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The Role of Insurance in Dealing With Catastrophic Risks from Natural Disasters

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The Increasing Importance of Natural Disasters

Natural disasters are now on the societal radar screen where they previously have received relatively little notice and attention except when a catastrophic event occurs. The reason is succinctly summarized in a 1995 column in the Washington Post entitled Natural Disasters: A Budget Time Bomb.

Over the past five years the cost of natural disasters has been rising at an alarming rate. In that time, 11 catastrophes have cost the nation more than $1 billion each. Hurricane Andrew and California’s Northridge earthquake together cost more ($24 billion) than what the government spends annually on running the federal court system, aiding higher education and pollution control, combined (Emerson and Stevens 1995).

We have not yet developed a coherent strategy for coping with the changing role that natural disasters plays in our lives. There is general agreement that it is important to take steps to reduce losses from future disasters. In fact, the Federal Emergency Management Agency (FEMA) considers mitigation the cornerstone of its activities over the coming years. (FEMA 1995). However, it is unclear what mechanisms will be used to achieve this objective because it will require increased expenditures to make structures safer in hazard-prone areas. Two questions which need to be addressed in this regard are:

1. Who should bear the costs of making hazard-prone communities safer?

2. Who should pay for the losses after a disaster occurs?

If one uses an efficiency criterion, then the responsibilities both before and after a disaster should lie with the residents in these areas and their local governments. If one introduces questions of distribution or equity then the general taxpayer may be expected to absorb a portion of the costs of disasters.

Our current natural disaster policy places a large financial burden on all residents of this country after a disaster occurs. Under the Stafford Disaster Relief and Emergency Assistance Act of 1988, the federal government provides funds to cover at least 75 percent for repair of public facilities (U.S. Congress 1995). For catastrophic events, such as the Hurricane Andrew of 1992 and the Mississippi floods of 1993, the entire cost of these repairs was provided by the federal government. It is thus not surprising that there has been little interest by municipalities in investing in loss-reduction measures for these facilities since they know they will be covered by government funding. Similarly there has been virtually no interest by
state and local governments in purchasing insurance against losses to their buildings. A 75 percent grant is much more attractive than buying coverage.¹

With respect to the private sector the federal government offers low interest loans to uninsured disaster victims through a Small Business Administration disaster loan program. Under the current arrangement homeowners and businesses suffering damage from a disaster can obtain a low interest loan to aid their recovery. The interest rate varies between 4 percent and 9 percent. These programs can be costly to the taxpayers if there is a large amount of loans given in one year at below-market rates. During the period from 1977 through 1993 approximately 21 billion were loaned to disaster victims by the SBA (U.S. Congress 1995).

This paper argues that it is important to shift more of the financial burden of natural hazards from the general taxpayer to those at risk and to take steps to reducing the future losses from these catastrophes. In theory, insurance is an attractive policy tool for satisfying both of these objectives. Those residing in hazard-prone areas would pay a premium which reflects their risk, and are rewarded with lower rates if they adopt protective measures which mitigate their future losses. In practice insurers are reluctant to offer coverage against catastrophic risks such as earthquakes, hurricanes and floods² and residents in these hazard-prone areas have been reluctant to adopt cost-effective loss reduction measures (LRMs). It thus may be necessary to combine insurance with other policy tools, such as building codes and land-use regulations, to successfully reduce losses. This is especially true if taxpayers or society, as a whole, bear some of the risk of natural disasters. Furthermore there needs to be the interest and cooperation of a set of other stakeholders from the private sector, such as financial institutions and the building industry, as well as assistance from the federal, state and local governments in dealing with catastrophic risks.

Insurance in Theory

The potential for using insurance as an effective policy tool for reducing losses from future natural disasters depends on the impact of catastrophic risks on the supply of coverage and whether those at risk are willing to engage in cost-effective mitigation measures when rewarded by having to pay lower premiums on their policies. We will examine both of these questions by constructing a simple scenario where an insurer is faced with the potentially large loss due to a perfectly correlated risk.

