

Rules rather than discretion: Lessons from Hurricane Katrina

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Abstract This paper explores options for programs to be put in place prior to a disaster to avoid large and often poorly-managed expenditures following a catastrophe and to provide appropriate protection against the risk of those large losses which do occur. The lack of interest in insurance protection and mitigation by property owners and by public sector agencies prior to a disaster often creates major problems following a catastrophic event for victims and the government. Property owners who suffer severe damage may not have the financial resources easily at hand to rebuild their property and hence will demand relief. The government is then likely to respond with costly but poorly targeted disaster assistance. To avoid these large and often uneven *ex post* expenditures, we consider the option of mandatory comprehensive private disaster insurance with risk-based rates. It may be more efficient to have an *ex ante* public program to ensure coverage of catastrophic losses and to subsidize low income residents who cannot afford coverage rather than the current largely *ex post* public disaster relief program.

Keywords Natural hazards · Mitigation · Insurance

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1 Introduction

In their Nobel Prize winning contribution Kydland and Prescott (1977) show that a discretionary policy, which may be optimal given the current situation, may not necessarily result in a socially optimal policy in the longer run. As a specific example of this general proposition, the authors note that unless individuals are initially prohibited from locating in a flood plain, it will be very difficult politically to force these people to leave their homes. In making decisions to locate there, Kydland and Prescott indicate that these individuals believe that the Corps of Engineers will subsequently build dams and levees if enough people choose to build homes in these flood plains. A large number of homeowners then decide to locate in these high hazard areas for that reason and the Corps of Engineers is forced to invest in flood control projects. Hence the need for having explicit enforced rules restricting development in these areas, rather than giving people discretion to choose where they would like to live.

In the case of New Orleans, the Corps of Engineers did not adequately shore up the existing levees to protect the New Orleans greater metropolitan area from flooding because of cost increases, design changes caused by technical issues, environmental concerns, legal challenges and local opposition to portions of the project. The Corps project fact sheet from May 2005 noted that the appropriated amounts in the President's budget for fiscal year 2005 were insufficient to fund new construction projects that included levee enlargement to enhance protection in the New Orleans Metropolitan area (United States Government Accountability Office, 2005). The interested parties concerned with the hurricane threat to the Gulf Coast acted as if a disaster such as Katrina would not occur within the next few years. This is sometimes referred to as the NIMTOF (Not in My Term of Office) phenomenon. It was convenient to ignore the numerous studies that warned of the devastation that could occur in the Gulf Coast from a major hurricane. The media highlighted a potential catastrophe in the New Orleans area with the Pulitzer Prize-winning articles in *The Times-Picayune* that appeared on June 23–27, 2002, which stated that the existing levees were inadequate and that one of the nation's alleged highest priorities was to reinforce these flood control projects. A story in the October 2004 edition of the *National Geographic* warned about what could be the most devastating natural disaster in the US history (Bourne, 2004). The scenario painted in this piece became reality 10 months later.

This paper addresses the problem of what public policies might be put in place prior to a disaster to avoid large and often poorly-managed expenditures following a catastrophe and to provide appropriate protection against the risk of those large losses which do occur. We consider the social optimality of property-owners' disaster insurance and location decisions, but we do not assume, as did Kydland and Prescott, that property owners are expected utility maximizers and are forward looking. Instead, we argue that individuals utilize simplified heuristics in making their decisions and do not anticipate the government coming to the rescue in the wake of a flood, hurricane or earthquake but demand relief after suffering losses from a natural disaster. More specifically we show that many individuals move into hazard-prone areas without considering the likelihood or consequences of a disaster rather than calculating either what they should do to protect themselves or what the government will do should they locate there. Public sector agencies may also behave in ways that are inconsistent with optimal social policy by not using the principles of benefit-cost analysis when making their decisions as to whether to protect an area as illustrated by the Corps of Engineers decision not to strengthen the New Orleans levees.

