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HAS THE TIME COME FOR COMPREHENSIVE NATURAL DISASTER INSURANCE?

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ABSTRACT

This paper examines the role that insurance coupled with mitigation can play in reducing losses from future natural disasters while at the same time providing funds for recovery. After examining the decision processes of three interested parties who will be at the centerpiece of such a program, *residents in hazard-prone areas, insurers/reinsurers and the government*, I provide a rationale for comprehensive disaster insurance as an integral part of a hazard management program. To reduce future losses there is a need for creative private-public partnerships through economic incentives and well-enforced regulations and standards (e.g. building codes). It is also important to consider whether insurance coverage should be voluntary or mandatory, what types of special arrangements should be given to low income families in high hazard areas and whether government should have a role in providing protection against losses from mega-catastrophes.

1. Introduction

Hurricane Katrina has raised a number of questions regarding the role that insurance can or should play in providing protection against natural disasters. Preliminary estimates suggest that it will be the most costly disaster in the history of the insurance industry with total claims ranging between $40 and $55 billion (Towers Perrin 2005). The previous year's Hurricanes Charley, Frances, Ivan and Jeanne that hit Florida in the fall of 2004 produced a combined total loss of $24 billion. Each of these disasters was among the top 10 most costly insurance losses in the world from 1970-2004. (Wharton Risk Center 2005, Chapter 3). As a result of these losses, some insurers are reexamining the role they can and should play in providing financial protection against losses from mega catastrophes from natural disasters.

Victims from Katrina have been complaining about receiving substantially less than the actual cost of repairing or rebuilding their damaged or destroyed residence. A standard homeowners policy, normally required as a condition for a mortgage, provides protection against damage from fire, hail, winter storms, tornadoes and wind damage, but not from rising water due to floods and hurricanes.[2] Many homeowners suffering rising water damage did not have flood insurance even though they were eligible to purchase such a policy through the National Flood Insurance Program (NFIP), a public program administrated by the Federal Emergency Management Agency (FEMA) that was established in 1968.[3] In the Louisiana parishes affected by Katrina the percentage of

[2] A homeowners policy does cover some water damage if it is caused by the wind such as from wind driven rain or from the wind creating a hole in the roof or breaking a window.
[3] For more details, see Pasterick, (1998). See also http://www.fema.gov/nfip.

homeowners with flood insurance ranged from 57.7 percent in St. Bernard's to 7.3 percent in Tangipahoa. Only 40 percent of the residents in Orleans parish had flood insurance (Insurance Information Institute 2005).

The federal government is committed to providing liberal disaster assistance to aid the victims of Katrina and rebuild the Gulf Coast. A few days after Katrina hit landfall, the US Senate voted nearly $60 billion in federal aid. Under the Federal Emergency Management Agency (FEMA) Individual and Households Program, an eligible household may receive up to $26,200 in grants for disaster-damaged property.[4] In addition, the Small Business Administration (SBA) offers loans of up to $200,000 to eligible homeowners for repairs to damaged primary residences and loans of up to $1.5 million for damage to business property, machinery and inventory.[5]

Following a cataclysmic disaster such as Katrina, there is considerable interest by the media and key interested parties in taking steps to reduce the consequences of another such event and to examine alternative ways of spreading the losses should such a disaster occur. However, unless one takes action in the near future to address these problems, it is likely that the next crisis will push this issue off the legislative agenda.

This paper complements others in this volume by examining the role that insurance can play in combination with other strategies for encouraging loss reduction and for aiding the recovery process following natural disasters. In a book on the topic written eight years ago, as part of a National Science Foundation funded grant

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[4] More detail on these federal commitments can be found at http://www.oes.ca.gov/Operational/OESHome.nsf/PDF/Katrina%20PDFs/$file/TransHousProg10-4.pdf

[5] The annual interest rate on the home loans is either 2.687% or 4%, respectively depending on whether the victim does not or does have credit available elsewhere. For SBA business loans, the interest rates for those without and with credit are 4% and 6.557% respectively. Either business or home loans can be for a maximum of 30 years. For more information on the SBA disaster loan program go to www.sba.gov/disaster

spearheaded by Dennis Mileti on assessing the damage from natural disasters, we noted the following:

> Our position is that the economic costs of natural disasters to the nation are too high and are likely to soar in the future unless some steps are taken to change recent trends. Insurers can address these problems in a constructive manner *only* through joint efforts with other stakeholders, and through the use of strategies that combine insurance with monetary incentives, fines, tax credits, well-enforced building codes, and land-use regulations. For example, one way to reduce future losses is to utilize insurance with well-enforced building codes and land-use regulations to successfully reduce losses. (Kunreuther and Roth, Sr. 1998 p.4)

The time appears ripe for formulating a comprehensive disaster insurance program whereby all natural hazards are required to be part of a standard homeowner policy. Under such a program rates should be based on risk and residents in hazard-prone areas should be provided with economic incentives or required to undertake cost-effective mitigation measures.

The next section examines the decision processes of three interested parties who would be at the centerpiece of such a hazard management program: residents in hazard-prone areas, insurers and reinsurers who sell financial protection prior to a disaster and the federal government who often provides victims with financial assistance following a catastrophic event such as Katrina. Section 3 suggests a rationale for comprehensive disaster insurance as an integral part of a hazard management program and discusses how it could be utilized in combination with other initiatives to achieve a set of desired objectives. After discussing the set of challenges in implementing such a program in Section 4, I outline the elements of a possible public-private partnership in the following section. Section 6 provides a summary and conclusions.

2. Decision Processes of Key Interested Parties

When a person at risk makes a decision on whether to buy insurance and an insurer determines whether to sell it, there are two basic components that economic theory suggests should be taken into account: the likelihood of a disaster and the resulting damage from such an event. These concepts can be illustrated with the following simplified example with respect to actions taken by a hypothetical homeowner and insurer concerned with the hurricane risk:

> ***Homeowner:*** The Lowe family has a house in New Orleans that it owns outright and wants to determine whether to purchase insurance to cover wind damage from a future hurricane. Utilizing historical records and the best available information from experts, it estimates the likelihood of such a disaster damaging its house next year to be 1 in 100.[6] Should a hurricane occur the wind damage will be $55,000. A homeowners insurance policy has a $5,000 deductible so that the Lowes will be responsible for covering the first $5,000 in damage and the insurer would pay for the remaining amount[7]. *How much is the Lowe family willing to pay for such coverage?*
>
> ***Insurer:*** The ABC insurance company wants to determine how much it should charge the Lowe family to cover damage to its house from wind damage, knowing that it will also be insuring a number of other homes in the New Orleans area. It uses the same data as the Lowe family collected and thus estimates the likelihood of such a disaster damaging its house next year to be 1 in 100 and the resulting

[6] For simplicity I am assuming that this is the only hurricane that will cause damage to the Lowes' house.
[7] I assume that the coverage limit on the insurance policy is high enough to cover the losses above the deductible.

wind damage to be $55,000. *How much should ABC charge for an insurance policy with a $5,000 deductible?*

To answer this question, the ABC company first determines that the expected annual claims payment to the Lowe family given the $5,000 deductible would be $500 [i.e. 1/100 ($55,000-$5,000)]. To cover its cost of capital, marketing and other administrative expenditures and still make a normal profit, ABC sets the premium at $750. The Lowe family makes a decision on whether to buy insurance from ABC by comparing the premium of $750 with the 1 in 100 chance of losing $50,000. If the Lowe family is sufficiently risk averse, being concerned with the impact of a loss of $55,000 on their ability to meet other normal expenditures, they should be willing to pay $750 to protect themselves against the possibility of a catastrophic loss. By parting with a relatively small amount of money, they avoid a low-probability high-consequence event.

Residents' Decisions Regarding Insurance[8]

Relevant Factors Variations on this hypothetical example are often used in textbooks to explain why it is rational for well-informed individuals and businesses to purchase insurance even though they are charged rates above their expected losses. In reality, most residents in hazard-prone areas have limited knowledge of the hazard. There is considerable evidence from field studies and controlled experiments that prior to a disaster individuals underestimate the chances of a catastrophic disaster occurring. In fact, many potential victims of disaster perceive the costs of getting information about the hazard and costs of protection to be so high relative to the expected benefits that they do not consider investing in loss reduction measures or purchasing insurance (Kunreuther and Pauly 2004).

