EARTHQUAKE INSURANCE AS A HAZARD REDUCTION STRATEGY
THE CASE OF THE HOMEOWNER

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ABSTRACT

In this paper a case is made for requiring homeowners in
earthquake prone areas throughout the country to purchase insurance
and adopt cost-effective loss reduction measures (LRMs). There is
substantial empirical data showing that many homeowners do not
voluntarily purchase insurance because they perceive the
probability of the event to be so low that "it cannot happen to
me". One reason that few individuals take steps to mitigate losses
is that they have short-time horizons and are not convinced that
the long-run expected benefits from the LRMs justify the upfront
expenses.

The paper also provides data indicating that many insurance firms
will suffer substantial losses from a catastrophic earthquake. Many
insurers claims will be from indirect losses such as fire and
workers compensation which are covered by non-earthquake policies.
A federal reinsurance program, similar to the one proposed in the
Earthquake Hazards Reduction Amendments Act now before Congress,
appears to be an appropriate solution. In return insurers should be
able to reduce premiums from what they currently charge and provide
rate-based incentives to homeowners to encourage them to adopt
cost-effective LRMs.
1. SETTING THE SCENE

This paper focuses on ways that insurance can aid the financial recovery of homeowners suffering property damage from a severe earthquake, while at the same time reducing losses from future earthquakes.¹ In theory, insurance should be ideally suited to play both of these roles. A homeowner who has purchased earthquake insurance is protected against a severe loss through the payment of a small premium. If premiums are based on risk, then insurance should encourage individuals to adopt cost-effective loss reduction measures on their homes.

An Illustrative Example Consider the following hypothetical example to illustrate these points. Suppose that seismologists have estimated that the annual chances of a severe earthquake that will cause damage to a home in Memphis, Tennessee is 1 in 200, and that the total damage will be $20,000. If there were no deductible on the policy then the actuarially fair premium for insurance is $100.²

If a person is averse to risk and hence wants to pay a small premium to avoid a large loss, then insurance should be an

¹A discussion of the availability of earthquake insurance for small businesses enterprises can be found in Alesh et. al. (this volume).

²An actuarially fair premium is determined by multiplying the probability of the event by the resulting loss. In this case, .005 x $20,000 = $100.
attractive option even if the price of coverage somewhat exceeds $100. Following an earthquake the family will be reimbursed by its insurance company rather than having to finance recovery with their own resources, bank loans or disaster assistance from the federal government.

Now suppose that a homeowner could invest $50 to securely attach their water heater to the wall to prevent it from toppling during an earthquake. If gas or electrical lines are broken as the water heater falls, this may cause a fire as well as water damage.3 Suppose that by adopting this measure the best estimate of the reduction in damage to the home and contents if a severe earthquake occurs is estimated to be $4,000. This means that the insurer can now reduce the actuarially fair premium to the homeowner by $20 (i.e. .005 x $4,000).

If an insurer lowers the annual premium by $20, then the homeowner has to decide whether to invest $50 today to save $20 each year over the life of the house. It should be clear that this investment is a cost-effective one for any house that is likely to be occupied for even just a few years.4

Earthquake Insurance In practice earthquake insurance has only been partially successful in achieving either of these roles for

3See California Seismic Safety Commission (1992) for a detailed description of alternative loss reduction measures that can be adopted by homeowners.

4We will analyze the relevant tradeoffs in showing how to determine whether a particular mitigation measure is cost-effective in the next section.
residential structures. Earthquake insurance is offered throughout the country by private insurers. In California a typical homeowners policy is for $140,000 and costs $280. The policy would have a deductible of 10% (or $14,000) and cover the structure as well as the contents of the home. If there is a loss of $50,000 from the earthquake then the insurance company would pay $50,000-$14,000=$36,000. Twenty years ago approximately 5 percent of the homeowners purchased earthquake coverage in California; in 1992 the percentage had risen to 30 percent. (Roth, 1992).

The increased interest in insurance is partially due to the extensive media coverage of forecasts by seismologists that a catastrophic earthquake is likely to occur somewhere in California by the end of this century. In addition the California state legislature required insurance companies after 1984 to inform all policyholders with homeowners’ coverage that they could add the earthquake peril to their policy for an additional charge. (Mittler 1991). Still one needs to recognize that 70 percent of the homeowners in California currently do not have earthquake insurance.