The lack of interest in protection by property owners and by public sector agencies prior to a disaster creates major problems following a catastrophic event for victims and the government. Property owners who suffer severe damage may not have the financial resources

to rebuild their property and hence will demand relief. The government is then likely to respond with costly disaster assistance. To avoid these large *ex post* expenditures it may be useful to consider requiring insurance as a condition for residing in hazard-prone areas as a way of improving both efficiency and equity. This message has a similar ring to the Kydland-Prescott story about enforcing rules rather than allowing discretion, but for different reasons.

To motivate this discussion we provide empirical evidence that prior to a disaster many individuals believe the event will not happen to them so they behave as if the likelihood of a disaster causing damage to their property is zero. Hence they have no incentive to invest in protective measures voluntarily. After a large-scale flood, earthquake or hurricane, the government, representing other concerned citizens, will provide at least some financial assistance to aid the recovery of the unprotected victims—property owners and firms.

Hurricane Katrina provided graphic evidence of this behavior. Many homeowners suffering rising water damage from Hurricane Katrina did not have flood insurance even though they were eligible to purchase such a policy at a subsidized rate through the National Flood Insurance Program (NFIP).¹ The NFIP, which was established in 1968 by the federal government, provides highly subsidized rates for existing homes so that any risk-averse individual who made the appropriate calculations of the expected benefits and costs of purchasing such insurance should have wanted coverage. In the Louisiana parishes affected by Katrina the percentage of 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).

To aid the victims of Katrina and rebuild the Gulf Coast, the federal government subsequently committed to providing liberal disaster assistance. A few days after Katrina hit landfall, the US Senate voted nearly \$60 billion in federal aid. Under the Stafford Act as revised in June 2006, the maximum amount of assistance to any individual or household for repairing damaged property is \$25000 (FEMA, 2006). In addition, the Small Business Administration (SBA) offers loans of up to \$200000 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. According to the US Department of Homeland Security, as of April 2006, some \$88 billion in federal aid had been allocated for relief, recovery and rebuilding, with another \$20 billion requested, to help victims of Hurricanes Katrina and Rita to recover and rebuild. Although this figure represents an historical record of federal aid in the aftermath of a natural disaster, it has fallen far short of providing complete and timely protection against all uninsured losses from the hurricane.

The paper is organized as follows. The next section determines the optimal insurance decision for a homeowner who maximizes expected utility.² We then provide evidence from the laboratory and the field as to the limitations of this model for characterizing individual behavior. The empirical data present a picture of a consumer who is poorly informed, in the spirit of Daniel McFadden's recent Presidential address to the American Economic Association (McFadden, 2006). We then present an alternative sequential model of choice that reflects consumer limitations in collecting and processing information.

Section 3 examines the implications of a sequential model of choice for public policy. Section 4 outlines a possible improved program: a system of required comprehensive disaster insurance as an alternative to *ex post* disaster assistance. Such a program might represent an alternative kind of public sector involvement that could reduce losses prior to a disaster, cover

¹ For more details on the structure of the National Flood Insurance program see Pasterick (1968).

² A very similar model could have been constructed for mitigation as a substitute for insurance.

catastrophic losses, and/or to subsidize low income residents who cannot afford coverage. The concluding section summarizes the arguments in the paper and suggests directions for future research.

2 Models of insurance choice by homeowners

2.1 An expected utility model

The Waterman family in Orleans Parish with wealth W is considering how much flood insurance coverage (I) to purchase next year against water damage to their house from a future hurricane in the area. To keep the analysis simple and without loss of generality we assume only two states of nature—flood or no flood with annual probabilities p and $1-p$ respectively. If a flood occurs, the damage to the Waterman house will be L dollars. The cost of insurance per dollar coverage is z . According to Federal income tax laws any uninsured loss from a natural disaster can be written off on the family’s federal income taxes at the marginal tax rate t based on the Waterman’s current income. $D(I, L)$ is the amount of disaster assistance the family will receive should they have I dollars of insurance coverage and L dollars of losses.³

We assume that there are no moral hazard problems so that the Waterman family will not take advantage of purchasing insurance by either being more careless or putting objects in harm’s way (e.g. moving unwanted furniture to the basement). Furthermore we assume that the insurer has the same information about risk as the Waterman family, and charges risk-based premiums, so that there will be no adverse selection problems.

