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# The Choice of Trigger in an Insurance Linked Security: The Mortality Risk Case

by

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# Agenda

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## 1. Introduction

## 2. Model Framework

## 3. Results

- Limited Liability
- Introduce Indemnity and Index Hedge
- Incentive Effects of Hedging

## 4. Conclusion



# Introduction

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- In December 2003, Swiss Re introduced the first insurance-linked security (ILS) relating to life-insurance risk
- Hedge for excessive mortality risk
- Designed to cover correlated mortality surprises such as pandemics
- Potential for excessive *longevity* hedges as well (correlated risks resulting from mortality improvements due to genetics etc.)
- Structure similar to CAT bonds



# Introduction

## – Growing Importance of Index Triggers in CAT Bond Transactions

**RISK CAPITAL/TRANSACTIONS BY TRIGGER TYPE**

Year	Indemnity		Parametric		PCS (Index)		Modeled	
	\$MM	#	\$MM	#	\$MM	#	\$MM	#
1997	431.0	3	90.0	1	112.0	1	0.0	0
1998	846.1	8	0.0	0	0.0	0	0.0	0
1999	602.7	7	100.0	1	0.0	0	282.1	2
2000	507.0	4	303.0	2	150.0	1	179.0	2
2001	150.0	1	270.0	2	265.0	2	281.9	2
2002	355.0	2	631.5	3	200.0	1	33.0	1
2003	260.0	2	1,119.8	4	350.8	1	0.0	0
2004	227.5	1	267.8	2	547.5	2	100.0	1
<b>TOTAL</b>	<b>\$3,379.3</b>	<b>28</b>	<b>\$2,782.1</b>	<b>15</b>	<b>\$1,624.5</b>	<b>8</b>	<b>\$876.0</b>	<b>8</b>

- On an annual basis, accounts for each of Pioneer, Arbor, Phoenix, Redwood Capital III/IV, Redwood Capital V/VI and Foundation Re programs as single issues.
- Pioneer/Arbor takedowns are considered separate transactions in the year in which the takedowns actually occurred (Pioneer: 2002 and 2003, Arbor: 2003 and 2004)..

Source: Guy Carpenter (2005)



# Introduction – Related Literature

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## Securitization versus traditional (Re)Insurance

- Introduction: *Doherty* (JACF 1997), *Croson and Kunreuther* (JRF 2000)  
→ Key issues: reinsurance default risk, transaction cost, moral hazard versus basis risk
- Insurance economics modeling approaches:  
*Doherty and Mahul* (Working Paper 2001), *Doherty and Richter* (JRI 2002), *Nell and Richter* (GPRI 2004)

## Incentive distortions because of limited liability, “Judgment Proof Problem”

- *Shavell* (IRLE 1986), *MacMinn* (GPRI 2002)

## Fisher-Model

- *MacMinn* (JRI 1987) (2005)



# Introduction – Scope of this Paper

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- Shareholder value maximizing (re)insurer
- Effort determines underwriting results
- (Re)insurer is subject to insolvency risk  
→ judgment proof/underinvestment problem
- ILS based on actual losses vs. index  
→ moral hazard vs. basis risk
- What are the incentive effects of ILS?
- Can ILS create shareholder value?



# The Model

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In the absence of any ILS, the reinsurer's stock market value is the value of its book of business:

$$S(a) = \int_{\Omega} \max \{0, \Pi(a, \omega)\} dP(\omega)$$

- $\Omega = [0, \zeta]$  : set of states of nature  $\omega$
- $\Pi(a, \omega) = \Gamma(\omega) - L(a, \omega) - a$
- $\Gamma(\omega)$  : premium income (including investment result)
- $L(a, \omega)$  : loss on book of business
- $a$  : (cost of) underwriting effort
- $p(\omega)$  : basis stock price,  $P(\omega) = \int_0^{\omega} p(\varepsilon) d\varepsilon$



# The Model (cont.)

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## Assumption

The reinsurer's payoff  $\Pi(a, \omega)$  satisfies the **principle of decreasing uncertainty (PDU)**:

$$\frac{\partial \Pi}{\partial \omega} > 0 \text{ and } \frac{\partial^2 \Pi}{\partial \omega \partial a} < 0$$

- After compensating for the change in the mean, the PDU provides a decrease in the risk in the Rothschild-Stiglitz sense (MacMinn and Holtmann 1983).



