EARTHQUAKE DAMAGE INSURANCE

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I. INTRODUCTION

People tend to think of earthquakes as absolute risks, overwhelming all possible defenses. While the effects of such risks are in fact enormous, it does not follow that we are helpless in devising protective measures.

The literature of insurance and risk management provides the basic alternatives for the management of the earthquake risk. Avoidance of the loss exposure is not, of course, possible. Loss control measures may influence the dimension of loss severity, but not the probability of loss. Risk retention can be either in the form of self-insurance for commercial risks or deductibles for homeowners. Insurance is the cornerstone in all social arrangements for protection against the financial losses from earthquakes.

Insurance plays two major roles. First, it is a means of distributing losses without resorting to the devices of bankruptcy, reconstruction loans, and relief and welfare payments. Second, in the course of distributing those losses, with or without public subsidy, it has a capacity to exercise guidance over the extent to which people expose themselves to risk from natural causes.

Even if incurance were no more effective than a public welfare system in redistributing losses promptly from a natural disaster to prevent severe hardship to disaster victims, it offers other benefits which would commend it to private and public consideration. On the private side, it might provide more direct and less cumbersome means of indemnifying losses with greater dignity on the part of the recipient. On the public side, it might guide future exposure to hazards in a fashion that would reduce the net public losses from future events.

These benefits notwithstanding, the problem is that the insurance industry is reluctant to insure this risk. Although transfer of the earthquake risk is basically highly acceptable to the insured, it may not be to the insurer. The result of this stalemate is often that little financial planning takes place before the event occurs, a reliance is placed on post loss financing, often in the form of relief activities of governments.

In the following section of this paper we shall examine the issue of the insurability of earthquakes from the supply side by: (1) analysing whether the earthquake risk violates the insurability conditions, (2) discussing the most serious violations of insurability, namely correlation and uncertainty, (3) examining other risk-sharing mechanisms besides insurance, and (4) proposing protential institutional arrangements and organizational forms which might address this risk more adequately.

In the third section of this paper it will be shown that an appropriately designed system of earthquake damage insurance can be expected over a period of years to encourage purely private actions which will, aside from any governmental measures, tend to reduce the physical and economic vulnerability of cities and industry to earthquakes. The desired effect can be achieved by providing the earthquake damage insurance according to a schedule of differential rates - allowing, e.g., relatively cheap insurance to property located in safe areas; and only relatively expensive insurance to property located in dangerous areas, not of sound construction and susceptible to fire.

The overall objective of such an insurance program is to induce socially desirable private behavior through the mechanism of the price system. Lest hopes be raised too high, it should be pointed out immediately that a number of qualifications will be discussed in turn:

1. The desired objective will not be attained in the short-run; a definite improvement may be attained in perhaps ten years, but hardly in one or two.

2. It follows from (1) that, at least for the short-run, administrative fiat for urgently needed improvements to reduce the vulnerability to earthquakes cannot be entirely dispensed with.

3. The argument along welfare lines which is used in this paper is only correct to a rough approximation, since the insurance premius to be charged will be far from perfect estimates of risk.

4. In addition, there are administrative problems which must not be minimized, as well as serious political objections on the part of interested parties.

While these difficulties undoubtedly weaken the case for the proposal made here, it will also be shown that no available alternative - including doing nothing-is free from objections, which may be even more damaging.

In the final section of this paper we shall make a proposal for the establishment of an Earthquake Damage Insurance Organization, and we shall describe its main characteristics and its insurance and reinsurance functions.

Finally, we should mention that in this paper we shall be discussing «earthquake damage insurance» and not the broader type of «earthquake insurance». The former refers only to direct property damage caused by an earthquake, while the latter would in addition include: fire, workers' compensation, auto physical damage, life, accident and health, lost potential output from unemployment, income not earned, goods and services not produced, and tax revenues not collected. The subject is limited in this way in order to keep the paper within reasonable bounds, and there is no intention to minimize the importance of other types of earthquake insurance.

II. SUPPLY OF EARTHQUAKE INSURANCE

A. Insurability of Earthquake Loss Exposures

The general belief in the insurance industry is that a market for earthquake insurance cannot exist[1]. The problems most frequently cited by the insurance industry with regard to the earthquake risk are:

1. Inadequate capacity to absorb the catastrophic losses resulting from a major earthquake; in such a case the industry would be unable to provide its current level of insurance capacity because surplus will have been compromised.

2. Too much uncertainty about the probability and magnitude of loss; therefore, it is impossible to set a premium with any degree of confidence.

3. Inadequate private reinsurance.

4. Adverse selection, defined as only the high risks demanding insurance.

5) Restrictive tax laws which do not allow the insurance company to reserve for infrequent, not yet incurred losses.

