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The Choice of Trigger in an Insurance Linked Security

Innsbruck, alpS Seminar, July 5, 2007

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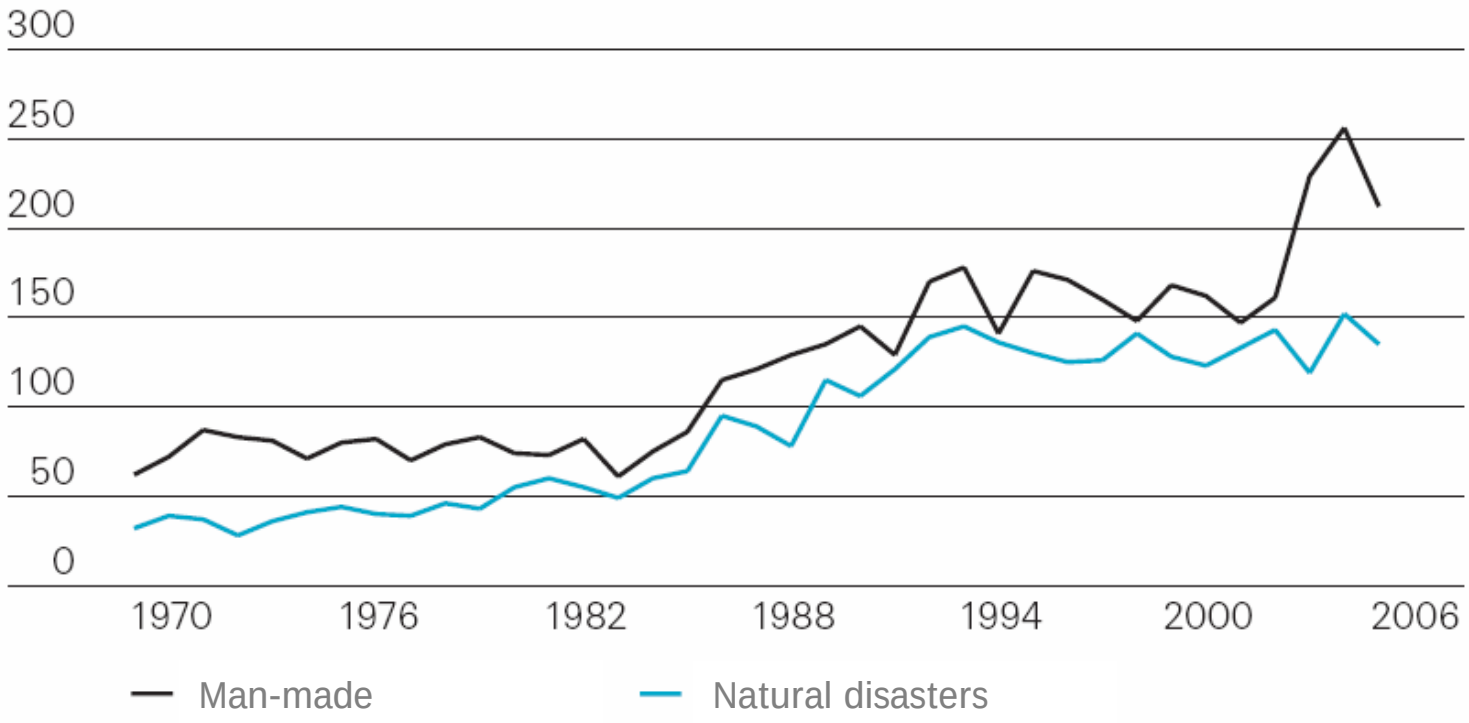
joint work with:

Richard MacMinn (Illinois State U)

Agenda

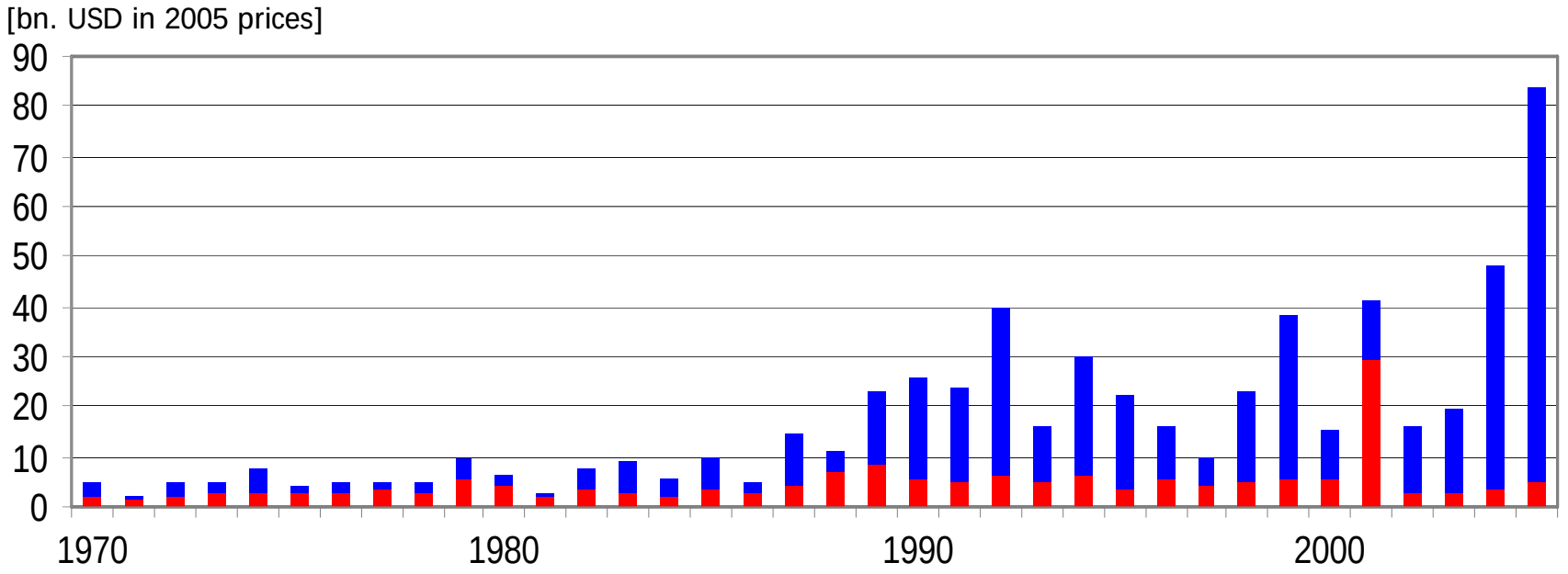
1. Introduction
2. ILS vs. Traditional Reinsurance
3. Scope of the Paper
4. Sketch of Model and Important Results
5. Conclusion

Increasing number of catastrophic events (1970-2006)



