The Liability Regime of Insurance Pools and Its Impact on Pricing

Lukas Reichel and Hato Schmeiser,
University of St.Gallen

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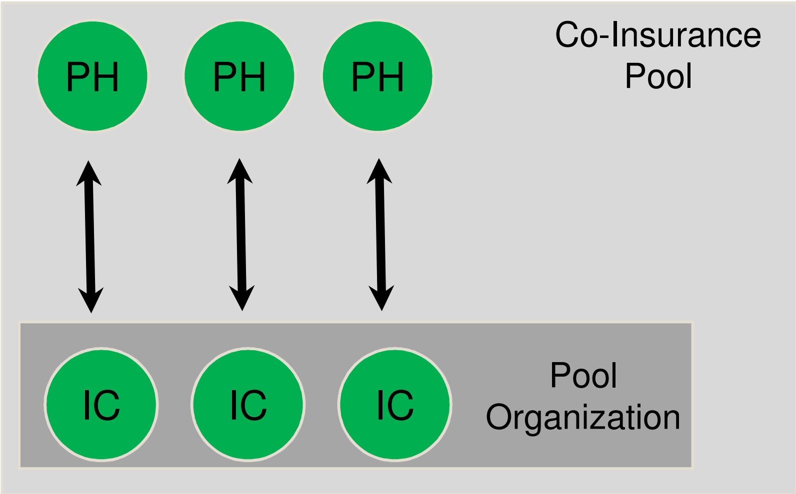
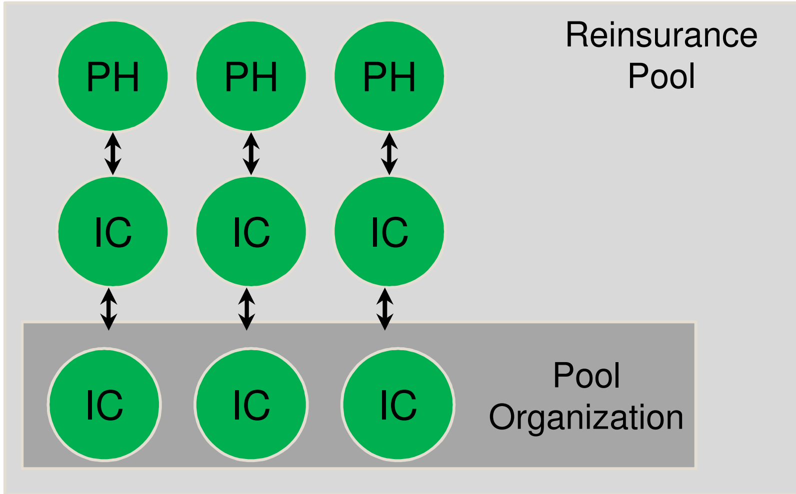
Institute of Insurance Economics
University of St.Gallen

Insurance Pools in Practice

According to *Farny (2011)* insurance pools are **mutual organizations of several insurance companies** having been founded for the purpose of **insuring a special type of risk** and appear either as **co-insurance pools** or **reinsurance pools**.





European Commission (2013) gives an overview about the pool landscape in Europe:

- The study figured out 51 pools in the EU; most of them (11) cover energy risk
- Among interviewed pools (44): 30% reinsurance pools, rest co-insurance or both