In this section we shall undertake a more formal examination of the insurability issue in relation to the earthquake risk. The following discussion of

the insurability conditions will provide a basis for examining feasible and appropriate roles for insurance in the management of the earthquake risk[2].

1. Probability of Loss. For a risk to be insurable it must be uncertain from the perspective of the insured, but certain from the perspective of the insurer. Unfortunately, the earthquake risk is uncertain from both the perspective of the insured and the insurer. Determining the collective loss distribution for an earthquake has been a highly in certain process, because the sample size of earthquakes on any given fault system typically is very small; therefore, expected aggregate losses are only approximate to a factor of two or three.

If insurers lack confidence in their estimates of the probability of a major earthquake, they will charge higher premium for coverage (i.e., the risk premium or buffer fund required will be higher). This confounds the already depressed demand for earthquake insurance. Long-term predictions on the order of years or decades are currently being made, but seismology still is not an exact science. The probabilistic uncertainty which still exists makes it difficult for the insurance industry to set premiums with any confidence.

2. Independence of Loss Exposures. Ideally, an insurable risk is comprised of a large number of independent risks. It is known from portfolio theory, however, that when there is positive correlation between risk exposures, all of the risk cannot be diversified away by increasing the number of policies in the portfolio[3].

Independence of risk exposures is certainly a condition which the earthquake risk violates seriously. The damage from earthquakes, like damage from other natural disasters such as floods, tornados, and hurricanes, is of catastrophic potential because its damage to insured exposure units is not independent of other insured exposure units, and consequently is less amenable to diversification through insurance.

3. Indentifiable and Measurable Losses. An insurable loss ideally should be well-defined as to time, place and amount. In order for insurance contracts to be effective, an insurer must be able to determine when and where such losses occurred. The earthquake risk meets this criterion, in one respect, because there is no uncertainty as to whether a quake occurred and at what time[4].

However, with respect to losses caused by an earthquake, there is always some uncertainty as to whether damage reported to an insurance company for

compensation actually occurred as a result of a recent earthquake or was a pre-existing problem.

In addition, the earthquake risk produces measurable losses ex post, but there is great difficulty in predicting the magnitude of the loss ex ante because of the uncertainty mentioned above.

4. Moral Hazard. Moral hazard refers to the inclination of the insured to affect either the probability or magnitude of loss due to the presence of insurance. The earthquake risk is vulnerable to moral hazard problems if there is little correlation between the rates charged and the true risk the insured brings to the insurer's portfolio. If this is the case, the insureds will blithely build on faults and be reluctant to voluntarily use mitigation techniques to reduce potential earthquake - caused damages.

Another problem associated with earthquakes is the high potential for fraud, Fraudulent arson claims are very likely to be filed after an earthquake and, as stated before under the identifiable loss criterion, there is significant opportunity for homeowners and other insureds to clain that a loss occurred as a result of an earthquake when it might have occurred prior to the quake.

Deductibles and coinsurance are commonly used by insurance companies to control for moral hazard problems and currently are used to manage the earthquake risk. The deductible on an earthquake endorsement for a homeowner typically is 10% of the value of the house and 10% on anything else built on the lot.

5. Adverse Selection. Adverse selection refers to the inability of the insurer to differentiate between good and poor risks because of imperfect and asymmetric information on the quality of the risk. The insurance industry claims this is a problem with the earthquake risk; it asserts only high risks demand earthquake insurance.

It is difficult to believe that the insured should have more information regarding the probability and magnitude of an earthquake risk than an insurance company. It is not difficult to believe that only those at high risk (i.e., living near a known fault) would be demanding earthquake coverage and that consequently it would be very expensive. If underwriting standards are very lax or it is very expensive to accurately rate an earthquake risk, it is true the resulting premium would have to be set very high to address the resultant problem of adverse selection.

B. Problems: Correlation and Uncertainty

From the proceeding discussion we may derive that the most serious violations of insurability of the earthquake risk are mainly those related to the conditions of independence of exposure units and relative certainty of aggregate expected loss. In this section we shall analyze various ways which may be used in practice to deal with these problems.

1. Correlation and Diversification. Analyzed below are a few of the possible ways an insurance company could use to diversify the earthquake risk.

Multi-line Business

The insurance company may write multi-line business with low correlation across lines which would manage the undiversifiable risk within the earthquake market. To the extent that earthquakes are not perfectly positively correlated with other lines of business and might even be negatively correlated with other lines of business (if an insurance company is also insuring other risks), it should be able to insure the earthquake risk.

To test this hypothesis with regard to the utilization of an all-risk natural hazard policy, Dan Anderson[5] computed the coefficient of variation for flood, hurricane, tornado, earthquake and total catastrophe property losses over 51 territories in the U.S.A. (50 States plus Washington, D.C.). The results indicated that, with the exception of tornado losses[6], an insurer writing an all - risks policy would exhibit less variability between territories in its loss experience than an insurer writing a specified peril only.

