A Note on Decision-Making Under Uncertainty

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By introducing considerations of probability, an attempt can be made to extend the economic theory of choice to conditions involving uncertainty. The heroic assumption must be made that the situations to be modeled are such that it is valid and useful to utilize the theory of probability. This has given rise to discussions concerning subjective probability and a large literature on probabilistic preferences and the theory of utility. Problems concerning gambling and risk preference have been examined, and several alternatives for optimal behavior have been suggested. For example, Savage has offered a man who wishes to minimize regret. In other words, after the event, when he looks back, he wishes to have acted in such a manner that he will be least sorry concerning the outcome.

Bayesian and "maximin" principles[1] have also been suggested as manners in which the individual should cope with lack of knowledge. The simple examples given here illustrate the behaviors manifested in following these different principles. In Figure 1 a simple 2 x 2 payoff matrix is presented. The decision maker must choose between one of two actions, knowing that "Nature," or the environment, may also make a choice, which affects him. For example, if both select their second alternative, the payoff is 7 to the decision-maker. The principle he follows will depend upon his view of the forces and motivations present in his environment.

FIGURE 1

"Nature"

The Decision-maker

	1	2
1	1	9
2	2	7

The Bayesian assumption says that all the actions of "Nature" are equiprobable, and thus the optimal behavior under this assumption will be to select the first alternative, with an expected payoff of:

$$1/2 \,(1) + 1/2 \,(9) = 5.$$

The maximin assumption has the decision-maker believe that the environment is "out to get him." In this case he will select his second alternative, assuming that, since the worst will happen, he can at least guarantee 2 for himself.

FIGURE 2

"Nature"

The Decision-maker

	1	2
1	1	0
2	0	2

The "regret payoff" is illustrated in Figure 2 for the same situation. If he selected his second alternative and the environment did likewise, he would obtain 7 (Fig. 1) but could have obtained 9 (by selecting his first alternative); hence his regret is 2.

Shackle has constructed a "potential surprise function" which he feels dominates many major decisions, which must be made in face of uncertainty, which cannot be adequately portrayed by considerations of probability. All the methods noted above depend upon assumptions as to how to deal with uncertainty. Which is the "best" assumption depends upon the application and knowledge of human behavior.

In spite of the limitations of models of probability, operations research and industrial statistics have, however, flourished by applying normative models of economic man acting under probabilistically portrayed uncertainty. Theoretical models of inventory, sequential sampling and various queuing problems have been actively applied. These have already influenced the inventory levels of the whole economy and have had an effect on the understanding of reliability and risk in areas as diverse as individual credit risks, quality control in production, and stockpiling for emergency.

One area in which the applications have been fewer but the implications deeper is that of dynamic programming. This methodology deals with situations where at each period the decision maker chooses an action which influences a sequence of events stretching off into the possibly indefinite future. In subsequent periods he has the opportunity to modify the effects of previous decisions by current action. Although this theory still deals with statistical uncertainty and mathematical expectations, the rules of decision generated as dynamic program solutions have more of the flavor of over-all long-range strategic decisions. Dividend and investment policies can be studied as dynamic programs. However, the mathematics of functional equations used in dynamic programming is, unfortunately, difficult and still relatively underdeveloped.