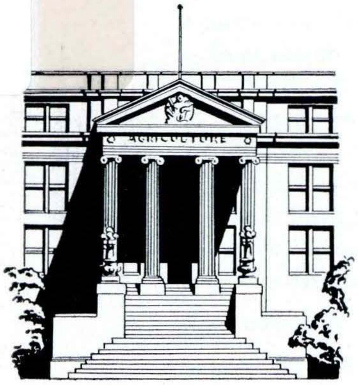

Theories of Choice In Relation to Farmer Decisions

by John L. Dillon and Earl O. Heady

Department of Economics and Sociology

AGRICULTURAL AND HOME ECONOMICS EXPERIMENT STATION
IOWA STATE UNIVERSITY of Science and Technology

RESEARCH BULLETIN 485 OCTOBER 1960 AMES, IOWA

CONTENTS

Theories of Choice In Relation to Farmer Decisions[1]

BY JOHN L. DILLON AND EARL O. HEADY

Farmers make decisions in an uncertain environment. Within a given year, weather and, consequently, yield are uncertain—even though more perfect knowledge exists relative to the mean, distribution and other statistics of yield over a period of years. Prices, especially for livestock where little government stabilization is provided, are particularly variable and give rise to difficulty of optimum choice. In addition to these main sources of uncertainty, many farmers are also faced with uncertainties stemming from personal and group relationships. An example of the latter is the length and conditions of tenure on rented farms.

Within this environment of uncertainty, farmers must make choices of the combinations of crop and livestock products to produce, the farm practices and resource mixes to employ, the scale of operations and capital investment and other decisions which lead to profits or losses. While the decision environment is highly uncertain, recommendations to farmers on physical practices and economic organization are often, and perhaps even typically, made as if the future were known with absolute certainty. Over the previous two decades, however, certain theories were developed which recognized the existence of uncertainty in economic choice. These theories generally supposed that subjective notions or expectations were formulated with respect to future events, and that decision makers formulated choices accordingly—using various precautionary measures to conform with the degree of uncertainty and their ability to withstand the risks attached to unfavorable outcomes. More recently, theories of choice have been developed which suppose much less knowledge, or subjective anticipation, of the probability of future events. These theories of choice, or models for decisions under absolute uncertainty, define strategies which can be used by decision makers when they assume meager or no knowledge about likelihood of outcome of alternative future events.

Some of the latter theories might have promise in application to decisions by farm managers (a) in the normative sense of explaining the types of decisions which *should be made,* relative to the particular goals of the farmer and his family and his decision environment as it affects the degree of conservatism in choices and (b) in a descriptive sense of explaining the methods and procedures used in making decisions when the outcome is uncertain. The purpose of this study is to examine decision models or choice theories as they might apply, in both senses, to choice of farmers.

Development and application of useful decision models could be of extreme importance to farming. Individual farmers typically make their own decisions without aid of a staff of assistants and with the full financial burden of outcomes falling upon themselves. Hence, if decision models which correspond to the decision environment (i.e., capital position, family responsibilities, degree of uncertainty, risk aversion and other characteristics conditioning the farmer's willingness to take chances in his choices) could be developed, they would cause research findings and educational recommendations to gain wider acceptance and greater application to the individual's situation. But for such choice theories to have practical application, they must correspond roughly to the procedure which farmers can and do use. Hence, this study has the twin objectives of (1) determining the degree of correspondence between the procedures farmers use in making decisions and various choice theories and (2) specifying situations in which farmers would be better off in using alternative models, as compared with the methods currently used.

This study is of general methodological nature. It is restricted to a particular set of decisions—namely, choices with respect to cattle feeding over the economic horizon of a single year. It also refers to a particular age, tenure and geographic strata of farm managers. It has been so restricted because it is an initial investigation relating formal choice theories to farmer decisions.

The discussion which follows refers to *Nature.* This term is used in the convention of game theoretic models. It refers not only to weather but also to other things, persons and groups which "serve as an opponent" of the farmer in causing his choices to have different degrees of success. Use of the term Nature thus eliminates the need for continued redefinition of the persons or things for which farmers must develop strategies in decisions.

[1] Project 1135 of the Iowa Agricultural and Home Economics Experiment Station.