This decrease in variability utilizing the less than perfect positive correlation between hazards benefits the insured by making the earthquake insurance more affordable and increases the insurability of the earthquake hazard through decreased risk.

Reinsurance

Reinsurance can permit diversification across geographic boundaries even within the earthquake line. There is no reason to believe earthquakes in different parts of the world are correlated. Consequently, if this diversification opportunity is not already recognized and used, more reinsurance should be available for earthquake insurance on a global perspective.

Diversification through Capital Markets

The residual claims of the insurer may be diversified in capital markets if stockholders hold diversified portfolios. Only that component of the risk that is not so diversifiable, the systematic risk, counts in capital markets according to the Capital Asset Pricing Theory[7]. In one sence, earthquakes are not correlated with the Stock Exchange, in that change in the stock market has no causal effect upon whether or not earthquake occurs. But does it work the other way? Does the occurrence of an earthquake affect the stock market? For the American economy, the GNP in 1988 was approximately 4.235 trillion dollars and a loss of $40 billion[8], significant as it is, is still only a loss of about 1%. The destruction of wealth of that magnitude could conceivably affect the value of the stock market and, if so, would minimize the opportunity to diversify the risk of earthquakes through the stock market. It is an empirical question whether the stock market exhibits systematic risk with earthquakes and that question has not been answered yet.

Intertemporal Diversification

Possibilities exist for intertemporal diversification that can exploit negative correlation over time between quakes. Long-term earthquake insurance based on risk in a manner similar to the way life insurance is issued today could be marketed. The rationale for developing such a plan for earthquake insurance is that if rates are to be based on expected losses, companies must be guaranteed premium for a long time span. Proponents of this scheme contend that insurance companies could effectively discourage homeowners from canceling their policies after a short period of time for a stated cash - value by requiring a large initial investment to give the customer a vested interest[9]. This approach would only work, however, with properties that are currently efficiently located and whose owners have incentives to repair or rebuild damaged property following an earthquake.

This type of plan was attempted most recently with Marsh & Mc Lennan's QUAKE program, a Barbados - based captive insurance company which would provide limits of $75 million in physical damage and in business - interruption coverage[10]. Policyholders would be charged a one-time premium and capital contribution and would receive a 10-year policy that could not be canceled by the insurer. As of yet, this plan, however, has not issued its first policy. An explanation offered for Quake's difficulties is that is was announced in the middle of a soft market when earthquake capacity was high and prices were low.

Consequently, the notion of a significant one-time premium and capital contribution was unappealing[11].

2. Uncertainty and Mutualization. The positive correlation and catastrophic potential would seem to make the earthquake risk automatically uninsurable. However, as Marshall[12] has shown, when losses are heavily correlated, the mutual form of insurance can be effective in managing this risk when the stock insurance form of organization might be less successful. According to Marshall, insurance can be thought to function under two principles:

1. the reserves, or transfer principle, and
2. the mutualization, or pooling principle.

Under «the reserves principle», the risk is transferred to an external risk bearer for a fixed fee. Under «the mutualization principle», the policyholders jointly hold the residual claims on the pool; thus total losses are shared among policyholders by some combination of prepaid premium and retroactive dividend based on undiversifiable risk, risk which would have deterred demand under the reserve form of insurance.

Reserves Principle

Without insurance individuals and firms who experience risk must lay up reserves. While they may do this individually, they soon discover that there are economies in combining their respective individual reserves. Insurance under the reserves principle leaves the accumulation and management of reserves to the insurance companies and exploits the economies in pooling reserves. Insurance on the reserves principle is impossible for risks to which the law of large numbers does not apply. When this law does not apply, the insurer needs the same amount of reserves that the insureds, separately but in aggregate, would need given the same probability of ruin. There is no economy in pooling risks and hence no role for insurance under the reserves notion. As Marshall explains: «the reserves principles is efficient only when aggregate loss is perfectly certain»[13].

The Mutuality Principle

The mutuality principle, however, defines insurance as an obligation to share losses suffered by others. Mutual companies issue contracts which, besides the obligation to indemnify losses, include a dividend to the consumer which depends on the overall performance of the company. Consequently, the essence of mutual insurance is that the purchase of insurance is bundled with an equity interest in the insurance pool.

Doherty and Dionne[14] show that the mutual form, when combined with reinsurance, is preferred to the stock, or reserves solution. Under the mutual form, the insured fully insures idiosyncratic risk[15] and chooses some level of external reinsurance which generally is less than full. The level of reinsurance selected depends on the representative's degree of risk aversion and the cost of external risk bearing. In contrast, the stock contract requires the stock insurance company to directly bear the external cost of risk. Consequently, because this entails a proportional loading of the insurance premium, the insured can only partially insure his idiosyncratic risk under the stock form, which is less optimal than the mutual risk bearing benefits.

