



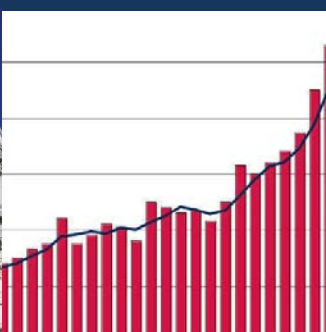
MANAGING LARGE-SCALE RISKS IN A NEW ERA OF CATASTROPHES

**Insuring, Mitigating and Financing Recovery
from Natural Disasters in the United States**

– Executive Summary –

March 2008

*An Extreme Events Project of the
Wharton Risk Management and Decision Processes Center
in conjunction with
Georgia State University
and the Insurance Information Institute*



THE WHARTON RISK MANAGEMENT AND DECISION PROCESSES CENTER

Established in 1984, the Wharton Risk Management and Decision Processes Center develops and promotes effective corporate and public policies for low-probability events with potentially catastrophic consequences through the integration of risk assessment, and risk perception with risk management strategies. Natural disasters, technological hazards, and national and international security issues (e.g., terrorism risk insurance markets, protection of critical infrastructure, global security) are among the extreme events that are the focus of the Center's research.

The Risk Center's neutrality allows it to undertake large-scale projects in conjunction with other researchers and organizations in the public and private sectors. Building on the disciplines of economics, decision sciences, finance, insurance, marketing and psychology, the Center supports and undertakes field and experimental studies of risk and uncertainty to better understand how individuals and organizations make choices under conditions of risk and uncertainty. Risk Center research also investigates the effectiveness of strategies such as risk communication, information sharing, incentive systems, insurance, regulation and public-private collaborations at a national and international scale. From these findings, the Wharton Risk Center's research team – over 50 faculty, fellows and doctoral students – is able to design new approaches to enable individuals and organizations to make better decisions regarding risk under various regulatory and market conditions.

The Center is also concerned with training leading decision makers. It actively engages multiple viewpoints, including top-level representatives from industry, government, international organizations, interest groups and academics through its research and policy publications, and through sponsored seminars, roundtables and forums.

More information is available at <http://opim.wharton.upenn.edu/risk>.

The Role of Applied Research in Advancing Knowledge on Large-Scale Risks

The *Managing and Financing Extreme Events* project was initiated in 1996 as a joint activity between the Wharton Risk Management and Decision Processes Center and the Wharton Financial Institutions Center. From its inception, this program was concerned with the role of mitigation, insurance and capital market instruments in managing catastrophic risks arising from natural hazards. Given the evolution of the terrorism threat worldwide and the September 11, 2001 attacks against our country, the project expanded to deal with these events.

In 2004, the Wharton Risk Center took the lead in launching a large project on the future of terrorism risk financing in the United States – the *TRIA and Beyond* initiative. The research was undertaken with a core group of project Sponsors in conjunction with over 50 public and private organizations here and abroad. Findings were presented at a conference in October 2005 at the Cannon House Office Building in Washington, DC, where government, business leaders and terrorism experts discussed long-term sustainable strategies for the nation to recover from future terrorist attacks. With the renewal of TRIA in December 2007, we continue to work actively on this front.

Wharton Risk Center's current multi-year initiative, *Managing Large-Scale Risks in a New Era of Catastrophes*, focuses on hurricane risk and flood hazard, and on providing protection to homeowners. It was launched in 2005, a few months after Hurricane Katrina made landfall. A report on the first phase of the study was issued in February 2007. Building on those preliminary findings, this report provides a series of in-depth analyses of the efficiency and equity of current disaster insurance markets and mitigation programs in the United States, the impact of state-based regulations on insurance protection and the loss distributions among different stakeholders.

DIRECTION AND COMPOSITION OF THE STUDY

This study is undertaken under the direction of Howard Kunreuther and Erwann Michel-Kerjan at the Wharton School of the University of Pennsylvania.

Contact them directly regarding information about this report, the study itself, or on becoming a sponsor of the Wharton Extreme Events project.

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**PREFACE
AND
EXECUTIVE SUMMARY**

The recent upsurge in hurricanes, coupled with increasing residential and commercial development in coastal areas of the United States, has exposed people and property to an entirely new scale of destruction, with cascading effects on homeowners, businesses located within these devastated areas and those depending on them, insurance and financial markets, and the public sector. In 2005, three major hurricanes – Katrina, Rita and Wilma – made landfall in the Gulf of Mexico within a six-week period, killing over 1,500 people and leading to insurance reimbursements and federal disaster relief of over \$180 billion – an historic record. These three storms occurred after four other hurricanes had caused severe damage in Florida in 2004.

The occurrence of damaging hurricanes is highly variable and uncertain from year to year. Despite alarming weather forecasts in 2006 and 2007, the only hurricane to make landfall in the United States since 2005 was a Category 1 hurricane. However, it is unavoidable that in the coming years, more hurricanes will strike the Atlantic and Gulf coasts, and other parts of the nation will experience severe floods and earthquakes causing extreme damage to residential and commercial property and infrastructure.

Episodes of terrorism share certain similarities with natural disasters. The first successful attack on U.S. soil, against the World Trade Center, occurred in 1993. Over the next eight years, not a single attack was perpetrated by an international terrorist organization in the U.S. As time passed, the nation was lulled into a false sense of security. Then Al Qaeda launched its second, and much more devastating, attack on the morning of September 11, 2001.

While terrorism and natural disasters are different, they have several important features in common – uncertainty and wide variances in losses from one year to the next. Experts and decision makers face challenges in assessing the risks associated with these extreme events, developing strategies for reducing future losses, and facilitating the recovery process following a major disaster.

In the past seven years, we have entered a new era of catastrophes. Our nation is facing large-scale risks at an accelerating rhythm, and we are more vulnerable to catastrophic losses due to the increasing concentration of population and activities in high-risk coastal regions of the country. The question is not *whether* catastrophes will occur, but *when*, and *how frequently* they will strike, and the extent of damages they will cause.

Now is the time to develop and implement economically-sound policies and strategies for managing the risk and consequences of future disasters. Absence of leadership in this area will inevitably lead to unnecessary loss of lives and economic destruction in the devastated regions.