Source: Swiss Re, Economic Research & Consulting, sigma 2/2007

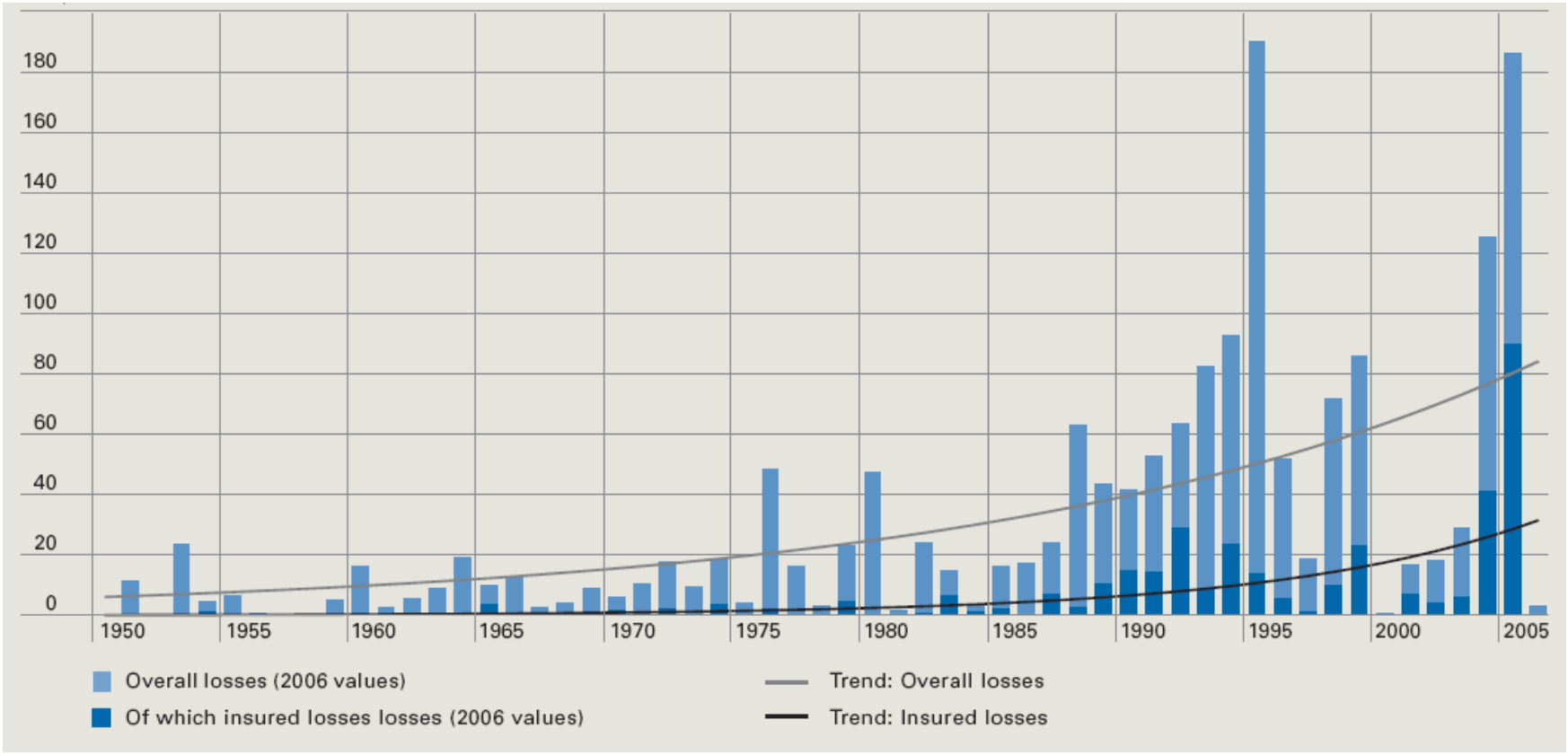
Insured catastrophe losses (1970-2005)



Source: Swiss Re, Economic Research & Consulting, sigma 2/2006

Catastrophe losses (1950-2006)

[bn. USD in 2006 prices]



Source: Munich Re

Introduction

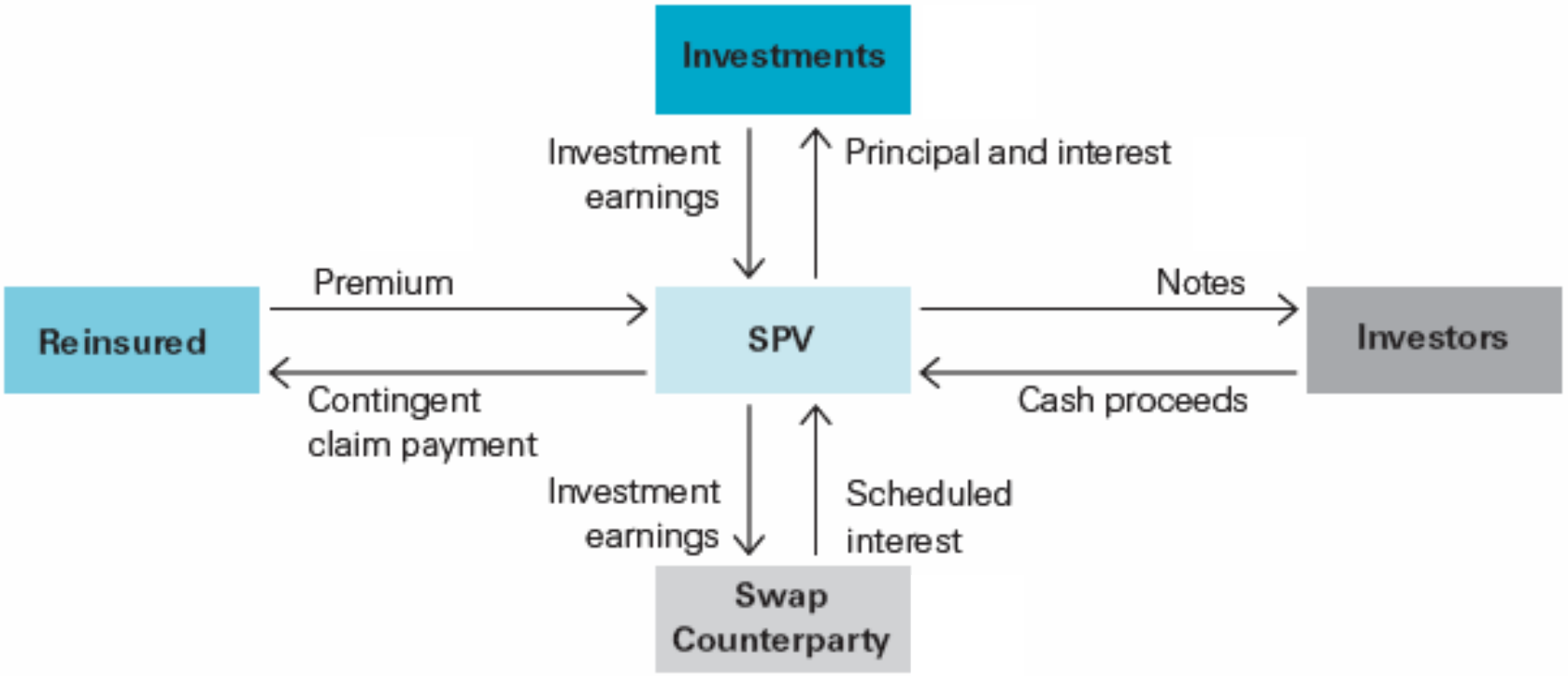
- Late 80s / early 90s catastrophic losses led to an interest in transferring natural disaster risk via the financial markets ($\rightarrow$ insurance linked securities, ILS)
- Various types of instruments were introduced, without yet representing a significant market size.
- Recent development: ILS issues relating to other areas of risk.

  Examples:
  - Extreme mortality bonds (since 2003)
  - FIFA bond (first security to cover terrorism risk; 2003)
  - also: auto insurance risk and even liability risk have been securitized

Insurance-Linked Securities (ILS) – Examples

- **Insurance derivatives**
- **Contingent refinancing** via catastrophe put options
  - After a predefined catastrophe the primary can issue its own stock to a counter-party at a fixed price.
- **Catastrophe (cat) bonds**
  - Interest and/or principal are (partially) forgiven, if a certain catastrophic event occurs.
- **Sidecars**
- **Regulation XXX securities**

Typical Structure of a Cat Bond Transaction



Source: Swiss Re Capital Markets

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Structure of a Cat Bond – An Example

