THE ECONOMICS OF PROTECTION AGAINST LOW PROBABILITY EVENTS

Howard Kunreuther

January 1981
WP-81-3

Paper prepared for the
Conference on Information Processing
and Decision Making
Graduate School of Management
University of Oregon
March 1-3, 1981

INTERNATIONAL INSTITUTE FOR APPLIED SYSTEMS ANALYSIS
A-2361 Laxenburg, Austria

TABLE OF CONTENTS

THE ECONOMICS OF PROTECTION AGAINST LOW PROBABILITY EVENTS*/**

Howard Kunreuther

I. INTRODUCTION

There has been a growing literature emerging in the social sciences on the failure of consumers to protect themselves against events which they perceive as having a relatively low probability of occurrence even though it may produce substantial damage to their property, cause them personal injury or perhaps even loss of life. In some cases, firms have also been reluctant to offer protective options to individuals or they devote little effort to promoting these products.

The following three examples illustrate these points.

---

*The research report in this paper is supported by the Bundesministerium fuer Forschung und Technologie,F.R.G., contract no. 321/7591/RGB 8001. While support for this work is gratefully acknowledged, the views expressed are the author's and not necessarily shared by the sponsor.

**This paper reflects discussions with a number of individuals in the course of my work on decision processes for low probability events. In particular, my thinking on many points has been clarified through interchanges with Baruch Fischhoff, Jack Hershey, Paul Kleindorfer, Sarah Lichtenstein, Mark Pauly, Paul Schoemaker, Paul Slovic and Amos Tversky as well as with my IIASA colleagues John Lathrop, Joanne Linnerooth, Nino Majone, Michael Thompson and Peyton Young.

(1) A large number of drivers did not voluntarily purchase automobile insurance until they were required to do so (Bernstein 1972). Today, most states in the U.S. regulate rates and there have been charges of discrimination in the pricing and distribution of automobile insurance (MacAvoy 1977).

(2) Flood insurance was not offered to U.S. residents in hazard-prone areas on a large-scale level until 1968 when a subsidized joint federal-private program was initiated.[1] Even though the federal government highly subsidizes the premium, few residents purchase policies today unless they are required to do so as a condition for a new mortgage. Most insurance agents have also not encouraged their policy-holders to purchase this coverage nor provided them with information on the availability of this insurance (Kunreuther, et. al. 1978).

(3) Relatively few individuals voluntarily wear seat belts even though they are aware that by doing so they will reduce the consequences of an automobile accident. Firms have been reluctant to install air bags in automobiles even though surveys of consumers suggest that the majority of drivers would be in favor of such action (Insurance Institute for Highway Safety 1980).

Each of the above examples indicates the inability of the private market to provide protection against low probability events. A principal reason for such market failures is that consumers and/or firms have limited information on both the nature of the hazards they face as well as the available protective options.[2]

This paper systematically explores how different types of imperfect or partial information impact on consumer and firm interactions in the context of the above three examples. It also examines the effect of alternative prescriptive

measures, such as incentive systems or government regulations on performance. Specifically, the following questions will be addressed:

(1) How do the decision processes of consumers impact on the performance of the market? What effect do systematic biases and simplified decision rules have on equilibrium price-quantity values?

(2) How do firms and consumers update their information through learning? What role does statistical data and personal experience play in the dynamics of the decision process?

The next section of the paper details a framework of analysis and the relevant assumptions. Sections III through V illustrate the framework by considering each of the above three examples in turn. The concluding section summarizes the findings and suggests directions for future research.

II. FRAMEWORK FOR ANALYSIS

A. Relevant Assumptions

The framework which guides the analysis is presented in Figure 1 where the adjustment process and flow of information is depicted between the two relevant parties—consumers and firms. To simplify the analysis assume that there are at most two groups of consumers at risk, each of whom faces a single loss (X) which is correctly estimated. Consumers in group H have a relatively high probability of a loss, while those in group L have a relatively low chance of a loss. At the end of period t, each group i has their own perception of the probability of a loss (φ_{it}) which may differ from the true probability (Φ_{it}) $i=L,H$. Consumers base their estimate of Φ_{it} on some weighted average of their previous estimate. Consumers may revise their estimate φ_{it} as t changes by incorporating new data such as a recent experience with the hazard. This updating process may occur

even if the true probability, Φ_{it}, remains stable over time. Unless specifically stated, Φ_{it} is independent of human action so there are no problems of moral hazard.[3]

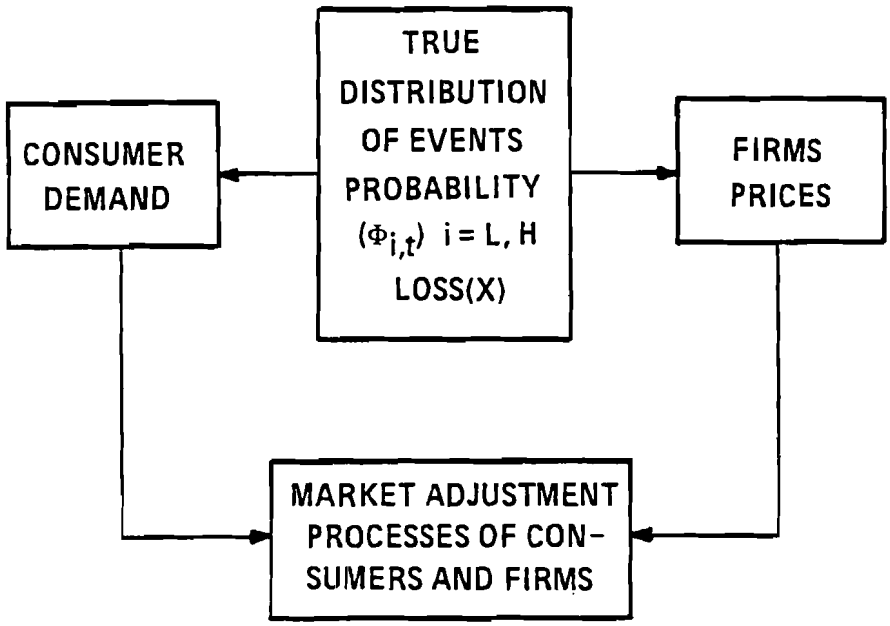

Figure 1. Framework for Analysis

Firms also correctly estimate the loss but may perceive the probability of its occurrence to group i in period t to be different from φ_{it}. The firm markets a protective measure (e.g., insurance, safety devices) and may discriminate between consumers by charging them different prices based on their risk classification scheme. As we shall see in the next section, firms may have a menu of more than two prices even though there are only two risk groups, because they have imperfect information on individuals. As data is accumulated over time, the set of prices will also change. Let P_{jt} be the price charged during period t to consumers in classification j. At the end of period t demand for the protective activity by a consumer in group i who is in classification j is denoted

by Q_{jt}^{i} where

$$Q_{jt}^{i}=f\left(\varphi_{it},P_{jt},X\right)$$

with

$$0\leq Q_{jt}^{i}\leq X.$$

Firms set their prices P_{jt} as a function of their ability to classify consumers and their perceptions of consumer demand ($\bar{Q}_{jt}^{i}$) at different prices. If firms had perfect information on each individual's demand curve and its risk group then there would be only two prices—one for the high and low risk groups. Since $i=j$ we specify demand and premiums in this situation as simply Q_{it} and P_{it} $i=L,H$. The other extreme would be the case where the firm had no information on any consumer and set one price for both groups possibly based on misinformation regarding the true risk, Φ_{it}, and the consumer's decision rule. If the firm charges only one price in period t to both risk groups, this will be denoted as P_t.

In the three examples which follow, I am interested in exploring the nature of the equilibrium between supply and demand at the end of any period t. Specifically, what prices are charged for the protective measures? How are these prices affected by the type of information which firms and consumers have on the probability of a loss, the types of decision rules which consumers utilize, and firms perception of this behavior. What are the welfare implications of these prices to high and low risk type consumers and how might government policy help rectify any imbalances?

The resulting equilibrium will also depend upon the number of firms marketing the product and the degree of competition between them. We will consider two extreme cases: (a) the firm is a monopolist; and (b) the firm is in a competitive market where it is costless for new firms to enter or exit from the industry and consumers have *no* search costs in obtaining data on premiums. These

polar cases enable us to determine the sensitivity of information imperfections to market structure so as to understand more clearly when alternative policy prescriptions such as incentives and regulations may be desirable.

B. An Illustrative Example

To illustrate the above framework more concretely let us consider the case where both the consumer and firm have perfect information. The resulting equilibria in this ideal world can then be contrasted with the more realistic cases to be explored in the next three sections when the informational assumptions for the firm and consumer are relaxed. For this example and later ones, graphical analysis and numerical examples will depict the resulting equilibria.

Figure 2 depicts a situation where consumers have the option of purchasing insurance to cover a portion or all of their loss of X dollars should a disaster occur. Firms offer coverage to consumers in each risk group i at a price per unit coverage of P_{it} $i=L,H$. If the probability of a loss for each group remains stable over time, then so will the price of insurance. Consumers are assumed to be averse to risk, estimate the probability of a loss to be Φ_{it}, and choose the optimal amount of insurance by maximizing expected utility. Then the demand curves for consumers in each risk group is given by D_{it} $i=L,H$, and full coverage will be purchased if $P_{it}=\Phi_{it}$. Firms are assumed to know Q_{it} as well as Φ_{it}. If losses are not correlated between individuals, then it is realistic to postulate that in this ideal case firms will set their premiums so as to maximize expected profits for each risk group which we denote as $E(\Pi_{it})$.