THEORIES OF CHOICE UNDER UNCERTAINTY

Uncertainty prevails when the decision maker has no objective knowledge about the probability of occurrence of the various possible states of Nature. While he may know Nature's possible alternatives, he knows nothing about the probabilities of each event or alternative. In recent years, theories of decision making have been developed to treat such circumstances. Theories of Wald,[2] Savage,[3] Laplace[4] and Hurwicz[5] are examples and will be outlined first. The more general theories of decision making of Simon[6] and Shackle,[7] as they relate to absolute uncertainty, then will be described. The discussion which follows will be in terms of a generalized payoff matrix such as that shown later.

Decision Theories Specific to Problems of Uncertainty

The theories in this group have a number of common features. They are not general theories, but each provides a mathematical algorithm for selecting the best act or choice. The best act is defined tautologically as that selected by the algorithm. Also, they are rational theories to the extent of being mathematically well-defined and objective. The postulated algorithm in each case is precise and never leads, given the end of profit maximization and the decision maker's problem setting, to ambiguous selections under a given set of circumstances.

There are no *a priori* theoretical grounds for selecting one of these theories over another. The preferred algorithm depends on the decision maker's psychological make-up, judgement and problem setting. Hence, there is no single best mathematical procedure for solving a decision problem under uncertainty. An infinite number of algorithms are possible, but it is doubtful whether criteria more plausible than those discussed here are useful for normative analysis of empirical situations. Too, those explained are not so complex that it would be impossible for them to describe procedures of farm decision makers.

WALD CRITERION

The Wald, or maximin, criterion provides for selection of that act or strategy which has the maximum minimum payoff. A pure act refers to selection of a single course of action, such as planting a single crop variety or feeding only one kind of cattle. If a mixed strategy—the selection of a combination of alternatives such as feeding several classes of cattle—is permissible and if the payoff matrix has no saddle point, then that mixture of strategies should be chosen which has the maximum minimum expected payoff. A saddle point refers to a matrix of strategies and payoffs which specifies selection of a single course of action. This criterion is equivalent to treating the problem as a two-person zero-sum game as outlined by Heady and Candler,[8] a procedure that assumes that the worst possible result will occur. Hence, the maximum minimum refers to selecting the strategy or act, or mixture of these, which will minimize loss if we suppose that Nature will do its worst or which will provide the maximum profit outcome when it is supposed that Nature will cause losses to be the minimum possible. Since Nature actually is playing a passive role and not actively trying to defeat the decision maker, the Wald theory is extremely conservative. In a manner, the Wald criterion selects a set of strategies which will give the decision maker a given income with "smallest chance" attached to it.

SAVAGE CRITERION

This theory considers the regret that might be felt after the true state of Nature is known and it is realized that a larger payoff might have been obtained had a different choice been selected. The procedure provides a solution to minimize this regret. To this end a new payoff matrix, termed the risk or regret payoff matrix, is constructed from the actual payoff matrix $[a_{ij}]$. Each element, r_{ij}, of the regret matrix $[r_{ij}]$ is the amount that would have to be added to the original element a_{ij} in order to equal the maximum payoff in the jth column. Thus

$$(1) \quad r_{ij} = \max_j a_{ij} - a_{ij} \quad .$$

Where only pure acts may be selected, the Savage criterion specifies that act which minimizes the maximum regret. If the regret matrix has no saddle point and mixed strategies are permissible, that mixture of acts which minimizes the maximum expected regret is chosen. Like the Wald theory, the Savage criterion is conservative in assuming that the worst, the largest possible regret, will occur.

HURWICZ CRITERION

The Hurwicz criterion, sometimes known as the pessimism-optimism index, considers both the best and the worst payoffs for each act. It is of the following form as proposed by Hurwicz: Let β, a fixed number between 0 and 1, denote the decision maker's level of pessimism. With each act or course of action $A_i°$ associate the index $\beta \min_j a_{ij} + (1-\beta) \max_j a_{ij}$. That act should then be chosen which maximizes this index. If the decision maker has no optimism, then we have $\beta = 1$. The procedure then is equivalent to Wald's criterion. Thus the Wald theory is a special case of the Hurwicz theory.

[2] Wald, A. Statistical decision functions. Wiley and Sons, New York. 1950.

[3] Savage, L. J. The theory of statistical decisions. Jour. Amer. Stat. Assoc. 48: 238-248.

[4] Reported in Luce, R. D. and Raiffa, H. Games and decisions: introduction and critical survey. Wiley and Sons, New York. 1957. pp. 102-124.