A Disaster Scenario

Consider an insurer who wants to offer coverage against earthquake damage in a seismological active area of California where there are N identical uninsured pieces of property. Property owners are interested in purchasing coverage if it is available at a price they perceive to be reasonable or fair. Seismologists have been asked to estimate the probability of a severe earthquake occurring in this area and the resulting damage that is likely to occur.

Given the limited historical data on earthquakes, seismologists indicate that their best estimate of the annual probability is p, but that the figure could range from P min to P max. Should such an event occur,

¹A very comprehensive study by Burby (1992) and his colleagues reveals that most local governments have not adopted hazard mitigation measures or purchased insurance. More specifically, a study by French and Rudholm (1990) of the damage to public property in the Whittier Narrows, California, earthquake of October 1987 revealed that few public buildings were protected by earthquake insurance, even though it was readily available from the private sector.

²Since 1968 flood insurance has been provided under a federal program established by the National Flood Insurance Act. Private insurers normally cover wind damage from hurricanes as part of their homeowners policies except in high-risk areas with beach/windstorm pools. Earthquake insurance in California is now provided by the California Earthquake Authority—a state-run earthquake insurance company.
it will cause losses to each structure of \( L \) dollars. If this is the only damaging earthquake that will occur in the area, then the insurer must determine the impact that such an event will have on its surplus.

Residents in the area are able to reduce their losses from a future disaster to \( L^* < L \) by investing in an LRM at a cost of \( C \) dollars which is incurred up front. The expected annual benefits of adopting such a measure, using \( p \) as an estimate of the probability, is \( p \times (L - L^*) \). If the structure is expected to last \( T \) years then the total discounted expected benefits of the mitigation measure is

\[
\sum_{i=1}^{T} p(L - L^*)(1+d)^i
\]

**Insuring Catastrophic Losses**

Final decisions as to what premiums an insurance firm should charge are made by underwriters. They receive advice from actuaries who analyze statistical data on the risk. There is a growing literature which suggests that underwriters are likely to be risk averse and hence concerned with the magnitude of the losses in setting a price for a particular type of risk. For one thing there are asymmetries of information between outside investors who provide capital to the firm and inside managers who utilize it. Greenwald and Stiglitz (1990) have shown that if professional managers are rewarded with a share of profits but suffer substantial damage to their personal career prospects should their firm becomes insolvent, then they will be risk averse in their actions. In other words, underwriters face nondiversifiable career risks while stockholders, who can diversify their portfolio, may be risk neutral. Hence underwriters may set higher premiums to lower the probability of insolvency of the firm than would be in the best interests of its investors.

Mayers and Smith (1990) provide an additional financial reason why underwriters may be risk averse. They point out that the provisions of the corporate tax code yields a convex tax function for low levels of taxable income and a linear function for taxable income above some threshold. A company can thus reduce its expected liability by reducing the variance of pre-tax income. Should an underwriter be faced with two risks that have the same expected loss, the one with the greater variance would normally trigger a higher premium.

If insurers are indeed risk averse then the premium that they will charge will be a function of their current surplus or wealth \( W \) and the number of policies \( N \) that they write. There are two alternative models which have been proposed in the literature for determining what actions insurers are likely to take if they are risk averse. The standard model is expected utility theory where the underwriter determines the premium so that the underwriter is indifferent between having the insurer assume this new risk with each of the \( N \) property owners purchasing a policy protecting them against their loss \( L \) or having the insurer not provide coverage. For the above example, the pricing relationship is given by:

\[
U(W) = (1-p) U(W+NP) + p U(W+NF-NL)
\]  

Using expected utility theory the insurer will focus on the best estimate of \( p \) to calculate expected losses since there is perfect correlation among the risks. However, the underwriter will be concerned with the magnitude of the loss \( (NL) \). For a specified value of \( N \) the insurer will want to charge a higher premium

\[\text{footnote}{The assumption that the risks are perfectly correlated means that the insurer faces a single loss. Hence he is indifferent to the ambiguity associated with the probability using expected utility theory. Should the correlation of the risks have been less than one then ambiguity surrounding \( p \) would have caused the premium to be higher than if \( p \) were well-specified. See Hogarth and Kunreuther (1992) for more details on this point.}\]
the more risk averse it becomes. Alternatively it can reduce the number of policies that it writes and charge a lower premium on each policy since the expected total loss will be reduced.

