



The Actuarial Profession

making financial sense of the future

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Factors Affecting the Prices of Catastrophe Bonds

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SORRENTO - ITALY

Contents

- This presentation is not about how a CAT bond should be priced
- It is about
 - how the market has priced the CAT bonds at the time of the issue
 - the factors that affect the prices of a bond
 - comparisons of prices and risk protection between different risk transfer mechanisms
- The analysis can be used in
 - Estimating prices of bonds
 - Portfolio analysis
 - Risk protection assessment
- It provides a framework for analyzing and monitoring the price movements of CAT bonds and reinsurance
 - Construct market index
 - Measure changes in perception of risk

Catastrophe bonds (1)

- Bond which pays coupon and returns capital at the end of the term if an event has NOT occurred
 - $\text{Coupon} = \text{LIBOR} + \text{Spread}$
- Term
 - 1 to 5 yrs – average a bit less than 3 yrs
- Size
 - from a few million \$ to a few hundreds of million \$
- Expected Loss
 - Usually less than 5%
 - Full analysis
- Peril
 - Multi-Peril, US Hurricane, US Earthquake, European Wind, Japanese Earthquake, Mediterranean Earthquake, etc.

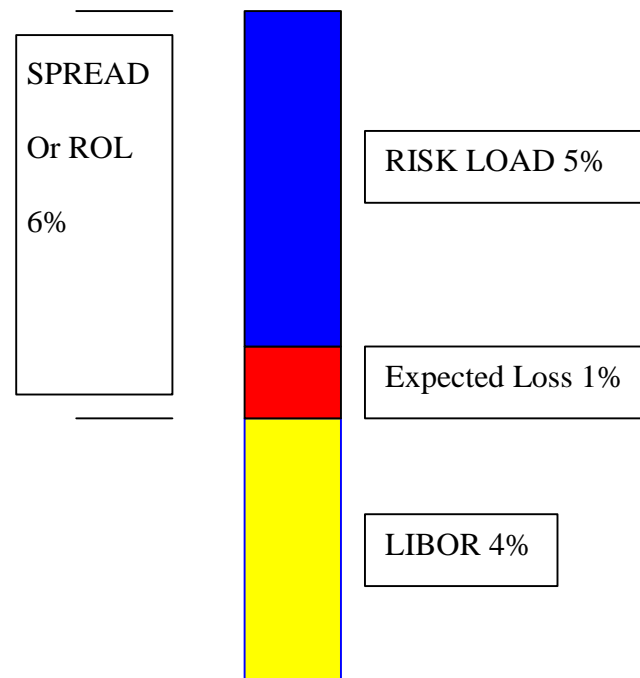
Catastrophe bonds (2)

- Trigger
 - Indemnity
 - Index
 - Modelled Portfolio
 - Parametric
 - Combination
- Time of Issue
 - State of the Market
- Other
 - Sponsor
 - Manager
 - Shelf issue
 - etc

Risk Transfer Mechanisms

	Reinsurance Retrocession	Catastrophe Bonds	ILWs
Coverage	All Perils, All Territories	Mainly Property Catastrophe	Mainly Natural Catastrophe
Trigger	Generally Indemnity	Indemnity, Index, Modelled, Parametric, Combination	Industry Loss
Reinstatements	Usually Available	Usually 1 Limit	Usually 1 Limit
Expected Loss	Available at most levels	Majority have Expected Loss <5%	Usually up to 20%
Data/Modelling	Falls mainly on reinsurer	Extensive external assessment	Limited, Tailored Trigger
Security	Counter Party Risk, Could be fully Collateralised	Fully Collateralised	Counter Party Risk, Could be fully Collateralised
Seller	Reinsurer, Side Cars, Funds	ILS investors, Funds	Reinsurer, Side Cars, Funds

Spread, Risk Load, Expected Loss, Benchmark Rate



Statistical Analysis

- ✓ Allows us to quantify differences between the spreads of different types of bonds
- ✓ Helps to separate the effect of the different factors
- ✓ People are not very good at separating random effects from a real trend. They can be easily “fooled by randomness”
- ✓ Gives estimates about the errors in our estimates
- ✗ Subjective choice of model
- ✗ Trends may be hidden in randomness (“fooled by trends”)
- ✗ Limited amount of data

Data

- 192 bonds issued between Jan 2003 and June 2008
- Limited amount of data
- Correlations in the data

