“New Strategies for Dealing with Earthquake Hazard”

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New Strategies for Dealing with the Earthquake Hazard

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Introduction

The likelihood of a relatively severe earthquake occurring in urban areas along the Atlantic seaboard of the United States is higher than most people think. A number of scenarios as to the consequences of such a quake are described by Klaus Jacob (infra). New York City is considered to be of low seismicity but earthquakes have been known to occur there. For example, in 1737 severe shaking in the area reportedly toppled chimneys. In August, 1884, there was the strongest earthquake ever recorded in the New York City (NYC) area. It occurred at Rockaway Beach, about 17 miles from NYC and was felt over 70,000 square miles from Vermont to Maryland but caused little damage to structures (Scawthorn and Harris, 1989). The projected damage from a quake of magnitude 6.0 in the NYC area would be estimated to cause over $19 billion in building damage (Scawthorn et al., infra).

The picture with respect to losses from earthquakes in California and Japan is a very different one. Since 1989, three quakes have each caused billions of dollars in damage, with each quake worse than the previous one. The Loma Prieta earthquake in the Santa Cruz area of California (1989) caused damage in the range of $7 billion. More recently, the Northridge earthquake of January 17, 1994 produced damage in the range of $20 billion while the Kobe, Japan, earthquake, which occurred exactly one year later, produced well over $100 billion in losses (Scawthorn et al., infra).

1. This paper draws on material in Kunreuther (1996).
Economic Consequences of Earthquakes: Preparing for the Unexpected

Damages from earthquakes can come from various sources. The most obvious losses are to direct property due to shaking as well as fire triggered from the earthquake. Then there are indirect losses such as business interruption risk which may trigger unemployment in industries and businesses. For example, the Japanese car makers lost production of 40,000 units worth $350 million during the month after the Kobe earthquake (Valery, 1995).

This paper examines the challenges facing society today in reducing losses from future severe earthquakes. Although it is almost certain that such an event will occur in the near future, it is uncertain when and where this will happen, and how much the damage will be. Given the great uncertainty surrounding the occurrence of a future quake, there has been relatively little attention given to the implementation of protective measures to reduce these losses.

A key challenge for society is how to increase the demand for protection to reduce future damage from disaster and protect victims against financial losses. Succeeding sections of this paper briefly review reasons and empirical evidence as to why few people voluntarily adopt cost-effective loss reduction protective measures and purchase insurance. The paper then turns to the supply of protection by examining the roles that building codes, land use regulations, and insurance have played. The concluding section proposes a disaster management program where these policy tools can be more effectively employed in combination with other market mechanisms to reduce future losses from earthquakes and other natural disasters.

Why is There Limited Demand for Protection?

The literature on decision processes with respect to low probability high consequence events provides considerable insight into why most residents in hazard-prone areas do not protect themselves against the losses from earthquakes and other natural disasters. Some of the reasons for their behavior are described below:

2. See Camerer and Kunreuther (1989) for a summary of the literature on low probability high consequence events.

Ignoring the costs associated with the eventual event and insuring against the event is a common strategy that has not happened. For example, residents initially assumed the earthquakes were uncommon. They did not worry about the consequences of an earthquake; they assumed the event would not happen. This was called the natural law of unintended consequences.

Budget considerations for residents do not consider a fire and a hurricane as natural disasters and are not affected by the risk of future earthquakes. To focus groceries, residents are likely to focus on other areas, so the cost of building codes and land use regulations can be seen as principal and not the natural disasters themselves.

A blinding of the public to the possible damage that may occur and the cost of repairing it is also seen in the perception that a future event is not going to happen which creates other methods of protection.

Myopia, a lack of understanding of the need for protective measures, is also an important reason that benefits from protective measures are not fully realized. Structural engineering is also a technique used by behavioral economists to attempt to improve decisions for insurance is used as a way to increase demand for protection.

A simple comparison of the costs and benefits of a policy has failed to occur. For example, a person who spent $25,000 on a home and was insured for $25,000 experienced an earthquake and $25,000 in damage. If he had not insured his home, the total damage would have been $25,000. This suggests that the insurance of the homeowner was worth $25,000. If there is no insurance, there is no reduction in the probability of a disaster occurring, and thus the insurance is not worth anything. If there is insurance, there is a reduction in the probability of a disaster occurring, and thus the insurance is worth $25,000.

3. The costs of a future event are estimated to be between $25,000 and $500,000. The cost of an earthquake is estimated to be between $25,000 and $500,000 for a small event and up to $500,000 for a large event.
Ignoring the Event. There is limited interest in mitigation measures and insurance because many people perceive that the disaster will not happen to me. In analytic terms, it appears that many individuals initially focus on 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 they estimate p < p*, then they assume that the event “cannot happen to me” and take no protective actions.

