

Working Paper

DECISION MAKING FOR LOW PROBABILITY
EVENTS: A CONCEPTUAL FRAMEWORK

Howard Kunreuther

November 1980
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International Institute for Applied Systems Analysis
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ABSTRACT

Recent empirical evidence from field surveys and controlled laboratory experiments reveal anomalies with respect to decisions by individuals to protect themselves against low probability, high loss events. In particular, behavior is frequently at odds with what would be predicted by standard models of choice which involve benefit-cost comparisons.

This paper develops a framework for analyzing decisions for low probability events and discusses their policy implications. The framework highlights the following four interrelated components:

- (1) Type of information collected by individuals in making their decisions (i.e., accuracy of data on losses, probabilities and protective options);
- (2) The decision process of individuals (e.g., expected utility maximization, threshold models);
- (3) Implications of policies on specific groups (e.g., affected individuals, general taxpayers); and
- (4) Welfare implications (e.g., equity and efficiency considerations).

Examples from studies on natural hazards, health and safety problems will be used to illustrate how this framework synthesizes descriptive models of choice with policy prescription. The paper concludes by suggesting directions for future research.

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Howard Kunreuther

I. INTRODUCTION*

Society has become increasingly concerned with developing appropriate measures for mitigating the consequences of low probability events which have potentially large losses. It should be recognized at the outset that what is a low probability event for one interested party may be viewed as a high probability event for another. Similarly, the relative magnitude of the losses is also a function of where one sits. For example, the chances of suffering a severe property loss from a natural disaster or a severe injury from an automobile accident may be viewed as very small by a single individual but treated as relatively high by a government agency concerned with national losses. Property damage from a fire may appear staggering to the affected family but seem relatively small at a more aggregate level because of the different bases used to evaluate consequences.

This paper proposes a conceptual framework for dealing with events which are perceived to have a small chance of occurrence by at least one of the interested parties. The approach emphasizes the importance of undertaking descriptive analysis as a critical input for prescriptive recommendations.

After outlining the framework (Section II), I will illustrate its applicability in Section III with several examples which have both personal significance (e.g., safety of power mowers and motor vehicles) as well as societal importance (e.g., siting of LNG facilities). The importance of understanding decision processes as

*I would like to thank Uday Apte for helping to gather material on the illustrative examples discussed in section II of the paper.

a critical input to policy is underscored by empirical data on individual decision making with respect to insurance protection against natural hazards. Section IV summarizes key results from a large-scale field survey and controlled laboratory experiments which comprised this four-year study and illustrates the possible roles that the public and private sectors can play in providing better protection against future losses. In the concluding section, a more formal model is proposed which incorporates the decision processes and the role of information as critical inputs for developing prescriptive measures.

II. DEVELOPING A GENERAL FRAMEWORK

Figure 1 depicts a conceptual framework for structuring the analysis. An appropriate starting point is Problem Formulation (Box 1). Before undertaking a detailed analysis one needs to identify and define the problem. What are the goals and objectives corresponding to the particular area of concern? Can one gain insight into the nature of the problem through an historical perspective? This initial definitional phase is critically important as it enables one to undertake a detailed descriptive or behavioral analysis which can then be linked to alternative strategies. Furthermore, it helps limit the types of policies or plans that are relevant and provides guidelines for evaluating them.¹

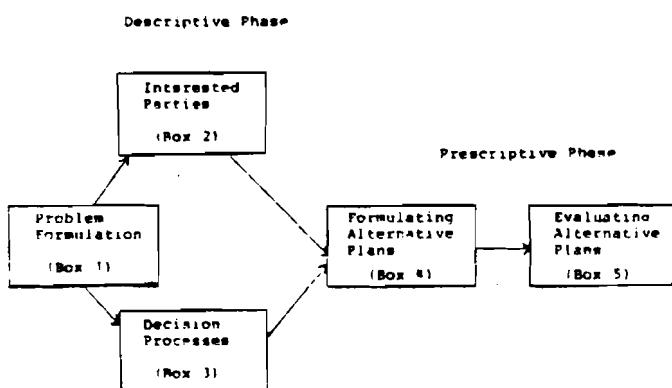


Figure 1. Conceptual framework for analysis structure.

Let us turn now to the descriptive phase. We need to define and describe explicitly the *interested parties* (Box 2) impacted by the problem. Three sectors are considered in the illustrative examples which follow: consumers (i.e., those who demand the particular products or are directly or indirectly affected by it); firms or enterprises (i.e., the organizations or business or supply the product); and government (i.e., public sector agencies or bureaus who interact with the private sector-consumers and enterprises). For each problem there are a set of legal and political constraints which determine how information currently flows between the three sectors and the groups within each sector. It is important to understand the dynamics of this interaction: *who interacts with whom, and when* this interaction takes place.