Subject of Our Study

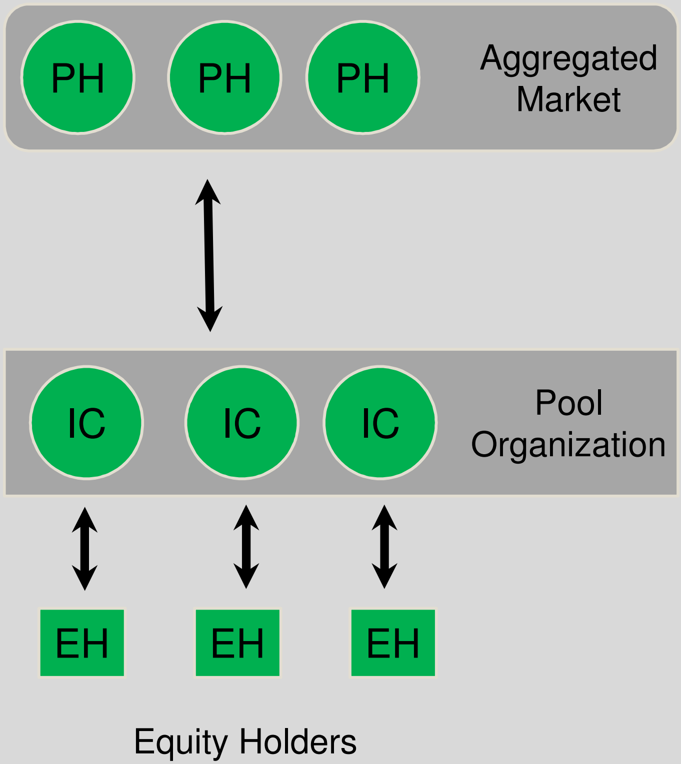
Previous Literature Explicitly Dealing with Pools

Optimal/Fair Risk Sharing	Diversification Benefits	Legal/ Organizational	State Pools/ Public-Private Partnership
Ambrosino et al. (2006), Fragnelli and Marina (2003), Mahul and Wright (2003)	*Kraut (2013)*	*Rimsaite (2013), Ehling (2011)*	*Cummins (2006), Michel-Kerjan and Pedell (2005), Jaffee and Russell (2000)*

Motivation	**Our study is motivated from a legal point of view:** What happens if one or more pool insurers default on the policyholders' claims?	
Market Observation	**Regime of *Several Liability*** A default of one insurer is not compensated by other insurers	**Regime of *Joint Liability*** Policyholders have access to the insurers' aggregated funds
Research Subject	Quantify the regimes' effects on pricing as well as equity requirements and discuss risk-shifting problems in both regimes	

