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PSYCHOLOGICAL RESEARCH ON DECISIONS UNDER UNCERTAINTY: IMPLICATIONS FOR AGRICULTURAL ECONOMICS

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Introduction

The popular view of psychology seems to be that the discipline is concerned with three issues--sex as a determinant of behavior, learning theory as exemplified by rat mazes, and an ever expanding myriad of counseling methods and programs related to overcoming various psychological problems. If these three areas were the total content of psychology, this paper would not have a purpose other than perhaps to titillate the audience with considerations of the risk associated with sex and/or to consider the usefulness of alternative counseling programs to overcome pathological risky behavior such as playing Russian roulette. The content of psychology, however, is much broader than these three issues. In particular, development of expected utility and subjective probability theories by mathematicians, statisticians and economists simulated considerable psychological research on risky decision making. Earlier survey articles on this research were provided by Edwards (1954, 1961); subsequent extensive surveys include Kogan and Wallach and Slovic, Fischhoff and Lichtenstein. The interdisciplinary origins of this research have recently been reemphasized; psychologists concerned with decision making often publish in statistical and economics journals. This recent psychological literature has begun to be recognized by agricultural economists. Prominent examples include the textbook by Anderson, Dillon, and Hardaker and papers presented at the 1976 CIMMYT Conference (Roumasset, Boussard, and Singh). More detailed consideration of this psychological research may be helpful to agricultural economists.

Rather than reviewing all of the psychological literature on risk, this paper considers selected areas which the authors judge may be most interesting to agricultural economists. Emphasis is placed on recent research by cognitive psychologists on probability judgments. For the uninitiated, some consideration of the content of cognitive psychology may be helpful. In an article written for statisticians, Hogarth delineated cognitive psychology as follows:

> ...cognitive psychology...may be taken to encompass the study of perception, problem solving, judgmental processes, thinking, concept formation and human information processing in general. This activity has been directed toward understanding the mechanisms by which man confronts and interprets the stimuli with which he is faced and has also particularly sought to specify his abilities and limitations as an information processing system (p. 272).

Actually many agricultural economists have been introduced to cognitive psychology since the behavioral theory of the firm was greatly influenced by principles derived from cognitive psychology (Simon).

The purpose of this paper is to present selected literature from psychology which describes how individuals make probabilistic judgments. Particular issues emphasized are cognitive biases, or heuristics, used in probabilistic decisions, the implications of cognitive biases for agricultural economics methodologies for optimal risky decisions, and prospect theory, a revision of expected utility theory to accommodate cognitive biases. A central proposition of this paper is that the psychological literature raises serious questions concerning the usefulness and validity of elicitation of utility functions and subjective probability distributions for optimal decisions under uncertainty. Other agricultural economists have recently expressed similar propositions (Young; Roumasset). The psychological literature provides further evidence to support such propositions.

Cognitive Biases

Decisions under uncertainty involve probability judgments about the likelihood of future occurrences. Observation of events over time provides the basis for these judgments. In order to make a judgment, one must first observe the relevant events, make inferences about relationships, then make judgments about the probability of future events. Even though this seems a perfectly rational approach, recent work by psychologists has shown that certain cognitive biases may affect how information is processed and utilized. These biases, or heuristics, systematically affect how people perceive events, store them in memory, and retrieve them for future use. Thus, decision makers may base judgments on biased information. Three heuristics which have been identified are representativeness, availability, and anchoring (Tversky and Kahneman, 1974).

Representativeness refers to the degree to which an event resembles its population. When using this heuristic the person judges the probability of an event by how much it (1) is similar in essential features to the parent population, and (2) reflects the process by which it is generated. Similarity to the parent population is most easily explained by using one of Kahneman and Tversky's examples. People are first given this description: "All families of six children in a city were surveyed. In 72 families the exact order of births of boys and girls was GBGBBG" (Kahneman and Tversky, 1972, p. 432). Then they are asked to estimate the number of families in which the exact birth order was BGBBBB. The two birth sequences are not equally representative: The first contains three girls and three boys, while the second contains only one girl and five boys. The latter sequence does not reflect the proportion of boys and girls in the parent population. Most people judge the latter sequence--BGBBBB--as being much less likely, even though the two sequences have the same probability of occurrence.