The other key element of the descriptive phase is the *decision processes* (Box 3) of each of the involved interested parties. By decision processes we

mean the collection and processing of information relevant to the problem being analyzed. Recent empirical evidence from field and experimental studies have revealed systematic biases with respect to the processing of information and simplified rules in combining data in making decisions (Fischhoff, et al. 1980; Kunreuther, et al. 1978; and Tversky and Kahneman 1974). These findings shed considerable light on the relative importance of external events, such as past experience, as well as internal dynamics, such as discussions with others, in influencing decisions on low probability events. It is thus clear that the collection and processing of information are likely to be closely tied to the relevant constraints and the interactions between the interested parties.

Turning now to the prescriptive phase, there is a need to *formulate alternative plans* or courses of actions (Box 4) for coping with a particular problem. The generation of goals and objectives for any problem will suggest a set of plans to be considered. Two types of institutional arrangements between the interested parties circumscribe the types of plans which can be considered. One extreme is for consumers and firms to interact through a market system without any government involvement. The other extreme is for government to impose strict regulations which gives the private sector no freedom of choice. Most strategies are between these two extremes: the government sector utilizes incentives such as subsidies and taxes along with some regulations and information exchange to guide consumer and firm market interactions.

Finally, there is a need to *evaluate plans* (Box 5). How well different policies perform will be influenced by the decision processes of the interested parties. The ranking of different policies is also contingent upon the relative importance given to the interested parties. If residents in hazard-prone areas are deemed important enough to merit special treatment after a disaster, then Strategy A may be much more appealing than Strategy B. On the other hand, if disaster victims are deemed responsible for their own recovery, then Strategy B may be seen as preferable to Strategy A. In evaluating different measures one has to include the compliance costs which must be paid by the sellers as well as the enforcement costs which utilize government funds.²

III. ILLUSTRATIVE EXAMPLES

The framework depicted in Figure 1 can be applied to a set of problems which involve protective measures to reduce the probability of an event or mitigate its consequences. The section begins with those which involve personal safety and conclude with broader societal issues. The purpose of these illustrations is to show how the framework can structure analysis; no detailed evaluation of alternatives is undertaken.

Safer Power Mowers

Should power mowers be made safer? Each year approximately 75,000 people come in contact with moving power mower blades which can cause severe injuries. Nearly 10,000 of the blade-contact injuries involve amputations of fingers or toes (Washington Post 1979a). The problem involves a tradeoff between the costs of producing a safer mower and the reduction in injuries which presumably would result. In this case, the relevant *interested parties* are

the homeowner or gardener who has or desires a power mower; the lawn mower industry; and the Consumer Products Safety Commission (CPSC), the regulatory agency with the responsibility for approving safety standards in this area.

The *decision processes* of consumers plays a critical role in evaluating any policy. If individuals are careless because they feel that nothing can happen to them when they utilize a mower, then it may be necessary to make power mowers safer. In addition, or as an alternative, warnings could be provided on the dangers of the mower (e.g., not to use it on wet grass). How well this information is actually processed by individuals determines how well such a policy works.

With respect to *alternative plans*, the CPSC has proposed mandatory safety standards in designing power mowers.³ Industry claims that this regulation, which would increase the cost of a power mower by \$35, is too strong. In evaluating these plans questions of product liability arise: Is the manufacturer responsible should there be an injury from a mower? A recent case awarded \$6000 to a man who lost part of his foot in a lawn mower. The company claimed that the accident, which occurred because the person's foot slipped on wet grass, could have been avoided had he read the user manual which warned: "Do not use this mower on Wet Grass." In this case ignorance was considered an excuse and the claim was upheld (Business Week, February 12, 1979).

Motor Vehicle Safety

What are the appropriate safety measures for reducing deaths and injuries from motor vehicles? This question has some significance when one studies the statistics for the United States: "In 1977, motor vehicles caused 47,700 deaths, 1,900,000 disabling injuries, and approximately \$12 billion in property damage" (Bick and Hohenemser 1979). At present less than 20% of the drivers or passengers in private vehicles protect themselves by wearing seat belts even though they are installed in all cars. Here, the *problem involves the tradeoffs* between personal freedom and possible adverse consequences to individuals and society when people do not voluntarily protect themselves. The relevant *interested parties* are the drivers and passengers, the automobile industry, and the National Highway Traffic Safety Administration, the regulatory agency empowered to deal with motor vehicle safety.