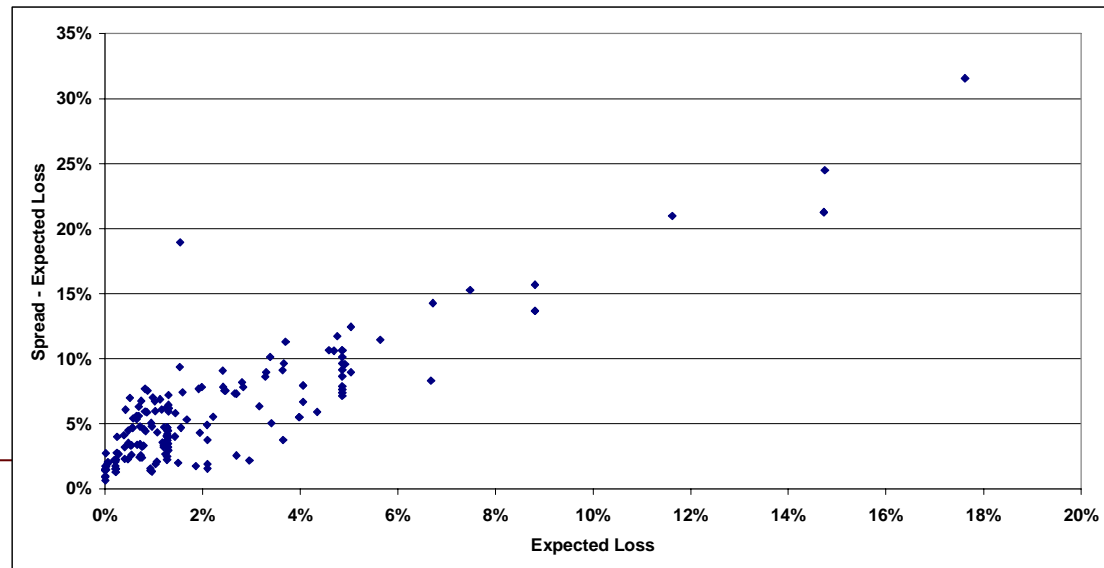
	Industry Index			
	indemnity	Modelled Loss	parametric	Grand Total
US Hurricane only	5	28	7	40
Multi-peril including US Hurricane	26	23	19	68
US Earthquake		16	18	34
Japanese Earthquake			10	10
European Storm, Japanese Typhoon, other	5	3	24	32
Non-Peak Territories		1	7	8
Grand Total	36	71	85	192

Data

- Retrocession data covering 2007 and 2008 renewals, representing around 40% the market
- Reinsurance data covering all perils US for 2006, 2007 and 2008 – around 600 contracts
- Reinsurance/Retro contracts have been included only if risks had been modelled
 - Allowance for proportional and per risk

Structure of the Model

- What do we model?
 - Spread
 - Ratio (Spread/Expected Loss)
 - Risk Load
- Asymptotic behaviour
 - Unsafe to extrapolate



Structure of the Model

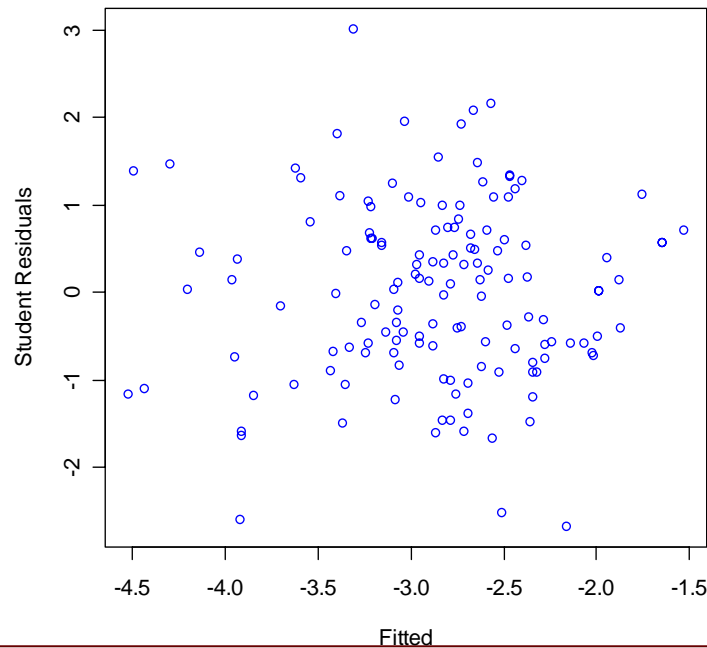
- Additive Model v Multiplicative Model
 - Multi – peril risk load is higher
 - *Risk Load +1% across the board, or Risk Load * 115%?*
 - Hard market
 - *Risk Load +1% across the board, or Risk Load * 115%?*
 - Linear Model: Constant Variance
 - *Transformation*
 - *General Linear Model*
 - *Generalised Linear Model*
- One model for all bonds or more than one models?
 - Trial and Error
 - *Significant Factors including Interaction Terms*
 - *Error Term (Distribution and Variance)*

Structure of the Model

- Linear Model
 - A priory choice of structure by the user
- Smoothers
 - Data show the relation between dependent and independent variables
 - Choice of smoother and degrees of freedom