[5] Hurwicz, Leo. Optimality criteria for decision making under ignorance. Cowles Commission Paper. No. 355. Chicago. (mimeo.) 1951.

[6] Simon, H. A. Models of man. Wiley and Sons, New York. 1957.

[7] Shackle, G. L. S. Expectations in economics. Cambridge University Press, London. 1949.

[8] Heady, Earl O. and Candler, Wilfred V. Linear programming methods. Iowa State University Press. Ames, Iowa. 1958. Ch. 14.

LAPLACE CRITERION

The Laplace prinicple of insufficient reason is the oldest of all the decision theories. It specifies that since information about the likelihood of occurrence of the various possible states of Nature is zero, the decision maker should act as though each of Nature's states has an equal chance of being the true state, the state to be realized. The expected utility associated with act $A_i°$ is therefore $\sum_{j=1}^{m} a_{ij}/m$ where m is the number of possible states of Nature. The act which has the largest expected utility should be chosen.

THE SAVAGE SUBJECTIVE PROBABILITY THEORY

Savage[9] has developed a second theory, not to be confused with his minimax regret criterion. The later theory shows how subjective *a priori* probabilities may be attached to the various states of Nature under absolute uncertainty. The later theory postulates that a complete preference ordering of all acts exists for the decision maker, apart from any consideration of the payoffs relevant to each act. Under these conditions, an optimal set of subjective probabilities could be attached to Nature's states. The decision problem then can be handled in subjective terms as a risk problem, provided only that the expected value of the payoff distributions are considered by the decision maker. It is a normative approach. A decision maker following this logic would base his choice on maximization of the expected utility of the consequences, such utility being derived not only from the payoff itself, but also from his preference for each course of action or act apart from its payoff. The Savage theory allows for the fact that utility need not be derived solely from money income.

THE SIMON THEORY OF THE SATISFICER

Simon[10] postulates that in complex situations of the real world, the decision maker simplifies the problem by considering not all possible alternatives but only some subset which is commensurate with his capabilities of solution. He also assumes that the decision maker behaves as a "satisficer," seeking a course of action that is "good enough," rather than as a "maximizer" seeking the best possible course of action: The decision maker has some aspiration level which he tries to attain. An act whose outcome may lie below this level is regarded as unsatisfactory. In a given situation there may be a number of satisfactory considered acts. The first one of these to be studied may or may not be accepted. So long as the chosen act meets the aspiration level of the decision maker, he is behaving in what Simon terms an intendedly rational manner. This theory is descriptive and not normative (i.e., it attempts to explain only how decision makers *do* act, and not how they *should* act).

[9] Savage, L. J. Foundations of statistics. Wiley and Sons, New York. 1954

[10] Simon, *op. cit.*

THE SHACKLE THEORY OF POTENTIAL SURPRISE AND FOCUS OUTCOME

Shackle[11] stresses psychological variables and has postulated a theory of decision making for nondivisible nonseriable situations—decision situations where actuarially certain outcomes cannot be assigned. Shackle doubts that the use of mathematical probability by ordinary decision makers is logical and substitutes possibility, or degrees of belief, in its place. Shackle's degree of belief concept becomes operational in his theory through its relationship to potential surprise. The degree of belief a decision maker feels in a possible outcome is defined as corresponding uniquely to the degree of surprise which he feels himself exposed to if that outcome should occur.

In making a decision, Shackle postulates that the decision maker considers each possible outcome in relation to its potential surprise, sighting for each act what he terms a focus gain-focus loss pair of outcomes. Following other literature, we will consider focus best-focus worst pairs. These are the "good" and "bad" outcomes for each act which, when taken in conjunction with their associated potential surprise, have the greatest attention-arresting power. By some conscious or subconscious method these pairs are standardized in terms of utility. The standardized pairs, one set for each act, then are evaluated, perhaps intuitively, on the decision maker's gambling indifference system. The act whose standardized focus outcome pair lies highest on this loss versus gain indifference system then will be selected as the best act. Shackle's theory is purely descriptive and has no normative intent.

