Turning to the uncertainty of the risk, a recent survey of underwriters illustrates how ambiguity affects their premium-setting behavior. A questionnaire asked underwriters of primary insurance companies and reinsurance firms to specify the prices they would charge to insure a factory against property damage from a severe earthquake under the following four cases: case 1, well-specified probabilities (p) and known losses (L); case 2, ambiguous probabilities (Ap) and known losses; case 3, well-specified probabilities and uncertain losses (UL); and case 4, ambiguous probabilities and uncertainty losses.[5]

For the nonambiguous case, the probability of the earthquake (p) was set at either 0.01 or 0.001, and the loss should the event occur (L) was specified at either \$1 million or \$10 million, yielding four different scenarios (these well-specified scenarios are $p = 0.005$, L = \$1 million; $p = 0.005$, L = \$10 million; $p = 0.01$, L = \$1 million; and $p = 0.01$, L = \$10 million). Standardizing the premium set by the underwriter at 1 for the nonambiguous case allows us to examine how ambiguity affects pricing decisions. Table 6-1 depicts the ratio of the other three cases relative to the nonambiguous case (p,L) for the four different scenarios that were distributed randomly to underwriters in primary insurance companies.

For the highly ambiguous case (Ap,UL), the premiums were between 1.43 to 1.77 times higher than they were for a nonambiguous risk. The ratios for the other two cases were always above 1 but less than the Ap,UL case (Kunreuther, Hogarth, and Meszaros 1993).

Turning to the fear of crippling catastrophic losses, empirical analyses show that insurers have a right to be worried. In the past several years, several disasters within close proximity to each other have caused billions of dollars in damage to different regions of the country and created large losses to the insurance industry. The insurance industry's catastrophic losses during 1989–92 were more than \$34 billion in 1992 dollars, more than the combined total for such loss during the previous twenty-one years ("ISO President Outlines Steps" 1993).

Table 6–1: Ratio of Underwriter Premiums for Ambiguous or Uncertain Earthquake Risks Relative to Well-Specified Risks

Scenario	*Case 1, p,L*	*Case 2, Ap,L*	*Case 3, p,UL*	*Case 4, Ap,UL*	*Number of respondents*
$p = 0.005$ L = \$1 million	1	1.28	1.19	1.77	17
$p = 0.005$ L = \$10 million	1	1.31	1.29	1.59	8
$p = 0.01$ L = \$1 million	1	1.19	1.21	1.50	23
$p = 0.01$ L = \$10 million		1.38	1.15	1.43	6

Note: Ratios are based on mean premiums across number of respondents for each scenario.
Source: Adapted from Kunreuther, Hogarth, and Meszaros 1993, table 3.

To be more specific, damage from the 1989 Loma Prieta earthquake caused more than $900 million in losses to the insurance industry (California Department of Insurance 1991–92). The losses to the insurance industry from Hurricane Andrew are now estimated to be $15.5 billion, making it the single most costly natural disaster in history. Insurers such as State Farm and Allstate suffered financial losses from Andrew of $3.5 and $2.5 billion, respectively (Snyder 1993). A computer simulation model indicates that if Hurricane Andrew had hit Miami, the losses could have exceeded $40 billion and led to many more than the seven insolvencies that resulted from the actual disaster (Insurance Services Office 1994).

A recent study also suggests that a catastrophic earthquake would have severe consequences on the surplus held by private insurers in the United States (Doherty, Kleffner, and Kunreuther 1991). Data were collected from eighteen insurance firms providing earthquake coverage in California to determine the financial impact to them should a disaster occur of the same magnitude and geographic location as the 1906 San Francisco earthquake. The study found that if such a catastrophic earthquake were to occur, five out of the eleven firms with surpluses less than $2 billion would suffer losses that would exceed their surplus and cause them to be insolvent. The seven larger firms in the survey with surpluses exceeding $2 billion would be less severely affected by the catastrophic earthquake. Although none of these large firms would be insolvent, three of them would have to curtail their current business or raise new capital because their surplus would be sufficiently depleted that they would not be able to meet current regulatory guidelines.