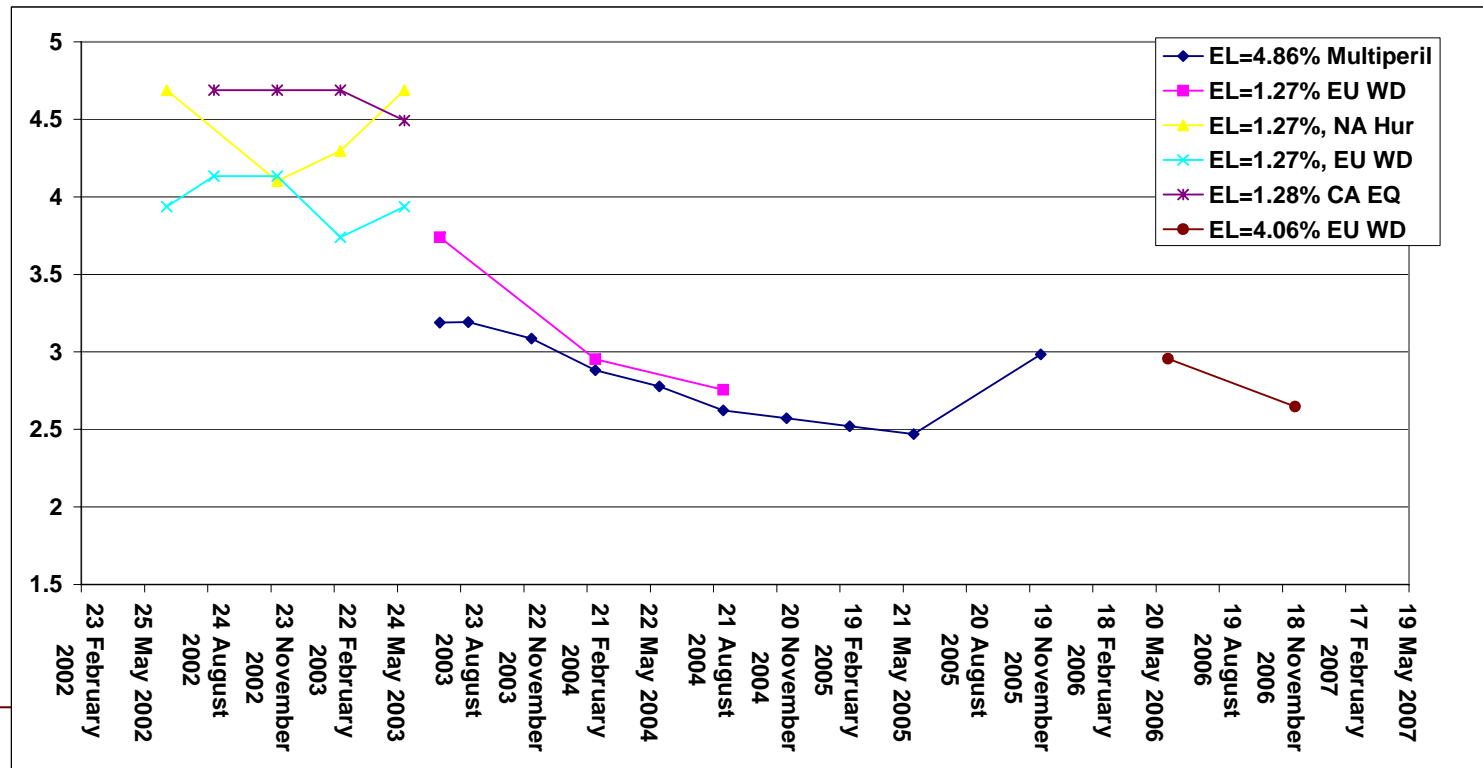
Fit of the model for US and Multi-territory perils

- Current Model Choice
 - two power models for two groups of territories
 - with smoothing functions