Our Model

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



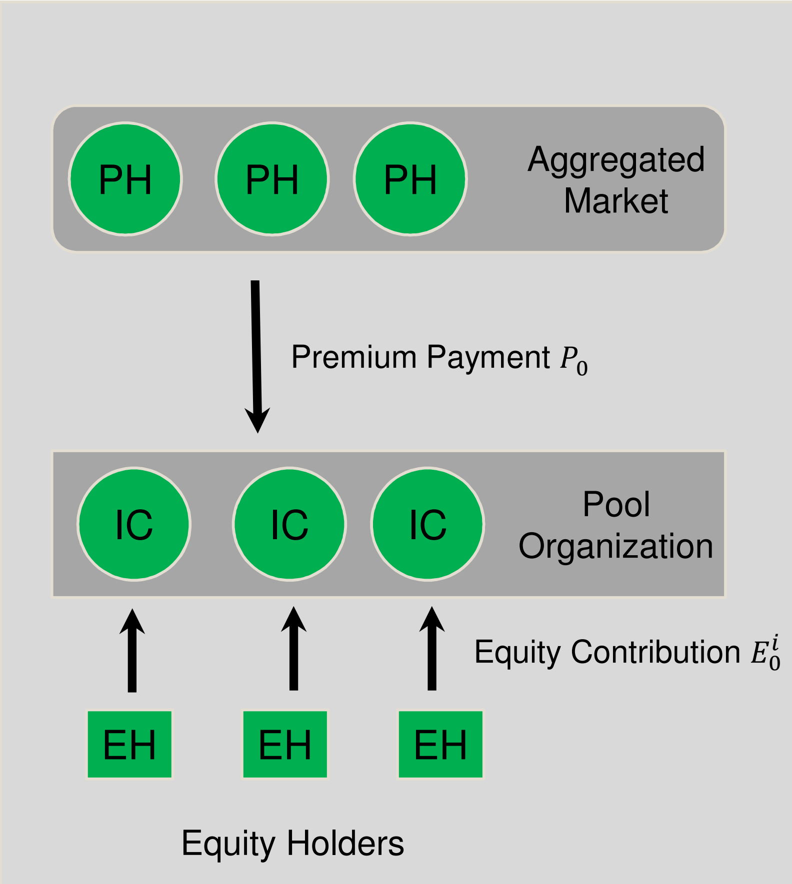
Groups of stakeholders

Model assumptions

- Pool is composed of insurers $i = 1, \ldots, n$
- ICs organized as stock companies and equity holders seek profit maximization
- Pool holds no own balance sheet or funds, business is disclosed in the ICs' balance sheets; separated investments
- ICs underwrite only pool business
- Complete market and no arbitrage opportunity → pricing under an unique risk-neutral measure
- Pricing is net of administrative costs, deductibles and any reinsurance
- Two-period-consideration: Premium and equity payments at time t = 0; claims payment and investment return at time t = 1
- Insurer defaults if liabilities at t = 1 exceed available assets
- α_i denotes the risk share of insurer i, β_i the premium share

Our Model – Positions at Time t = 0

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



Payoffs at time t = 0

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

$$A_0^i = E_0^i + \beta_i P_0$$

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.

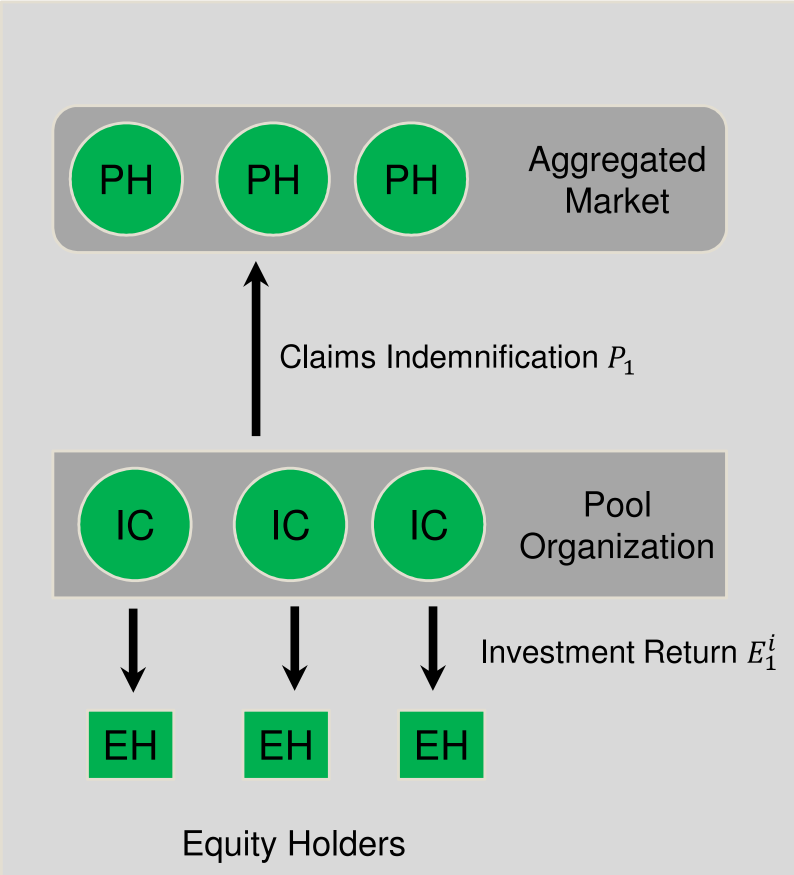
$$\left(P_0, E_0^1, \ldots, E_0^n\right) = \left(PV(P_1), PV(E_1^1), \ldots, PV(E_1^n)\right)$$

→ 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)*



Payoffs at time t = 1

PH Level

At time t = 1 the policyholders receive an indemnification amounting to

$$P_1 = C_1 - D_1$$

D_1 is the pool's shortfall. Its size depends on the liability regime at hand:

Several Liability

$$D_1 = \sum_{i=1}^{n} \left[\alpha_i C_1 - A_1^i \right]^+$$

Joint Liability

$$D_1 = \left[C_1 - \sum_{i=1}^{n} A_1^i \right]^+$$

EH Level

The payoff of IC i to its equity holders at time t = 1 is

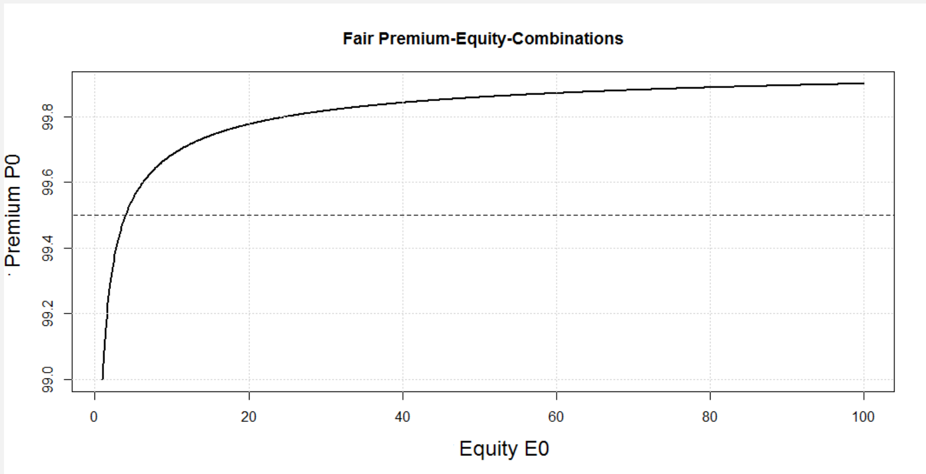
$$E_1^i = \left[A_1^i - \alpha_i C_1 \right]^+ \qquad E_1^i = \left[A_1^i - \alpha_i C_1 - G_1^i \right]^+$$

We have formally defined G_1^i to be in line with joint liability's default mechanism in practice.

Numerical Example – Setting (1/2)

- Pool claims are modelled as jump-diffusion process (GBM & Poisson Process, *Merton (1976)*)
- Assets returns are modelled as ordinary GBM
- The claims' face value at time *t* = *0* is fixed at $\boldsymbol{PV(C_1) = 100}$ **(A1)**
- We assume identical risk and premium share, i.e. $\boldsymbol{\alpha_i = \beta_i}$
- To reduce numerical and illustrative complexity we set ***n* = *2***
- $\boldsymbol{\alpha_1} \in \{\mathbf{0.0, 0.1, \ldots, 1}\}$; for ensuring comparability of different shares and liability regimes we focus on a reference case for which the contract safety level is throughout $\boldsymbol{PV(D_1) = 0.5}$ **(A2)**
- **(A1) & (A2)** → Fair pool premium in reference case $\boldsymbol{P_0 = PV(P_1) = PV(C_1) - PV(D_1) = 99.5}$

Price



Safety level

Find – as function of $\boldsymbol{\alpha_1}$ and the liability regime – values for $\boldsymbol{E_0^1}$ and $\boldsymbol{E_0^2}$ s.t.

$$\left(\boldsymbol{P_0, E_0^1, E_0^2}\right) = \left(\boldsymbol{PV(P_1), PV(E_1^1), PV(E_1^2)}\right)$$