[8] This subsection draws on material in Kunreuther (1996)

This reluctance to invest in protection voluntarily is compounded by *budget constraints*. For some homeowners with relatively low incomes, disaster insurance is considered a discretionary expense that should only be incurred if there are residual funds after taking care of what they consider the necessities of life. In focus groups on the topic, a typical reaction of such a homeowner living in a hazard-prone area to the question "Why don't you have flood or earthquake insurance?" is "I live from pay day to pay day".

Another factor that has been purported to limit homeowners from wanting to purchase insurance is the expectation of liberal disaster assistance following a catastrophic event. As discussed below, earlier studies on this issue suggest that individuals did **not** anticipate receiving any federal aid following a disaster. Given the media coverage of the disaster assistance promised to uninsured victims after Hurricane Katrina, the general public may revise their views as to whether the government will come to the rescue if they are unprotected.

The decision process for many residents in hazard prone areas appears to follow a sequential model of choice. As a first stage in such a process individuals relate their perceived probability of a disaster (p) to a threshold level of concern (p^*), which they may unconsciously set. If $p < p^*$ they do not even think about the consequences of such a disaster by assuming that the event "will not happen to me". In this case they do not take protective actions. Only if $p > p^*$ will the individual or family consider ways that they can reduce the risk of future financial losses.

The contingent weighting model proposed by Tversky, Sattath and Slovic (1988) provides a useful framework for characterizing individual choice processes with respect

to this lack of interest in purchasing insurance voluntarily. In this descriptive model, individuals make tradeoffs between the dimensions associated with alternatives, such as probability and outcomes. The weights they put on these dimensions are contingent, because they may vary depending on the problem context and the way information is presented.

The decision to ignore events where $p < p^*$ may be justified if a person claims that there is limited time available to worry about the vicissitudes of life. Hence s/he needs some way of determining whether to pay attention to some risks. For these individuals only after the occurrence of a disaster does this event assume sufficient salience that it is on their radar screen.

Empirical Evidence Data supporting such a sequential model of choice has been provided through homeowners surveys of insurance purchase decisions in flood, hurricane and earthquake-prone areas undertaken over 25 years ago (Kunreuther et.al. 1978). Data from more recent surveys of homeowners in California undertaken by Risa Palm and her colleagues lend further confirming evidence to such a process. Four mail surveys undertaken since 1989 examine the spatial and demographic characteristics of those homeowners who had purchased earthquake insurance. The findings indicate that insurance purchase is *unrelated* to any measure of seismic risk that is likely to be familiar to homeowners. Rather past experience plays a key role in insurance purchase decisions. (Palm 1990; Palm 1995).

To illustrate, consider the Loma Prieta earthquake of 1989, which caused substantial damage to property in Santa Clara County, and to a lesser extent, Contra Costa County, California. In these counties, there were major differences in responses to

the 1989 and 1990 survey. In 1989 prior to the earthquake, about 34 percent of the uninsured respondents in both counties felt that earthquake insurance was unnecessary. By 1990, only about 5 percent gave this response. This finding suggests that a disaster causes individuals to think about ways they can protect themselves from the next event and that insurance now becomes an attractive option.

There is also empirical evidence that many homeowners who purchase insurance are likely to cancel policies if they have not made a claim over the course of the next few years. (Kunreuther, Vetschera and Sanderson 1989) In the case of flood insurance this finding is particularly striking since the NFIP requires that homes located in Special Flood Hazard Areas purchase insurance as a condition for federally-backed mortgages. To determine the extent FEMA examined applications for disaster assistance from 1549 victims of a flood in August 1998 in Northern Vermont and found that 84 percent in special flood hazard areas did not have insurance, 45 percent of whom were required to have it. A study by Geotrac revealed that more than one-third of the properties damaged in a 1999 flood in Grand Forks, North Dakota were non-compliant with the mandatory insurance purchase requirement. (Tobin and Calfee 2005).[9] With respect to earthquake insurance, eight years after the creation of the California Earthquake Authority (CEA) in 1996 by the state of California, the take-up rate for coverage is down from 30 percent to 15 percent. (Risk Management Solutions 2004).

Insurance is thus likely to be treated by many individuals as an investment rather than a protective measure, so that those who purchased insurance and did not collect on their policies over the next few years feel that their premium payments have been wasted.

[9] With the passage of the 1994 National Flood Insurance Reform Act lenders who fail to enforce the flood insurance requirement can be fined up to $350. Prior to that time no penalties were imposed.

In the case of flood insurance, this finding also indicates that some banks, who were expected to enforce the requirement that individuals in high-hazard areas purchase flood coverage, looked the other way.

Insurers' Decisions Regarding Coverage[10]

Law of Large Numbers Based on economic theory insurers who supply coverage to those at risk are assumed to maximize expected profits. If the insurer is concerned about the variability of profits, the ideal risk is one where the potential loss from each insured individual is relatively small and independent of the losses from other policyholders. As the insurer increases the number of policies it issues in a year, the variance in its annual losses decreases. In other words, the *law of large numbers* makes it highly unlikely that the insurer will suffer an extremely large loss relative to the premiums collected.

Fire is an example of a risk that satisfies the law of large numbers since losses are normally independent of one another.[11] To illustrate its application, suppose that an insurer wants to determine the accuracy of the estimated fire loss for a group of identical homes valued at $100,000, each of which has a 1/1,000 annual chance of being completely destroyed by fire. If one assumes that only one fire can occur in any structure during the year, the expected annual loss for each home would be $100 (i.e. 1/1000 x $100,000). As the number of fire insurance policies n increases, then the variance of the expected annual loss or mean decreases in proportion to n. As a general rule, it is not necessary to issue a large number of insurance policies to reduce the variability of expected annual losses to a small number if the risks are independent of each other.

[10] This subsection draws on material in Kunreuther and Pauly (2006)
[11] A notable exception was the Oakland, CA fire of 1991, which destroyed 1941 single-unit dwellings and damaged 2069 others.

Safety-first Model Insurers are also concerned with providing coverage against events, such as earthquakes and hurricanes, where they can suffer severe losses should they write a large number of policies in the affected region due to high correlation between policies. Actuaries and underwriters both utilize heuristics that reflect these concerns.

Consider the case of estimating the premium for wind damage to homes in New Orleans from future hurricanes. Actuaries first use their best estimates of the likelihood of hurricanes of different intensities to determine an expected annual loss to the property and contents of a particular residence such as the Lowe home. They then increase this figure to reflect the amount of perceived ambiguity in the probability and/or the uncertainty in the loss. Underwriters utilize the actuary's recommended premium as a reference point and then focus first on the impact of a major disaster on the probability of insolvency or some prespecified loss of surplus to determine an appropriate premium to charge. In some states there is a premium on file with the state insurance department that guides their actions.[12] Underwriters then consider the impact that marketing coverage at different feasible premium levels will have on the number of policies sold and the firm's expected profits (Kunreuther 1989).

Roy (1952) first proposed a safety-first model to characterize this type of firm behavior. In the context of insurance, such a model explicitly concerns itself with insolvency when determining the maximum amount of coverage the insurer should offer and the premiums to charge. Stone (1973) formalized these concepts by suggesting that

[12] In many states premiums are subject to prior approval by the Insurance Department. There is a mechanism that would enable an underwriter to charge a different premium than the one on file and approved but the procedure is quite cumbersome and time consuming so it generally not done for personal lines of insurance such as homeowners policies. I am grateful to Gary Grant and David Hayes for pointing this out to me.

an underwriter who wants to determine the conditions for a specific risk to be insurable will first focus on keeping the probability of insolvency below some threshold level (q^*).

The focus of insurers on insolvency will vary depending on the character of share ownership and managerial agency costs. Mayers and Smith (1990) suggest that the transaction costs associated with insolvency explains the demand for reinsurance by property/liability companies. Greenwald and Stiglitz (1990) contend that managers suffer damage to their personal career prospects if their companies become insolvent and that they cannot diversify their risk as owners of the firm can. By this logic, underwriters would focus on the insolvency constraint where the owners of the firm would be less likely to do so.

To illustrate the nature of a safety-first model for underwriters, suppose that the insurer expects to sell m policies, each of which can produce a loss L if a natural disaster occurs. Then the underwriter would like to set the premium z^* at a level so that the probability of insolvency is no greater than q^*. Risks with more uncertain losses or greater ambiguity will cause underwriters to want to charge higher premiums. The situation will be most pronounced where the losses are likely to highly correlated as in the case of hurricanes and earthquakes.

