9.1 Introduction

This chapter investigates alternative approaches for dealing with problems that not only affect individuals but also have important societal consequences. Such problems typically involve a broad spectrum of interests from consumers and businesses to special interest groups and government agencies. Our particular focus is on low-probability, high-consequence events, as these bring out clearly the importance of understanding decision processes for prescribing public policy. More specifically, biases are known to exist regarding the way different interested parties deal with risks. Society is now struggling with many of these issues, and they will assume even more prominence as technology advances. The problems include such diverse areas as automobile safety, energy, environment, natural and technological hazards, consumer product safety, and occupational risks.

Based on an understanding of the decision processes of the different actors, what type of policy tools should be utilized in allocating resources? Frey and Eichenberger (1989) suggest that private markets may be inefficient when there is uncertainty because of individual limitations in collecting and processing information on the risk. For example, motorists know that their chances of being involved in an accident are low but few can specify the probabilities of being injured, or whether driving to work is more or less dangerous than a trip on the open highway which takes twice as long. There is a general awareness that protective mechanisms, such as seat belts or air bags, will reduce the impact of an accident, but little thought is generally given to the specific benefits of using these devices.

A related factor that limits the use of markets in allocating resources is that the rules of thumb for evaluating protective measures often do not involve benefit-cost trade-offs. Many individuals in hazard-prone areas fail to engage in loss-prevention activities such as purchasing insurance because they use a simple rule like "It won't happen to me" or "I don't have to worry about this." Hence, they do not compare the cost of the protective measure with the reduction in expected loss from adopting it.

The inverse of the "It won't happen to me" rule is often invoked for projects that involve technological risks such as the construction of a nuclear power plant or the siting of a hazardous waste incinerator. The public often assumes that "if it can go wrong it will" (Murphy's Law). In essence, people focus only on the potential consequences of an accident at such facilities rather than on the chances of its occurrence. This concern with consequences may explain the difficulty in finding homes for facilities that the public considers hazardous, even though scientific experts feel they are safe. Both of these heuristics focus only on a single dimension—in the first case, "probability," and in the second case, "outcome."

A third issue that has important public policy implications concerns the aggregate impact of a systematic underreaction or overreaction to low-probability events. The relationship between micromotives and macrobehavior has been explored in detail by Thomas Schelling (1978) using a variety of social contexts. It has particular relevance to situations in which individuals utilize simplified rules of thumb such as those described previously.

For example, if few individuals purchase flood insurance even though it is highly subsidized by the federal government, then many unprotected homeowners are subject to a large personal loss if a flood severely damages their residence. Each individual in a flood-prone area should find subsidized flood insurance attractive, assuming he or she is risk averse (or even slightly risk seeking) and wishes to maximize expected utility. By not purchasing coverage an individual appears to be behaving irrationally. Should a homeowner be the only one uninsured, then she undoubtedly would have to shoulder the consequences personally. However, if most of the victims are unprotected, then the political consequences of not providing relief may be so severe that Congress will put together a generous relief package.1

Homeowners are likely to assume that after the next catastrophic earthquake, flood, or hurricane, Congress will respond generously again. In fact, the decision not to take protective action, which appears to be irrational if the individual believes he is personally responsible for the loss, may be justified ex post if there is an unexpected generous response by other parties.

A fundamental issue in public policy is how much to rely on the private market to allocate resources and to what extent, if at all, government

1 For example, Tropical Storm Agnes in 1972 caused approximately $2 billion in damage and less than $100 million of this was covered by insurance. As a result, the Small Business Administration offered $5,000 forgiveness grants to all victims, whether insured or uninsured, and 1% loans for the remaining portion of the damage (Kuenreuther, 1973).
should be involved in protective decisions prior to the occurrence of a low-probability event. In part this hinges on past experience, societal expectations, and the nature of the events. We shall illustrate some instances in which private markets operate especially poorly. From a policy perspective, such market failures are important because they involve not only private risks to the affected individuals but also social risks to others beyond those actually making the decisions.

9.1.1 Automobile safety

Wearing a seat belt reduces the personal risk of injury in a car accident whether or not air bags are installed. Prior to 1985, less than 20% of motorists wore seat belts voluntarily, even though it was widely known that seat belts save lives (Williams and Lund, 1986). It appears that many people do not wear seat belts because their personal probability estimates have an optimistic bias (cf. Weinstein, 1987).

In a survey of motorists, Svenson (1981) found that 90% of drivers felt that they were better drivers than average. Those drivers often justify their optimism by saying “it hasn’t happened to me.” Others admit a self-control problem, finding it too cumbersome to buckle up (see Schelling, 1983). We, as a society, bear some of the costs of these injuries through subsidized medical payments and lost productivity, not to mention the financial and emotional impact that a serious injury poses to the victim’s immediate family. For these reasons, it may be appropriate to mandate the use of seat belts.

9.1.2 Natural hazard protection

There is considerable evidence that many individuals do not voluntarily protect themselves against a host of low-probability natural hazards. Few homeowners adopt inexpensive loss reduction measures even though this would mitigate losses should a disaster occur. For this reason, earthquake-resistant design requirements were incorporated in California building codes following the extensive damage to structures from the 1933 Long Beach earthquake (Petak and Atkinson, 1982).

What role should benefit–cost analysis play in determining the relative merits of mitigation measures for hazards such as earthquakes? What role should the federal government play in providing insurance protection when the private sector finds it unprofitable to market such coverage? In addressing these questions, one has to take into account issues of resource allocation (efficiency) as well as distributional concerns across stakeholders (equity).

9.1.3 Siting technological facilities

Technological facilities, like nuclear power plants and storage facilities for radioactive waste, may benefit society but concentrate risk in the regions where these facilities are located. Although scientists and experts emphasize that the health, safety, and environmental risks are very low, people who live near a proposed facility are usually strongly opposed to them. Their fears are caused by factors such as the unknowability and uncontrollability of the hazard and its catastrophic potential. These risk perceptions are not normally considered by experts (Fischhoff, Watson, and Hope, 1984; Slovic, 1987).

Compensation given to the host communities is an obvious policy tool suggested by economists for locating facilities. However, if the affected public feels that the risk to health and safety exceeds some critical level, it may view monetary payments as a bribe and refuse to accept the facility (Kunreuther, Fitzgerald, and Aarts, 1993).

These three examples illustrate that effective policies must consider psychological and sociological factors as well as economic ones. In many cases, market-based solutions may be inappropriate for dealing with these issues.

Kenneth Arrow (1963b) has suggested that “when the market fails to achieve an optimal state, society will, to some extent at least, recognize the gap, and nonmarket social institutions will arise attempting to bridge it” (p. 247). A set of policies ranging from providing better information to strict government regulation may fill this gap and improve social welfare. Before evaluating these programs we shall examine the conditions required for a private market to function for choices involving well-specified risks.

9.2 The performance of the economic market under risk

For most situations involving the trading of goods and services, private market mechanisms generally perform very well without the need for government interference. For problems involving risk and uncertainty, the assumptions required for a market system to allocate goods and services efficiently may not be satisfied by either buyers or sellers. Furthermore, there may be other social objectives, such as equity and distributional considerations, that may conflict with the efficient resource allocation process under a free-market system.

A free-market system leads to an efficient outcome if the allocation of resources between parties cannot be rearranged to improve at least one person’s situation while not worsening the position of others. This condition, known as Pareto optimality, was discussed in Chapter 7. The fol-
lowing example will be used to illustrate the types of assumptions that are sufficient for a Pareto-optimal resource allocation under conditions of uncertainty:

Assume a large number of consumers with identical wealth and the same utility function, each of whom faces an identical loss of $L$ dollars (e.g., a fire destroying their home) which can occur with a known probability, denoted by $p$, that is independent of any steps taken by the consumer. Each potential loss is uncorrelated with any other loss. Many identical firms offer insurance policies to protect the consumer against this potential loss. What price and amount of insurance coverage will firms offer? How much protection will consumers want to purchase?

This paradigm describes an important class of problems facing those who demand and supply protection against risk. The following assumptions regarding the knowledge and behavior of the consumers and firms are necessary and sufficient for an efficient solution to emerge.

- Consumers and firms agree on the values of $p$ and $L$.
- Consumers will purchase that amount of insurance which maximizes their expected utility.
- Each firm sets a price for insurance that maximizes its expected profit.
- Each firm is so small that its particular transaction volume with consumers has no noticeable effect on the price of insurance.
- There is no cost of entry or exit by firms.
- There is no collusion between either consumers or firms in their transactions.
- The actions of any one consumer or firm do not influence the welfare of others.

To determine the nature of the equilibrium price and quantity, there is a need to be more specific about the behavior of firms and consumers. Consider a representative insurance company—Gibraltar. It offers a price (r) per dollar of insurance that maximizes its expected profits. Since the probability of a loss is given by $p$, the firm will make zero expected profits if $r = p$. The total amount of coverage $D(r)$ that consumers purchase will be a function of $r$, so that the expected profit $[E(\pi)]$ for each firm is given by

$$E(\pi) = D(r)[r - p]$$  \hspace{1cm} (9.1)

Now, given these assumptions, it can be shown that insurance firms like Gibraltar Company will all end up charging the same price $r = p$. If $r > p$, then positive expected profits would result; other firms would enter the market with a lower price to share in these profits. Eventually price would be driven to $p$, where each firm would just cover its costs. Clearly a price $r < p$ is not feasible since negative expected profits would result.

