Insurance as an Integrating Policy Tool for Disaster Management: The Role of Public-Private Partnerships

Howard Kunreuther, M.EERI

Insurance can play a key role in facilitating public-private partnerships for dealing with the losses from future natural disasters. This paper proposes a hazard management program, which links insurance with other policy tools and brings together key interested parties concerned with earthquakes. It stresses the importance of identifying and assessing the risk, understanding both the decision processes of individuals in hazard-prone areas and the insurability issues associated with the earthquake risk. A series of policy-related questions raise issues for future research.

INTRODUCTION

The economic costs of natural disasters have taken a quantum leap since 1989 and are likely to soar in the future unless some critical steps are taken to change this trend. Insurance is a potentially powerful policy tool for both reducing future losses from hazards while also providing financial protection should a disaster cause damage to ones property and/or its contents.

Insurers, however, 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 have the insurers join forces with banks and financial institutions who would require that the house meet certain building code standards before they issued a mortgage and make insurance a requirement as a condition for a mortgage. Insurers could reduce their premiums to reflect the lower risks from the adoption of these codes.

The role of insurance in facilitating public-private partnerships is the key theme of a book entitled Paying the Price, published by the Joseph Henry Press. It brings together the views of a number of experts who are concerned with the role that insurance in combination with other policy tools can play in reducing future losses from natural disasters. This paper summarizes the principal findings from the book and relates them directly to the challenges that we face in dealing with the losses from future natural disasters. I will illustrate these ideas by focusing on the earthquake peril.

The next section discusses the nature of the problem, the key interested parties and the potential role that insurance can play along with other policy tools for reducing losses and providing protection. Section 3 then turns to the identification and risk assessment issues and how one deals with uncertainty which is endemic when one deals with low-probability/high-

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MULTIPLE STAKEHOLDERS

The key interested parties concerned with natural disaster damage, their principal roles, and their linkages with each other are depicted in Figure 2. At the top of the figure are the reinsurance industry, the capital markets and federal government agencies, each of whom have special roles to play with respect to providing protection against catastrophic losses. The Federal Emergency Management Agency (FEMA) and other federal agencies have stressed the importance of building codes and enforcement of regulations to reduce losses from natural disasters.

Reinsurers relate to insurers in the same manner that insurers do to property owners. They provide protection to primary insurers by insuring a portion of their claims in exchange for a premium. For all but the largest insurance companies, reinsurance is a prerequisite to offering insurance against natural disasters when there is a potential for catastrophic losses. Recently the capital markets have provided private insurers access to funds in the form of catastrophic bonds. The insurer borrows from investors or an institution at higher than normal interest rates to cover extreme losses from hurricanes and earthquakes that exceed a trigger amount. If this amount is exceeded then the interest on the bond, the principal, or both, are forgiven.\(^1\)

The primary insurance companies, as shown in Figure 2, provide direct insurance coverage to residential and commercial sectors for losses such as those caused by fires (including those resulting from earthquakes) and wind damage from tornadoes and hurricanes. Primary insurance companies offer this coverage through the standard homeowners' policies normally required as a condition for a mortgage, and through commercial multi-peril policies.

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consequence events. The assessment of the risk is a critical input to determining the insurability of a particular risk. Section 4 focuses on whether the earthquake hazard is insurable and if new public-private partnerships, in the spirit of the California Earthquake Authority (CEA), are needed to provide protection to property owners. Section 5 then turns to the demand side of the equation and looks at the changing market for earthquake coverage in California.

If insurance is to play an important role in helping to reduce future losses it needs to be intimately connected with mitigation. The challenge in using insurance to encourage the adoption of cost-effective loss reduction measures is the subject of Section 6. Section 7 is devoted to the appropriate roles of the state insurance regulator with respect to setting rates, imposing coverage requirements, and minimizing the probability that firms will become insolvent following a catastrophic disaster. Section 8 proposes a hazard management program for reducing disaster losses and providing money for recovery. The success of such an effort depends on the ability of insurers to work closely with other interested parties such as financial institutions, public sector agencies, and the capital market. The concluding section provides a brief summary and suggests directions for future research.

At the end of each section a series of policy–related questions are raised that are designed to stimulate discussion. Not surprisingly, there are no easy answers to these questions. Everyone recognizes that the problem of managing catastrophic losses is a challenging problem.

**NATURE OF THE PROBLEM**

Since 1989 insurance and reinsurance firms have suffered losses from disasters in the United States that have wreaked havoc with their balance sheets. Figure 1 depicts the magnitude of the catastrophic losses experienced by the insurance industry in the United States from 1949 to 1997. The drastic change from 1989 to 1997 is obvious. Prior to Hurricane Hugo in 1989 (where insured losses were over $4 billion), the insurance industry had never suffered any loss of over $1 billion from a single disaster. Since that time they have had 10 disasters which exceeded this amount with Hurricane Andrew in 1992 causing over $15 billion in insured losses and the Northridge Earthquake of 1994 resulting in over $12.5 in insured losses. Commercial development has followed the population's movement to coastal areas, and this has increased the potential economic losses from natural disasters in this part of the country. A significant amount of damage from natural disasters would be averted if wind and seismic building codes were adopted and enforced, and if individuals took protective measures.