The underwriter may realize that for some risks the desired premium z^* will be higher than the rate the State Insurance Department will allow the firm to charge. Even if the desired premium z^* is allowed, it may not yield a positive expected profit given the resulting low demand and the cost of capital, marketing and administrative expenses. In either case the risk will then be viewed as uninsurable by the underwriter.

Empirical Evidence The empirical evidence based on surveys of actuaries and underwriters supports the hypothesis that higher premiums will be recommended for risks with ambiguous probabilities and/or uncertain losses.[13] In a mail survey of professional actuaries conducted by the Casualty Actuarial Society, 463 respondents indicated how much they would charge to cover losses against a defective product where the probabilities of a loss was well specified at $p=.001$ and where they experienced considerable uncertainty about the likelihood of a loss. When losses are independent the median premium values were five times higher for the uncertain risk than for the well-specified probability. This ratio increased to ten times when the losses were perfectly correlated. (Hogarth and Kunreuther 1989).

For underwriters a questionnaire was mailed to 190 randomly chosen insurance companies of different sizes asking them to specify the prices which they would like to charge to insure a factory against property damage from a severe earthquake, to insure an underground storage tank and to provide coverage for a neutral situation (i.e. a risk without any context). Probabilities and losses were varied. The probability of loss and the size of the claim were either well-specified or there was ambiguity regarding the likelihood of the loss and/or the claim size. The underwriters wanted to charge more for the same amount of coverage when either the probability was ambiguous and/or the claim size was uncertain. (Kunreuther et al. 1993).

Surplus and Capacity Considerations Hurricanes, where there is significant damage from the wind, could have a noticeable impact on the surplus of insurers who have provided standard homeowners and business coverage to a large number of

[13] This behavior reinforces the importance of distinguishing between risk and uncertain outcomes, a concept first introduced by Knight (1921) and then examined empirically forty years later by Ellsberg (1961).

residents and businesses in the impacted areas. Eleven smaller property-casualty insurance companies with a large book of business in Florida became insolvent as a result of losses from Hurricane Andrew, in 1992, the largest number of hurricane-related insolvencies in U.S. history On the other hand, there was only one insolvency, a small insurer, following the four hurricanes in Florida in 2004 (King 2005). To date there have been no reported insolvencies after Hurricanes Katrina, Rita and Wilma in the fall of 2005.

Following Hurricane Andrew property insurance became more difficult to obtain as many insurers limited their concentrations of insured property in coastal areas to reduce the likelihood of future catastrophic losses from hurricanes. To increase the supply of coverage by insurers the state established the Florida Hurricane Catastrophe Fund (FHCF) in 1993 as a mandatory reinsurance program.[14] The Cat Fund has been activated three times---twice in 1995 when it paid $13.1 million for Hurricane Opal and $47.2 million for Hurricane Erin and again in 2004 when the Fund paid out $2.3 billion due to the four hurricanes that hit Florida out of total insured losses of $21 billion. (King 2005).

At a theoretical level, Winter (1988, 1991), Gron (1994), and Doherty and Posey (1997) postulate that a particular severe flood, earthquake or hurricane could have a very negative impact on the availability of insurance. They develop a *capacity constraint model* that predicts insurers will cut back on their supply of coverage after a catastrophe

[14] The FHCF operates as a tax exempt source of reimbursement to property insurers above a given retention limit should industry hurricane losses exceed $4.5 billion. Reimbursement is limited to available assets (retained earnings) and borrowing ability of the Fund. Each insurer has an individual deductible, which is its proportionate share of the $4.5 billion industry aggregate. Insurers can choose from three reimbursement options for their losses (45%, 75% or 90%) depending on how much they want to pay for reinsurance to the Florida Cat Fund. (King 2005)

if their surplus is significantly reduced and they cannot obtain reinsurance or the post-disaster reinsurance prices have risen so it is unprofitable for them to purchase coverage. Doherty, Kleffner and Posey (1993) suggest that a principal reason why insurers restricted their coverage against wind damage immediately following Hurricane Andrew was because some insurers' surplus were significantly reduced. Premiums were increased to reflect the shortage in supply, which created opportunities for new investment. The establishment of a number of start-up insurers, notably the new Bermuda companies, following Hurricane Andrew, can be explained in this way. Eventually the insurance market settled down and prices and capacity returned to normal levels. (Wharton Risk Center, 2005). In fact, during in the past few years there has been a considerable influx of new capital in the insurance/reinsurance, market as will be discussed below.

Tax Considerations Harrington and Niehaus (2003) show that tax costs could be substantial for catastrophic coverage due to the large amount of capital that must be held in relation to the expected claim costs. Under U.S. tax policy, insurers cannot establish tax deductible reserves for losses until they have occurred. Harrington (this volume) concludes that the current tax on private sector investment of capital to back catastrophe insurance is counterproductive and proposes a system of tax-deferred reserves to help correct the problem.

Government Decisions Regarding Disaster Assistance

If individuals are unprotected against financial losses from a large-scale disaster the government is likely to respond with disaster assistance.[15] Federal disaster assistance is purported to create a type of Samaritan's dilemma: providing assistance after a

[15] Trebilcock and Daniels (this volume) discuss alternative philosophical position as to who should be responsible for the costs of disaster ranging from libertarianism to paternalism.

catastrophe reduces the economic incentives of potential victims to invest in protective measures prior to a disaster. If the expectation of disaster assistance reduces the demand for insurance, the political pressure on the government to provide assistance after a disaster is reinforced or amplified.

The empirical evidence on the role of disaster relief suggests that individuals or communities have **not** based their decisions on whether or not to invest in mitigation measures by focusing on the expectation of future disaster relief. Kunreuther et al (1978) found that most homeowners in earthquake and hurricane prone areas did not expect to receive aid from the federal government following a disaster. Burby et al. (1991) found that local governments that received disaster relief undertook more efforts to reduce losses from future disasters than those that did not. This behavior seems counter-intuitive and the reasons for it are not fully understood.

Whether or not individuals incorporate an expectation of disaster assistance in their pre-disaster planning process, a driving force with respect to the actual provision of government relief are large-scale losses from disasters. (Moss 2002). The Alaska earthquake in 1964 and the spate of disasters that followed over the next eight years led the Small Business Administration (SBA) to provide low interest loans, and in some cases forgiveness grants, to aid uninsured victims of earthquakes, floods and hurricanes. The most extreme example of liberal disaster relief was after Tropical Storm Agnes in June 1972 that caused severe flooding in Pennsylvania and New York, five months before a Presidential election. Few homes had flood insurance so that the SBA provided $5000 forgiveness grants and 1% loans to rebuild the house and in some cases to retire

existing mortgages. Of the $675 million in homeowners loans following Agnes, 67% were in the form of forgiveness grants (Kunreuther 1973).

3. Disaster Insurance as an Integral Part of a Hazard Management Program

Insurance can encourage risk mitigation prior to a disaster through premium reductions and/ or lower deductibles while providing financial assistance after a disaster through claim payments. If insurance is to play a central role in a hazard management program then rates need to be based on risk so that those in disaster-prone areas are responsible for the losses after a disaster occurs. A limitation of any government insurance program is that premiums are not likely to be risk-based given political pressure to make coverage affordable to those residing in high-hazard areas.

Current Insurance Programs for Natural Hazards

Current insurance programs for residents in hazard prone areas are segmented across perils. Standard homeowners and commercial insurance policies, normally required as a condition for a mortgage, cover damage from fire, wind, hail, lightning, winter storms and volcanic eruption. Earthquake insurance can be purchased for an additional premium in all states except California where today one normally buys an earthquake policy for residential damage through the California Earthquake Authority, a state-run privately-founded earthquake insurance program. Earthquake coverage for businesses in California is often included in a commercial policy or can be purchased from private insurers as a separate rider. As noted in the introduction, flood insurance for residents and businesses is offered through the National Flood Insurance program, a public-private partnership created by Congress in 1968.[16]

[16] For more details on each of these insurance programs see Kunreuther and Roth (1998).