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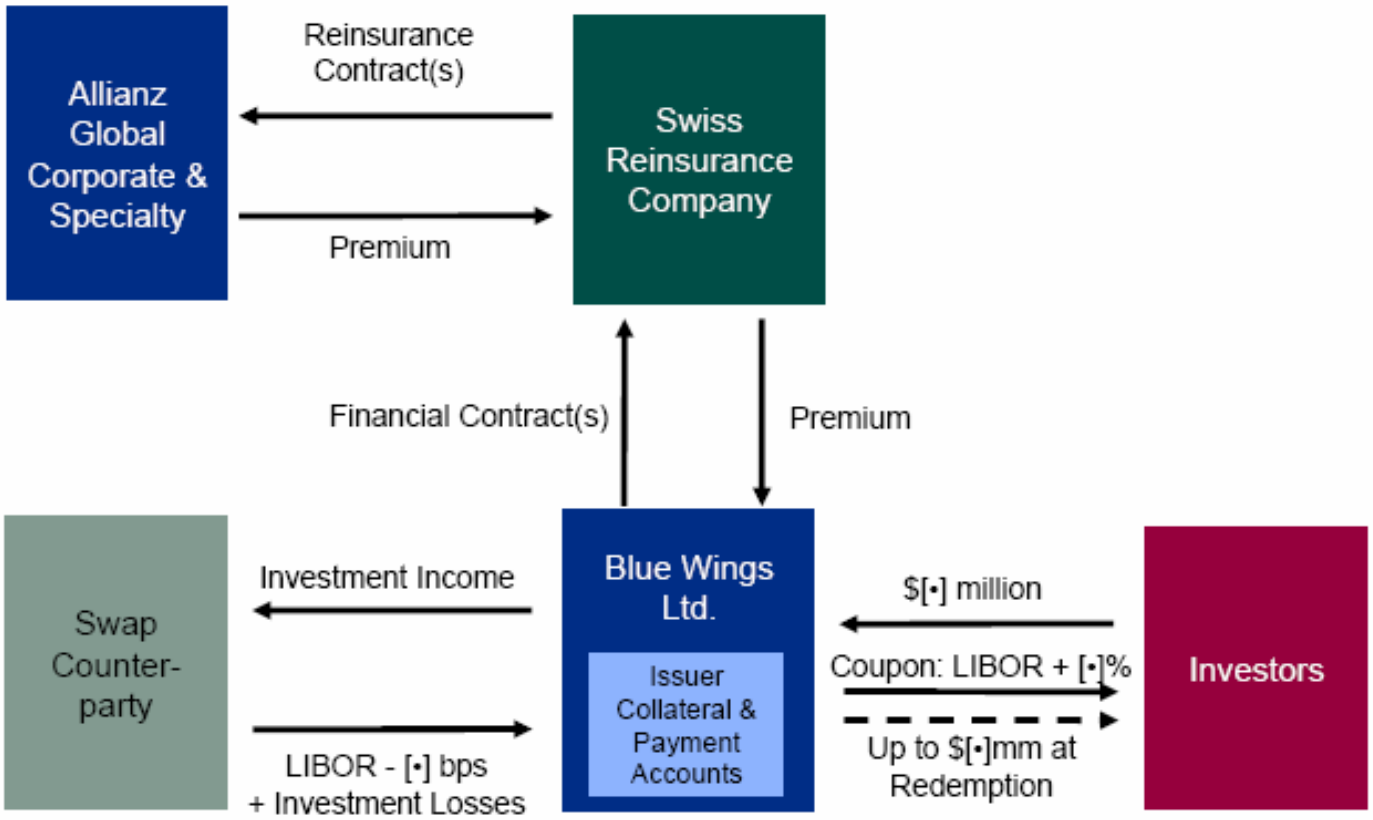

Market Development

1992	CBOT catastrophe futures
1997	First issuance of credit-rated CAT bonds and notes
2001	First issuance of sidecars
2003	First issuance of extreme mortality risk bonds First issuance of terrorism risk related bonds
2006	First issuance of regulation XXX securities
2007	Reappearance of exchange-traded catastrophe derivatives • NYMEX CAT Risk Index Futures and Options • CME Hurricane Futures and Options

Cat Bonds – Number of Transactions and Issue Size

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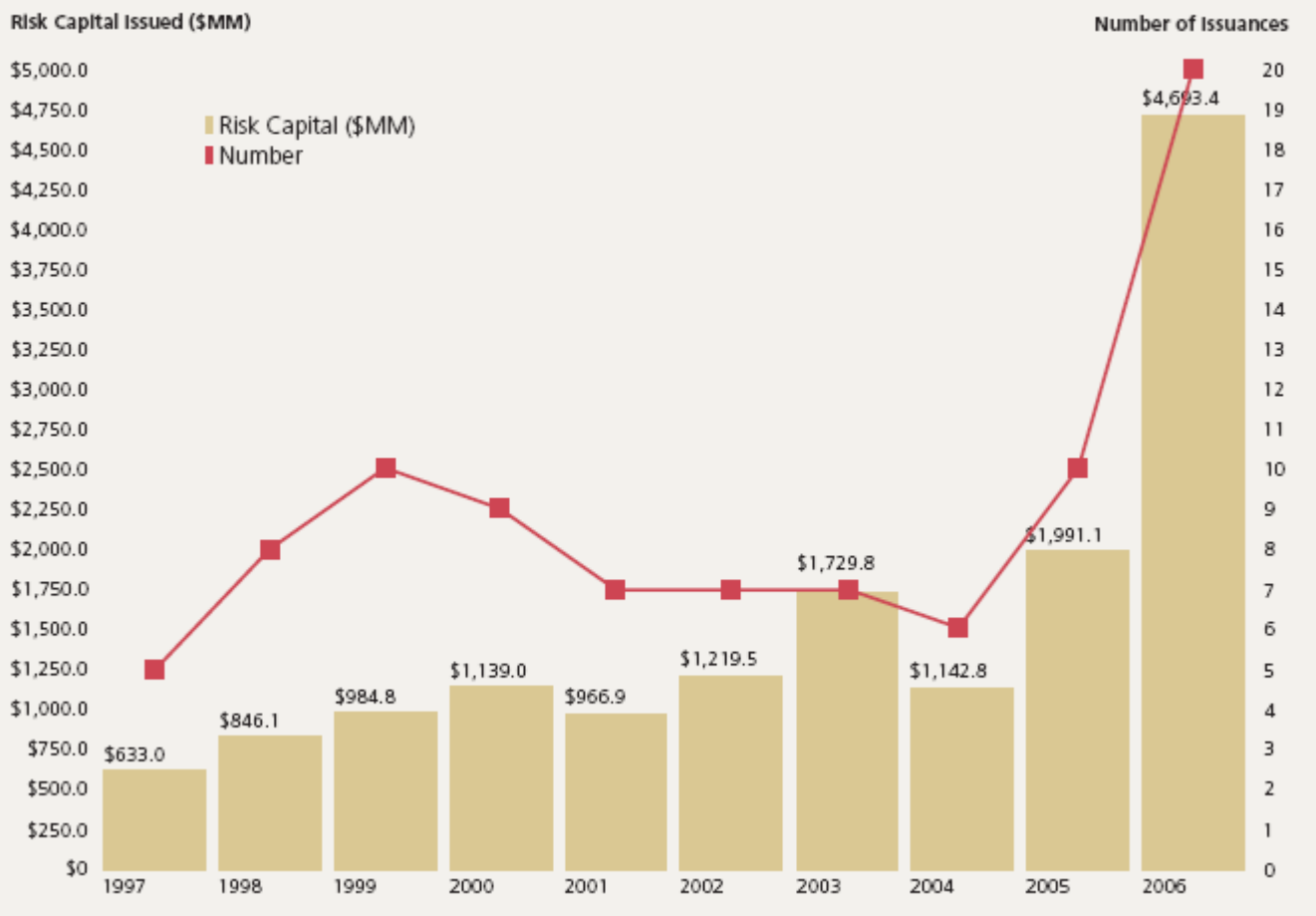
2006: Sharp increase in cat bond activity

[Although in 2005 the first cat bond was triggered (Kamp Re) as a consequence of Hurricane Katrina]



Source: Guy Carpenter (2007)

Cat Bonds – Risk capital by peril

YEAR	U.S. EARTHQUAKE	U.S. HURRICANE	EUROPEAN WINDSTORM	JAPANESE EARTHQUAKE	JAPANESE TYPHOON	OTHER
1997	112.0	395.0	0.0	90.0	0.0	36.0
1998	145.0	721.1	0.0	0.0	80.0	45.0
1999	327.8	507.8	167.0	217.0	17.0	10.0
2000	486.5	506.5	482.5	217.0	17.0	129.0
2001	696.9	551.9	431.9	150.0	0.0	120.0
2002	799.5	476.5	334.0	383.6	0.0	0.0
2003	803.8	416.1	474.1	691.2	277.5	100.0
2004	803.3	660.8	220.3	310.8	0.0	0.0
2005	1,269.0	994.0	830.1	138.0	0.0	405.0
2006	2,228.7	2,294.9	1,166.0	824.1	400.3	507.5
TOTAL	**$7,672.4**	**$7,524.6**	**$4,105.9**	**$3,021.6**	**$791.8**	**$1,352.5**