The equilibria for the two polar cases are also illustrated in Figure 2. When the firm is a monopolist it will set the premiums at P_{it}' so that each consumer purchases less than full coverage. In a purely competitive environment with

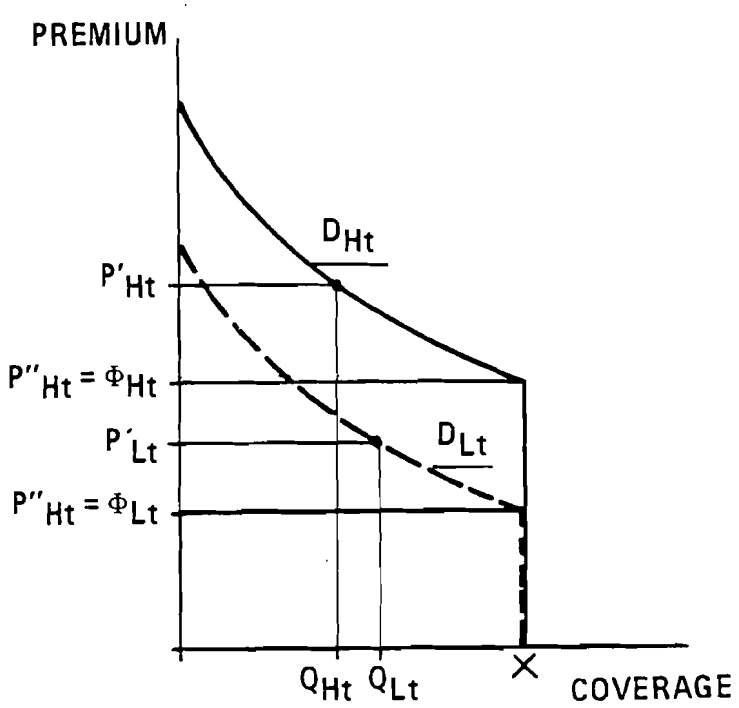

Figure 2. Premium Structure for Monopolist and Competitive Firms with Perfect Information.

costless entry or exit by firms, and no costs of search by consumers, the equilibrium price will be at $P_{it}=\Phi_{it}$ and $E(\Pi_{it})=0$ $i=L,H$ for each firm in the industry. If a firm sets $P_{it}<\Phi_{it}$ it will lose money; if $P_{it}>\Phi_{it}$ then other firms can charge a price between P_{it} and Φ_{it}, make positive profits and attract all consumers in risk group i.

A numerical example depicted in Figure 3 illustrates the premium structure for both the monopolist and purely competitive industry for the case where $X=40$ $\Phi_{Lt}=.1$ and $\Phi_{Ht}=.3$. Consumers all have the same utility function $U_i(Y)=-e^{-cY}$ with the risk aversion coefficient c=.04. If the firm is a monopolist it will set P'_{it} so as to maximize

$$E(\Pi_{it}^{'})=(P_{it}^{'}-\Phi_{it})Q_{it} \qquad (i=L,H)$$

knowing that Q_{it} is determined by each consumer maximizing his/her expected

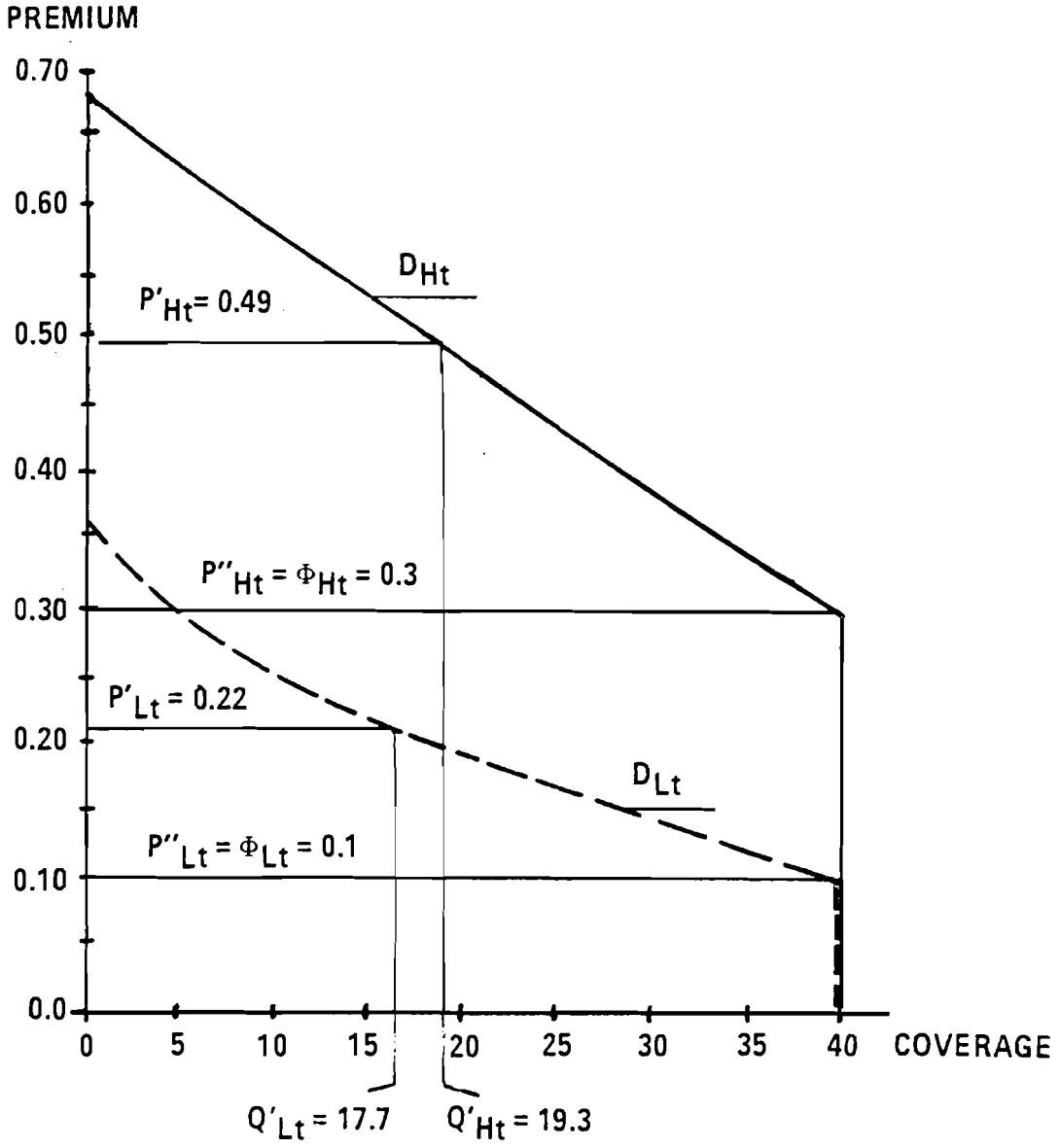

Figure 3. Illustrative Example of Premium Structure with Perfect Information.

utility. As shown in Figure 3, the optimal premium structure in this case is $P_{Lt}^{'}$=.22 and $P_{Ht}^{'}$=.49 which results in Q_{Lt}=17.7 and Q_{Ht}=19.3 and yields expected profits of $E(\Pi_{Lt})$=2 and $E(\Pi_{Ht})$=3.77 for the two respective risk groups. In a purely competitive industry the respective prices charged for the high and low

risk groups will be the actuarial fair rates of $P_{Lt}^{''}=.1$ and $P_{Ht}^{''}=.3$ and full insurance will be demanded since consumers are risk averse. By definition, expected profits for all firms in the industry will be zero.

Let us now briefly turn to the impact of market structure on consumer welfare. It is clear from the above example, and true in general, that competition improves the welfare of each of the risk groups from what it would have been in a monopoly situation. The threat of new firms entering the market forces each firm to set the lowest premium consistent with their information on the risk and the consumer's demand curve. In contrast, the monopolist can exploit his uniqueness by charging higher rates. The question as to when regulation is appropriate for improving welfare thus hinges on the type of market situation which consumers face. As we shall see in the next section, it also depends on information imperfections by firms.

III. IMPERFECT INFORMATION BY FIRMS: THE CASE OF AUTOMOBILE INSURANCE[4]

A. Relevant Assumptions

Suppose that firms have imperfect information on the risk characteristics of consumers. A typical example would be firms marketing automobile insurance to drivers, some of whom may be considered to be high risk and others low risk. In the context of the above framework, these two categories reflect different probabilities of having an accident.

In this section we will consider the case where firms know what the probabilities are of an accident by a good or bad driver as well as the proportion of each type driver in the population. To focus on the impact of imperfect information by firms we assume that consumers know whether they are good or bad

drivers but a firm cannot classify any new applicant and hence is initially forced to charge a single premium.[5] Over time the firm learns about the characteristics of its old customers through their loss experience. This information enables them to classify consumers through a Bayesian updating procedure and charge differential prices. The real-world counterpart of this behavior is the common practice followed by insurance firms of "experience rating" whereby those with good driving records are charged lower premiums than those who have had accidents.[6]

The other institutional consideration which forms a part of this analysis is the differential information that firms have on the characteristics of consumers desiring insurance. Insurance companies who obtain specific knowledge of their customers characteristics through experience have no incentive to share this information with other firms. Hence these uninformed firms have no way of confirming whether a new applicant is telling him the truth about his past experience.

Given the above assumptions we can examine the characteristics of the market and contrast the resulting equilibrium with the ideal case discussed in the previous section. Let us start the analysis by first considering how premiums are set when firms have no information on the risk characteristics of the specific applicant. For concreteness we will assume that firms are maximizing expected profits and that consumers maximize expected utility. Similarly, firms are assumed to utilize Bayesian updating procedures for incorporating loss experience into their classification scheme.