Insurers provided coverage against earthquakes, floods and hurricanes without any public sector involvement until after suffering severe losses from a major disaster. In the case of earthquakes, the Northridge, CA earthquake of January 1994 caused $12.5 billion in private insured losses while stimulating considerable demand for coverage by residents in earthquake-prone areas of California. Insurers in the state stopped selling new homeowners policies because they were required to offer earthquake coverage to those who demanded it. This led to the formation of the California Earthquake Authority (CEA) in 1996 which raised the deductible from 10% to 15% and limited the losses that insurers can suffer from a future earthquake (Roth, Jr. 1998).

Flood insurance was first offered by private companies in the late 1890s and then again in the mid 1920s. The losses experienced by insurers following the 1927 Mississippi floods and severe flooding in the following year led all companies to discontinue coverage by the end of 1928 (Manes 1938). Few private companies offered flood insurance in the next forty years. Following Hurricane Betsy in 1965 which caused considerable damage to New Orleans, Congress passed the Southeast Hurricane Disaster Relief Act which provided up to $1,800 in forgiveness grants for those who suffered damage not covered by insurance. A study on the feasibility of flood insurance authorized by the Act reached the conclusion that some type of federal subsidy was required. Building on this study Congress passed the National Flood Insurance Program (NFIP) in 1968. Today the federal government is the primary provider of flood insurance for homeowners and small businesses. Private insurers market coverage and service policies under their own names, retaining a percentage of premiums to cover administrative and marketing costs. Communities that are part of the program are required to adopt land use

regulations and building codes to reduce future flood losses (Pasterick 1998). Private insurers provide coverage for larger commercial establishments. The private insured losses for commercial property damage and business interruption losses from Hurricane Katrina have been estimated to be as high as $15-$25 billion. (Hartwig 2005).

As pointed out above, coverage from wind damage is provided under standard homeowners and commercial insurance policies. Following Hurricane Andrew, which caused $21.5 billion in insured losses (in 2002 prices) to property in the southern coast of Florida, some insurers felt that they could not continue to provide coverage against wind damage in hurricane-prone areas within the State, especially in view of the risk that insurance rate regulation might prevent them from charging the high rates that would be required to continue writing coverage. This led to the formation of the Florida Hurricane Catastrophe Fund that reimburses a portion of insurers' losses following major hurricanes (Lecomte and Gahagan 1998).

A Case for Comprehensive Disaster Insurance

The idea of a comprehensive disastern insurance program where all natural disasters are covered by a single policy is not a new one. In 1954 Spain formed a public corporation, the Consorcio de Compensation de Seguros (CCS) that today provides mandatory insurance for so-called "extraordinary risks" that include natural disasters and political and social events such as terrorism, riots and civil commotion. Such coverage is an add-on to property insurance policies that are marketed by the private sector. CCS pays claims only if the loss is not covered by private insurance, if low income families did not buy insurance and/or the insurance company fails to pay because it becomes

insolvent. The government collects the premiums and private insurers market the policies and handle claims settlements (Freeman and Scott 2005).

In France, a homeowners policy also covers number of different natural disasters along with terrorism. The main difference comes at the reinsurance level which is partially provided by a publicly owned reinsurer, the Caisse Centrale de Reassurance, for flood, earthquakes, and droughts, and by an insurance pool with unlimited government guarantee for terrorism. There is no public reinsurance for storms. (Michel-Kerjan and de Marecellus in press)

Prior to Hurricane Katrina some insurers discussed the need for a national disaster insurance program that covers all natural hazards. Katrina has brought this issue to the fore since there were a number of residents in the area who had homeowners insurance but not flood coverage and were told that their damage was caused by rising water not wind. Those who did have flood insurance and suffered large losses from the rising waters were only able to cover a portion of their losses with their claim payments because the maximum coverage limit of the flood insurance program is $250,000.[17]

Expanding the standard homeowners policy marketed by private insurers to include earthquake and flood has considerable appeal if the rates reflect the risks faced by those residing in hazard-prone areas. By setting risk-based premiums, one signals to those considering moving into hazard-prone areas what the expected losses are from natural disasters. If the resident decides to adopt mitigation measures against one or more

[17] There is a private insurance market for those who would like to purchase higher coverage limits.

hazards, then the insurer can reduce the premium to reflect the lower loss that would occur from future disasters.[18]

An all-hazards insurance program also reduces the variance associated with insurers' losses relative to their surplus in any given year. Consider an insurer marketing coverage nationwide. It will collect premiums that reflect the earthquake risk in California, hurricane risk on the Gulf Coast, tornado damage in the Great Plains states and a flood risk in the Mississippi Valley. Using the law of large numbers discussed above, this higher premium base and the diversification of risk across many hazards reduces the likelihood that such an insurer will suffer a loss that exceeds its surplus in any given year.

Of course, there is some chance that there will be a series of disasters leading to greater catastrophic losses than if one were covering fewer hazards. One only has to look at the damage from Hurricane Katrina to understand this point. If insurers were covering the water and wind damage from hurricanes, then their losses would have been considerably higher than they currently are estimated to be, but the premiums they collected would also have been greater to reflect the additional risk. If insurers wanted protect themselves against such large losses, they could purchase private reinsurance and/or utilizing risk-linked securities such as catastrophe bonds. An open question that we will discuss in the next section is whether there is a need for public sector involvement for covering a portion of insured losses from a mega-catastrophe.

An all-hazards program may also be attractive to both insurers and policyholders in hurricane-prone areas because it avoids the costly process of having an adjuster

[18] If a home that is mitigated can suffer damage from a neighboring structure that is not, then the insurer should this into account when determining the premium discount. This type of interdependency creating negative externalities provides a justification for well-enforced building codes.

determine whether the damage was caused by wind or water. This problem of separating wind damage from water damage has been a particularly challenging one following Hurricane Katrina. Across large portions of the coast, the only remains of buildings are foundations and steps where it will be difficult to reach a settlement due to the difficulty in determining the cause of damage. In these cases insurers may decide to pay the coverage limits rather than litigating about whether the damage came from water or wind because of the high costs of taking the case to court. For a house still standing, this process is somewhat easier since one knows, for example, that roof destruction is likely to be caused by the wind and water marks in the living room are signs of flooding (Towers Perrin 2005).

Another reason for having an insurance policy that covers all hazards is that there will be no ambiguity by the homeowner as to whether or not she has coverage. Many residing in the Gulf Coast believed they were covered for water damage from hurricanes when purchasing their homeowners policies. In fact, lawsuits were filed in Mississippi and Louisiana following Katrina claiming that homeowners policies should provide protection against water damage even though there are explicit clauses in the contract that excludes these losses (Hood 2005).

The attractiveness of insurance that guarantees that the policyholder will have coverage against all losses from disasters independent of cause has also been demonstrated experimentally by Kahneman and Tversky (1979). They showed that 80 percent of their subjects preferred such coverage to what they termed probabilistic insurance where there was some chance that a loss was not covered. What matters to an individual is the knowledge that she will be covered if her property is damaged or

destroyed, not the cause of the loss. Furthermore by combining all hazards in a single policy, it is more likely that a property owner will consider purchasing insurance against the financial loss from a disaster because it is above her threshold level of concern. Such a policy has added benefits to the extent that individuals are unaware that they are not covered against rising water or earthquake damage in their current homeowners policy and if uninsured victims do not demand or obtain disaster assistance to repair their property.

Naturally, an all-hazards insurance policy will be more expensive than the standard homeowners policy because it is more comprehensive. A resident in New Orleans would now have coverage against both wind and water damage and would be paying more for this added protection. If premiums are based on risk then policyholders would only be charged for hazards that they face. Thus a homeowner in the Gulf Coast would theoretically be covered for earthquake damage but would not be charged anything for this additional protection if the area in which they reside is not a seismically active area. In promoting this all-risk coverage one needs to highlight this point to the general public who may otherwise feel that they are paying for risks that they do not face.

Linking Insurance with Mitigation Measures

In theory insurance can encourage individuals to adopt loss reduction measures through by lowering premiums. In practice, it is hard to sell this idea because the premium reduction given to the homeowner is normally relatively small compared to the cost of a mitigation measure. To illustrate, suppose that the Lowe Family can reduce its loss from wind damage caused by a hurricane by bracing their roof trusses and installing straps or clips where the roof decking and roof supports meet at a cost of $1500. If the

annual probability of a hurricane causing wind damage to their house is 1/100 and reduction in loss due to strengthening the roof in this manner is $27,500, then the expected annual benefit from roof mitigation to the Lowes is $275 and a risk-based insurance premium should be reduced by that amount.