Until 1990 a much larger proportion of homeowners purchased earthquake insurance in California than in the Central and Eastern United States even though there has been severe seismic activity in these parts of the country in the 19th century. In fact, the most severe earthquake to ever strike the United States was near the town of New Madrid, Missouri. Beginning in December 1811 and extending through February, 1812 the area experienced a series of
massive earthquakes. The largest of these quakes was felt over about 1 million square miles---half the continental United States.

A survey of 25 insurers writing homeowners insurance within the seven state area which comprises the New Madrid fault, revealed that in 1989 less than 12% of the 3 million residences had purchased earthquake coverage. (CPCU 1992). Only after Iben Browning estimated that there was a 50 percent chance that a severe earthquake would occur on the New Madrid fault during a two day period centering on December 3, 1990, was there a surge of demand by homeowners in coverage.

Although seismologists strongly disagreed with Browning's prediction and estimated that the probability of such an event was about 1 in 60,000, these same insurance companies reported that the percentage of homeowners who had an earthquake policy in December 1990 had risen to an average of 37%. In Kentucky almost 60% of homeowners with policies from these 25 companies had purchased earthquake coverage and in Missouri just under 50% had purchased an earthquake rider with their homeowners policy. (CPCU 1992). State Farm reports that more than 650,000 of their policyholders in the eight states near the fault added an earthquake endorsement to their homeowners policies, mostly in the two months prior to the December 3 prediction. (Johnson et. al. in press).

Even though Browning's prediction turned out to be erroneous, the extensive media coverage surrounding this "event" sparked considerable interest and awareness of earthquakes in the Central United States. This is evidenced by the very small decline
in insurance coverage in this region one year later. Across the seven state area 35 percent of the homeowners still had earthquake coverage as of December 1991. However, if past behavior is any guide to the future, this percentage is likely to drop considerably over the next 10 years if the New Madrid area does not experience any moderate or severe earthquakes.

**Loss Reduction Measures** Few homeowners have voluntarily undertaken loss reduction measures to reduce damage to their homes even when the benefits are high and the costs are relatively low. A 1974 survey of more than 1,000 California homeowners in earthquake prone areas revealed that only 12 percent of the respondents had adopted any protective measures. Many of these actions involved little or no cost, such as removing or securing objects that might fall. (Kunreuther et. al. 1978).

Fifteen years later there was little change in the situation, despite the increased awareness by the public of the earthquake hazard. In a 1989 survey of 3,500 homeowners in four California counties subject to earthquake damage, only between 5 and 9 percent of the respondents in each of these four areas reported adopting any LRMs (Palm et. al. 1990). A follow-up survey of residents affected by the October 1989 Loma Prieta earthquake by Palm and her colleagues, revealed that few residents invested in any type of loss-reduction measures.

**Insurance Industry Concerns**
Insurance companies have been willing to offer earthquake coverage to homeowners but are deeply worried about the impact that a catastrophic earthquake will have on their financial condition. The industry fears that the surplus or net worth of most companies will be sufficiently reduced if there is a severe earthquake, so that they will be forced to restrict coverage on all lines of insurance. They are also concerned that some of the smaller firms are likely to become insolvent (Earthquake Project 1989).

Interestingly enough these concerns are only partially related to the amount of earthquake insurance that is marketed today. Much of the projected damage and losses from an earthquake may be due to fire, business interruption, workers compensation and general liability which are covered by other insurance policies. Hence even if the insurance industry decided to discontinue earthquake coverage completely, it would still suffer severe financial losses because it would be forced to pay claims from these other policies in force. For example, if a fire were triggered by the earthquake, a homeowner whose residence burned could collect from his homeowners policy even if he did not have earthquake coverage.

The next section of the paper examines the reasons why most homeowners are reluctant to purchase earthquake coverage and will not invest in mitigation measures. Section 3 summarizes the results of a study indicating the financial impact of a catastrophic earthquake on small, medium and large sized insurance firms. Based on the above findings, the concluding section argues for more
stringent building codes, actions by the federal government to require homeowners to purchase earthquake insurance, and federal reinsurance protection to assist insurance companies in the event of a catastrophic earthquake.