Guiding Principles

A coherent strategy is necessary to assure a sustainable recovery from large-scale disasters and the appropriate future development of hazard-prone areas. This report provides the elements for developing such a program by focusing on the roles of mitigation, insurance and other risk transfer instruments. These issues are complex. They challenge our capacity as a nation to work together despite very different agendas and priorities regarding the role and responsibilities of the private and public sectors in dealing with catastrophic risks.

The following two guiding principles underlie the research team's analyses and proposed strategies for using the insurance infrastructure to deal more effectively with natural disasters:

Principle 1: Premiums Reflecting Risk

Insurance premiums should be based on risk in order to provide signals to individuals as to the hazards they face, and to encourage them to engage in cost-effective mitigation measures to reduce their vulnerability to catastrophes.

Principle 2: Dealing with Equity and Affordability Issues

Any special treatment given to homeowners currently residing in hazard-prone areas (e.g., low-income uninsured or inadequately insured homeowners) should come from general public funding and not through insurance premium subsidies.

This report addresses several basic questions:

- How can the above principles guide the design of insurance and mitigation programs for reducing future disaster losses and providing financial support for victims of these events?
- What roles can the key interested parties affected by natural disasters play in implementing these programs?
- Who should pay (and how much should they pay) to mitigate damages from future natural disasters and the losses that occur following these events?
- How can the analyses detailed in this report help inform private sector decisions and the policy debate in state legislatures and the U.S. Congress?

Focus of the Study

To address these questions, we focus on four states (*Florida, New York, South Carolina and Texas*) and metropolitan areas in each of these states (*Miami-Dade area, FL; New York City area, NY; Charleston area, SC; Houston area, TX*). These regions have the largest property exposure to hurricane risk in the country and also present significant differences in insurance market regulation and public/private risk sharing systems.

Florida presents a specific challenge due to its hurricane exposure, increasing population and rapid economic development, all of which makes this state a world peak-zone for extreme event coverage and capital allocation. Recently, it has been a source of controversy because its state government has intervened in the functioning of the private insurance market more explicitly than any other state in the country. For these reasons, we devote special attention to Florida, both for the hurricane risk and flood hazard.

Key Findings

The report consists of fourteen chapters organized in four parts. We present both conceptual and empirical findings using data from several sources acknowledged at the end of the Executive Summary. The relevant analyses supporting these findings are documented in the chapters themselves.

PART I: CAUSE FOR CONCERN

The first four chapters of the report detail the factors that have led to a major increase in damage from natural disasters over the past fifteen years (Chapter 1); the current institutional arrangements, including the regulatory environment and characteristics of the market for insuring and mitigating risks from hurricanes (Chapters 2 and 3); and an analysis of the National Flood Insurance Program (Chapter 4). The key findings are summarized below.

1. There has been a major increase in the cost of great natural catastrophes worldwide over the past fifteen years. A comparison of these economic losses (insured and non-insured) over time reveals a huge increase: \$53.6 billion (1950-59), \$93.3 billion (1960-69), \$161.7 billion (1970-79), \$262.9 billion (1980-89) and \$778.3 billion (1990-99). The current decade has already seen \$420.6 billion in losses, principally due to the 2004 and 2005 hurricane seasons, which produced historic records.

2. Property values at risk in hazard-prone areas in the U.S. have drastically increased in recent years. The key socio-economic factors causing the increased losses are the *development in hazard-prone areas* and *increased value at risk*. For example, the population of Florida was 2.8 million in 1950, 13 million in 1990 and is projected to grow to 19.3 million in 2010. Today, 80 percent of insured assets in Florida are located near the coast, the high-risk area of the state. The insured exposure in Florida coastal areas was \$1.9 trillion in 2004 and is growing, increasing the likelihood of severe economic and insured losses from future hurricanes unless cost-effective mitigation measures are implemented. Other coastal states also have large property values exposed to flood and hurricane risks. Today, over 50 percent of the U.S. population lives in coastal counties.

3. The impact of climate change is not clear, but is of growing concern. Some scientists have suggested that the series of major hurricanes that occurred in 2004 and 2005 might be partially attributable to the impact of a change in climate. There is a growing concern that global warming might lead to the occurrence of much more intense hurricanes hitting the coast over a shorter period of time.

4. Natural disasters involve a large number of key interested parties who often have different agendas and priorities. These stakeholders include homeowners in hazard-prone areas, insurers and reinsurers, banks and other financial institutions, the capital markets, risk modeling firms, rating agencies, the construction industry and developers, the real estate community, other businesses, and local, state and federal governmental agencies. For each of these stakeholders it is necessary to consider how their values and goals shape their agendas for assessing and managing these risks.

5. Insurance market regulation varies significantly across states. Differences in market regulation across states constitute a challenge for the development of a coherent national strategy. Florida has significantly tightened its grip on insurers' rates and other market practices in response to heavy political pressure from coastal property owners and other interest groups. Regulatory responses in other coastal states have been less restrictive, but that could change depending on market developments and political pressure.

6. A wind/water controversy emerged in the aftermath of Hurricane Katrina, creating further uncertainty related to the issues of insurer liability. Coverage for flood damage due to rising water is explicitly excluded in homeowners insurance policies, but coverage for these losses is available through the federal government's National Flood Insurance Program (NFIP). Nevertheless, following Hurricane Katrina, lawsuits were filed in Louisiana and Mississippi for damage alleged by insureds to have been caused by wind, and alleged by insurers to have been caused by water. Although insurers eventually won these cases, some companies have been reluctant to write new homeowners policies in these states, given the uncertainty of contract enforcement.

7. There has been significant growth in residual market mechanisms that provide coverage to property owners who are not able to obtain insurance from private insurers. Florida's property insurance residual market mechanism, the Citizens Property Insurance Corporation (Citizens), has experienced significant growth in recent years, with legislative changes in 2007 allowing Citizens to compete with private insurers. Citizens has now become the largest provider of wind coverage in Florida. By law, it can pass virtually all its deficit to private insurers in the state through *ex post* assessments, which has caused some private insurers to leave the Florida market. The growth of Citizens is effectively socializing a large portion of the catastrophe risk in the state. Residual market mechanisms in the other coastal states we studied have also grown, but to a much lesser degree than in Florida.