To evaluate the expected benefit to the Lowe family from investing in such a mitigation measure, one should take into account the expected life of the Lowes' home and then determine what the discounted savings would be over this period of time. If the house were expected to last for the next 15 years and the Lowes' annual discount rate were 8%, then the expected discounted benefits would be $2,092, which would exceed the cost of the roof mitigation measures by $592. In fact, such an investment would be justified on cost-benefit grounds for any house that would be expected to last more than 8 years.

If the insurer reduced the Lowes' homeowners premium by $275, would the family invest in the mitigation measure? Empirical evidence on individuals' decision processes with respect to adoption of protective measures suggests that they would not. Individuals tend to be myopic and often compare the expected benefits next year with the incurred costs. If the Lowes' used such a short time-horizon to determine whether they should invest in roof mitigation, they would consider it to be an unattractive use of funds since they would incur an upfront cost of $1500 in return for a lower premium of $275. In addition, if the Lowe family had budget constraints they would consider this to be an additional reason not to invest in this loss reduction measure.

One way to encourage adoption of cost effective mitigation measures is to have banks provide long-term mitigation loans that could be tied to the property. The bank

holding the mortgage on the property could offer a home improvement loan with a payback period identical to the life of the mortgage. For example, a 20-year loan for $1,500 at an annual interest rate of 10% would result in payments of $145 per year. If the annual premium reduction due to the adoption of the mitigation measure is greater than $145 per year, an insured homeowner would have lower total payments by investing in mitigation (Kleindorfer and Kunreuther, 1999). In order for such a program to achieve its desired impact, insurance premiums need to be risk-based so that the premium reduction for undertaking the mitigation measure exceeds the annual home improvement loan payment.

Role of Building Codes

Building codes require property owners to meet standards on new structures but normally do not require them to retrofit existing structures. Often such codes are necessary, particularly when property owners are not inclined to adopt mitigation measures on their own due to their misperception of the expected benefits resulting from adopting the measure and/or their inclination to underestimate the probability of a disaster occurring.

Cohen and Noll (1981) provide an additional rationale for building codes. When a structure collapses, it may create externalities in the form of economic dislocations and other social costs that are beyond the financial loss suffered by the owners. For example, if a poorly designed structure collapses in a hurricane, it may cause damage to other buildings that are well designed and still standing from the storm. Knowing this an insurer may offer a smaller premium discount than it would otherwise have given to a homeowner investing in loss reduction measures

4. Challenges in Developing a Comprehensive Insurance Program

To develop a comprehensive disaster insurance program where rates are based on risk one needs to obtain scientifically based estimates on the likelihood of each of the hazards occurring in different regions combined with estimates by engineers and other experts on the resulting damage to structures and to people in harms way. These risk assessments are essential ingredients for determining the actuarially fair rates for providing insurance coverage. After developing risk-based premiums, key interested parties from the private and public sector need to address several issues: whether special treatment should be given to low income residents who may be unable to afford coverage, how to promote cost-effective mitigation measures and the alternative options for providing financial protection against losses from mega-catastrophes.

Risk Assessment [19]

The science of assessing catastrophe risk has been improved in recent years through the development of computer-based models that have combined experts' estimates of the likelihood and consequences of future disasters with historical occurrences of these events. The resulting catastrophe models provide estimates of future losses to different regions of the country by overlaying the properties at risk with the potential risk from different natural hazards.

These data can be captured in an exceedance probability (EP) curve that specifies the probabilities that a certain level of losses will be exceeded for a given geographical area. The losses can be measured in terms of dollars of damage, fatalities, illness or some

[19] This section is based on Grossi and Kunreuther Chapter 2 (2005). A more detailed discussion of the use of exceedance probability curves in estimating risks from earthquakes and hurricanes can be found in other chapters of that book.

other unit of analysis. An EP curve is particularly valuable for insurers and reinsurers to determine the size and distribution of their portfolios' potential losses. Using an EP curve, they can determine the types and locations of buildings they would like to insure, what coverage to offer, and what price to charge. To keep the probability of insolvency at an acceptable level, insurers can also use an EP curve to determine what proportion of their risk needs to be transferred to reinsurers, the capital markets, and/or the government.

To illustrate with a specific example, suppose an insurer was interested in constructing an EP curve for a given portfolio of insurance policies covering wind damage from hurricanes in a southeastern U.S. coastal community. Using probabilistic risk assessment, the catastrophe model would combine the set of events that could produce a given dollar loss and then determine the resulting probabilities of exceeding losses of different magnitudes. Based on these estimates, the insurer can construct an EP curve that depicts the probability that losses will exceed a particular level.

An insurer utilizes its EP curve for determining how many structures it will want to include in its portfolio given that there is some chance that there will be hurricanes causing damage to a subset of its policies during a given year. More specifically, if the insurer wanted to reduce the probability of a loss from hurricanes that exceeds a critical level, it could reduce the number of policies in force for these hazards, decide not to offer this type of coverage at all (if permitted by law to do so), increase the capital available for dealing with future catastrophic events and/or transfer some of its risk to other parties in the private and/or public sector.

Given the uncertainties associated with risk estimates from an EP curve, insurers may want to limit their coverage against certain risks in order to reduce the chances of a

large decrease in surplus through a catastrophic loss, such as some insurers experienced after Hurricane Andrew in 1992, the Northridge earthquake in 2004 and now Hurricane Katrina. This coupled with inadequate insurance premiums in high-hazard areas are why some insurers do not want to provide coverage today against earthquakes in California and wind damage from hurricanes in the Gulf Coast states.

Setting Risk-Based Premiums

If one believes that those residing in hazard-prone areas should be responsible for bearing their own financial burden after suffering losses from a natural disaster, then insurance rates should reflect the risk. Property owners residing along the Gulf Coast should pay considerably more for insurance against wind and water damage from hurricanes than in other parts of the country. Individuals residing in areas where floods, tornadoes and hurricanes are unknown should pay next to nothing for insurance that covers these hazards. However, if they face an earthquake hazard their premiums should reflect this risk. Such a system of risk-based premiums encourages individuals in low risk areas to buy coverage and avoids the problems of adverse selection.

The challenge in implementing such a program tomorrow is that the premiums charged to those residing in the highest risk areas are likely to be considerably greater than they currently are today. In fact, many states regulate rates so that premiums do not reflect the actual risks borne. As Harrington (this volume) points out, programs in California, Florida, Hawaii and Louisiana as well as other states have put caps on market insurance rates and created state pools to provide catastrophic reinsurance coverage at

subsidized rates. Such mechanisms are likely to expose policyholders to significant rate increases following large losses, as is now occurring in Florida and Louisiana following Hurricane Katrina (Hartwig and Wilkerson 2005).

Some homes in high-risk areas are owned by low income families who cannot afford the costs of insurance or the costs of reconstruction should their house suffer damage from a natural disaster. One issue that needs to be addressed is whether subsidies should be provided to this group in the form of low interest loans and grants for insurance by a federal, state or local government agency. Since uninsured low income victims are likely to receive federal assistance after a disaster, this type of subsidy would reduce the cost to taxpayers following a disaster. A risk-based insurance program with subsidies to low income individuals would enable insurers to set the appropriate rates over time unless they are prevented from doing so by state regulation.

Given the existing system of state rate regulation and the need for special treatment for low income residents in high hazard areas, there are political challenges in implementing the proposed program. The use of catastrophe models and exceedance probability curves can be extremely useful in this regard for legitimizing the types of rates that should be charged. An open question is whether regulators will use these models in determining the rates they are willing to approve.

Private Sector Protection against Catastrophic Losses

A study of the capacity of the U.S. property-casualty insurance industry to respond to catastrophic events during the late 1990s by Cummins, Doherty and Lo (2002) concluded that the industry could pay more than 90 percent of the losses from a $100 billion disaster. However, the authors indicate that such an event would cause the failure

of approximately 140 insurance companies and would lead to significant premium increases and supply side shortages.

Given the large increase in insurance / reinsurance industry capital since that time, and some modest progress in the use of capital market instruments to spread risk further, insurers / reinsurers are much less vulnerable today than implied by the Cummins, Doherty, and Lo analysis. For example, Hurricane Katrina has spurred an influx of insurance and reinsurance capacity. As of Dec. 1, 2005, nineteen insurers announced plans to raise $9.95 billion in new capital and eleven new start-ups in Bermuda and one in the Caymans plan to raise an additional $8.65 billion. It is likely at least $20 billion will eventually be raised (Hartwig 2005). One needs a more detailed analysis over the coming months as to how much insurance and reinsurance will be available today to cover catastrophic losses from hurricanes and other natural disasters.