An alternative to the expected utility model is a safety-first model of insurer behavior. A.D. Roy (1952) developed such an approach by suggesting that firms wanted to keep the probability of a large loss as low as possible. James Stone (1973), a former Commissioner of Insurance in Massachusetts, built on these concepts by developing a model of underwriting behavior in which insurers are presumed to want to maximize expected profits but are limited from doing so by constraints of solvency and stability. Since our interest here is on the impact of a catastrophic loss on the solvency of the firm we will focus only on the former constraint.

The solvency constraint relates aggregate losses for the risk in question to the current surplus plus the premium charged. Let X be a random variable representing the total loss from the insurer's current portfolio of risks. If the insurer is considering providing coverage for the earthquake risks and expects to sell N policies, then the underwriter will recommend a premium P* so that:

\[ \text{Probability} \left[ X + NL > W + NP^* \right] < p^* \]  

where \( p^* \) is a preassigned probability that reflects safety first considerations.

To illustrate the implications of the solvency constraint in the safety-first model suppose that the insurer had wealth of \( W = 2000 \) and a portfolio of a sufficiently large number of independent risks so it was confident that \( X = 1000 \). If an earthquake had a probability of \( p = 1/100 \) with \( L = 100 \) then the actuarially fair premium \( = 1 \). If the losses from the earthquake were perfectly correlated and \( p^* < 1/100 \), then an insurer who charged an actuarially fair premium \( P^* = 1 \) would determine the number \( N \) which met the solvency constraint by solving for

\[ 100 + N 100 < 2000 + N \]  

In this case \( N = 10 \) which indicates that the insurer would want no more than 10 earthquake policies in an area subject to severe seismic risk. Should the underwriter want to increase the number of earthquake policies in a single area, it would either have to increase its assets \( W \) and/or raise the premium on an earthquake policy.

Encouraging Mitigation Activity

Underwriters can encourage individuals to engage in loss-prevention measures. The most obvious way to provide such incentives is through premium reductions which reflect the lower risk from a property owner investing in a protective measure. To illustrate this point consider the above example and assume that each of the structures is not anchored to its foundation and hence can move after an earthquake occurs. This can cause a fire from broken gas lines, and damage the foundation, floors, walls, windows and other utility connections as well as the contents of the structure. (Seismic Safety Commission 1994). The cost to bolt the structure to its foundation is \( C = 1500 \) and the reduction in loss should a quake occur is \( L - L^* = 27,500 \).

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4The stability constraint requires a probability less than \( p^* \) that the loss ratio should a disaster occur exceeds a certain target level \( r^* \).
5The cost estimate for such a measure on a one story house built prior to 1940 is between $1000 and $2000; the estimated reduction in damage would be between $25,000 and $30,000 should a disaster of the magnitude of the 1989 Loma Priem earthquake occur (Gallagher Associates 1990). The figures chosen in the above example are midpoints of the ranges of these two estimates.
If the underwriter’s best estimate of the annual probability of an earthquake affecting the community was $p = 1/100$, then the premium reduction which could be provided to any resident who adopted this LRM would be $275 plus any insurer savings on administrative or loss adjustment expenses from the policyholder making a lower claim after an earthquake. Table 1 depicts the present value of the premiums saved for the length of time that the structure will be occupied based on a 4 percent annual discount rate.\textsuperscript{6} If the structure is occupied for seven years or more than the savings in premiums (based on a $275 annual premium reduction) would more than offset the $1500 upfront cost of bolting the structure to its foundation.

Rather than reducing premiums to encourage mitigation one impose a deductible on an insurance policy or specify a cap on insurance coverage so the individual must bear a larger fraction of the costs of the disaster himself. Zeckhauser (1995) has shown that if an insured individual is risk averse, he will be more likely to undertake loss prevention measures if his insurance policy is capped at some maximum value rather than by offering him a higher deductible. He shows that such a policy avoids the problem of distribution distortion whereas a higher deductible D encourages policyholders to put their effort into reducing D while not paying attention to catastrophic losses where they are covered by insurance. As the cap on coverage is lowered there is an incentive to undertake measures which reduce the larger losses.