# Limited Liability and Incentives

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The effort taken by the unhedged reinsurer,  $a^u$ , is determined by maximizing

$$S^u(a) = \int_{\Omega} \max\{0, \Pi(a, \omega)\} dP(\omega) = \int_{\delta}^{\zeta} \Pi(a, \omega) dP(\omega)$$

where  $\delta$  is defined by  $\Pi(a, \delta) = 0$

The socially efficient level of effort,  $a^e$ , is determined by maximizing

$$T(a) = \int_0^{\zeta} \Pi(a, \omega) dP(\omega)$$



# Limited Liability and Incentives

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## Judgment Proof Problem

(Shavell 1986, Kahan 1989, MacMinn 2002)

If  $\delta > 0$ , the level of care selected by the (unhedged) reinsurer is less than the socially optimal level,  $a^u < a^e$ .

$$\begin{aligned} \left( \frac{dT}{da} - \frac{dS^u}{da} \right) \Big|_{a=a^u} &= \int_0^\zeta \frac{\partial \Pi(a^u, \omega)}{\partial a} dP(\omega) - \int_\delta^\zeta \frac{\partial \Pi(a^u, \omega)}{\partial a} dP(\omega) \\ &= \int_0^\delta \frac{\partial \Pi(a^u, \omega)}{\partial a} dP(\omega) > 0 \end{aligned}$$



# Indemnity Hedge

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Payout  $\max\{0, L(a, \omega) - i\}$   $i$  : trigger level.

→ Option price:

$$C^m(a, i) = \int_0^\gamma (L(a, \omega) - i) dP(\omega)$$

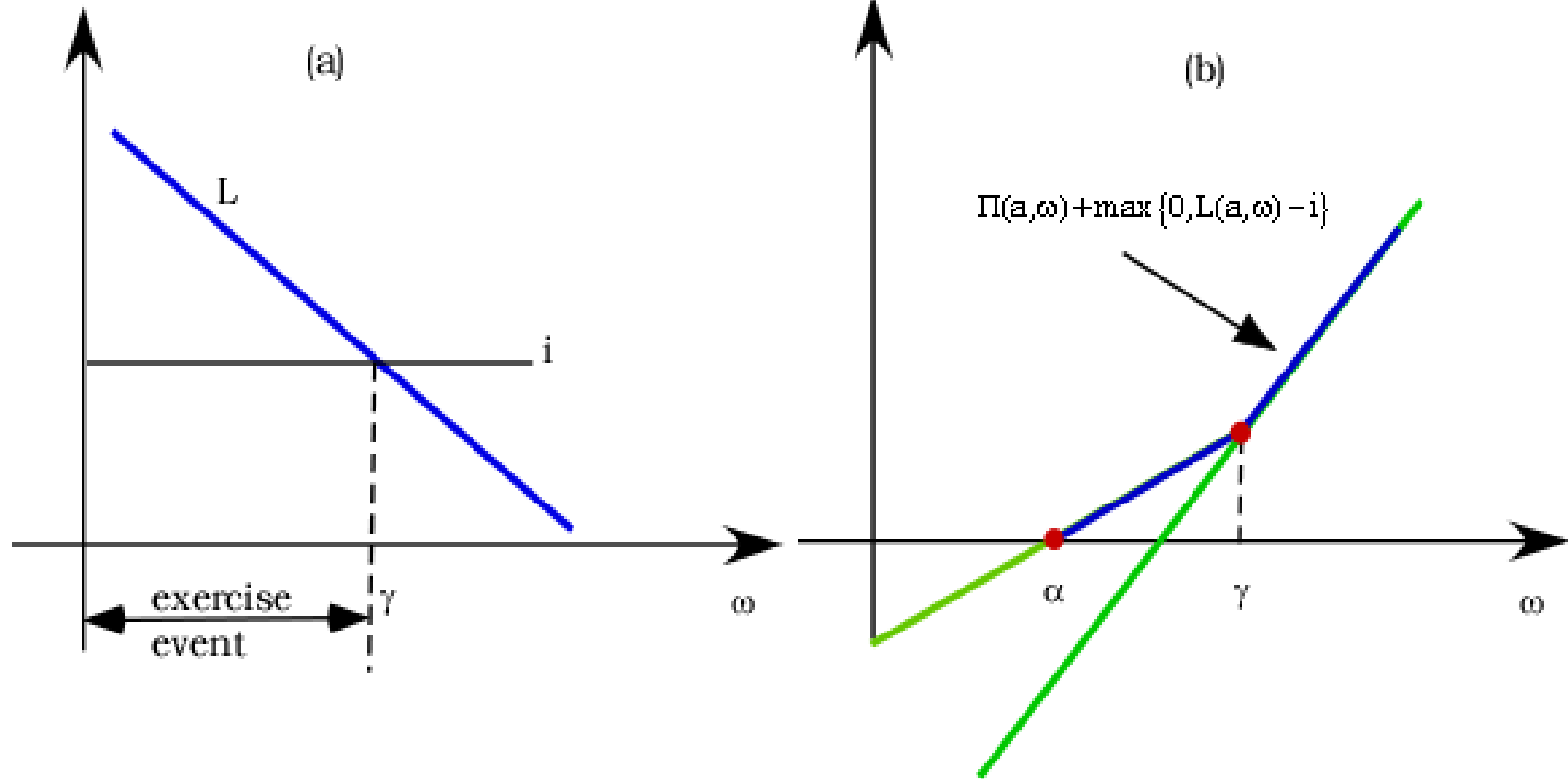
where  $\gamma$  is the state such that  $L(a, \gamma) - i = 0$