Consumers determine the amount of coverage to purchase that maximizes their expected utility given a selling price of $r$. Consider a representative homeowner, Jane. She has initial assets ($A$) and a von Neumann–Morgenstern utility function that displays risk aversion. Jane knows that if there is a fire she will lose $L$ dollars unless she purchases insurance to cover all or part of this loss. On the other hand, if a fire does not occur then she will be out of pocket by the amount of money spent on insurance. These two events occur with probabilities $p$ and $(1 - p)$ respectively. The expected utility $U(\pi)$ associated with an amount $D(r)$ of coverage is thus given by:

$$E[U(D(r))] = pU[A - L + (1 - r)D(r)] + (1 - p)U[A - rD(r)]$$  \hspace{1cm} (9.2)

Expected utility in equation (9.2) is maximized by setting $dE[U(D(r))]/dD(r) = 0$. This yields the following equilibrium condition for the consumer:

$$\frac{(1 - p)r}{p(1 - r)} = \frac{U'[A - L + (1 - r)D(r)]}{U'[A - rD(r)]}$$  \hspace{1cm} (9.3)

where $U'$ represents the marginal utility of a particular wealth level. The left-hand side of (9.3) is a contingency price ratio, which reflects the expected cost of insurance should no disaster occur (i.e., $(1 - p)r$) to the expected net gain in assets from insurance should a disaster occur (i.e., $p(1 - r)$). The right-hand side of (9.3) represents the ratio of marginal utility of wealth in a "disaster state" to marginal utility of wealth in a "nondisaster state" if $D(r)$ dollars of insurance were purchased.

If insurance is offered at a price that reflects the risk (i.e., $r = p$), then the right-hand side of (9.3) equals 1. Jane will then want to purchase full coverage (i.e., $D(r) = L$) in order for the right-hand side of (9.3) to be 1. She will now be indifferent between having a fire or not having a fire, since the utility in both these states of the world is identical (due to full coverage). Here again we have simplified the example by assuming there are no costs associated with replacing the goods and that the damaged property and contents do not have any sentimental value.

The equilibrium for this simple problem is characterized as follows. Firms like the Gibraltar Company are willing to trade contingent claims...
at a price \( r = p \) to consumers. The claim is contingent upon the insured's house being damaged or destroyed by fire (excepting fraud). Consumers like Jane are willing to purchase full coverage at the market price.

### 9.3 Examining the assumptions

Economists have used the performance of the free-market system as a benchmark to evaluate policy options for dealing with the more complicated problems that arise in the real world. It is for this reason that we explicated the set of simplifying assumptions about consumer and firm behavior. When these conditions are satisfied, a free market will produce solutions that are Pareto optimal without any interference by the public sector or the presence of special institutional arrangements within the private sector.

The free-market model resembles the no-friction model of the physicist. It does not normally provide a picture of the world as we know it, but is a valuable tool for shedding light on a complicated reality. Most of the assumptions for the preceding insurance problem are not satisfied in practice. For one thing, there are problems associated with information collection and processing by consumers and firms. Furthermore, there are factors such as market power, externalities, and public goods that produce market inefficiencies and may call for the government to formulate policies for improving social welfare. This chapter will not dwell at length on these latter factors, since they have been covered very well in other policy texts (see, e.g., Stokey and Zeckhauser, 1978). Our attention, instead, will be focused on the importance of understanding decision processes as a basis for developing relevant policy tools.

#### 9.3.1 Biased information

There is considerable evidence, as pointed out in Chapter 3, that individuals have great difficulty estimating the chances of uncertain events occurring, particularly if they are low-probability risks. For example, the public, as well as scientists, cannot easily differentiate an event whose chances of occurring is \( 10^{-7} \) from one with a probability \( 10^{-5} \), a risk 100 times as large (Zeckhauser and Viscusi, 1990).

If consumers underestimate the probability of a disaster, then they will not purchase full insurance voluntarily unless firms commit the same error. The premium charged by insurers will be seen as too high by the homeowners in relation to their estimate of the chances of a loss. Policy questions thus arise. If there are social benefits of having homeowners protected with coverage, can data on the probability be assembled and provided to the consumer to correct this misperception? When is it more cost-effective simply to require individuals to purchase coverage?

Similar policy questions could be raised regarding the loss dimension. Homeowners in California overestimate the magnitude of losses to their wood-frame homes from a severe earthquake, perhaps because of media coverage and salient films such as *Earthquake*. Should experts attempt to correct this biased loss estimate if at the same time individuals underestimate the chances of such an event occurring? Or should two wrongs be left to make a right? If yes to the first question, what actions should be taken and how costly will they be? What are the likely impacts on behavior?

For many events, such as earthquakes, there is a limited statistical data base from which to determine the probability and resulting losses to property or health in a given region of the country. In this case, insurers set their premiums based on ambiguous information. The prices for these ambiguous hazards tend to be higher because of uncertainties in the data (Hogarth and Kunreuther, 1989; Kunreuther, Hogarth, and Meszaros, 1993).

For other problems, firms may have difficulty discriminating between good and bad risks. Which applicants for medical coverage are healthy, which unhealthy? If the individuals themselves know but insurers do not, then firms cannot charge differential premiums. This opens up the possibility of adverse selection where only the poorer risks purchase coverage, premiums increase to cover losses, and eventually the market becomes very thin or collapses (Akerlof, 1970).

What steps can be taken to correct this failure? Some private sector remedies are possible, such as requiring applicants to have a medical examination and using the results as a basis for the premium. Another possible solution is requiring everyone to purchase medical insurance. Then firms can charge a single premium across all classes of risks, such that the good risks subsidize the poor risks. Of course, if the consumer does not know his or her own health status relative to others, then adverse selection ceases to be a problem. In this sense, information imperfections on both the demand and supply side may lead to a more efficient market than if only firms did not know consumers' risk characteristics.

#### 9.3.2 Consumer decision rules

Individuals often use simplified decision rules for making their choices. Tversky et al. (1988) propose a contingent weighting model in which individuals make biased trade-offs between dimensions such as probability and utility. The weights placed on dimensions are contingent on the way information is requested (response modes) and the problem context.

Many of the heuristics for dealing with low-probability risks seem to follow a contingent weighting process. An extreme form of such a rule is when all the weight is placed on a single dimension. For example,
some individuals may decide that if the probability of an accident is below a threshold value of $p^*$, they will not reflect on its occurrence and hence will not consider the loss dimension.

If large groups of people at risk are unprotected against potential disasters because they use such probability threshold models, then what alternative policy options should be considered? There is no easy answer to this question since it involves issues of paternalism (i.e., forcing people to protect themselves against their will) as well as possible cross-subsidization to unprotected individuals by the rest of society (e.g., providing uninsured disaster victims with liberal federal aid). What is very clear, however, is that in many situations the private market will allocate resources differently from what would be predicted from normative models of consumer choice.

9.3.3 Firm decision rules

The problems faced by firms are similar to those of consumers. They use rules of thumb that reflect specific constraints. For example, a case study of a chemical company revealed that prior to the Bhopal, India, chemical explosion it was using techniques of risk assessment to determine acceptable standards for operating a plant. The normal procedure was to design production processes so that the chances of an accident were at or below an acceptable probability level. Following Bhopal, instead of focusing on the probability dimension, the emphasis was placed on an analysis of worst outcome scenarios and ensuring that they would not occur.

The company felt it needed to take this action on grounds of accountability and justification to its employees, stockholders, board of trustees, and concerned governmental groups (Bowman and Kunreuther, 1988).

This behavior is typical of many corporations. Although profit maximization may be an objective, the driving force behind many actions is satisfying a set of constraints that serve as focal reference points. March and Shapira (1992) point to a growing literature in both organizational and individual behavior suggesting that managers often make risk decisions by setting the probability of falling below the reference point at some fixed number. Events whose chances of occurrence are estimated to be below this value are put in the category "it cannot happen to me." (Mitroff and Kilmann, 1984). This approach of setting probability thresholds has been used by the Nuclear Regulatory Commission in the design of safety procedures for operating its facilities (Fischhoff, 1983) and by the insurance industry in setting premiums (Stone, 1973).

4 The Bhopal disaster occurred in December 1984. Methyl Isocyanate gas escaped from a Union Carbide plant, leading to more than 2,000 deaths and causing illness in countless others. For more details on the Bhopal accident, see Shrivastava (1987).

Suppose a disaster occurs whose probability was perceived to be below the threshold (such as Bhopal) and hence had been classified as "not worth worrying about." The availability bias will now lead firms to imagine how easily such a disaster could happen again. In other words, the disaster now becomes a new focal point. Firms will want to avoid any situation that resembles the disaster that just occurred. They do not rationally estimate new probabilities but will recommend steps to prevent future occurrences without making expected benefit–cost trade-offs.