Marshall asserts that the efficiency gains from the mutual form of insurance are not realized in practice because the mutual companies operate in accordance with the reresves principle and have never exploited their unique advantage by pioneering new areas of risk. This notion was expressed in 1974, right before the dramatic increase in the market share of mutuals in the medical malpractice insurance market in the mid 1970's. Also subsequent to Marshall's paper, risk retention groups and «mutual like» pools organized by the major brokers have emerged to solve failures in specific insurance markets, such as pollution and liability[16].

3. Risk Spreading Mechanisms other than Insurance. If a major earthquake should occur, the costs of the risk of earthquake would also be spread through the following mechanisms.

Inflation

The inflationary effect of an earthquake (caused by owners of now scarce resources, who capitalize on reduced supplies and capture their rent) will be borne widely by consumers in local, regional and national markets. This is because consumers will ultimately be competing with each other and with investors for these resources, and the costs will be spread to some extent through the price system. This spreading mechanism would happen with or without the existence of insurance and results because of the destruction of wealth and creation of shortages.

Taxes

Municipalities spread the cost of uninsured losses through raising taxes. These losses will always be spread through the tax base, either before a loss through taxes to pay for insurance or after experiencing a loss without insurance through increased taxes to pay for direct damage to municipal property.

Incurrence companies will receive a tax break following the occurrence of an earthquake since insurers' taxes are related to underwriting results and claims payments are tax deductible. As a consequence, the cost of losses is again partially borne in the tax base, but this time at a national level.

A similar argument can be made about uninsured losses experienced by industries and homeowners. Uninsured losses are tax deductible, with the level of risk spreading equal to the tax rate of those who incurred the losses multiplied by the level of the deduction. The cost of this tax deduction is also borne by the general tax payers.

National Disaster Relief

During the postwar period, the national governments have played an increasing role in providing disaster relief. Before that time some agencies had been given specific authority to render assistance in particular kinds of disaster aid. The current trend is to provide an orderly and continuing means of assistance by the national government to local authorities in carrying out their responsibilities to alleviate suffering and damage resulting from major disasters.

The national government provides assistance to the people of a disaster area through (1) grants for the restoration of public property, and (2) low-interest loans and assistance to individuals.

Pauly, Kunreuther, and Vaupel[17] have proposed a theory to explain the public's increased reliance on government assistance rather than mandated optimal insurance purchases. They show why cost-effective preventive measures and compulsory conventional market insurance will be rejected by the political process. It is possible to achieve support for managing the risk with what they refer to as «impliciti mutual insurance» or retroactive financing of losses through national assistance. In general this financing approach is perceived as more efficient because the tax paid «premium» and benefits are exactly proportional to whatever the frequency of loss turns out to be and it does not require any resources to be sacrificed before the losses occur. To the extent that this is implicit mutual insurance, these reasons are consistent with the reasoning of Marshall for utilization of pooling or mutuals to manage uncertain, catastrophic losses.

III. PRICING: VULNERABILITY AND DIFFERENTIAL INSURANCE RATES

A. Insurance Rates and Incentives

The desired effect of reducing the physical and economic vulnerability of cities and industry to earthquakes can be achieved by providing insurance according to a schedule of differential rates; that is, insurance rates will be based on the risks involved in insuring different types of property. For example, certain locations will be safer than others; certain types of construction will be more resistant to earthquakes and others less; and some materials will be less likely than others to collapse and to wreck other structures and materials. In all these cases, it would be desirable to insure the safer property at a relatively low rate, and the poor risk at a high rate.

What is more important is that such a schedule of differential rates will, through the price system, tend to encourage voluntary private actions in the direction of reducing vulnerability to earthquake. For every possible step in this direction, an appropriately reduced insurance premium would (ideally) be offered. Clearly, rational self-interest would lead to the adoption of all measures such that the private cost of change is less than the private gain in terms of reduced premiums. When these conditions apply, we may say that, at least as a first approximation, the social cost of change (diversion of resources) is less than the social cost (the risk of destruction) of maintaining the status quo. While movement in the opposite direction (the abandonment of protective measures where the cost of maintaining them is greater than the gain in terms of insurance premiums) is also theoretically possible and will undoubtely occur to some extent, it is not believed that this will be very important in practice - always assuming that the premium are correctly adjusted. Underlying this opinion is the belief-based on empirical observation - that the economy has not as yet taken sufficiently into account the earthquake risks[18].

The isnurance program should, therefore, lead on balance to a net reduction of vulnerability. As a matter of fact, wherever the cost of maintaining protective measures are greater than fair insurance differentials received, there is a prima facie case in favor of abandoning those measures on the ground that the social cost exceeds the social gain.