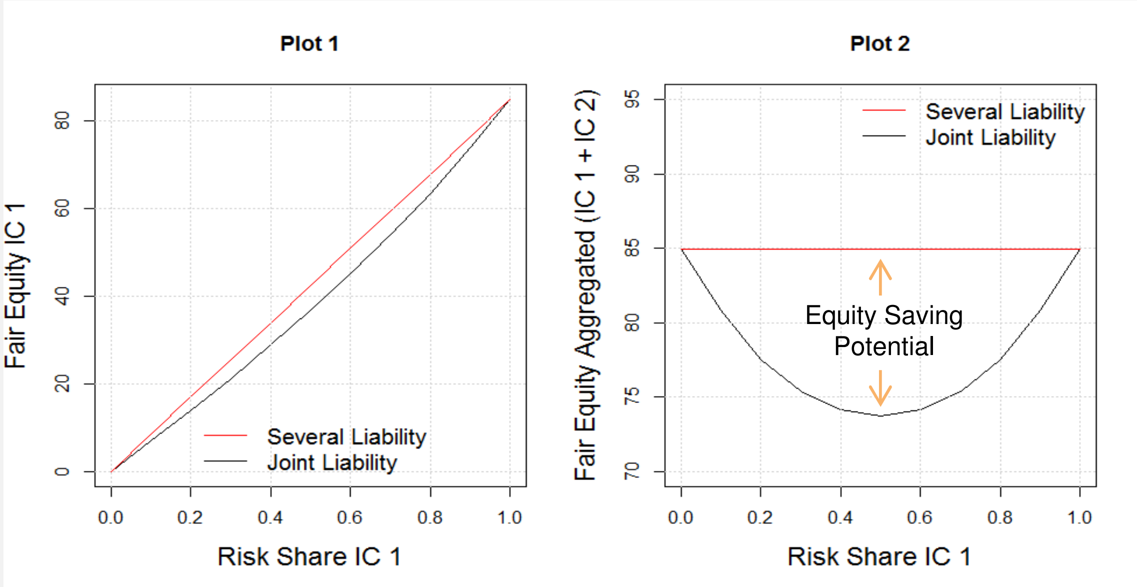
Numerical Example – Setting (2/2)

- Pool claims are modelled as jump-diffusion process (GBM & Poisson Process, *Merton (1976)*)
- Assets returns are modelled as ordinary GBM
- The claims' face value at time $t = 0$ is fixed at $\boldsymbol{PV(C_1) = 100}$ **(A1)**
- We assume identical risk and premium share, i.e. $\boldsymbol{\alpha_i = \beta_i}$
- To reduce numerical and illustrative complexity we set ***n* = 2**
- $\boldsymbol{\alpha_1} \in \{\mathbf{0.0, 0.1, ..., 1}\}$; for ensuring comparability of different shares and liability regimes we focus on a reference case for which the contract safety level is throughout $\boldsymbol{PV(D_1) = 0.5}$ **(A2)**
- **(A1) & (A2)** → Fair pool premium in reference case $\boldsymbol{P_0 = PV(P_1) = PV(C_1) - PV(D_1) = 99.5}$

	Case I Uniformity	**Case II** Pos. Correlation	**Case III** Neg. Correlation	**Case IV** Case I, II and III with income taxes	**Case V** Incr. Asset Risk (w/o taxation)
Risk-free Rate	3%	3%	3%	We revoke the assumption of a frictionless market and introduce in line with *Doherty and Garven (1986)* corporate income taxation.	3%
Asset Process					
Volatility IC1	20%	20%	20%		20%
Volatility IC2	20%	20%	20%		**35%**
Correlation	0.0	**0.5**	**- 0.5**	Policyholders are burdened with present value of tax payment at time $t = 0$. → Some degree of risk-aversion and inability to replicate payoffs is assumed for policyholders.	0.0
Claims Process					
Volatility Diffusion	10%	10%	10%		10%
Jump Freq.	10 yr.	10 yr.	10 yr.		10 yr.
Jump Factor	1.5	1.5	1.5		1.5
Corr. Asset-Claims	0.0	0.0	0.0	Applied tax rate $\tau = 35\%$	0.0

Numerical Example – Results Case I

	Case I Uniformity
Risk-free Rate	3%
Asset Process	
Volatility IC1	20%
Volatility IC2	20%
Correlation	0.0
Claims Process	
Volatility Diffusion	10%
Jump Freq.	10 yr.
Jump Factor	1.5
Corr. Asset-Claims	0.0



Observations

- Fair equity required for pre-given safety level increases for both regimes in risk/premium share
- For all allocations: $E_0^i(Several\ Liability) \geq E_0^i(Joint\ Liability)$
- For the marginal cases: $E_0^i(Several\ Liability) = E_0^i(Joint\ Liability)$
- The aggregated equity reaches for joint liability a minimum at $(\propto_1, \propto_2) = (\mathbf{0.5}, \mathbf{0.5})$
- For several liability, the aggregated equity is constant