Although California is the source of much of the data on which these conclusions are based, there is sufficient information from the Central and Eastern United States suggesting that the policy recommendations are even more applicable to this part of the country. There is appears to less concern with earthquakes in the Central and Eastern United States than in California, and as we have already noted the potential damage could be enormous should another New Madrid-like earthquake occur again.

2. FAILURE OF HOMEOWNERS TO ADOPT PROTECTIVE MEASURES

The literature on decision processes of individuals with respect to low probability high consequence events provides considerable insight into the reasons why most individuals do not purchase insurance voluntarily against natural hazards. The contingent weighting model proposed by Tversky, Sattath and Slovic (1989) provides a useful framework for characterizing individual choice processes with respect to this lack of interest in adopting protective measures such as insurance.

In this descriptive model, individuals make tradeoffs between the dimensions associated with alternatives such as probability and outcomes. The weights they put on these dimensions are contingent, because they may vary depending on the problem context and the way
information is presented. People often weight these dimensions differently than would be suggested by normative models of choice.  

The expected utility model, a cornerstone of normative economic analysis, provides a useful reference point for studying individual behavior under uncertainty. If a homeowner makes decisions according to this approach, then she weights the disutility of the losses to her property resulting from earthquakes of different magnitudes by the probability that each of these events will occur. By investing in insurance and mitigation measures, the impact of the earthquake can be reduced.

Expected utility theory offers a systematic procedure for contrasting the expected costs and benefits from different alternative strategies for dealing with the earthquake including not taking any action. The optimal strategy for each individual will depend on the shape of her utility curve. A utility curve depicts the value associated with different levels of wealth. If an individual is risk averse, then the expected utility model will normally evaluate the decision to purchase earthquake insurance as an attractive option as long as the premiums are not extraordinarily high; investing in cost-effective loss reduction measures will also be viewed as desirable.  

In practice, a minority of homeowners behave according to

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5See Camerer and Kunreuther (1989) for a more detailed discussion of the decision processes of individuals with respect to low probability high consequence events.

6For an excellent introduction to utility theory and its implications for decision making see Raiffa (1968).
expected utility theory or other normative models of choice, such as benefit-cost analysis. Below I suggest some of the reasons why there is limited interest in protective activities against earthquakes and other natural hazards.

\textbf{It Cannot Happen to Me} Many individuals initially focus on the their perceived probability of a disaster \((p)\) and unconsciously set a threshold level \((p^*)\) below which they do not worry about the consequences at all. If their estimate of \(p < p^*\) then they assume that the event "cannot happen to me" and take no protective actions. This threshold model of behavior also explains why many motorists have refused to wear seat belts voluntarily. They perceive that the chances of an accident are so small that "it won't happen to me". (Slovic et. al. 1978).

This decision to ignore events where \(p < p^*\) is exacerbated by a tendency for individuals to underestimate the probability of a future disaster if they have not personally experienced the event. For this reason many individuals do not believe that they will suffer damage to their homes even in areas where seismologists have predicted that though there are is likely to be a severe earthquake in the next decade.\(^7\) For example, Robert Ketter, who directed the National Center for Earthquake engineering Research at SUNY Buffalo, predicted that the probability that a

\(^7\)Similar behavior has been found with motorists estimates of their driving ability. Svenson (1981) found that over 90 percent of subjects interviewed that they were "above average" in their driving ability.
major earthquake will occur somewhere in the Eastern United States by the year 2010 is virtually 100 percent (Warfel 1992).

It is easy to see why this behavioral strategy violates the tenets of expected utility theory or benefit-cost analysis. Instead of weighting the outcome from an event by its perceived probability of occurrence, individuals who utilize a threshold model treat low probabilities as having a zero chance of occurrence. They don’t even consider the consequences from events which they treat as impossible, when, in fact, they may actually occur.

Myopic Behavior One reason that homeowners will not invest in cost-effective loss reduction measures is that their calculation of benefits is based on very short-time horizons. In other words, they focus on the upfront expenditures, not recognizing that the potential benefits will be reaped for as long as the house is occupied. By being relatively myopic in their planning behavior they may conclude that the investment in a protective measure is unattractive.