The optimal amount of insurance I^{opt} will be determined by maximizing the Waterman’s expected utility $E[U(I)]$:

$$E[U(I)] = pU[W - L + I(1 - z) + t(L - I) + D(I, L)] + (1 - p)U(W - zI)$$

where

$$0 \leq I \leq L$$

More specifically I^{opt} is determined by setting $dE[U(I)]/dI = 0$ which yields

$$\begin{aligned} & \frac{(1 - p)z}{p[1 - z - t + D'(I^{opt}, L)]} \\ &= \frac{U'[W - L + I^{opt}(1 - z) + t(L - I^{opt}) + D(I^{opt}, L)]}{U'(W - zI^{opt})} \end{aligned} \tag{1}$$

with D' and U' being partial derivatives, valued at I^{opt}

It is straightforward to determine the amount of insurance I^* an individual should purchase given that $0 < I < L$. Whenever the value of I^{opt} determined by (1) is between 0 and L , then this is the actual amount of insurance a homeowner should purchase. Should (1) yield a value of $I^{opt} > L$, which could be the case if the insurance premium is subsidized so that a person would want to buy more than full coverage, then $I^* = L$. If the solution to (1) indicates that $I^{opt} < 0$, then the individual will not purchase any coverage and $I^* = 0$.

³The amount of disaster assistance is assumed to have no impact on the uninsured losses that a person can write off for tax purposes.

The LHS of (1) is a contingency price ratio reflecting the tradeoff between the marginal benefit of not having insurance (the numerator) and the marginal benefit of having coverage (the denominator). The RHS is the ratio of the marginal utility of an individual in the disaster state to the marginal utility in the non-disaster state. A rational individual will be more likely to buy insurance as her value of L increases and/or as the premium z decreases relative to p . Insurance coverage will be less attractive according to this model when an individual expects significant disaster relief as a function of her uninsured losses and magnitude of her loss (L) and the higher the tax write-off for uninsured losses (t).

2.2 Empirical evidence on the expected utility model

Individuals normally purchase insurance on an annual basis and thus must decide each year whether to renew or cancel their policy assuming they have this discretion. In the case of residents in hazard-prone areas the annual probability of a disaster damaging their structure is not high; it is within the range of 1 in 50 to 1 in 500. So, while the financial losses should such an event occur can be significant, the great majority of people will not have observed an event close at hand recently. The evidence on decision making under uncertainty in these low probability cases suggests that many individuals do not utilize an expected utility model such as the one characterized above to determine how much insurance coverage to purchase. There are data from field and controlled laboratory experiments showing that those at risk do not even seek out information on probabilities in making their decisions on low probability, high consequence events. (Magat et al., 1987; Camerer and Kunreuther, 1989). When consumers are asked to justify their decisions on purchasing warranties (a form of insurance) for products that may need repair, they rarely use probability as a rationale for purchasing this protection unless the data on likelihoods are given to them explicitly (Hogarth and Kunreuther, 1995).

People have difficulty dealing with probabilistic information for small likelihood events because they need a context in which to evaluate the data. In one study individuals were presented with either a probability or an actuarially fair insurance premium characterizing the risks associated with the discharge of a hypothetical toxic chemical, Syntox (Kunreuther et al., 2001). The chemical had the potential for causing fatalities to individuals living near the fictitious ABC chemical plant located on the outskirts of an urban center in New Jersey. To give some reference points, respondents were also provided with the probability of death from a car accident. Finally, the participants were asked a set of questions regarding how risky they perceived the facility to be.