Figure 4 graphically depicts the resulting prices in the initial period 0 for the monopolist (P_0') and for a firm in a purely competitive industry (P_0'') using the parameters from the previous example and assuming there are an equal percentage of good and bad risks in the population.[7] Turning first to the mono-

polist, the contrast with the case of perfect information is striking. Since the firm cannot distinguish between the high and low risks, it finds that the optimal price to charge is P_0'=.49, a value so high that the low risk consumers will not

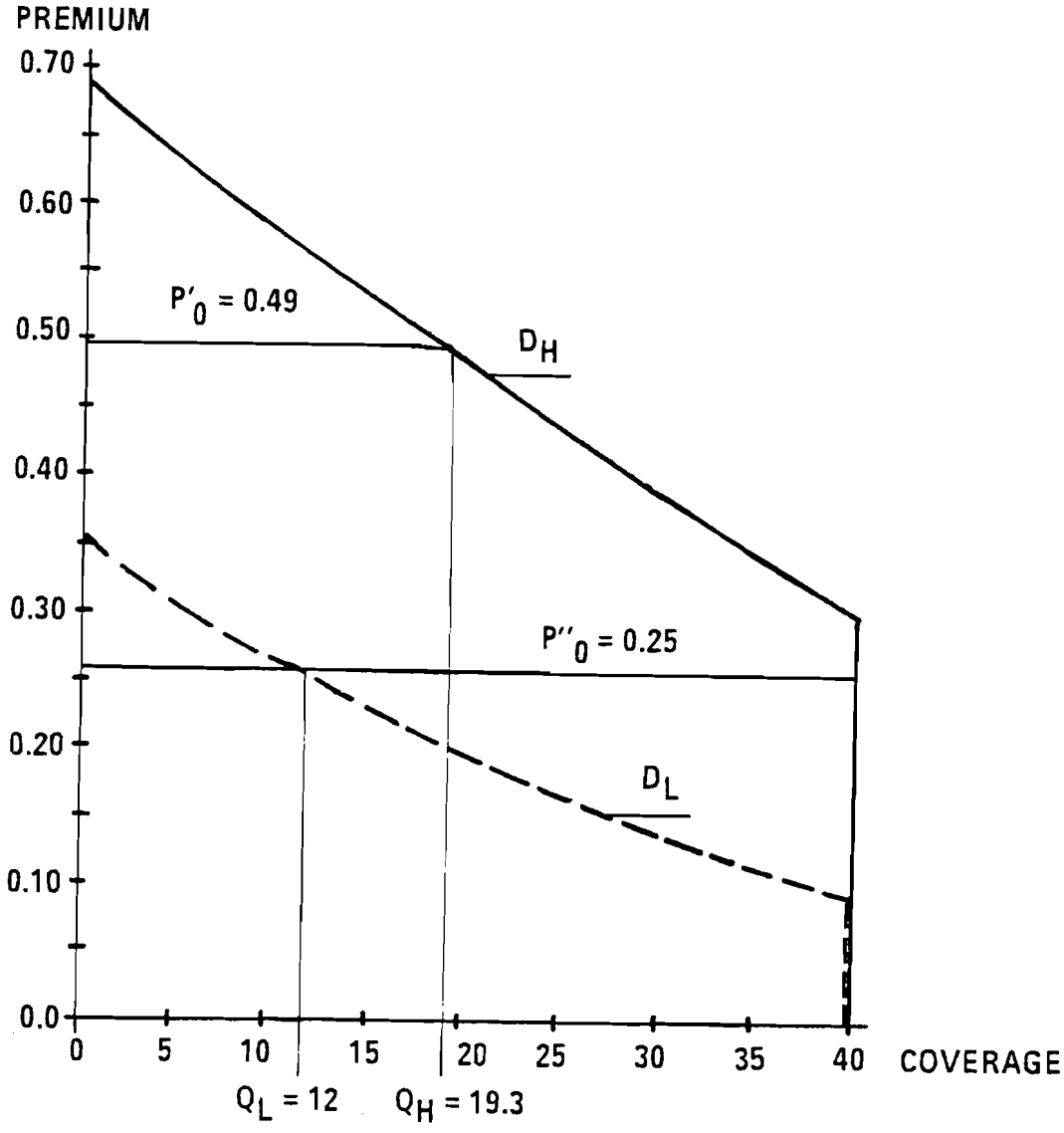

Figure 4. Illustrative Example of Initial Premium Structure by Firm with Imperfect Information.

demand any insurance. It is thus no coincidence that the initial price is the same as the premium charged to high risk customers when the monopoly firm had perfect information.

This particular example illustrates the phenomenon of adverse selection which has been discussed in the economics literature as a cause of market failure (See Arrow 1963; and Akerlof 1970). In this case adverse selection refers to the ability of the individuals at greater risk to take advantage of the suppliers imperfect knowledge. Because a firm has imperfect information on the risk characteristics of potential customers, it charges a premium which is so high that only the highest risk individuals demand coverage.

Where there is costless exit and entry, then each firm in the industry sets a premium which yields zero expected profits as shown by $P_0^{"}=.25$ in Figure 4. In this case the high risk individuals are offered insurance and naturally buy full coverage (i.e., $Q_H=40$). Low risk individual subsidize the high risk group and hence purchase only partial coverage ($Q_L=12$). Compared to the case of perfect information illustrated in Figure 3, the high risk individuals clearly gain at the expense of low risk applicants. This phenomenon is a fairly general one in markets with imperfect information. Those who are the worst risks get lumped together with better risks and hence benefit by not being identifiable as long as the equilibrium premium induces both groups to buy coverage.[8]

Let us now turn to the case where firms learn about the characteristics of their customers through loss data. During each time period an individual can suffer at most one loss, which if it occurs will cause X dollars damage. This information is recorded on the insurer's record and a new premium is set for the next period which reflects his overall loss experience. Informed firms do not disclose their records to other firms. Individuals who are dissatisfied with their new premium can seek insurance elsewhere. Other firms will not have access to the insured's record and hence cannot verify whether an applicant has had few or many losses under previous insurance contracts. Hence the uninformed firms just treat the individual as a new customer.

The premium structure for the informed firm is determined in the following way. Let period t be defined as the length of time a group of customers has remained with the same firm. Then there will be $t+1$ different classifications reflecting the number of losses j ($j=0,1,\ldots t$) during this interval of time. Let P_{jt} represent the price charged to those consumers who have suffered exactly j losses in a t period interval. The premiums $P_{jt}, j=0 \cdots t$, have to be sufficiently low so that the uninformed firms cannot undercut these prices to attract customers from the informed firm, and still make a profit.

A little reflection suggests the nature of the solution: as j increases then P_{jt} will also increase, since the proportion of high risk consumers increases with j. Hence, if an uninformed firm charges a premium less than P_{jt} it will attract all those customers with j or more losses. Hence, each premium P_{jt} must be sufficiently low so that the uninformed firms cannot make a profit by attracting customers with j thru t losses.[9] Let these values be designated as $\bar{P}_{jt}$. In essence $\bar{P}_{jt}$ represents an upper bound on the set of prices offered on the market. If the informed firm finds that it maximizes profits for any given classification j by setting $P_{jt}<\bar{P}_{jt}$ then, of course, it is in the firm's best economic interest to do so. Due to imperfect information by firms on the true risk, some of the high and low risk consumers will be misclassified on the basis of their losses. Over time, these statistical errors will decrease as the population sorts itself into appropriate groups.

B. An Illustrative Example

Figure 5 illustrates the nature of the solution by considering a simple one period example (i.e., $t=1$) with two classifications based on $j=0$ or 1. Using the same parameters as in the previous problem (see Figure 3) we find that the optimal premiums P''_{jt} in the competitive industry are $P''_{11}=.29$ and $P''_{01}=.25$,

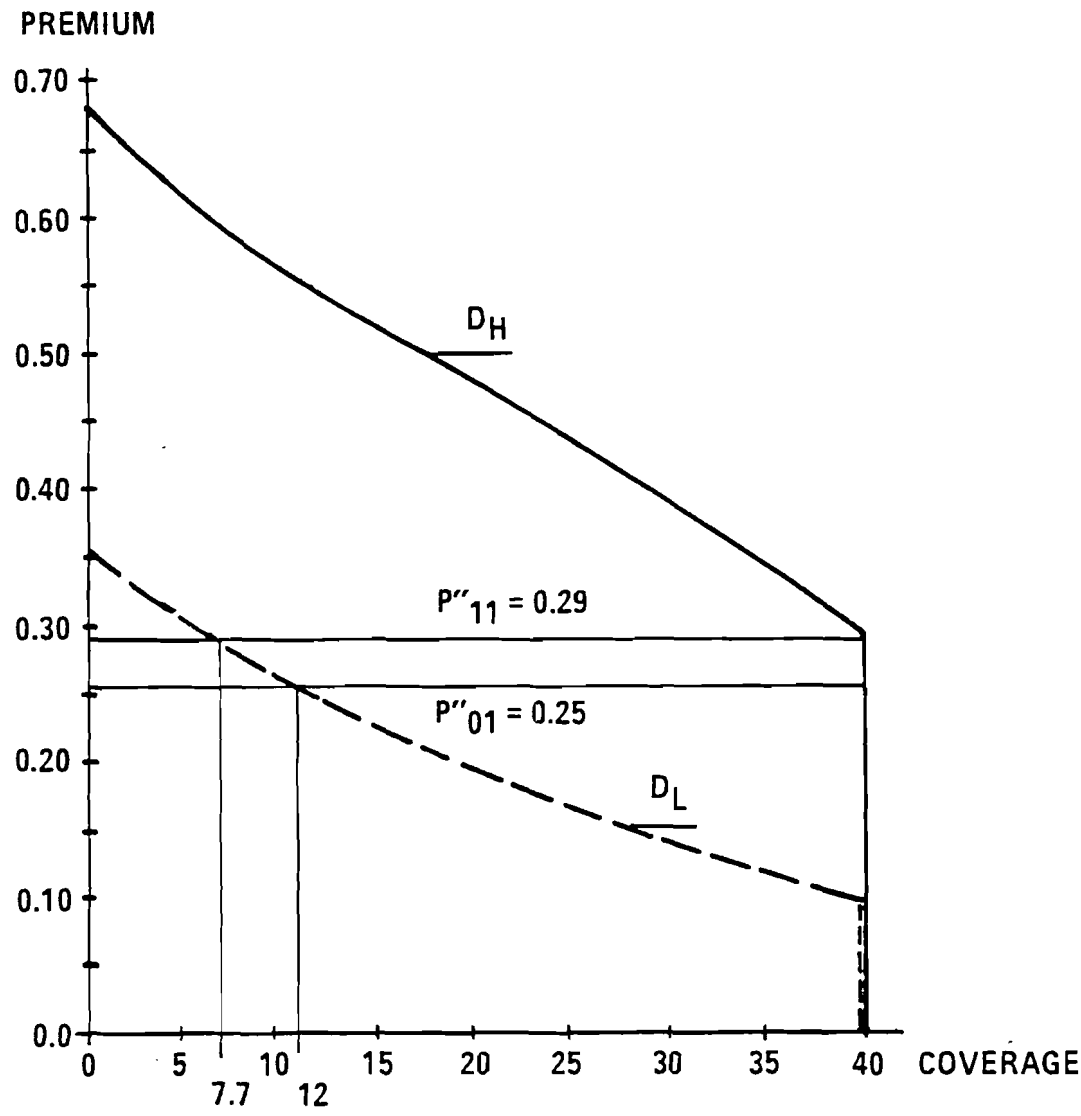

Figure 5. Premium Structure for Informed Firms at End of Period 1.

yielding expected profits of $E(\Pi''_{11})=0$ and $E(\Pi''_{01})=.23$ respectively. In the case of $j=1$, the resulting price yields zero profits because any $P_{11}>.29$ would have led an uninformed firm to set a lower price, induce all of those consumers with 1 loss to purchase from them while still making a profit. For $j=0$, the informed firm can exploit its information on losses and make a profit by charging the

same premium that a new firm would charge if it could not distinguish between risk classes, $P''_{01} = P''_{0} = .25$. The informed firm estimates that the proportion of low risk customers with 0 losses is .56 rather than their initial estimate of .5. This enables them to make a profit for customers with zero losses.

