Snapshot

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 Spring 1999 meeting in Philadelphia on June 14–15. The meeting opened with a dinner on the evening of the 14th. Brian Duppereault, Chairman, President and CEO of ACE Ltd. of Bermuda, led the dinner discussion focusing on the conflict between the traditional insurance regulatory view of "looking backward" and the "looking forward" view supported by new modeling technologies. While relevant to other areas of insurance, the issue is especially critical in the CAT area.

The formal meeting on the 15th was divided in two thematic pieces. The morning focused on substantive discussions of the several projects related to the financing of CAT risks; and the afternoon was devoted to shorter updates on those research initiatives related to industry structure and regulation, "model cities", and mitigation. In the fall 1999 meeting, the intention is to reverse the order with the bulk of the meeting devoted to more substantive discussions on industry supply and demand analysis, the impact of regulation, modeling and uncertainty, and mitigation analyses.

During the luncheon break, Steve Levy, the CAT project manager, demonstrated the project website. The website contains links to relevant papers, "snapshots" of previous meetings, a "members only" page with participant contact information, etc. Steve demonstrated a new link on the "advisory board" page. All of the project's advisory board firms are listed with a link to their respective home pages. Working with Guy Carpenter as a beta-site, we have also provided additional links to CAT related publications from the firm. Other members of the advisory board were invited to contact Steve to establish similar links to relevant publications from their firms. The site is beginning to attract significant traffic. We view this latest enhancement as broadening CAT information content available to the public and an opportunity to afford increased visibility for our industry participants in this area.

What follows is a "snapshot" summary of the research discussions, highlighting key elements of the day's presentations. What unfortunately cannot be captured in these notes is the richness of the discussion that took place from the diverse set of experienced perspectives represented in the group.

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Can Insurers Pay for the "Big One"? Measuring the Capacity of the Insurance Market to Respond to Catastrophic Losses"

J. David Cummins, Professor of Insurance and Risk Management, Wharton
Neil Doherty, Professor of Insurance and Risk Management, the Wharton School
Anita Lo, Ph.D. Candidate, Insurance and Risk Management, Wharton

David Cummins and Neil Doherty discussed their efforts to develop a theoretical and empirical analysis of the capacity of the U.S. property-liability insurance industry to finance major catastrophic property losses. The topic is important because catastrophic events such as the Northridge earthquake and Hurricane Andrew have raised questions about the ability of the insurance industry to respond to a disaster in the $100 million range. At first glance, the U.S. property-liability insurance industry, with equity capital of more than $300 billion should be able to sustain a loss of this magnitude. However the reality could very well be different; depending on the damage distribution and coverage spread on the one hand, and between insurer losses and industry losses on the other. As such the prospect of a mega-catastrophe brings the real threat of widespread insurance failures and unpaid insurance claims.

> The industry is clearly much better capitalized than it was prior to Hurricane Andrew. But funding the "Big One" would still seriously disrupt the functioning of insurance markets.

Doherty described development of the theoretical model used as their basis of analysis. He showed that the necessary conditions for industry capacity to be maximized is that all insurers hold a proportionate share of the industry underwriting portfolio. Based on the theoretical construct, the researchers derived an option-like model of insurer responses to catastrophes. The result is an insurer response function where the total payout is a function of the industry and company expected losses, industry and company standard deviation of losses, company net worth, and the correlation between net worth and company losses. Utilizing 1997 insurer financial statement data to estimate the capacity of the industry to respond to catastrophic losses, two samples of insurers were used – a national sample, to estimate the vulnerablity of the industry as a whole, and a Florida sample, to measure the capacity of the industry to respond to a localized event or events. These data were analyzed to estimate the capacity of the industry to bear losses ranging from the expected value of loss, up to a loss equal to total company resources. They then developed a measure of industry *efficiency* equal to the difference between the loss that would be paid if the industry acts as a single firm and the actual estimated payment based on the option model. They demonstrated that national industry efficiency ranges from about 78 to 85 percent, based on catastrophe losses ranging from zero to $300 billion, and from 70 to 77 percent, based on catastrophe losses ranging from $200 to $300 billion.