People were not able to distinguish between probabilities which ranged from 1 in 10,000 to 1 in 1 million in judging the riskiness of the facility. Surprisingly, the study also found that subjects did not respond to insurance premiums as a signal of risk. While individuals may not be able to think meaningfully about what a 1 in 100,000 chance of death means, they certainly know what a \$15 premium means. Yet individuals perceived no difference between the perceived risks of the ABC chemical plant, whether the annual premiums paid for coverage against fatalities from the release of Syntox were \$15.00, \$1.50 or 15 cents.

With respect to obtaining such data on their own, 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 even consider purchasing insurance (Kunreuther and Pauly, 2004). 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 to be 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.” (Kunreuther et al., 1978). This implies that an increase in premiums will cause people to buy less insurance, and that this negative impact on demand would not be offset by a compensating increase in loss probability. In contrast to the expected utility model where the demand for insurance depends on the premium relative to the expected loss, demand appears to depend only on the premium for a given amount of coverage.

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 (Kaplow, 1991; Harrington, 2000; Smetters, 2004). These studies claim that the expectation of federal disaster assistance creates a type of Samaritan’s dilemma: providing assistance after a catastrophe reduces the economic incentives of potential victims and the communities in which they live to invest in protective measures prior to a disaster. Empirical studies on this issue, however, suggest that decision makers do not report that they anticipate receiving any federal aid following a disaster. For example, 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) showed that local governments that received disaster relief undertook more efforts to reduce losses from future disasters than those that did not. This lack of expectation regarding disaster assistance prior to a disaster seems counter-intuitive and the reasons for it are not fully understood.

What is well understood is that large-scale losses from disasters are a driving force with respect to the actual provision of government relief (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. An 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 the SBA provided \$5000 forgiveness grants and 1% loans to rebuild houses, and in some cases to retire existing mortgages (Kunreuther, 1973). This special legislation highlights the point made by Kydland and Prescott that policymakers may be forced to respond to situations they had not anticipated in advance.

Public assistance is far from a perfect substitute for good private insurance. It normally takes longer to be paid than would the claims from private insurance policies, the compensation from the government falls short of total losses, and the amount and terms of the disaster assistance depend on random political influences including the proximity of the disaster to the date of the next national election. Thus the combination of low private insurance and haphazard public disaster relief may lead to inefficiency as well as high levels of government spending.

2.3 A sequential model of choice

Rather than using the expected utility model, many residents in hazard prone areas appear to follow a sequential model of choice. As a first stage in such a process individuals relate their perceived annual probability of a disaster causing severe damage to their property (p) to a threshold level of concern (p^*), which they may unconsciously set. If $p < p^*$ they assume that there is nothing to worry about and hence do not have to undertake protective measures such as purchasing insurance. 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 depend 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.

Data supporting such a sequential model have 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). More recent field surveys of homeowners in California undertaken by Risa Palm and her colleagues lend further confirming evidence to such a process. Four mail questionnaires undertaken since 1989 examine the spatial and demographic characteristics of those homeowners who had purchased earthquake insurance. The findings indicate that insurance purchase is strongly influenced by past experience but unrelated to any measure of seismic risk from experts (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. Insurance coverage by homeowners between 1989 and 1990 rose from 40.4 to 50.9 percent in Santa Clara County and from 22.4 to 29.3 percent in Contra Costa County. It is hard to explain this behavior by using a Bayesian learning model since most individuals residing in California know that the likelihood of another earthquake causing damage to their homes is lower after one has occurred because the stress in the fault lines have been relieved.

There is also empirical evidence that many homeowners who initially purchase insurance are likely to cancel policies if they have not made a claim over the course of the next few years (Kunreuther et al., 1985). 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 that residents in hazard-prone areas adhere to the law, 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). 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 was down from 30 percent to 15 percent (Risk Management Solutions, 2004). Insurance appears to be treated by many individuals as an investment rather than a protective measure. Those who purchase coverage and do not collect on their policies over the next few years feel that their premium payments have been wasted. In the case of flood insurance, this finding also indicates that some banks, which were expected to enforce the requirement that individuals in high-hazard areas purchase flood coverage, looked the other way.