The capital markets have recently emerged as a complement to reinsurance for covering large losses from disasters. Through new financial instruments, known as catastrophe bonds, an insurer or reinsurer can access needed funds following a disaster. If the losses exceed a pre-specified amount, then the interest on the bond, the principal, or both, are forgiven. To justify the risks of losing their principal and/or interest, capital market investors demand a large enough risk-adjusted return to invest in these bonds. This comes in the form of a higher than normal interest rate when no disaster occurs. However, investors (e.g. hedge fund managers, pension fund managers) are concerned with the impact of the investment on the performance of their portfolio should they suffer

a loss.[20] These factors partially explain why it has been necessary to issue cat bonds with relatively high interest rates.

The Wharton Risk Center working jointly with the three leading modeling companies (AIR Worldwide, EQECAT and Risk Management Solutions) recently completed an analysis of the performance of catastrophe bonds in reducing the risks relative to their costs for a hypothetical insurer providing protection to homeowners facing possible disaster losses in three U.S. cities: Oakland and Long Beach, CA (earthquake damage) and Miami/Dade County, FL (hurricane damage). The analysis revealed that while catastrophe bonds reduce catastrophic losses and hence the probability of insolvency, the relatively high interest rates reduce both an insurer's expected profits and return on assets (ROA). An analysis of multi-region cat bonds that provided protection against cat losses in Oakland, Long Beach and Miami revealed that it would lower the likelihood that an investor will lose a given amount of principal due to the diversification of the risk. Hence the interest rate on the cat bond could be reduced, thus making it more attractive to the insurer. (Grossi and Kunreuther 2005, Chapter 9)

To date catastrophe bonds have not been a major source of funding for catastrophic losses for the reasons described above. There have been only 120 cat bonds issued to date with approximately $10 billion raised by March 2005 (Cummins 2005). Regulatory, accounting and tax issues are also preventing the cat bonds from being used more widely. Another impediment to the widespread use of cat bonds is that it requires specialized knowledge and skills. Investors without these attributes are likely to allocate their funds elsewhere (Jaffee 2005).

[20] For more details on the reasons why investors are concerned with investing in cat bonds see Bantwal and Kunreuther (2000).

Role of the States

In order for the private sector to be given the opportunity to provide insurance using risk-based premiums, State Insurance Departments have to support this effort. In theory there is no reason for regulators to have to approve rates and/or use models, but instead should rely on competition within the insurance industry. If some states decide to regulate, then they should consider all the evidence when determining what rates to approve. In particular, they should use the data from the modeling firms and other experts to allow rates in high hazard areas to reflect the likelihood and expected losses from future disasters. Furthermore there needs to be recognition that any insurance company established by the state cannot undercut private insurers with respect to the rates that are being charged.

Florida provides a graphic illustration of the challenges one faces in this regard. In recent years there has been considerable development in hurricane prone regions along the coast. Florida's coastal population rose from 7.7 million to 10.5 million between 1980 and 1993, an increase in 37 percent (Lecomte and Gahagan 1998). This trend is continuing, so it is not surprising that Florida has suffered more hurricane damage than any other state in the past 20 years.

Following Hurricane Andrew the Florida legislature established the Florida Windstorm Underwriting Association (FWUA) and the Florida Residential Property and Casualty Joint Underwriting Association (FRPCJUA), two residual market mechanisms providing insurance to individuals who are unable to obtain coverage in the voluntary market. In August 2002, Citizens Property Insurance Company, a state-run insurer, was established as a merger of these two entities. Following Hurricane Wilma in October

2005 the insurer's losses were estimated at $1.4 billion so that the Citizens Property Insurance Corporation Board approved a filing of a 16 percent increase for those homes in high risk areas. This follows a 7.8 percent assessment levied in the summer of 2005 for losses from the four hurricanes that occurred in 2004 (BestWire 2005).

Today there is recognition that the rates currently being charged are much too low relative to the risk. Unless the state insurer charges rates commensurate with the risk of loss it will be undercutting the private insurance market. Subsidized rates will also encourage further development in hurricane-prone areas of Florida and will not provide appropriate economic incentives for property owners to invest in mitigation measures.

Use of Multi-State Insurance Pools

In past years the National Conference of Insurance Legislators (NCOIL) has considered a multistate Natural Disaster Compact, modeled after the Florida Hurricane Catastrophe Fund, to increase available resources, and further spread geographic risks. A share of property premium collected in each state in the pool would be used to finance mega-catastrophes in these states. This concept has obvious appeal to the most disaster-prone states, and has an equal lack of appeal to states where disasters are rarer. These pools face a number of legal and political challenges which may make it difficult for them to be initiated (Kunreuther and Roth 1998).

A successful example of the use of an insurance pool is the one that provides coverage against catastrophic losses from nuclear power plant accidents in the United States. The Price-Anderson Act, originally enacted by Congress in 1957, limits the liability of the nuclear industry in the event of a nuclear accident in the United States. At the same time, it provides a ready source of funds to compensate potential accident

victims that would not ordinarily be available in the absence of this legislation. Price-Anderson sets up two tiers of insurance. Each utility is required to maintain the maximum amount of coverage available from the private insurance industry - currently $300 million per site. If claims following an accident exceed that primary layer of insurance, all nuclear operators are obligated to pay up to $100.59 million for each reactor they operate payable at the rate of $10 million per reactor, per year. As of February 2005, the U.S. public currently has more than $10 billion of insurance protection in the event of a nuclear reactor incident (Wharton Risk Center 2005, Chapter 2).

Federal Involvement

To deal with mega-disasters that cannot be covered by the private sector Lewis and Murdoch (1996) proposed that the federal government offer catastrophe reinsurance contracts, which would be auctioned annually. The Treasury would auction a limited number of excess of loss (XOL) contracts covering industry losses between $25 billion and $50 billion from a single natural disaster. Insurers, reinsurers, state and multi-state pools would be eligible purchasers.[21] XOL contracts would be sold to the highest bidder above a base reserve price which is risk based. Half of the proceeds above the reserve price would go into a mitigation fund, with the remainder retained to cover payouts. This federal reinsurance effort would be part of a broader program involving mitigation and other loss reduction efforts.

Another proposed option is for the federal government to provide reinsurance protection against catastrophic losses that cannot be covered by the private sector. Insurers would contribute to the fund by being assessed premium charges in the same

[21] Harrington (this volume) points out that specific Congressional proposals to date have involved low thresholds such as $2 billion that would substantially crowd out private sector coverage.

manner that a private reinsurance company would levy a fee for excess-loss coverage or other protection. One advantage that the federal government has over private reinsurers is its financial ability through taxing and borrowing authority to cover a disaster that occurs in the next few years before sufficient funds are built up to cover these losses.[22]

5. A Private-Public Partnership for Mitigating Losses and Providing Financial Protection Following Disasters

The rationale for a comprehensive disaster insurance program seems sufficiently compelling in the light of past disaster experience that a concerted effort should be undertaken to develop such a program in the near future. In this section we sketch out the elements of such a program and suggest ways it can be combined with other public-private sector initiatives to reduce future disaster losses.

A Multi-Layered Insurance Program

In order to encourage those at risk to take protective measures while at the same time providing protection to private insurers against catastrophic losses there needs to be a multi-layered program that involves both the public and private sectors. The elements of such a program have been proposed by Doherty, Kleindorfer and Kunreuther (1990) for insuring against environmental pollution and by Litan (2005) for insuring against natural disasters.

The first level of disaster losses should be borne by the victims themselves in order to encourage them to adopt safer measures and to avoid moral hazard problems that might otherwise occur if individuals behaved more carelessly because they knew they were fully protected against the risk. This form of self-insurance is equivalent to having a deductible on

[22] See Harrington (this volume) for a more detailed discussion on how the federal government could provide reinsurance against large catastrophic losses.

an insurance policy. The magnitude of the deductible could vary depending on the amount of coverage in place (e.g. a percentage deductible), the needs of those at risk and their willingness to trade off a lower price for less first dollar protection.