A simple example illustrates this point. Suppose that a homeowner has the option of bracing the concrete foundation of her sixty year old one-story house currently valued at $100,000 so that it is prevented from going off its foundation should a severe earthquake occur. The cost of this loss reduction measure (LRM) is estimated to be $1500; the reduction in damage from undertaking
this action is $27,500 should a severe earthquake occur.\textsuperscript{8} If the homeowner estimates that the probability (p) of such an earthquake occurring next year and damaging their house is greater than .054 (i.e. $1500/$27,500) then the expected benefits would exceed the cost of the mitigation measure even if the life of the house was one year.

Table 1 depicts the critical annual probability (p) above which the family would want to invest in this LRM as a function of the time horizon in years over which the family computes the benefits of this measure, using a real discount rate of 4 percent.\textsuperscript{9} If the family assumes that they will be in their home for the next 10 years then the critical probability of a future earthquake for the LRM to be cost-effective will be .0065 (i.e. 65 in 10,000). Naturally if the homeowner estimates the probability of a severe earthquake to be extremely low, then the cost of the LRM will be too high relative to expected benefits even if a long time-horizon

\textsuperscript{8}The 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 Prieta earthquake occur. (Gallagher Associates 1990).

\textsuperscript{9}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) utilize a 4 percent rate by noting that the interest rate on long-term treasury bonds is 8\% and the "core" inflation rate (all consumer items less the food and energy components) is about 4 percent. The difference (i.e. 4\%) is a measure of the real rate of interest on risk-free investments. (p.19)
were utilized.¹⁰

Role of Disaster Assistance  One of the arguments that has been advanced as to why individuals do not adopt protective measures, is that they assume liberal aid from the government will be forthcoming should they suffer losses from a disaster. Under the current system of disaster assistance, the Governor of the State(s) can request that the President declare a "major disaster" and offer special assistance if the damage is severe enough. For example, loans will be provided to homeowners and businesses from the Small Business Administration for repair, rehabilitation or replacement of damaged real and personal property.

There does not appear to be any evidence suggesting that individuals refuse to purchase insurance or do not undertake LRM's because they feel they will be bailed out by the government should they suffer damage. In fact, survey data from the 1970s suggests just the opposite pattern. Although most uninsured homeowners were aware that the Small Business Administration (SBA) provided aid to victims, these respondents had little knowledge of the terms of the loan and most did not anticipated turning to the federal government for relief should they suffer damage from a disaster. Their decision not to purchase insurance was primarily due to other factors such as not perceiving the hazard to be a serious problem. (Kunreuther et. al. 1978).

¹⁰This calculation assumes that if a quake occurs during the time horizon the mitigation measure would be intact, so that the $1500 cost would not have to be incurred again.
It may be that homeowners attitudes toward the federal government have changed in the intervening period, but there is no a priori reason to believe that this has been the case. In fact, there should be even lower expectations of liberal disaster assistance today than fifteen years ago, since the SBA loan policy has become much more restrictive in recent years: there are no more forgiveness grants and the interest rate on loans is only slightly below the market rate rather than at the one percent rate granted to victims of Tropical Storm Agnes in 1972.11

This does not mean that special relief measures won't be passed by Congress following the next severe earthquake, if relatively few of the victims have purchased insurance and/or adopted mitigation measures. Suppose disaster assistance measures, such as those following Tropical Storm Agnes, were instituted and the Internal Revenue Service continues to allow disaster victims to deduct their uninsured casualty losses on their income tax returns. Then there is even less reason for homeowners to purchase insurance voluntarily and adopt cost-effective LRM's in the future. To avoid such a situation there is a need for required earthquake insurance and more stringent building codes than we currently have in place.

3. WHY INSURERS DO NOT PROMOTE EARTHQUAKE COVERAGE

Based on expected benefit/cost criteria, earthquake insurance should be an attractive item for private insurers to market

11Uninsured homeowners who suffered damage following Tropical Storm Agnes were also eligible for forgiveness grants of up to $5,000.
actively. For residential insurance, the premium to loss ratio over the first 60 years that earthquake insurance was offered in California (1916-76) averaged 30 to 1 (Atkisson and Petak 1981). In fact, the Loma Prieta earthquake of 1989 gave the insurance industry its first losing year since 1906 in terms of premiums and losses for earthquake coverage alone. Yet the industry has been reluctant to promote coverage to the residential sector.