It may then be asked: Would not the absence of insurance lead to exactly the same result? The answer to this question is yes - in principle - but only

under the assumption that the government's policy will be not to offer compensation for earthquake damage. In the author's opinion, in the absence of an insurance program, it will be politically impossible for the government not to compensate for damage. The inequity of the fortuitous distribution of losses is so generally recognized that the only practical question seems to be whether to spread risk through an insurance program or without such a program. It has been shown that simple compensation without insurance tends to discourage private efforts designed to reduce vulnerability, since those making the expenditures involved do not gain relative to those who leave their property in a highly vulnerable condition[19]. In fact, simple compensation will encourage the abandonment of any protective measures of nonzero cost as already exist. In terms of the effect on vulnerability, therefore, earthquake damage insurance will be superior to simple compensation. Whether or not it would be superior to no insurance combined with a policy of not compensation is a much more doubtful question. Since the combination of no insurance with no compensation is considered close to impossible politically, the question is more of theoretical than practical importance.

The two main feasible methods for spreading the burden of loss are, then, a simple program of government compensation or a scheme of earthquake damage insurance. It should be noted that partial compensation, being a compromise between simple compensation and no compensation at all, would have consequences for vulnerability intermediate between the harmful effect of the former and the favorable effect of the latter. The improvement with respect to vulnerability, however, is purchased at the expense of the inequity of forcing unlucky individual property - owners to bear the uncompensated fraction of losses due to earthquake.

Finally, it should be noted that differential insurance rates are not the only method for achieving the desired effect. An appropriately differentiated special local tax might be levied, or there could be differentiated compensation schemes in which the proportion of loss to be redeemed for various types of risks might be announced to property — owners in advance, to encourage them to reduce vulnerability. These proposals, unlike simple compensation, would all work in the right direction. They have been rejected on grounds of administrative or political impracticality.

B. The Long-run Influence

The question might well be asked: Will the effect of the proposed program be substantial enough to produce a noticeable reduction in a society's vulnerability

to earthquake? It must be remembered, first of all, that the proposal made here aims at a long-run effect. Even granting this, it might be thought that insurance differentials will be only a very small element in the whole complex of factors which influence a firm's decision to locate, for example, in one city or another. Similarly, a typical person will not be inclined to change his place of residence merely because he can get cheaper earthquake damage insurance on his household goods in a different locality.

Arguments of this sort fail to take into account the fact that changes in economic circumstances always influence only persons and firms on the margin. It is not an effective argument to say that a typical firm will not be influenced to move solely by insurance differentials. The typical firm may not be induced to move, but there will be some firms which may be close to the margin of moving away. The extra inducement of the insurance will, for such firms on the margin, be sufficient to swing the balance toward change. In fact, if any firm is not induced by profit-and-loss calculations to move there is a prima facie case in favor of the proposition that it should not move, since the economic advantages of its present site remain dominant even considering the earthquake risk. Furthermore, relocation is not the only way, and probably not the most effective way from the national point of view, of reducing vulnerability to earthquake; effective and less costly methods of protection will also be encouraged by the insurance differentials. It will be cheaper, in general, to incorporate vulnerability-reducing features in new construction than to add them to already existing buildings. This is especially clear for drastic changes like relocation, which may require abandonment of such plant, fixtures, and machinery as cannot conveniently be moved. Therefore, it is to be expected that the most powerful influence of the differential insurance rates may be upon the location and construction of new facilities for expansion or for replacement of worn-out or obsolete equipment or plant.

C. The Costs of Change

The various risk-reducing measures to be encouraged by the proposed insurance program all involve certain social costs. These costs are of two types; the direct cost of making the change (e.g., abandoning a still useful plant in a vulnerable area), and the continuing cost either in terms of direct outlay (as in maintaining fire-protection equipment) or loss of economic efficiency (e.g., producing at a safer but economically inferior location). The question before us now is the consideration which should be given to such costs as an argument against attempting to influence vulnerability through an insurance program. This objection is, in a sense, opposite to the above argument that the program may

not have enough effect. Assuming that the insurance rates can be made to reflect the risks, it is maintained that this argument should be given no weight whatsoever.

The reason for this assertion, which may seem extreme, is simply that in all economic calculations from now on, the threat of earthquake is a factor which should be given weight. The insurance program does not influence vulnerability by creating a new set of incentives; rather, it reflects, by inserting the new data into the price system via an insurance mechanism, the situation already created by the threat of earthquake. The costs of change represent the normal adaptation of the economy to a changed situation and, presumably, would not be undertaken unless they were less than the costs of maintaining the status quo in the face of the changed situation.