The insurance industry was caught off guard by the very large increase in exposure in hazard-prone areas and hence had significantly underestimated the losses that could occur. Given the large increase in the magnitude of losses from recent disasters, insurers and reinsurers are concerned about their financial ability to cover claims from future catastrophic disasters. They have thus been reluctant to provide coverage against wind damage from hurricanes in certain parts of Florida and earthquake insurance in California. New institutions, such as the California Earthquake Authority, have emerged to try and satisfy this demand. It is thus not surprising that property owners in these hazard-prone areas are experiencing greater difficulty today than in the past in acquiring insurance and are paying considerably more for it.
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Today coverage for shaking damage from earthquakes can be purchased as an addition to homeowners' policies in all states except California. A new public-private partnership, the California Earthquake Authority (CEA), formed in 1996, offers homeowners in the state earthquake coverage as a separate policy. For commercial structures, earthquake protection for property damage coverage is often included as part of a multiperil policy.

**POLICY IMPLICATIONS**

A coherent strategy has not yet been developed for coping with the changing role that natural hazards are playing in our lives. There is general agreement that it is important to take steps to reduce losses from future disasters. In fact, FEMA introduced a National Mitigation Strategy in December 1995 with the objective of strengthening partnerships between all levels of government and the private sector to ensure safer communities. This strategy was developed with input from state and local officials as well as individuals and organizations with expertise in hazard mitigation (FEMA, 1997).

One question that needs to be addressed is the appropriate roles of the private and public sectors in financing the cost of recovery from large-scale natural disasters. To the extent that private insurance markets provide protection against catastrophe risk, policymakers must decide how these markets should be regulated. They must also determine the role of land-use regulations and building codes and the extent to which private choice and incentives will guide hazard mitigation efforts. Within the realm of public choice, decisions also must be made with respect to the delegation of authority among the different levels of government and its agencies. In evaluating these options policymakers must consider how various government actions affect the behavior of firms and individuals in responding to catastrophe risk.
IDENTIFICATION AND ASSESSMENT OF RISK

In order to determine a risk management strategy for managing earthquakes it is important to be able to identify and assess the probability and consequences of events of different magnitude. In the case of low probability-high consequence (LP-HC) events there are limited past data on which to base these estimates and one must rely on scientific data to undertake these analysis.

New scientific studies and engineering analyses offer an opportunity to estimate the risks and potential losses of future disasters more accurately than in the past. Currently, there are a number of publications on the use of expert opinion in probabilistic risk assessment (Clemen and Winkler, 1992; Cooke, 1991) that can be utilized for a sensitivity analysis of damage parameters and loss estimation (Earthquake Engineering Research Institute, 1997). Many of these scientific and engineering studies have been incorporated in a regional loss estimation model (HAZUS) developed by the federal government to estimate monetary losses as well as other types of impacts from an earthquake event (e.g., hospital and shelter requirements) (National Institute of Building Sciences, 1997).

New advances in information technology have also led to the development of catastrophe models (CMs) which have proven very useful for quantifying risks based on estimated probabilities and expected damage. A catastrophe model is the set of databases and computer programs designed to analyze the impact of different scenarios on hazard-prone areas. A CM combines scientific risk assessments of the hazard with historical records to estimate the probabilities of disasters of different magnitudes and the resulting damage to affected structures and infrastructure (U.S. Congress, 1995).

Specifically, CMs combine the characteristics of the disaster with characteristics of the property in the affected region to determine a damageability matrix. This matrix provides information on the potential losses from disasters of different magnitudes to the structures at risk. Depending on the type of insurance coverage available, one can then estimate the insured loss per property (see Insurance Services Office [1996]). The information from a CM can be presented in the form of expected annual losses and/or the probability that in a given year the claims will exceed a certain amount. CMs can also be used to calculate estimated insured losses from specific hypothesized events (e.g., a severe earthquake hitting Los Angeles or San Francisco).

Figure 3 illustrates the interaction between these different components of the CM for the earthquake hazard.

SUPPLY OF INSURANCE

In order for insurance and reinsurance companies to be willing to supply coverage against specific risks, they must view them as being insurable. This section focuses on what it means for a risk to be insurable and how this concept applies to the earthquake problem.

Two conditions must be met before insurance providers are willing to offer coverage against an uncertain event. Condition 1 is the ability to identify and estimate the chances of the event occurring, and the extent of losses likely to be incurred when providing different levels of coverage. Condition 2 is the ability to set premiums for each potential customer or class of customers. This requires some knowledge of the customer’s risk in relation to others in the population of potential policyholders.
Figure 3. Modeling the effects of earthquake shake damage on insured losses.

If Conditions 1 and 2 are both satisfied, a risk is considered to be insurable. But it still may not be profitable. In other words, it may impossible to specify a rate for which there is sufficient demand and incoming revenue to cover the development, marketing and claims costs of the insurance and yield a net positive profit. In such cases the insurer will opt not to offer coverage against this risk.

CONDITION 1: IDENTIFYING THE RISK

To satisfy this condition, estimates must be made of the frequency at which specific events occur and the magnitude and nature of the resulting losses. Such estimates can be based on data from previous disasters and scientific analyses of what the future is likely to bring.

With respect to the earthquake risk, the California Insurance Department has prepared a detailed questionnaire that insurers are required to complete annually that elicits information to estimate the Probable Maximum Loss (PML) from a major earthquake in each designated seismic zone in the state. Although the data from individual insurers is kept confidential, the aggregate results are published.

To supplement these past data, one has to rely on scientific information on the risk. With respect to earthquakes, experts have been working to reduce the ambiguity and uncertainty in predicting the location, severity, frequency of occurrence, and physical effects of these events. Over the past 20 years seismologists have discovered factors that influence the probability of an earthquake in a specific area, by examining geologic records, looking at actual events, and conducting experiments on how the ground responds to earthquake processes. However, scientists are still uncertain as to how different factors interact with each other and their relative importance (Hanks and Cornell, 1994).
Engineers have focused on the nature, distribution, and level of damage from earthquakes. However, there is still considerable uncertainty about the damage earthquakes are likely to cause to different structures. Hazard risk maps have been drawn for earthquakes, but they only provide rough guidelines as to the likelihood and potential damage from specific events. The recent use of geographic information systems (GIS) for incorporating geologic and structural information for a region has enabled scientists to estimate potential damage and losses from different earthquake scenarios. The data for the region are stored in the form of GIS maps of ground shaking estimation, maps of shaking and fault rupture and maps of damage to structures in the region (King and Kiremidjian, in press).