Potential for Catastrophic Losses The principal reason that insurance and reinsurance firms do not actively marketing coverage is their concern with the impact of a catastrophic earthquake on their surplus. The industry fears that many firms may become insolvent even with their current insurance in force. By promoting earthquake coverage actively, insurers would be signalling to the outside world that they are not worried about the consequences to them of the Big Quake.

Evidence supporting the insurance industry's fears comes from a study of the consequences of a catastrophic earthquake (CE) on the solvency of private insurers. (Doherty et. al. 1992). Data

\[12\] Earthquake premiums in 1989 for separate earthquake policies, which are normally on residential structures, was $334 million while losses were $433 million. Earthquake coverage for commercial structures are normally included in a package with other perils. My thanks to Richard Roth, Jr. for providing this information from the California Department of Insurance.

\[13\] The financial strength of insurers is measured by their surplus or equity. The surplus provides a safety net if the aggregate losses from all the company's policies in force turns out to be larger than the premiums collected plus the interest earned on the investment of these premiums.
were collected from 18 insurance firms providing earthquake
coverage in California, to determine the financial impact to them
should there be a reoccurrence of a disaster of the same magnitude
and geographic location as the 1906 San Francisco earthquake.

The study found that if such a CE occurred, 5 out of the 11
firms with surpluses less than $2 billion would suffer losses that
would exceed their surplus and cause them to be insolvent. The 7
larger firms in the survey with surpluses exceeding $2 billion
would be less severely affected by the CE. Though 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 from the CE that they could not meet
current regulatory guidelines.

All primary insurers use the reinsurance market to protect
themselves against the possibility of large losses from events such
as a CE. Since reinsurance data is not 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 predicted to be insolvent from the CE without
reinsurance responded to the survey; all of them would still be
insolvent, even if the reinsurers paid all their claims.

Earthquake insurance covers primarily "shake damage" while
other insurance such as homeowners coverage and workers
compensation covers the indirect losses such as fire following
earthquake and injuries to employees. The indirect losses from a CE
exceeds the shake damage for every insurance firm in the sample. Perhaps the most revealing result from the study is that even if there were no earthquake insurance in place today, the indirect losses to the insurance industry would account for almost $26 billion of the $40 billion of the estimated insured losses from the projected earthquake.

The impact of a CE 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 that they can charge for such an event is relatively small because of its low probability, but the losses to them from a CE could be enormous. Hence it is not surprising that reinsurance for property catastrophes from natural disasters, such as earthquakes, is expensive and extremely difficult to obtain today, with large companies, like Lloyd’s of London, greatly reducing its catastrophe exposure. (Roth 1992).

Concern with Ambiguous and Uncertain Risks Insurers are much more likely to provide protection against risks where the probability (p) of an event is well-specified and the magnitude of the resulting loss (L) is known. Life insurance is the classic example of such a risk, since actuarial tables define the probabilities of a person dying at different ages given their current age and health status; the loss is the face value of the policy. I will label this as the non-ambiguous case. An earthquake is an event where there is considerably more uncertainty with respect to the chances of its
occurrence as well as the magnitude of the resulting damage to property.

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. For the well-specified case, the probability of the earthquake was either .01 or .001 and the loss should the event occur was known at either $1 million or $10 million, yielding four different scenarios. Within each scenario there were four different cases ranging from the non-ambiguous case to the highly ambiguous case where the probability was ambiguous (Ap) and the loss uncertain (UL).

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 non-ambiguous case (p, L) for the four

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1 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.