**Insurance in Practice**

The use of insurance as a policy tool for shifting the financial burden to those in hazard-prone areas and reducing losses from natural disasters present several challenges. Because the risks from these events are ambiguous, actuaries and underwriters want to price them higher than if they were well-specified. Furthermore insurers are reluctant to provide extensive coverage against these events because they are worried about the impact that a catastrophic disaster would have on their balance sheet. One way to reduce these losses is by encouraging property owners to invest in mitigation measures. Few insurers, if any, have offered rate reductions to those who undertook such actions. Even if they did provide such an incentive, it is unlikely that property owners would incur the upfront costs to make their structures safer.

**Pricing Ambiguous Risks**

Insurers are more concerned with risks that are ambiguous and will want to price them higher than if they were non-ambiguous. Earthquakes and hurricanes clearly fall into this category. Despite significant advances in computer modeling and simulations of the impact of natural disasters on losses in a given community or region of the country there is still considerable uncertainty regarding the ability to estimate probabilities and losses.\textsuperscript{7}

This uncertainty in both $p$ and $L$ is likely to be translated into higher premiums for the same amount of coverage. A recent survey of underwriters illustrates how ambiguity affects their premium-setting behavior. A questionnaire was mailed to underwriters of primary insurance companies and reinsurance firms asking them to specify the prices which they would charge to insure a factory against property damage from a severe earthquake under the following four different cases: Case 1: well-specified

\textsuperscript{6}The discount rate is equivalent to the real rate of interest, which is the difference between the current interest rate and the inflation rate. Litan et. al. (1992) in their study of earthquake mitigation measures utilize a 4 percent rate by noting that the interest rate on long-term treasury bonds is 8 percent and the “core” inflation rate (all consumer items less the food and energy components) is about 4 percent. The difference (i.e., 4 percent) is a measure of the real rate of interest on risk-free investments. (p. 19)

\textsuperscript{7}For a more detailed discussion of new directions in ratemaking based on improved data bases and recent advances in computer technology see Insurance Services Office (1994).
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 uncertain losses.\(^8\)

For the non-ambiguous case, the probability of the earthquake (p) was set at either .01 or .001 and the loss should the event occur (L) was specified at either $1 million or $10 million, yielding four different scenarios.\(^9\) If one standardizes the premium set by the underwriter at 1 for the non-ambiguous case, then one can examine how ambiguity affects pricing decisions. Table 2 depicts the ratio of the other three cases relative to the nonambiguous case (p, L) for the four different scenarios which 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 if underwriters priced 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)].

These data taken alone cannot discriminate as to whether an expected utility model or a safety-first model better explains insurers’ decisions to raise premiums when there is uncertainty and ambiguity. When the losses are perfectly correlated the insurer can treat the risk as if it was a single loss. According to expected utility theory the premium charged should be the same whether the probability was well-specified as “p” or whether there was considerable ambiguity around p as long as the best estimate of the ambiguous probability was also “p.” In the safety first model, ambiguity in p does matter even when the risks are perfectly correlated. If expert 1 estimated the probability of an earthquake to be p1 > p, this may lead the insurer to constrain its coverage or raise its premium in ways that it would not do if the insurer looked only at the best estimate of the probability “p.” (Berger and Kunreuther 1994).

An empirical study of insurers’ behavior for perfectly correlated risks does suggest that premiums are higher if probabilities are ambiguous than well-specified. Actuaries in U.S. firms were surveyed and asked to price a warranty on a component of a new line of microcomputers when there were either 10,000 or 100,000 policies sold. The probabilities of failure were varied from p=.001 to p=.01 and p=.10; there was a perfect correlation between the failure of one component and all the others. In one case, the premium was more than eight times higher in the ambiguous case than it was in the non-ambiguous one. (Hogarth and Kunreuther 1992). The results of this survey lend some support to a safety-first model of underwriter behavior in the spirit of Stone (1973) rather than expected utility maximization.