Budget Constraints. Another factor which determines why some residents do not invest in protective measures is that they feel they cannot afford the expenditure given their level of income. In a set of focus group interviews of homeowners in flood and earthquake prone areas, several participants indicated that budget constraints were the principal reason why most residents do not purchase coverage against natural disasters. One uninsured worker noted that:

A blue-collar worker doesn’t just run up there with $200 [the insurance premium] and buy a policy. The world knows that 90 percent of us live from payday to payday...He can’t come up with that much cash all of a sudden and turn around and meet all his other obligations (Kunreuther et al., 1978, p. 113).

Myopia. Another reason that homeowners may not invest in protective measures is that they do not appreciate that the potential benefits from their upfront expenditure will be reaped for as long as the structure 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 the Shaker family has the option of bracing the concrete foundation of its sixty year old one-story house (currently valued at $100,000). The cost of this loss reduction measure is $1500. Suppose that engineers have estimated that the reduction in earthquake damage from undertaking this action is $27,500.3

3. 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).
Economic Consequences of Earthquakes: Preparing for the Unexpected

To keep the calculations simple, assume that the only time that the loss reduction measure reduces damage is when a severe earthquake affects the area. 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 only one year.

Table 1 depicts the critical annual probability (p**) above which the family would want to invest in this measure 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. If the family assumes that they will be in their home for the next 10 years, then the critical annual probability of a future earthquake for the loss reduction measure to be cost-effective will be .0065 (i.e. 1 in 154). Naturally, if the homeowner estimates the probability of a severe earthquake to be below this value, then the cost will still be too high relative to expected benefits even if a ten year horizon were utilized.

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 that 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 re-

4. Of course, if the homeowner focuses on the benefits of the loss reduction measure across earthquakes of different magnitudes, then the concept of a critical value of p** has no meaning. It only holds when there is a single event such as a severe earthquake. In fact, people have a difficult time thinking about probability distributions associated with events and often focus on a worst case scenario in making their decisions. In such cases, the concept of a critical probability value would be a relevant concept for making a decision on whether to invest in a protective measure. For more details on the types of decision rules individuals utilize in making decisions see von Winterfeldt and Edwards (1986) and Kleindorfer et al. (1993).

5. 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% 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%. The difference (i.e. 4%) is a measure of the real rate of interest on risk-free investments (p. 19).
quest that the President declare a “major disaster” and offer special assistance if the damage is severe enough. For example, loans will be provided to home-owners 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 property insurance because they feel they will be bailed out by the government should they suffer damage. The only empirical data examining this question was a survey undertaken more than 20 years ago. The findings suggest just the opposite pattern. Although most uninsured homeowners were aware that the Small Business Administration provided aid to victims, these respondents had little knowledge of the terms of the loan and most did not anticipate 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).

### Empirical Evidence on Demand for Protection

**Adoption of Loss Reduction Measures.** 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.

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6. There is evidence, however, that many farmers do not purchase crop insurance because they have been bailed out by Congress following natural disasters, especially drought. Chite (1992) summarizes the federal proclivity to provide disaster assistance even though insurance is available.
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 even a slight decrease in the adoption of any loss reduction measures in earthquake prone areas, despite the increased awareness of the public of the quake 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 counties reported adopting any loss reduction measures (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.

Purchase of Earthquake Insurance. To date, the most comprehensive cross-sectional studies on the demand for disaster insurance have been undertaken with homeowners in California facing the earthquake hazard. Twenty years ago, approximately 5 percent of the homeowners purchased earthquake coverage in California; by the end of 1994, approximately 25 to 30 percent of the residences in the State were insured against this hazard. There is considerable variation, however, in coverage ranging from 35-40% coverage in cities around San Francisco and Los Angeles to approximately 5 percent in cities north of San Francisco and in the central parts of California. (Personal Correspondence with Richard Roth, Jr., 1995)

Four mail surveys have been undertaken by Risa Palm since 1989 to examine the spatial and demographic characteristics of those homeowners who had purchased earthquake insurance (Palm, 1990; Palm, 1995). Four counties (Contra Costa, Santa Clara, Los Angeles and San Bernardino) were selected to represent both northern and southern California, urban and suburban counties, and areas that varied in their degree of seismic risk as reflected in past earthquake events.