8. Insurers' cumulative total profits in Florida from 1992-2006 have been *negative* during the entire period. While the market price of homeowners insurance has significantly increased in coastal areas (especially in Florida), insurers are still concerned about earnings volatility and the possibility that their long-term profits will be negative in high-risk areas. Florida has experienced the greatest absolute increase in the average homeowners premium among the four states studied, from \$723 at the start of 2002, to \$1,465 in the first quarter of 2007. In coastal areas, premiums have tripled or even quadrupled for some homeowners. Nevertheless, at the end of 2006, insurers had a \$11.6 billion cumulative deficit on their Florida's homeowners business based on the period 1992-2006. Higher insurance premiums, coupled with no hurricane losses in 2007 in Florida, have improved insurers' long-term performance but companies are still extremely concerned about the future of their operation in this state.

9. Flood coverage, which is provided exclusively by the federal government through the National Flood Insurance Program (NFIP), has significantly increased over the past fifteen years. The number of flood insurance policies covered nationwide by this program increased from 2.5 million in 1992 to over 5.6 million at the end of 2007. The total property value covered by the program during this period increased from \$237 billion to over \$1.1 trillion.

10. Choice of flood insurance deductibles, coverage limits and cost per dollar of coverage have changed over time. Florida alone represents nearly 40 percent of the entire NFIP portfolio, so we focus our analysis on that state. Floridians reacted to flood damage caused by the 2004 hurricanes by choosing lower deductibles and higher coverage limits. Our analysis of several million flood insurance policies reveals that in 2005, almost 80 percent of policyholders chose the lowest possible deductible (\$500). Even though homeowners increased their insurance coverage between 2000 and 2005, almost three-quarters were still below the \$250,000 maximum coverage limit. One reason for this large percentage is that many homes had property values below this limit. On the cost side, the average premium per policy in Florida is among the lowest in the nation. Despite several major flooding episodes in 2004 in Florida, the premium paid per \$1,000 of coverage significantly decreased in all but two counties between 2000 and 2005.

11. Thirty percent of each dollar paid for flood insurance coverage goes to private insurers participating in the NFIP Write-Your-Own (WYO) program. These insurers play the role of financial intermediaries between policyholders and the NFIP but do not bear any of the risk. Over the period 1968-2005, these private insurers received over \$7.4 billion (excluding the loss adjustment expenses for which we do not have data) in fees. Turning to the financial operation of the program, prior to the 2005 hurricane season, which inflicted nearly \$18 billion in flood claims, the NFIP had a cumulative deficit of about \$3 billion after 37 years of operation.

PART II: UNDERSTANDING THE DEMAND AND SUPPLY OF DISASTER INSURANCE

Part II of the report looks at how homeowners make decisions on whether to purchase insurance (Chapter 5); and how insurers/reinsurers decide on the amount of coverage to offer and what price to charge for this protection (Chapters 6 and 7). New developments with respect to alternative risk transfer instruments involving the capital and financial markets are also analyzed (Chapter 8). The last two chapters of Part II provide conceptual and detailed empirical analyses of the factors influencing the demand for and supply of homeowners insurance coverage (Chapters 9 and 10). The key findings are summarized below.

12. Empirical evidence reveals that most individuals do not use cost-benefit analysis in their insurance purchase decisions. Some people correctly understand risk and have adequate insurance coverage, but others do not. A key factor that explains these homeowners' decisions not to purchase insurance or to buy inadequate levels of coverage is *underestimation of the risk*. In fact, some homeowners in hazard-prone areas believe that the disaster will **not** happen to them. Some families also face budget constraints which limit their interest and/or ability to voluntarily purchase adequate insurance to cover replacement costs should they suffer a major loss. This behavior is especially likely in areas where property values have increased rapidly.

13. Homeowners' decisions related to the purchase of insurance are driven by a variety of goals other than only financial protection. These may include reduction of anxiety (i.e., obtaining peace of mind), satisfying mortgage requirements, and satisfying social norms (e.g., purchasing insurance because one's friends and neighbors have coverage).

14. The number of Presidential disaster declarations has dramatically increased over the past 50 years with notable spikes during election years. There were 162 Presidential disaster declarations during the period 1955-1965 and 545 declarations between 1996-2005. Despite this upward trend, there is no empirical evidence that individuals are uninsured or underinsured because they expect to receive federal disaster relief following a disaster.

15. Insurers are likely to charge higher premiums if there is ambiguity associated with estimating the likelihood and consequences of a risk. A recent survey of actuaries and underwriters by the Wharton Risk Center revealed that insurers would charge 25 percent higher premiums for ambiguous risks than for risks with probabilities that were well specified.

16. Due to the unpredictability and sizable losses associated with catastrophes, insurers need to allocate more capital to cover the losses in the tail of the probability distribution. The need to secure an adequate rate of return on capital is not sufficiently understood. In particular, the prices charged for catastrophe insurance must be high enough, not only to cover the expected claims and other expenses, but also to cover the costs of allocating capital to underwrite this risk. For truly extreme risks, the resulting premium can be as much as 5 to 10 times higher than the expected loss, so as to provide investors with a fair return on equity and also maintain the insurer's credit rating. Following the 2004-2005 hurricanes, rating agencies instituted more stringent criteria for providing protection against catastrophic risk. This led insurers to allocate even more capital to cover the tail of the loss distribution.

17. While catastrophes are often characterized as low-probability/high-consequence events, the data suggest that they are expected to occur with a much higher frequency than in the past. Catastrophe models and exceedance probability (EP) curves have been more used in recent years by insurers to estimate their risks from natural disasters and manage their portfolios. Working with the risk modeling firm Risk Management Solutions (RMS) we determined aggregate residential losses associated with a series of hurricane scenarios for our four focus states. Using Florida as an illustrative example, we specified an EP curve that revealed a 15 percent annual probability of an insured loss in the state of at least \$10 billion, and a 5 percent annual probability that insured losses will exceed \$25 billion.