**Concern with Catastrophic Losses**

Insurers are reluctant to provide coverage against natural hazards because of the fear of catastrophic loss and their inability to price the risk to reflect this concern. Prior to 1998 the industry had not experienced actual losses from a single catastrophe that exceeded $1 billion. Since that time the industry has experienced 14 such events. (Insurance Services Office 1994a). Hurricane Andrew, which hit the Florida coast, caused insured damage of over $16 billion and the Northridge earthquake of 1994 produced estimates over $12.5 billion in insured losses, more than three times the total earthquake premiums California insurers collected in the 25-year period prior to the disaster. (Insurance Information Institute 1995).

\(^8\)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 Lmin to Lmax.*

\(^9\)These well-specified scenarios were p=.005 L=$1 million; p=.005 L=$10 million; p=.01 L=$1 million and p=.01 L=$10 million.
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In many states, including California and Florida, insurers do not have the freedom to set rates without prior approval. Given the concern of many insurance firms with insolvency from a large-scale disaster, they either want to raise their rates to levels which have not been permitted by state regulators and/or reduce the number of policies which they have sold in a given part of the country. They have been restricted from taking these steps. For example in Florida the percentage of homeowners policies that an insurer can cancel or nonrenew in any one year must be less than 5 percent statewide and 10 percent in any one county until November 1996 (this has been since extended to 1999). Insurers who offer coverage in Florida are also forced to share in the future losses of those individuals who buy coverage from a Residential Joint Underwriting Association (JUA). These JUAs were set up to provide coverage to those homeowners who could not purchase or renew their policy from a private insurer. Hence they generally represent a higher risk and their premiums may not reflect this. (Insurance Information Institute 1995).

After Hurricane Andrew and the Northridge earthquake, insurers had a difficult time finding enough reinsurance at a price they are willing to pay to protect themselves against catastrophic losses. There is great concern in the industry with the impact of a future catastrophic earthquake or hurricane where insured damage could be over $100 billion. The insurance and reinsurance industry feels it will not have enough capacity to cover future losses from such disasters.

Inability to Encourage Mitigation Activity

To date insurers have normally not utilized either premium reductions, lower deductibles or coverage limits as incentives to encourage property owners to adopt mitigation measures. It is difficult to understand their rationale for not offering some return for actions that promise to reduce losses given that this has been standard practice in other lines of insurance. For example, discounts currently exist on life insurance policies for nonsmokers, on automobile insurance policies for cars with passive restraints and on fire insurance policies for commercial buildings with sprinkler systems.

Informal discussions with industry personnel suggest several reasons for the reluctance to offer bonuses for investments in LRMs. Underwriters claim that there is not sufficiently good data available on the impact that specific mitigation measures will have on loss reduction for specific structures. More specifically, insurers do not feel that they have a good handle on the probability of a disaster (p) and the reduction in loss (L) to compute the premium reduction for undertaking specific actions.

Second many companies apparently feel that the current rates that they are allowed to charge property owners in hurricane and earthquake prone areas are so low that the adoption of an LRM by a property owner only brings the risk closer to the actuarial rate. Hence they feel there is no reason why a premium reduction should be given. Data from the previous example illustrates that this line of argument is incorrect. Suppose that for a given structure p=1/100 L=$100,000 so that the actuarial premium is $1000 but insurers are forced to provide coverage at a premium of $500. If a homeowner bolted the structure to its foundation then L*=72,500 and the actuarial loss were $725. If insurers gave a premium reduction of up to $275 to induce the property owner to adopt this measure they would have higher profits than if it was not utilized.

Of course, if insurers do not want to encourage property owners to purchase coverage because they feel the rates are too low, then they certainly would have no incentive to push cost-effective mitigation measures and then lower their rates in return. When they are required to renew almost all their policyholders, as in Florida, then they should have an incentive to encourage cost-effective mitigation through rate reductions.

