

Managing Catastrophic Risks

A Research Program of Wharton's Financial Institutions Center *And*
Risk Management and Decision Processes Center.

The Wharton Managing Catastrophic Risks research project and industry forum held its Winter 1998 meeting in Philadelphia December 14-15. The meeting opened with a dinner on the evening of the 14th. Morton Lane, of Sedgwick-Lane Financial, led a dinner discussion on the role of public finance in dealing with natural disasters in the global environment. His remarks specifically focused on the potential for the World Bank to utilize securitization vehicles to better manage sovereign risk credit exposures.

The December meeting brought together the research team, our industry sponsors, research partners and the project's Technical Advisory Committee. In addition to Insurance Services Office Incorporated (ISO), our research partners include three of the leading catastrophe modeling firms. The Technical Advisory Committee is comprised of nationally recognized experts in the fields of engineering, seismology, meteorology, statistics and public policy. They have been working with Wharton researchers and the three modeling firms to enhance our understanding of the elements of uncertainty inherent in the modeling of natural disasters.

In the months preceding the December meeting, members of the Technical Advisory Committee met with each of the modeling firms in preparing their assessment of the technologies being employed and approaches taken to recognize the uncertainties associated with the phenomena of natural hazards. The December meeting agenda centered on the issues of uncertainty, beginning with discus-

sions led by the modeling firms and members of the Technical Advisory Committee. Howard Kunreuther and Paul Kleindorfer pursued the uncertainty theme further in the morning discussions with their analysis of the implications of uncertainty and mitigation on insurers and homeowners.

The afternoon discussion began with Karen Clark of Applied Insurance Research outlining the next stage of the research being done by the modeling firms and the Wharton research team. In this phase the three firms will work to jointly apply their modeling approaches to a single city, Charleston SC. Working with the Wharton researchers, they will further develop the framework for quantifying uncertainty in Cat risk assessment. David Cummins led the next segment of the meeting, providing a framework for better understanding the implications of uncertainty to the pricing of Cat securities. Jim Moore expanded the discussion with a review of his work on tail estimations in Cat loss distributions. Vivek Bantwal and Howard Kunreuther then discussed preliminary results of their modeling of the effects of uncertainty and mitigation on issuers and investors of Cat securities.

The day ended with a discussion led by Anthony M. Santomero on the 1999 research agenda and included remarks from John Kollar of ISO on their work in support of several specific project initiatives.

What follows is a snapshot summary of the meeting, highlighting key elements of the presentations. What unfortunately cannot be captured in these notes is the

richness of the discussions made possible by the variety and depth of the expert perspectives gathered together for the meeting.

Uncertainty in Catastrophe Modeling

Introduced by: Robert Whitman of the Technical Advisory Committee (MIT)

Presented by Weimin Dong (RMS Inc.)

Dennis Kuzak (EQECAT)

Graham Cook (Applied Insurance Research)

Comments from the Technical Advisory Committee, Bill Iwan (Caltech)

Mark Johnson (U. Central FL)

Peter Sparks (Clemson U.)

Robert Whitman (MIT)

Catastrophe modeling, while essential to the understanding and management of catastrophes, is unavoidably fraught with uncertainty. Understanding the various types and causes of uncertainty, and devising ways to control for their effects, is a top research priority of the project. Robert Whitman, member of the Technical Advisory Committee and Professor Emeritus of Geotechnical Engineering at MIT, laid the groundwork for this session by briefly outlining the causes and magnitude of modeling uncertainty and the hard choices presented to anyone trying to model complex phenomena such as hurricanes and earthquakes. He stressed that ultimately, we are bound to have incomplete knowledge and data of the underlying natural phenomena, as well as incomplete knowledge of the details of the property at risk. Therefore the processes of event generation and damage estimation present in all catastrophe models each represent different sources of uncertainty, the magnitudes and interaction of which will vary from case to case.

To illustrate these points, representatives from each of the three modeling firms then

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outlined the specifics of modeling uncertainty in their treatment of the model cities under study—Oakland CA and Long Beach CA (earthquake) and Miami FL (hurricane). A concluding discussion examined the challenges involved in extending the model cities analyses to include commercial and life-line infrastructure.

Impact of Uncertainty and Mitigation on Insurers and Homeowners

Presented by Howard Kunreuther and Paul Kleindorfer (Wharton)

Continuing with the morning's treatment of uncertainty, Wharton Professors Howard Kunreuther and Paul Kleindorfer turned the group's attention to two questions related to uncertainty:

- What are the impacts of uncertainty on insurers?
- What are the benefits and costs of mitigation to insurers and homeowners?