18. Insurance premiums are affected by expected losses and the variance in losses, due to the cost of capital. We compared the potential insured losses from hurricanes within Miami-Dade County with 46 counties in the northern part of Florida. Taken together, these 46 counties have the same expected annual insured losses as Miami-Dade County; however, the standard deviation of losses for Miami-Dade is \$4.2 billion, and for the 46 northern counties it is \$2.8 billion. The cost of capital to cover losses should then lead to higher premiums in Miami-Dade County than in these portions of northern Florida if insurers had the freedom to charge premiums reflecting risk.

19. Reinsurers consider both the expected loss *and* the variance of losses in their portfolio when pricing different layers of coverage. An analysis of different layers of reinsurance for a constructed portfolio of all the homeowners policies in Florida reveals that the average annual loss decreases with higher layers (because they are less likely to occur), but the variance of the losses increases. This leads to a higher price per dollar of coverage for the higher layers, which are normally associated with truly catastrophic losses.

20. Due to the severe hurricanes in 2004 and 2005, the United States reinsurance market hardened in 2006. Premiums rose on average 76 percent between July 1, 2005 and June 30, 2006 but have fallen somewhat since that time. The large increase in premiums attracted eight new major entrants into the market and \$26-\$27 billion of new capital during the period between Hurricane Katrina and June 30, 2006. Between July 1, 2006 and June 30, 2007, prices fell slightly and continued to fall at the January 2008 renewal. They are currently still considerably higher than they were at the beginning of 2005.

21. The significant increase in reinsurance prices after the 2005 hurricane season in the U.S., along with more stringent criteria by rating agencies for providing protection against catastrophic risk, has led to historic records in catastrophe bond issuance and the development of a multi-billion dollar market for other innovative financial instruments, such as industry loss warranties and sidecars. We provide up-to-date information on the evolution of this market. In 2006, twenty cat bonds were issued for \$4.7 billion, compared with eleven issued in 2005, the previous record. In 2007 the total value of cat bonds issued for natural disasters alone was \$7.1 billion. In 2006, a total of nineteen sidecar transactions were completed, providing over \$4 billion of capacity to the insurance market; that volume decreased to \$1.7 billion in 2007.

22. There is a need to expand catastrophe risk securitization, as it still represents a small proportion of the capital in the global insurance market today. We propose three complementary ways that could effectively trigger a much more significant volume of capital entering the insurance-linked securities (ILS) market: (1) increasing the interest of a broader base of investors through risk tranching; (2) addressing the basis risk challenge through index-based derivatives; and (3) developing new products such as those based on equity volatility dispersion.

23. An analysis of the demand for homeowners insurance policies in the four states studied reveals that a given increase in the price of insurance results in a similar percentage decrease in the amount of insurance purchased. Our analysis of several million policies, including the portfolios of several large insurers and the state of Florida insurer, Citizens Property Insurance Company (Citizens) over the period 2000-2005, reveals that a 10 percent increase in the average premium in Florida yields an 8.9 percent reduction in the number of people buying insurance. Similar behavior occurs in other states.

24. The elasticity of supply at the county level is very high. A 10 percent increase (decrease) in price that homeowners are willing to pay for insurance coverage will yield a 27 percent increase (decrease) in the quantity of policies supplied by insurers. This high supply price elasticity has the following important implication for rate regulation: if rates are significantly suppressed by the regulator, there would likely be a severe availability issue.

25. Using portfolio data provided by six large insurers, we find that homeowners insurance premiums are highest in Florida relative to New York, South Carolina and Texas. The mean policy premium for our sample companies is \$6,160 for Florida, approximately \$5,000 for South Carolina, \$2,375 in Texas, and only \$760 in New York. If we examine the premiums per \$1,000 of coverage, we see that Florida is the highest at \$8.13 per \$1,000 of coverage, followed by Texas at \$7.89, then South Carolina at \$5.14, and New York at \$3.94.

26. Many people choose low deductibles on their homeowners policy. Consistent with the literature and our analysis of the flood insurance market, a large percentage of the homeowners insurance policies in our sample have relatively low deductibles. In Florida and South Carolina, over 50 percent of the homeowners have a deductible of \$500 or less. In New York, 75 percent of homeowners have a deductible of \$500 or less.

Concluding Note on Part II: Taken together, these findings reveal that most homeowners do not undertake cost-benefit comparisons in making their insurance purchases. They often choose low deductibles, are influenced by budget constraints and are likely to underestimate the risk. The analysis also quantifies the degree to which the demand for insurance is sensitive to price. In the four states studied, a given percentage increase in the price of homeowners insurance results in a similar percentage decrease in the amount of insurance purchased.

In addition to looking at expected losses, insurers and reinsurers are forced to allocate considerable capital to protect themselves against catastrophic losses to satisfy investors' and rating agencies' concerns. There has been a significant increase in the use of alternative risk transfer instruments (e.g. catastrophe bonds) since 2005 to complement reinsurance, but these financial instruments still represent a small fraction of capital in the global insurance market. The analysis of the supply of coverage indicates that if regulators suppress rates too much, there is likely to be a severe decrease in the availability of coverage.

PART III: PROTECTING HOMEOWNERS AGAINST NATURAL DISASTERS

We begin this part by examining what proportion of homeowners in hurricane-prone areas is uninsured, and whether affordability is a significant determinant of insurance status for homeowners residing in these areas (Chapter 11). We then provide insight into how residents in hazard-prone areas decide whether to mitigate their property, and the economic incentives that have been provided for encouraging them to do so (Chapter 12). We also examine how the insurance programs currently in place impact those affected by the hurricane risk (*status quo analysis*). We then determine how much coverage is likely to be made available and what premiums would be charged in a hypothetical unregulated market where rates are determined only by the law of supply and demand (*competitive market analysis*) (Chapter 13). The key findings in Part III are summarized below.

27. American Housing Survey data reveal that for different definitions of the affordability threshold, a significant number of owner-occupied homes in eight sample cities are owned and insured by households with income below those thresholds. There is often confusion in the policy debate about *affordability* of insurance because there is no clear definition of the term. If one defines an affordability threshold as 200 percent of the poverty line, then between 16 percent (Dallas) and 31 percent (Tampa) of residences are owned by households who cannot afford insurance. If affordability is defined as 125 percent of the poverty line, the percentage varies from nearly 7 percent in Dallas to 17 percent in Tampa. Among these low-income households, between 66 and 92 percent (depending on the city) *are* insured, even when there is no mortgage that requires them to purchase coverage. These results have important policy implications: any plan that directs insurance subsidies to all low-income homeowners will allocate a large proportion of these funds to those who are already insured.