The effects of premiums on the demand for insurance in a sequential model are more ambiguous than in an expected utility model. As indicated above, given that p is high enough that people pay attention, higher premiums do discourage purchasing coverage and lower premiums to some extent encourage it. However, many people choose not to obtain flood

coverage even when their rates are highly subsidized because they perceive the likelihood of a flood to be below their threshold level of concern. It may also be the case that a decision to build or improve property is related to insurance premiums, with high premiums discouraging building in high risk areas and low premiums encouraging it, but we do not know the importance or magnitude of this incentive.

In short, in the sequential model the minority who buy insurance voluntarily may pay attention to higher prices relative to lower prices, even when they do not discriminate between higher and lower loss probabilities when these likelihoods are below p^* or there has been no recent loss-producing event. However, the empirical evidence on the ability of insured individuals to relate premiums to risk is at present inconclusive.

3 Public policy and sequential consumers

If consumers generally ignore both loss probabilities and potential government assistance in deciding whether or not to buy insurance and how much insurance to purchase, public policy toward natural disasters can be simpler than in a world in which public actions produced private reactions. Under this sequential model, some consumers will decide to buy private insurance at a given premium and some will not. When a disaster strikes, some victims will not have insurance to cover their losses and others will have incomplete coverage. The rationale for government intervention in such cases is altruistic sentiments of other citizens with an expectation that the government will bail them out should they suffer losses in the future.

Concern for our fellow citizens as well as our own needs should disaster strike home makes us want our government to help out, and in a democracy the public sector responds. How far this assistance will aid the financial recovery of victims depends on the strength of these feelings, and on the magnitude of the disaster. In this view of the world, much of the common concern for a “Samaritan’s dilemma” affecting citizen-protective activities seems misplaced. We taxpayers would be much better off if people who lived in disaster-prone areas bought insurance, but most of these residents do not invest in this type of financial protection voluntarily.

Public intervention based on our concern for fellow citizens can be straightforward: provide as much assistance as our conscience dictates to fill in the observed gaps in coverage, both in terms of *ex ante* protective activities (like the aforementioned levees) and in terms of *ex post* financial assistance. If such choices represent outcomes that are incomplete or inefficient according to the “selfish” expected utility model, it is irrelevant because people are not using this model of choice anyway.

While some public officials might contemplate expected-utility-based efficiency as a goal in a democracy, they would have a difficult time implementing the higher taxes needed to support more complete prevention or protection. If, as hypothesized, local citizens do not anticipate catastrophes or generally think they are impossible until after they occur, higher local taxes to pay for *ex ante* protection will not gain support. And higher local taxes to pay post-disaster benefits will not be feasible, given the diminution in the value of the tax base.

If others than those who might potentially benefit are to pay, their motivation will have to be altruistic with some expectation for themselves should they suffer losses in the future.⁴ While it is always risky to speculate on positive models of political behavior, it does seem that

⁴ The alternative and rational argument, that payment now for others sets the stage for a *quid pro quo* should disaster strike here, will founder based both on non-enforceability and the assumed absence in citizens of the expected utility motivation that would justify such an argument.

the case for full efficiency in the expected utility sense is difficult to make in a democratic model where few voters make decisions in that fashion. One implication of this simpler sequential model of choice is that it explains the common finding of “deficiencies” in public sector activities prior to a disaster, whether by the Corps of Engineers or FEMA, as the natural and political equilibrium of a system in which misinformed and distracted citizens are also misinformed and distracted voters. Once the disaster occurs, then the victims and the general public are concerned and the amount of federal disaster assistance by FEMA and other agencies as well as the decision to invest in better protection by the Corps of Engineers is determined by political forces that are difficult to predict in advance.