Echoing the same theme as above, the *decision processes* of consumers are critically important for designing prescriptive measures. Empirical evidence from laboratory studies suggests that one reason people do not voluntarily take protective action such as wearing safety belts, is because they feel that the probability of an accident is so small that they don't have to worry about it (Slovic, et al. 1978). A survey conducted by National Analysts (1971) for the Department of Transportation revealed that those most likely to wear belts are ones who have been asked by others to wear them. This raises the question of the importance of personal influence in the decision making process.

At a policy level there are several options which can be considered. Market mechanisms such as lower insurance premiums for cars equipped with passive restraints (e.g., automatic belts or air bags) could encourage people to voluntarily adopt these measures. Some countries do not pay insurance claims for injuries if it is shown that the individual has not protected himself with a safety belt, thereby providing economic incentives for individuals to use them. A stronger measure, utilized in some countries is to impose a fine for those not

wearing the belt. An extreme measure would be to require that all autos be equipped with a passive restraint. Each of these measures has to be evaluated on a number of dimensions, the most important being the costs of imposing the particular approach and the potential benefits. As in all the examples in this section some parties will be helped while others will suffer depending on which alternative is chosen.

Cigarette Smoking

Should one impose restrictions on cigarettes to deter individuals from smoking and if so how should this be done? This question is stimulated by empirical data which suggests that annually 350,000 lives are lost and approximately \$18 billion in hospital bills are incurred from diseases caused by smoking (Washington Post 1979b). The relevant *interested parties* are smokers, non-smokers, the tobacco industry and the Office of Smoking and Health, a regulatory agency concerned with the effects of cigarette smoking.

The *decision processes* of smokers are critical to the design of alternative policies. If individuals are aware that smoking is harmful to them but ignore these potential effects, either because they feel "nothing will happen to me," then additional information campaigns are unlikely to change behavior. There is also the question as to how sensitive the smoker is to price changes in cigarettes should additional taxes be imposed.

The spectrum of *alternative plans* range from market solutions (do nothing and let people suffer the consequences) to strict regulation (banning cigarettes). Recent proposals have involved a set of incentive systems, such as increasing taxes and using the revenue to help smokers quit (Harris 1980), or prohibiting smoking in certain public places (e.g., hospitals, theaters, and retail stores) (Washington Post 1979b). In evaluating these plans one recognizes that different importance weights on the relevant interested parties may lead to different rankings. For example, a policy of "do nothing" favors the smokers and the tobacco industry while banning cigarettes has the reverse effect. Taxation policies and fines for smoking in certain places falls somewhere between the above two extremes.

Siting of LNG Facilities

Liquefied natural gas (LNG) is a potential source of energy which requires a fairly complicated technological process that has the potential, albeit with very low probability, of creating severe losses. To import LNG the gas has to be converted to liquid form at about 1/600 the volume. It is shipped in specially constructed tankers and received at a terminal where it undergoes regasification and is then distributed. The entire system (i.e., the liquefaction facility, the LNG tanker and the receiving terminal and regasification facility) can cost more than \$1 billion to construct (Office of Technology Assessment 1977). The siting problem of interest is whether one should locate facilities for regasifying and shipping LNG and if so where would be the best place. The *interested parties* are the residents of areas considered as potential sites, those benefiting from this additional source of energy, the gas companies or consortium who are willing to invest in a proposed project and government agencies at the Federal, state, and

local level who have responsibility for trading off the costs (including potential losses from an accident) and benefits of any decision.

Turning now to the *decision process* associated with siting, there are questions as to how each of the groups utilize information on the probability of any accident to an LNG terminal and the resulting consequences. One of the controversies emerging in the siting debate is whether one can or should specify an acceptable level of risk. Some risk assessments of a particular site focus on the chances of a catastrophic accident and conclude that it is acceptable if the probability is below some critical level. Others have utilized worst case scenarios and paid attention to the consequences without paying much attention to the chances of its occurrence.⁴ There is also a need to understand how the different interested parties weigh the safety issue in relation to other concerns of a siting policy such as the economic impacts, effects on the environment and how LNG serves national energy policy.

The formulation of alternative strategies will be greatly impacted by the decision process of the different parties. One way of clarifying differences between the groups is to specify who is responsible for damages should an accident occur. If the location of an LNG facility is viewed primarily as a private venture, then some form of insurance should be offered to gas companies to protect them against catastrophic losses. If this type of coverage is not available on the private market, then government may have to provide this protection. A complementary set of plans may involve compensating residents of a proposed siting area for decreases in their real estate value and perhaps provide them with lower energy rates in return for their increased risk in the future. An alternative is to pass regulations such as the one by the Department of Energy which requires that new sites be in remote areas or in locations with relatively small population densities.