Source: Guy Carpenter (2007)

YEAR OF ISSUE	SPECIAL PURPOSE VEHICLE	SPONSOR	RISK AMOUNT ($ MM)	TRANCHES	RATING	PERIL	RISK LOCATION
2003	Vital Capital Ltd.	Swiss Re	400.0	Notes	A+ (S&P)	Extreme Mortality	U.S./UK/France/ Italy/Swizterland
2005	Vital Capital II Ltd.	Swiss Re	62.0	Class B Notes	A (S&P)	Extreme Mortality	U.S./UK/France/ Italy/Swizterland
–	–	–	200.0	Class C Notes	A- (S&P)	–	–
–	–	–	100.0	Class D Notes	BBB (S&P)	–	–
2006	Tartan Capital Ltd.	Scottish Re	75.0	Class A Notes	AAA (S&P)	Extreme Mortality	U.S.
–	–	–	80.0	Class B Notes	BB (S&P)	–	–
2006	Osiris Capital p.l.c.	AXA	129.0	Class B-1 Notes	AAA (S&P)	Extreme Mortality	U.S./France/Japan
–	–	–	64.5	Class B-2 Notes	A- (S&P)	–	–
–	–	–	150.0	Class C Notes	BBB (S&P)	–	–
–	–	–	100.0	Class D Notes	BB+ (S&P)	–	–

Source: Guy Carpenter (2007)

Outstanding Risk Capital by Peril

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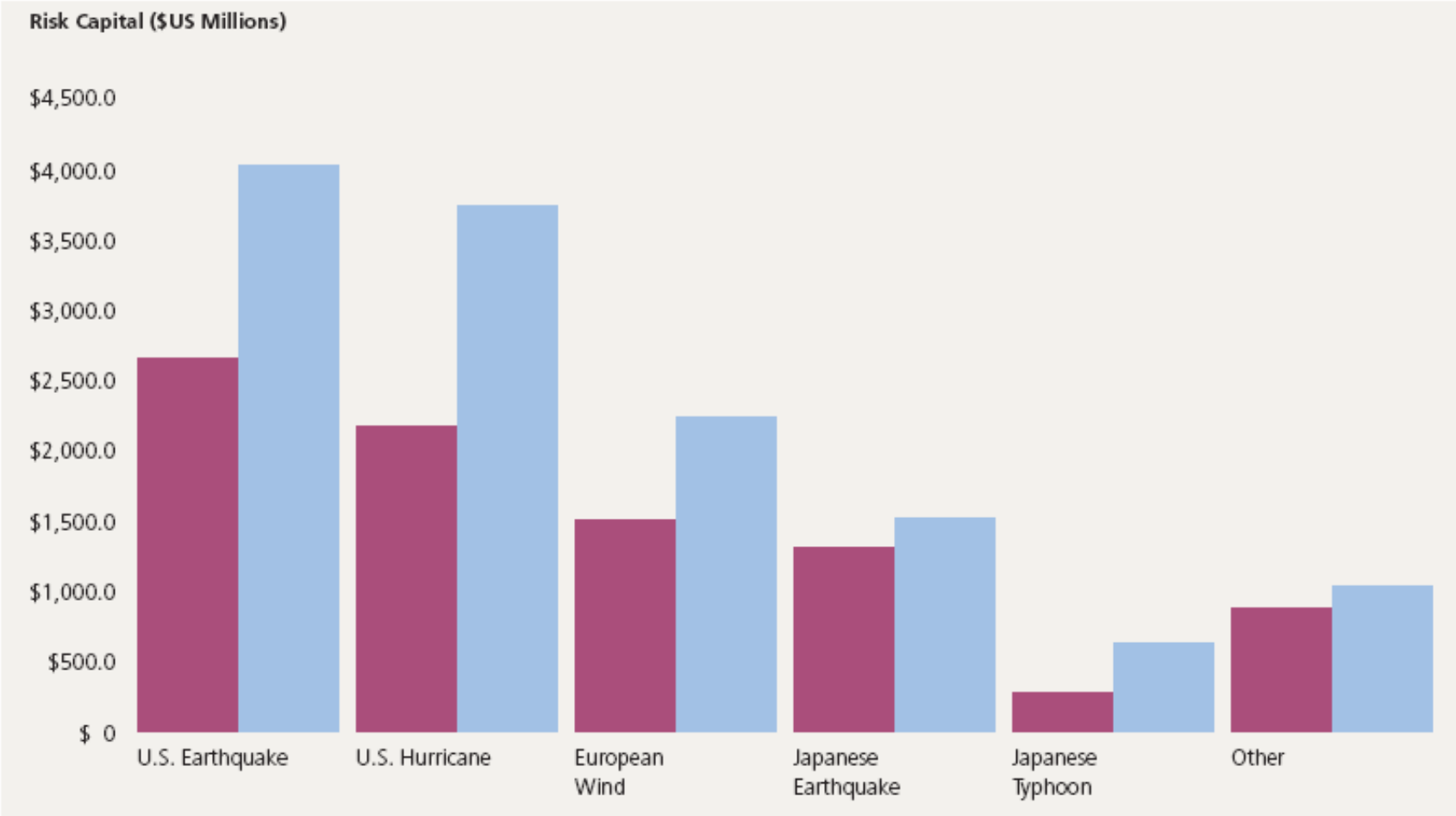

Source: Guy Carpenter (2007)

Total ILS Issued and Outstanding

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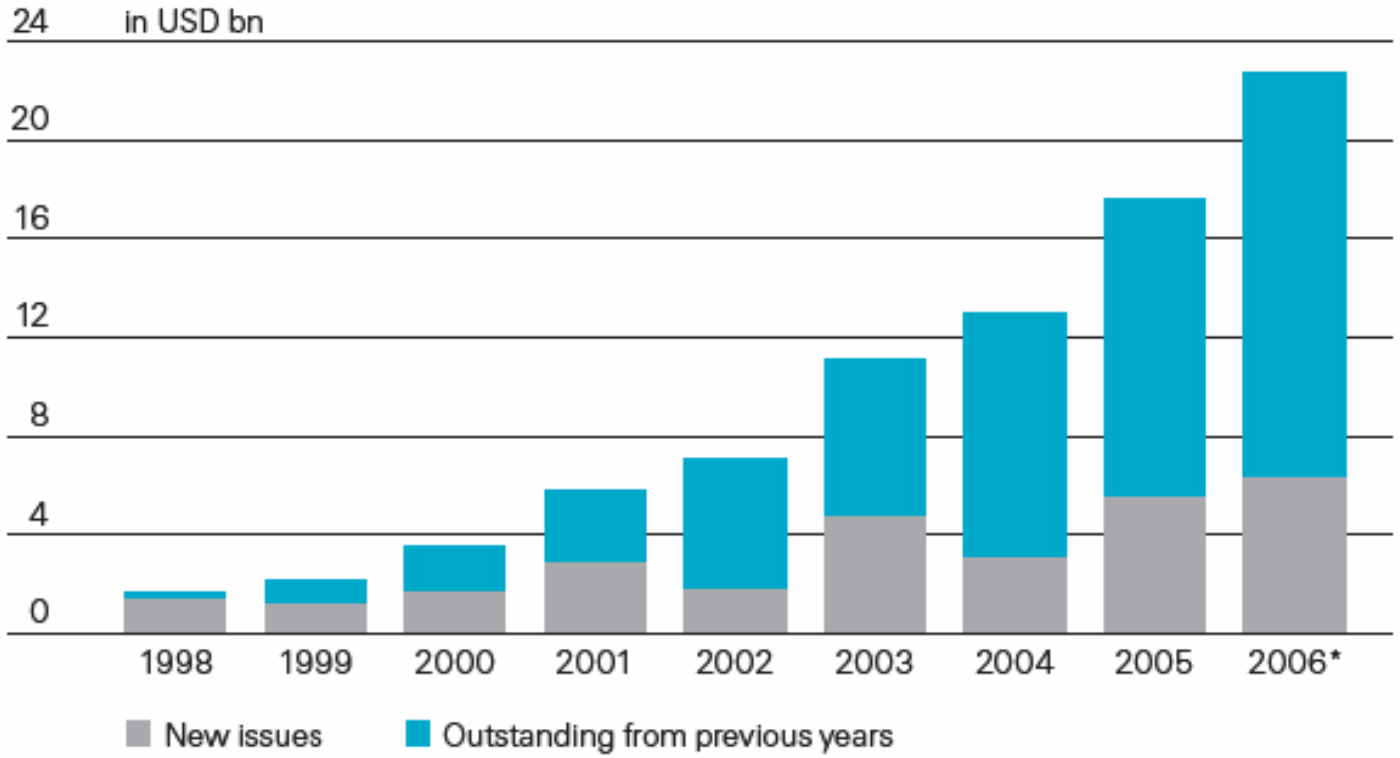