4 Advantages of mandated comprehensive disaster insurance⁵

The previous sections have documented the lack of consumer interest in purchasing disaster insurance voluntarily prior to a catastrophe, and the inefficiency of government assistance as a form of insurance following a major disaster. This section makes the case for some form of required or mandated comprehensive natural disaster insurance with additional public sector involvement for assuring supply of protection against catastrophic losses at reasonable premiums for coverage that cannot be handled by the private market in the form of reinsurance, catastrophe bonds or insurance pools. Insurance would obviate the need for disaster assistance for property damage. The public sector may need to provide subsidies for insurance to low income residents whose remaining consumption would be substantially reduced by the cost of coverage. We also consider the desirability of basing private premiums on site-specific risk rather than averaging premiums over a wide geographic area.

4.1 Efficiency improvements from expanding homeowners coverage

Current insurance market institutions distinguish between events based on the cause of that damage. The typical homeowners’ policy covers losses from “all perils” with only a few exceptions such as earthquakes or floods. Earthquake insurance can be purchased from the private sector for an additional premium. In California one normally buys an earthquake policy for residential damage through the California Earthquake Authority, a state-run privately-funded earthquake insurance program,⁶ although some private insurers offer earthquake coverage today. As pointed out in the introduction, subsidized flood insurance for residential structures is offered through the National Flood Insurance Program (NFIP).

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, so they were ineligible for claims payments. Those who did have flood insurance and suffered large losses from the rising waters were only able to cover a portion of their losses because the maximum coverage limit for flood insurance under the NFIP is \$250000 on building property and \$100000 on personal property (Hartwig and Wilkinson, 2005b).

Expanding the standard homeowners’ policy marketed by private insurers to include earthquake and flood thus has considerable appeal. Its primary benefit is integration of disaster

⁵This subsection is based on Kunreuther (2006).

⁶For more details on the California Earthquake Authority see Roth, Jr. (1998).

relief into the private insurance vehicle rather than administering some of the assistance through politically influenced and non-competitive government agencies. Anticipated public payment for disaster relief can be turned into *ex ante* subsidies in the form of grants or low-interest loans to make the required coverage affordable for low income residents in high hazard areas.

A mandated all-natural-hazards insurance program also might reduce the variance associated with nationwide insurers' losses relative to their surplus in any given year.⁷ Consider an insurer marketing coverage to homeowners throughout the country. 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 flood risk in the Mississippi Valley. Because of the mandate, insurers need not be concerned that buyers in any part of its portfolio will drop coverage should it charge high premiums based on risk. Using the law of large numbers, 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.

Such insurance may also be attractive to both insurers and policyholders in hurricane-prone areas because it avoids the costly process of having an adjuster 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 perils, including natural hazards regardless of type, 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 insured 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. How these policies are framed also matters. Are they characterized as an investment on which one might obtain a high return, are they presented as a way of pooling risk in the community, or are they sold simply as insurance? By combining all natural disasters into a single policy, it is more likely that a property owner will consider purchasing insurance because the likelihood

⁷ Insurers who offer coverage in one region of the country could have the variance of their losses increase by combining all-hazards in one policy. For example, a Florida insurance company providing protection against hurricane damage might find the variance in losses to be higher than it is today if both wind and water damage were covered under a homeowners policy. It would collect more premiums than before but may still want to purchase additional reinsurance than it currently does to cover the possibility of a very large loss resulting from a future hurricane.

of some loss is above her threshold level of concern and search becomes rational. If all natural hazards were included in a homeowners' policy, the risk might be large enough to get the consumer's attention (Kunreuther and Pauly, 2004). Such a policy has added benefits to the extent that individuals are unaware that they are unprotected against rising water or earthquake damage in their current homeowners' policy.

4.2 Risk-based premiums for mandated insurance: Further considerations

If one believes that those residing in hazard-prone areas should be responsible for bearing their own financial burden for losses from a natural disaster, then insurance rates should reflect the risk. The use of catastrophe models and exceedance probability curves can be extremely useful in this regard for determining and legitimizing the types of rates that should be charged. (Grossi and Kunreuther, 2005).

Risk-based rating can be efficiency-improving in several dimensions. It provides a signal to individuals as to the risk they actually face so they can make a different decision as to whether or not they want to invest and reside there. High premiums in high risk areas might even prod sequential decision makers into considering loss probabilities and therefore making more rational investments in mitigation. Such insurance is efficient by having those at risk bear the expected costs of residing in hazard-prone areas, and therefore potentially deciding to live in areas with lower expected housing costs.