Finally insurers feel that property owners would not adopt cost-effective LRMs even if the premium were reduced because they do not make the benefit-cost tradeoffs as illustrated by Table 1. They point to
surveys reported in Palm (1995) which revealed that only 10 percent of homeowners invested in any type of structural loss-reduction measure whether or not they were affected by recent earthquakes in the state. If an insurer perceives that they will be at a competitive disadvantage by incurring administrative costs and marketing expenses for encouraging these actions which will have little if any impact on behavior, then there is a financial basis for their lack of interest in promoting loss reduction measures through premium reductions and/or lower deductibles.

A Proposed Program for Reducing Disaster Losses

The above evidence suggests that private insurers are reluctant to play a major role in offering protection against disasters with catastrophic potential because they feel that their rates are inadequate and that they may become insolvent if a Big One occurs in the future. Furthermore they have little interest in encouraging property owners to adopt loss reduction measures through premium incentives. On the demand side of the equation, there has been limited interest by homeowners in the voluntary adoption of cost-effective mitigation measures.

A new approach is needed for dealing with natural disasters which combines market-mechanisms, such as insurance, with well-enforced standards such as building codes. In addition, there is a need for new programs that offer financial protection to insurers against catastrophic losses. The elements for the design of such a program are now in place and will be explored below:

**Enforcing Building Codes**

One way to encourage the adoption of cost effective loss reduction measures is to have states incorporate them in their building codes and give each building that meets or exceeds these standards a seal of approval. To institutionalize such a procedure financial institutions could require an inspection and certification of the facility as a condition for instruments obtaining a mortgage. This inspection, which would be a form of buyer protection, is similar in concept to termite and radon inspections normally required today when property is financed. The success of such a program requires the support of the building industry as well as a group of well-qualified inspectors who will provide accurate information as to whether existing codes and standards are being met.

Since most property owners do not voluntarily adopt cost-effective LRMS, building codes can serve an important function in reducing property damage from future disaster in ways that can be justified using benefit-cost analysis. Cohen and Noll (1981) provide an additional rationale for building codes. When a building collapses it may create 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.

There is a need for developing a level playing field through standardized well enforced building codes because there is limited interest by engineers and builders in incurring costs that they feel will hurt them competitively. Interviews with structural engineers concerned with the design of earthquake-resistant structures indicate that they have no incentive to design 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).

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 enforce these building codes. A more well designed building against natural disasters should be rewarded with lower premiums, lower deductibles and/or higher coverage limits on their insurance policy.
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Of course, strengthening building codes does not address the problem of the large number of existing structures that must be retrofitted with mitigation measures.

**Encouraging Adoption of Loss Reduction Measures**

The empirical evidence does suggest that individuals do not invest voluntarily in protective measures because they underestimate the probability of an event, are constrained by limited budgets to incur the high up front costs in return for the much lower annual premium reduction and because they have short time horizons either due to high discount rates or myopia (Kunreuther 1996).

Consider the example in the previous section where \( p=1/100 \) and the reduction in loss \( L-L^*=27,500 \) so that the expected annual benefit is \$275. The cost of the mitigation measure is \( C=1500 \). If the homeowner underestimates \( p=1/200 \), then the perceived expected benefits would be \$137.50. Should the homeowner only have a time-horizon of several years then the investment will not be viewed as attractive. Finally budget constraints may lead the property owner not to invest in the measure even if it was viewed to be cost-effective.

One way to address these limitations is for the bank to give a home improvement loan for the life of the mortgage on the property. For example a 20-year loan for \$1500 at a 10 percent annual interest rate would result in monthly payments of \$176. If the annual premium reduction from insurance reflected the expected benefits of the mitigation measure (i.e., \$275) then the homeowner will have lower total payments by investing in mitigation than not undertaking the measure.

**Financial Protection to Insurers Against Catastrophic Losses**

Over the past few years there has been the emergence of new financial instruments to protect insurers against losses from catastrophic events, although they have had limited market penetration. These instruments infuse the insurer with additional capital should there be a catastrophic loss to avoid the chance of insolvency. In this sense they represent diversification of assets over time rather than across geographical boundaries.