Medium and small-size insurers in the United States use the reinsurance market to protect themselves against the possibility of large losses from events such as a catastrophic earthquake (some of the large personal lines insurers do not purchase any reinsurance). Because reinsurance data are not in the public domain, a questionnaire was distributed to the eighteen firms in the sample to determine the amount of catastrophic reinsurance in force. Fourteen companies responded to the survey. Three of the five firms that were predicted to be insolvent from the catastrophic earthquake if they did not have reinsurance responded to the survey; all of them would still be insolvent even if the reinsurers paid all their claims.

The impact of a catastrophic disaster on the private reinsurance market has not been well studied. These firms are likely to face an even greater problem than the primary insurers if such an event occurs. The premiums that the reinsurers believe they can charge for such an event are relatively small because of its low probability, but their losses from a large-scale disaster could be enormous.

If one looks at the catastrophe-related claims that have been paid for all disasters in the United States in the past forty years, 45 percent have been paid since 1990. As a result of the extraordinary trend in both the frequency and severity of natural catastrophes, the capacity of reinsurance to cover insurers and their policyholders has diminished. The largest U.S. reinsurance broker reports that between 1989 and 1993, the amount of catastrophic reinsurance that it was able to place for its client base decreased 57 percent (Nutter 1994).

A proposed program for integrating insurance with mitigation

Homeowners and insurers are thus reluctant to deal with natural disasters for very

different reasons. Many homeowners at risk are not anxious to purchase insurance because they believe that the disaster will not happen to them; others have compared costs with potential benefits and may believe that insurance and loss-reduction measures are not good investments. Private insurers are reluctant to promote coverage against hurricanes, floods, and earthquakes because the risk is uncertain and they are concerned with the financial consequences to them of a catastrophic disaster. Hence they want to limit their exposure.

The present situation can be costly to all of the interested parties concerned with disasters. First, the potential damage from natural hazards will be larger than it would be if cost-effective, loss-reduction measures were adopted on new and existing property. Second, the large losses and potential insolvencies to insurers resulting from a catastrophic disaster will significantly reduce their surplus and lead them to set higher premiums and restrict coverage on policies that are unrelated to the specific disaster in question (that is, automobile coverage, homeowner's insurance).

In other words, the impact of a particularly severe flood, earthquake, or hurricane could have a negative impact on the availability of insurance throughout the country (Doherty and Posey 1992; Gron 1989; Winter 1988, 1991). Doherty, Posey, and Kleffner (1992) examine how insurers responded to a variety of surplus shocks in the past. Their analysis suggests that only 50 percent of the lost surplus is likely to be replaced following a catastrophic loss, so that the availability of coverage in many different lines of insurance will have to be reduced.

Third, many uninsured homeowners will be saddled with large recovery costs following a severe disaster. If the past is a guide to the future, the federal government will come to the rescue by providing victims with liberal disaster relief. Hence all citizens will have to pay for the losses generated by severe disasters in the future.

To cope with each of these three problems, the following elements of a hazard management program should be explored. A more detailed discussion of the objectives of such a program and an expanded treatment of the interaction between different policy tools can be found in Kunreuther, Ericksen, and Handmer (1993).

Institute more stringent building codes on new homes

Relevant government agencies should develop stringent building codes that incorporate cost-effective mitigation measures on new structures and ensure compliance with, and enforcement of, the codes. The limited voluntary adoption of these measures on existing homes in the United States suggests that innovative ways are needed to encourage homeowners and the building industry to modify structures to meet appropriate standards. This means ensuring that key players, like the building industry and homeowners, support the program.[6]

Although building codes can serve an important function in reducing future property damage, Cohen and Noll (1981) provide an additional rationale for having them. The collapse of a building may create economic dislocations and social costs in addition to the economic loss suffered by the owners. These may not be taken into account when owners evaluate the importance of adopting a specific mitigation measure.

Use seals of approval on structures that meet codes

Each building that meets or exceeds the specific building code could be given a seal of approval. This would provide homeowners with the knowledge that the building has been safely designed and built in accordance with a federal or national code. One way to institutionalize the procedure would be for financial institutions to require an inspection of the facility at the time that a mortgage is issued. This inspection, which would be a form of buyer protection, is identical in concept to the termite inspection that is normally required as a condition for obtaining a mortgage in the United States. A new homeowner is unlikely to know how safe the structure is, so this inspection should be viewed as desirable.[7]

Use insurance to encourage hazard mitigation

To reduce their losses from disasters, insurers may want to limit coverage to structures that are given a seal of approval. If banks require insurance as a condition for a mortgage, then financial institutions together with the insurer can help to enforce building code regulations. The reduction in potential losses from the adoption of building codes should be reflected in reduced premiums, lower deductibles, or higher coverage limits.