A system of risk based premiums also provides economic incentives to homeowners to invest in cost-effective loss prevention measures. Today insurance rates in high hazard areas are subsidized so that insurers have little reason to offer coverage, let alone provide premium discounts for the adoption of mitigation measures. For example, in Florida insurance rates along the coast subject to hurricanes are regulated so that the rates are below the risks (Grace et al., 2004). The Citizens Property Insurance Company, a state-run insurer established in 2002 as a residual market mechanism to provide insurance to individuals who are unable to obtain coverage in the voluntary market, accounted for approximately 20 percent of the homeowners insurance in the state at the end of 2004 with premiums at \$1.2 billion.⁸ Following the hurricanes of 2005, a number of additional insurance policies were transferred to Citizens, so their share of the Florida insurance market is somewhat higher today than at the end of 2004.

In order for the private sector to provide insurance using risk-based premiums, state Insurance Departments will have to support this effort. Harrington (2006) points out that 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 occurred in Florida and Louisiana following Hurricane Katrina (Hartwig and Wilkerson, 2005a). The implementation of a mandate requiring everyone to purchase coverage will give regulators less of a reason to bow to political pressure to cross-subsidize rates from intense minorities, such as high-income residents with large homes in high-risk areas, who can afford this coverage.

There are also distributional issues that have to be dealt with under such a system. Some homes in high-risk areas are owned by low-income families who will have to reduce their other consumption substantially, perhaps below a socially acceptable level, in order to pay

⁸ More details on the Citizens exposure in the Florida insurance market at the end of 2004 can be found at http://www.citizensfla.com/mo_reports/12-04morep.asp.

Table 1 Proposed comprehensive disaster insurance program

Layer	Who bears the cost
1 Self insurance	Property owner
2 Private insurance	Insurance companies
3 Risk transfer	Reinsurers and capital markets
4 State funds, multi-state pools	State and federal government and federal reinsurance

the costs of risk-based 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 in the form of low-interest loans or grants should be provided to this group by a federal, state or local government agency to enable them to purchase insurance or invest in mitigation. This could be in a form similar to the food stamp program today where the funds in this case would have to be used to purchase insurance. Risk-based insurance premiums would also discourage lower income households from moving into areas where the cost of residing there is high relative to their benefits from that location compared to living somewhere safer.

4.3 A public-private partnership

This section considers mandated comprehensive natural disaster insurance in combination with other public-private sector initiatives to reduce future disaster losses. It incorporates features of a proposal by Doherty et al. (1990) for insuring against environmental pollution and by Litan (2006) for insuring against natural disasters. Table 1 summarizes the four layers comprising the program.

Layer 1 is self-insurance by the homeowners 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 an insurance policy. The magnitude of the deductible could vary depending on the amount of coverage in place (e.g. a percentage deductible) and the needs of those at risk. Of course, if higher deductibles were permitted, homeowners who choose such policies would not be eligible for disaster assistance to cover the cost of those deductibles.

Some upper limits would therefore need to be placed on the deductibles in the mandatory insurance program, with the maximum deductible probably falling with income, perhaps offset by larger insurance subsidies. That is, a well-off household might be permitted to take insurance with a five figure deductible, because such a deductible would still be small relative to their total wealth. A low income household might be forbidden from purchasing inexpensive but incomplete coverage that puts a larger share of their wealth at risk. To offset the more expensive premium, the poorer household might be given a larger subsidy. Doing so would leave them less needy in the event of a disaster than if they were permitted to purchase a higher deductible.