APPLICATION TO A SIMPLE PROBLEM

To illustrate selection of acts under the various decision theory criteria and to illustrate differences in selected acts or courses of action, we resort to a simple algebraic example. It will have particular reference in the empirical analysis of this section. The payoff matrix resulting from the choices open to the decision maker (the left-hand column or A_i rows) and the possible acts of Nature (the right-hand or S_j columns) is as follows:

	Decision maker's alternatives	States of Nature S_1	S_2	S_3	S_4
(2)	A_1	2,500	3,500	0	1,500
	A_2	1,500	2,000	500	1,000
	A_3	0	6,000	0	0
	A_4	1,500	4,500	0	0

WALD CRITERION

Using this algorithm, that act or combination of acts is selected which has the maximum minimum payoff. Inspection of the matrix shows that a saddle point exists at the a_{23} position with a payoff of 500. Hence, A_2 should be selected. This course is selected because the Wald criterion assumes that Nature will "do its worst" (column S_3) and the decision maker will "select the best" (row A_2) in this column. Where

[11] Shackle, *op. cit.*

a saddle point does not exist, he will select a combination of strategies or rows. But an example of this type is not necessary for illustrating differences in game theoretic criteria.

Savage Criterion

When this criterion is used, the aim is to minimize the maximum regret that may be felt *ex post*. To this end, the regret matrix is calculated as indicated in equation 1. Hence, we have for $[r_{ij}]$

$$(3) \quad \begin{bmatrix} 0 & 2{,}500 & 500 & 0 \\ 1{,}000 & 4{,}000 & 0 & 500 \\ 2{,}500 & 0 & 500 & 1{,}500 \\ 1{,}000 & 1{,}500 & 500 & 1{,}500 \end{bmatrix}$$

where each element in each column of the payoff matrix (2) is subtracted from the largest a_{ij} of that column.

If only pure strategies are allowed, A_4 must be selected, for its maximum regret of 1,500, in any column, is smaller than that for any other act (row). With mixed strategies permitted, the decision maker should use rows A_1, A_3, A_4, allocating his resources among them in the proportions of 9 : 23 : 68, respectively.[12] With such a mixed strategy, his maximum expected regret would be 1,365, or less than for a single act.

Hurwicz Criterion

The choice under this algorithm is the act for which the value of $(\beta \min_j a_{ij} + (1 - \beta)\max_j a_{ij})$ is a maximum, remembering that β is an index of the decision maker's level of pessimism and lies between zero and one. The minimum and maximum payoff values for each act, rows in the payoff matrix (2), are:

A_1	:	0,	3,500
A_2	:	500,	2,000
A_3	:	0,	6,000
A_4	:	0,	4,500

Since the minimum-maximum payoff pair for A_3 dominates (has better outcomes and none worse than) those of A_1 and A_4, the choice will always lie between A_2 and A_3, regardless of the size of β. Which act out of A_2 and A_3 should be selected depends on the value of β.

If

(4) $\beta(500) + (1-\beta)2{,}000 > \beta(0) + (1-B)6{,}000$ which implies

(5) $\beta > 8/9$,

then A_2 should be selected. If the inequality in equation 4 is reversed, we find that for

(6) $\beta < 8/9$

A_3 should be selected. When

(7) $\beta = 8/9$

either A_2 or A_3, or some mixture of these two acts, should be selected.

Laplace Criterion

Since there are four possible states of Nature in the payoff matrix (2), the principle of insufficient reason says that a probability of 0.25 should be given to each of these states. The expected value of each act, average across columns, is then:

A_1	:	1,875
A_2	:	1,250
A_3	:	1,500
A_4	:	1,500

A_1 has the maximum expected value and should be selected.

Simon's Satisficer Theory

If the decision maker had an aspiration level of zero, he would be satisfied with any of the four acts available. All of them guarantee at least a zero payoff. With an aspiration level greater than zero, A_2 must be selected, since this row has no zeroes; A_2 is still the best act even if the aspiration level is greater than 500.

Shackle's Theory of Potential Surprise and Focus Outcomes

Since absolute uncertainty prevails, the standardized focus outcomes are simply the pairs of best and worst payoffs for each act. Inspection shows that they are:

A_1	:	3,500,	0
A_2	:	2,000,	500
A_3	:	6,000,	0
A_4	:	4,500,	0

Acts A_1 and A_4 are dominated by A_3; the latter has better outcomes and none worse. The choice, therefore, lies between A_2 and A_3, since the worst outcome for A_2 is not as bad as that of A_3. Which of these should be selected depends on the decision maker's gambling indifference system. The greater his disposition to gamble, the more likely it is that A_3 would be selected; the smaller this disposition, the greater the chance that A_2 would be chosen. At any rate, either A_2 or A_3 must be selected. A_1 or A_4 should never be selected.