Former governor of Massachusetts Michael Dukakis reacted in this way by preventing the Seabrook 1 nuclear power plant from operating in the mid-1980s. According to Dukakis, the New Hampshire plant, two miles from the Massachusetts border, did not contain evacuation plans that would "protect the lives of the people in Massachusetts living within the 10 mile evacuation zone." The former governor also indicated that "the likelihood (of a major accident at Seabrook) is irrelevant," suggesting that he was using an outcome threshold, perhaps for political reasons (Wessel, 1986).

In other cases, firms may go through explicit benefit–cost calculations to determine whether to install safety equipment on their products. But this can backfire. The classic case of such an action was the decision by Ford not to make an $11 per car improvement that would have prevented gas tanks from breaking so easily both in rear-end collisions and in rollover accidents. Table 9.1 depicts the relevant calculations from an internal Ford memorandum showing that the total cost of such an improvement would be $137 million and the expected benefit only $49.5 million (Dowie, 1977).

In the case of the Ford Pinto, the highly negative publicity from the discovery of the memo, as well as the large number of damage suits arising from the defect, led Ford to make these improvements on later Pinto models. The example raises difficult questions about the role of the liability system in inducing firms to adopt protective measures. Did Ford act ethically in pursuing a cost–benefit analysis? Why did they use such a low value of life ($200,000) rather than a more realistic figure (somewhere between $3 million and $6 million) in evaluating this new design? When is it appropriate to pass health and safety regulations that force product improvements that would not otherwise be made (i.e., under a free-market system)? Those questions are addressed in an interesting book by Viscusi (1991) on the role of the products liability system in dealing with those risks.

9.4 Evaluating alternative policies

In their discussion of guidelines for making social choices and designing policies, Stokey and Zeckhauser (1978) specified two fundamental principles that we subscribe to wholeheartedly in our analysis.
Table 9.1. The cost of dying in a Pinto

Printed below are figures from a Ford Motor Company internal memorandum on the benefits on an $11 safety improvement which would have made the Pinto less likely to burn. The memorandum purports to "prove" that the improvement is not cost effective.

**Benefits**

* Savings: 180 burn deaths, 180 serious burn injuries, 2,100 burned vehicles.
* Unit cost: $200,000 per death, $67,000 per injury, $700 per vehicle.
* Total benefits: $180 × ($200,000) + $180 × ($67,000) + $2,100 × ($700) = $49.5 million

**Costs**

* Sales: 11 million cars; 1.5 million light trucks.
* Unit cost: $11 per vehicle.
* Total cost: 11,000,000 × ($11) + 1,500,000 × ($11) = $137 million


**Principle 1:** The well-being of society depends solely on the welfare of the individual members, those alive today as well as future generations. For example, if people, upon being properly informed, remain concerned about environmental issues, then the impact of a particular program on air or water quality should be taken into account as a part of the policy process; otherwise, it will not be deemed relevant.

**Principle 2:** Trade-offs among individuals are unavoidable. In making any policy decision, it is likely that some people will be made better off by these actions, while others will be made worse off. For example, if a regulation is passed requiring air bags in all cars, those motorists who would have preferred driving without this protection will be upset. Other car owners who want air bags in their cars will be pleased at the lower price of this feature due to the economies of mass production. Taxpayers who will not have to pay some of the medical expenses of car victims will also appreciate this regulation. Whether this policy is more desirable than a voluntary program requires making trade-offs.

### 9.4.1 Efficiency and equity considerations

A comparison of alternative policies for dealing with a specific problem requires some determination of social welfare. This, in turn, requires a definition of individual welfare and a specification of an aggregation process over people and time. Standard policy analysis assumes that individual welfare reflects a person's total well-being (i.e., the goods and services he or she consumes, the activities undertaken, etc.). Furthermore, an individual is assumed to be the best judge of her own welfare. However, there is no general agreement on how one constructs a social welfare function. Should one give equal weight to the well-being of each individual? If not, how should one determine the degree of importance of one person or group over another (such as future generations)? The two criteria that normally are used to evaluate alternative policies are **efficiency** and **equity**.

A policy is considered efficient relative to the status quo if the well-being of society is improved by undertaking this policy. One criterion that satisfies efficiency is maximizing net benefits so that the gainers from a change over the status quo could, in theory, compensate the losers (Sciotosky, 1941). If this compensation were actually made, then everyone is indeed better off in the process. Sciotosky's principle only stipulates that this should be possible (i.e., that net gains exceed net losses), not that the compensation actually occurs. Standard benefit–cost analysis is an example of such a criterion, since it recommends that a particular policy be introduced if the total benefits to all parties exceed the total costs.

In reality, the implementation of a particular program may leave some individuals or groups worse off than under the status quo because it is impossible or undesirable to compensate them for their perceived loss. Not only is it difficult to measure their dissatisfaction with a particular program, but if people knew they would be receiving something in return for their discomfort, they would have a strong incentive to misrepresent their feelings.

The **equity** concerns of public policy programs have become increasingly important in cost–benefit formulation. For example, Medicare recognizes the need to aid elderly residents who cannot afford normal hospital care; younger taxpayers subsidize this group. In providing uninsured disaster victims with liberal relief, the government has determined that this special group should be aided by all U.S. taxpayers.

### 9.4.2 Philosophical and ethical considerations

The balance between efficiency and distributional considerations for specific problems is reflected in existing legislation, regulatory mechanisms, and incentive systems. Specific programs must be evaluated in the context of the existing social and cultural systems in which policy is formulated.

---

5 For more details on the challenges in constructing social welfare functions, see Stokey and Zeckhauser (1978).
Table 9.2. Benefits and costs of dam construction

<table>
<thead>
<tr>
<th>Type of farmer</th>
<th>Annual irrigation benefit</th>
<th>Failure of dam</th>
<th>Per capita cost of dam construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe farmer</td>
<td>$2,500</td>
<td>0</td>
<td>$2,000</td>
</tr>
<tr>
<td>Farmer at risk</td>
<td>$2,500</td>
<td>$60,000</td>
<td>$2,000</td>
</tr>
</tbody>
</table>

Constructing a dam. The following example illustrates the impact of different philosophical systems on the choice process.

Consider the decision on whether to construct an earthen dam in a particular farming community in order to provide irrigation water. Table 9.2 depicts the relevant information regarding the proposed project. All farmers in the community are assumed to be risk neutral and identical (in terms of income, wealth, and amount of land), except for their location relative to the dam. If the dam fails, the safe farmers will face no property damage, but farmers at risk will sustain losses of $60,000 each. Hydrologic engineers have estimated that the annual probability of such a disaster occurring is .01, so that the expected annual loss to each farmer at risk is $600. The expected yearly benefit to each farmer from irrigation water provided from the dam is $2,500, whereas the per capita annual cost for constructing the dam if each farmer in the community paid an equal share is $2,000. Should the community invest funds obtained from taxes to build the dam?

The proposed project is an example of a public good. Each safe farmer would invest his own resources in the project only if he knew that other farmers would also contribute their share. Some type of coordination to raise funds will be necessary if the project is to have a chance of being approved. Suppose each farmer uses the following decision rule regarding the investment of funds in community projects:

- Approve if the expected personal benefits exceed the expected costs.
- Disapprove otherwise.

With this rule, the safe farmers would favor the project (net annual benefit of $500), whereas those at risk oppose it (net annual cost of $100). It is thus not clear what should be done if each farmer paid an equal share. Each safe farmer would obtain a net benefit of $500, whereas each farmer at risk would suffer a net expected loss of $100 (i.e., $2,500 − .01($60,000) − $2,000). Different ethical systems would suggest different types of actions for the community based on the proposed plan. Let us examine four different systems that have been proposed in the literature (see Schultzze and Kneese, 1981, for more details).

A utilitarian system, based on the concepts of Jeremy Bentham and John Stuart Mill, implies that the criterion for action should depend on maximizing the utility of the community as a whole (J. Baron, 1988). Since all farmers are assumed to be risk neutral, the criterion of maximizing expected utility is equivalent to maximizing expected net benefits of the community.\(^6\) The final decision then depends on the proportion of safe farmers in relation to those at risk. Since the expected benefit to the safe farmers is five times the expected costs to the risky ones, the community should build the dam if more than 20% of the farmers are in the safe category.

If there were some type of voting rule to determine whether to invest these funds, then an additional criterion would have to be satisfied. For example, if a referendum were held in the community, requiring approval by a majority of the citizens before funds could be invested, then at least 50% of the farmers voting would have to be "safe" ones.

An egalitarian system evaluates actions by maximizing the utility of the most deprived individuals. According to this philosophical position, which has been associated with John Rawls (1971), individuals should behave as if they were unaware of what their status would be in society. Under this “veil of ignorance,” people may elect to use the following criterion: Choose the policy that achieves the highest expected welfare for the worst-off member of society. However, only extremely risk-averse people would a priori adopt this criterion under a veil of ignorance. Under the assumption that all the farmers are risk neutral, the dam should not be constructed, since those most at risk will be worse off if the project is approved than if it is not.\(^7\)

One way for the dam to be built using Rawls’s criterion would be for the safe farmers to contribute a larger per capita share through taxes than those farmers at risk. If there were an equal number in each group, then contributions of $2,300 by each safe farmer and $1,700 by each farmer at risk would produce the same net expected benefits (+$200) for each farmer and yield enough funds for constructing the dam.