IV. INSURANCE AGAINST NATURAL HAZARDS⁵

Let us now turn to a more detailed study of homeowner decisions on whether to protect themselves against the consequences of natural hazards. The results raise a set of policy-related issues. They also shed light on the decision processes individuals are likely to use when dealing with situations such as those discussed in the previous section.

Problem Formulation

The problem of interest is the appropriate role of the public and private sectors in providing insurance protection against the consequences of natural hazards and relief in the aftermath of a disaster. An historical perspective with respect to this problem is relevant here. Annual losses from natural disasters in the United States is frequently over \$1 billion dollars. Relatively few homeowners have voluntarily purchased insurance against the consequences of floods and earthquakes, even though coverage is easily available and in the case of floods highly subsidized by the federal government. In the past, the U.S government has responded to the financial plight of the uninsured victims by providing liberal relief in the form of low interest loans and grants to aid the recovery efforts.

Evidence on increased federal disaster relief is provided by comparative data on the Small Business Administration (SBA) disaster loan program. The growth of the program is easily seen in Figure 2; the increase is particularly significant in the case of home loans where both the total number and total dollar values in the 1966-76 period were more than 25 times what they were in the first 12 years of the program. It is striking that the \$1.2 billion approved by the SBA for victims of Tropical Storm Agnes represented almost four times the entire amount allocated by the SBA for all disasters between fiscal years 1954 and 1965. Over \$540 million of the amount approved by the SBA for victims of this disaster were in the form of forgiveness grants which did not have to be repaid.

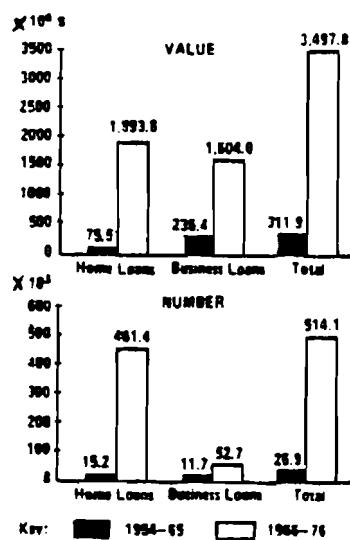


Figure 2. Small business administration disaster loans.

Interested Parties

Insurance against floods is provided by the Federal Insurance Administration with highly subsidized rates on existing property; new property is charged a premium based on estimated risk. For insurance to be offered to residents and businesses in a hazard-prone region, the community must agree to adopt land use regulations and building codes to reduce future losses from the hazard. Earthquake coverage is offered to the public by private companies. Even though coverage is not expensive (\$2 per \$1000 coverage on wood-frame homes in California with a 5% deductible), less than 3% of the homeowners in this earthquake-prone state have bought this insurance.

The interested parties for this problem are thus the Federal Insurance Administration (a government agency), the private insurance industry (i.e., companies and agents), the Small Business Administration, the residents in hazard-prone areas, and the general taxpayer who covers the subsidized portion of flood coverage and the subsidized portion of disaster relief.

Decision Processes

What are the factors which influence individuals to purchase insurance protection against relatively low probability events such as floods and earthquakes? To answer this question field survey questionnaires and controlled laboratory experiments were undertaken. The field survey involved face-to-face interviews with 2,055 homeowners residing in 43 areas throughout the United States subject to coastal and riverine flooding, and 1,006 homeowners living in 18 earthquake-prone areas of California. Half the respondents had purchased flood or earthquake insurance, the other half had not. The controlled laboratory experiments undertaken by Paul Slovic, Baruch Fischhoff, and Sarah Lichtenstein, at Decision Research, shed light on the causal relationships between variables entering into the insurance decision. A few of the key findings from this study which relate to individual decision processes are now summarized.

Although most uninsured homeowners interviewed were aware that flood and earthquake coverage existed, the majority were unaware that they were eligible to purchase a policy. Those who were aware had no reliable knowledge of the costs of a policy. The subsidized flood rate is between \$2.50 and \$3.50 per \$1000 coverage depending on the proportion of coverage devoted to structure and contents. The earthquake premium on wood-frame homes in California averages \$2 per \$1000. Hence any homeowner estimating the respective rates between \$2 and \$4 for flood coverage and \$1 and \$3 for earthquake insurance was classified as reasonably accurate. Figure 3 shows that most of the insured homeowners were accurate in their estimate or underestimated the premium. Few uninsured individuals had accurate information and a large proportion overestimated the premium. This finding suggests that the uninsured individuals had not made any conscious effort to obtain information on rates from their insurance agent even if they knew coverage was available.