**CONDITION 2: SETTING PREMIUMS FOR SPECIFIC RISKS**

Once the risk has been identified, the insurer needs to determine what premium it can charge to make a profit while not subjecting itself to an unacceptably high chance of a catastrophic loss. There are a number of factors that play a role in determining what prices companies would like to charge. I will only briefly review these factors in the discussion that follows. More details can be found in Kunreuther (1998). The insurers are assumed to be free to set the premiums at any level they wish. In reality, state regulations often limit insurers in their rate-setting process.

**Ambiguity of Risk**

Not surprisingly, the higher the uncertainty regarding the probability of a specific loss and its magnitude, the higher the premium will be. As shown by a series of empirical studies, actuaries and underwriters are averse to ambiguity so that they tend to charge higher premiums than if the risk were well specified.

**Adverse Selection**

If the insurer sets a premium based on the average probability of a loss, using the entire population as a basis for this estimate, those at the highest risk for a certain hazard will be the most likely to purchase coverage for that hazard. In an extreme case, the poor risks will be the only purchasers of coverage, and the insurer will lose money on each policy sold. This situation, referred to as adverse selection, occurs when the insurer cannot distinguish between the probability of a loss for good- and poor-risk categories. The assumption underlying adverse selection is that purchasers of insurance have an informational advantage by knowing their risk type. Insurers, on the other hand, are assumed to have to incur considerable expense to collect information to distinguish between risks.

**Moral Hazard**

Providing insurance protection to an individual may lead that person to behave more carelessly than before he or she had coverage. If the insurer cannot predict this behavior and relies on past loss data from uninsured individuals to estimate rates, the resulting premium is likely to be too low to cover losses. Moral hazard refers to an increase in the probability of loss caused by the behavior of the policyholder. Obviously, it is extremely difficult to monitor and control behavior once a person is insured. How do you monitor carelessness? Is it possible to determine if a person will decide to collect more on a policy than he or she deserves by making false claims?
Correlated Risk

Correlated risk refers to the simultaneous occurrence of many losses from a single event. If a risk-averse insurer faces a highly correlated losses from one event, it may want to set a high enough premium not only to cover its expected losses but also to protect itself against the possibility of experiencing catastrophic losses. An insurer will face this problem if it has many eggs in one basket, such as providing earthquake coverage mainly to homes in Los Angeles County rather than diversifying across the entire state of California.

Summary

In theory insurers can offer protection against any risk that they identify, and for which they can obtain information to estimate the frequency and magnitude of potential losses as long as they have the freedom to set premiums at any level. However, due to problems of ambiguity, adverse selection, moral hazard, and highly correlated losses, they may want to charge prices that considerably exceed the expected loss. For some risks the desired premium may be so high that there would be very little demand for coverage at that rate. In such cases, even though an insurer determines that a particular risk meets the two insurability conditions discussed above, it will not invest the time and money to invest in the product. More specifically, the insurer must be convinced that there is sufficient demand to cover the development and marketing costs of the coverage through future premiums received.

If rates are regulated, as they generally are by states, then the premiums that insurers are allowed to charge will be so low that insurers may prefer not to offer coverage. This was the case with respect to earthquake insurance in California. In 1985 a California law required insurers writing homeowners coverage on 1 to 4 family homes to offer quake coverage on this structure. Since rates were regulated by the State, insurers felt they were forced to offer coverage against structures in old or poor condition without the rates necessarily reflecting the risk. This opened them up to the possibility of adverse selection.

The Northridge quake of 1994 with its high insured losses created a large demand for earthquake coverage. Many insurers were concerned that if they satisfied all this demand, as they were required to do by the 1985 law, they would face too high a risk of insolvency following another severe earthquake. Hence they decided to stop offering quake coverage or restricted selling homeowners policies in the state.

THE CURRENT SCENE

What is the current scene in California today with respect to the supply of earthquake insurance? The State legislature authorized the formation of the California Earthquake Authority (CEA) in 1996 for protection against damage to homeowners' property. Total funding of $105 billion with insurers providing up to $6 billion and the remainder from the reinsurance industry and Berkshire Hathaway. Rates were raised from their current levels and the deductible was increased from 10% to 15%. This meant that if one purchased full insurance on a house valued at $200,000, the property owner would have to pay the first $30,000 of repairs from future quake damage. Private insurers can still offer coverage against

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2 At the time of the formation of the CEA, the capital market had never been used to back potential earthquake losses. In the proposed plan capital markets were given the opportunity to cover the layer of losses from $7 to $8.5 billion. Before the markets had a chance to raise the full amount of capital, Warren Buffet of Berkshire Hathaway offered to cover the layer with his company’s funds, and the insurance Commissioner accepted his offer (Roth, 1998).
earthquake risks but the CEA is the principal form of coverage that is being supplied to homeowners. All commercial insurance is still provided by the private sector.

As we will show in the next section the demand for coverage under the CEA has declined dramatically. Hence those providing layers of protection now have an even more attractive investment than they may have thought initially. They knew they would receive a fixed premium for their layer which yielded a very high expected return even if everyone with quake insurance prior to the formation of the CEA renewed their policy. With the large number of cancellations, the reinsurers and Berkshire Hathaway have what amounts to a risk-free investment, since it is almost impossible that their layer will be impacted by losses from a major earthquake.