IV. FINANCING EARTHQUAKE INSURANCE

At attempt will be made to give the roughest sort of guess as to the probable liability of an earthquake damage insurance program. The term «probable liability» is used as opposed to «potential liability»; the latter is the entire value of policies issued, while the former is an estimate of the damage likely to be suffered in actuality by policyholders. In order to have an average rate level reflecting the overall degree of risk, the probable liability must be corrected by a factor representing the probability of earthquake, and then divided by the total of policies outstanding. The result of this calculation is the average annual premium.

Since we only want orders of magnitude, we shall simply guess here at figures of DRS 500 billion of potential coverage, a 10 per cent damage level, and a 10 per cent risk of earthquake occurring in a given year. Then to get an approximately correct effect on incentives, rates should be set capable of accumulating one-tenth of a fully paid-up fund in the given year. We wish to set the rates as if we were accumulating such a fund; whether or not to establish a reserve fund is a separate problem. One further modification is that, for reasons to be explained later, at a 10 per cent damage level it will only be desirable to compensate at the rate of 90 per cent for losses.

This calculation would require DRS 4.5 billion to be paid in during the given year (no adjustment for interest is made). Since the figure for total wealth insured is DRS 500 billion, this implies an annual premium of 0.9 per cent of value on the average. The rate could conceivably go up to almost 10 per cent for property

whose complete destruction was certain in the event of earthquake and, on the other hand, would be essentially zero for exceptionally safe property.

It will be noted that the fiscal problems involved in handling such collections will be of the first magnitude.

These problems are in one respect mitigated but in others made worse by the probability that the plan will be, as discussed here, voluntary rather than compulsory. The fact that no one needs to sign up will mean that the potential liability, the probable liability, and the required premium income will all be less by an unknown but probably large factor. This will reduce the magnitude of the financial problem, but will leave the average rate required as high as before. In fact, the element of adverse selection will tend to raise the average rate required.

Furthermore, we would like to add to this discussion two more points, concerning compensation policy and reserve funds.

It will be useful to make clear what the fundamental objective of the compensation policy should be. Without extended argument, we shall assert that the objective, which we shall call the Equitable Principle[20], should be to restore the relative position of those who lose property by the earthquake so that they are no worse off than the nation as a whole. Since the earthquake will reduce the real national wealth, the restoration of the absolute position of those who lose property would mean an actual gain for them relative to the rest of the community. It follows from the Equitable Principle that the proportion of actual loss compensated should be 1 minus the overall proportionate loss of national wealth; if, for example, 10 per cent of the national wealth is destroyed in the earthquake, the real value of the compensation should be at the rate of 90 per cent of the real value of the loss. This calculation assumes that money and other claims to wealth are not destroyed.

On the issue of the reserve fund, we may note that an ordinary insurance company must have a reserve fund in order to maintain solvency in periods when cash outgo may exceed cash income. For earthquake damage insurance, in the period before an earthquake there will be only income and no outgo; should an earthquake occur, however, outgo is likely to exceed income by far.

If the insurance program is administered by an Earthquake Damage Organization, it might seem absolutely necessary that the Organization build up a reserve fund to meet its future liabilities. However, there is a fundamental difference between liabilities of private individuals or corporations and liabilities

of the government, and so it does not necessarily follow that the Earthquake Damage Organization must or even should follow sound business practice appropriate for a private insurance company. By its taxing power and its ability to create money, the government is in a position to call into existence assets to meet its own liabilities.

Whether it would be wise to conduct the insurance program without a reserve can only be determined by an exploration of the likely consequences of the several different possible policies, which cannot be done within the limits of this paper[21]. We may merely mention that, in the absence of a reserve, the appropriate procedure to redistribute the remaining national wealth would involve a capital levy. In all probability, a very considerable inflation would be unavoidable. To the extent that a reserve exists, of course, assets will be available for meeting compensation claims without calling on the general credit of the government.

V. PROPOSALS

This paper has examined the issue of the earthquake risk and has identified the main problems, namely uncertainty and correlation. Potential strategies for diversification have been recommended, namely through capital markets, across lines, across time, and geographically be means of reinsurance. These strategies notwithstanding, the fact remains that the private insurance industry is reluctant to insure this risk.

It is the contention of this paper that at least a partial way out of this impasse would be an appropriately designed System of Earthquake Damage Insurance which will, in addition, encourage purely private actions to reduce the physical and economic vulnerability to this risk. A large effect on vulnerability can be achieved, provided that (1) the connection between the insurance and the vulnerability problem is recognized, and (2) considerable care is exercised in establishing rates according to risk. In the absence of such an insurance program, political realities will probably require public assistance for damage. This expectation will encourage a socially harmful type of behavior with respect to vulnerability.

Below are analyzed briefly the main characteristics of a proposed earthquake insurance scheme.