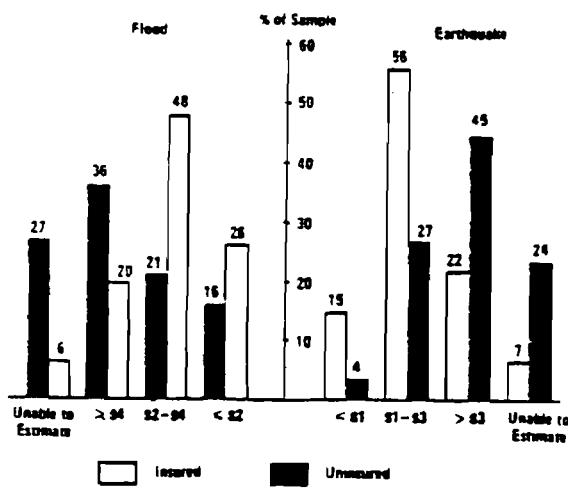


Figure 3. Subjective estimates of insurance premium.
(per \$1,000 coverage)

With respect to the hazard itself, both insured and uninsured individuals had imperfect information on the probability and consequences of a severe flood or earthquake causing damage to their property and contents. When homeowners were asked to estimate the chance of a severe flood or earthquake damaging their property in the next year, 15 percent of the respondents in flood areas and 8 percent of those in earthquake areas, were unable to provide any sort of estimate. Some people thought the probability of a disaster hitting them was quite high—1 chance in 10—yet they said they had purchased no disaster insurance. Others believed the chances of a disaster affecting them was almost nil—1 in 100,000—yet they had purchased disaster insurance. It seems clear that a number of individuals participating in the field survey do not understand the concept of probability. The findings are consistent with the heuristics and biases implied by controlled laboratory experiments over the past decade (Fischhoff, et al. 1979; Tversky and Kahneman 1974).

It is tempting to attribute this casual attitude about the risks of natural hazards and protective activities to homeowners' beliefs that the federal government will bail them out in a crisis. But Figure 4 indicates that the majority of *uninsured* residents anticipate *no aid* at all from the government even when they expected to suffer large losses from a disaster. Most of these people were aware that the SBA provides aid to the victims, but they had little knowledge of the loan terms or whether they could receive forgiveness grants. On the basis of these results, one can conclude that most homeowners in hazard-prone areas have not even considered how they would recover should they suffer flood or earthquake damage. Instead they treat such events as being so unlikely that they ignore the consequences altogether.

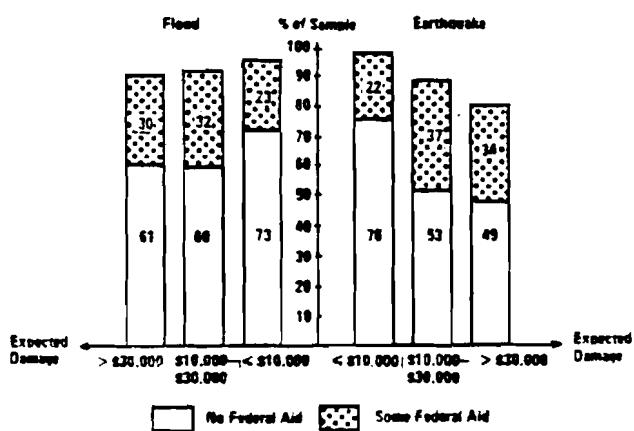


Figure 4. Impact of federal aid on uninsured homeowners.

What variables influence a person's decision to purchase insurance? A key factor is a belief that the hazard is a serious problem. This concern is found primarily among people who have had past experience with the hazard. "You ask me why I didn't have insurance before the June 1972 flood" said one homeowner in Norristown, Pennsylvania. "We had the flood in September of '71 and I had two

feet of water in my basement. And I felt this I can tolerate and this is probably as high as it will ever get." To his chagrin, this man suffered severe property damage in 1972. Only then did he decide that he needed insurance. Another uninsured flood victim, said that his rationale was that "the \$60 in premiums they could use for something else. But now they don't care if the figure was \$600. They're going to take insurance because they've been through it twice and they've learned a lesson from it."