28. While affordability measurements based on ability to consume and on household choices capture static notions of affordability, one also needs to consider the fairness in changes in homeowners insurance premiums over time. In particular, if changes in premiums are distributed very unevenly across households, one could view those subject to very large increases as not being treated fairly and justly. While our analysis reveals that raising premiums to reflect risk would lead to only a very small increase in the number of homeowners classified as *unable* to afford insurance, if some homeowners see their premiums jump by thousands of dollars in a given year, while others see modest changes, a case could be made that one subgroup is being singled out for unfair premium increases. There is a need for innovative programs to address this inequity.

29. The adoption of building codes significantly reduces damage from hurricanes. Based on a sample of over 5,600 homeowners impacted by Hurricane Charley in 2004, residences built under wind-resistant standards that were enforced in 1996 had a claim frequency of 60 percent less than those that were built pre-1996. Furthermore, claims for pre-1996 damaged homes resulted in an average of \$24 per square foot compared to \$14 per square foot for those constructed between 1996 and 2004.

30. Despite the cost-effectiveness of mitigation measures, many homeowners do not voluntarily invest in them. In contrast to insurance, where premiums cover a six month or annual period, mitigation measures (e.g., strengthening the roof of one's house) require a large upfront expenditure which yields benefits over the length of the life of the property. The principal reasons that homeowners do not invest in such measures are that they do not consider the long-term benefits of their investment, underestimate the risk due to excessive optimism, and do not learn sufficiently from past experience. On the other hand, social norms can lead individuals to take steps to reduce future disaster losses. If all homeowners in your hurricane-prone neighborhood installed strong storm shutters, then you would very likely want to follow suit.

31. It is possible to significantly increase use of mitigation measures by enforcing building codes, developing economic incentive programs such as tax rebates, and by adopting zoning ordinances. Collaboration between the public and private sectors is critical in this regard. For instance, tax credits can be given to property owners who purchase building supplies used to make their homes more storm resistant. Mitigation grants are available to low-income families for retrofitting their homes, and matching grants (on a dollar-for-dollar basis) can be made available to all homeowners in the state, as authorized in the South Carolina's Omnibus Coastal Property Insurance Reform Act of 2007.

32. The proportion of losses covered by private insurers for a 100-year hurricane under current insurance programs in place (*status quo*) differs widely among the four states studied. Using a hurricane with a return period of 100 years as our base case, we find that should this event occur in South Carolina, private insurers would cover 80 percent of the loss, compared to about 70 percent in New York and 50 percent in Texas. In Florida, private insurers would cover 25 percent of the loss, and the state-operated insurer, Citizens, 10 percent. Private reinsurance covers less than 10 percent of the losses in New York and South Carolina and over 17 percent of the loss in Texas. In Florida, private reinsurance would cover 20 percent of the losses and the Florida Hurricane Catastrophe Fund over 30 percent. The actual dollar amounts of loss to residential properties from a 100-year hurricane are much lower in South Carolina and New York than in Texas and Florida. We provide similar loss-sharing analyses for 250-year and 500-year hurricanes for each state.

33. If a hurricane with a return period of 100 years were to occur in 2008, the deficits to the Florida Hurricane Catastrophe Fund (FHCF), Citizens Property Insurance Corporation (Citizens) and the Texas Windstorm Insurance Association (TWIA) would be \$21.2 billion, \$5.7 billion and \$3.6 billion, respectively. Both Citizens and the FHCF would assess private insurers operating in Florida to recoup the necessary funds for the claims they could **not** meet from their reserves. Should this occur, all residential and commercial policyholders in the state will pay a significant portion of these losses through *ex post* recoupment. An open question is whether these policyholders realize the extent of this *ex post* payment.

34. Mitigation has the potential to provide significant cost savings in all four states. In our analysis of the effect of mitigation, we consider two extreme cases – one in which no one has invested in mitigation, the other in which everyone has invested in predefined mitigation measures. For a 100-year hurricane, mitigation would reduce the potential losses by 61 percent in Florida, 44 percent in South Carolina, 39 percent in New York, and 34 percent in Texas. In Florida, the use of mitigation leads to a \$51 billion savings for a 100-year event, and a \$83 billion savings for a 500-year event. Should a 500-year event occur tomorrow, full mitigation would save the Miami-Dade area \$58 billion and the Houston area \$34 billion. These findings are important given the costly capital required for insurers to cover the tail of the distribution of extreme events. Enforcing mitigation significantly reduces, if not eliminates, this tail.

35. Under a scenario where insurers are permitted to charge premiums reflecting risk, the private sector will be able to cover most (if not all) losses from severe hurricanes if homeowners mitigate their property and private reinsurance is in place. In this case, if insurers were to devote 10 percent of their surplus to provide coverage against a 100-year hurricane in a given state, they would be able to cover 100 percent of the market in all four states. For a 500-year event, they would be able to cover 100 percent of the market in New York and South Carolina, 94 percent of the market in Texas, and 66 percent in Florida.

36. Except for Florida, which constitutes a peak-zone for catastrophe exposure, insurers would need to allocate only a small portion of their surplus to provide full coverage under a competitive market if adequate mitigation and private reinsurance were in place. If all single-family dwellings in the state were mitigated, and if private reinsurance and alternative risk transfer mechanisms were in place, based on the *status quo*, the percentage of insurers' surplus necessary to insure all homes against a 100-year hurricane is 1.1 percent in South Carolina, 1.4 percent in New York, 6.7 percent in Texas, and 15.4 percent in Florida.

37. If one determines premiums based on loss costs and adds a 50 percent loading factor to reflect additional expenses (administrative, marketing and claim assessment costs, and cost of capital), coastal communities, which have the highest risk of wind damage from hurricanes in each of the four states we study, will pay significantly more for insurance than other regions in these states. This is particularly true in Texas, where Calhoun, Aransas and Galveston Counties would be charged over nine times the average for the entire state. The ratios for the most hazard-prone counties in each of the other three states are on the order of four to five times the average premium across the state.

