Liability</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Net Present Value Ratio</strong></td>
<td></td>
<td></td>
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<tr>
<td><strong>Pricing Parameters</strong></td>
<td><strong>Actual Parameters</strong></td>
<td><strong>NPV Ratios</strong></td>
</tr>
<tr>
<td>( \sigma_1 )</td>
<td>( \sigma_2 )</td>
<td>( PV(D_1) )</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
<td>99.6</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
<td>99.6</td>
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<td>99.6</td>
</tr>
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<td>20%</td>
<td>20%</td>
<td>99.6</td>
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<td>20%</td>
<td>20%</td>
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</tr>
<tr>
<td>20%</td>
<td>20%</td>
<td>99.6</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
<td>99.6</td>
</tr>
</tbody>
</table>

- Higher asset volatility appears as immunization strategy against adverse effects from risk shifting in a regime of joint liability.
- Information asymmetry may induce race for most risky investment between both insurers but can also motivate to engage to a common investment policy and more transparency.

**Insurer 1 can also shift assets into more risky investments**

- Any risk shift of one insurer is immaterial for the other insurer.
- Risk shifting not as measure for immunization.
- Position of policyholder more sensitive to adverse effects of risk shifting.
- No incitements for insurers to commit to a restricting investment policy.
Conclusion

- Regime of joint liability can serve as measure of equity substitution (less equity provides same safety level as in a regime of several liability)
- Might be of interest if equity is associated with capital costs → Regime of joint liability becomes the cheaper alternative
- Cost advantages vanishes as asset correlation of pool insurers is high or if risk sharing is unbalanced
- Joint liability can force insurers to conduct monitoring of co-insurers → policyholder can save costs and efforts for monitoring

Outlook

- Assuming risk-aversion do policyholder value one regime more than the other?
- What are effects of joint liability if insurers possess second line of business without joint liability?
- How is joint liability handled in Solvency II regime due to counterparty risk?
Thank You!

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