As shown in Figure 5, another important factor in influencing the purchase of a policy appears to be knowing someone who has purchased coverage or discussing insurance with a friend, neighbor or relative. The following example graphically illustrates this point. In a pretest of the questionnaire in San Francisco, a homeowner responded to one of the questions by saying that he did not have earthquake insurance. A friend of his who was listening to the interview commented that he had himself purchased such insurance a few years before. The respondent was dumbfounded and asked his friend about the availability of earthquake coverage and how much it cost. "I'm going to have to look into earthquake insurance myself," he added.

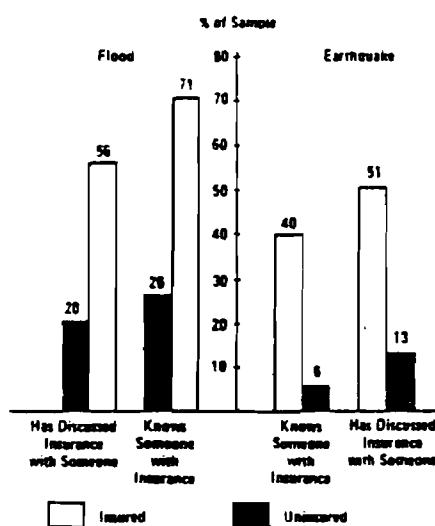


Figure 5. Interpersonal communication between insured and uninsured.

The controlled laboratory experiments on insurance undertaken at Decision Research provides further insight into these results.⁶ Subjects were exposed to a variety of risks that had different losses and probabilities associated with them. By keeping the premium constant for all risks and varying the losses and probabilities in such a way that the expected loss (loss multiplied by probability) was the same, it was possible to test the importance of probability and loss on insurance purchase decisions.

One would expect that individuals should prefer to insure themselves against events having a low probability of occurrence but a high loss rather than against those having a high probability and low loss. The reverse was found to be true for a variety of experimental formats. These results suggest that if the chances of an event are sufficiently low, people do not even reflect on its consequences. In other words, people are primarily interested in buying insurance if

they feel the probability of a disaster is high enough for them to stand a good chance of getting a return. They thus view insurance as an *investment* rather than as protection.

Formulating Alternative Policies

There are a set of alternative policies for dealing with the natural hazards problem outlined above. The current institutional arrangements for floods and earthquakes illustrates the role of incentives and regulations to supplement market mechanisms.

In the case of the flood hazard, the federal government offers subsidized premiums as an incentive for residents to purchase coverage. They also are imposing specific land use regulations on communities who participate in the flood program. More recently banks have required homeowners to purchase flood insurance as a condition for obtaining a mortgage. Those who apply for federal relief after a disaster are also required to purchase coverage as a condition for obtaining a low interest loan. For these groups, flood insurance is mandatory rather than voluntary.

Protection against earthquake damage has been more of a private rather than public affair. No one is required to purchase insurance as a condition for a mortgage or a disaster loan. Even though coverage is available, there has been no great effort made by insurance companies or their agents to actively market policies. The insurance industry claims that it does not have enough reinsurance capacity to cover the damage from a catastrophic quake in a populated area of California if most residents and businesses were protected with insurance. Today the principal government role with respect to the hazard is through local building codes and ordinances on the design of structures and the provisions of federal aid to cover the uninsured portion of an earthquake loss.

Other programs for coping with the problem are stimulated by the following questions:

- (1) What types of information would enable people to make better decisions for coping with the risk? How can either the insurance industry, government at all levels (i.e., federal, state, and local) and/or public interest groups aid in this effort?

One course of action is to make flood and earthquake coverage more attractive by presenting information through normal channels. The insurance agent may serve an important and useful function in this regard. To the extent that he has the trust of his clients, he can stimulate their awareness of the hazard by telling them the chances of a disaster occurring and the potential losses that could result. One way for the agent to increase the client's concern with the hazard may be to present information on the probability of a disaster on a different time interval than the traditional one year period. For example, in describing the chances of a 100 year flood, the agent could note that for someone living in a house for 25 years, the chances of suffering damage at least once will be .22. He can also provide details as to what coverage is available and how much it costs. Since most individuals seem to treat insurance as an investment, the agent should educate his clients that the biggest return on their policy is to have no return at all.⁸

- (2) What is the balance between the use of market mechanisms for equating supply and demand, developing appropriate incentives (e.g., taxes and subsidies) as well as regulatory measures (e.g., required insurance coverage) in the design of a hazards strategy?