Individual Cat Bonds with Similar Features

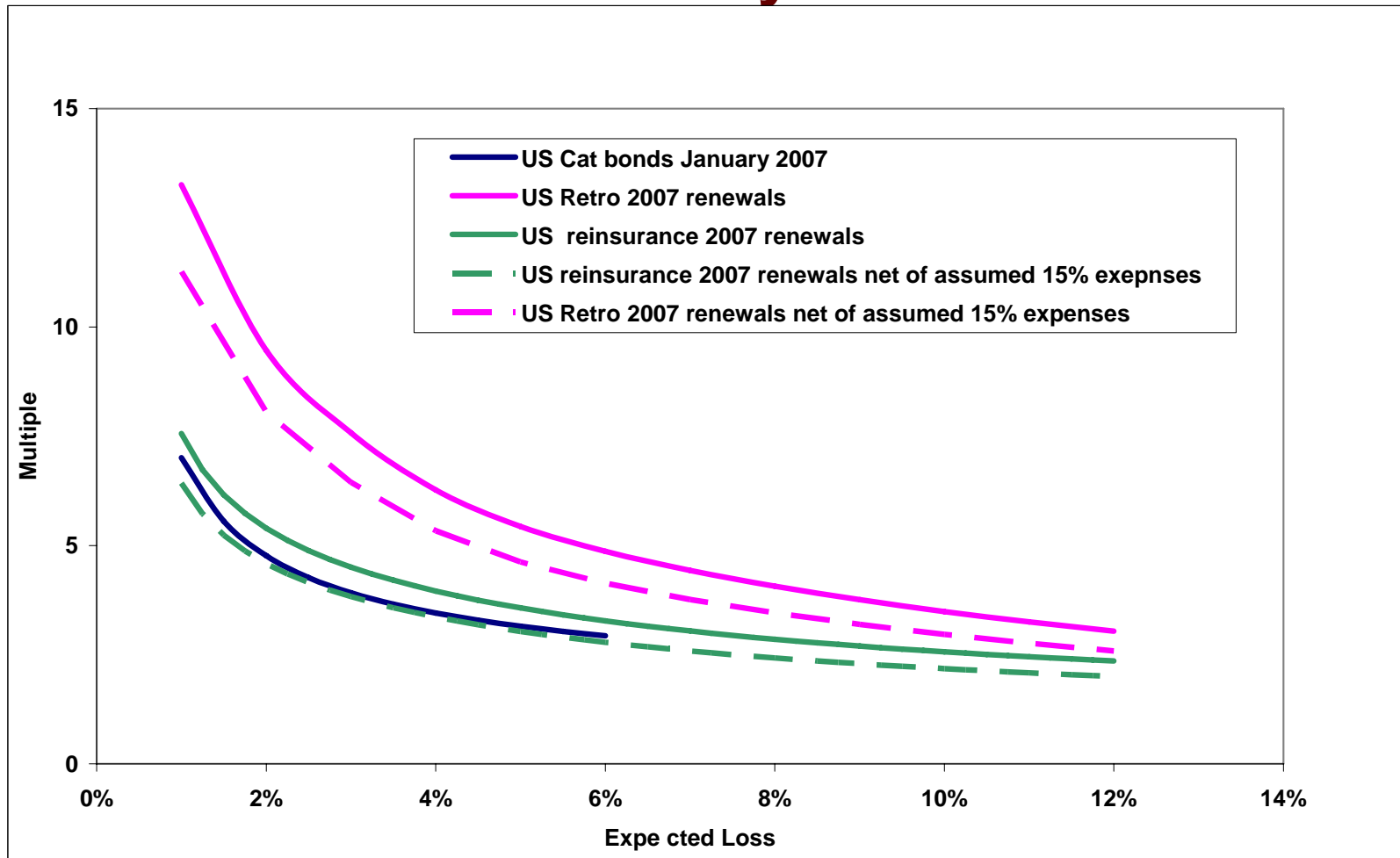
- Useful, but maybe not necessarily the best way
 - Different Expected Losses
 - Different Perils and Triggers
 - Random Effects



Main Driver of Risk Load: Expected Loss

- Expected Loss
 - It is an annualised rate
 - Different models may come up with different estimates
- Alternative Factors
 - Probability of Loss and Conditional Expected Loss
 - Rating Agencies rate
 - Statistically not as good as expected loss
- It does not seem to be a simple linear relation between risk load and expected loss
- Minimum Risk Loads
 - Liquidity Premium
 - Expenses
 - Threshold by corporate bonds?