They conclude that the industry has more than adequate capacity to pay for catastrophes of moderate size. (E.g., based on both the national and Florida samples, the industry could pay at least 98.6 percent of a $20 billion catastrophe. For a catastrophe of $100 billion, the industry could pay at least 92.8 percent.) However, even if most losses would be paid for an event of this magnitude, a significant number of insolvencies could occur, disrupting the normal functioning of the insurance market, not only for property insurance but also for other coverages.

Finally, they assessed the ability of the industry to respond to catastrophic losses based on 1997 capitalization levels compared to 1991 capitalization levels. This was motivated by the sharp increase in capitalization following Hurricane Andrew and the Northridge earthquake. (In 1991, the industry had $0.88 in equity capital per dollar of incurred losses, whereas in 1997 this ratio had increased to $1.56). Their model indicated that for a catastrophe of $100 billion, the lower bound estimate of industry capacity in 1991 was only 79.6 percent, based on the national sample, compared to 92.8 percent in 1997. For the Florida sample, they estimate that insurers could have paid at least 72.2 percent of a $100 billion catastrophe in 1991 and 89.7 percent in 1997. Thus, the industry is clearly much better capitalized now than it was prior to Hurricane Andrew.

In conclusion, the results suggest that the gaps in catastrophic risk financing are presently not sufficient to justify Federal government intervention in private insurance markets in the form of Federally sponsored catastrophe reinsurance. However, even though the industry could fund the "Big One", doing so would seriously disrupt the functioning of insurance markets and cause price increases for all types of property-liability insurance. Thus, it appears that there is still a gap in capacity that provides a role for privately and publicly traded catastrophic loss derivative contracts. For a fuller description of this research see their paper with Anita Lo entitled "Can Insurers Pay for the 'Big One'? Measuring the Capacity of an Insurance Market to Respond to Catastrophic Losses," available on the project website.

The Basis Risk of CAT Loss Securities

J. David Cummins, Professor of Insurance and Risk Management, Wharton
David Lalonde, Applied Insurance Research
Richard D. Phillips, Assistant Professor Georgia State University

This session provided an empirical analysis of the basis risk of index-linked catastrophic loss (CAT) derivative securities. The project was motivated by the emergence of CAT derivative securities in 1992 and the subsequent growth and evolution of the market. CAT derivatives securitize losses from random catastrophic events, providing an innovative new approach to financing catastrophic risk.

> Contrary to the contention of prior researchers, the new evidence showed that it is not necessary for an insurer to be large in order to hedge effectively using index-linked contracts.

The presenters noted that interest in these securities has grown for a variety of reasons. Potential hedgers, such as insurers and industrial firms exposed to catastrophic risk, have become interested because of the increasing frequency and severity of property loss due to hurricanes and earthquakes since the late 1980s. As noted in the capacity research discussion, there is growing recognition that projected catastrophes in the $30 to $100 billion range may be beyond the capacity of the international insurance and reinsurance markets. Although losses of this magnitude may be significant events in terms of insurance markets, they are small in relation to the value of traded securities and hence can easily be absorbed by securities markets. Moreover, catastrophic losses are "zero-beta" events, rendering CAT securities extremely valuable to investors from a portfolio diversification perspective.

By way of introduction, it was shown that to date, the principal trading in CAT securities has been in two types of contracts: (1) Index-linked CAT call option spreads of the type traded on the Chicago Board of Trade; and (2) insurer-specific CAT bonds, where a specified

catastrophic event triggers total or partial forgiveness of the repayment of principal. An important difference between these types of contracts is that index-linked call spreads typically pay off on an industry-wide loss index while the payoff on CAT bonds is based on insurer-specific loss experience. Thus, CAT bonds have very low basis risk but are subject to moral hazard, resulting from potential manipulation of reported losses by insures, while index-linked options have low moral hazard but are subject to an indeterminate amount of basis risk.