Financial institutions may play a key role here by requiring some type of natural hazard insurance as a condition for a mortgage on residential property. Several types of policies deserve consideration. One option would be a broader form of homeowners insurance which combines flood and earthquake. A less extreme proposal would be to add only earthquake coverage to a standard homeowners policy and maintain the current flood insurance program. A third option would be to maintain the current insurance coverage and provide disaster relief to special groups or for special situations. Distributional cost considerations may suggest that special treatment be given to low-income or elderly residents.

Evaluating Strategies

Any strategy or program impacts on the interested parties in different ways. The evaluation phase forces policy makers to come to grips with the question as to the appropriate role of the public and private sectors in hazard management. To illustrate, consider two contrasting scenarios. In scenario 1, acts of God, such as floods and earthquakes, are viewed as a public responsibility; then liberal disaster relief should be provided to all victims and/or highly subsidized insurance offered to residents in hazard-prone areas. In scenario 2, individuals are expected to assume the responsibility for protecting themselves against the hazard; then private insurance should be offered and those who decide not to purchase coverage voluntarily will be forced to suffer the consequences. Scenario 1 is equivalent to assigning a high weight to potential victims and a low weight to the general taxpayer. Scenario 2 gives increased importance to the general taxpayer. In this case, policies which require individuals faced with a risk to bear the cost of potential losses are viewed as being attractive. How this evaluation process currently takes place and should take place in the future is an important topic for discussion.

V. TOWARDS A DESCRIPTIVE MODEL OF CHOICE

The examples presented above suggest the need for an understanding of the decision processes of the interested parties before one can recommend different policies. A first step in this direction is depicted in Figure 6 where the three interested parties—consumers, firms, and government—are linked to a set of events (e.g., catastrophes, accidents) each of which has a probability and loss associated with it. To make the problem more concrete and realistic assume that there are n different consumer groups some of which have different possible losses and probabilities associated with a particular event. For example, there may be different exposures to a certain hazard so that the chances of incurring a specified loss will differ between individuals. Assume that there are m identical firms each providing the same type of protection (e.g., insurance) against the consequences of these events.

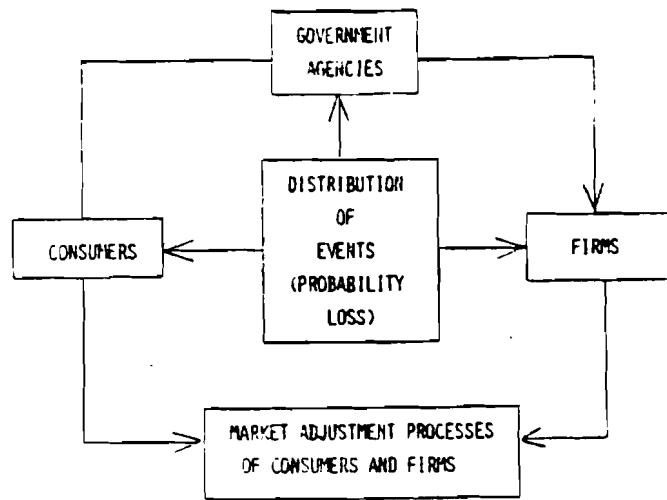


Figure 6. Descriptive component.

Performance of a Market System

Given this simplified world it should then be possible to analyze how well a market system operates under a variety of different assumptions regarding the accuracy of information by consumers and firms on the distribution of events. For example, suppose consumers and firms have perfect information on the probability and loss distribution of events. What type of insurance policies will be offered to consumer groups? How does the situation change when there is imperfect information by either or both of these parties?

A similar analysis can be undertaken if one postulates different types of decision rules used by consumers or firms. For example, suppose that each consumer evaluates the benefits and costs of purchasing insurance and chooses an amount (possibly no coverage) which maximizes expected utility. How much insurance will each consumer group purchase and what types of coverage will firms offer? Suppose, on the other hand, that consumers utilize a threshold model of choice: if the probability of the event is perceived to be below some critical level then the person ignores its consequences and does not consider any type of protection; otherwise they purchase the amount of coverage which maximizes expected utility. What impact will such a behavioral model have on the types of insurance policies offered by firms and the degree of protection adopted by consumers? In a similar vein one can investigate the impact of a model where factors such as past experience and discussions with friends and neighbors trigger search for new information and interest in protective measures such as insurance.

The impact of different assumptions regarding the accuracy of information and alternative decision rules can be investigated either at one point of time or in a dynamic context. When one looks at the situation over time then there is a need to specify the different rules that consumers and firms are likely to utilize for updating information on the probability and consequences of specific events. As shown by Arrow (1963) and Akerlof (1970) there are problems of adverse

selection when firms have misinformation or imperfect information on the risks each of the n consumer groups are facing. For example, if firms cannot distinguish between high and low risk groups they may set a premium based on the average probability of a loss. If consumers have accurate information on the hazard, high risk groups will find this policy to be much more attractive than low risk groups, and will purchase a proportionately larger share of the total coverage. Over time, claims experience leads firms to set higher and higher premiums, thus making insurance less and less attractive to those in the lower risk classes. Eventually the only group who finds insurance to be attractive are those in the highest risk class.