Modelled US Hurricane Multiples January 2007



Comparisons

Cat Bonds v Retro/Reinsurance

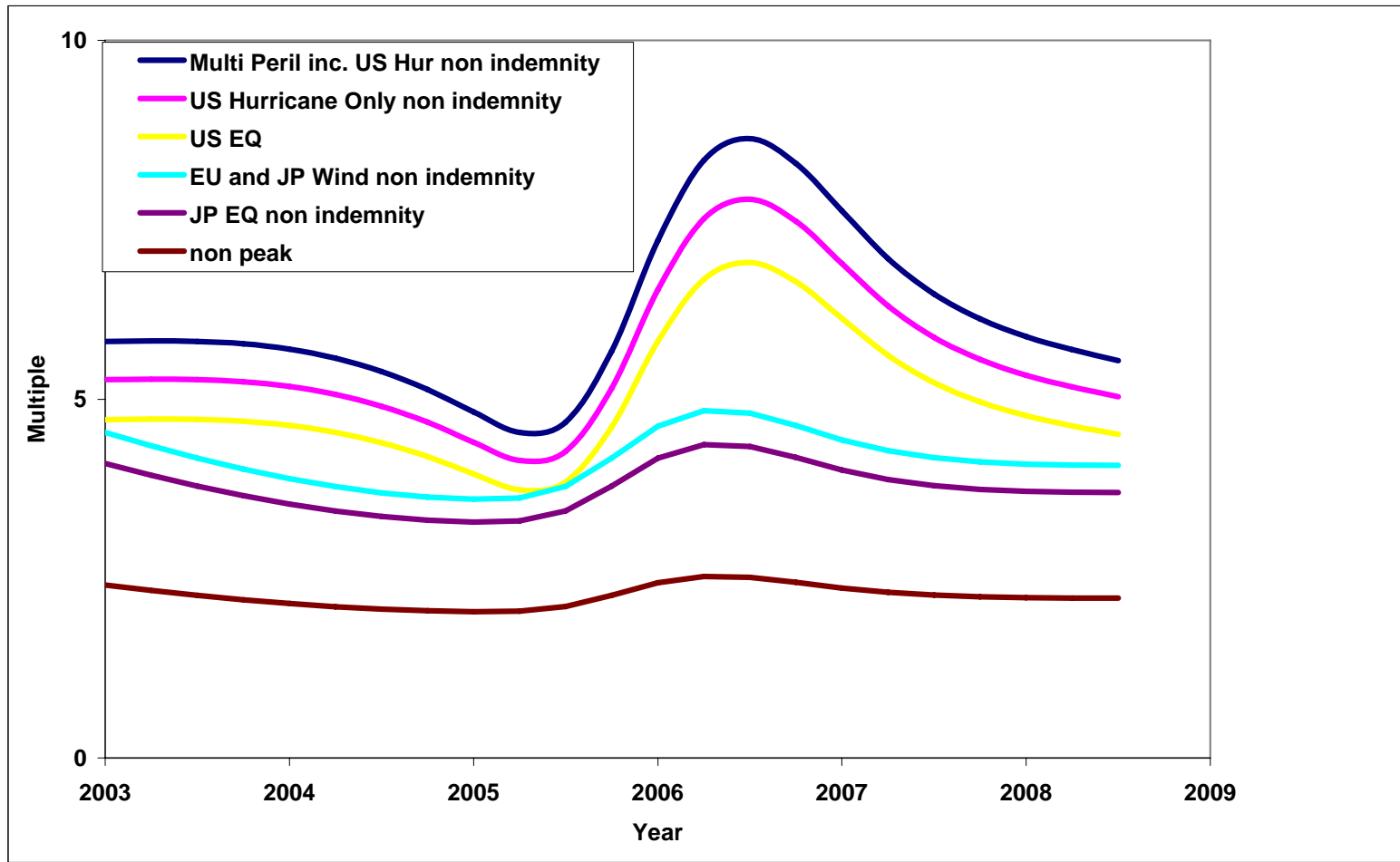
- Direct comparisons not straightforward
 - Some issues
 - Cat bonds mixture of retro and reinsurance
 - Data quality of retro portfolios
 - Un-modelled risks in retro book?
 - Treatment of expenses
 - Bonds fully collateralised
 - Retro v Cat Bonds
 - Risk loads seem to be higher
 - Indemnity retro triggers may not be possible to place easily in cat bond markets
 - Reinstatement generally available for retro
 - Reinsurance risk loads closer to those for bonds
-

Factors Affecting Risk Load

Date of Issue

- Date of Issue
- Novelty premium in early years
- Market Cycle
 - 2005 Hurricanes
 - Cycle has been more pronounced for bonds including US perils
 - Cycle has been less pronounced for non US perils
 - “Payback” for reinsurers
- Updates of Vendor Models
- Risk loads seem to be levelling off.
 - However, there is significant price volatility.
 - More issues required to draw firmer conclusions

Modelled Multiples for Cat Bonds for Different Perils/Territories (EL=1%)



Factors Affecting Risk Load

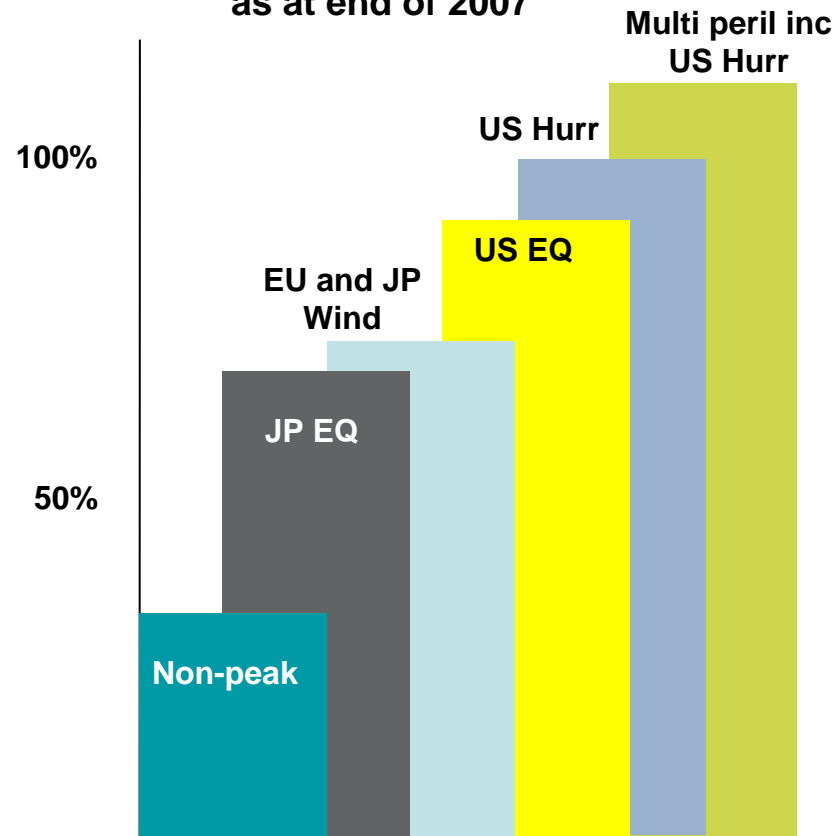
Perils/Territory

- Peril/Territory statistically more significant factor than Trigger
 - The exact difference varies with the market cycle
 - E.g. US EQ around the same level as European Wind before Katrina, but higher after
 - Correlation of perils with the rest of the portfolio