→ For several liability no effects from increasingly diversified risk-sharing; also no effect from increasing ***n***

Numerical Example – Results Case I, II and III

	Case I Uniformity	**Case II** Pos. Correlation	**Case III** Neg. Correlation
Risk-free Rate	3%	3%	3%
Asset Process			
Volatility IC1	20%	20%	20%
Volatility IC2	20%	20%	20%
Correlation	0.0	**0.5**	**- 0.5**
Claims Process			
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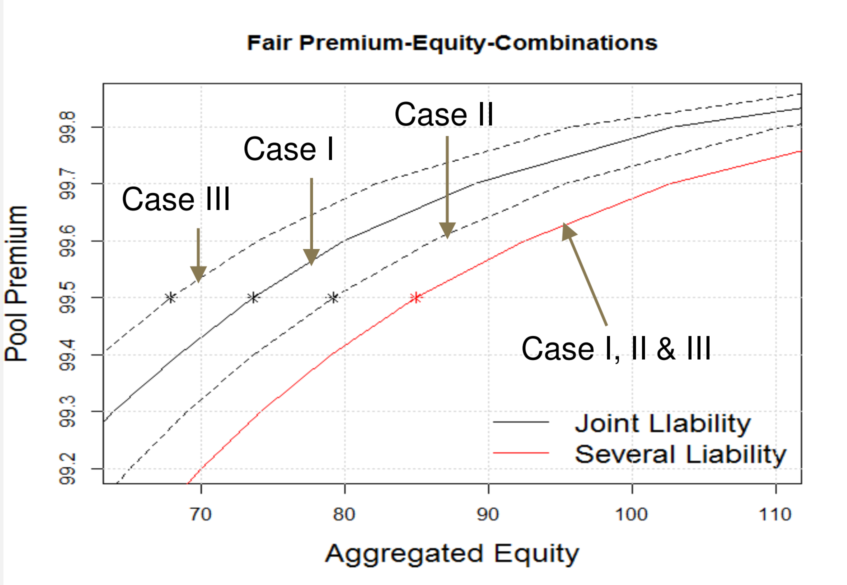


Observations

- Plot shows fair premium-equity-combinations (aggregated) for the allocation $(\propto_1, \propto_2) = (\mathbf{0.5}, \mathbf{0.5})$
- In a regime of several liability, the fair combinations do not depend on the ICs' asset correlation
- In a regime of joint liability, negative correlation reduces the required equity for keeping the safety level
- In contrast, positive correlation in a regime of joint liability increases the equity requirement
- Severalliabilityappears as limit case of jointliabilityas correlation goes towards 1