The above example illustrating market failure is important for prescriptive purposes because it indicates that the private sector may not provide satisfactory protective solutions to potentially disastrous events, either because of misinformation and/or because of the decision processes of the interested parties. The lack of protection may then be very costly to both the disaster victims (who may not be able to get protection or are unaware of the consequences of the hazard) as well as the general taxpayer (who may have to foot the bill after a disaster occurs). The example also suggests the importance of determining what information consumers and firms have available, how accurate these data are and how they are actually utilized in the decision-making process.

Role of Government

If consumers and/or firms have misinformation, one of the important roles that the third party, government, can play is to provide better data on the hazard itself (e.g., losses, probabilities of its occurrence) as well as ways of protecting oneself (e.g., available insurance, type of coverage and its cost). It can also provide monetary incentives to encourage certain actions (i.e., subsidies) as well as disincentives (i.e., fines, taxes) to inhibit or discourage certain types of behavior. Finally, it can regulate or require certain types of actions.

The success of each of these approaches depends on the decision processes of the interested parties and the objectives of different policies. Thus, if consumers are maximizing expected utility then a subsidized insurance premium would lead to an increase in demand for coverage. This type of incentive system would have no effect for any consumer who behaved according to a threshold model and perceived the probability of an event to be below his critical level. In the latter case the only way to induce interest in insurance is to provide information on the hazard so that the probability is perceived to be above the critical level(s) or to require the person to have insurance coverage.

From a dynamic viewpoint there is a need to understand differences in *ex-ante* estimates and *ex-post* valuations and their effect on policy. Prior to a disaster an individual is likely to behave with one set of estimates of the probability and losses. After an event occurs he may revise his estimate considerably, partly on the basis of the new information (i.e., updating his prior estimates of probabilities and losses) but also because of the nature of this decision process (e.g., he now views the probability to be above a critical threshold level and hence is concerned with possible losses). If government policy responds to these *ex post* perception changes in a way that was unanticipated prior to the disaster, this process has to be understood before one designs policies. A clear example of this behavior is in the natural hazards field: government provided liberal disaster relief after the occurrence of a disaster because few people protected

themselves prior to the event. If crises normally trigger unanticipated reactions due to political and social pressures (c.f., the Three Mile Island response), then this process must be taken into account in designing appropriate strategies for dealing with low probability-high consequence events.

Finally, there are a set of philosophical and ethical issues that have to be addressed directly when evaluating the role of government as part of any alternative plan. Given our increased understanding of the imperfect information and simplified rules that people use in making decisions, there is the open question as to "when should we protect individuals from themselves?" If policy makers have learned from experience that there is *ex post* regret by uninsured consumers after an event, what type of incentives or regulations, if any, should be taken *ex ante*? There is no easy answer to this query but it should be explicitly addressed as an issue regarding the appropriate role of government in dealing with the consequences of low probability events. It also illustrates the interaction between the descriptive and prescriptive components depicted in the conceptual framework (Figure 1) which has motivated this paper.

NOTES

1. For an excellent discussion of how one can specify goals and objectives for societal problems, see Keeney and Raiffa 1976, Chapters 1 & 2.
2. For an analysis of alternative remedies proposed by the Federal Trade Commission in the context of these and other costs, see Federal Trade Commission 1979.
3. The specific standards are that the foot cannot reach the blade of the mower and that the blade must stop within 3 seconds of release of the power switch so the hand cannot reach the turning blade.
4. These differences are clearly seen in the LNG siting debate in California. For more detail on this case, see Ahearn 1980, in press; Deutsch in press; Kunreuther 1980; and Linnerooth 1980.
5. The material in the next section summarizes the findings from a four-year study supported by funds from the National Science Foundation. Readers interested in more detail are referred to Kunreuther, et al. 1978.
6. More details on the insurance experiments can be found in Slovic, et al. 1977. The material also appears in Kunreuther, et al. 1978, Chap. 7.
7. A more detailed discussion of policy options appears in Ginsberg and Kunreuther (in press).
8. Kunreuther and Schoemaker (in press) provide a more detailed discussion of the role of the agent and the insurance industry in promoting the sale of flood coverage.

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