An elitist system is exactly the opposite of an egalitarian system. Actions that further enhance the position of those who are best off are taken. Inequalities in wealth and income would thus be exacerbated by using this criterion as a guideline. In the previous example, where all farmers

\(^6\) Alternatively, one could translate the data in Table 9.2 into utilities by constructing the safe and risky farmer’s utility functions using methods described in Chapter 4.

\(^7\) If farmers were risk averse, then there would be even more reason not to build the dam using Rawls’s criterion, since the disutility of the $60,000 loss if the dam failed would be that much worse relative to the $2,500 irrigation benefit and $2,000 per-capita cost of the dam.
are equal prior to any decisions on the dam, approval would be given since the safe farmers would be much better off than those at risk. Any actions that would benefit this group, whether or not they harmed those at risk, would be approved. Although this system may not have much appeal to readers, it is in fact the one that has dominated for much of human history. It is captured in the oft-heard comment, “the rich get richer and the poor get poorer.”

A libertarian system is the basis for a free-market system; it also uses the Pareto criterion as a guide to judging future actions. If the status quo is the baseline from which to judge future actions, then any project that harms a single individual would not be approved unless that person were sufficiently compensated so he or she had at least the same expected utility after a project than before.

In the case of the proposed dam, the project would be rejected unless some ways were found to provide funds for the farmers at risk so they would not sustain a net loss. This could take the form of a lower per-capita cost for the farmers at risk than for the safe farmers to finance the construction of the dam. Or some type of disaster relief fund could be disproportionately financed by the safe farmers to cover the rebuilding of damaged property if the dam failed.

It is interesting to note that by maintaining the status quo the safe farmers are worse off than had the project been approved. But this is irrelevant if the farmers at risk are worse off by building the dam. This is one reason why safe farmers may want to cross-subsidize those at risk. In any event, some farmers are damned if you construct the dam and others are damned if you don’t.

9.4.3 Ex ante and ex post considerations

In designing programs that take into account efficiency and equity considerations, it is important to examine the interested parties’ reactions to a specific risk before (ex ante) and after (ex post) accidents or disasters occur.

Consider automobile manufacturers’ decisions about voluntarily installing passive restraints (i.e., automatic seat belts) in any of their new cars. Manufacturers will be strongly influenced by a consumer’s willingness to pay for this additional feature when buying a new car. Consumers must make their own decisions on whether to demand this additional feature prior to driving the car extensively. For illustrative purposes, suppose statistical analyses reveal that the expected medical expenses following an accident are as follows:

- With seat belt on ($X_1$): $20,000.
- Without seat belt on ($X_2$): $70,000.

Suppose that a prototype driver, Bill, is risk neutral and does not voluntarily wear manual seat belts. He is willing to buy a car with a passive restraint if he perceives the expected benefits next year in reduced medical expenses to be greater than the cost of the automatic restraint. Automobile manufacturers currently estimate the extra cost of this feature on a car to be $100. Suppose Bill correctly estimates the probability ($p$) of receiving the expected savings of $50,000 from having a car with a passive restraint.

Using benefit–cost analysis, then he would be willing to pay at least $100 for the automatic seat belt if he perceived his annual probability ($p$) of a severe car accident to be greater than .002 if he planned on owning the car for only one year. As Bill increases the number of years he expects to keep the car, his subjective probability of a severe accident could fall considerably below .002, and still justify his purchasing a car with a passive restraint.

Suppose Bill followed a threshold model and did not consider the consequences of an accident if his estimate of $p$ were below $p^*$. If he perceived $p < p^*$ (the threshold level), he would have no interest in safety measures designed to reduce a loss. If society bears some of the cost of unprotected accident victims, then it would be appropriate to consider regulations requiring passive restraints in automobiles.

How concerned should we be with consumers’ ex ante decision rules when they may misperceive the information (e.g., underestimate probabilities of losses, or use decision rules such as threshold models that ignore possible outcomes)? There is no straightforward answer to this question. At one extreme is a position based on a libertarian philosophy: Let people make their own free choices so long as they do not harm others in the process.

If a person driving alone doesn’t want to buckle up or prefers not to buy a car with an automatic seat belt, that is her choice so long as she pays for the consequences. In reality, if an individual has a severe accident, society will bear part of the medical expenses. Everyone will be affected by the loss in productivity due to absence from work, and the immediate family will bear emotional as well as out-of-pocket costs from this injury. The scenario suggests that there are ex post costs, the distribution of which must be recognized in designing ex ante policies. In this case, one has to understand more fully the way individuals process information and the type of decision rules they use.

Requiring passive restraints also has negative features. Consumers may find the restraints chafing and cumbersome, so that they detract from their driving pleasure.\footnote{Motorcycle riders who are opposed to wearing helmets often make the argument that wearing this protective device is too confining.} Regulations do have limitations when there are con-
sumers of different types. Suppose consumers fall in the class of high- and low-risk drivers and are aware of their own skills. Low-risk drivers may be unwilling to buy a car with an automatic restraint and might feel it is an imposition, or change their driving behavior toward more risk-taking (Peltzman, 1975). Cars may also differ in their safety features. Even if all drivers purchased the same car and were all of the same skill, some might be risk takers and others risk avoiders. Risk takers who have correct information on probabilities of an accident may still prefer to take their chances by not investing in safety devices even if they know that they would have to bear the full medical expenses from a crash. A passive restraint requirement would be opposed by this group. Similarly, there are those motorists who always wear a seat belt and would view the installation of passive restraints as an unnecessary expense.

Clearly, there are no easy answers to questions that arise because of ex ante and ex post differences between individuals. Not only will ethical and philosophical issues play a role here (e.g., libertarian vs. egalitarian positions), but so will the degree of misinformation among consumers, businesses, and policy makers. In addition, there are costs associated with implementing alternative policies that also need to be incorporated into the evaluation process.

9.5 A framework for developing public policy programs

A principal purpose of this book is to propose prescriptive strategies for improving the decision processes of individuals, organizations, and groups. We view the free-market system as a reference point for guiding the development of these programs. From a decision process perspective, we have already noted that there are systematic biases in the way individuals estimate probability and outcomes. Furthermore, the choice process by individuals when facing uncertain outcomes may not be accurately represented by assuming expected utility maximization.

In developing prescriptive recommendations for problems that involve both private and social risks, we generally favor policies that offer individuals as much choice as possible. Figure 9.1 depicts the framework that guides the development of alternative programs. The current institutional arrangements (the status quo) affect the benefits and costs of different strategies, which range from a free-market approach at one extreme to regulation at the other.

In the presentation that follows we order the different strategies by constraining individual choice as little as possible at the outset and then examining more restrictive options where these seem to be indicated. Hence, the first line of attack is simply to provide information to the relevant decision makers. Thereafter, we examine economic incentives for modifying behavior, and lastly we consider the role of regulations and standards for meeting efficiency and distributional objectives. Certain regulatory programs may be more cost-effective than attempts to provide information and have the public freely make its decisions. Policy makers should examine all four programs before determining which course of action to adopt.

9.6 Provision of information

The principal purpose of this approach is to correct systematic biases in estimating probabilities and outcomes, while at the same time recognizing the types of decision rules that individuals use in processing such data. Misperceptions of probabilities may be due to an availability bias or a failure to appreciate that the magnitude of the probability estimate is a function of the relevant time domain. Preferences between two alternatives may be greatly influenced by how the outcome from each of these decisions is presented or framed. Finally, other features of behavior, such as reluctance to make trade-offs, need to be recognized in designing programs for better handling uncertainty.

The material in this and the next two sections draws on Camerer and Kunreuther (1989).
9.6.1 Correcting availability biases

Better reporting of data by the media may be one way to correct discrepancies between actual frequency data and overestimation of probabilities due to an availability bias. A study of causes of death found that most people perceive the likelihood of deaths from highly reported disasters such as fires and homicide to be much higher than those from events such as diabetes and breast cancer that are rarely reported in the media (Combs and Slovic, 1974). The statistical fact, however, is that the latter two diseases together actually take twice as many lives as the two more dramatic events.  

A bias in favor of available data implies a bias against data that are hard to imagine (Slovic, Fischhoff, and Lichtenstein, 1978). In a study of fault tree judgments, for example, auto mechanics were given a variety of fault trees showing causes of a car failing to start, including a "miscellaneous" category. Mechanics attached too small a probability to the miscellaneous branch, even when an important cause of failure (e.g., the "electrical system") was omitted. However, they were more accurate than students who undertook the same task but strongly suffered from the "out-of-sight--out-of-mind" bias. This finding suggests that expertise partially counteracts the availability bias. By explicitly providing data through fault trees and asking individuals to record these outcomes for future reference, one may improve an individual's ability to calibrate the probability estimation process (see Fischhoff, 1982; Dube-Rioux and Russo, 1988).