This study provides new information on the basis risk of index-linked CAT securities by providing extensive simulations of the hedging effectiveness of the contracts for 255 insurers writing 95 percent of the insured property values in Florida, one of the states most severely affected by exposure to hurricanes. The estimates were obtained by simulating catastrophic events using a sophisticated model developed with Applied Insurance Research (AIR). The model combines actuarial data, historical, and climatological data, with meteorological models of the underlying physical processes that drive the severity and trajectory of hurricanes. Taking advantage of detailed county level data on the amount of insured property value exposed to loss reported to the Florida insurance regulator, the authors used the AIR model to obtain very accurate estimates of insurer losses over a simulation sample of 10,000 years of hurricane experience.

The principal finding was that insurers of all sizes can hedge effectively using statewide loss indices. Hedging is more effective using sub-state indices. Contrary to the contention of prior researchers, the new evidence showed it is not necessary for an insurer to be large in order to hedge effectively using index-linked contracts. These findings have important implications not only for insurer usage of index-linked CAT securities but also for underwriting exposure management. The results should also be of interest to insurance regulators and policymakers concerned about the increasing interest in index-linked securities by insurers. Finally, these results also provide a useful case study of the development of a new asset class, insurance-linked CAT securities, and thus provide guidance for the securitization of other unconventional financial exposures.

Moral Hazard in Reinsurance Markets

Neil Doherty, Professor of Insurance and Risk Management, Wharton
Kent Smetters, Assistant Professor of Insurance and Risk Management, Wharton

The presentation began with a discussion of moral hazard, noting that moral hazard arises in insurance contracts because the insured usually has control over factors that influence the probability or severity of loss, but the insurer pays the bill. They went on to say that same incentive problems arise in reinsurance. Here, primary companies control underwriting and loss settlement, but the reinsurer (at least at the margin) pays for losses. Like other principle-agent problems, there are standard contract design features to control these incentive problems. The reinsurer may monitor the activities of the primary or may charge a premium that is sensitive to prior losses (either retrospective or experience rating). A further control is the use of risk sharing such as deductibles or coinsurance. These control devices may be explicit or implicit. Reinsurance is often based on a long term relationship in which implicit controls can operate and where reputation is also at stake if the primary abuses its control over ultimate losses.

Using a model of panel data of U.S. property liability firms, they find evidence that more reinsurance does lead to greater use of loss sensitive premiums and more monitoring.

It was proposed that moral hazard costs takes one of two forms: First, losses may increase relative to a non-insured level since the primary exercises a lower level of control. Second, controlling the incentive problem itself imposes a cost. For example, experience rating throws risk back onto the primary insurer. Thus part of the cost of moral hazard is that the primary may have less risk protection. The overall cost is the sum of the excess losses, and direct and opportunity costs of the contractual controls.

Against this backdrop, Doherty and Smetters outlined a model that predicts: That moral hazard should result in excess losses, and the use of experience and retrospective ratings. The sensitivity of premiums to retro and experience rating should increase with the level of reinsurance and monitoring, which also should increase with the level of reinsurance.

Using a model of panel data of U.S. property liability firms, they find evidence that more reinsurance does lead to greater use of loss sensitive premiums and more monitoring. A second test of the model looked at the differences in moral hazard when reinsurance is placed with unrelated firms and when it is placed with affiliates. Absent any transaction costs for intra- group activities, there should be no moral hazard in transactions between affiliates. It was noted that this assumption is too strong, and in actuality one would expect some moral hazard with differing controlling mechanisms. They find then that between affiliates, moral hazard is controlled more by use of monitoring than by loss sensitive premiums.

These results suggest that moral hazard imposes real contracting costs in traditional reinsurance relationships. These costs arise because reinsurance is an indemnity contract. This analysis therefore directs attention to new forms of hedging in which payoffs are not based directly on the primary insurer's loss but on some "instrument" (e.g. a market index) which is correlated with the insurer's loss but over which he has little control. Thus, the success of such devices may depend on whether the cost of basis risk offers a more efficient control over moral hazard than traditional contractual devices.