Some of these instruments, such as a **finite risk product**, provide funds to the insurer should they suffer a catastrophic loss. J.P. Morgan and Nationwide Insurance successfully negotiated such a transaction. Under the arrangement Nationwide borrowed \$400 million from J.P. Morgan which is placed in a trust fund composed of U.S. Treasury securities. Nationwide pays 9.922 percent on the funds (i.e., investors get a 9.922 return on their investment) which is secured by 30-year notes which pay 7.7 percent. The difference between these two rates of return can be viewed as Nationwide’s annual premium. If a catastrophe occurs, Nationwide can obtain funds to pay for part of the losses by issuing up to \$400 million in 30-year surplus notes substituting them for the Treasury securities. Now the investor’s risk is increased since their investment is backed by Nationwide credit rather than Treasury’s. (Mooney 1995) A similar financial arrangement, but one with more extreme consequences to investors is Act of God bonds, whereby investors provide capital to be used by the insurer if a catastrophe occurs. In this case investors obtain a large return on their investments (e.g., 15 percent) to reflect their higher risk.

Both of these financial products address the solvency constraint [equation (2)] associated with the safety-first model. Let \( B \) be the amount of capital which an insurer receives should it negotiate some type of financial arrangement like a finite risk product or Act of God bond; \( Z \) reflects the annual premium, such as the interest rate differential on the finite rate, which the insurer pays to obtain these funds. Then (2) now becomes:
Probability \([X + NL-B > A+NP-Z] < p^*\) \hspace{2cm} (3)

Viewed in this way the underwriter should then be able to specify the magnitude of the needed funds \((B)\) in relation to the cost \((Z)\) required to enable the insurer to provide coverage against a risk which has catastrophic potential.

Other financial instruments are catastrophic insurance futures contracts and call spreads. Introduced by the Chicago Board of Trade (CBOT) in 1992, they enable an insurer to hedge against their underwriting risk by attracting capital from insurance and non-insurance segments of the economy. The CBOT offers four catastrophe future contracts based on geographical areas: East Coast, Midwestern, West and National.

An investor buys a calendar-quarter contract on a $25,000 premium block; the cost would be $2,500 for a contract at a 10 percent loss ratio. For every percentage point above a 10 percent loss ratio the buyer receive $250 more than cost for every contract purchased. For example, if loss experience increases the expected catastrophe loss ratio to 12 percent, at settlement the buyer would receive $3000 for every contract purchased. For an insurance company purchaser, the investment income would help offset the additional catastrophe losses incurred from the disaster that drove up the loss ratio. If no catastrophes occur, the contract is worthless at maturity.\(^{10}\)

In the context of equation (3), the benefits \(B\) are based on the magnitude of catastrophic losses from the disaster to the entire insurance industry rather than to a specific firm. The premium \(Z\) reflects the cost of the contract. In other words, the underwriter has less control over the revenue flowing into the firm after a disaster because it is based on total, coverage written by all insurers. For this reason this instrument is likely to be less attractive to any insurer the less correlated its risk is to the entire portfolio of insurance against a specific event.

The National Economic Council (NEC) has developed a proposal recommending that the federal government offer catastrophe reinsurance contracts that would be auctioned annually. The proposal would establish a program in which the Treasury would auction a limited number of excess-of-loss 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. Contracts would be sold to the highest bidder above a base reserve price which is risk-based. Half of the proceeds above the reserve price would go into a mitigation fund, with the remainder retained to cover payouts. The task force envisioned the reinsurance program starting to phase out after five years in expectation that a private market would emerge for this level of coverage. (National Economic Council 1995)

Another 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 the resources at the federal government’s disposal enable them to cover catastrophic losses without charging insurers the higher risk premium that private investors would require. If one views the private sector as the first line of attack on the problem, then one would only want to resort to federal reinsurance as an avenue of last resort.