The case of monopoly behavior over time is uninteresting for this example since the firm has set its initial premium so high that only the high risks will purchase insurance. Thus the premium remains stable over time unless there is a change in the estimated probability of a loss. Had the monopolist set a price where both high and low risk consumers purchased a policy then the updating procedure would have been identical to the one described above, except that P'_{jt} $j=0....t$ would be determined by maximizing $E(\Pi'_{jt})$ for each classification j since there would be no uninformed firms with whom to concern oneself. Prices would thus be the same or higher than in the competitive case.

C. Welfare and Policy Implications

What are the welfare implications of the above analysis of firm imperfections? Two principal points emerge. First, adverse selection may create a situation where low risk individuals will *not* demand insurance because the premium is too high. Secondly, when both groups have coverage, low risk individuals will ***always*** subsidize high risk consumers whether or not they have an accident. Those who suffer a loss will be misclassified into a higher rate category as indicated by P_{11}. Those who do not suffer a loss will pay a lower premium than P_{11} but it will be above the actuarial rate because some high risk individuals will also be in this category.

The results of this dynamic model of learning have an interesting interpretation in the context of Cyert and March's (1963) study on the behavioral theory

of the firm and Williamson's (1975) work on impacted information. Suppose we view policyholders as an integral part of the firm as in a mutual insurance company where every insured individual is a member of the company. Any time there is a subsidy we can refer to this situation as one of organizational slack. As defined by Cyert and March "slack consists in payments to members of the coalition in excess of what is required to maintain the organization" (p. 36.) In the context of this example, those in the highest risk class have no economic incentive to leave their insurance firm because their premiums are either actuarially fair or being subsidized.

The low risk group has the reverse reaction—all the members are being charged more than the actuarial rate but other firms cannot distinguish their special status because of impacted information. They are thus forced to remain with their current firm because others in the industry are not privy to the information on their relative risk. At the risk of generalization, we find that if firms do not have perfect information on their clients, insured individuals who are worse than the average will remain because of organizational slack while those who are better than average will not switch because of problems of impacted information.

What are the implications of this behavior for prescriptive analysis? Obviously public disclosure of the information that firms use to set their rates would benefit the low risk consumers at the expense of the higher risk group. Suppose drivers could present a certified copy of their accident record from Company A to a competitor. To the extent that this option was pursued by consumers, impacted information would be reduced and monopoly profits curtailed.

Monopoly profits by firms also provides some justification for regulating insurance premiums. Many states currently have a prior approval regulatory system where justifications for rate increases must be filed with state insurance

commissioners along with supporting documents. According to these laws rates are not to be excessive, inadequate or unfairly discriminatory. As in all questions involving regulation one has to balance the potential benefits of forcing firms to reveal information with the paperwork and transaction costs involved in having the company justify each rate increase. More empirical data is needed to provide a better data base on which to judge these impacts. The material reported in MacAvoy (1977) is an excellent start in this direction.

D. Future Research Questions

Future research on firm behavior can investigate the following sets of questions in the context of the above framework.

(1) What are the implications for market behavior if firms utilize updating procedures which differ from a Bayesian analysis? For example, suppose firms develop a rate classification scheme which only changes the premium if a driver incurs two or more accidents in a given time period. Alternatively, suppose firms have only 3 or 4 classifications no matter how many periods the individual is insured with the firm. If consumers have no losses for a certain number of consecutive years, they are automatically placed in the lowest risk classification. How will these systems affect price and quantity equilibria for the high and low risk groups?

(2) Suppose one introduces search costs into the analysis so that consumers are reluctant to seek out new companies unless their premiums increase from period t to $t+1$ by more than s dollars or z percent. What are the implications of this action on firm behavior as well as on market equilibrium values?

(3) How does one incorporate equity considerations such as income level as well as societal concerns regarding discrimination by age or sex into this analysis? There is considerable controversy now on this topic stimulated by the Massachusetts hearings on automobile insurance rates in 1977.

(4) What are the likely differences to emerge between insurance premiums and the level of protection in states which are highly regulated (e.g., New Jersey) moderately regulated (e.g., Texas) or rely on market forces (e.g., California).[10] An understanding of the decision processes utilized by firms and the degree of imperfect information on characteristics of consumers are important factors to incorporate in the analysis of this comparative problem.

(5) Finally, we have assumed throughout this analysis that consumers have perfect information on their own risk classification. What is the impact of different types of market or regulatory systems if consumers have misperceptions of their risk and behave in ways which differ from maximizing expected utility? This very broad topic requires considerable research. The next section introduces some of the impacts of consumer imperfections on prices and market structure.

IV. IMPERFECT INFORMATION BY CONSUMERS: THE CASE OF FLOOD INSURANCE

Let us now reverse the coin from the previous section by considering the case where firms have perfect information on the risk characteristics facing the consumer, but individuals threatened with a loss of X dollars are imperfectly informed of the risk which they face. An example of this situation is the provision of flood insurance to residents of hazard-prone areas. Hydrologic data have

been analyzed by groups such as the Corps of Enginers to determine the actuarial risk faced by different structures in the flood plain, but residents of the area may perceive the risk incorrectly.

A. Misestimation of Probability

To begin the analysis suppose that consumers misestimate the probability of a loss. There is considerable empirical evidence from recent laboratory experiments supporting this assumption. Tversky and Kahneman (1974) describe the biases and heuristics which cause systematic misestimates of probability even by mathematically sophisticated individuals such as statisticians and engineers. They characterize one of these heuristics as availability whereby one judges the probability of an event by the ease with which one is able to imagine it. In the case of the flood hazard, two individuals with the same objective risk may estimate the probability of a future flood differently depending upon whether they have recently experienced a disaster. Fischhoff, Slovic, and Lichtenstein (in press) have categorized a set of biases in perceptions that individuals exhibit with respect to low probability events. These findings are based on a series of laboratory experiments and field survey data which they and others have undertaken.

B. An Illustrative Example

What is the impact of such misestimation on equilibrium prices and demand for insurance protection. The simplest way to illustrate this effect in the context of the previous example is to assume that all individuals in the hazard-prone area have the same objective risk— Φ_{Ht}. Some individuals in the group correctly perceive the probability of a disaster while others underestimate its

value, perceiving it to be Φ_{Lt}. To isolate the effect of misperception of probability on market adjustment processes, consumers are assumed to choose the amount of protection which maximizes their expected utility. The demand curve for consumers who correctly estimate $\varphi_{Ht}=\Phi_{Ht}$ is designated by D_{Ht}. Those who incorrectly estimated the risk to be $\varphi_{Ht}=\Phi_{Lt}$ have their demand curve given by D_{Lt}. Firms know the true probability, and the decision rule on which the consumer bases his decision. However, they cannot differentiate between consumers who correctly perceive the risk and those who do not. Hence, they set just one premium P_t'' for the competitive situation and P_t' for the monopoly case.

Figure 6 illustrates the resulting equilibria for the case where $\Phi_{Ht}=.3$ and some consumers correctly estimate its value while others assume $\varphi_{Ht}=.1$. In a competitive market the premium will always remain at $P_t''=\Phi_{Ht}=.3$ because any higher premium would induce firms to enter the industry, charge a slightly lower price but one above .3 and still make a positive expected profit. Any lower premium would create losses. If consumers underestimate the probability of a disaster they will find this premium to be relatively unattractive to them and purchase little insurance protection, in this example $Q_{Lt}=6.2$. In fact, it should be clear from this analysis that if the consumer sufficiently underestimates the chances of a flood he may desire no insurance simply because the premium is too high relative to the perceived utility of protecting himself.[11]

The monopolist wants to set his premium so he maximizes expected profits. If he assumes that individuals correctly estimate the chances of a disaster then he sets his price at $P_{Ht}'=.49$, the same value as the one given in Figure 3 when both parties were assumed to have perfect information. In this case, those individuals who misperceive the probability to be $\varphi_{Ht}=.1$ will purchase no coverage while consumers with accurate information will buy $Q_{Ht}'=19.3$. At the other end