In addition to reflecting the parent population, uncertain events are viewed as the outcome of uncertain processes and therefore should appear to be random. The two general features which seem to characterize randomness are irregularity and local representativeness. For example, in a series of fair coin tosses an outcome of HTHTHT, which is regular, is judged much less likely than an outcome of HTTHTH, which is irregular and therefore appears to be more random. Local representativeness can be described as a belief that the law of large numbers applies to small numbers as well; people presume that the essential characteristics of a parent population should be present not only globally in a large sample, but also locally in each component of the sample (Kahneman and Tversky, 1972).

The use of representativeness in making probability judgments can lead to errors since probability and representativeness may not be influenced by the same factors. For example, in probability judgments, base-rate information should be considered, but representativeness may be used instead. In studies where people are given a description of a person, then asked to guess the person's occupation, the tendency is to use the personality charcteristics rather than objective information about occupation frequency in making the judgment. In fact, the frequency of the occupation in the population is a better piece of information to use.

Another potential error is in the lack of sensitivity to sample size. The representative heuristic is often used when people are asked to evaluate the problem of obtaining a particular result in a sample drawn from a population. When representativeness is used to make a judgment on a sample statistic, the judgment will be essentially independent of the sample size, because of the similarity--or representativeness--of a sample statistic to a population parameter does not depend on the size of the sample (Tversky and Kahneman, 1974).

A second heuristic which is used in making decisions in uncertain situations is availability, or the ease with which relevant instances come to mind. The strength of a relationship between two events influences availability which in turn affects judgment of frequency. In some cases, this process may give an entirely accurate picture of reality since frequent events are usually easier to recall. However, other factors influence availability and may lead to erroneous conclusions about the frequency of events (Tversky and Kahneman, 1973).

Bias in availability may occur in the initial sampling of events, in storage, or in recall. Factors which may influence initial sampling include the emotional or personal relevance of the event, the imaginability or concreteness of the event, the ordering of occurrence, and the salience, extremity, and severity of the event. In addition, events which actually occur are more likely to be noticed than non-occurrences.

Events are more easily stored in memory and are easier to recall if they can be linked with information already stored, and if the information can be coded verbally and in terms of a "mental picture" (Nisbett and Ross).

For example, a farmer may overestimate the frequency of dry years, because of the emotional and financial impact of this event. This may be especially true if a dry year has recently occurred. Another example would be in the area of equipment breakdowns. Each time a piece of machinery needs repairs, the farmer loses time and must make a decision about "repair" or "replace" or "get by without." Thus the event--machinery breakdown--is likely to be attended to, remembered and easily recalled. Non-occurrences of breakdowns--the number of times when such breakdowns might occur but do not--are not as likely to be remembered. When asked about the frequency of machinery breakdowns a farmer may then overestimate their occurrence and possibly their severity.

Just as the frequency of a single item can be overestimated, so can the occurrence of pairs of items be overestimated. If two items tend to have a high degree of association, this strength of association may be used to assess the frequency with which the pair occurs. This bias, termed illusory correlation, (Chapman and Chapman) is explainable in terms of the availability heuristic. Two items which are highly related will tend to be stored in memory together and thus retrieved together. However, the phenomena of illusory correlation may cause a person to see a relationship when none exists. For example, if the farmer sees many advertisements that link Fertilizer A with a high yield, he may develop an association between Fertilizer A and high yield on the basis of this exposure. When asked about the actual frequency of high yields derived from Fertilizer A, the farmer may therefore be more likely to overestimate the frequency of this occurrence. (This example is an extrapolation from Chapman and Chapman's work. No data exist which support the above example, but it would make an interesting research problem.)

A third bias, known as anchoring, may also affect probability judgments. An initial value, either given or computed, is taken as the starting point and additional judgments are made in terms of this point. Estimates depend on this starting point and tend to be biased toward it. Although some adjustment may be made, it is typically insufficient (Tversky and Kahneman, 1974).

Elicitation Methodologies

The cognitive biases discussed in the previous section suggest that human beings will not perform very well in elicitation paradigms and that such methodologies will yield unreliable utility functions and subjective probability distributions. Subjective probability distributions will likely reflect all three heuristics. Since utility functions are usually elicited with abstract examples, the impact of the biases may not be as readily apparent. However, it is plausible that the income or wealth levels used in the elicitation will be related to past concrete events stored in memory. Therefore, elicited utility functions will also reflect the heuristics. This section presents two sets of research results which support the view of weaknesses in elicitation methodologies. The preference reversal phenomena, which has direct implications for elicitation methodologies, is considered first. Then, the ability of people to overcome their statistical biases is considered.