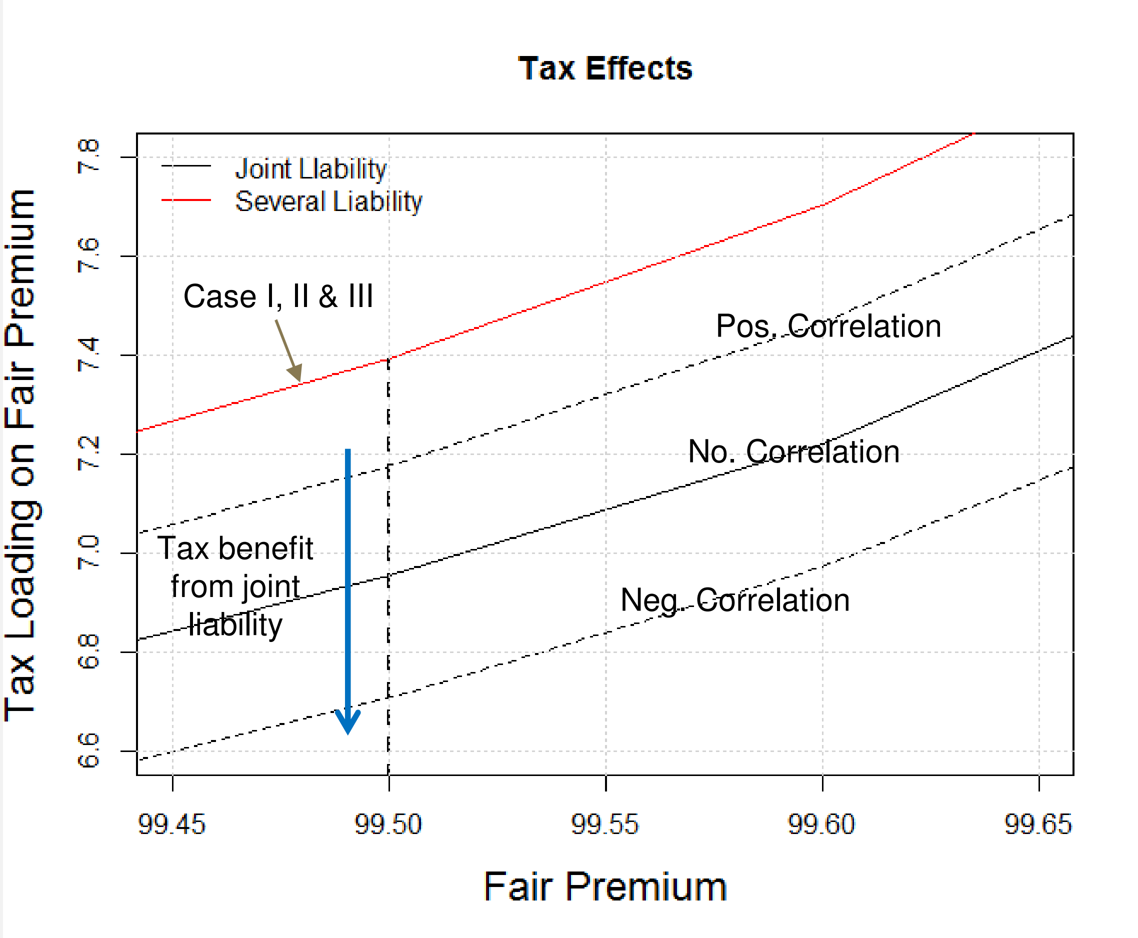
Numerical Example – Results Case IV

Case IV
Case I, II and III with income taxes

We revoke the assumption of a frictionless market and introduce in line with *Doherty and Garven (1986)* corporate income taxation.

Policyholders are burdened with present value of tax payment at time $t = 0$.
→ Some degree of risk-aversion and inability to replicate payoffs is assumed for policyholders.