Recognizing the presence of availability biases suggests that making risks more salient should encourage people to adopt protective measures. A study by Viscusi and Magat (1987) showed that mentioning the potential hazards associated with specific products (e.g., cleaning agents) led people to take more precautionary actions (e.g., wearing rubber gloves, storing the product in a childproof location). The product labels themselves indicated the types of actions that could be taken ("Keep out of reach of children"), which surely helped the process. Some individuals overreacted to the hazard by taking more precautionary actions than deemed desirable using benefit-cost criteria while others underreacted. Another example is Jay Russo's (1977) study on unit pricing, which shows how changing the information display about prices improved shopping in supermarkets for consumers, in part by facilitating comparisons across package sizes and brands. (For an overview of similar field studies about product information provision, see Russo and LeClerq, 1991.)

9.6.2 Changing the probability reference point

Empirical evidence suggests that individuals or firms do not pay attention to particular events because they perceive their probability of occurrence to be below a given threshold. This behavior can prove costly to both the individuals at risk as well as the rest of society should a disaster or accident occur. To encourage the adoption of protective activities, information on the probabilities of the event could be presented in a form that would lead people to pay attention.

Some individuals may not associate a time dimension with probability and hence may specify a threshold value $p^*$ that is invariant to time. For example, suppose a homeowner on the 100-year flood plain accurately estimates the annual probability of a flood to be .01, but has a $p^* > .01$. There would be no interest on his part in purchasing flood insurance. If probabilities were aggregated over time to make them seem larger, this person might protect himself more often. For example, if this homeowner were told that the chances of experiencing at least one damaging flood in the 100-year flood plain within the next 25 years were .22, then he might pay attention to the event and buy flood insurance.

This approach has been used to increase seat belt use. The chance of a fatality on an average car trip is extremely low (about $0.0000025$), well below the threshold many people set before paying attention to a risk. But over a lifetime of driving, the probability of a fatality is .01 (Schwalm and Slovic, 1982). In one study, 39% of respondents who were given lifetime probability figures said they would use seat belts, compared to 10% of those who were provided with the single-trip probability.  

Other forms of presenting probability data may also encourage protective behavior. Viscusi and Magat (1987) described the risk from a bleach as 50 gas poisonings for every 2 million homes, rather than as the equivalent probability $p = .000025$ (which equals 50/2,000,000). They then indicated that a new bleach would yield a 50% decrease in gas poisonings, rather than stating that the new probability would be $p = .0000125$. Consumers were willing to pay more for the new bleach when the benefits were stated as "percentage reduction in poisonings" rather than as a "reduction of the probability of poisoning."

There are many ways to express risk, like annual fatality rates per 100,000 persons at risk (Crouch and Wilson, 1982) or the amount of an activity

---

10 Interestingly, the subjects underestimated the number of deaths on all four of these events. This is consistent with the availability bias, since these particular causes of death involve a single person or a small group, and hence are not usually newsworthy events.

11 A fault tree shows possible causes and subcauses (in the form of branches) of events...
that increases a person's chance of death by 1 in 1 million per year (Richard Wilson, 1979). The impact of providing data in these various forms has not been sufficiently examined. Furthermore, some argue (Slovic, 1986) that the standard errors and assumptions associated with these risk estimates, which are often quite large, should be explained, and that confidence intervals be presented. Otherwise, people may distrust the entire analysis.  

9.6.3 Targeting information to specific groups

One way to deal with problems of misperception is to provide individuals with more accurate data on which to base their decisions. Suppose the National Highway Traffic Safety Administration (NHTSA) is considering a campaign to tell individuals the statistical probability of an accident \( p \), so that decisions to buy a new car with automatic seat belts will be made with these data in mind.

If the NHTSA knew precisely those individuals who would take action on the basis of the new information, then they could perhaps single the group out for some type of special mailing. Not only is it difficult to obtain such figures on consumer willingness to process data, but most information campaigns are viewed as a public good where a message is beamed out indiscriminately to a large population through the mass media.

Assume that NHTSA is considering a television information campaign that will cost \( D \) dollars. It is only willing to undertake these expenditures if the costs exceed the expected benefits, which in this case are the reduction in injuries and fatalities due to wearing a seat belt. In order to estimate benefits, some kind of monetary value has to be placed on a human life and the savings in medical expenditures. In the case of fatalities, the dollar value would reflect future losses in productivity as measured by projected future earnings. With respect to injuries that could have been avoided by wearing a seat belt, one would again have to use a lost productivity measure. Jones-Lee (1989) and Viscusi (1992) examine how one could assign such values.

Consider the total population \( (N) \) of identical individuals who currently do not wear seat belts and hence might be candidates for purchasing an automobile with passive restraints. An analysis by the NHTSA reveals that if each person made his purchase decision on the basis of \( p \), then he would be willing to pay for this additional safety feature. Suppose a certain proportion of the population \( (a) \) actually revises its probability of an accident on the basis of the statistical evidence presented. The remaining fraction of the population, \( 1 - a \), does not receive the information from the campaign and/or does not take the time to register the information on accident probabilities. They will continue to buy an automobile without a passive restraint. For NHTSA to undertake this campaign, there must be a sufficient proportion of the affected population willing to change its behavior so that the expected gain to society in the form of reduced costs of accidents must exceed the cost of providing these data.

This example illustrates the types of comparisons that NHTSA would have to make to determine whether to undertake such a campaign. Suppose the increase in medical expenses per serious accident were \$50,000 if the motorist did not wear a seat belt and that \$10,000 of this extra cost were covered by the government through funds from general tax revenues. If \( p = .002 \), then the expected annual savings from taxpayer dollars for every person who buckled up would be \$20 (i.e., \(.002 \times \$10,000\)).

Suppose 25 million people in the United States currently do not wear seat belts. If \( D = \$5 \) million, then 250,000 of these people would have to purchase cars with passive restraints to justify the costs of the campaign using a one-year payback period. Thus, in this example, \( a > .01 \) would justify the television campaign. If one computed the discounted expected benefits over a longer time horizon, then the campaign would be even more attractive and lower values of \( a \) could justify it.

9.6.4 Willingness to accept and willingness to pay

Prospect theory assumes that the magnitude of pain of losses from a reference point is larger than the amount of pleasure experienced from equivalent gains; this property is called "loss aversion" (Tversky and Kahneman, 1991). This asymmetry creates an "inertia effect": People demand a much larger price to sell a good than they would pay to buy it (Knetsch and Sinden, 1984). For instance, Thaler (1983) found that people would only pay \$800 for an inoculation to reduce a hypothetical risk of death from 0.001 to 0 ("willingness to pay"), but they would have to be paid \$100,000 to be exposed to a disease resulting in a 0.001 chance of death ("willingness to accept"). Economic theory predicts willingness to pay and accept should be about the same, except for a small income effect.

Viscusi and Magat (1987) found that if the risk of a product was increased by 5 injuries per 10,000, most consumers claimed they would not buy the product at any price. The actual magnitude of the risk was irrelevant to their decision. To illustrate, consider the case where there is a 10 in 10,000 chance of an injury from the use of a toilet bowl cleaner.

---

13 The emerging literature on risk communication explores ways of presenting information on probabilities and outcomes of hazards. For a selected bibliography see Covern, Sandman, and Slovic (1989).
Most people would not buy the product at any price when the risk is increased to 15 in 10,000. However, when asked the maximum that they would pay to reduce the risk from 15 in 10,000 to 10 in 10,000, the average price increased by .65. Related experimental results on this type of commission bias and reference point effect have been reported by Rttov, Hodes, and Baron (1989).

Dramatic differences have also been observed in the willingness to accept (WTA) a hazardous facility nearby and the willingness to pay (WTP) to locate the same facility elsewhere. In phone surveys related to the siting of a high-level nuclear waste repository, over 70% of respondents would not accept a facility in a geologically safe location within 100 miles of their homes, even if they were paid up to $5,000 per year for the next 20 years. Yet, only 40% of the respondents said they would pay an extra $100 in annual taxes over 20 years to move a repository scheduled to be built nearby to a more distant location (Easterling and Kunreuther, 1993). Issues of fairness and nontradability of conditions involving risk to life undoubtedly influence these decisions.

Asymmetries between WTA and WTP imply that measures of "contingent valuation" (the value people place on activities with voluntary contingent risk), which are widely used in public policy analysis, reflect other factors besides probabilities and outcomes. Concerns with justification, accountability, and responsibility are important elements of individuals' decision processes (as discussed in Chapter 5). The fact that they are difficult to quantify does not diminish their importance. To date, these concerns have not been an explicit part of analytic models of choice under uncertainty, which may partially explain why psychologists have indicated that people's preferences are labile and unreliable (Fischhoff and Furby, 1988).

A comprehensive assessment of the use of the contingent valuation method (CVM) for assessing preferences for societal problems can be found in Cummings, Brookshire, and Schulze (1986) and R. Mitchell and Carson (1988). By bringing together economists and psychologists to critique this research, their study offered a set of recommendations for improving the CVM approach, while recognizing its limitations for policy purposes. More recently, a series of studies by economists and psychologists has evaluated and critiqued this approach. The recent debate between Kahneman and Knetsch (1992a,b) and V. Kerry Smith (1992) reflects the current tensions with respect to the use of this technique for policy purposes.