In the past couple of years investment banks and brokerage firms have shown considerable interest in developing new financial instruments for protecting against catastrophic risks (Russell and Jaffee, 1996). Their objective is to find ways to make investors comfortable trading new securitized instruments covering catastrophic exposures, just like the securities of any other asset class. In other words, catastrophe exposures would be treated as a new asset class. Turning to the public sector, today there is no federal reinsurance against earthquakes despite numerous congressional proposals over the year to provide protection against losses from mega-catastrophes.

DEMAND FOR EARTHQUAKE INSURANCE

Until the recent set of earthquakes beginning with the Coalinga 6.7 magnitude earthquake in 1983 and culminating in the most damaging of all quakes, the Northridge earthquake of January 1994, the demand for earthquake insurance by homeowners had been rather sluggish. In fact, in the early 1970s several insurance companies were pushing earthquake insurance in CA through aggressive advertising campaigns but found an unwilling market (Syfert, 1972).

In the 1970s less than 10 percent of the homes were insured against earthquake damage. By 1995 over 40 percent of the homes in many areas along the coast were insured against this risk. Since the threat of earthquake damage is much less in the interior of the state, fewer homes have been insured in inland cities such as Fresno and Sacramento (Palm, 1998). Data from the California Insurance Department indicates that as of the end of 1994 approximately 30 percent of homeowners in the State had purchased earthquake insurance.

The principal reasons that homeowners have given for their lack of interest in purchasing insurance is that they either feel the chances of a future disaster are so low that it is not worth worrying about and/or because of budget constraints (Kneuether, 1996). With the formation of the CEA many individuals who had earthquake coverage canceled their policies because they felt that it was too expensive and that they would not be adequately protected with the 15 percent deductible. As of July 1997 the number of earthquake policies written through the CEA is about half of what they had anticipated. Those who had earthquake insurance before and are now choosing not to buy the CEA policy have been complaining, as are those who are still renewing their coverages. This suggests that there is a strong interest among many property owners in protecting their homes against earthquake damage (Roth, 1998).

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3 More details on the formation of the CEA and its structure can be found in Roth (1998).
SURVEY FINDINGS ON INSURANCE PURCHASE

Three surveys of a population of owner-occupiers in Contra Costa, Santa Clara, Los Angeles, and San Bernardino Counties in 1989, 1990, and 1993 showed a dramatic increase in earthquake insurance purchase from the 1973-74 baseline, and a gradual increase in all these counties over the four-year study period (Palm, 1995). Contra Costa County had the lowest percentage of earthquake insurance purchase, starting at 22 percent insured in 1989 and ending with 37 percent insured in 1993. The highest percentage of earthquake insurance purchase was in Santa Clara County, with the percentage of insured properties jumping from 40 to 54% following the in the four years following the Loma Prieta earthquake of 1989.

In the 1989-1993 surveys, those who purchased insurance were asked to assess factors that affected their purchase decision. The most important motivating reason for those who purchased insurance was that “I worry that an earthquake will destroy my house or cause major damage in the future.” The other factors that motivated homeowners to purchase coverage were “the fear that they would have lost an important part of their equity from the earthquake” and that “they would not have funds to rebuild their damaged home.”

The least important reasons for purchasing insurance were “my neighbors or friends or relatives or colleagues convinced me to have earthquake insurance,” “my real estate agent encouraged me to buy it,” and “my mortgage lender suggested that I have it.” Insurance purchase was thus motivated by anticipated losses, fear that governmental aid will be unavailable or insufficient, and an estimate of likely damages as opposed to the cost of premiums. The influence of family, friends, real estate agents, or mortgage lenders was negligible.

These survey findings represent a distinct change from the factors influencing purchase decision in the early 1970s, when knowing someone with insurance and talking about insurance with someone were among the most influential factors in causing the household to consider and buy earthquake insurance (Kunreuther et al., 1978). The shift from the influence of friends and neighbors to a focus on the risk of a quake and economic benefits of insurance suggests that the early 1970s represented an early stage of the diffusion of an innovation while the late 1980s and 1990s was a much later stage. That is, when earthquake insurance was relatively new and uncommon, it took a personal acquaintance with an insured individual to motivate the spread of insurance among California households. Now that so many people already have earthquake insurance, assessments of risk and cost have become the motivating factors.

INSURANCE AND MITIGATION

Mitigation, such as bolting the foundation to the house, differs from insurance in that there is an upfront cost associated with the investment in exchange for a stream of benefits accruing over time in the form of reduced expected losses from natural disasters. For example, if a property owner were to bolt the structure to its foundation, it might cost the property owner $1,500. Should a severe earthquake occur in the vicinity of the property, the damage might be reduced by $20,000 if the house is prevented from toppling off its foundation. These expected benefits from mitigation would continue to accrue over the lifetime of the property.

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* This section draws heavily from Kleindorfer and Kunreuther (in press).
THEORY AND REALITY OF MITIGATION

Of special interest for public policy are cost-effective risk mitigation measures (RMMs). These are any mitigation measures for which the discounted expected benefits over the life of the property are greater than the upfront investment expenses and other costs associated with the measure. In theory, all of the interested parties concerned with natural disaster losses should view such a measure favorably. The property owner should see this as an attractive investment that will increase the value of his residence or business. The insurer knows that losses will be reduced should a disaster strike the area. The contractor and developer should find it easier to sell a property that is better designed against hazards even if it costs more than one which is relatively unsafe. Public sector agencies at the state, local and federal levels should celebrate the lower need for disaster assistance due to the reduced losses from future disasters.