Types of Coverage. Commercial properties may be insured, as they do

currently, under several types of endorsements covering natural disasters that attach to basic commercial fire insurance policies.

Non-commercial (residential and personal) property will come under the proposed earthquake insurance system, which is a cooperative program between the government and the private insurance sector. Coverage could take the form of specific earthquake insurance combined with comprehensive fire policies. This insurance may be purchased from any insurance company participating in the scheme mentioned above.

Insurance Carrier. Three different layers of coverage should be utilized. The first layer consists of the retention of the lowest tier of losses. This will encourage loss mitigation techniques and optimal land use (e.g., restricted construction of new buildings in known fault zones). Risk retention can be either in the form of self insurance for commercial risks or deductibles for homeowners.

Private insurers should be willing to provide standard coverage against the next layer of losses as long as there is a well specified upper limit on that exposure. As a substitute for insurance provided by a conventional insurer, the second layer could be provided by an industrial pool, or a group captive arrangement, or any analogous mutual form of insurance.

The government could provide the last layer of coverage and, because of the catastrophic potential, some form of reinsurance. Since the government is concerned with providing compensation to victims of an earthquake rather than making a profit, there would need to be less concern with developing actuarially sound reinsurance premium. The incentives for risk reduction already lie in the first two layers of coverage/Moreover, by having the government directly involved in the insurance scheme, it has the opportunity and incentive to promote and regulate earthquake mitigation through building codes and other measures.

Administration. The administration of the proposed insurance scheme will require the establishment of an Earthquake Damage Insurance Organization, which will be managed by professional insurers under the supervision of the State. Its main functions will be to establish the premium rates, to manage the reserve funds, and to implement the reinsurance transactions.

Premium Rates. The complicated system of differentiated insurance rates will be based on the «basic rate» which will be determined by the property's susceptibility to destruction, classified by the building's structure and by location. To determine applicable rates, basic rates will be modified by other factors, such

as: suscepibility to fire originating within the structure, susceptibility to spreading fire, etc.

Mandatory Vs. Voluntary Insurance. This issue must be examined only in relation to non - commercial earthquake damage insurance. Commercial insurance should always be on a private basis.

Under the proposed insurance scheme, it is expected that the insurance industry will capitalize on its expertise in claims management, marketing, and administration. As far as the underwriting issue is concerned, it should be emphasized that the design of the insurance and reinsurance mechanisms should assign a proportionate amount of risk to private insurers, otherwise they will have no incentive to appropriately assess risks. In that case, mandatory purschase of earthquake insurance would cause cross - subsidization. On the other hand, however, making insurance mandatory would make the coverage less expensive because of reduced marketing costs and a greater spread of the risk. Perhaps most important of all, universal coverage would entirely eliminate the problem of demands for compensation sure to arise after an earthquake, on behalf of those who have failed to take out insurance. With the qualifications made above, no mandatory insurance is proposed here.

Insurance Pools. The state has strong reasons to promote the formation of insurance pools, based on the mutual form of insurance, to cover insurance needs within the second layer of the proposed insurance scheme. The mutual form of insurance is designed specifically for uncertain risks, like earthquakes.

Insurance Subsidies. Social welfare will be increased in the long - run if the government subsidizes the purchase of earthquake insurance instead of providing compensation after a loss has occurred. Also, the government should undertake some informational campaigns which will impress upon the public the consequences of earthquakes; this will enhance the demand for this coverage.

Promotion of Loss Control. The State should actively promote loss control measures which may influence the severity of damages after the occurrence of an earthquake. Examples of such measures are: prohibition of construction of new buildings in known fault zones, establishment and strict implementation of building codes, information and training concerning reactions during an earthquake, etc.

Reinsurance and Reserve Funds. All earthquake insurance policies issued by direct writers will be reinsured with the Earthquake Damage Insurance Organization: the amount of reinsurance will be the excess of own retention. This

portfolio will be protected by an excess of loss reinsurance treaty between the Earthquake Damage Insurance Organization (EDIO) and the government. A part of this portfolio could be retro ceded to the local as well the international reinsurance markets.

All premium income, less commissions to direct writers, should be deposited with EDIO, which would hold the accumulated premium reserves and investment income. This arrangement would be preferable even if it meant zero retention levels by direct insurers. In such a case the underwriting incentives of the insurers should be enhanced by greater retrocessions.

Under the proposed reinsurance scheme a considerable amount of the aggregate earthquake risk would be transferred to the government budget. Given the extent of distribution of loss which take place in the other layers of the proposed insurance scheme, it is suggested that no special reserves should be assigned in the government budget to fund this potential liability.