9.6.5 Reluctance to make trade-offs

Mental accounting, as discussed in Chapter 4, often simplifies decisions by segregating dollars and nonmonetary outcomes into separate categories. This makes trade-offs across different kinds of mental accounts — like dollars for lives — especially difficult. Communities will spend enormous time and energy to save "identifiable lives." For example, recall the great amount of time and energy residents of a small Texas community voluntarily spent in rescuing eight-month-old Jessica McClure, who fell into a well, and the national publicity that this one incident generated. In contrast, society has elected not to spend large sums of money on risk-reducing activities such as improving highway safety funds, which would, of course, be expected to save many more "statistical lives." Spending freely to save an identifiable life is a public affirmation of how much we love life, a gesture that celebrates the idea that life is sacred at any cost.

Reluctance to make the trade-offs between dollars and lives leads to misguided arguments, common in public debate, that "zero risk" is the only tolerable level of risk. The desire for zero risk may have an important impact on behavior. Consider an insect spray that costs $10 per bottle and results in 15 inhalation poisonings and 15 skin poisonings for every 10,000 bottles sold. Viscusi and Magat (1987) found that, on average, survey respondents with young children were willing to pay about $2.38 more for a spray that reduced both these risks to 5 per 10,000 bottles sold, and $8.09 more for a spray with no risk at all. This finding supports the hypothesis that people are willing to pay an extra premium for zero risk. When people are asked how much they would pay to reduce the number of bullets in a game of Russian roulette, most people are willing to pay considerably more to eliminate the last bullet than to reduce the number from, say, 9 to 4 (Zeckhauser, 1973).

Budgetary constraints are sometimes a useful device for forcing regulatory agencies and individuals to prioritize their expenditures, but trade-offs between benefits and costs are generally not made explicitly. Responses from a telephone survey of households conducted by Kahneman and Knetsch (Cummings et al., 1986, pp. 191–192) on willingness to pay for hypothetical environmental changes illustrate this point. They found that Toronto residents were willing to pay approximately the same amount to clean up one lake as they would pay to clean up all the lakes in Canada. People appear to have mental budgets as to how much they would allocate for reducing an environmental risk. Spending the budget is a symbolic act that expresses their values in a qualitative way without having to pay explicitly to clean up the lakes.

\[\text{Schelling (1968) wrote: "Let a six year old girl with brown hair need thousands of dollars for an operation that will prolong her life until Christmas, and the post office will be swamped with nickels and dimes to save her. But let it be reported that without a sales tax hospital facilities in Massachusetts will deteriorate and cause a barely perceptible increase in preventible death — not many will drop a tear or reach for their checkbook."} \]
9.7 Economic incentives

Economic incentives may induce individuals and businesses to undertake actions they would otherwise find unattractive. An incentive can either be positive, such as a rebate or subsidy, or negative, such as a penalty or fine for not taking action.

Incentives may be useful in convincing consumers to invest in seatbelts, reinforce homes to reduce potential damages from earthquakes, or purchase insurance against floods. The costs of these measures are often viewed as particularly burdensome because they are incurred up front, while the benefits are contingent on experiencing a loss. Those who invested in earthquake mitigation measures (e.g., safer construction) never see any return from this cost until an earthquake occurs and even then may not be aware as to how much more damage would have occurred if they had not adopted this measure. With respect to insurance, the premium paid for homeowners coverage only yields a return if there is damage to property or contents.

9.7.1 Insurance incentives to consumers

One seemingly attractive incentive for adopting loss-reduction measures is to reduce insurance premiums on coverage against a particular event. Consider the cost associated with a protective measure such as the purchase of a passive restraint or the premium paid for an insurance policy. Let \( p \) = annual probability that a loss will be experienced and \( b \) = the annual benefits of the measure. As shown in Chapter 4, mental accounting by individuals based on the concepts of prospect theory suggests that the way incentives are presented to individuals may influence their behavior.

To illustrate, consider the passive restraint example and assume that the insurance industry would save \( b = \$12,500 \) in medical expenses if there were a serious accident with probability \( p = .002 \). Then the actuarially fair annual premium reduction is \$25, somewhat less than the cost of a passive restraint. For most protective activities the benefit–cost ratio will be unattractive if a one-year horizon is used; over the life of the product the discounted benefits of premium reductions are likely to exceed this cost. In a 1987 mail survey of 331 motorists, half residing in Pennsylvania and the other half in New York, 70% indicated they would not purchase a passive restraint for \$100, even if their annual insurance premiums were reduced by \$25 (Kunreuther and Easterling, 1988). If they planned to keep the car for more than five years, then the discounted benefits of their ownership of the vehicle would have exceeded the cost of the passive restraint, assuming a discount rate of no more than 8%.

At a more general level, one can determine the required ratio of expected annual benefits to upfront costs of protective measures as a function of the individual’s discount rate and the amortization period for the particular loss-protective measure. Figure 9.2 depicts this ratio for two different discount rates (10% and 5%) for amortization periods ranging from 1 year to 10 years under the assumption that the cost is incurred at the beginning of the year and benefits are received at the end of each year. Even with a horizon as short as 3 years and a discount rate of 10%, the expected benefit only has to be 40% of the cost of the protective measure to be considered attractive by the consumer.

People may be reluctant to invest in passive restraints or other loss reduction measures because current expenses and future benefits are recorded in different mental accounts. Suppose the normal annual insurance premium was \$500. Using the value function of prospect theory, Figure 9.3 shows that the annual savings of \$25 from investing in a passive restraint will be extremely small (in value terms) compared with the immediate expense of \$100. Mental accounting suggests that people may prefer to separate a small loss into a larger loss and a small gain, because the marginal disutility of the additional loss is less than the marginal utility of the gain (Thaler [1985] calls this the “silver lining” effect).

In the passive restraint example, the insurance industry could offer policyholders a \$25 refund at the end of each year for investing in a passive restraint. By reframing the problem in this way, motorists would view the loss reduction measure as an investment in a mental savings account that yields a dividend of \$25 each year. As shown in Figure 9.3, the value of such a gain, or \( v(\$25) \), is considerably higher than the value of a reduction in premiums, \( v(-\$475) - v(-\$500) \).

In the same spirit, insurance companies might induce more risk-averse actions on the part of their clients by charging larger premiums up front, but then providing a rebate if a person does not suffer a loss. In controlled laboratory experiments, people prefer more expensive insurance with a possible refund over equivalent standard insurance (Slovic, Fischhoff, Lichtenstein, Corrigan, and Combs, 1977).

Companies have experimented with programs that reframe the problem so that individuals receive specific rewards for taking care. Mutual of Omaha has sold disability coverage that refunds all premiums at age 65 if no claims are made. The company earns interest on the money and creates a reverse moral hazard: People may not make small claims when they are near 65 because they would have to forgo the refund. A related incentive system was offered by the Mendocino County Office of Education in California, which gave a \$500 deductible health insurance policy to employees. They set aside \$500 to cover each employee’s deductible; employees get to keep whatever remains of the \$500 at the end of the year. Medical care expenses were substantially reduced during the first

---

15 The discounted benefits are derived by computing \( \sum b/(1 + i)^t \) where \( i \) is annual discount rate and \( t \) is the length of time that the individual plans on owning the product.
Figure 9.2. (Expected annual benefit/cost ratio required to invest in protective measures)

Figure 9.3. Value function for analyzing passive restraint problem

four years of the program. Besides reframing costs and benefits, such a refund reduces moral hazard by inducing employees to take better care of themselves.

Experimental evidence supports the hypothesis that rebates are attractive to individuals. E. Johnson, Hershey, Meszaros, and Kunreuther (1993) offered 100 people, mostly University of Pennsylvania hospital employees, two disability insurance policies that pay two-thirds of the employee's salary as long as he or she is unable to work. Policy 1 cost $70 and has no refund. Policy 2 costs $90 per month and offers a refund of $12,000 if the employee does not file a claim within five years. The refund is equivalent to the sum of the additional premiums.

Policy 1 should be preferred both because of the time value of money and because the rebate would not be paid if a claim were made. The rebate policy was preferred by 57% of the respondents and the average premium that people were willing to pay for it was $12.65 higher than
Policy. On the average, respondents felt there was a 3.6% chance of 
not collecting on the policy, which makes the finding that rebates make 
a difference even more convincing.

Another potentially effective insurance incentive is withholding pay-
ments to victims for failure to take protective action. About 60% of sur-
vey respondents who do not wear seat belts said they would buckle up 
if their claims payments depended on it (Kunreuther and Easterling, 1988).
Withholding medical coverage appears to be a more effective policy tool 
than paying extra compensation. Since 1983, Nationwide Insurance Com-
pany has paid twice as much compensation to policyholders injured in 
crashes while wearing seat belts, and $10,000 to the family of policy-
holders killed while wearing seat belts. A random sample of motorists 
in Connecticut indicates that these policies have not increased seat belt 
use. Even though Nationwide widely advertised, the study revealed that 
9% of their policyholders wore seat belts, compared to 14% of those 
purchasing insurance from other companies (Robertson, 1984).