Table 2 depicts the percentage of households who indicated they had purchased insurance in each of the sampled areas. With respect to the first three surveys, there is a substantial increase in the proportion of homeowners with insurance in each of the four counties surveyed. This can be partially attributed to the Loma Prieta earthquake of 1989, particularly with respect to the nearby county of Santa Clara.
Table 2. Percentage of Households with Earthquake Insurance in California from Four Different Surveys

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<td>Contra Costa</td>
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<td>29.3</td>
<td>36.6</td>
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<tr>
<td>Santa Clara</td>
<td>40.4</td>
<td>50.8</td>
<td>54.0</td>
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<tr>
<td>Los Angeles</td>
<td>39.6</td>
<td>45.8</td>
<td>51.6</td>
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<tr>
<td>San Bernardino</td>
<td>29.2</td>
<td>34.6</td>
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<td>CITY</td>
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<td>64.9</td>
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<td>Redlands</td>
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<td>Western San Fernando Valley</td>
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and to a lesser extent Contra Costa county. The 1994 survey reveals an even larger percentage with earthquake insurance, with almost 65 percent of those sampled in Cupertino claiming they had coverage.

It is important to recognize that these data only reflect homeowners decisions in one area of the country. The decision processes by firms and organizations in the private and public sectors may be very different from these; furthermore, there may be large cultural differences in how individuals in other countries, particularly non-Western ones, decide whether to adopt protective measures and/or purchase insurance coverage.

Nature of Supply of Protection

Building Codes. The primary form of protection against losses from earthquakes are building codes. In the United States, the local political jurisdiction typically regulates the design and construction of new buildings through the use of these codes. Most of the codes focus on the health and safety of occupants with emphasis on resistance to fire and structural failure and electrical safety (Office of Technology Assessment, 1995). In a study of the use of these codes, May and Birkland (1994) point out that local government’s willingness and ability to undertake risk reduction programs (e.g. retrofitting ordinances, land use and zoning measures) is a function of local political demands and community resources rather than objective risk or previous earthquake experience.
Economic Consequences of Earthquakes: Preparing for the Unexpected

In many communities, the codes are not well-enforced because there is inadequate staffing and training of building inspectors. Insurance experts, according to the Insurance Information Institute, have indicated that 25 percent of the insured losses from Hurricane Andrew could have been prevented through better building code compliance and enforcement (Insurance Research Council, 1995).

Land-Use Planning. The principal form of land use planning for earthquakes is the Alquist-Priolo Act of 1972, passed by the California State Legislature. It was designed to prohibit location of developments and structures for human occupancy across the trace (e.g. within 250 meters) of an active fault. While the intent of the Act is sound, the actual legislation permits development to occur if an engineering geologist evaluates the site and makes recommendations for “safe” construction which the property owner agrees to. Hence the Act has done little to slow development along active fault lines (Shah and McCormack, 1995).

With respect to homes which have already been constructed in high-hazard zones, the Alquist Priolo Act required California real estate agents or sellers to inform prospective home buyers if the property being sold lies within 1/8 mile of a trace of an active earthquake fault. A study by Palm (1981) indicates that the legislation has failed to produce a measurable response either in buyer behavior or housing price trends.

Insurance. Today there are sophisticated computer models for estimating the risks from earthquakes which enable insurers to vary earthquake rates by zip code to reflect the varying soil conditions and location of active faults (U.S. Congress, 1995). Despite the increased accuracy in being able to estimate rates, the insurance industry is more concerned about offering coverage against earthquakes than they ever have been.

There appear to be two principal reasons for this concern. First, the Northridge earthquake itself created insured losses of $12.5 billion, more than 3 times the total earthquake premiums California insurers collected in the 25 year period prior to the disaster (Insurance Information Institute, 1995). Hence insurers feel that their premiums understate the risk associated with the disaster. Given state insur...
surance regulations, they do not have the freedom to raise the rates without prior approval and have not been able to do so.

A second reason for insurers concern is the fear of a future catastrophic earthquake 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 a catastrophic earthquake. Although the total annual capacity worldwide is hard to estimate, it is unlikely to be more than $50 billion (Valery, 1995).

Summary. Policy tools exist which could play an important role in reducing future losses and offering protection to those residing in hazard-prone areas, but they are working imperfectly at best. Building codes are often not implemented because of a shortage of inspectors. Land-use regulations are in place for some highly seismic areas but they can be overridden by engineer-geologists and the new property owner. Insurance is available against earthquake damage but the industry is very reluctant to market coverage for fear of suffering catastrophic losses which may lead to insolvency of many firms.

What Can Be Done?

There is a need for a disaster management program which encourages mitigation while providing protection to victims if there is a future earthquake or other natural disaster. The elements of such a program are outlined below.