15 The other two cases were (1) the probability was well-specified (p) and the loss uncertain (UL) and (2) the probability was ambiguous (Ap) and the loss known (L). In this survey a well-specified probability is defined as a situation where there are considerable past data on particular events so that "all experts agree that the probability of a loss is p". 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 known 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 $L_{\text{min}}$ to $L_{\text{max}}$. 
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 non-ambiguous risk. The ratios for the other two cases were always above 1 but less than the (Ap,UL) case. [Kunreuther, Hogarth and Meszaros (in press)]

4. WHAT SHOULD BE DONE NOW

The above evidence suggests that homeowners and insurers are reluctant to deal with the earthquake problem for very different reasons. Many homeowners at risk are not anxious to purchase insurance because they feel the disaster will not happen to them; others who have compared premiums with potential benefits may feel the price is too high relative to the coverage that they would obtain. Few homeowners have adopted cost-effective LRM systems because they utilize short-time horizons in determining the expected benefits from investing in mitigation measures.

The insurance industry is reluctant to market coverage actively because they fear the consequences of a catastrophic quake, and hence want to limit their exposure. Their premiums are significantly higher than expected cost because of their concerns with potential indirect losses from a catastrophic earthquake as well as the ambiguity associated with the risk. One option would be for insurers to only pay for shake and indirect losses only if policyholders have purchased earthquake coverage, as is currently done in Japan. However, it is highly unlikely that private insurers
in the United States would be allowed by State insurance commissioners to adopt the Japanese system.

The current situation can be costly to all of the interested parties concerned with disasters. First, the damage from earthquakes will be larger than it would be if cost-effective LRMs were adopted on new and existing homes. Second, insurance and reinsurance firms will suffer severe financial losses from a CE, with some companies becoming insolvent. Third, many uninsured homeowners will be saddled with large recovery costs following a severe earthquake.

If the past is a guide to the future and the status quo is maintained, the federal government will come to the rescue by helping the insurance industry to cope with its financial losses and provide victims with liberal disaster relief. Hence all U.S. citizens will have to pay for the losses generated by future severe earthquakes. To cope with each of these three problems the following elements of a program should be explored.

Institute More Stringent Building Codes Since many homeowners do not voluntarily adopt cost-effective LRMs, building codes can serve an important function in reducing property damage from future earthquakes. 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.

Implementing building codes on new construction is much easier than with existing structures, since the potential buyer has a choice as to whether or not to purchase the home. A study undertaken for FEMA by Dames and Moore (1990) identified a set of cost-effective LRM s that could be incorporated into state and local government earthquake ordinances. A more recent study on the economic impact of earthquake mitigation measures by Litan et al. (1992) provides a justification for more stringent building codes on new construction in Shelby County including the city of Memphis, Tennessee.

Requiring homeowners to invest in improving their existing homes may be protested for the same reason that they are not voluntarily adopted: the costs are too high. In many cases the family may feel that it cannot afford to invest in this measure even if they are convinced that the expected long run benefits outweigh the expenses. Many of the poorly constructed homes are owned by low-income families so that these budget constraints may be real. Low interest loans or special grants to these groups may be necessary for them to undertake these protective measures.

These subsidies can be justified on both equity as well as on economic grounds. If one can reduce the damage to these homes from a future earthquake by reinforcing the foundation, for example, there will savings in future disaster relief process.
Institute federal earthquake reinsurance. Given the apparent
inability of the private reinsurance market to provide sufficient
reinsurance to cover losses from a catastrophic earthquake (Roth
1992), some type of federal reinsurance may be necessary. The
special advantage of such a federal program is that it reduces
uncertainty about probability and consequences of a CE and should
enable insurers to reduce their premiums for earthquake coverage.

The Earthquake Hazard Reduction Amendments Act, which was
introduced in the U.S. Congress in June, 1991 (H.R. 2806)\(^{16}\), would
have the federal government provide excess reinsurance coverage to
all insurers and reinsurers if a catastrophic earthquake results in
at least $10 billion of insured losses. Private insurance firms
would pay reinsurance premiums set by the Federal Emergency
Management Agency based on actuarial principles, and these would be
set aside in a tax-exempt fund. If a catastrophic earthquake
strikes before sufficient reinsurance premiums have been collected,
then money may be borrowed from the Treasury but the principal and
interest will be repaid from future reinsurance premiums. (Mittler

By reducing the potentially devastating consequences of a
catastrophic earthquake to private insurers, it should be possible
for them to reduce premiums over their current levels. Insurance
industry actuaries estimate that the average gross annual premiums

\(^{16}\)A Senate companion bill (S. 2533) was introduced on April 7,
1992 that is identical to H.R. 2806 except that it would expand the
insurance coverage for certain losses resulting from volcanic
eruption.
for a California homeowners policy under the proposed program would range from $49 to $91 with a 5% deductible; premiums for homeowners residing in states affected by the New Madrid fault would range from $9 to $17, assuming a 5 percent deductible. (Warfel 1992). These prices are considerably lower than present premiums for residences in these parts of the country.