9.7.2 Incentives for insurers to offer protection

We have already pointed out in Chapter 4 that ambiguity regarding the 
probability associated with an event may play an important role in the 
decision processes of insurance managers. Few insurers offer coverage 
against political risk to industrial firms investing in developing coun-
tries with potentially unstable political systems. The principal argument voiced 
by insurers has been the difficulty in estimating the probabilities 
associated with losses of different magnitudes (Kunreuther and Kleindorfer, 

Similar behavior has been observed regarding earthquake coverage where 
premiums are much higher than past loss experience would justify. Over 
the first 60 years (1916–1976) that this coverage was offered in Califor-
nia, $269 million in total premiums were collected but only $9 million in 
losses were experienced (Petak and Atkinson, 1982). Of course, part 
of the rationale for this high premium–loss ratio is the possibility of highly 
correlated losses should a big earthquake occur. However, a significant 
reason is also the uncertainty of the probability of the next severe quake.

Many of the societal problems associated with health and safety risks 
involve considerable ambiguity on both the probability dimension and the 
loss side so that the private insurance market has played a limited role in 
providing coverage. Consider the problem of environmental pollution 
damage. There is considerable ambiguity about the relationship between 
the exposure to a particular chemical and the possibility of contracting 
cancer (Anderson, Chrostowski, and Vreeland, 1990). Many years may 
elapse between the discovery of a leak from a hazardous waste storage 
facility and actual human exposure to a particular chemical, followed by 
a long latency period until the manifestation of the disease. In many cases 
it is difficult to attribute the cause of any cancer to the leak, since there 
are multiple pathways to this disease.

New toxic torts, new environmental legislation, and court decisions 
have increased the uncertainty associated with the magnitude of the losses 
should a suit be filed (Cheek, 1990). It is thus not surprising that insurers 
have all but discontinued offering environmental pollution coverage. Sce-
arios presented to actuaries and underwriters as part of a survey reveal 
that the premiums that they would charge to protect against the leak of 
an underground storage tank increases dramatically if the probability of a 
loss is ambiguous and/or the loss is uncertain in contrast to the risk 
being well specified (Kunreuther, Hogarth, and Meszaros, 1993).

An economic incentive system would be desirable that induces insurers 
to reduce their potential losses while at the same time making the situation 
attractive enough for them to provide coverage at affordable rates. To 
do this, a three-tiered system has been proposed that involves a well-
specified risk-sharing arrangement among the insured party, the insurer, 

Figure 9.4 indicates that the first layer of protection is self-insurance by 
industry itself. This is equivalent to a deductible on an insurance policy 
and is an incentive for industrial firms to use safer production techni-
cues to reduce the loss. The second tier of coverage would be offered by 
private insurers, but there would be an upper limit on their potential losses 
so they could determine what premiums to charge. The third tier of the 
proposed program would require the government to provide coverage above 
the limit specified in Layer 2. A government agency would have to levy 
a fee on industrial firms to cover the potentially large losses they face.
The limits on each of the layers depend on the type of coverage, total 
premiums written, and the number of insurers involved.

There is a close relationship between this three-tiered system and nu-
clear liability insurance protection in the United States. In 1957 two in-
surance pools were formed that made $60 million of liability coverage 
available to protect nuclear power plant operators. In the same year, the 
Price-Anderson Act was passed in which the federal government provided 
up to $500 million of indemnity in excess of the $60 million purchased 
by the pools. Congress would determine the need to provide funds for 
losses beyond the $560 million total.

Congress amended the Price-Anderson Act in 1975 by having the in-
surance pool bill each operator of a nuclear power plant up to $5 million 
for a pro rata share of the loss in excess of the pool's insurance. The 
objective was to phase out the government's indemnity by forcing the 
nuclear power industry and the insurance pool to cover the $560 million.
dictability on the nature of liability settlements improves, the government's role might be mitigated or reduced.

9.7.3 Compensation or benefit-sharing for social risks

At a societal level, economic incentives such as compensation have been advocated for sharing the benefits of proposed new projects with those who may be adversely affected by them (Raiffa, 1982). The obvious examples of facilities that have been searching for homes are solid waste facilities for trash disposal, low-level radioactive waste facilities for disposal of industrial, military, and medical residuals, and prisons for relieving the overcrowded jails in most states. In theory, compensation can induce people to accept facilities that benefit others more than themselves. For example, communities could be given funds for their internal needs (e.g., new hospitals, improved education system) in return for agreeing to host a prison or incinerators.

In practice, compensation has rarely been used in siting hazardous facilities because communities will only agree to host facilities if they do not create excessive health, safety, or environmental risks (Kasperson, 1986b). A number of acronyms have emerged to describe the public's and the politician's attitudes toward these facilities, such as the familiar NIMBY (not in my backyard) and the politically realistic expression NIMTOF (not in my term of office).

There are a few cases where compensation has been used successfully, but they are the exceptions rather than the rule. The town council of North Andover, Massachusetts, approved the siting of a regional resource recovery plant in exchange for a $1 per ton royalty for all waste deposited there (O'Hare, Bacow, and Sanderson, 1983). A coal-fired plant in Wyoming was approved because the utility company established a $7.5 million trust fund to preserve a stretch of the Platte River that was a migratory bird habitat (Lave and Romer, 1983). The Kodak Company agreed to compensate people in Rochester, New York, for decreases in property values that resulted from siting an industrial facility nearby ("Kodak," 1988).

A compensation agreement was negotiated by the city of Revelstoke and the British Columbia Hydro and Power Authority for building a hydroelectric dam next to the city. B.C. Hydro agreed to pay for damages caused by the dam, and gave funds to improve the city's water and sewage systems and build a recreation facility (Skaburska, 1988).

Compensation is often rejected if it is perceived as a bribe for bearing social risk. Hence, it is essential for the community to feel that the perceived risks from the facility are acceptably low and that well-enforced monitoring and control procedures will detect any changes in this risk.
over time. Furthermore, the community or region hosting the facility wants to have the power to shut down the facility until the problems causing the increased risks to health and safety are remedied (Carnes et al., 1983).

If we assume there is a well-established need for a new facility and that the perceived risks are considered acceptable by the affected parties, a competitive bidding procedure between candidate sites, such as the one discussed in Chapter 7, might prove useful (Kunreuther, et al., 1987). Each community could demand funding for its own internal use in exchange for hosting the facility. The community or region selected to host the facility would receive funds from those who benefit from the facility. These include the developer, firms and organizations who will use the facility, and other communities or regions who are candidates for the host site and plan on using the facility.

A bidding procedure is most likely to be seriously considered if the default option (e.g., doing nothing) is perceived as more costly to all communities than locating the facility somewhere. In other words, the construction of a facility must satisfy the Pareto criterion that at least some are made better off than they are with preservation of the status quo, and none worse off. Compensation or benefit sharing may be an important feature of the siting process for just this reason. In addition, one needs to consider distributional issues so that all parties consider both the process and the outcome to be fair and equitable.

One procedure that addresses both equity and efficiency concerns is a lottery-auction mechanism (Kunreuther and P ortny, 1991). Each of the potential host communities specifies the compensation (or benefit-sharing arrangement) that it would require to host the facility. Call the maximum amount of compensation demanded \( c^* \). A lottery is then used to determine a candidate site. At the end of this stage, the winner of the lottery is the default host community and \( c^* \) dollars are earmarked for its use if the facility is hosted there.

Following the lottery, an auction is held in which all of the candidate sites, including the lottery winner, can reduce their bid below \( c^* \) but at a level that leaves them at least as well off as not having the facility. The lowest bidder hosts the facility and gets the amount of compensation it bid. The other communities, the developer, and the beneficiaries of the facility pay compensation to the host community and/or the siting authority according to some prespecified rule. If no community bids less than \( c^* \), the lottery winner would be the actual site and would receive \( c^* \).

This procedure acknowledges some of the psychological principles of behavior described in previous chapters. By conducting an auction after a lottery, communities may perceive themselves as losing funds by not bidding for the facility. The initial lottery changes the reference point, so compensation may be viewed as a benefit rather than a bribe. The random lottery is equitable because it is equally likely for a high-income area and a low-income area to be chosen. Poor communities are not forced to accept the facility at a low price.17

There are challenges in implementing such a procedure. How will the beneficiaries of the facility be taxed to pay the compensation to the host community? How does one take into account differential risks between communities? Institutional procedures to address these issues can be developed, but there must be general agreement that the default option (e.g., the status quo) is unacceptable. Most important, studies show that communities will not consider compensation unless they are confident that a facility is safe and that appropriate control procedures will be used.

9.8 Regulations and standards

Regulations and standards are intended to protect our health, safety, and environment. Our interest here is in the role that mandatory insurance coverage, standards, and fines can play in dealing with the types of biases observed in individual and firm decision processes.

9.8.1 Requiring insurance

For some risks, it may be cheaper and more efficient to mandate insurance than to induce people to take those steps voluntarily. For example, the federal government tried to promote flood insurance by subsidizing it (instead of providing disaster relief after floods). Few people bought policies; the government provided disaster relief anyway (Kunreuther et al., 1978). Of course, a governmental commitment to eliminate disaster relief is not credible (Rodrick and Zeckhauser, 1988), since living up to the commitment creates a short-run inequity that may outweigh long-run efficiencies.

Home buyers in flood-hazard areas must now buy flood insurance to get federally insured mortgages. This regulation is appealing in several ways. It is easy to enforce. It shifts the costs of floods from taxpayers, who pay for disaster relief, to insurance companies who collect premiums to bear such costs. The regulation also creates demand for private insurance. Since the regulation forces many homeowners to be insured, neigh-

---

16 Each community should be willing to participate in the lottery because whichever is chosen will be paid \( c^* \), the maximum amount any community bid.