Improve Risk Estimates. The occurrence of Hurricane Andrew and the Northridge earthquake has stimulated the insurance industry to develop computer-generated simulation models indicating what could happen in hurricane and earthquake-prone areas over periods of 10 years, 100 years, 1,000 or even 10,000 years. These models incorporate estimates of the disaster probabilities and engineering studies of damage to specific types of properties to estimate rates for specific types of property. Based on different disaster scenarios such as a specific hurricane or earthquake, they provide a range of estimates of insured losses that are likely to occur (U.S. Congress, 1995).

Use seals of approval on structures meeting 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 structure 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 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 a group of well-qualified inspectors who will provide accurate information as to whether existing building codes and standards are being met.

**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 enforce these building codes. A building well designed against natural disasters should be rewarded with lower premiums, lower deductibles and/or higher coverage limits on their insurance policy than structures that are poorly designed.

**Expand Protection to Insurers Against Catastrophic Losses.** New forms of coverage against catastrophic losses from natural disasters are now being explored to supplement traditional private reinsurance. One new development by reinsurers is the creation of **finite risk products** which involve transfers of underwriting and investment risk that are designed to smooth the ceding insurer’s losses over a number of years by establishing a special fund to meet future insured disaster losses. Each year the fund grows by a defined portion of the reinsurance premium. At the end of the reinsurance program, the fund is returned to the ceding insurer if it has not been used to cover losses. If the fund balance is negative, the reinsurer would require some degree of deficit repayment by the insurer. Another instrument is **catastrophic insurance futures contracts and call spreads** introduced by the Chicago Board of Trade which enable an insurer to hedge against his underwriting risk.7

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7. See Cummins and Geman (1995) for a more detailed discussion on these hedging mechanisms and the challenges in pricing them.
Legislatures in risk-prone states have recently begun to provide some security and stability for financing catastrophic losses experienced by insurers. The California State legislature recently passed a bill creating the California Earthquake Authority that would utilize private insurance industry funding for an initial tax-exempt one-shot payment of $1 billion relieving them of future earthquake losses. There would be a $3 billion assessment on insurance companies after a quake; $2 billion to be raised from reinsurers (normal premiums) and another $4.5 billion from lines of credit from banks, Act of God bonds assessment of policyholders and the insurance industry. If the quake losses are above $10.5 billion, then claims are prorated.

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.

One advantage of all these programs is that it reduces uncertainty to private insurers about the consequences of a catastrophic disaster, so that they should be able to lower their premiums for disaster coverage. This protection will also greatly reduce the likelihood that insurers will cut back on the availability of coverage in the future, as they did following Hurricane Andrew and the Northridge earthquake.

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 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. The proposed disaster management program relies on a set of policy tools for encouraging loss reduction measures against
Economic Consequences of Earthquakes: Preparing for the Unexpected

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. They need to work closely with public sector agencies at the federal, state, and local levels to achieve their objectives.

Acknowledgments

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Economic Consequences of Earthquakes: Preparing for the Unexpected


Abstract

The January 17, 1994, earthquake in California directly uprooted over 93,000 households from their homes. Over 600,000 people were displaced, representing about 12% of the population, which was directly affected. A large percentage of these families (about 90%) were from homes that were not damaged. Electrical, gas, and hot water services were not restored for several months, and hospitals, nursing homes, and families of senior citizens were most affected. In addition, 30,000 families were forced to spend an extraordinary amount of money to repair and refurnish their homes. The Kobe earthquake in Japan in 1995 is a reminder of how vulnerable we are to natural disasters. Kobe, a city of about 1.5 million people, was destroyed by an earthquake of magnitude 7.2. The resulting losses have been estimated at 10% of the GDP of Japan. The earthquake, which caused 6,000 deaths, 10,000 injuries, and 50,000 homes destroyed, had a significant impact on the Japanese economy. The earthquake caused widespread damage to infrastructure, communications, and transportation systems. It also disrupted supply chains and caused a significant decrease in economic activity. The earthquake also had a significant impact on the psychological well-being of the Japanese population. Many people were left homeless and without basic necessities, leading to increased stress and anxiety. The psychological impact of the earthquake was further compounded by the fact that it occurred during a period of economic recession and political uncertainty. The Kobe earthquake highlights the importance of preparedness and resilience in the face of natural disasters. It is crucial to invest in infrastructure and disaster preparedness to minimize the impact of future earthquakes. It is also important to provide support and resources to those affected by these disasters. The Kobe earthquake serves as a poignant reminder of the vulnerability of our society to natural disasters and the need for preparedness and resilience.