Require earthquake insurance. One way to reduce pressure for special disaster assistance following a severe earthquake is to require homeowners in these hazard-prone areas to purchase earthquake insurance today. The Earthquake Hazards Amendment Act (H.R. 2806) takes an important step in this direction by requiring homeowners who acquire new mortgages or refinance existing mortgages backed or insured by the federal government to purchase earthquake coverage.

Furthermore residential property in earthquake prone states will not qualify for federally backed mortgages unless the states comply with cost-effective loss reduction measures specified by FEMA, or the homeowner voluntarily takes steps to mitigate damages from future earthquakes.17 Homeowners who adopted mitigation measures would be charged lower premiums and/or offered smaller

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17The proposed legislation is similar in spirit to the provisions of the National Flood Insurance Program. For a summary of this program and other federal insurance and disaster relief programs see Mittler 1992 Chapter II.
deductibles than those who did not. (Mittler 1992).  

**Summary** Given the tendency for individuals to avoid thinking about low probability high consequence events and to focus on short-time horizons, it appears necessary to take steps to require them to purchase insurance and adopt cost-effective loss reduction measures. The fact that the insurance industry faces indirect insured losses from an earthquake that are covered by other policies, such as fire and workers compensation, argues for some type of federal reinsurance. This should enable insurers to reduce the premiums on existing earthquake coverage, and hence make coverage more attractive and affordable.

By coupling the insurance requirement with mitigation measures and risk-based premiums, we will have taken a giant step in reducing losses from future earthquakes as well as aiding the recovery process of homeowners who suffer severe damage to their property. For areas, such as the central and eastern United States, the proposed requirements are likely to be particularly relevant, given the perception by many residents that they do not face any danger of a serious quake in the future.

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18 Kunreuther and Kleffner (in press) show that requiring loss mitigation measures is even more justifiable when one homeowners have to purchase earthquake insurance. They show that when one requires full insurance, even with premiums based on risk, there is less incentive for a homeowner to adopt cost-effective LRM than if they were uninsured. The reason is that they are already protected against earthquake losses with their insurance coverage.
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TABLE 1

Critical Annual Probability Level of Future Earthquake
to Justify Bracing Pre-1940 One-Story House

<table>
<thead>
<tr>
<th>Time Horizon in Years</th>
<th>Critical Probability of Future Earthquake</th>
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<tr>
<td>1</td>
<td>.054</td>
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<td>2</td>
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<tr>
<td>5</td>
<td>.012</td>
</tr>
<tr>
<td>10</td>
<td>.0065</td>
</tr>
<tr>
<td>25</td>
<td>.0035</td>
</tr>
</tbody>
</table>

Source: Adapted from Kunreuther, Doherty and Kleffner (1992) Table 1


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>p, L</th>
<th>Ap, L</th>
<th>p, UL</th>
<th>Ap, UL</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>p = .005, L = $1 million</td>
<td>1</td>
<td>1.28</td>
<td>1.19</td>
<td>1.77</td>
<td>17</td>
</tr>
<tr>
<td>p = .005, L = $10 million</td>
<td>1</td>
<td>1.31</td>
<td>1.29</td>
<td>1.59</td>
<td>8</td>
</tr>
<tr>
<td>p = .01, L = $1 million</td>
<td>1</td>
<td>1.19</td>
<td>1.21</td>
<td>1.50</td>
<td>23</td>
</tr>
<tr>
<td>p = .01, L = $10 million</td>
<td>1</td>
<td>1.38</td>
<td>1.15</td>
<td>1.43</td>
<td>6</td>
</tr>
</tbody>
</table>

N = Number of Respondents

* Ratios are based on Mean Premiums Across Number of Respondents for Each Scenario

Source: Adapted from Table 3 in Kunreuther, Hogarth and Meszaros (in press)