Role of Reinsurance and CAT Bonds for Dealing with Natural Hazard Risks

David Croson, Assistant Professor of Operations and Information Management, Wharton
Howard Kunreuther, Professor of Operations and Information Management, Wharton

David Croson and Howard Kunreuther outlined two objectives in mind for this session. First, they wanted to examine how reinsurance coupled with capital market instruments can expand coverage to those residing in areas subject to catastrophic losses from natural disasters. Second, they show how catastrophe-linked financial instruments can utilize models so that the price of protection can be lowered from its current level. After laying out their objectives Kunreuther began by outlining the various types of stakeholders and their differing concerns with respect to catastrophic risks, insolvency risk, reinsurance, and financial instruments. These stakeholders are: Homeowners and Businesses at Risk; Insurers; Reinsurers; Investors in Catastrophe Bonds; The Government (reinsurer of last resort). He also proposed six principles for designing catastrophic risk transfer systems. They are:

1. Utilize scientific risk estimates and engineering analyses to reduce uncertainty

and form a basis of common understanding between buyer and seller of catastrophic risk-transfer instruments of the risks to be handled, and the appropriate prices of each "layer" of protection.

2. Develop incentives for reducing moral hazard by using deductibles, coinsurance, placing restrictions on agent's actions post contract, and relying on long-term relationships.
3. Expedite settlement for catastrophic claims so as to increase consumers' willingness to pay for primary insurance. (Consumers place the highest marginal value on reimbursement from their insurance company precisely when the damage to their property is greatest).
4. Link premium payments to non-catastrophic claims periods, i.e. separate the timing of cash-flow events from the provisions of economic value through insurance.
5. Employ capital-market instruments to reduce credit risk
6. Customize risk transfer instruments to address basis risk by using simulation tools to design contractual relationships to fit specific disaster scenarios.

Only a combination of insurance, reinsurance, cat bonds and some amount of “government reinsurance” as the financial instrument of “last resort” can possibly meet the objectives of differing stakeholders.

Croson then contrasted typical policies with "State-contingent Reinsurance" which pays out settlement contingent on the severity of the catastrophe itself, not the loss suffered by the insurer. While this can be a real advantage with respect to speed of pay-out, state-contingent reinsurance still has similar problems to the standard excess-of -loss contract in that there is a credit risk associated with insolvency of the reinsurer, and moral hazard costs associated with the behavior of the insurer. Finally, Crosen outlined the working of catastrophe bonds. While they have an advantage over reinsurance because they eliminate credit risk to the insurer, they also introduce basis risk to the insurer if there is any imperfect correlation between the actual losses incurred and the payments received.

The point of this exercise was to conclusively demonstrate the futility of adherence to any "single solution concept" for a multiple stakeholder reality. Only a combination of insurance, reinsurance, cat bonds, and some amount of "government reinsurance" as the financial instrument of "last resort" can possibly meet the objectives of the differing stakeholders.

Croson indicated that one way to deal with catastrophic risk is to use "state-contingent" payment structures based on customized indices where claims would be paid based on the predicted, rather than actual, outcome. Any residual risk would be either retained by the insurer or hedged with a customized reinsurance policy. The two sides might even agree to run a specific model after a catastrophe using parameters from the actual event in question to determine the amount of funds to be transferred. If 100% indemnification was absolutely necessary then “model gap reinsurance,” could be used but it would reintroduce moral hazard risk entirely at that layer.

In conclusion Croson and Kunreuther pointed out the need for further research to clarify the extent that more accurate models (and customized contracts based on them.) could significantly reduce basis risk. Other interesting topics would be to investigate just how much "extra" capacity the use of Cat bonds by primary insurers would generate for the reinsurance industry, and finally, how government might be able to supplement a cat bond/reinsurer combination by the imposition of special taxes.