* data through August 25, 2006

Source: Swiss Re Capital Markets

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Insurance Securitization vs. Traditional (Re)Insurance

Typical explanation for the interest in risk securitization: Capacity limits of the insurance industry.

→ Insurance markets' capacity could also be extended through market entries or through capital flowing into the industry.

→ Which features define significant differences between traditional (re)insurance and securitization instruments?

In particular: What are the (potential) advantages of risk securitization over insurance products?

Potential Triggers in an ILS

Indemnity/company-based trigger: Payout to the issuer is based on the insurer's actual losses

Industry index: industry losses resulting from catastrophic events (for example, PCS in the U.S.)

Parametric index: Physical characteristics of a catastrophe (e.g., strength of an earthquake)

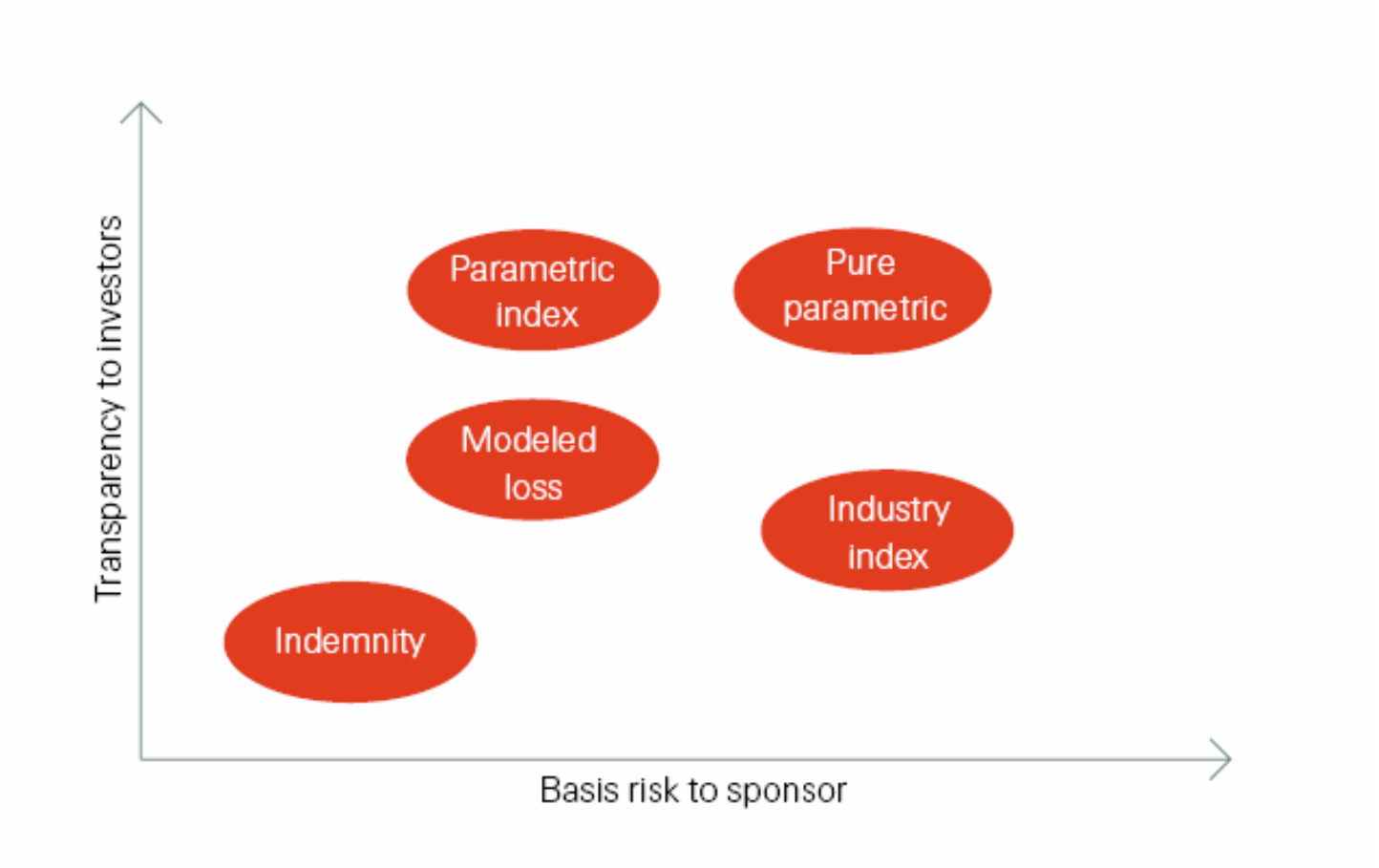
Modeled-loss trigger: uses physical parameters of a catastrophe as input into an ex-ante agreed-upon model which generates a "loss" value

Hybrid trigger: uses more than one trigger type in a single transaction, for instance, hurricane in the U.S. and flood in the UK (more complex: sequential event triggers)

Some aspects for a comparison

- **Basis risk**
- **Moral hazard**
- Transparency for investors
- Default risk
- Transaction costs
- Speed of availability of necessary information
- Information disclosure required?

Transparency and Basis Risk



Source: Swiss Re (2004)

Some aspects for a comparison

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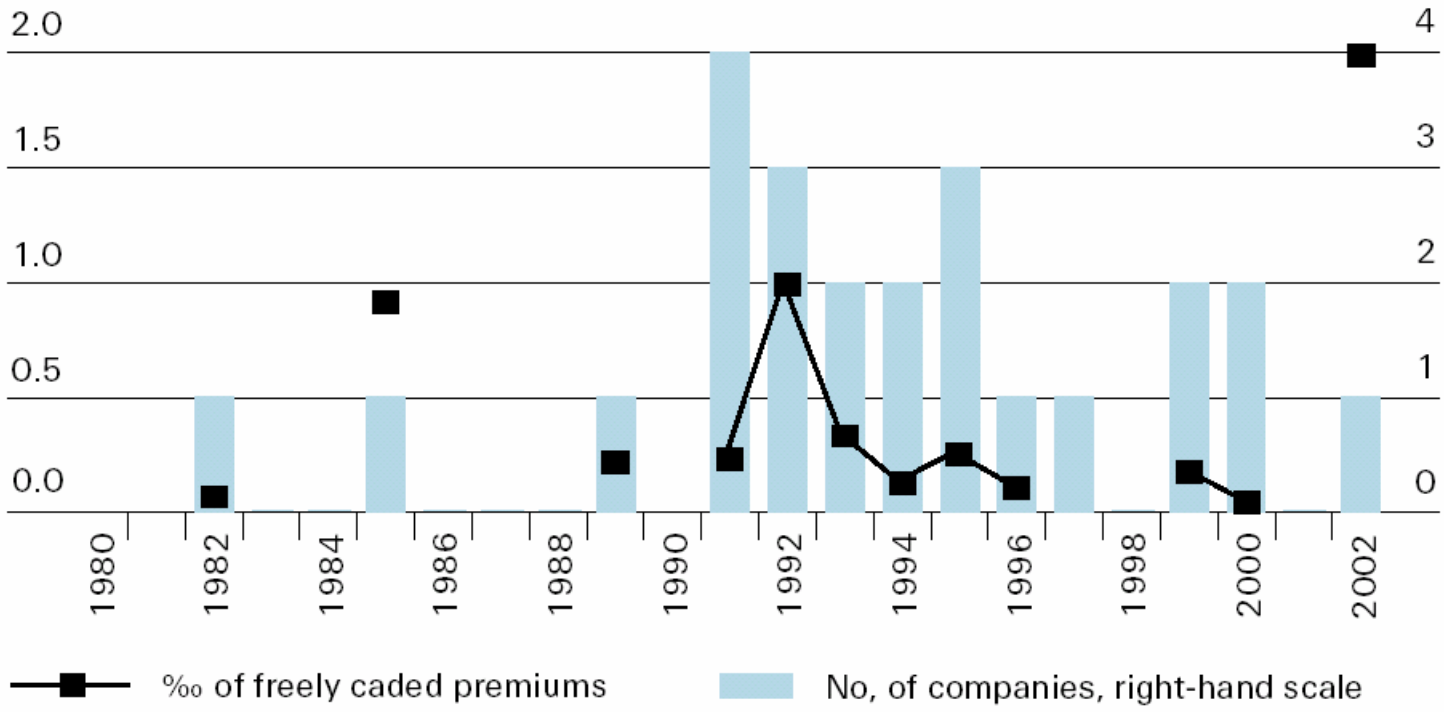
Reinsurer Bankruptcies