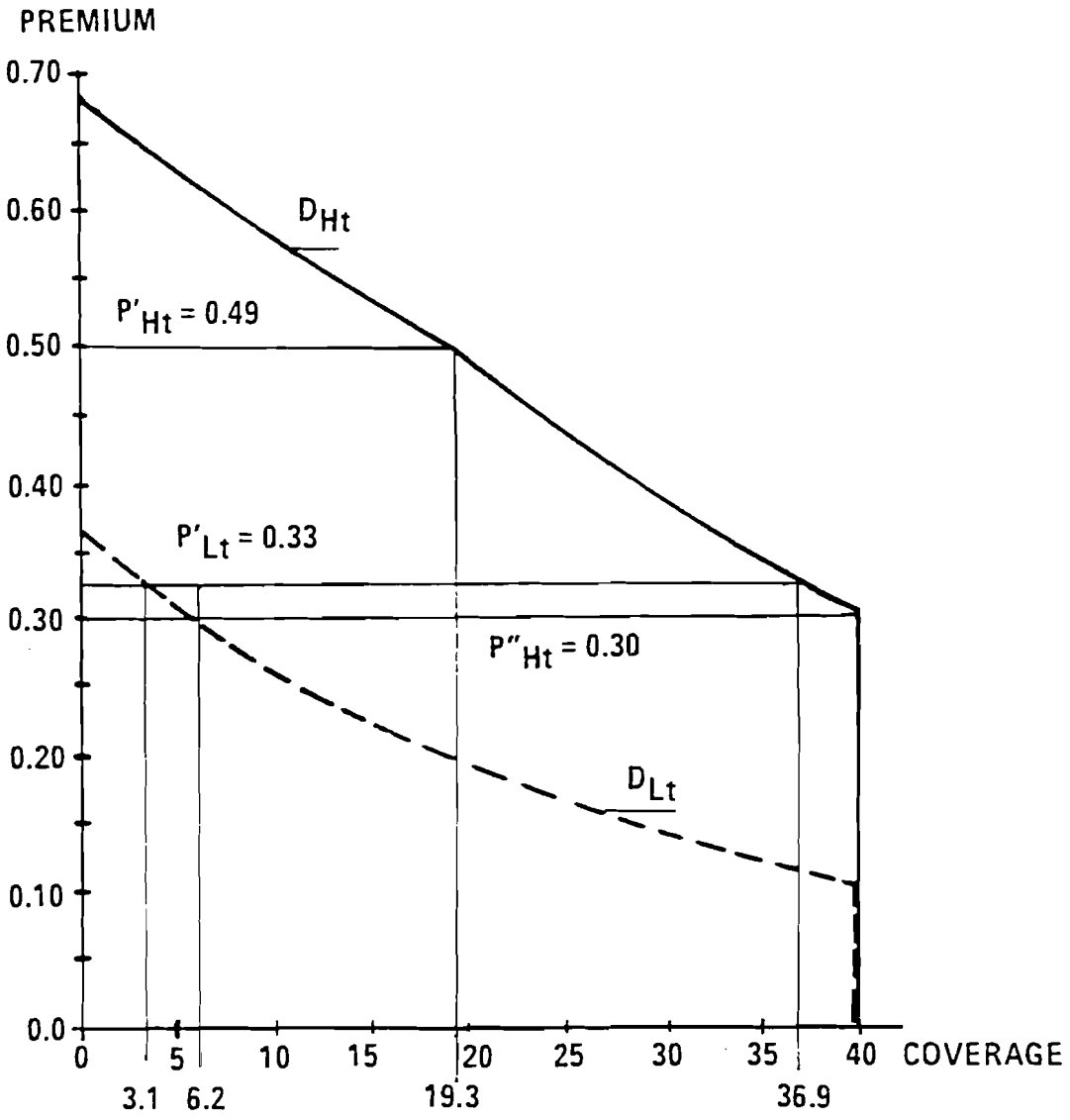

Figure 6. Premium Structure with Imperfect Consumer Perceptions on Φ_H.

of the spectrum, the monopolist may assume that all individuals estimate φ_{Ht}=.1. In this case he sets his premium so he maximizes profits given the demand curve D_{Lt} and chooses a value of P'_{Lt}=.33, thus eliciting a demand of Q'_{Lt}=3.1. Those who correctly estimate Φ_{Ht} will purchase 36.9 units of insurance. If the monopolist assumes that there is a fraction w who correctly estimates the probability and another fraction $(1-w)$ who misestimate it then the premium,

which maximizes expected profits, will be somewhere between .33 and .49.

This simple example illustrates a somewhat obvious conclusion: even if the market is competitive with free entry and exit, individuals will purchase limited protection if they underestimate the risk. Firms will not set the premium below the actuarial rate unless they also underestimate the risk. Hence, the equilibrium price makes the purchase of a large amount of insurance relatively unattractive to those who perceive the risk to be smaller than it actually is.

C. Impact of Behavioral Decision Rules

The above model still assumes that individuals are behaving as if they maximized some objective function such as expected utility. There is considerable empirical evidence which suggests that actual behavior of individuals regarding low probability events is based on a different decision process than the one described above. Building on the work of Herbert Simon one can hypothesize that individuals' actions are constrained by their limited ability to collect and process information. Hence they attempt to satisfy some objective through the use of simplifying heuristics rather than optimizing behavior. One such heuristic which appears to explain protective behavior regarding low probability events is a threshold model of choice, whereby individuals do not concern themselves with the consequences of an event unless they perceive the probability of its occurrence to be above a specified level φ_i^* (Slovic, et. al. 1977).

Field survey data of 3000 individuals in flood and earthquake prone areas, half of whom were insured and the other half not, suggests that individuals utilize a sequential model of choice in determining whether to purchase coverage or not, where a threshold probability is an important part of the choice process (Kunreuther, et. al. 1978). Unless individuals perceive the hazard to be a serious problem and have engaged in discussions with friends and neighbors about

insurance, they are unlikely to buy coverage. The most important variable determining the perceived severity of the problem is past experience with the hazard, thus suggesting that the probability of the disaster occurring has been raised above some critical threshold φ_i^*. Once the individual has decided that he is interested in protection, there is a tendency to utilize simplified decision rules which reflect human limitations in formulating and solving complex problems.

There has been considerable work in recent years to determine the process of choice once the individual has reached the stage where he/she wants to balance costs and benefits. For the single attribute problem discussed here where the tradeoffs are in monetary terms,[12] Kahneman and Tversky (1979) have formulated prospect theory as an alternative to utility theory. Thaler (1980) has also provided a number of examples illustrating the tendency of consumers to incorporate regret into their decisions and their failure to ignore sunk costs as part of the analysis of a problem.

The importance of accurately describing the factors influencing the consumer's demand curve for protection cannot be overemphasized. Unless one understands the process by which choices are made, it will be difficult to evaluate how well the market is likely to work and the prescriptive alternatives which may be appropriate.

To be more concrete on this point, suppose that the consumer has reached the stage in his sequential decision process whereby he is seriously interested in some protective mechanism such as insurance. There are several heuristics which appear to play a role in the final purchase decision. Rather than viewing the situation probabilistically, individuals may consider the cost of a policy in relation to the amount they are likely to collect should a disaster occur. This *price/loss ratio* may explain the popularity of flight insurance where for a very

small premium one can receive thousands of dollars worth of coverage. A comment from a homeowner in a flood-prone area illustrates how the perceptions of the premium in relation to the loss may be important, particularly after a past experience with the event.

> I've talked to the different ones that have been bombed out. This was their feeling: the $60 (in premiums) they could use for something else. But now they don't care if the figure was $600. They're going to take insurance because they have been through it twice and they've learned a lesson from it. (Kunreuther, et. al. 1978, p.112).

Another factor which influences the decision on taking protective action is the *price* itself. If the premium is above some critical level then this will discourage the purchase of coverage even if the risk is perceived to be high. In trying to understand the impact of an income or budget constraint on coverage one uninsured homeowner in a flood-prone area noted:

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

A final factor which may determine how much protection an individual is likely to purchase is the tendency to view this expenditure as an *investment* rather than a contingent claim. In other words, the person wants to purchase insurance if he feels that he has a good chance of obtaining some return on his investment. This may explain the great popularity of first dollar coverage and the preference for low deductibles on the part of individuals.[13] It also is related to the concept of regret utilized by Thaler (1980) as an explanation for this behavior. Once an uninsured individual has experienced a disaster he may regret not having purchased a policy. His natural response is to protect himself against future events by purchasing a large amount of coverage. The same

phenomena also explains why individuals cancel their insurance policy after not collecting on it after a few years: they regret having made an investment which has not paid off.

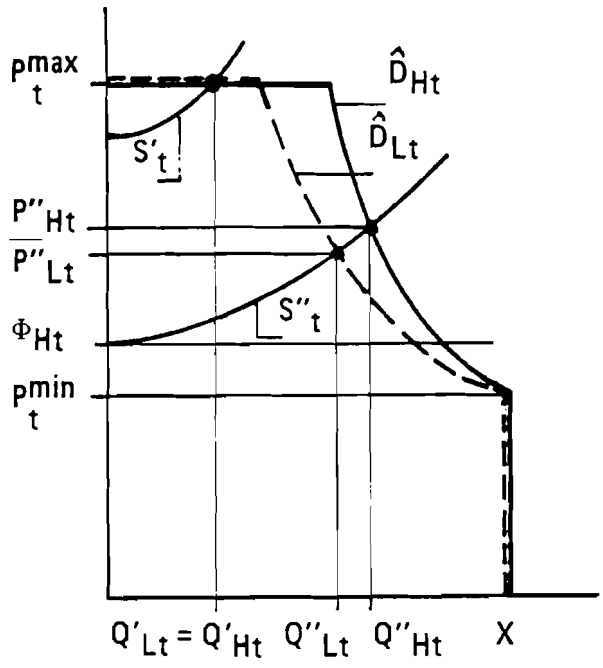

Figure 7. Example of Premium Structure with Behavioral Consumer Decision Rules.

A simple schematic model illustrating how the above heuristics could be incorporated into a demand curve for insurance is depicted in Figure 7 for persons whose threshold probability is above φ_t^*. As in the previous example, we assume there is only one risk, Φ_{Ht}, but that there are two groups of consumers: those who correctly perceive the risk with demand curve $\hat{D}_{Ht}$, and those who incorrectly perceive it to be Φ_{Lt} with demand curve $\hat{D}_{Lt}$. Once the premium is above some critical upper limit (P_t^{max}), it is assumed there will be no interest in

insurance by either group of consumers because of a budget constraint. If $P_t = P_t^{max}$, an individual is likely to buy a relatively large amount of coverage because of concerns of regret and his view of insurance as a good investment. As the premium decreases he will increase coverage until the premium/loss ratio is sufficiently low that he wants to purchase full protection. We have denoted this lower bound as P_t^{min}. Both P_t^{max} and P_t^{min} are assumed to be independent of the probability of a disaster since they are influenced by factors such as budget constraints or premium/loss ratios. According to the above discussion the following factors appear to influence the shape of the demand curve for each risk group i:

A. $\varphi_{it} \leq \varphi_{it}^*$ φ_{it} *(threshold concept)*

B. $\varphi_{it} > \varphi_{it}^*$

$P_{it} \geq P_t^{max}$	$Q_{it} = 0$ *(budget constraints)*
$P_t^{min} < P_{it} < P_t^{max}$	$0 < Q_{it} < X$ *(premium / loss / ratio considerations)*
$P_{it} \leq P_t^{min}$	$Q_{it} = X$ *(sufficiently low premium / loss ratio)*

Let us now turn to the supply side. Firms have an additional problem in marketing coverage against a disaster such as a flood where damages between individuals are highly correlated. They must concern themselves with the possibility of a catastrophic loss which may have adverse consequences on their financial stability and short-run operations. There are two principal ways in which they can protect themselves against this possibility: (1) they can only offer coverage to a maximum number of consumers at a fixed premium per dollar of protection, or (2) they can purchase reinsurance to cover the loss above a certain amount and can charge a premium per dollar coverage which increases as the amount of coverage increases. This type of premium schedule reflects

risk aversion on the part of the firm and the need to reinsure a portion of the loss.