Losses in Layer 2 would be covered by private insurers with the amounts of coverage based on their surplus, their current portfolio and their ability to diversify across risks. Firms with limited assets that insure policyholders in only one region of the country will want to take on a much smaller book of business than large insurers with policies written in many states and/or protect themselves through risk transfer mechanisms. Layer 3 would consist of private sector risk transfer mechanisms that include reinsurance and catastrophe bonds with the proportion of funds allocated by insurers to each of them depending on the prices and the available coverage. Layer 4 would cover large scale losses. It could take the form of multi-state pools for providing coverage in certain regions of the country subject to particular hazards, such as hurricanes in the Gulf Coast states. The federal government could also offer catastrophe reinsurance contracts and/or provide pre-funded federal reinsurance for mega-catastrophes.

Linking Insurance with Other Initiatives

For a comprehensive disaster insurance program to reduce losses from future disasters it needs to be linked with other private-public sector initiatives. The importance of well-enforced building codes and land-use regulations to control development in hazard-prone areas becomes an important part of such a program. If some states and the federal government are providing protection against catastrophic losses, they can also require these risk-reducing measures as part of such a private-public partnership. As discussed in Section 3, banks and financial institutions can offer home improvement loans for mitigation

measures tied to mortgages on existing structures. This option will be financially attractive to property owners if they obtain a yearly premium reduction on their insurance policy that exceeds the annual payments on the home improvement loan.

Communities can also offer tax incentives to encourage property owners to adopt mitigation measures. The city of Berkeley has encouraged home buyers to retrofit newly purchased homes by instituting a transfer tax rebate. The city has a 1.5 percent tax levied on property transfer transactions; up to one-third of this amount can be applied to seismic upgrades during the sale of property. Qualifying upgrades include foundation repairs or replacement, wall bracing in basements, shear wall installation, water heater anchoring, and securing of chimneys. Since 1993, these rebates have been applied to 6,300 houses, representing approximately $ 4.4 million in foregone revenues to the city (Earthquake Engineering Research Institute, 1998).

Open Issues

Voluntary or Required Coverage In developing a comprehensive insurance program one of the open issues is whether all property owners should be required to have this insurance coverage. Since banks normally require homeowners coverage and commercial insurance as a condition for a mortgage, a sizable number of property owners would automatically have all-hazards protection.

There will be some individuals who either own their house outright or are not required by their bank to purchase insurance. They may decide to take their chances and not purchase coverage. If there are enough of these uninsured individuals and the past is a guide for the future, the federal government is likely to provide financial following the next large-scale disaster. In this case one would want to consider making insurance

protection mandatory. A related option would be for the federal government to levy a tax on all property in the United States with the payment based on the actuarial risk. The government would then cover the catastrophic losses from natural disasters. If such a tax were imposed, then one would need to separate out the catastrophic portion of the loss from lesser damage that would continue to be covered by a homeowners or commercial insurance policy.

Role of Regulation If insurance is to provide the appropriate signals to residents in hazard-prone areas, risk-based premiums must be charged. State insurance departments need to give insurers complete freedom to charge these rates subject to solvency concerns that regulators may have if unduly low premiums are proposed by some insurers. One of the advantages of a risk-based system is that it rewards individuals who undertake mitigation measures by providing them with lower premiums. If premium are subsidized in high-hazard areas then the insurer has limited economic incentives to provide coverage to these property owners and no reason to reward them with a lower premium that fully reflects the expected benefit of adopting a loss reduction measure.

If one wants to encourage the use of capital market instruments to cover catastrophic losses, it would be useful to reexamine the current regulations and accounting practices that restrict the use of these instruments today. Jaffee (2005) has indicated three issues that deserve consideration. Accounting standards currently do not allow insurance firms to reflect the risk transfer achieved by non-indemnity catastrophe funds on their financial reports filed with state insurance regulators. A new Financial Accounting Standards Board proposal as it relates to Special Purpose Vehicles (SPVs) used in issuing cat bonds may also have detrimental effects on the cat bond market. A

third area is whether one can gain more favorable treatment for the SPVs issuing a catastrophe bond.

Special Treatment for Low Income Families There are likely to be a number of low income residents who reside in high hazard areas. These individuals may not be able to afford the relatively high premiums that they would be charged on their disaster insurance policy. They also may not have funds available to invest in mitigation measures even if offered a home improvement loan. Serious consideration should be given to special treatment to this group by public sector agencies at either the local, state and/or federal levels on both equity and efficiency grounds. There needs to be a more detailed analysis as to what proportion of the homes in high-hazard areas are occupied by low income residents and the types of subsidies that should be offered them so they can afford insurance and invest in cost-effective mitigation measures.

6. Summary and Conclusions

This paper suggests the possible advantages of some type of comprehensive disaster insurance program as an alternative to current insurance arrangements where water and earthquake damage require separate policies. To encourage cost-effective mitigation and increase private sector involvement such a program would require *risk-based rates*. Policyholders would assume the first layer of losses, the private sector would cover the middle layers of losses and state, multi-state pools and/or the federal government would provide protection against truly catastrophic losses through some type of pre-funding arrangement. To reduce future losses there is a need for creative private-public partnerships through economic incentives and well-enforced regulations and standards. (e.g. building codes). It is unclear whether coverage should be voluntary or

mandatory and what types of special arrangements should be given to low income families in high hazard areas.

Future research should focus on ways of obtaining better data to reduce the uncertainties surrounding the risk assessment process, how one can provide better information on the risk, alternative ways of reducing the risk faced by different interested parties ranging from the potential victims to government agencies. There is also an opportunity to undertake studies as to how different stakeholders incorporate the concept of probability into their decisions. A 250-year flood has a very specific meaning to an actuary determining insurance rates, but is likely to be interpreted in a very different way by residents in hazard-prone areas subject to this type of disaster.

By reducing uncertainty of the risk and more fully understanding the decision making process of the key interested parties, there is a better chance of developing a sustainable comprehensive and long-term hazard management program. In this regard, it is important to consider ways that communities and regions affected by disasters can develop strategies for reducing future losses. For example, what types of measures can be utilized for reducing losses to the existing infrastructure and lifelines that have an impact on the welfare of the residents in hazard-prone areas? One should also consider the positive externalities associated with risk reducing measures for natural disasters. For example, strengthening property against floods, earthquakes and hurricanes may have side-benefits such as providing added protection against terrorism attacks.

Finally when developing a hazard management strategy it is important to take into account the current institutional arrangements and the types of information individuals, firms and organizations in the private and public sectors utilize on the risk. Without a

clear understanding of the political and social landscape as well as how choices are actually made, we are likely to develop policies and programs that will not achieve their desired impacts.

Hurricane Katrina offers us an opportunity to learn from past mistakes and develop programs and policies that have a chance of reducing future losses by bringing theory and practice closer together. This chapter and others in this book examine the important roles of risk assessment and risk perception in developing risk management strategies for reducing future disaster losses and rebuilding stricken communities. We need to capitalize on the interest by the public and private sectors in taking steps to address these problems today rather than waiting until next large-scale disaster to occur.

REFERENCES

Bantwal, Vivek and Howard Kunreuther, (2000) "A Cat Bond Premium Puzzle?" *Journal of Psychology and Financial Markets*,. 1: 76-91.

BestWire (2005) "Florida's Last-Resort Homeowners Insurer to Raise Rates 15%" November 22.

Burby, Raymond J. with Beverly A. Cigler, Steven P. French, Edward J. Kaiser, Jack Kartez, Dale Roenigk, Dana Weist, and Dale Whittington. (1991). *Sharing Environmental Risks: How to Control Governments' Losses in Natural Disasters*. Boulder, CO: Westview.

Cohen, Linda, and Roger Noll. (1981). The economics of building codes to resist seismic structures. Public Policy (Winter):1-29.

Cummins, David (2005) "Should the Government Provide Insurance for Catastrophe?" Paper presented at 30th Annual Economic Policy Conference Federal Credit and Insurance Programs Federal Reserve Bank of St. Louis, Oct. 20-21.

Cummins, David, Doherty, Neil, and Lo, Anita (2002) "Can Insurers Pay for the 'Big One'? Measuring the Capacity of the Insurance Market to Respond to Catastrophe Losses" *Journal of Banking and Finance* 26:557-83.

Doherty, Neil, Anne Kleffner, and Lisa Posey (1992), *Insurance Surplus: Its Function, Its Accumulation and Its Depletion.* Boston, Mass.: The Earthquake Project.