Source: *sigma* 5/2003

Some aspects for a comparison

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- Default risk
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Cat Bonds – Transactions by Trigger Type

YEAR	INDEMNITY		PARAMETRIC		PCS (INDEX)		MODELED		HYBRID	
	$MM	#	$MM	#	$MM	#	$MM	#	$MM	#
1997	431.0	3	90.0	1	112.0	1	0.0	0	0	0
1998	846.1	8	0.0	0	0.0	0	0.0	0	0	0
1999	602.7	7	100.0	1	0.0	0	282.1	2	0	0
2000	507.0	4	303.0	2	150.0	1	179.0	2	0	0
2001	150.0	1	270.0	2	265.0	2	281.9	2	0	0
2002	355.0	2	631.5	3	200.0	1	33.0	1	0	0
2003	260.0	2	1,119.8	4	350.8	1	0.0	0	0	0
2004	227.5	1	267.8	2	547.5	2	100.0	1	0	0
2005	859.4	4	491.7	3	0	0	640.0	3	0	0
2006	172.5	2	1,260.0	7	1,422.0	6	157.2	1	1,681.7	4
TOTAL	**$4,411.2**	**34**	**$4,533.8**	**25**	**$3,046.5**	**14**	**$1,673.2**	**12**	**$1,681.7**	**4**

Source: Guy Carpenter (2007)

Cat Bonds – Growing Importance of Non-Indemnity Triggers

- In recent years, there seems to be a trend towards index based (or rather: non-indemnity based) triggers
  - suggests that the moral hazard / transparency argument is valid *and that*
  - sponsors are becoming more comfortable with and better at evaluating the basis risk.

(note, however, that sidecars – which come with the same moral hazard issues as traditional reinsurance – have also been very popular in recent years)

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Related Literature

Securitization versus traditional (Re)Insurance

- *Doherty* (1997), *Croson/Kunreuther* (2000)
- Insurance economics modeling approaches:
  Doherty/Mahul (2001), *Doherty/Richter* (2002), *Nell/Richter* (2004), *Laux/Brandts* (2007)

Incentive distortions because of limited liability / "Judgment Proof Problem"

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

Related Literature

Doherty, N. A. (1997). "Financial Innovation in the Management of Catastrophe Risk." Journal of Applied Corporate Finance **10**(3): 84-95.

Croson, D. C. and H. C. Kunreuther (2000). "Customizing Indemnity Contracts and Indexed Cat Bonds for Natural Hazard Risks." Journal of Risk Finance **1**(3): 24-41.

Doherty, N. A. and O. Mahul (2001). Mickey Mouse and Moral Hazard: Uninformative but Correlated Triggers. Working Paper. Wharton School.

Doherty, N. A. and A. Richter (2002). "Moral Hazard, Basis Risk and Gap Insurance." Journal of Risk and Insurance **69**(1): 9-24.

Richter, A. (2003). Catastrophe Risk Management - Implications of Default Risk and Basis Risk. Working Paper. Illinois State University.

MacMinn, R. D. (1987). "Insurance and Corporate Risk Management." Journal of Risk and Insurance **54**(4): 658-77.

MacMinn, R. (2004). The Fisher Model and Corporate Finance. Taipei, forthcoming.

Brief Overview

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

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The Model

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

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

Ω : set of states of nature

$R(a,\omega) = \Pi - L(a,\omega) - a$

Π : premium income

$L(a,\omega)$: loss on book of business (with $\frac{\partial L}{\partial \omega} < 0$ and $\frac{\partial^2 L}{\partial \omega \partial a} > 0$)

a : (cost of) underwriting effort

The Model (cont.)

Assumption

The reinsurer's payoff R and the loss satisfy the principle of decreasing uncertainty (PDU):

$$\frac{\partial \mathrm{L}}{\partial \omega} < 0 \quad \text{and} \quad \frac{\partial^2 \mathrm{L}}{\partial \omega \partial \mathrm{a}} > 0$$

- 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).

If bankruptcy risk exists, we find:

$$a^{sv} < a^{e}$$

a^{sv}: Shareholder value maximizing effort level.

a^{e}: Socially efficient level, maximizing total firm value (taking into account the potential consequences of a bankruptcy for other stakeholders).

$\rightarrow$ What is the effect of introducing hedging?

Modeling the Hedge

- Payoff function for an indemnity-based transaction:

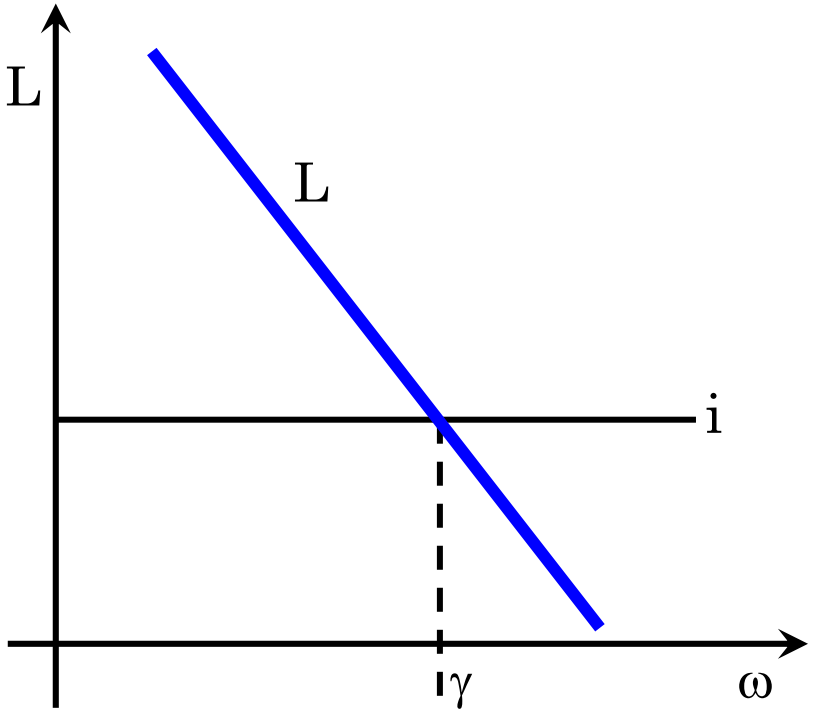
$$\max\left\{0, L(a,\omega) - i\right\}$$