The government could require insurance as a condition for federally backed mortgages. In the United States, the National Flood Insurance Program has such a condition for homes located in Special Flood Hazard Areas. Unfortunately, this requirement has not been routinely enforced. A survey conducted in Texas following a major flood in 1989 revealed that 79 percent of the owners of damaged properties who were required to purchase flood coverage when taking out their mortgages were uninsured at the time of the disaster (U.S. General Accounting Office 1990).

An interesting set of competitive pressures creates a lack of interest by banks in requiring homeowners to take flood insurance as a condition for a mortgage. Prospective homeowners who are not concerned with the flood hazard will want to obtain their mortgage from a bank that does not require flood coverage. Until a recent court decision in the state of Connecticut, banks were *not* fined if a house in the floodplain was uninsured nor did they have to pay for flood damage if the house was flooded. For similar reasons, banks have no incentive to ensure that homeowners renew the flood insurance coverage they purchased at the time of their mortgage.

Fines or other penalties should be imposed on lenders who are obligated to require flood insurance but do not do so. A recent bill introduced into the U.S. Congress would require lenders to inform purchasers of how to obtain insurance and penalize them up to $350 for each violation. This penalty may only be partially successful in forcing banks to take the appropriate action. A much more effective penalty would be to hold banks and financial institutions responsible for the costs of repairing an uninsured home that had been required to have coverage (Kunreuther and White 1994; the maximum amount of the fine could be determined by the amount of insurance that the structure would have under required coverage).

Develop all-natural hazards insurance

The insurance industry should be encouraged to market a new type of homeowner's

insurance that includes protection against earthquake, flood, and hurricane damage. Rates would be based on risk, with the potential losses diversified throughout the country. This type of insurance policy would also eliminate having to determine the causes of a loss, as insurers in the United States currently have to do for hurricane damage.

Institute government reinsurance

The federal government should provide reinsurance protection against catastrophic losses from all disasters on the newly designed homeowner's policy. Private insurance firms would build up the fund by being assessed premium charges in the same manner that a private reinsurance company levies a fee for protection. The need for such a government fund arises from the apparent inability of the private reinsurance market, due to limited financial capacity, to provide sufficient protection against large-scale disasters that might occur in the United States.

The advantage of a federal reinsurance program is that it reduces uncertainty to insurers about the consequences of a catastrophic disaster and should enable them to reduce their premiums for disaster coverage. By having federal involvement in one portion of the natural disaster program, it is then possible for some government agency (for example, the Federal Emergency Management Agency) to play a more salient role in encouraging the enforcement of mitigation measures.

In addition, federal reinsurance for catastrophic losses would restore the financial conditions of insurers following a catastrophic loss and hence greatly reduce the likelihood that insurers will reduce the availability of coverage in the future. For example, following Hurricane Andrew eight companies announced that they would reduce coverage in Florida due to their severe losses. Insurers also reduced availability of homeowner's insurance in other hazard-prone areas such as the Massachusetts shoreline (Blanton 1993).

Subsidize low-income families

Many poorly constructed homes are owned by low-income families who cannot afford the costs of mitigation measures on their existing structure nor the costs of reconstruction should their house suffer damage from a disaster. Two measures should be undertaken to aid these households:

- Low-interest loans and grants to adopt cost-effective mitigation measures or to relocate their home.
- Special disaster assistance to aid their recovery process.

In summary, coupling insurance requirements with building codes and risk-based premiums for adopting cost-effective, loss-reduction measures would constitute a giant step toward reducing losses from future natural disasters as well as aiding the recovery of homeowners who suffer severe damage to their property.

Open questions and issues

This concluding section raises a set of questions and issues that need to be considered by countries as they reflect on the role of insurance as part of a hazard management program. They are grouped under headings that address the insurability issue and the role of insurance coupled with other policy tools in reducing losses from future natural hazards.