Update: The Impact of Regulation on Catastrophe Insurance

Paul Kleindorfer, Professor of Operations and Information Management, Wharton
Robert Klein, Associate Professor of Risk Management, Georgia State University

Paul Kleindorfer and Bob Klein provided a brief overview of the extent of their current research. The intent is to empirically address interactions across multiple stakeholders, i.e. homeowners, businesses, insurers, reinsurers, the construction and real estate sector, and regulatory institutions. In their analysis they will address three questions:

1) What is the structure and performance of the catastrophe insurance market? How do factors such as, interdependencies, profits, risk exposures, and distribution impact the performance of the market?
2) What is the impact of regulation of this market on pricing adequacy, pricing precision, and financial risk?
3) What is the current state of the market, and what future sustainable states of the market are possible?

The study will seek to identify the factors that most affect supply and demand and the magnitudes of their relative effects, including the pricing of CAT coverage and alternative policy provisions.

A brief discussion followed outlining the structural drivers of supply demand and regulatory controls:

"Demand structure" (i.e. why consumers buy what they do) obviously contains several components. Items such as location, demography, price, policy features such as the presence or absence of bundling, "quality" effects such as perceived solvency and claims processes, and finally, how products are distributed, all impact consumer choice. In addition, consumers have other risk management options open to them, the most obvious being where to live, what type of construction to choose and what type of "mitigation", if any, to employ.

"Supply Structure" describes how the consumer business of insurance is conducted. Salient features would be the degree of competition, geography, profitability, solvency, exposure, loss costs, marketing costs, organizational form, financial structure, and regulatory/solvency constraints. Obviously, insurance companies attempt to maximize profits in the face of these variables.

"Regulatory Impact" on such things as pricing adequacy, pricing precision, and financial risk has important effects on all parties. In particular the freedom to manage ones' risk exposure is critical to everyone from the individual consumer to the largest company, and regulation produces, sometimes quite consciously, distortions in the market which may negatively affect the sustainability of institutions. The initial phase of this portion of the study will focus on describing aggregate cross-subsidies, rate adequacy, and the interaction of reserves, exposures, and public financing.

For their analysis, the researchers will utilize detailed premium record data obtained from ISO on insurance transactions, supplemented by information on expected costs for different policies and risk characteristics. The data will, for the first time, provide an empirically grounded understanding of the supply and demand for CAT-related coverage provided in residential insurance policies. The study will seek to identify the factors that most affect supply and demand and the magnitudes of their relative effects, including the pricing of CAT coverage and alternative policy provisions.

Update: Mitigation Study

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Following the December '98 meeting, the "Model Cities" activities were expanded to include two additional areas of research. First, preliminary analyses began on the use of mitigation and insurance for reducing losses to commercial structures in Oakland and Long Beach (earthquake hazard), and Miami/Dade County (hurricane hazard). Second, the logistics of performing an earthquake hazard analysis of properties in Charleston, South Carolina by Risk Management Solutions, EQE International, and Applied Insurance Research were considered. The results of the "commercial structure mitigation study" were presented during this session. The "Charleston Study" results will be presented at a future meeting.

In the analyses, structural mitigation techniques to commercial structures were examined and direct economic losses only (i.e. building and contents damage) were analyzed. Deductible levels were set at 0% and 10% and an annual servicing cost per structure was estimated to be $250. Reinsurance was not considered in the initial study. In the model cities of Oakland and Long Beach, the structures chosen for mitigation were reinforced masonry shear wall structures. The mitigation measure studied increased the lateral resistance of this type of structure through the addition of roof-to-wall connections around the perimeter of the building (for flexible diaphragm structures) and the addition of braced frames or shear walls (for rigid diaphragm structures). For the city of Miami, commercial joisted-masonry structures were mitigated through the installation of storm shutters (i.e. protection of window openings).

Simulation results yielded qualitative results similar to the analyses of residential structures. Mitigation proved to be beneficial to insurers via lower insolvency probabilities, lower expected losses, and increased profitability through lower capacity restrictions. Future analyses will include the effects of business interruption on losses and the average cost of these mitigation measures.

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Visit the project website at:
http://fic.wharton.upenn.edu/fic/wfic/catrisk.html