REFERENCES

1. Currently the U.S. insurance industry maintains that a market for private earthquake insurance cannot exist and is preparing a proposal which asserts that the earthquake risk can only be handled through federally provided and mandated insurance. The proposed Bill, known as the «Earthquake Project» (June 1988). calls for the establishment of the Federal Catastrophic Insurance and Reinsurance Corporation.
2. The discussion is based on: Principles of Risk Management and Insurance, Vol. 1 (Malvern, Pennsylvania: American Institute, 1978), pp. 282-293. See, also, Joan Schmit, «A New View of the Requisites of Insurability», JOURNAL OF RISK AND INSURANCE, June 1986, pp. 320-329.
3. See, for example, The Financial Theory of Pricing Property-Liability Insurance Contracts, by Stephen R. D' Arcy and Neil A. Doherty, S.S. Huebner Foundation, University of Pennsylvania, Philadelphia, 1988, chapter 3.
4. The problems with environmental impairment insurance serve as an example of the importance of this insurability criterion. Environmental pollution damage occurs over a long period of time at a relatively constant rate; consequently, the time of occurrence is difficult to determining and the insurance policy in force at the time of occurrence is subject to dispute.
5. *Anderson Dan,* «All-Risks Rating within a Catastrophic Insurance System», JOURNAL OF RISK AND INSURANCE, Vol. 4, 1976, pp. 629-651.
6. Tornadoes already exhibit minimal variance relative to the variances of the other three hazards.
7. See *Stephen D' Arcy and Neil Doherty,* The Financial Theory of Pricing..., Ibid, chapter 4.
8. Estimates of probable maximum losses (PML) associated with earthquakes, made for the Earthquake Project mentioned above, range between $40 and $70 billion.
9. *See Kunreuther H.,* «The Case for Comprehensive Disaster Insurance», JOURNAL OF LAW AND ECONOMICS, 1968, pp. 133-163.
10. See *Hilder D.,* «Marsh & McLennan Organizes Insurer for Earthquake Coverage in California», WALL STREET JOURNAL, Sept. 28, 1987, p. 36.
11. *See Milligan J.,* «What happens if an Earthquake Strikes?» INSTITUTIONAL INVESTOR, March 1988, pp. 173-177.
12. *See Marshall J.M.,* «Insurance Theory: Reserves Versus Mutuality», WESTERN ECONOMIC JOURNAL, Vol. 12, Dec. 1974, pp. 476-492; and Marshall J.M., «Insurance as a Market in Contingent Claims: Structure and Performance», BELL JOURNAL OF ECONOMICS AND

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13. *Marshall J.M.,* «Incurance Theory....», Ibid, p. 485.
14. *Doherty N. and Dionne G.,* «Risk Pooling and Contract Structures» Working Paper, Wharton School, University of Pennsylvania, 1987.
15. This type of risk refers to situations were all individuals in a group face the same ex ante probability distribution for a random variable; but, ex post, different members of the group obtain different realizations of the random variable.
16. *Danzon P.,* Medical Malpractice: Theory, Evidence and Public Policy (Cambridge, Mass: Harvard University Press, 1985).
17. Pauly *M., Kunreuther H., and Vaupel J.,* «Implicit Mutual Insurance», PUPLIC CHOICE, Vol. 43 (1984), pp. 45-64.
18. The issue of low demand for earthquake insurance has been examined by many researchers. See, for example, Kunreuther H., «Causes of Underinsurance against Natural Disasters», THE GENEVA PAPERS ON RISK AND INSURANCE, Vol. 9 (1984), No 31, pp. 206-220. Kunreuther has suggested two scenarios to explain why consumers behave contrary to standard economic insurance demand theory assuming risk aversion. Consumers may either (1) underestimate the losses and/or probability of disaster so that the benefits of insurance protection appear unattractive relative to the cost of the policy, or (2) they assume the probability of a disaster is sufficiently low that it is not worth worrying about; concequently insurance is not even considered as an option. To deal with the first problem correct information just needs to be provided (but nobody really knows what is correct), and with regard to the second problem either information must be provided in a manner which impresses upon the consequences of an earthquake or some form or regulatory action must be imposed.
19. See *Harry Watson,* «The Effects of Compensation for Uninsured but Insurable Losses, JOURNAL OF RISK AND INSURANCE, September 1984, pp. 498-512. It is shown, also, that it will always be optimal to use a premium subsidy (to induce purchase of insurance) and offer no compensation for an uninsured loss.
20. See *Hirscliefer Jack and Riley J.C.,* «The Analytics of Uncertainty and Information - An Expository Survey», JOURNAL OF ECONOMIC LITERATURE, Vol. 17 (1979), pp. 1375-1421.
21. For the interaction of incurance and fiscal policy, see: Andrew Abel, «The Implications of Insurance for the Efficacy of Fiscal Policy», JOURNAL OF RISK AND INSURANCE, June 1988, pp. 339-378.