\(^{10}\)See Cummins and Geman (1995) and Harrington, Mann and Niehaus (1995) for a more detailed discussion on these hedging mechanisms and the challenges in pricing them.
Subsidize Low Income Families

Many poorly constructed homes are owned by low-income families. Many cannot afford the costs of mitigation measures on their existing structure nor 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 for the purpose of adopting cost-effective loss reduction measures (LRMs) or for them to relocate their home to a safer area. Since low income victims are likely to receive federal assistance after a disaster, subsidizing these mitigation measures can also be justified on efficiency grounds.

Summary and Conclusions

The proposed disaster management program relies on a set of policy tools for encouraging loss reduction measures against natural hazards and providing recovery funds to disaster victims. For it to be successful it requires the active involvement of a number of interested parties from the private sector such as insurers, banks and financial institutions, builders and contractors as well as enforcement of building codes by government officials. There may be a role for government in providing assistance to low income families to engage in mitigation measures and to recover after a disaster, and to provide catastrophic reinsurance if the private sector does not offer such coverage. They need to work closely with public sector agencies at the federal, state and local levels.

With respect to future directions for research there is a need to specify the types of cost-effective mitigation measures that could be applied to new and existing structures. Only then can insurers, builders, and financial institutions work together to incorporate these measures as part of building codes and provide property owners with appropriate rewards for adopting them. This effort will require better data on disaster losses from different events than we currently have available. The computer models which simulate natural disaster losses are based on representative community profiles and do not focus on individual structures. Yet the data should be available to take these steps and indicate appropriate reductions in risk to specific structures that utilize certain LRMs.

Finally I have only alluded in the introduction to the large cost that all taxpayers incur to repair public sector damage from natural disasters. Public structures should be encouraged to take out insurance and engage in mitigation measures. One way to do this is to change legislation so that a lower percentage of damage is covered by federal funds to repair these structures. These funds would not be provided unless municipalities implemented cost-effective mitigation measures.

Another alternative is to levy property taxes on all community residents to cover losses to public structures from disasters. This is a form of community-based insurance with all residents paying a share in proportion to the value of their property. To my knowledge this alternative has not been seriously proposed as part of future legislation. However, if there is a feeling by Congress that the responsibility for disaster lies primarily with the private sector or at the local level, then insurance, incentives, taxes and well-enforced local building codes will have a higher profile in the future than they do today.
TABLE 1

Present Value of Bolting House to a Foundation Based on Number of Years that Structure is Occupied (Discount Rate 4 Percent)

<table>
<thead>
<tr>
<th>Number of Years</th>
<th>Present Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$265</td>
</tr>
<tr>
<td>2</td>
<td>519</td>
</tr>
<tr>
<td>3</td>
<td>763</td>
</tr>
<tr>
<td>4</td>
<td>998</td>
</tr>
<tr>
<td>5</td>
<td>1224</td>
</tr>
<tr>
<td>6</td>
<td>1441</td>
</tr>
<tr>
<td>7</td>
<td>1713</td>
</tr>
<tr>
<td>10</td>
<td>2230</td>
</tr>
<tr>
<td>15</td>
<td>3058</td>
</tr>
<tr>
<td>20</td>
<td>3737</td>
</tr>
<tr>
<td>25</td>
<td>4296</td>
</tr>
<tr>
<td>50</td>
<td>5908</td>
</tr>
</tbody>
</table>

TABLE 2

Ratios of Underwriters Premiums for Ambiguous and/or Uncertain Earthquake Risks Relative to Well-Specified Risks

<table>
<thead>
<tr>
<th>SCENARIO</th>
<th>CASES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>p,L</td>
</tr>
<tr>
<td>p=.005 L=$1 million</td>
<td>1</td>
</tr>
<tr>
<td>p=.005 L=$10 million</td>
<td>1</td>
</tr>
<tr>
<td>p=.01 L=$1 million</td>
<td>1</td>
</tr>
<tr>
<td>p=.01 L=$10 million</td>
<td>1</td>
</tr>
</tbody>
</table>

N= Number of Respondents
*Ratios are based on Mean Premiums Across Number of Respondents for Each Scenario
Source: Kunreuther, Meszaros, Hogarth and Sptanka (1995)
References