Preference Reversal Phenomena

The preference reversal phenomena was first reported in 1971 (Lichtenstein and Slovic) and has subsequently been replicated several times, most recently by economists (Grether and Plott). While the paradigm is not equivalent to those used in the elicitation methodologies, the implications of this phenomena should receive serious consideration, since it is possible that the same results could be obtained from elicitation.

The phenomena relates to choices between two lotteries, A and B. These lotteries have two payoffs, zero and a positive amount, and can be characterized by ($\$_1$, P_i) where $\$_1$ is the positive payoff and P_i is the probability of $\$_i$ being obtained. In the lotteries, $\$_A < \$_B$ and $P_A > P_B$. The experiments which yield preference reversals involve two steps. One step determines the subject's preference between the lotteries, while the other step determines the subject's reservation price to sell the lotteries, $\overline{\$_A}$ and $\overline{\$_B}$.

Grether and Plott note that expected utility theory would imply that $\overline{\$_A} > \overline{\$_B}$ if A is preferred to B. This prediction follows from noting that $\overline{\$_i}$ are certainly equivalents such that individuals are indifferent between $\overline{\$_i}$ and ($\$_i$, P_i). By transitivity, $\overline{\$_A} > \overline{\$_B}$ if A is preferred to B. However, a large proportion of people violate this prediction in all the experiments. The implications of these results are obvious. Certainty equivalents need not have any relationship to preferences for a lottery.

Persistence of Biases

Readers strongly committed to statistical decision theory will likely suggest that these biases can be overcome. For example, Anderson, Dillon, and Hardaker conclude a short discussion of heuristics with the view that more research is necessary to determine necessary adjustments to elicitation methodologies to minimize these biases (pp. 19-21). In a discussion of a paper by Tversky before the Royal Statistical Society, D. V. Lindley took a stronger position: "Why do you spend your time studying how people make decisions, when we know how they should make decisions? Would it not be better to devote your energies to teaching them the principles of maximum expected utility?" (Emphasis in the original) (p. 181). This section reviews some evidence on this issue.

Statistical training and/or experience is useful in overcoming the cognitive biases. Tversky and Kahneman (1974) note that statistically sophisticated researchers do not commit some of the statistical fallacies but still tend to use some of the heuristics. A study by Winkler explicitly considered the effect of statistical training in ability to assess personal probability distributions. The experiments involved three sets of subjects at the University of Chicago: (1) Graduate business students with only an introductory course in statistics, (2) Graduate business students with a minimum of a course in business statistics which emphasized Bayesian methods, and (3) Ph.D. candidates and a professor in statistics. Not surprisingly, Winkler concluded that the performance of the third group was much superior. However, little difference existed between the first and second groups. Hogarth reviews several studies that compare statistical abilities of statisticians with substantive experts. In these experiments, weather forecasters tend to demonstrate as much statistical expertise as statisticians. Hogarth suggests that this result can be explained by the constant feedback on prediction which weather forecasters receive. As Tversky and Kahneman (1974) note, the experiences of most people do not provide the feedback to allow learning the appropriate statistical rules.

These findings are not promising with respect to the abilities of farmers to meaningfully use statistical concepts for elicitation processes. Obviously, very few, if any, farmers possess advanced graduate study in statistics. In addition, farm management is not likely to provide the feedback or training to overcome use of heuristics. While farm managers must make many probabilistic decisions due to the risks inherent in agriculture, the sequential production process does not provide constant feedback as in the case of weather forecasters. For example, observations on yields are typically only received once a year, at harvest while yield forecasts had to be formed before planting.

Prospect Theory

Early psychological research on risk tended to focus on evaluation of normative expected utility theory as a descriptive model of human behavior with most findings being negative. Recently revised theories of human behavior are being advanced (Slovic, Fischhoff, and Lichtenstein). This section reviews one of these theories, prospect theory, developed by Kahneman and Tversky (1979), which may be of interest to agricultural economists. Prospect theory is quite new and has been subjected to limited testing. However, it is consistent with the results of research which contradicts expected utility theory.