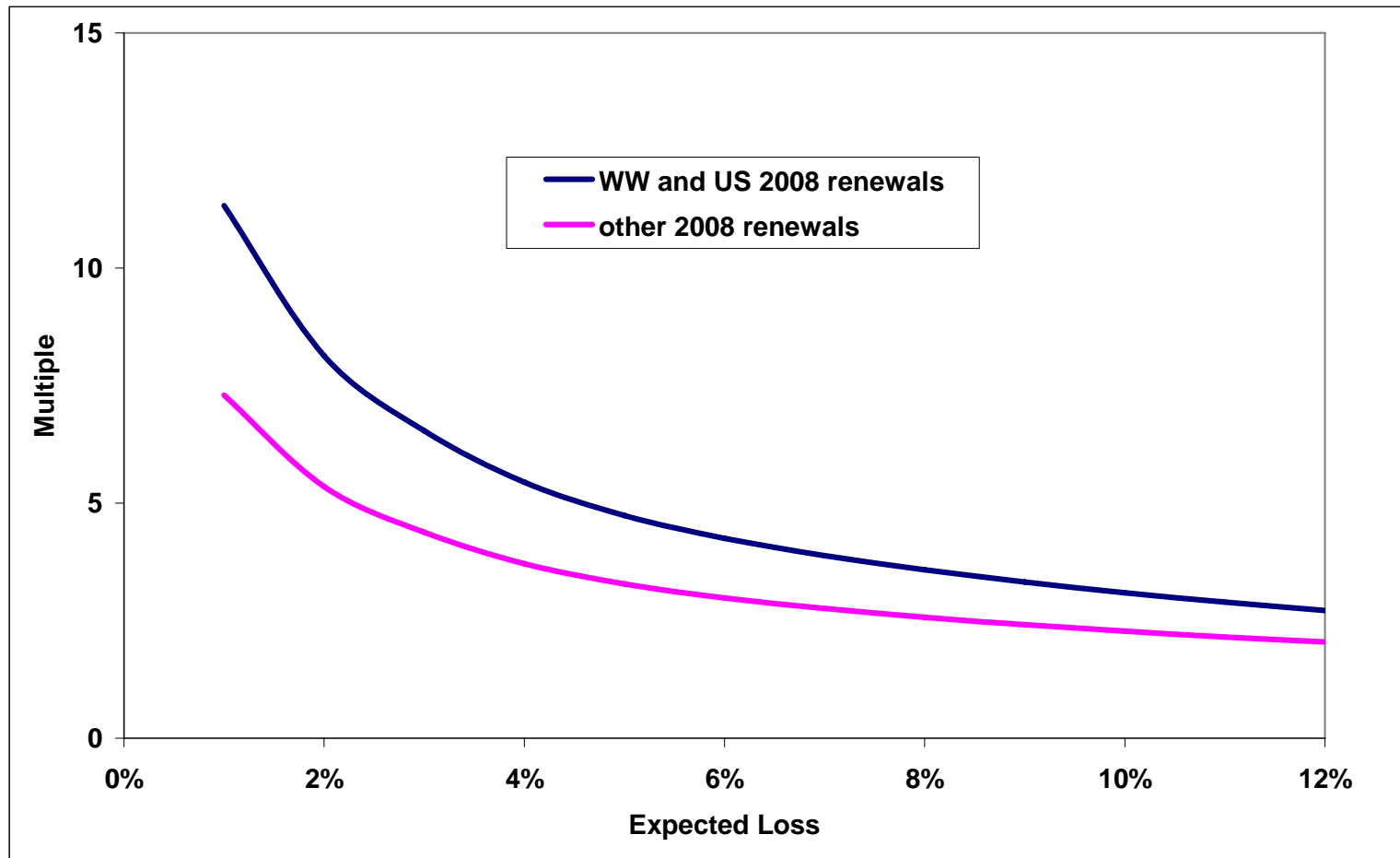
Factors Affecting Risk Load Perils/Territory Cat Bonds

Approximate Relative Risk Load by Peril

as at end of 2007



Factors affecting Risk Load Perils/Territory Retrocession



Factors affecting Risk Load

Perils and Trigger

- Relation between Peril and Trigger
 - More parametric bonds for non peak perils
 - Statistical model attempts to separate effect of Peril and Trigger
- Limited data
 - Very few indemnity bonds not covering perils including US Hurricane.
 - Reputation of sponsor