# Indemnity Hedge

$$\alpha < \gamma$$

Figure 1



$$\alpha : \Pi(a, \alpha) + \max\{0, L(a, \alpha) - i\} = 0$$

$$\gamma : L(a, \gamma) - i = 0$$



# Index Hedge

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Payout  $\max\{0, I(\omega) - i\}$        $i$  : trigger level.

$I(\omega)$ : index with  $\frac{dI}{d\omega} < 0$

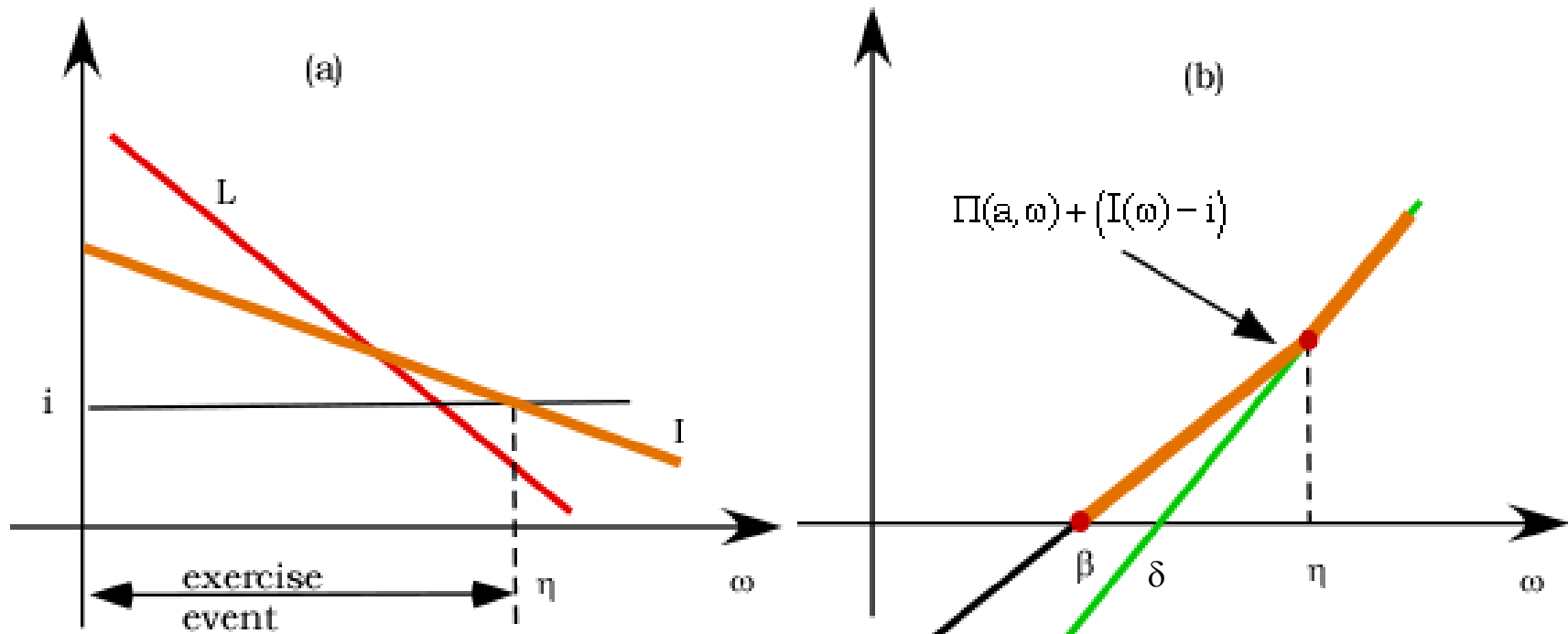
→ Option price:

$$C^b(i) = \int_0^\eta (I(\omega) - i) dP(\omega) \quad (\eta : I(\eta) - i = 0)$$