The reality is quite different. Few property owners voluntarily adopt mitigation measures nor do insurers provide incentives for these investments through premium reductions reflecting the decreased losses associated with the property. Housing values do not appear to reflect the benefits of mitigation measures, perhaps because people don't want to be reminded that they live in a hazard-prone area. As a result, developers and contractors have no economic incentive to build safer structures since it means incurring costs that they feel will hurt them competitively because the RMMs are undervalued by the potential buyers. Interviews with structural engineers indicate that they have no incentive to build structures that exceed existing codes because they have to justify these expenses to their clients and would lose out to other engineers who did not include these features in the design (May and Stark, 1992).

The empirical data on studies of mitigation adoption in hazard-prone areas of the United States suggest that individuals are not willing to invest in mitigation measures despite the rather large damage that either they and/or their friends and neighbors suffered from recent disasters. For example, after Hurricane Andrew in Florida in 1992, in terms of economic losses the most severe disaster in the United States, most residents in hurricane-prone areas appear not to have made improvements to existing dwellings that could reduce the amount of damage from another storm.

A July 1994 telephone survey of 1,241 residents in six hurricane-prone areas along the Atlantic and Gulf Coasts revealed that 62 percent indicated that they had not installed hurricane shutters, used laminated glass in windows, installed roof bracing, and/or made sure that side walls were bolted to the foundation either before or after Hurricane Andrew (Insurance Institute for Property Loss Reduction, 1995). Studies of the added costs of materials and labor for hurricane-resistant designs indicate that this will add no more than 4-5 percent to the cost of a new home and that the additional expense is not substantial relative to the added benefits of safety and security (Urnwehr, 1994). A recent do-it-yourself guide to hurricane retrofit by the Institute for Building and Home Safety (IBHS) recommends home improvements that individuals can make themselves or can share with the contractor doing the work for them (Institute for Building and Home Safety, 1997).

With respect to investing in RMMs to reduce quake damage, measures such as strapping a water heater with simple plumbers tape, can normally be done by residents at a cost of under $5 in materials and one hour of their own time (Levenson, 1992). This RMM can reduce damage by preventing the heater from toppling during an earthquake, creating gas leaks and causing a fire. Yet these and other mitigation investments are not being adopted by residents in earthquake-prone areas. A 1989 survey of 3,500 homeowners in four California
counties subject to the hazard reported that only between 5 and 9 percent of the respondents in each of these counties reported adopting any loss reduction measures (Palm et al., 1990).

A follow-up survey by Palm and her colleagues in 1993 revealed that between 20 to 25 percent of the homes in the two counties affected by the 1989 Loma Prieta earthquake (Santa Clara and Contra Costa) had bolted their house to the foundation. Less than 10 percent of homeowners in the two southern counties in the survey (Los Angeles and San Bernardino) had undertaken this measure (Palm, 1995). This behavior suggests that individuals do not believe that investing in the RMM will increase their residence's property value. They have either short time horizons and/or severe budget constraints which either reduce their perceived net benefits from RMMs or simply prevent them from making the investment (Kunreuther, 1996).

Turning to the relationship between insurance and mitigation some interesting findings emerge from the surveys undertaken by Risa Palm and her colleagues. Palm and Carroll (1998) report that that those who had adopted mitigation measures, such as arranging heavy objects that were less likely to fall and investing in measures strengthening the house, were also more likely to buy quake insurance than those who had not taken these loss reduction measures. This raises the question as to whether certain types of individuals want protection for reasons that have to do with their perception of the risk than their intrinsic worries and concerns. Since insurers did not reduce earthquake insurance premiums for those who have mitigated, one would expect that those who take protective measures would have less interest in insurance protection than before they adopted an RMM. Palm’s findings raise the interesting question as to what factors influence the demand for insurance coverage besides perception of the risk.

WHY IS THERE LIMITED INTEREST IN MITIGATION?

To determine individuals decision processes with respect to RMMs and how much an individual is willing to pay for investing in such measures, a set of controlled experiments were conducted in Pennsylvania and California (Kunreuther, Oncuier, and Slovic, 1998). One example of a question posed to individuals participating in this survey was to ask them to specify the maximum they were willing to pay (WTP) for bolting the structure of their house to its foundation if they planned to reside in it for exactly 5 years, given that the expected annual reduction in damage from the RMM was approximately $500. They were then asked to specify a maximum WTP if they expected to live in the house for exactly 10 years. In other words, their time horizon (T) for residing in their house was doubled but nothing else in the experiment was changed.

Table 1 presents the distribution of these WTP figures for 84 students at the University of Pennsylvania. Half of these students were not told what the RMM cost to install and the other half were told that the price of installing the RMM was $1,500. The data reveal that only 12 percent of the individuals would be willing to pay over $2,000 for the measure if the price was not given and they expected to live in the house for 5 years. The proportion in this category increases to 18% for the group who were given a price of $1,500. In other words, a relatively small proportion of subjects behaved as if they made decisions based on benefit-cost comparisons using a reasonable discount rate.