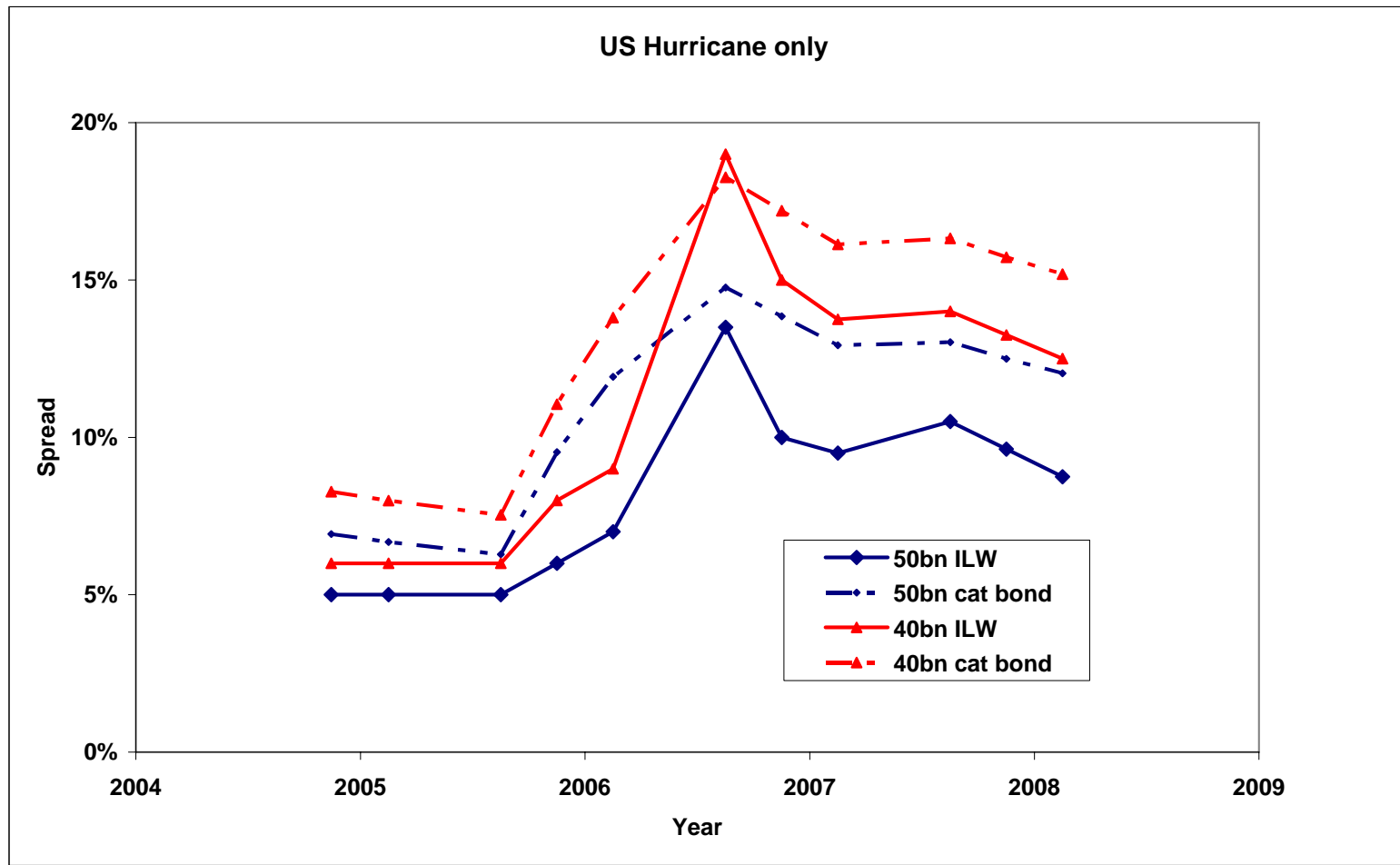
Factors affecting Risk Load Trigger

- Perils including US Hurricane
 - Risk Load for indemnity bonds around 5 -10% higher than for other types of trigger
 - Limited data
 - Large percentage of indemnity bonds issued by established insurers such as USAA, Chubb, etc.. Market familiarity and comfort with these bond issues
 - Risk Load for Parametric bonds a bit lower than that for index/modelled portfolio, but not statistically significant
 - Market perception about better quality of data and vendor models for the US
- Perils not including US Hurricane
 - Hardly any indemnity bonds
 - Risk Load for parametric triggers 15-20% lower than for other triggers

US Industry Loss Warranty (ILW)