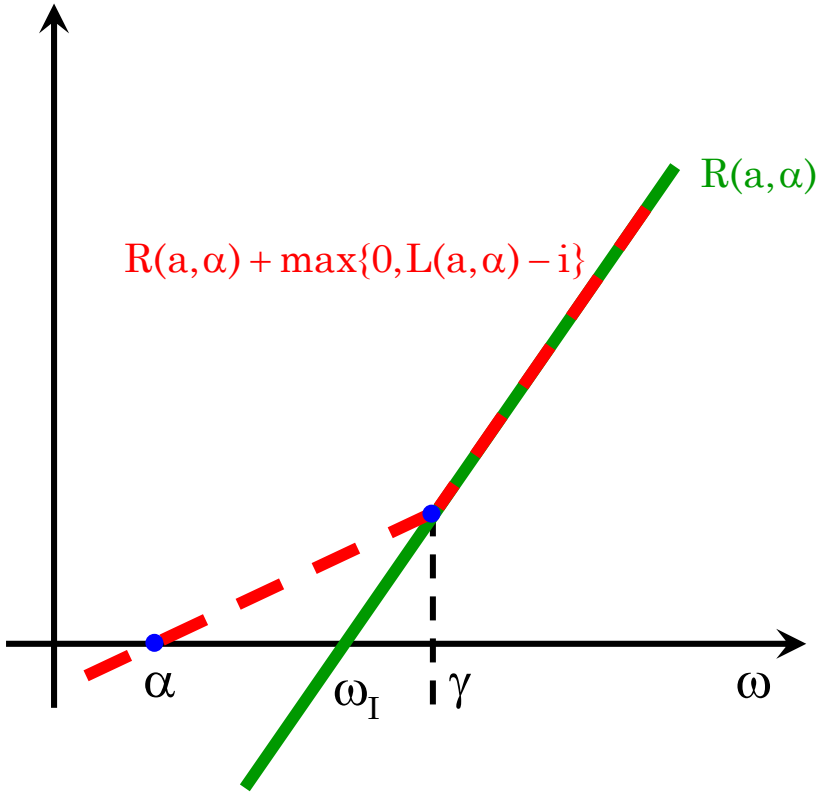
- Payoff function for the index hedge:

$$\max\left\{0, I(\omega) - i\right\}$$

where i is the trigger and $I(\omega)$ an index with $\frac{dI}{d\omega} < 0$

Indemnity Hedge





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

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

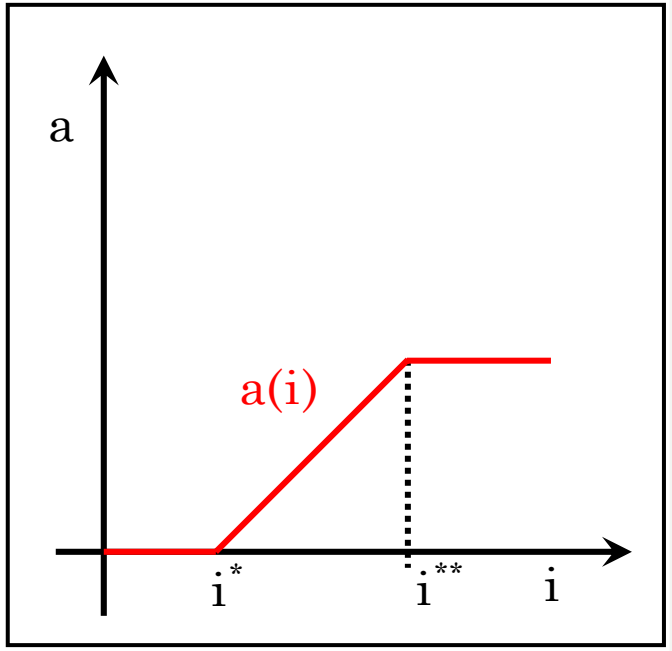
- Can hedging improve the incentive deficit due to the judgment proof problem?
- With the hedge in place, the organization maximizes shareholder value. This determines the underwriting effort $a(i)$ (**reaction function**)
- Indemnity hedge creates moral hazard
- Index hedge creates basis risk, but no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

Incentive Effects of Hedging – Results

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

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

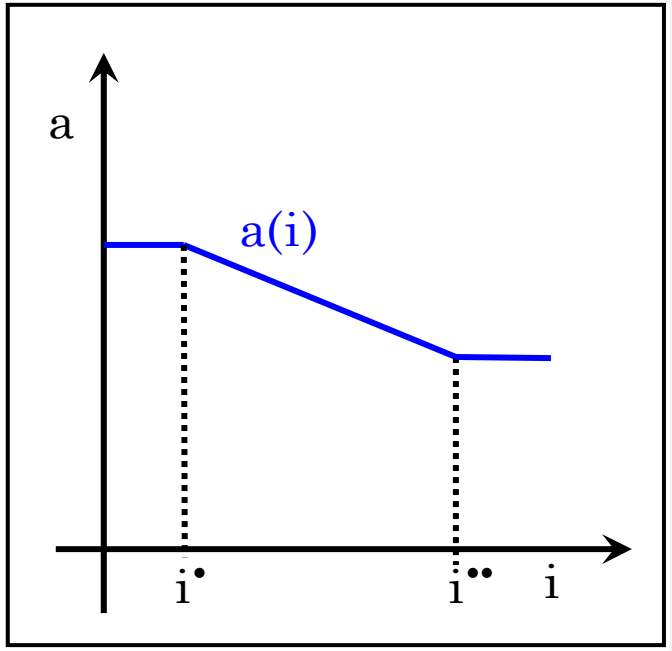
→ Incentive problem is aggravated.



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 $i^{\bullet}$ exists, such that bankruptcy risk can be entirely avoided through the hedge, even the first-best optimum is reached. ($a(i)=a^e$, $i \leq i^{\bullet}$)



Conclusion

- Insolvency risk / limited liability causes underinvestment in effort
- 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