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5 The expected annual reduction in damage was specified in the following manner. The reduction in damage from preventing the house from toppling off its foundation is $20,000. The risk mitigation measure (RMM) is assumed to reduce the annual probability of an earthquake causing the structure to topple off its foundation from 1/20 to 1/40. Hence the expected annual benefits of the RMM are approximately (1/20-1/40) $20,000 = $500.
Table 1. Distribution of Max Willingness to Pay (WTP) % individuals in each category

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<th>Price Not Given</th>
<th>Price Given= $1,500</th>
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<td>10 Years</td>
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<tr>
<td>$0-$500</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>$501-$1,000</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>$1,001-$1,500</td>
<td>45%</td>
<td>17%</td>
</tr>
<tr>
<td>$1,501-$2,000</td>
<td>31%</td>
<td>36%</td>
</tr>
<tr>
<td>$2,001-$2,500</td>
<td>5%</td>
<td>14%</td>
</tr>
<tr>
<td>$2,501-$3,000</td>
<td>5%</td>
<td>14%</td>
</tr>
<tr>
<td>$3,000 up</td>
<td>2%</td>
<td>7%</td>
</tr>
<tr>
<td>Number of Subjects = 42</td>
<td>Number of Subjects = 42</td>
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</tr>
</tbody>
</table>

More specifically, a risk-neutral person should be willing to pay as much as $2,085 if his/her annual discount rate was 10% and s/he expected to live in their house for 5 years. When the time horizon is lengthened to 10 years the maximum WTP for a risk-neutral investor facing an annual cost of capital of 10% increases to $3,380. Yet only 7% of the subjects who were not given the price chose to spend more than $3,000; the percentage increases to 17% for this group when the price was specified to be $1,500. These results suggest that RMMs may need to be very cost effective indeed if they are to be adopted through normal private choice without regulation.

Similar findings emerged from a survey of 252 individuals visiting the Exploratorium Museum in San Francisco. Now three different time horizons (T) for residing in the house were utilized: 5 years, 10 years and 20 years for obtaining the maximum WTP when the price of the quake RM was given at $1,500. As in the earlier experiment, a significant proportion of the respondents had either high effective discount rates (the mean value varied between 67% and 74% depending on the values of T) or did not change their maximum WTP as the time horizon for residing in the house was increased. For the case where the length of time in the house was extended from 5 to 10 years, 45% of the subjects did not change their expressed WTP for the protective measure (Kunreuther, Oczuler, and Slovic, 1998). The large group of individuals who maintain the same WTP as the time horizon changes may be because these individuals cannot afford to pay more and/or they believe that the cost of the RMM is fully capitalized in the selling price of the property value.

Taken together with earlier studies on individuals behavior with respect to low probability high consequence events, these results suggest that some property owners are reluctant to invest in cost-effective RMMs because they do not make the implied tradeoffs between spending money now in return for potential benefits over time. Such non-adoption behavior may be further exacerbated by developers who may believe (perhaps incorrectly) that they are unable to recover the costs of RMMs in increased selling prices for the structures. Insurers and regulators may need to provide additional incentives and/or building codes so that these cost-effective measures will be adopted.

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6 These high discount rates are consistent with empirical findings on the reluctance of individuals to incur the high immediate cost of energy-efficient appliances in return for reduced electricity charges over time (Haussman, 1979; Kempton and Nisar, 1987).

7 See Camerer and Kunreuther, 1989 for a summary of these studies.
ROLE OF BUILDING CODES

Building codes mandate that property owners adopt mitigation measures. Such codes may be desirable when property owners would otherwise not adopt cost-effective RMMs because they misperceive the benefits from adopting the RMM and/or underestimate the probability of a disaster occurring. For example, suppose the property owner believes that the losses from an earthquake to the structure are $20,000 and the developer knows that it is $25,000 because it is not well constructed. There is no incentive for the developer to relay the correct information to the property owner because the developer is not held liable should a quake cause damage to the building. If the insurer is unaware of how well the building is constructed, then this information cannot be conveyed to the potential property owner through a premium based on risk. Inspecting the building to see that it meets code and then providing it with a seal of approval provides accurate information to the property owner.

If these property owners were forced to cover their own disaster losses, then one might contend that they should be left to their own devices since they would have only themselves to blame for not taking preventive action. However, all taxpayers bear some of the costs of restoring damaged property through low-interest federal loans and grants. Hence there is an economic justification to all citizens to design structures to be safer.

Cohen and Noll (1981) provide an additional rationale for building codes. When a building collapses it may create externalities in the form of economic dislocations and other social costs that are beyond the economic loss suffered by the owners. These may not be taken into account when the owners evaluate the importance of adopting a specific mitigation measure. For example, if a building topples off its foundation after an earthquake, it could break a pipeline and cause a major fire that would damage other homes that were not affected by the earthquake in the first place. In other words, there may be an additional annual expected benefit from mitigation over and above the reduction in losses to the specific structure adopting this RMM. All financial institutions and insurers who are responsible for these other properties at risk would favor building codes to protect their investments and/or reduce the insurance premiums they charge for fire following earthquake.

If a family is forced to vacate their property because of damage that would have been obviated if a building code had been in place, then this is an additional cost that needs to be taken into account when determining the benefits of mitigation. In addition to these temporary food and housing costs, the destruction of commercial property could cause business interruption losses and the eventual bankruptcy of many firms. The impact on the fabric of the community and its economic base from this destruction could be enormous (Britton 1989). Litan et al. (1992, pp. 65-66) found that the temporary losses in economic output stemming from damage to workplaces could be as much as $7.6 billion from a major earthquake in the Shelby County/Memphis, Tennessee area, located near the New Madrid fault.

PROPOSED PROGRAM FOR DISASTER MANAGEMENT

The challenge society faces today is how to promote investments in cost-effective risk mitigation measures (RMMs), while at the same time placing the burden of recovery on those who suffer losses from natural disasters. In theory, insurance is one of the most effective policy tools for achieving both objectives because it rewards investments in cost-effective mitigation with lower premiums and provides indemnification should a disaster occur.