The impact of uncertainty on insurers' decisions and outcomes was examined for the three model cities (Oakland, Long Beach, and Miami). Each model was run to determine expected losses both with and without mitigation. The impact of the scenarios indicated by the modeling results were deter-

mined for premium setting and coverage limits, book of business characteristics (exposure, diversification and capacity), insolvency, profitability, reinsurance, and the pricing, design and availability of Cat bond investments. The results demonstrated for all three model cities that uncertainty had significant impacts on insolvency probability and book of business profitability. Furthermore it was shown that there are potentially large benefits to reducing sources of uncertainty through improved risk assessment. Finally, mitigation can be a significant benefit to insurers, particularly when uncertainty is high.

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The same approach was then applied to homeowner's decisions relative to mitigation. The results show that varying hazard frequency and structural vulnerability have a large impact on the break-even cost of mitigation. Sensitivity analyses of results show that short planning horizons (myopia) and high discount rates by homeowners are important factors in determining when mitigation will be attractive to homeowners. Furthermore, the degree of optimism by homeowners relative to the uncertainties can affect whether they find mitigation cost effective or not.

Overview of Proposed Methodology for the Uncertainty Study of Charleston, SC, with Emphasis on the Earthquake Peril

Presented by Karen Clark (Applied Insurance Research) on behalf of :
Applied Insurance Research, EQECAT, and Risk Management Solutions

The objectives proposed for this study are threefold: (1) to develop an objective, systematic framework for quantifying uncertainty in natural hazard risk assessment, (2) to develop standard terminology understandable to users of catastrophe risk assessment technology, and (3) to implement this framework for the earthquake peril in Charleston, SC and then perhaps extend it to hurricanes and flood hazard.

This study will proceed along the following lines. First, a comprehensive list of model parameters, with their associated uncertainties, will be compiled. Second, a loss sensitivity analysis will be performed for each key parameter in the models. Third, a loss sensitivity analysis for combinations of parameters will be made. Finally, a family of exceedance of loss curves will be created from which uncertainty around the mean EP curve can be measured.

The balance of this session comprised a discussion on how this program will be applied to the concrete case of Charleston, SC.

Pricing Considerations in the Catastrophe Market: Tail Estimation and Catastrophe Security Pricing

Introduced by David Cummins,
Presented by James Moore (Wharton)

The second afternoon session dealt with the difficult issues of setting insurance prices to cover losses for events of magnitudes beyond the levels seen in historical data. Such events have extremely low probability of occurrence but leave extreme damages in their wake.

Professor J. David Cummins began the session by framing a number of the issues. He highlighted joint research done with Chris

Lewis and Rich Phillips that explores pricing for theoretical national contracts to provide a layer of coverage for events resulting in damage in excess of \$25 billion. Estimates for minimum acceptable premiums were obtained by fitting a family of probability distributions to historical catastrophic property losses reported to Property Claims Services (PCS). A similar analysis was performed using simulations provided by Risk Management Solutions (RMS) from their proprietary engineering models. Dr. Cummins reported that the derived parametric distributions for loss severity from the RMS data were quite close to those obtained using historical data.

Jim Moore then examined the degree of estimation error in tail modeling using small sample variance estimation techniques and the discussed the implications this has for capital market pricing. Using jackknife and bootstrap re-sampling for the PCS hurricane data and historic loss ratios due to catastrophes, he showed that the uncertainty in tail estimation is rather substantial. In addition to having dramatic implications for pricing, this substantial uncertainty makes it difficult to categorically reject certain probability distributions in favor of other distribution choices. Using the measures of estimation variability obtained from the bootstrap as a guideline, Moore examined secondary market trading data for the 1997 Residential Reinsurance catastrophe bonds

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provided by Goldman Sachs. His estimates

indicate that the expected yield immediately after secondary market trading began was roughly 420 basis points above LIBOR under loss assumptions as per the offering memorandum. A more conservative expectation allowing for estimation variability would be roughly 300 basis points over LIBOR. He noted that this is still more than double the spread that the market demands for BB-rated issues with similar loss profiles. Further analysis indicated that the risk aversion implied by the market prices for CAT bonds was consistent with that needed to explain historical return spreads for stocks versus bonds.

Implications of Mitigation and Uncertainty in Pricing Catastrophe Instruments

Presented by Vivek Bantwal and Howard Kunreuther (Wharton)

A recent innovation in the financial community involves the development of securities with payoffs based on the occurrence of natural disasters. Since the pricing of these securities is based upon the frequency and severity of rare events, it is important to understand the right tail of an insurance company's exceedance probability (EP) curve. As part of a broader study on the effects of uncertainty and mitigation, Howard Kunreuther and Vivek Bantwal undertook an analysis of how these factors specifically influence the right tail and presented preliminary results.