Concluding Note on Part III: These findings reveal that in the cities we studied, most people purchase insurance even if they are classified as having income below the affordability threshold. At the same time, most individuals do not mitigate their homes because they cannot justify the upfront investment cost relative to the perceived benefits due principally to myopia, budget constraints and underestimation of the risk. Hence, there is the need for well-enforced building codes, tax rebates, zoning ordinances, and premiums reflecting risk that take the benefits of mitigation into account. If a major hurricane hits Florida in the near future, the state-run insurer, Citizens, will not be able to cover its losses, and all policyholders in the state will be assessed money to help defray its deficit. If insurers are allowed to charge premiums that reflect risk, they will be able to cover most, if not all, of the losses from hurricanes. Prices in some hazard-prone areas will be significantly higher than they are today.

PART IV: CREATING INNOVATIVE SOLUTIONS

The report concludes with proposed strategies to encourage individuals to purchase sufficient insurance and adopt mitigation measures (Chapter 14). This chapter also summarizes two disaster insurance bills which passed the U.S. House of Representatives in the fall of 2007 and are now pending in the U.S. Senate. We pose a set of questions for informing the policy debate with respect to this legislation. Key findings are summarized below.

38. Two principles should guide the development of new disaster insurance programs.

Principle 1: Premiums Reflecting Risk are necessary to provide signals to individuals as to the hazards they face and encourage them to adopt cost-effective mitigation measures. *Principle 2: Dealing with Equity and Affordability Issues* addresses ways to provide special treatment to homeowners currently residing in hazard-prone areas (e.g. low-income uninsured or inadequately insured homeowners).

39. Long-term homeowners insurance would stabilize insurance costs to homeowners in hazard-prone areas. Such a long-term policy could be tied to a mortgage, and home improvement loans can encourage the adoption of cost-effective mitigation measures. A program of insurance vouchers, similar in concept to food stamps, could assist low-income residents in disaster-prone areas to purchase adequate insurance coverage.

40. Several specific insurance-related proposals have been initiated that involve the private and public sectors.

- ***A Coastal Hurricane Zone (CHZ)*** has been proposed with regulations established by the federal government and consistent across states within the CHZ. After several years of operation, any surplus would be redistributed to homeowners, and deficits met through surcharges. Such a system would allow insurers to make long-term commitments of capital to provide coverage against wind damage from hurricanes.
- ***A national catastrophe fund*** has been proposed as a financial backstop for state catastrophe funds and augment private reinsurance.
- ***Auctioned reinsurance contracts*** could be developed by the federal government to cover truly cataclysmic events.
- ***Alternative risk transfer instruments*** offered by the financial market to cover catastrophic losses could be expanded through innovative products, making this market much more liquid than it is today.

41. A data collection and information sharing entity could be created to inform decision makers in the public and private sectors as to the extent of insurance penetration. The United States does not have a national system in place to ascertain demographically who has purchased insurance coverage and how much, and who is uninsured. We propose the creation of a national insurance data collection system to better understand the level of homeowners coverage against future disasters. This system could be implemented at a very small cost via the Internal Revenue Service (IRS), with homeowners answering a few questions about their property insurance coverage on their annual IRS tax returns.

Acknowledgments

This has been a truly collaborative effort with our research partners from Georgia State University, who performed a thorough analysis of the current state insurance regulatory systems and changes occurring over time. They also aggregated the data on homeowners insurance provided by some of our Sponsors, and performed detailed analyses of the demand and supply of insurance coverage under current programs. The Insurance Information Institute provided us with data on the vulnerability of hazard-prone areas and post-Hurricane Katrina legislative and legal actions.

The research team greatly appreciates the detailed data provided by leading insurers on their homeowners policies, data from the offices of state insurance regulators, the analyses undertaken by Risk Management Solutions on potential and expected losses from hurricanes, and the special computer runs on insurance groups' premiums and catastrophe exposure undertaken by the rating agency A.M. Best. The state funds in Florida (Citizens Property Insurance Corporation, and the Florida Hurricane Catastrophe Fund) and in Texas (the Texas Windstorm Insurance Association) also provided us with detailed information on their coverage and the nature of their operations. The Institute for Business & Home Safety provided us with data on the impact of mitigation measures and building code enforcement on the reduction in hurricane losses. The data from all these firms and organizations enabled us to undertake comprehensive quantitative analyses of supply of and demand for insurance, and to measure the performance of current and proposed insurance and mitigation programs. In addition, the Federal Emergency Management Agency (FEMA) provided the research team with access to the entire portfolio of the National Flood Insurance Program in the state of Florida so we could examine the performance of this program and the nature of coverage in place at a micro-level.

To our knowledge, this is the first time that these types of data have been collected simultaneously for several consecutive years, analyzed and interpreted in the context of existing state insurance regulatory systems and the structure of the property insurance market in the United States.

During the past two years, the research team has had fruitful meetings and discussions with key individuals and organizations interested in developing better risk management strategies for dealing with natural hazards. These include climate scientists, insurers, reinsurers, brokers, banks, trade associations, rating agencies, modeling firms, homeowners and businesses affected by natural disasters, the real estate industry, representatives from Congress and the White House, federal, state and local agencies, insurance regulators, public interest groups, international organizations, and experts from other universities and research institutions in the United States and abroad.

We have benefited from insightful discussions at workshops hosted by the Wharton Risk Center in June and December 2006 in Philadelphia, PA, and in October 2007 in Washington, DC, and from the many comments received on the preliminary findings issued in February 2007, and the first draft of this report, issued in October 2007.

Carol Heller of the Wharton Risk Center has been actively involved in the project over the past eight months, providing research and editorial assistance. Cynthia Anderson, Hannah Chervitz, Carol Heller, and Nikita Stanley all provided logistical support for the meetings and conferences associated with this project over the past two years.

Moving Forward

Our principal purpose in undertaking these in-depth studies is to examine alternative *long-term* sustainable strategies for reducing losses from natural disasters and providing financial support to victims of these events.