Doherty, N., P. Kleindorfer and H Kunreuther (1990). "Insurance Perspectives on an Integrated Hazardous Waste Management Strategy," *Geneva Papers on Risk and Insurance* 27: 407-427.

Doherty, Neil and Lisa Lipowsky Posey (1997). "Availability Crises in Insurance Markets: Optimal Contracts with Asymmetric Information and Capacity Constraints," *Journal of Risk and Uncertainty* 15, 55–80.

Earthquake Engineering Research Institute. (1998). *Incentives and Impediments to Improving the Seismic Performance of Buildings.* Oakland, CA: Earthquake Engineering Research Institute

Ellsberg, Daniel (1961) "Risk, ambiguity and the Savage axioms" *Quarterly Journal of Economics* 75;643-69.

Freeman, Paul and Scott, Kathryn (2005) "Comparative Analysis of Large Scale Catastrophe Compensation Schemes' in *Catastrophic Risks and Insurance* Paris: Organization for Economic Cooperation and Development (OECD) July.

Greenwald, Bruce and Stiglitz, Joseph (1990) "Asymmetric Information and the New Theory of the Firm; Financial Constraints and Risk Behavior," *American Economic Review: Papers and Proceedings* 80:160-65.

Gron, Anne (1994) "Capacity Constraints and Cycles in Property-Casualty Insurance Markets." *RAND Journal of Economics*, Volume 25, No. 1 pp. 110-127.

Grossi, Patricia and Howard Kunreuther (2005), *Catastrophe Modeling: A New Approach to Managing Risk*. New York: Springer.

Harrington, Scott (2006) "Rethinking Disaster Policy After Hurricane Katrina" *This Volume*

Harrington, Scott E. and Greg Niehaus, (2003), "Capital, Corporate Income Taxes, and Catastrophe Insurance" , *Journal of Financial Intermediation* 12: 365-389.

Hartwig, Robert (2005), "Hurricane Season of 2005: Impacts on US P/C Insurance Markets in 2006 & Beyond" December 1st Available online at http://www.disasterinformation.org/disaster2/facts/presentation

Hartwig, Robert and Claire Wilkinson, (2005), *Public/Private Mechanisms Handling Catastrophic Risk in the United States*, Insurance Information Institute, New York, N.Y. October.

Hogarth, Robin and Howard Kunreuther (1989) "Risk, Ambiguity and Insurance" *Journal of Risk andUncertainty* 2:5-35.

Hood, Jim (2005) "A Policy of Deceit" *New York Times* November 19 p. A27.

Insurance Information Institute (2005) "Flood Insurance: Facts & Figures" Nov. 15.

Jaffee, Dwight. (2005), "The Role of Government in the Coverage of Terrorism Risks", Chapter 7 in *Terrorism Risk Insurance in OECD Countries* Paris: Organisation for Economic Cooperation and Development (OECD) July.

Kahneman, D., and Amos Tversky (1979), "Prospect theory: An analysis of decision under risk." *Econometrica* 47(2):263-291.

King, Rawle (2005) *Hurricanes and Disaster Risk Financing Through Insurance: Challenges and Policy Options* Washington, D.C: Congressional Research Service March 25.

Kleindorfer, Paul and Howard Kunreuther. (1999). The Complimentary Roles of Mitigation and Insurance in Managing Catastrophic Risks. *Risk Analysis* 19:727-38.

Kunreuther, Howard. (1973). *Recovery from Natural Disasters: Insurance or Federal Aid?*. Washington, D.C.: American Enterprise Institute for Public Policy Research.

Kunreuther, H., R. Ginsberg, L. Miller, P. Sagi, P. Slovic, B. Borkan, and N. Katz (1978). *Disaster Insurance Protection: Public Policy Lessons*. Wiley Interscience.

Kunreuther, Howard (1989) "The Role of Actuaries and Underwriters in Insuring Ambiguous Risks" *Risk Analysis*, 9:319-28.

Kunreuther, Howard Hogarth, Robin, Meszaros, Jacqueline (1993), "Insurer Ambiguity and Market Failure," *Journal of Risk and Uncertainty* 7: 71-87.

Kunreuther, Howard (1996), "Mitigating disaster losses through insurance." *Journal of Risk and Uncertainty* 12: 171-187.

Kunreuther, Howard and Richard Roth, Sr. (1998), *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States*, Washington, D.C: Joseph Henry Press.

Kunreuther, Howard and Mark Pauly (2004) "Neglecting Disaster: Why Don't People Insure Against Large Losses?" *Journal of Risk and Uncertainty* 28:5-21.

Kunreuther, Howard and Mark Pauly (2006) "Anomalies in Insurance," *Foundations and Trends in Microeconomics,* Vol. 1 No. 2

Kunreuther, H., Sanderson, W. and Vetschera, R. (1985) "A Behavioral Model of the Adoption of Protective Activities", *Journal of Economic Behavior and Organization* 6: 1-15

Lecomte, Eugene and Karen Gahagan, (1998), "Hurricane Insurance Protection in Florida" in Howard Kunreuther and Richard Roth, Sr., eds., *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States,* Washington, D.C.: Joseph Henry Press: 97-124.

Lewis, Christopher and Kevin C. Murdock (1996) "The Role of Government Contracts in Discretionary Reinsurance Markets for Natural Disasters" , *Journal of Risk and Insurance* 63: 567-597.

Litan, Robert (2005) "Sharing and Reducing the Financial Risks of Future "Mega-Castrophes" Brookings Institute Economics Studies Working Paper November 11.

Manes, Alfred (1938), *Insurance: Facts and Problems*. New York: Harper and Brothers.

Mayers, David and Smith, Clifford (1990) "On the Corporate Demand for Insurance: Evidence from the Reinsurance Market" *Journal of Business* 63:19-40.

Michel-Kerjan, Erwann and Nathalie de Marcellis (in press) "Public-Private Programs for Covering against Extreme Events: The Impact of Information Distribution on Risk-Sharing" *Asia-Pacific Journal of Risk and Insurance*.

Moss, David (2002) *When All Else Fails: Government as the Ultimate Risk Manager* Cambridge: Harvard.

Palm, Risa (1990), *Natural Hazards: An Integrative Framework for Research and Planning*. Baltimore: Johns Hopkins University Press.

Palm, Risa (1995), *Earthquake Insurance: A Longitudinal Studies of California Homeowners*. Boulder: Westview Press.

Pasterick, Edward T. (1998), "The National Flood Insurance Program." in Howard Kunreuther and Richard J. Roth, Sr. (eds.), *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States*. Washington, DC: Joseph Henry Press.

Risk Management Solutions (2004), "The Northridge, California Earthquake. A 10-Year Retrospective", May.

Roth, Richard Jr. (1998) "Earthquake Insurance in the United States" in Howard Kunreuther and Richard J. Roth, Sr. (eds.), *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States*. Washington, DC: Joseph Henry Press.

Roy, A.D. (1952). Safety-first and the holding of assets. *Econometrica* 20:431—449.

Stone, James (1973). A theory of capacity and the insurance of catastrophe risks: Part I and Part II. *Journal of Risk and Insurance* 40:231-243 (Part I) and 40:339-355 (Part II).

Tobin, Richard and Corinne Calfee (2005) *The National Flood Insurance program's Mandatory Purchase Requirement: Policies, Processes, and Stakeholders* Washington, DC: American Institutes for Research.

Towers Perrin (2005) "Hurricane Katrina: Analysis of the Impact on the Insurance Industry." Available online at http://www.towersperrin.com/tillinghast/publications/reports/Hurricane_Katrina/katrina.pdf

Trebilcock, Michael and Daniels, Ronald (this volume) " Rationales and Instruments for Government Intervention in Natural Disasters"

Tversky, A., Sattath. S., and Slovic . P. (1988), "Contingent Weighting in Judgment and Choice." *Psychological Review*, 95, 371-384.

U.S. General Accounting Office (1990) *Flood Insurance: Information on the Mandatory Purchase Requirement* Washington, D.C. August.

Wharton Risk Center (2005), *TRIA and Beyond: Terrorism Risk Financing in the U.S.*

Winter, Ralph. (1988). "The Liability Insurance Crisis and the Dynamics of Competitive Insurance Markets," *Yale Journal of Regulation* 5, 455–499.

Winter, Ralph (1991) "The Liability Insurance Market", *Journal of Economic Perspectives*, Summer, 5, pp. 115-136.