Prospect theory includes two sequential stages in a decision process, editing and evaluation. Editing has the function of reducing the options and/or organizing them for ease of evaluation. Some forms of editing involve each prospect separately while others apply to sets of prospects. Editing single prospects includes coding, combination, and segregation. Coding involves converting the prospect to gains and losses from a reference point, usually the current position. Combination involves combining possibilities with identical outcomes. Segregation involves separating the risky component from the sure component. Editing sets of prospects involves cancellation, simplification, and detection of dominance. Cancellation involves elimination of components with equal outcomes and probabilities shared by prospects. Simplification involves rounding of outcome values and/or probabilities including discarding uncertain outcomes. Detection of dominance involves eliminating prospects which obviously have inferior outcomes in all situations.

After editing the remaining prospects are evaluated with the following equation:

$$(1) \quad V = \sum_{i=1}^{n} \Pi(p_i)\, v(x_i)$$

where V = value of prospect, $\Pi(p_i)$ = decision weight placed on outcome i, p_i = probability of outcome i being obtained, $v(x_i)$ = value of outcome i, x_i = measure of outcome i, perhaps dollars. The prospect which maximizes V is the desired choice. It can be noted that (1) is similar to expected utility theory, involving probability weights and value of each outcome. However, each of these major components differs from the components of expected utility theory.

The value function is similar to a utility function for gains and losses. However, Kahneman and Tversky (1979) postulate a particular form for the function. Individuals are risk averse for gains and risk seekers for losses, $v''(x) < 0$ for $x > 0$ and $v''(x) > 0$ for $x < 0$. In addition, a discontinuity exists at zero, $v'(x)$ is greater for $x < 0$ than $x > 0$.

The decision weights are related to subjective probabilities but are not required to follow the probability axioms. However, it is assumed to be a function of "objective" probabilities with $\Pi(0) = 0$ and $\Pi(1) = 1$. Outcomes with low p_i are overweighted, $\Pi(p_i) > p_i$. However, subcertainty is hypothesized for all outcomes, $\sum_{i=1}^{n} \Pi(p_i) < 1$. Thus, outcomes with p_i that are not small have $\Pi(p_i) < p_i$.

The differences between prospect theory and expected utility theory are considerable. These differences reflect the motivations for development of prospect theory. Prospect theory is not meant to be a normative framework, but a source of hypotheses for positive research on individual human behavior. Kahneman and Tversky do not expect that equation (1) would be empirically estimated because they also consider elicitation procedures unreliable (1979, p. 284). Rather, hypotheses concerning different prospects can be derived from this equation and subjected to empirical testing.

Implications for Future Research

The psychological literature discussed in this paper strongly supports the proposition that use of expected utility theory for normative firm research has doubtful validity. People are not good intuitive statisticians and available literature suggests that limited training in probability theory cannot overcome this difficulty. The implications for elicitation of preferences and subjective probability distributions are particularly serious.

Such a position does suggest a theoretical void in farm management research and extension. However, the use of a normative expected utility model has historically provided a limited role in farm management. Rather, much of farm management activity has concentrated on positive information to decision makers. The psychology literature does suggest reasons why this activity may be useful to farmers. With superior statistical training agricultural economists can presumably derive estimates that are not as subject to cognitive biases as those of farmers. These estimates allow farmers to evaluate their subjective estimates. Awareness of cognitive biases may also aid in identifying those forms of information which are most useful to the farmer, and the most effective presentation formats. These implications do not mean that economic theory should be purged from farm management research. Economic theory is useful in providing definitions of relevant economic concepts that concern producers; however, the expectation of normative use of the theory is unrealistic.

In the area of firm risk management, much research and extension has been consistent with this position. Because of the perceived difficulty, and limited applicability of elicitation methodologies, most activity has concentrated on information on risk in various activities rather than normative models. Most of the research has also been based on historical data. Despite the problems with objective data not necessarily representing the future (Anderson, Dillon, and Hardaker), such data provide a valid benchmark for producers to evaluate biased subjective expectations.

It must be stressed that psychology is largely concerned with individual behavior and the issues in this paper do not necessarily imply that expected utility theory is valid as a positive theory to predict aggregate behavior. Following Friedman, such a positive theory must abstract from various nuances of individual behavior. In a summary of psychological research on expected utility theory, Coombs supports the view that expected utility theory fulfills this methodological position: "In the work reported in this section, (expected utility) theory is found unacceptable as a descriptive theory of individual risky decision making, but it does provide a good approximation to data, which perhaps accounts for its viability in the face of persistent criticism." (p. 65). While exploration of the use of prospect theory as a source of aggregate hypotheses may be warranted, it is doubtful that it will aggregate as successfully as expected utility theory.

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