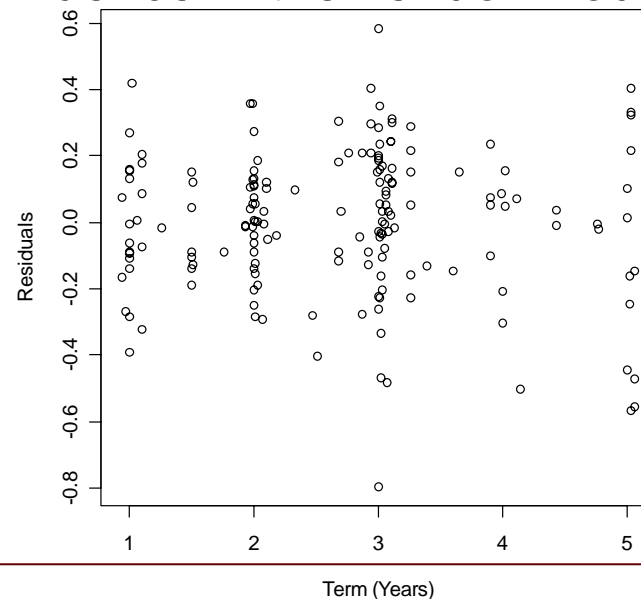
- ILWs pay if industry losses (usually based on index) is in excess of certain nominal amount
 - Contrast with cat bond comparisons based on expected loss
- Vendor model estimations of expected loss changed over time
 - Need to adjust for this
- ILW spreads seem to have been lower than those of Cat bonds
- Spreads got closer to those for cat bonds during the hard market following Katrina

US Industry Loss Warranty (ILW)



Some Comments on Other Features of Cat Bonds

- Term of the Bond
 - A bond with longer term is subject to greater uncertainties
 - E.g. changes in risk, but use of the same vendor model
 - Higher Risk Load may be expected
 - Statistically not a significant factor
 - Changes in level of confidence in the vendor models may have had some influence



Some Comments on Other Features of Cat Bonds

- Size of the bond
 - Higher size may require more investors bidding the price up
 - Not a statistically significant factor
- Time of issue within a year
 - Seasonality of some natural perils
 - May have psychological effect on investors
 - Not a statistically significant factor
 - There is seasonality in the prices in the second market, but here we consider prices at issue
- Sponsor/Manager/Model
- Shelf Issue
- Retro/Reinsurance/Insurance

Some Comments on Other Features of Cat Bonds

- Extension period
- Spreads on corporate bonds
- 1st or 2nd Event
 - Cat Bonds: Not a significant effect
 - Retrocession: 2nd event (back up) covers seem to have higher risk loads other things being equal
 - May reflect scepticism of underwriters about accuracy of natural hazards models for 2nd event
 - Prevailing market conditions after first event

Some Common Pricing Methods

- Standard Deviation

$$\text{Pr emium} = E[X] + a \cdot st.dev$$

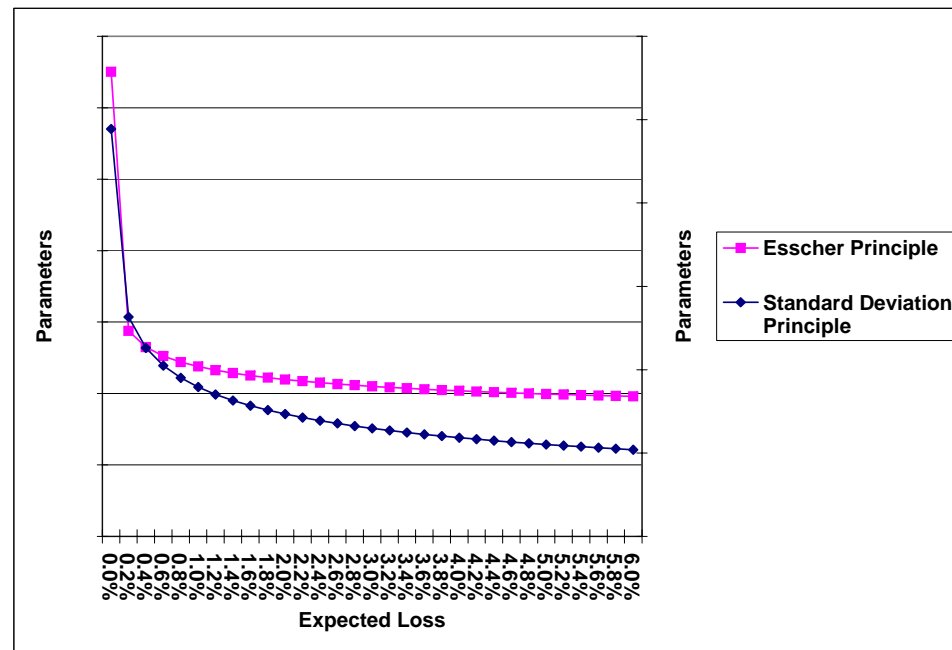
- Maximum Loss
- Esscher Principle

$$\text{Pr emium} = \frac{E[Xe^{aX}]}{E[e^{aX}]}$$

- Proportional Hazards

Approximate Implied Parameters of Standard Methods from Market Prices

- Implied parameters are not constant over the range of expected loss
- Market demands higher premium for lower expected losses
 - Parameter Uncertainty?



The End

- Statistical Modelling provides a good formal framework for analysing market prices
- Data collection and data limitations
- Main drivers
 - Expected Loss
 - also reflecting volatility
 - Peril
 - mainly reflecting correlation with the rest of the portfolio
 - Time of Issue
 - mainly reflecting state of the market, perceptions about risk
 - Trigger
 - basis risk, quality of data
 - Other
- Prices for different risk transfer mechanisms
 - Differences in coverage

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