Estimating the risk

- What risk-assessment techniques are currently available for determining the potential losses to structures in different hazard-prone areas?
- How costly is it to undertake these risk assessments?
- Is it appropriate for government to bear the costs of risk assessments, or should they be borne by residents in the hazard-prone community?

Enforcing building codes

- What are the challenges in having federal and state governments develop more stringent building codes and a low-cost system of compliance and enforcement at a local level of authority?
- Are adequate data available to specify cost-effective mitigation measures for different hazards?

Offering seals of approval

- How easy is it to determine whether a particular structure meets a specific code or standard to receive a seal of approval (building consents and code compliance permits)?
- How easy is it to determine whether a damaged building has or has not met the building code following a disaster?
- Who would determine whether a structure meets code (scientific experts, local government building inspectors)?
- Is it appropriate to require the local government to pay for the full damage from a disaster if the code has not been met?
- Will the threat of such a penalty induce local governments to inspect buildings carefully before a disaster to see that the building code is met?

Linking insurance with seals of approval

- What type of competitive pressures may lead insurers to provide coverage for structures that do not have seals of approval?
- Under what circumstances are banks likely to require insurance as a condition for a mortgage?

Offering premium reductions for adopting mitigation measures

- What are the most effective ways for insurers to reflect the loss reduction so that homeowners perceive the benefits of mitigation (such as lower deductibles, lower premiums, higher coverage, or some combination of these)?
- Can analogies from other types of coverage (such as fire insurance) assist the industry in answering the above question?

Developing an all-natural hazards insurance program

- Are there legal impediments in developing all-natural hazards insurance (for example, is it possible to include flood damage in such a program in the United States given the existing National Flood Insurance Program)?
- How feasible is it to charge rates based on risk that varies considerably from one region of the country to another?
- Should the insurance industry share the responsibility for, and cost of, identifying natural hazards on a regional basis?

Structuring federal reinsurance

- How can a government reinsurance program be structured so that it is not perceived to be a bailout for the insurance industry and so that companies are not inclined to buy less commercial reinsurance?
- What data are available to show that there is not enough private reinsurance capacity available to cover a catastrophic loss?
- How large a reduction in premiums or an increase in coverage at the same premium is possible under a government reinsurance program?
- Is there capacity for reducing premiums in a highly competitive market?

Subsidizing low-income families

- What are the appropriate measures of income to determine whether individuals qualify for loans or grants to undertake mitigation measures?
- What types of disaster assistance are most appropriate to aid the recovery of low-income families?

Notes

1. This paper reflects many helpful discussions with Neil Doherty, Dean Flesner, Eugene Lecomte, Frank Nutter, and Gilbert White. Support from the William and Flora Hewlett Foundation is gratefully acknowledged
2. A deductible refers to the amount of money that the policyholder has to pay from his or her own resources before collecting on insurance. In the United States, the normal deductible is 10 percent of the value of a policy. Hence if a homeowner purchases coverage of $100,000, then he would be responsible for covering the first $10,000 of any losses from an earthquake. An actuarially fair premium is determined by multiplying the probability of the event by the resulting loss. In this case, 0.005 x $20,000 = $100.
3. Similar behavior has been found with how motorists estimate their driving ability. Svenson (1981) found that more than 90 percent of subjects interviewed said that their driving ability was above average.
4. Even if the magnitude of the loss is uncertain, the insurer is normally protected by the upper limit on the policy it issues. Thus if a $250,000 house is insured against earthquake for only $100,000, then the insurer knows that the policy limit will define the maximum it will ever have to pay even if the house is destroyed by a severe shock.
5. An ambiguous probability refers to the case where "there is wide disagreement about the estimate of p and a high degree of uncertainty among the experts." A well-specified loss (L) means that all experts agree that if a specific event occurs, the loss will equal L. An uncertain loss refers to the situation where the experts' best estimate of a loss is L with estimates ranging from L_{min} to L_{max}.
6. The Insurance Institute for Property Loss Reduction in the United States is now in the process of establishing a relationship with the American Society of Home Inspectors to enhance compliance with the building code. The specific elements of the program have not been identified yet (personal communication with Paul Cogswell, May 6, 1994).
7. If a house does not meet the relevant building code, the question is whether it must be improved prior to sale or whether the new buyer simply must

receive this information. This area has both economic and political ramifications.

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