- 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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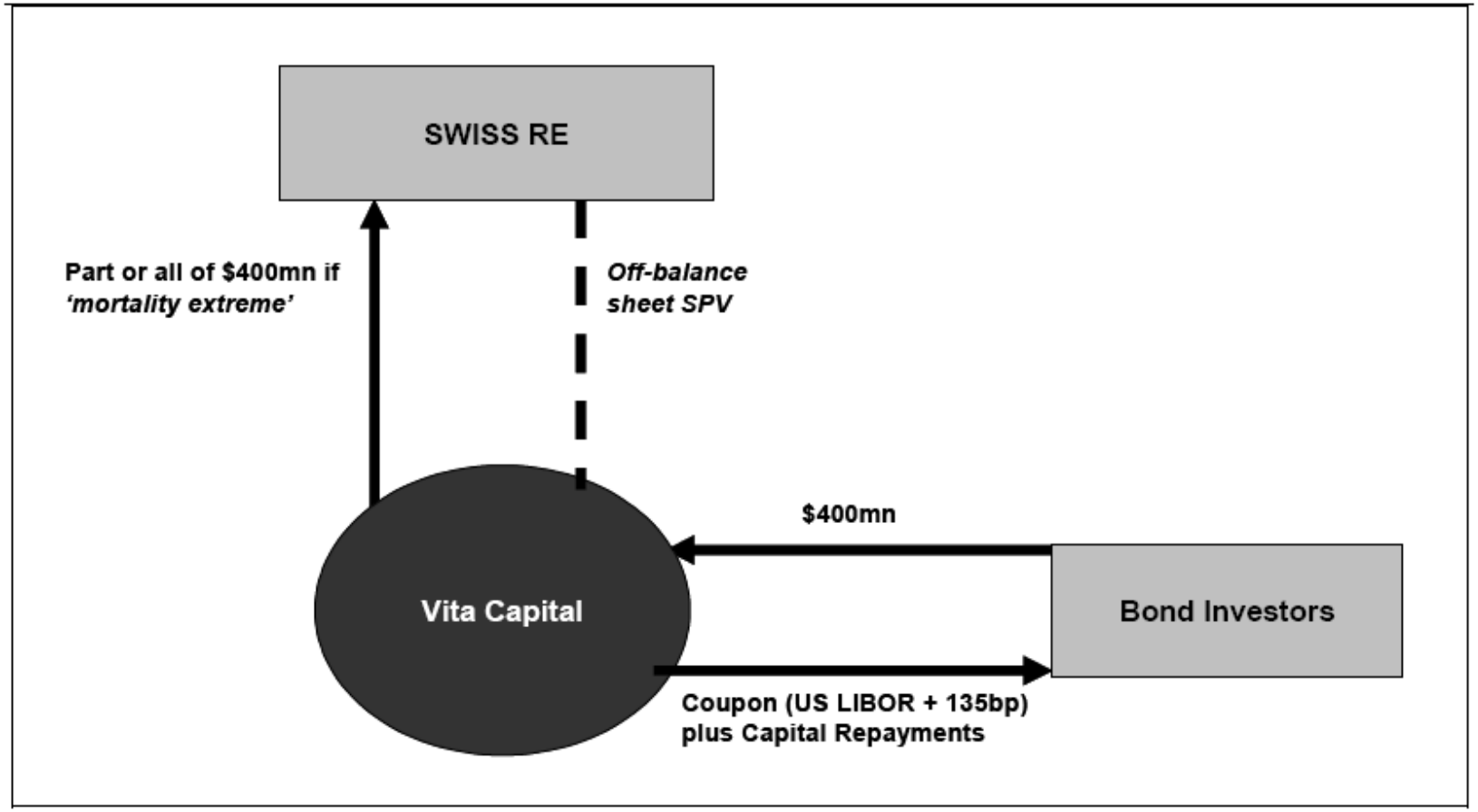
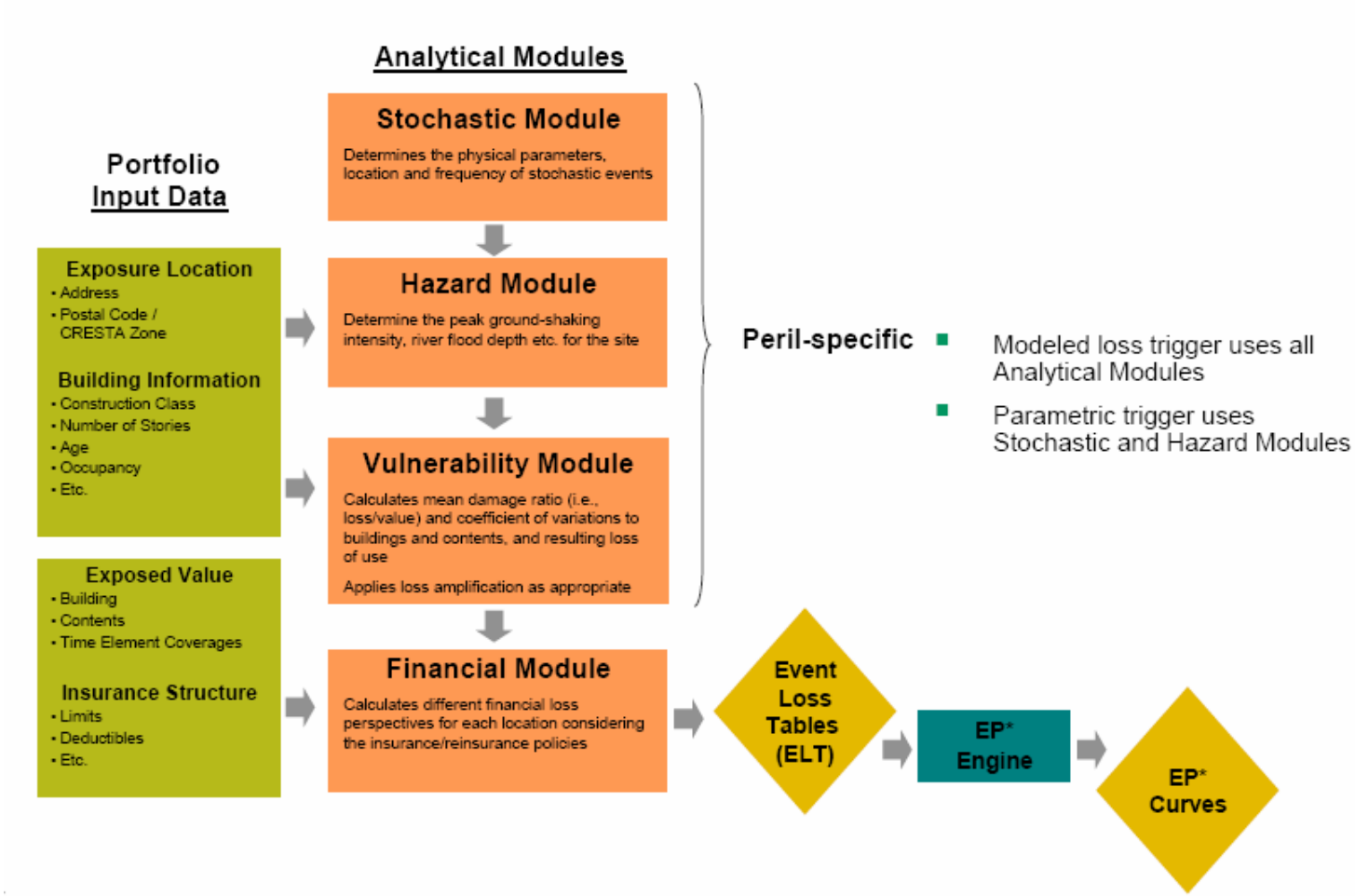
Vita Capital

Mortality-Based Security



Source: Company data, Morgan Stanley Research


Analytical Modules
Stochastic Module
Determines the physical parameters, location and frequency of stochastic events
Portfolio Input Data
Exposure Location
• Address
• Postal Code / CRESTA Zone
Building Information
• Construction Class
• Number of Stories
• Age
• Occupancy
• Etc.
Hazard Module
Determine the peak ground-shaking intensity, river flood depth etc. for the site
Vulnerability Module
Calculates mean damage ratio (i.e., loss/value) and coefficient of variations to buildings and contents, and resulting loss of use
Applies loss amplification as appropriate
Exposed Value
• Building
• Contents
• Time Element Coverages
Insurance Structure
• Limits
• Deductibles
• Etc.
Financial Module
Calculates different financial loss perspectives for each location considering the insurance/reinsurance policies
Peril-specific
Modeled loss trigger uses all Analytical Modules
Parametric trigger uses Stochastic and Hazard Modules
Event Loss Tables (ELT)
EP* Engine
EP* Curves

Cat Bond Transactions by Size

YEAR	<$50MM	≥$50MM, <$100MM	≥$100MM, <$200MM	≥$200MM	DEAL SIZE ($MM) AVERAGE	MEDIAN
1997	2	1	1	1	126.6	90.0
1998	3	3	1	1	105.8	63.1
1999	3	1	5	1	98.5	100.0
2000	1	2	4	2	126.6	136.5
2001	0	0	7	0	138.1	150.0
2002	1	1	2	3	174.2	175.0
2003	0	0	3	4	247.1	231.8
2004	0	0	3	3	190.5	185.2
2005	0	3	3	4	199.1	183.0
2006	0	3	8	9	234.7	175.0
TOTAL	**10**	**14**	**37**	**28**	**$168.8**	**$139.7**

Source: Guy Carpenter (2007)

Cat Bonds – Transactions by sponsor type

YEAR	INSURER		REINSURER		CORPORATE/GOVERNMENT	
	$MM	#	$MM	#	$MM	#
1997	521.0	4	112.0	1	0.0	0
1998	575.0	4	271.1	4	0.0	0
1999	460.0	4	424.8	5	100.0	1
2000	469.0	4	670.0	5	0.0	0
2001	150.0	1	816.9	6	0.0	0
2002	195.0	2	849.5	4	175.0	1
2003	730.0	3	768.0	3	231.8	1
2004	600.0	3	542.8	3	0.0	0
2005	1,071.0	4	920.1	6	0.0	0
2006	2,575.3	12	1,908.2	6	210.0	2
TOTAL	**$7,346.3**	**41**	**$7,283.3**	**43**	**$716.8**	**5**

Source: Guy Carpenter (2007)