We have depicted the latter situation in Figure 7 for both the competitive and monopoly firms. The upward sloping supply curves, S_t'' and S_t', reflect the case where firms are risk averse and concerned with possible catastrophic losses. Consumers who underestimate the probability of a disaster will thus pay a lower premium then those who correctly estimate the risk because they will be demanding less coverage. In the case of a competitive industry the optimal premiums and quantity pairs will be $\{P_{Lt}'' \quad Q_{Lt}''\}$, and $\{P_{Ht}'' Q_{Ht}''\}$ for the individuals who underestimate and correctly estimate their losses respectively. We have drawn the monopolist's supply schedule S_t' to illustrate a case where both those who underestimate the risk and those who correctly estimate Φ_{Ht} will purchase the same amount Q_t' at the premium P_H^{max}. The upward sloping supply curve discourages consumers from buying more than that quantity of insurance.

D. Welfare and Policy Implementation

This simple analysis has only hinted at the dynamics of the problem by suggesting how people's perceptions of the probability of an event may change over time due to past experience. From the welfare point of view, it is clear that consumers will purchase limited, if any, protection when they underestimate the chances of an event occurring. After a disaster they may regret not having purchased insurance and may revise their *ex post* estimate of the probability upwards. This type of reaction raises an important philosophical problem regarding the role of the private and public sectors in dealing with situations where there is wide diversity between *ex ante* and *ex post* estimates of the probability of an event occurring.

The history of disaster relief illustrates this point rather clearly. Most individuals in flood and earthquake prone areas have not protected themselves against these hazards with insurance because they perceived that the chances of an event were so small that they did not have to worry about the consequences. Little attention was given prior to the disaster by uninsured individuals to the possibility of receiving federal relief to aid them in their recovery. After the event victims pressured their Congressmen for special relief and new legislation was frequently passed providing people with generous aid. For example, Tropical Storm Agnes in June 1972 caused over $750 million worth of damage to private housing but only 1583 claims totaling approximately $5 million were paid under the National Flood Insurance Program. As a result, the federal government offered victims $5,000 forgiveness grants and 1 percent loans for the remaining portion of their loss (Kunreuther 1973). After the event victims may increase their subjective probability of the reoccurrence of this type of disaster. However, liberal relief may have had the effect of discouraging some victims from voluntarily purchasing flood insurance in the future.

There are a set of policy-related questions which are stimulated by this *ex ante/ex post* question. Specifically, can one make individuals more aware of the risks associated with a particular hazard so that they will want to voluntary protect themselves by focusing on the factors which influence their demand for protection? One way to encourage individuals to purchase insurance is to present information so that people perceive the probability of an event occurring to be above their critical *threshold level*. For example, in describing the chances of a 100 year flood, the insurance firm or agent could note that for someone living in a house for 25 years the chances of suffering a loss at least once will be .22. Consumers may then be willing to view the situation as serious, where they would not if data was presented in terms of the annual probability of a flood. By

presenting the same information in different forms or contexts people may behave differently.[14] If the principal reason for not purchasing coverage is the unusually high price in relation to an income or budget constraint then a reduction in the premium may be deemed desirable.

The appropriate prescriptive measures depend on the market situation. If firms have some degree of monopoly power, premium regulation may induce more consumers to purchase coverage. In the case of flood insurance, where the industry had not offered coverage because of previous catastrophic losses, some form of government reinsurance may induce them to market policies at premiums reflecting risk. In addition, some type of federal subsidy on premiums may encourage residents to buy coverage, although the experience of the National Flood Insurance Program is not encouraging in this regard.

If none of these incentives are successful and the public sector wants to reduce its financial commitments after a disaster, then some form of required coverage may be necessary. The simplest policy would be for banks and financial institutions to require insurance as a condition for a mortgage as a way of protecting their own investments. An alternative to the above recommendations is for the federal government to provide relief to disaster victims, using taxpayers money to finance this effort. This latter action explicitly assumes that disasters are a public rather than a private responsibility.

E. Future Research Questions

From the point of view of future research, the following questions need to be investigated to gain a better understanding of the interaction between firms and consumers:

(1) How can learning be more explicitly incorporated into an analysis of consumer demand over time? A protective mechanism can be viewed as an innovation which takes time to be adopted by large segments of the population. The diffusion process may be very important because of the impact that social norms may have on individual behavior. Schelling (1978) has treated this phenomenon in some detail and provides a number of interesting examples illustrating stable and unstable equilibria.

(2). How is firm behavior affected by changes in the demand curve of consumers over time because of past experience and personal influence? Both these factors appear to play an important role in impacting on the decision process over time.

(3) What impact do concepts such as regret, threshold behavior and consumer misperceptions have on market behavior and equilibrium price and quantities?

(4) What are the *ex ante/ex post* implications of alternative market and public sector solutions? What are the appropriate roles of the public and private sectors with respect to protective activities and recovery measures after a disaster?

V. ALL OR NOTHING PROTECTIVE MEASURES (THE CASE OF AIR BAGS IN AUTOMOBILES)

A. Relevant Assumptions

There is a whole class of additional protective measures where the consumer normally only makes a "purchase" or "not purchase" decision. Some items protect against property damage such as the installation of a burglar alarm or a sprinkler system. Others involve the possibility of reducing personal injury or

saving ones life such as inoculations, wearing safety belts or buying an automobile with an air bag installed.

These types of protective activities differ from insurance in two principal ways. The demand curve for the product is discontinuous at a critical price P^*. A price above P^* will cause the individual not to invest in the protective activity; if the price is at or below P^* he will adopt the measure. The product is normally offered by a supplier other than an insurance company since it involves costs of production. Hence it is possible to encourage consumers to purchase these protective mechanisms by making the level of insurance premiums or the magnitude of reimbursable claims after an accident conditional on whether the measure is adopted.

For example, in many countries in Europe those who have an accident and are not wearing their seat belts are able to claim only a portion of their insured loss. This penalty may encourage some drivers and passengers to wear seat belts. Similar incentives could be offered to consumers with respect to a reduction in theft insurance premiums if they install a burglar alarm, a reduction in fire insurance rates if the property has a sprinkler system, or lower health insurance premiums if they avail themselves of protective measures such as vaccines or medical check-ups.

In this section we will focus on the decision by consumers and manufacturers as to whether they should have air bags installed in cars. This type of protective mechanism explicitly introduces the concept of human lives into the picture. It also has been in the news recently since the U.S. Congress is debating whether to require automobile manufacturers to install air bags in future new cars.[15]

To begin the analysis, assume that a driver faces a single loss X which in this case is a severe personal injury. If his car does not contain an air bag then

the probability of this disaster is given by Φ_H. Should he decide to purchase a car with an air bag then this probability is reduced to Φ_L. In contrast to the earlier problems which involve tangible estimates of property damage, the consumer is now faced with the more difficult problem of estimating the value of a human life.[16]

Suppose that the consumer is a utility maximizer and thus incorporates the consequences, X, as part of his decision process. How would he determine whether or not to purchase a car with an air bag? The tradeoffs for this problem are as follows: there is an additional cost of the air bag, which is labeled P, that has to be contrasted with the reduction in the probability of an accident during a specified period of time, in this case the life of the car.[17] As Cook and Graham (1977) have shown there is a close parallel between the decision to invest in such a protective activity and the purchase of insurance.

For the purposes of this exposition assume that t is treated as the same length of time as an insurance policy so the analogy with the previous example holds. In this case one can trace out a curve showing the "willingness to pay" for an air bag as a function of the reduction in the probability of an accident. One simply finds the value of P where the utility of no protection exactly equals the utility of protection.

B. An Illustrative Example

Figure 8 depicts the "willingness to pay" curve for the same parameters as in the prototype example: $X=40$, $\Phi_H=.3$, $\Phi_L=.1$, so that the reduction in the probability of an accident is .2. As before the utility function of the consumer is $U_i=-e^{-cw}$ where $c=.04$. As seen in Figure 8, the consumer is willing to pay as much as $P^*=11.2$ for protection even though the expected loss (i.e., the fair insurance premium) is $(\Phi_H-\Phi_L)\,X=8$. Cook and Graham refer to this difference

of 3.2 as the pure protection benefit of the investment in air bags. It is the amount of money over and above the fair insurance premium necessary to compensate the individual for his life.