# Index Hedge

Figure 3



$$\beta : \Pi(a, \beta) + I(\beta) - i = 0$$

$$\eta : I(\eta) - i = 0$$



# Incentive Effects of Hedging with Asymmetric Info

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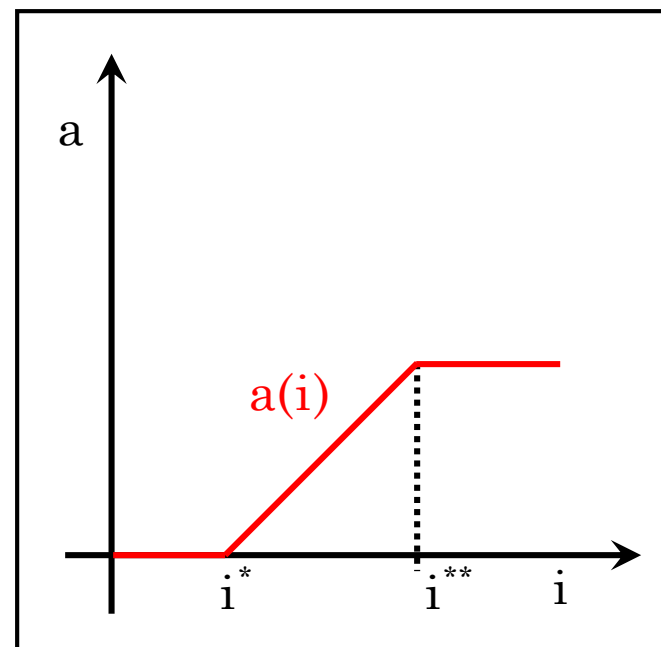
- Can hedging improve the incentive deficit due to the judgment proof problem?
- The hedge in place, the organization maximizes stock value in  $t=1$ . This determines the underwriting effort  $a(i)$  (reaction function)
- Indemnity hedge creates moral hazard
- Index hedge creates basis risk, but no moral hazard



# Incentive Effects of Hedging – Results

With **indemnity-based** hedging ...

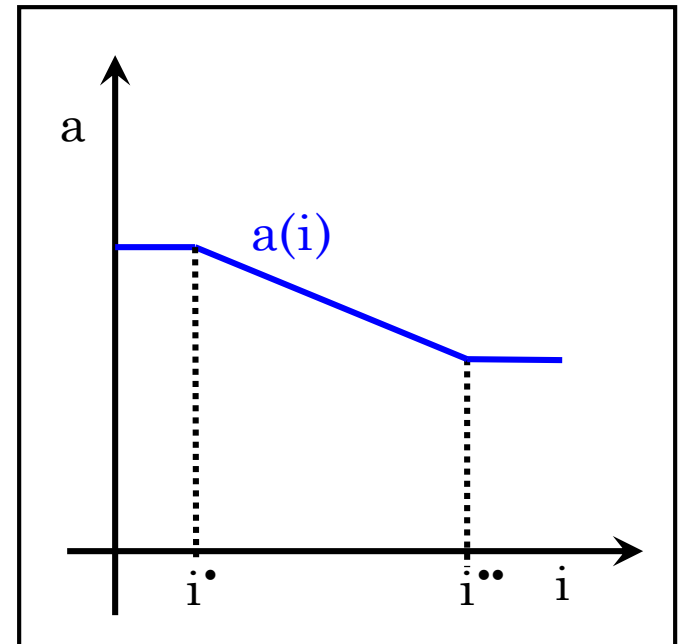
- the reaction function increases in  $i$ , i.e. the more protection, the lower effort.
  - incentives are completely eliminated if the trigger is sufficiently low.
- The incentive problem is aggravated.



# Incentive Effects of Hedging – Results

In the case of **index-linked** hedging ...

- under certain assumptions regarding basis risk, the reaction function *decreases* in  $i$ , i.e. the more protection, the greater the effort.
- if an  $i^*$  exists, such that bankruptcy risk can be entirely avoided through the hedge, even the first-best optimum is reached. ( $a(i) = a^e \quad i \leq i^*$ )



# Conclusion

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- Insolvency risk / limited liability reduces underwriting effort (→ underinvestment / judgment proof problem)
- Shareholder value maximization vs. other stakeholders' interests
- How does hedging affect incentives?
- Under asymmetric information, an indemnity hedge reduces the underwriting effort.
- An index hedge can improve incentives.
- If the index hedge can eliminate insolvency risk, it induces the first-best-optimum.



# Future Research

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- Model the shareholder value indirectly created by an ILS
  - Hedging as a signal that decreases capital cost
  - How does hedging affect incentives with respect to investment decisions etc.?
- Longevity risk



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# The Choice of Trigger in an Insurance Linked Security: The Brevity Risk Case

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