Applied tax rate $\tau = 35\%$



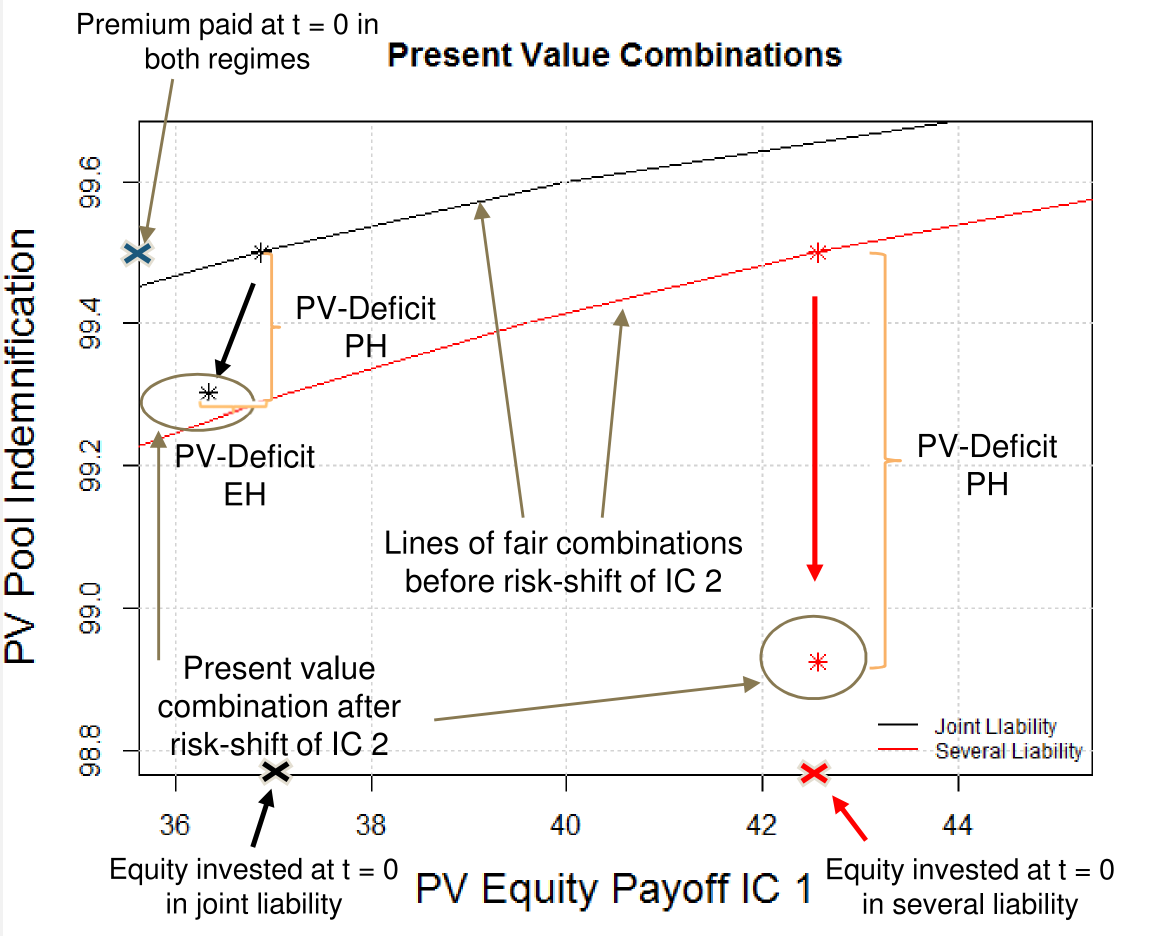
Observations

- In general, tax loading in a regime of joint liability is less than in a regime of several liability
- Tax benefit amplifies when asset correlation is negative
- Tax benefit shrinks as correlation goes towards 1

Numerical Example – Results Case V

	Case V Incr. Asset Risk (w/o taxation)
Risk-free Rate	3%
Asset Process	
Volatility IC1	20%
Volatility IC2	**35%**
Correlation	0.0
Claims Process	
Volatility Diffusion	10%
Jump Freq.	10 yr.
Jump Factor	1.5
Corr. Asset-Claims	0.0

Example assumes that PH, IC 1 and IC 2 hold at time t = 0 positions based on Case I → Risk-shift occurs after contract pricing



Observations

- Risk-shift of IC 2 solely affects policyholder in a regime of several liability: severe wealth transfer from PH to EH of IC 2
- In a regime of joint liability risk-shift affects policyholder as well as equity holders of IC 1: wealth transfer from PH and EH of IC 1 to EH of IC 2

Summarized Conclusions

Regime of Several Liability

- No diversification effects from risk sharing, just an allocation between several parties
- No impact of asset correlation on fair premium and equity values
- Risk-shifting problems only matter for policyholders

Regime of Joint Liability

- Increased diversification (i.e. $\alpha_i \to 1/n$) leads to reduced required equity to achieve the pre-given safety level
- Regime of joint liability will pass into several liability if risk allocation goes towards marginal allocation (i.e. only one insurer bears the business)
- Analogously, the regime will pass into several liability if asset correlation goes towards 1
- For increased negative correlation, the distinction between both regimes becomes more material
- Both equity holders as well as policyholders must be concerned about risk-shifting problems

→ From perspective of policyholder the regime of joint liability is preferable due to lower frictional costs and the utility to share the risk-shifting problem with other parties jointly

Thank You

Lukas Reichel
University of St.Gallen,
Institute of Insurance Economics
lukas.reichel@unisg.ch

Hato Schmeiser
University of St.Gallen,
Institute of Insurance Economics
hato.schmeiser@unisg.ch