17 For a more detailed discussion of equity problems associated with siting noxious facilities see Kaspersen (1986a) and MacLean (1986).
boring homeowners cannot be sure of getting generous disaster relief, which induces private lenders also to require insurance on homes for which they issue a mortgage.

It is important that the regulation was imposed only after economic subsidies failed to convince people to buy insurance voluntarily. Homeowners did not seem to make rational choices about insurance. They did not make trade-offs between the expected benefits of insurance and the premiums paid for protection. They rely on personal experience and discussions with friends and neighbors, often canceling their policy several years later because they did not experience any disasters and hence could not collect on their policy (Kunreuther, Sanderson, and Vetschera, 1985).

9.8.2 Role of standards

Judgments of riskiness are based on many dimensions other than statistical lethality. Risks that are perceived as uncontrollable or unknowable are feared even when they are statistically unlikely. A familiar example is air travel, which is uncontrollable by passengers but is much safer on a per mile basis than driving a car. The technologies perceived as most risky by individuals are those that evoke dread, such as nuclear power, and those such as chemical operations where the hazards are judged to be unobservable, unknown, delayed, or new. Experts may view these hazards as less risky than the public because experts focus only on statistical measures of risk, ignoring their emotional aspects. When accidents do happen, the public may interpret accidents as signals that technology is not as safe as experts claim (Slovic, Lichtenstein, and Fischhoff, 1984). These findings underscore a more general problem with low-probability risks – because of the small sample of occurrences, experts and the public may not be able to resolve differences in beliefs.

Policy tools that reduce statistical lethality or provide insurance against risk may not be effective because of these emotional responses. People may not seek out information on specific hazards because they fear what the knowledge will imply. Homeowners may be reluctant to test their homes for radon because they do not want to know that they and their children have long been exposed to the gas. Only after the EPA suggested that people should have their homes checked for radon have people been interested in undertaking tests. Testing for AIDS is similar: Because there is no cure for the disease, knowing that one has it causes misery and does not improve the chances of surviving (though it does help prevent the spread to others).

The presence of these emotional dimensions of risk suggests the need for enforceable standards that convince the public that the risks they face in their daily lives is acceptable. The presence of building codes for structures in hazard-prone areas may be due to the public's concern that they be protected by regulation rather than for them to trust a developer to follow appropriate specifications. A study of the Food and Drug Administration also revealed that regulations were deemed necessary in order to protect the public against its limited ability to determine which drugs are safe (Peltzman, 1974; Grabowski and Vernon, 1983).

When it comes to siting potentially hazardous facilities, communities will categorically oppose the project unless they are convinced that it meets rigorous safety standards and that it will be carefully monitored over time. For example, in the evaluation of a monitored retrievable storage facility in Tennessee, a local task force needed assurance that the facility was safe before even considering its operation and desirability (Peele, 1987).

9.8.3 Use of fines

Fines are a simple way of enforcing laws and regulations that require people to protect themselves against risks. The success of fines depends on the frequency of enforcement and the size of the penalty.

The framing of the regulation is likely to determine how people will react to it (Noll and Krier, 1990). Suppose there is a fine $F_1$ associated with violating regulation $R_1$ and a fine $F_2$ associated with violating regulation $R_2$. A regulatory agency is considering two types of policies regarding the enforcement of $R_1$:

- **Policy 1:** Whenever $R_1$ is violated, levy $F_1$.
- **Policy 2:** Whenever $R_1$ is violated and $R_2$ is also violated, then levy fines $F_1$ and $F_2$; if $R_1$ is violated alone, then no fine is levied.

The value function of prospect theory suggests that Policy 2 is likely to be highly ineffective relative to Policy 1 for two principal reasons. Given the convex shape of the value function in the loss domain, the addition of $F_1$ will have a much smaller impact on the individual or firm's value function than if levied independently [i.e., $V(-F_1) + V(-F_2) < V(-F_1 - F_2)$]. Furthermore, the probability of being fined for violating $R_1$ is much lower under Policy 2 than Policy 1. In fact, under Policy 2, $F_1$ can be avoided entirely by making sure one always meets 2.

Recent seat belt legislation illustrates programs across states resembling these two policies. Of the 42 states that had mandatory seat belt laws at
If the customer has preferred information on the use and is interested in the product with the security feature, then the firm would not sell. If not, the customer would still be willing to pay the extra amount for the feature. The cost of installation is negligible because the customer is well aware of the costs involved. If the price is right, the firm would not have to pass the cost back to the security feature.

Let $d$ be the decision to offer the security feature and $x$ be the cost of installation.

\[
(1) \quad d + x < (0) \quad d
\]

If the feature is not offered, the firm will want to add the security feature. This is responsible for the feature to be included.

(4.6)

Following the same reasoning as above, the firm's decision to offer the security feature depends on the cost of installation.

The firm's decision to offer the security feature depends on the expected cost of installation. If the expected cost is less than the cost of installation, then the feature will not be offered. If the expected cost is more than the cost of installation, then the feature will be offered.

The expected cost of installation is higher than the cost of installation.

In this case, the expected cost of installation is higher than the cost of installation. If the expected cost is higher than the cost of installation, then the feature will be offered. If the expected cost is less than the cost of installation, then the feature will not be offered.
minimizing expected losses, then the firm will want to install the safety device on its products even in the absence of liability if equation (9.4) is satisfied. The customer would know that if there were an accident, she would have to absorb the costs and hence would prefer to reduce the magnitude of the loss. As Shavell (1987) points out, if the firm did not install the safety device, its customers could go elsewhere. They would rather purchase the product from a competitor who charged a higher market price for a product with the safety feature.

One reason for introducing a regulation, and hence a negligence rule, has to do with imperfect information by consumers on the risks associated with specific products. Most consumers are unaware of the design features of many products and hence are incapable of evaluating the potential benefits of different features. If this lack of knowledge translates into an underestimation of \( L(0) - L(1) \), then there will be less incentive for them to want the firm to install the safety feature and charge a higher price for the product.

An additional reason for a regulation is that it may very well lower the per-unit cost of the safety feature from \( x \) to \( x^* \). At a price of \( x^* \), the inequality given by equation (9.4) might be satisfied, whereas it would not at a higher value of \( x \). From a social welfare point of view, it thus makes sense to encourage firms to mass produce safety in order to lower the per-unit cost to a level where it meets benefit-cost criteria.

The case of automobile manufacturers’ installing air bags illustrates both of these latter points. Customers have not demanded this feature in cars, undoubtedly because they underestimate both its potential benefits as well as the chances that they would be in a serious accident. Automobile manufacturers initially installed them selectively on cars at a price of $800. There was thus even less of a reason for car purchasers to take an interest in this feature. The U.S. Department of Transportation passed a regulation requiring all automobiles to have passive restraints either in the form of an automatic seat belt or an air bag by 1992. Once car manufacturers install air bags as part of standard equipment on some cars, the price of this safety feature is likely to drop substantially and demand for air bags will increase. Within a few years, we would expect air bags to be standard equipment on all automobiles.

9.9 Concluding remarks

We conclude this chapter with some observations regarding the linkage between decision processes and policy formulation. As a number of empirical studies have shown, individuals are often imperfectly informed about risk, so that buyers’ and sellers’ behaviors are not consistent with normative theories of choice, such as expected utility theory and Bayesian analysis.

Many of the societal problems involving risk entail additional difficulties for making rational choices: Experts frequently disagree with each other on the nature of the risk, and there are limited statistical data to settle these differences. Causality of uncertain outcomes (e.g., diseases) may be extraordinarily difficult to establish; hence, certain policies may be hard to justify on purely scientific ground.

Yet a set of guidelines for social policy emerges from our understanding of these impediments to the use of a free-market system. The different parties concerned with a particular problem need to appreciate their own limitations in dealing with risk and uncertainty. The consuming public needs to recognize that there is a price to pay for reducing risk, and hence trade-offs are required as society allocates its scarce resources. Business firms, when they design products and develop strategies, need to recognize nonstatistical features of risks, such as fear and dread, that affect public perception. Public sector agencies must also be cognizant of ambiguity aversion by both consumers and businesses and the need for clear guidance in their formulation of policy.

The issues facing society today require action at a number of different levels. To reduce risks, each individual can undertake personal loss prevention measures that may be as simple as following good health habits and investing in protective measures. At the next level, special interest groups can demand certain characteristics of life, such as a cleaner environment. This may require business organizations to develop new production methods that reduce waste and pollution, to manufacture products that meet environmental standards, and to dispose of their waste more carefully. These actions are costly and may require governmental agencies to play a role by promulgating regulations and standards to supplement market-based approaches, such as economic incentives.

We started the book by indicating that it was necessary to understand institutional arrangements and decision processes in order to develop meaningful prescriptions. In looking at the problems facing society today, we can see a number of opportunities to apply these principles. Better empirical data and improved theory should enable us to do a better job in designing meaningful policies at the individual, group, organization, and societal levels. This is the challenge facing decision sciences over the next decade.