Layer 2 consists of private insurance with the amounts of coverage based on insurers' surplus, their current portfolio, and their ability to diversify across risks. *Layer 3* is comprised of private sector risk transfer mechanisms that include reinsurance and catastrophe bonds. The proportion of funds allocated by insurers to each risk transfer mechanism will depend on the prices and available coverage. *Layer 4* provides financial protection against large scale losses. It could take the form of state funds or multi-state pools for providing coverage in certain regions of the country subject to particular hazards, such as hurricanes in Florida or the Gulf Coast states and earthquakes in California. The federal government could also offer catastrophe reinsurance contracts and/or provide pre-funded federal reinsurance for

mega-catastrophes. Layers 2–4 would be administered by private insurers; the government's role would be limited to assisting on the supply side. That is, in the ideal case, the work of selling insurance, collecting premiums, and paying claims would be done by the insurance company; the government reinsurance (from the consumer's viewpoint) would only serve to make the initial insurance premium lower or the availability of coverage greater. Only the primary insurer would need to deal with the government reinsurer, probably transferring a portion of the premium to it. The consumer need only talk to his primary insurer and would not need to get FEMA on the phone.

In order to avoid the inefficiencies and inequities associated with disaster assistance discussed in Section 3, homeowners in hazard-prone areas need to have purchased coverage prior to a catastrophic event. Since homeowners' insurance is currently required as a condition for a mortgage by banks and financial institutions, these entities would very likely require the comprehensive disaster insurance policy proposed here, but the benefit would need to be large enough to cover both the lender's liability and the homeowners' equity. States might well require homeowners who do not have a mortgage to purchase this coverage in much the same way that automobile insurance is mandatory today. Such a mandate could be enforced by linking property taxes to evidence of coverage, with a tax penalty or fine imposed on properties that cannot provide evidence of continuous insurance coverage.

For such 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. Banks 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. Between 1993 and 1998 these rebates were applied to 6300 houses, representing approximately \$4.4 million in foregone revenues to the city (Earthquake Engineering Research Institute, 1998).

There are likely to be a number of low-income residents who reside in high-hazard areas. 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. It may be more efficient for them to move to less risky areas rather than occupy what is, in effect, high cost housing.

5 Summary and future research needs

This paper discusses mandated comprehensive disaster insurance for all homeowners as an alternative to the current program because people today do not voluntarily protect themselves

against some natural disasters such as flood and earthquakes. As Kydland and Prescott (1977) show in their path-breaking paper, policy makers may develop policies that are not socially optimal if individuals are given unlimited discretion in making their choices. We have shown here that public disaster assistance is a form of insurance that is suboptimal relative to coverage purchased prior to the event where the premiums are based on the risks faced by the property owner. To the extent that some homeowners do not use a sequential model of choice but rather react in an expected utility maximizing way to premiums and to the presence of public assistance, such behavior will need to be taken into account in the design of an insurance program. Such a reaction, if widespread, would further strengthen the cases both for mandates and *ex ante* subsidies of insurance for lower income residents in the form of grants or low interest loans.

Future research requires a deeper understanding of the factors that influence individuals to purchase insurance and invest in protection voluntarily and those that discourage them from doing so. There is also a need for a study on the ability of the private market to provide insurance protection against disasters and the relative effectiveness of disaster assistance compared with comprehensive disaster insurance.

One also needs research on how to obtain better data to reduce the uncertainties surrounding the risk assessment process, how one can provide better information on the risk and alternative ways of reducing the risk faced by different interested parties ranging from the potential victims to government agencies. Future studies should therefore focus on 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.

We also need better research on the public decision making process. Is it reasonable to think that a proposal for a mandate can garner widespread voter support when many voters follow the sequential process of choice? Insurers and regulators will find their lives made easier by mandates, and voters in the affected areas will presumably not be distressed to learn of the disappearance of *ex post* disaster assistance payments they did not expect to receive in the first place. But as long as insurers price in an actuarial fashion, the mandate will mean a positive increase in housing costs for households who had not thought that these disasters could happen to them. Lower income people will have the increases cushioned (though not taken away entirely) by subsidies, but the middle class especially may object to being charged for insurance which they think they do not need and will never use. How to assemble at least a minimal winning coalition of citizens to make mandated coverage feasible is a crucial research topic.

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 effects.

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