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8 This section draws heavily from Kunreuther (1998).
The book *Paying the Price* proposes a program for managing disasters which recognizes the need for improving risk assessment to estimate risks associated with natural hazards. Its principal thrust is to suggest insurance in combination with other policy tools for encouraging individuals to adopt loss reduction mechanisms while protecting themselves against financial consequences of disasters. This may require a set of specific regulations or standards to deal with misperceptions of the risk as well as externality problems.

For such a program to be implemented, the insurance and reinsurance industry need to be closely linked with other interested parties in the private sector, notably the financial institutions, investment bankers, and the building and real estate communities. Also, government agencies at the local, state, and federal levels need a much clearer understanding of the importance of having insurance rates reflect the risks of living in hazard-prone areas, and of the possible need for multistate and/or federal arrangements to cover some of the losses from future disasters.

The different elements of a disaster management program with insurance playing an important integrating role are outlined below.

**IMPROVING ESTIMATES OF RISK**

Insurers will benefit from improved estimates of the risk associated with catastrophes in two ways. First, by obtaining better data on the probabilities and consequences of disasters, insurers will be able to more accurately set their premiums and tailor their portfolios to reduce the chances of insolvency. The improved information should enable them to more accurately determine their needs for protection through reinsurance or capital market instruments. Second, more accurate data on risk also reduces the asymmetry of information between insurers and other providers of capital. Investors are more likely to supply additional capital as they become increasingly confident in the estimates of the risks of insured losses from natural disasters.

**AUDITING AND INSPECTING PROPERTY**

One way to determine the ability of a structure to withstand the impact of natural disasters would be to inspect the property carefully. A careful appraisal of the structure is expensive. To date, such audits have been undertaken primarily on commercial risks where the insurer has absorbed the cost of the audit through its large premium base with the policyholder. With respect to residential properties at risk, one way to encourage the adoption of cost-effective risk-reduction measures would be to incorporate them in building codes and provide a seal of approval to each structure that meets or exceeds these standards.9

Banks and financial institutions could require that structures be inspected and certified against natural hazards as a condition for obtaining a mortgage. This inspection, which would be a form of buyer protection, is similar in concept to termite and radon inspections normally required when property is financed.10 The success of such a program requires the support of the building industry, of realtors, and of a cadre of inspectors, well qualified to provide accurate information on the condition of the structure.

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9 Kannan, A. and Kleffner, P. (1992) provide a rationale for strengthening building codes by analyzing the factors which lead individuals to avoid investing in mitigation measures even if they have accurate information on the risk.

10 These kinds of inspections are not routinely undertaken by banks today, even though it is in their interest to know as much about the risk as possible to protect their mortgages.
EMPHASIZING BUILDING CODES

One way to encourage the adoption of cost-effective mitigation measures is for banks and financial institutions to provide a seal of approval to each structure that meets or exceeds building code standards. Under the IBHS Showcase Community Program structures that meet predefined criteria would receive a certificate of disaster resistance. Upon receipt of that certificate, there would be a set of incentives provided by banks (e.g., lower mortgage rates), contractors and insurers. (personal communication with Harvey Ryland, November 1997).

The success of such a program requires the support of the building industry and a cadre of qualified inspectors to provide accurate information as to whether existing codes and standards are being met. Insurers may want to limit coverage only to those structures that are given a certificate of disaster resistance.\textsuperscript{11}

PROVIDING ECONOMIC INCENTIVES FOR MITIGATION

As pointed above, insurers could provide financial incentives in the form of lower premiums, lower deductibles, or increased coinsurance to encourage the adoption of cost-effective RMMS. If budget constraints prevent a property owner from investing in these mitigation measures, then insurers should consider having a bank or other financial institution provide funds through a home improvement loan with a payback period coterminous with the life of the mortgage.

Consider the following example, where the cost of an RMM on a piece of property in earthquake-prone country is $1,500. If the seismologists’ best estimate of the annual probability of an earthquake is $p = 1/100$, and the reduction in loss from investing in the RMM is $27,500$, then the expected annual benefit is $275$. A 20-year loan for $1,500 at an annual interest rate of 10 percent would result in payments of $145 per year. If the annual insurance premium reduction reflected the expected benefits of the RMM (i.e., $275$), then the insured homeowner will have lower total payments by investing in mitigation than not undertaking the measure.

Many poorly constructed homes are owned by uninsured low-income families who cannot afford the costs of mitigation measures on their existing structure or the costs of reconstruction should their house suffer damage from a natural disaster. Equity considerations argue for providing this group with low-interest loans and grants so that they can either adopt cost-effective RMMS, or relocate to a safer area. Since low-income victims are likely to receive federal assistance to cover uninsured losses after a disaster, subsidizing these mitigation measures can also be justified on efficiency grounds.

BROADENING PROTECTION AGAINST CATASTROPHIC LOSSES

New sources of capital from the private and public sectors could provide insurers with funds against losses from catastrophic events, which would alleviate insurers’ concerns that the next major disaster might leave them insolvent. They range from capital market instruments to insurance pools to federal solutions.

With respect to capital market solutions, in the past couple of years investment banks and brokerage firms have shown considerable interest in developing new financial instruments for protecting against catastrophic risks (Lewis and Davis, 1998). Their objective is to find

\textsuperscript{11} For more details on ways to make communities disaster-resistant, see Central U.S. Earthquake Consortium (CUSEC), 1997.
ways to make investors comfortable trading new securitized instruments covering catastrophic exposures, just like the securities of any other asset class. In other words, catastrophe exposures would be treated as a new asset class.