We are mindful that new alternative strategies may be extremely difficult to implement at this time, because, except for the California wildfires in the fall of 2007, our country has not experienced any severe disasters during the past two years. There is a tendency for all of us, whether in the role of homeowner, decision maker in a private or public sector organization, or as an elected official at the state, local or federal level to focus on short-term crises. However, our nation remains highly vulnerable to large-scale disasters. For this reason, decisions by Congress and other legislative bodies must be based on a sound long-term conceptual framework and well-documented empirical analyses.

The Sponsors of this study, and the public and private sector organizations with whom we have interacted, are listed on the following page. We look forward to continue working with them and others on the challenges of *Managing Large-Scale Risks in a New Era of Catastrophes*.

Howard C. Kunreuther and Erwann O. Michel-Kerjan
The Wharton School
Philadelphia, PA
March 1, 2008

Project Sponsors (alphabetical order; starting year):

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For information on joining the Wharton Risk Center's *Managing and Financing Extreme Events* initiative as an organization or an individual, please contact Howard Kunreuther or Erwann Michel-Kerjan at Kunreuther@wharton.upenn.edu or ErwannMK@wharton.upenn.edu

This report also benefited from data and ongoing interaction with the following organizations:

A.M. Best
Citizens Property Insurance Corporation
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Florida Hurricane Catastrophe Fund (FHCF)
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National Association of Insurance Commissioners (NAIC)
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White House
World Economic Forum
Zurich NA

Direction of the study:

Howard C. Kunreuther, Erwann O. Michel-Kerjan



Howard Kunreuther is the Cecilia Yen Koo Professor of Decision Sciences and Public Policy at the Wharton School, and Co-Director, Risk Management and Decision Processes Center.

He has a long-standing interest in ways that society can better manage low-probability/high-consequence events related to technological and natural hazards and has published extensively on the topic. He is a member of the OECD's High Level Advisory Board on Financial Management of Large-Scale Catastrophes; a Fellow of the American Association for the Advancement of Science (AAAS); a member of the National Earthquake Hazards Reduction Program's Advisory Committee on Earthquake Hazards Reduction; Distinguished Fellow of the Society for Risk Analysis, receiving the Society's Distinguished Achievement Award in 2001.

Dr. Kunreuther has written and co-edited numerous books and papers, including *On Risk and Disaster: Lessons from Hurricane Katrina*, (with Ronald J. Daniels and Donald F. Kettl; 2006), *Catastrophe Modeling: A New Approach to Managing Risks* (with Patricia Grossi; 2005), and *Paying The Price: The State of Natural Disaster Insurance in the United States* (with John Roth, Sr.; 1998). He is the recipient of the Elizur Wright Award for the publication that makes the most significant contribution to the literature of insurance. He received his Ph.D. in Economics from the Massachusetts Institute of Technology.



Erwann Michel-Kerjan is Managing Director of the Wharton Risk Management and Decision Processes Center at the Wharton School, where he also teaches *Value Creation* in the Wharton MBA program.

His work focuses on developing strategies and policies for managing and financing extreme events, primarily natural disasters and mega-terrorism, optimal catastrophe risk sharing in public-private partnerships, climate change, the economics of national security, energy interdependence and non-proliferation. His work also includes projects on critical services protection in collaboration with the defense industry and federal agencies. He has consulted with companies, governments and international organizations, and he is a founding member of the High Level Advisory Board on Financial Management of Large-Scale Catastrophes recently established by the Secretary General of the OECD (30 richest countries).

He has studied at or collaborated with McGill, Columbia and Harvard, and joined Wharton in 2002 after he completed his doctoral studies in economics and mathematics at the Ecole Polytechnique in Paris (at age 26).

Dr. Michel-Kerjan has authored or co-authored more than 40 publications at the crux of financial management and global risk governance, and his views regularly appear in leading media. His first book, *Treatise on New Risks* (with O. Godard, C. Henry and P. Lagadec), was published by Gallimard in 2002. From 2003 to 2005 he served on the OECD Task Force on Terrorism Insurance which published *Terrorism Insurance in OECD Countries* in July 2005, and in 2005 he co-led, with Howard Kunreuther, the Wharton initiative *TRIA and Beyond* on the future of terrorism risk financing in the United States. His most recent book, *Seeds of Disaster, Roots of Response: How Private Action Can Reduce Public Vulnerability* (with P. Auerswald, L. Branscomb and T. LaPorte, Harvard/George Mason University), is the first attempt to analyze the private efficiency-public vulnerability tradeoff in the context of extreme event management (Cambridge University Press, 2006; www.SeedsofDisaster.com).

In 2007, Dr. Michel-Kerjan was named a Young Global Leader by the World Economic Forum (Davos), a five-year nomination bestowed to recognize and acknowledge the most extraordinary leaders of the world under the age of 40.

Other lead authors:

Neil Doherty, Robert Klein, Marty Grace, Mark Pauly



Neil Doherty is the Frederick H. Ecker professor of insurance and risk management and chair of the Department of Insurance and Risk Management at the Wharton School.

A principal area of interest is in corporate risk management focusing on the financial strategies for managing risks that traditionally have been insurable. Such strategies include the use of existing derivatives, the design of new financial products and the use of capital structure. Dr. Doherty has written three books in this area, including *Corporate Risk Management: A Financial Exposition*, 1985; *The Financial Theory of Insurance Pricing*, 1987 (with S. D’Arcy); and *Integrated Risk Management*, 2000. Dr. Doherty is also interested in the economics of risk and information and has written papers on adverse selection, the value of information, and the design of insurance contracts with imperfect information and related issues. These papers have appeared in the *Journal of Risk and Insurance*, *Journal of Political Economy*, *Quarterly Journal of Economics*, *Journal of Public Economics*, *Journal of Finance*, and *Journal of Risk and Uncertainty*, among others. He is the co-author of *Managerial Economics* (2003, with B. Allen and K. Weigelt).

In 2005, Dr. Doherty coauthored two reports on the insurance industry. The first, *The Economics of Insurance Intermediaries* provided an economic analysis of some of the issues raised by Elliot Spitzer’s investigation into broker compensation and bidding for insurance. The second, *TRIA and Beyond*, as part of the Wharton Risk Center’s Managing and Financing Extreme Events project, provided an economic analysis of terrorism insurance and the public policy option facing the government with the expiration of TRIA.