With the help of Applied Insurance Research (AIR), Wharton explored the EP curve of a hypothetical insurance portfolio of five thousand homes in the Miami/Dade County model city. The effect of roof mitigation (bracing roof trusses and gable ends, affixing roof decking with adhesive and

screws, and installing hurricane straps or clips at the roof/wall joint) on this hypothetical portfolio was also examined. Such mitigation measures had been shown to be cost effective by earlier analysis, particularly at higher wind speeds.

In this analysis the investor was assumed to buy a hurricane bond at the beginning of the risk period at par (\$100) and received an uncertain dollar amount at the end of one period (e.g. one year). With probability q (1%), a default event or catastrophe will occur, in which case the investor receives a stochastic recovery amount, R . The other 99% of the time the investor gets back his or her principal plus the risk free interest rate ($r = 5.5\%$) and a promised spread ($s = 4\%$).

To quantify the effects of uncertainty, three EP curves were utilized corresponding to low, medium and high losses. These EP curves, representing three world states were generated by varying AIR's assumptions relating to the filling rates and vulnerability of hurricanes. The relative value of the hypothetical hurricane bond in terms of Sharpe ratios was then determined using each of these different curves. (The Sharpe ratio is defined as the ratio of the excess return to the dollar risk expressed as the standard deviation of the bond.)

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Two conclusions were then drawn from an examination of this relative value analysis. First, the hurricane bond was shown to provide excellent relative value for all

three world states. This was true even for the case in which investors were to focus their attention on the high loss curve. Here, they would still realize a Sharpe ratio that would be very attractive relative to that of traditional high yield debt. This finding implies that investors are more than fairly compensated for uncertainty in the tail. Second, it was shown that mitigation approximately doubles the Sharpe ratio for all three world states. Thus, if the hypothetical insurance company were to recognize that they had a portfolio of structures that were mitigated, they would very likely alter not just the terms of the bond but also their entire reinsurance program. In future work, Kunreuther and Bantwal intend to examine what effect mitigation has on the reinsurance attachment point for the right tail of the EP curve in future.

Update on ISO Activities Related to the Managing Catastrophic Risks Project

Presented by John Kollar

(Insurance Services Office, Inc.)

Participation in the Wharton Managing Catastrophe Risk Project is part of ISO's long history of researching and drawing attention to the industry's exposure to catastrophe losses. ISO's specifically collaborates with the Wharton Managing Catastrophe Risks Project by providing expertise and data for the following studies:

Supply and demand analysis: This study, being conducted by Paul Kleindorfer (Wharton), is examining whether the decision to purchase catastrophe insurance really does depend significantly on the cost of that insurance and will describe the

factors that influence the supply of insurance.

Two forthcoming ISO publications of interest, *Financing Catastrophe Risk: Capital Market Solutions* and *Managing Catastrophe Risk: The Update*, may be ordered directly from ISO at www.iso.com, or by calling 212.898.6000.

Basis-risk analysis: This study, being conducted by David Cummins (Wharton), examines the risk that insurers face when using indexed-based catastrophe options and some other forms of securitization (e.g., catastrophe bonds with triggers based on loss indexes) to hedge their catastrophe risk. The ultimate goal of this project is to aid in the creation of improved loss indexes which in turn will improve insurers' ability to use catastrophe options and other forms of securitization to hedge risk.

Market and regulatory analysis: The catastrophe-risk problem is not just economic in nature. It is also a social and political issue. How regulators and legislators decide to address catastrophe risk has significant effects on both insurers and the insured. This study, being conducted by Robert Klein (Georgia State University), examines these linkages and attempts to describe the magnitudes and method of action of their effects.

Two forthcoming ISO publications of potential interest to persons concerned about these issues are *Financing Catastrophe Risk: Capital Market Solutions* (January 1999), and *Managing Catastrophe Risk: The Update* (due out in early 1999). To order copies, contact ISO at www.iso.com, or call 212.898.6000.

Future Research Agenda, Group Discussion

Moderated by Anthony M. Santomero

The day's activities concluded with a group discussion of the planned 1999 research program. The topics to be pursued in 1999 are:

1. The role of mitigation and insurance in managing catastrophic risks and the effects of uncertainty therein.
2. Analysis of the structure, conduct, and performance of catastrophe insurance and reinsurance markets.
3. Estimation of the supply and demand functions for Cat-related coverage provided in residential property insurance and earthquake policies.
4. Evaluation of state-sponsored Cat risk financing mechanisms.
5. Measurement of the form and magnitude of reinsurance inefficiency via the use of a principal agent model.
6. Measurement of the level of basis risk for insurers of different sizes and distributions of business that attempt to hedge the risk of a major hurricane using indexed option contracts.

Those assembled endorsed this program as appropriate to the goals of the project and both timely and directly relevant to the problems that catastrophic risks currently pose to the industry and the nation at large.

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