In June 1997 the insurance company, USAA, floated act-of-God bonds that provided them with protection should a major hurricane hit Florida. A 2-year CAT bond was put together by Swiss Re Capital Markets and Credit Suisse First Boston in July 1997. The loss triggers were tied to California insurance industry earthquake losses based on the Property Claims Insurance Index for the state. Other financial arrangements, such as catastrophic insurance futures contracts and call spreads introduced by the Chicago Board of Trade (CBOT) in 1992 enable an insurer to hedge against its underwriting risk by attracting capital from insurance and non-insurance segments of the economy. (Cummins and Geman, 1995; Harrington et al., 1995). The Catastrophic Risk Exchange (CATEX) creates a marketplace where insurers, brokers, and the self-insured can swap units of their catastrophe risks by region and peril. For example, an insurer could swap units of California earthquake for Florida windstorm (Insurance Services Office, 1996).

Turning to insurance pools, the National Conference of Insurance Legislators (NCOIL) has considered a multistate Natural Disaster Compact, modeled after the Florida hurricane catastrophe fund, to expand the pool, increase available resources, and further spread geographic risks. This concept has obvious appeal to the most disaster-prone states, and an equal lack of appeal to states where disasters are more rare. 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. Under the Price-Anderson Act, a group of private insurers agreed to provide coverage to utility companies for losses that can total up to $8.2 billion. (U.S. Congress, 1995).

At the federal level, Lewis and Murdoch (1996) developed a proposal 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, and state and national reinsurance pools would be eligible purchasers. Another proposed option is for the federal government to provide reinsurance protection against catastrophic losses. Private insurers would build up the fund by being assessed premium charges in the same manner that a private reinsurance company would levy a fee for excess-loss coverage or other protection. The advantage of this approach is that resources at the federal government’s disposal enable it to cover catastrophic losses without charging insurers the higher-risk premium that either reinsurers or capital market instruments would require. If one views the private sector as the first line of attack on the problem, as we do, then one would only want to resort to federal reinsurance as last resort.

CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

This paper has emphasized the importance of forming public-private partnerships for reducing losses from natural disasters and providing adequate protection should an earthquake or other destructive event cause severe damage and disruption to a community or region. In this concluding section we pose a set of open questions for future research in each of the areas discussed in the previous section.
OPEN QUESTIONS ON IDENTIFICATION AND ASSESSMENT OF RISK

- How can we combine past data with scientific studies to model the risk?
- Are hazard- and loss-estimation modeling approaches sufficiently reliable and valid measures to guide the underwriting decision process?
- How can one better characterize the uncertainties in determining the probability of disasters of different magnitudes and the vulnerability of structures from these events?
- What information does the insurance industry want to better assess risks, and how does the industry anticipate obtaining this information in the near future?

OPEN QUESTIONS ON SUPPLY OF INSURANCE

- How serious are potential problems of adverse selection and highly correlated risks for insurers if they were to continue providing coverage to their current policyholders who had homeowners coverage and wanted quake coverage?
- What is the capacity of the private sector (insurers and reinsurers) to provide coverage for earthquake insurance if rates were based on risk?
- How can regulators balance off concern with equity and efficiency in recommending specific rates?
- What role can public-private partnerships, such as the California Earthquake Authority (CEA) play in providing protection against future earthquakes?
- What is the potential role of the capital markets in offering protection against catastrophic losses?
- Is there an appropriate role for the federal government to play in providing some type of reinsurance against mega-catastrophes?

OPEN QUESTIONS ON DEMAND FOR EARTHQUAKE INSURANCE

- What type of insurance do individuals want to purchase?
- What factors are important to individuals in their decisions to purchase coverage?
- What steps need to be taken to make the CEA more desirable to property owners in California?

OPEN QUESTIONS ON INSURANCE AND MITIGATION

- How can one determine what are cost-effective mitigation measures? How does one evaluate the benefits (indirect/direct) from mitigation? What empirical studies are necessary for determining the magnitude of the social costs and externalities that could be reduced through well-enforced building codes?
- What role can the insurance industry play in encouraging mitigation through incentives and what changes in institutional structure are needed for this to take place? How can other key parties (e.g. financial institutions, construction/real estate industry) aid the process of mitigation?
- What are the challenges in enforcing building codes and ways to improve this? Can community based programs play a key role in encouraging mitigation? Is the
community rating system associated with the National Flood Insurance Program a
model that one can build on for earthquakes?

- Can regulation of rates be used in combination with other policy tools such as
building codes to encourage mitigation?

OPEN QUESTIONS FOR PROPOSED DISASTER MANAGEMENT PROGRAM

- What are some specific opportunities for linking insurance with other policy tools to
reduce losses from future natural hazards?
- How can insurance coupled with other policy tools be utilized to bring different
stakeholders closer together to deal with natural disaster syndrome?
- What empirical studies are necessary for determining the magnitude of the social
costs and externalities that could be reduced through well-enforced building codes?
- Can we utilize past experience and engineering studies on building performance to
evaluate the cost-effectiveness of mitigation with sufficient precision that they can be
incorporated into building codes?
- What types of economic incentives aside from premium reductions (e.g., lower
deductibles, higher limits of coverage) are likely to be attractive to policyholders to
encourage them to adopt mitigation measures?
- What would be the most effective ways of providing subsidies to low-income families
to encourage them to adopt cost-effective RMMs?
- What impact will new capital market instruments have on the pricing and availability
of conventional reinsurance?

This is a very exciting time for the insurance and reinsurance industry to explore new
opportunities for dealing with catastrophic risks. If insurance can be used as a catalyst to
bring other interested parties to the table, it will have served an important purpose in helping
both the industry and society deal with the critical issue of reducing losses and providing
protection against damage from earthquakes, floods, hurricanes, and other natural disasters.

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