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Dr. Grace’s research has been published in various journals in economics and insurance concerning the economics and public policy aspects of insurance regulation and taxation, with a focus on industrial organization and econometrics. In particular, Dr. Grace has undertaken various studies of the efficiency of insurance firms, insurance taxation, optimal regulation of insurance in a federal system, and solvency regulation. His latest book is *Regulation, Pricing and Demand in Catastrophe Insurance Markets* (with Robert Klein, Paul Kleindorfer, and Michael R. Murray, 2003).

Dr. Grace is a former President of The Risk Theory Society and he is a current associate editor of the *Journal of Risk and Insurance*. He earned both a Ph.D. in economics and a J.D. from the University of Florida in 1987.



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He has written numerous articles, books and monographs on various topics in insurance and its regulation, including the structure and performance of insurance markets, insurance regulation and public policy, and the political economy of risk and insurance. His research has encompassed many areas of insurance and its regulation, including catastrophe risk and associated issues for insurance markets and public policy. Dr. Klein also has testified frequently at legislative and regulatory hearings on significant issues affecting insurance consumers and the industry.

Prior to joining Georgia State University in September 1996, Dr. Klein was the Director of Research and Chief Economist for the National Association of Insurance Commissioners. He also has served as staff economist for the insurance department and state legislature in Michigan. He has a B.A. (1976), M.A. (1982) and Ph.D. (1986) in economics from Michigan State University. Dr. Klein is a Sloan Fellow at the Financial Institutions Center at the Wharton School of Business. He has served on the Board of Directors for the American Risk and Insurance Association and currently serves on the editorial boards for the *Journal of Insurance Regulation and Risk Management and Insurance Review*.



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Dr. Pauly is a former commissioner on the Physician Payment Review Commission and an active member of the Institute of Medicine. One of the nation's leading health economists, Dr. Pauly has made significant contributions to the fields of medical economics and health insurance. His classic study on the economics of moral hazard was the first to point out how health insurance coverage may affect patients' use of medical services. Subsequent work, both theoretical and empirical, has explored the impact of conventional insurance coverage on preventive care, on outpatient care, and on prescription drug use in managed care.

Dr. Pauly is a co-editor-in-chief of the *International Journal of Health Care Finance and Economics* and an associate editor of the *Journal of Risk and Uncertainty*. He has served on Institute of Medicine panels on public accountability for health insurers under Medicare, and on improving the financing of vaccines. Dr. Pauly is a former member of the advisory committee to the Agency for Health Care Research and Quality, and most recently a member of the Medicare Technical Advisory Panel.

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Dr. Hartwig previously served as director of economic research and senior economist with the National Council on Compensation Insurance (NCCI) in Boca Raton, Florida, where he performed rate of return and cost of capital modeling and testified at workers' compensation rate hearings in many states. He has also worked as senior economist for the Swiss Reinsurance Group in New York and as senior statistician for the United States Consumer Product Safety Commission in Washington, DC. In 2005 and 2006 Dr. Hartwig served on the state of Florida's Task Force for Long-Term Homeowners Insurance Solutions.

Dr. Hartwig received his Ph.D. and M.S. degrees in economics from the University of Illinois at Urbana-Champaign. He received a B.A. in economics cum laude from the University of Massachusetts at Amherst and he also holds the Chartered Property Casualty Underwriter (CPCU) credential.



Paul Kleindorfer is the Anheuser Busch Professor of Management Science (Emeritus) at the Wharton School of the University of Pennsylvania and Distinguished Research Professor at INSEAD, France. Dr. Kleindorfer has held university appointments at Carnegie Mellon University, Massachusetts Institute of Technology, the Wharton School, and several and international research institutes. Until 2005, he was the co-director of the Wharton Risk Management and Decision Processes Center, which he co-founded in 1984 with Howard Kunreuther.

A world leading expert in global supply chain security, Dr. Kleindorfer's current research is focused on risk management, with emphasis on environmental management and on natural hazards and security risks. His most recent books include *Liberalization of the Postal and Delivery Sector* (with M. Crew, 2007), *Pricing and Demand in Catastrophe Insurance Markets*, (with M. Grace and M. Murray, 2003), and *Decision Sciences: An Integrative Perspective* (with H. Kunreuther and P. Schoemaker, 1993). He has consulted with companies and governmental agencies worldwide on risk management and restructuring in such sectors as postal service, chemical manufacturing and energy.

Dr. Kleindorfer holds several editorial and professional positions, including being current president of the Society for Economic Design. He graduated with distinction from the U.S. Naval Academy in 1961. He studied on a Fulbright Fellowship in Mathematics at the University of Tübingen, Germany (1964/65), followed by doctoral studies in the Graduate School of Industrial Administration at Carnegie Mellon University (Ph.D., 1970).



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In 1998, President William J. Clinton nominated and the Senate confirmed Dr. Rosenthal to serve a five-year term on the U.S. Chemical Safety and Hazards Investigation Board. From 2005 to 2007, Dr. Rosenthal served on the British Petroleum investigation 11-member panel chaired by former Secretary of State James A. Baker, III.

Dr. Rosenthal currently serves on the advisory committee of the USW Tony Mazzocchi Health and Safety Center and the OSHA Reactive Alliance. He previously served as the official U.S. industry delegate to the ILO Convention that developed the Guidelines for the Prevention of Major Industrial Accidents. Dr. Rosenthal has been a member of numerous committees, including the OSHA Reform committee of the American Industrial Hygiene Association (AIHA), the Technical Advisory Committee of the Environmental Management Division of the Los Alamos National Laboratory, the OECD Risk Terminology Project Steering Group, and the EPA Accident Prevention Subcommittee of the Clean Air Act Advisory Committee.

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Ms. Wilkinson joined the I.I.I. in 2003, after more than 10 years as a journalist reporting on international insurance issues and trends. Ms. Wilkinson previously served as U.S. bureau chief for the U.K.-based trade newspaper *Insurance Day*. Prior to her assignment to New York, she was deputy editor of *Insurance Day* in London. She also worked as a reporter for the *Financial Times* newsletter and contributed articles to insurance industry surveys published in the *Financial Times* newspaper.

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