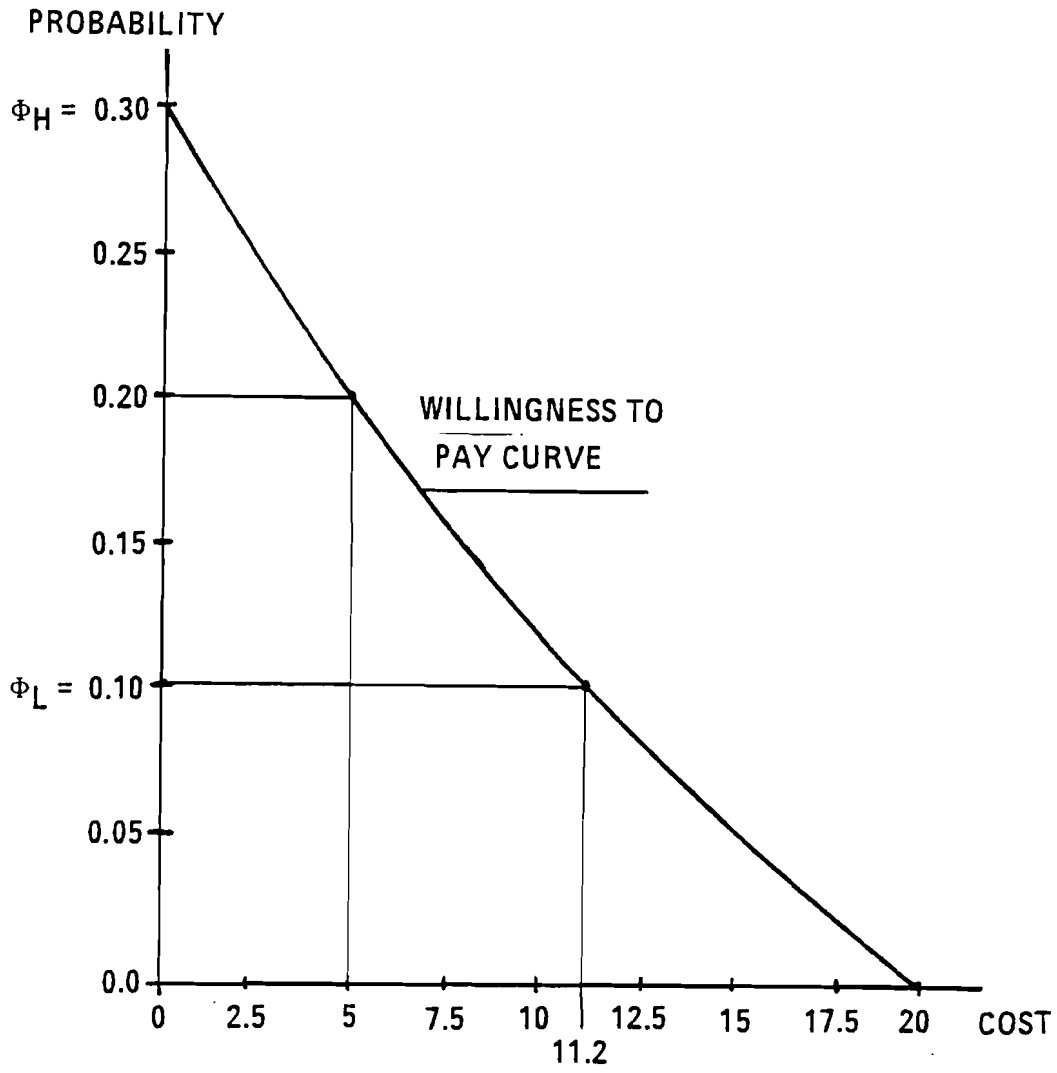

Figure 8. Willingness-to-Pay Curve as a Function of Reduction in Probability of Accident.

In this example, this differential is due to the degree of risk aversion of the individual since one has already defined the "value of a life" to be X=40.

Suppose, on the other hand, that one had information that an individual would pay as much as P^* for an air bag based on certain estimates of Φ_H and Φ_L as well as a known utility function. Then one could use the same analysis to determine the value of X where this person would be indifferent between buying and not buying protection. This could then be interpreted as a "value of human life".

The above analysis enables us to determine how misinformation on the risk impacts on the maximum an individual is "willing to pay" for protection. If, for example, Φ_H=.3 and Φ_L=.2, then a person will pay no more than P=5 for installing an air bag. Thus if consumers undervalue the benefits of protection due to imperfect information they will have a lower critical value P^* for determining whether or not they will avail themselves of protection.

There may be more serious problems than misinformation on probabilities which discourage the purchase of protective mechanisms. As indicated in the previous section, individuals are likely to use a set of simplifying heuristics which will have an important impact on their decision process. A critical threshold, for example, where consumers ignore the consequences of an accident if they feel the probability of its occurrence is less than φ^* would cause a group of consumers *not* to even consider the option of buying air bags, no matter how high they valued their life. Those who did not consider protective options because of *budget constraints* would be influenced solely by the price of the product rather than the benefits and cost tradeoffs depicted in Figure 8. Finally, if the decision was made on the basis of a *premium/loss ratio* then air bags should look extremely attractive at even a high price if the consumer interpreted the loss to be the saving of his life. The actual decision process by consumers is likely to be based on some combination of the above types of heuristics coupled with exogenous factors such as past experience (in this case, previous car accidents) and discussions with friends and neighbors.

C. Welfare and Policy Implications

What are the welfare and policy implications of different prescriptive measures for dealing with the apparent lack of interest in air bags by both consumers and automobile manufacturers? As in the flood insurance example, consumers should be provided with accurate information on the value and costs of these devices. Frequently individuals focus on the negative aspects of protective mechanisms without adequately understanding its advantages.[18]

This problem is exacerbated if there are conflicting views among interested parties revealing disagreement among experts. For example, in March 1980, *Reader's Digest* published an article on "Who Needs Air Bags?", which highlighted the deficiency of air bags—that it protects occupants in frontal crashes and not in side or rollover crashes without pointing out that occupant restraints of any kind play only a secondary role in these types of crashes. In a letter to the *Reader's Digest*, Joan Claybrook, head of the National Highway Traffic Safety Administration (NHTSA), pointed out these misrepresentations but the damage in negative publicity for these devices may already have been done. Automobile manufacturers and dealers have voiced their concern about air bags by claiming that their installation would increase product liability claims because occupants would charge that the device was inflated too soon, too late, or not at all in a crash. The NHTSA claimed this was not the case (Claybrook 1980).

The insurance mechanism could help resolve this above controversy. If insurance firms are willing to provide product liability coverage to automobile companies against lawsuits from charges that air bags are defective, then this provides an economic barometer of the expected risk and costs of the malfunctioning of this protective measure. On the demand side, consumers can be informed of the potential benefits of air bags by a lower insurance premium on their automobile policies. Today at least one insurance company offers a 30

percent reduction in premiums on medical payments, no-fault or extended benefits coverages if a person has an automatic seat belt (i.e., seat/shoulder belts that automatically restrain you when the door is closed) or an air bag. Whether the dollar savings in premium is sufficiently attractive to the consumer to induce her to voluntarily purchase a car with an air bag is an open question which should be investigated.

If one evaluates the welfare implications of alternative prescriptive measures, the question of *ex ante/ex post* valuations rears it head again. Kleindorfer and Kunreuther (1980) present an example illustrating the impact of misinformation by considering two alternative policies—mandatory vs. optional installation of air bags by car manufacturers. Suppose that a consumer underestimates the probability of a dangerous accident or its consequences on an *ex ante* basis so that he is not willing to incur the extra costs of protection. Furthermore assume that only after an accident does the individual learn about the real advantages of air bags and the probability of severe accidents. On the basis of these data and his past experience he is now willing to pay considerably more for this protection than before.

The proposed regulatory standards requiring the installation of air bags in cars implicitly assume that consumers underestimate the chances and consequences of car accidents and hence do not demand automatic protection. Requirements that all new cars be equipped with air bags reflects the feeling that consumers would prefer to have someone else make the decision on protection for them. Such a requirement would also penalize those drivers who regularly wear a seat belt and do not want to pay the extra money for having an air bag installed in their car. Whether this type of action is an appropriate step is thus likely to produce different reactions by interested parties.

A recent survey commissioned by the *N.Y. Times* clearly reveals the type of

conflicts likely to emerge. In response to a question "Would you favor or oppose requiring car manufacturers to equip all new cars with air safety bags?" approximately 45% of licensed drivers favored the regulation, 32% were opposed. When retail automobile dealers were asked the same question 93% were opposed to such a requirement (Insurance Institute for Highway Safety 1980). If these results are indicative of the general population of consumers and suppliers then this suggests that market mechanisms are not likely to encourage manufacturers to install air bags and that economic incentive systems such as insurance premiums should supplement regulations to encourage consumers to protect themselves against these low probability—high consequence events.

D. Future Research Questions

The following broad research questions present themselves here:

(1) How do consumers evaluate protective measures which affect their personal lives? Do they behave differently with respect to these actions than in their insurance decisions against personal property losses?

(2) What are the decision processes which firms utilize in introducing new protective innovations where there is no tangible return to the consumer unless an accident occurs?

(3) What is the role of incentives and regulatory actions when there are conflicts among the interested parties and there may be differences between *ex ante/ex post* views of the situation?

VI. SUMMARY AND CONCLUSION

This paper began by citing three examples where empirical data revealed that the market did not provide consumers with adequate or equitable protection against low probability events. The analysis which followed revealed that markets do not perform well in these cases because of information imperfections by consumers and/or firms.

In the case of automobile insurance firms frequently use experience rating to differentiate between drivers with different loss records. This process enables them to make monopoly profits because other firms do not have access to this information. The inability of firms to classify drivers with perfect accuracy also means that low risk individuals subsidize those in the high risk group.

In the case of flood insurance consumers have not voluntarily purchased highly subsidized rates because they either underestimate the probability of a loss and/or they utilize decision processes which rely on factors other than tradeoffs between costs and benefits. As a result the public sector has provided uninsured victims with liberal relief following a catastrophic disaster.

The air bag example shows that consumers may not demand protection against accidents which may involve serious injury or loss of life because they are more concerned with the cost of protection rather than evaluating the potential benefits of reducing the chances of a severe accident. Similarly automobile manufacturers and dealers prefer to maintain the status quo rather than adding protective features to their product which will raise its price.

Proposed prescriptive measures for coping with the problems of protection against low probability events should address these descriptive findings. What is the role of presenting information to consumers so they better appreciate why one may want to take preventive measures before a disaster occurs rather than

regretting not having done so after it is too late? Are there economic incentives which can aid in this process? What is the appropriate place of regulation in coping with problems of market failure?

There are no easy answers to these questions. What has become clear is that people do not do a good job in collecting and processing information regarding low probability-high consequence events. We must accept this empirical observation and incorporate it into our theory. This paper represents a small step in this direction. Considerably more work is needed in the future.

NOTES

1. The early history of flood insurance sheds some light on the reasons why companies have been reluctant to market policies. In 1897 an insurance company in Illinois offered flood coverage to property owners residing along the Mississippi and Missouri Rivers. Two severe floods in 1899 created catastrophic losses for the company, even washing away the home office. In the mid-1920's some insurance companies again attempted to market flood policies but severe flooding in 1927 and 1928 discouraged all responsible companies from continuing this coverage (Manes, 1938, p.161).

2. The theme of imperfect information and its effects on individual and market behavior has played an important role in recent literature in economics (Arrow 1963; Akerlof 1970;; Williamson 1975; and Thaler 1980), as well as in psychology (Tversky and Kahneman 1974; Slovic, Fischhoff and Lichtenstein 1977; Slovic 1978; Kahneman and Tversky 1979; Einhorn and Hogarth 1981).

3. For a more detailed discussion of the problems of moral hazard and its impact on insurance purchase decisions see Shavell (1979).

4. The material in this section summarizes recent research by Mark Pauly and myself. A more detailed discussion appears in Kunreuther and Pauly (1980).

5. The above problem has been examined by Rothschild and Stiglitz (1976), Spence (1978) and others in the context of static market equilibrium. These analyses assume that firms market price-quantity pairs of insurance contracts as a way of differentiating between high and low risks in contrast to the assumption here, similar to Pauly (1974), that firms set a price per unit of coverage without restricting the amount which any group can purchase.

6. A more detailed description of the practice of experience rating followed by firms in the U.S. appears in a detailed report of current practices by the insurance industry undertaken by the Stanford Research Institute (1976).

7. This assumption is equivalent to assigning an equal weight to the high and low risk groups in computing expected profit so that a meaningful comparison can be made with Figure 3. If the high risk group has a larger relative weight, then the resulting premium will also be higher.

8. The low risk group could have had such a small probability of an accident that its demand for insurance could have shifted sufficiently downward that the only premium yielding zero expected profits would have been at P_0"=.30. In this case the high risk group would pay the actuarially fair premium and the low risk group would not have demanded any coverage, a case of adverse selection.

9. Consumers are assumed not to have any search costs. If they had, then informed firms could capitalize on this transaction cost by charging even higher premiums than the ones specified above.

10. See MacAvoy (1977) for a description of the different types of regulatory systems and comparisons of the performance of the insurance industry in a highly regulated state (e.g., New Jersey) and one in which open competition prevails (e.g., California).

11. Consumers who overestimate Φ_{Ht} will purchase full coverage since they perceive the premium to be subsidized.

12. It is interesting to speculate whether protective decisions are viewed by individuals as having multiple attributes such as reducing anxiety, social norms, in addition to monetary tradeoffs. The sequential model of choice suggests one way of dealing with this problem. An alternative approach would be the method of preference trees proposed by Tversky and Sattath (1979) for describing the purchase of consumption goods such as automobiles or choosing a meal in a restaurant.

13. This *ex ante* behavior on the part of consumers is particularly interesting in light of the reluctance by victims to collect on a policy if the loss is relatively small. For example, an individual with a $50 deductible who suffers a $75 loss from an automobile accident may be reluctant to collect the $25 because of the processing costs as well as the fear that his insurance rates will be raised the next year. It would be interesting to confront him with this action and inquire why he did not initially take out a $100 deductible or whether he plans to do this on renewing his policy.

14. Empirical evidence on this point respect to insurance decisions and other choices under risk has been presented in a number of recent studies including Payne (1976); Fischhoff, Slovic, and Lichtenstein (1978); Grether and Plott (1979); Schoemaker and Kunreuther (1979); Hershey, and Schoemaker (1980); Schoemaker (1980) and Tversky and Kahneman (in press).

15. Proposed Congressional legislation would have required air bags in all large cars starting with the 1982 model year; the standard would have been extended to medium-sized cars in 1983 and small cars in 1984. This bill was defeated during the summer of 1980 so that the future status of air bags in cars is in doubt.

16. The problem is formulated in this way for consistency with the earlier example and the literature on the value of human life (see Linnerooth 1979). An alternative is to assume that the probability of an accident remains the same but that the consequences are reduced from a high loss X_H (e.g., loss of life) to a lower loss, X_L (e.g., some cuts and bruises).

17. To avoid complicating the analysis assume that the consumer intends to keep the car for its entire lifetime. Alternatively one can assume that the resale or salvage value of the car is independent of the installation of the air bag. Should the air bag have any intrinsic value at the time of selling a car this amount appropriately discounted would be subtracted from P in determining the cost of this protective measure.

18. In Holland, for example, many drivers refuse to wear seat belts because of a concern with being trapped in their cars should it accidentally be pushed or driven into a canal.

REFERENCES

Akerlof, G. 1970. "The market for 'lemons': Quality uncertainty and the market mechanisms. *Quarterly Journal of Economics*, 84:488-500.

Arrow, K. 1963. "Uncertainty and the welfare economics of medical care." *American Economic Review* 53:941-973.

Bernstein, G.K. 1972. testimony before the U.S. Senate Subcommittee on Housing and Urban Affairs, 92nd Congress, S.2794. A bill to amend the National Flood Insurance Act of 1968 to increase flood insurance coverage of certain properties, to authorize the acquisition of certain properties and for other purposes, Washington, D.C.: Government Printing Office.

Claybrook, J. 1980. "Letter to Reader's Digest," in *Insurance Institute for Highway Safety Status Report*, April 15, 1, pp.6-7.

Cook, P., and D. Graham. 1977. "The Demand for Insurance and Protection: The Case of Irreplaceable Commodities," *Quarterly Journal of Economics*, 91:143-56.

Cyert, R., and J. March. 1963. *A Behavioral Theory of the Firm*, Englewood Cliffs, New Jersey: Prentice-Hall.

Einhorn, H., and R. Hogarth. 1981. "Behavioral Decision Theory: Processes of Judgment and Choice". *Annual Review of Psychology*. (forthcoming).

Fischhoff, B., P. Slovic, and S. Lichtenstein. 1978. "Fault trees: Sensitivity of estimated failure probabilities to problem representation." *Journal of Experimental Psychology: Human Percept. Performance*, 4:330-44.

Fischhoff, B., P. Slovic, and S. Lichtenstein. in press. "Lay Foibles and Expert Fables in Judgments about Risk," in T. O'Riordan and R.K. Turner (eds.), *Progress in Resource Management and Environmental Planning*, Vol. 3, Chichester: Wiley.

Grether, D.M. and C.R. Plott. 1979. "Economic theory of choice and the preference reversal phenomenon." *American Economic Review*, 69:623-38.

Hershey, J.C., and P.J.H. Schoemaker. 1980. "Risk Taking and Problem Context in the Domain of Losses: An Expected Utility Analysis." *The Journal of Risk and Insurance*, 47:111-132.

Insurance Institute for Highway Safety. 1980. "Consumer Survey Finds Strong Support for Air Bags" Status Report No. 15:p.2 August 6th.

Kahneman, D., and A. Tversky. 1979. "Prospect theory: An analysis of decision under risk." *Econometrica* 47:263-291.

Kleindorfer, P., and H. Kunreuther. 1980. "The descriptive and prescriptive aspects of health and safety regulation." in *Benefits of Health and Safety Regulation*. J.H. Behn and A. R. Ferguson, eds., Cambridge, Mass.: Ballinger.

Kunreuther, H. 1973. *Recovery from Natural Disasters: Insurance or Federal Aid*. Washington, D.C.: American Enterprise Institute.

Kunreuther, H., R. Ginsberg, L. Miller, P. Sagi, P. Slovic, B. Borkan, and N. Katz. 1978. *Disaster Insurance Protection: Public Policy Lessons*. New York: Wiley.

Kunreuther, H. and Pauly, M. 1980. "Equilibrium in Insurance Markets with Experience Rating" (mimeo)

Linnerooth, J. 1979. "The Value of Human Life: A Review of the Models," *Economic Inquiry* 17:52-74.

MacAvoy, P. (ed.). 1977. *Federal- State Regulation of the Pricing and Marketing of Insurance*. Washington, D.C.: American Enterprise Institute.

Manes, A. 1938. *Insurance: Facts and Problems*, New York: Harper.

Pauly, M. 1974. "Over Insurance and Public Provision of Insurance: The Roles of Moral Hazard and Adverse Selection." *Quarterly Journal of Economics*, 88:44-62.

Payne, J.W. 1976. "Task complexity and contingent processing in decision making: An information search and protocol analysis." *Organ. Behav. Hum. Performance*, 16:366-87.

Readers Digest. 1980. "Who needs air bags?," *Readers Digest*, March.

Rothschild, M., and J. Stiglitz. 1976. "Equilibrium in competitive insurance markets: An essay in the economics of imperfect information." *Quarterly Journal of Economics*, 90:629-649.

Schelling, T. 1978. *Micromotives and macrobehavior.* New York: Norton.

Schoemaker, P.J.H. 1980. *Experiments on Decisions Under Risk: The Expected Utility Hypothesis.* Boston, Mass.: Martinus Nijhoff Publishing Co.

Schoemaker, P.J.H., and H. Kunreuther. 1979. "An Experimental Study of Insurance Decisions," *The Journal of Risk and Insurance*, 46:603-618.

Shavell, S. 1979. "On Moral Hazard and Insurance," *Quarterly Journal of Economics*, 92:540-562.

Slovic, P. 1978. "The Psychology of Protective Behavior," *Journal of Safety Research*, 10:58-68.

Slovic, P., B. Fischhoff, and S. Lichtenstein. 1977. "Behavioral decision theory," *Annual Rev. Psychol.*, 28:1-39.

Slovic, P., B. Fischhoff, S. Lichtenstein, B. Corrigan, and B. Combs. 1977. "Preferences for Insurance Against Probable Small Losses: Insurance Implications," *The Journal of Risk and Insurance*, Vol. 44.

Spence, M. 1978. "Product differentiation and consumer choice in insurance markets." *Journal of Public Economics*, 10:427-447.

Stanford Research Institute. 1976. *The Role of Risk Classifications in Property and Casualty Insurance: A Study of the Risk Assessment Process.* Menlo Park, California: Stanford Research Institute.

Thaler, R. 1980. "Toward a positive theory of consumer choice." *Journal of Economic Behavioral Organization*, 1:39-60.

Tversky, A., and D. Kahneman. 1974. "Judgment under certainty: Heuristics and biases," *Science* 185:1124-1131.

Tversky, A., and D. Kahneman. in press. "The Framing of Decisions and the Rationality of Choice," *Science*, (forthcoming).

Tversky, A., and S. Sattath. 1979. "Preference Trees", *Psychological Review*, 86:542-73.

Williamson, O. 1975. *Markets and Hierarchies.* New York: The Free Press.