Hence, different outcomes would be selected depending on the decision maker's psychological state and his direct goals. With these consistent to various criteria, the decision with respect to the payoff matrix (2) would be A_2 for Wald, A_4 for Savage regret and pure strategies, $0.09A_1 + 0.23A_3 + 0.68A_4$ for Savage regret with mixed strategies, A_3 when β of Hurwicz is less than 8/9 but A_2 when β is greater than 8/9, A_1 for the Laplace criterion, any of the four or A_2 for the Simon criterion depending on the aspiration level and A_2 or A_3 for the Shackle approach.

[12] This solution is obtained by analyzing the negative regret matrix as a linear programming problem. Heady (Application of game theory in agricultural economics. Canadian Jour. Agr. Econ. May 1958.) has illustrated the method.

SOURCE AND COLLECTION OF THE DATA

We analyzed decisions made by a group of Iowa farmers with respect to cattle feeding to determine the extent to which these decisions correspond to the game theoretic models previously outlined. The group of farmers studied, of course, had no knowledge about formal decision criteria or the computations necessary for their solution. The procedures which they follow in choices or decisions, however, must correspond to these or other decision models. Hence, it should be possible to examine actual decisions and determine which of the models, although even unwittingly, various strata of farmers most nearly use.

The data to be analyzed were collected in the course of a four-stage panel survey. A population of 77 farmers constituted this panel. The survey was primarily oriented to farmer price expectations and decisions on cattle feeding made relative to them. Discussions were held with each farmer in June, August and October of 1957 and in January 1958.

Description of the Population

The population consisted of farmers who: (1) were farming in Marshall County, Iowa; (2) were between 30 and 50 years of age in June 1957; (3) had owned and operated at least 80 acres of farmland during the 3 years prior to June 1957; (4) had fed an average of at least 25 feeder cattle in each of the three feeding seasons prior to the survey; and (5) had cooperated in all stages of the survey. Restrictions 1 to 4 were aimed at controlling possible tenure and age effects and guaranteeing that respondents occupied a decision-making role and had more than a modicum of experience in the feeder-cattle operation. The restrictions were used to help insure a more homogeneous group for analysis with respect to decision making.

The means of some selected characteristics of the respondents are listed in table 1. The left side column of figures refers to the population of 77 farmers. Included in this population are two farmers who had extremely large farm businesses relative to the other members of the population. In terms of acres operated, capital invested and gross income, their farm operation was twice the size of that of any other member of the population. The means of the selected characteristics therefore are also presented, in table 1, with these two farmers excluded.

Considerable variation existed among the 77 farmers in certain characteristics. Five of the 77 were professional men who had invested in farming while still maintaining their professional practices. Two devoted the majority of their time to small-town businesses. Two operated large seed corn plants, and one farmed as a sideline to general contract work. Only one farmer worked part time as a nonfarm laborer. At least 1 year of college had been completed by 17 of the farmers, while 20 of the 77 had not completed high school. Some rented land was farmed by 24 of the farmers. Sixteen had an equity of 100 percent. Further details of the personal, financial and farm organization characteristics of the population are presented in Appendix A.

Survey Procedures

An initial sample of 120 farmers satisfying characteristics 1 to 4 was drawn from a list developed from ACS data and farm interviews. Originally, the aim was to interview a random sample of 70 from the 120. An initial survey indicated that 95 of the 120 farmers were eligible, while two additional members of the population were found. Of these 97 farmers, 20 were not available or refused to cooperate at some stage of the survey. The number of cooperating farmers at each stage of survey was as follows: first stage, 85; second stage, 82; third stage, 77; and fourth stage, 77. Not all data from the four-stage survey are summarized in this manuscript.

INTERVIEWER BIAS

Because it was desired to complete each stage of the survey within the smallest possible time, three interviewers were used for the first survey, five for the second and three for the third. Three interviewers assisted in all three stages of personal contact. Before commencing field work, each interviewer was instructed in detail on the aims and implications both of each question he had to ask and of the over-all study and on the general conduct of an interview. All completed schedules were checked for irregularities which might arise through interviewer bias or mistakes. Where difficulties or inconsistencies existed, the respondent was contacted again and the query clarified. Through these techniques it was hoped that interviewer bias was reduced to a minimum.

A check on responses to one of the most important questions strongly indicates that interviewer bias was not present. The data analyzed are shown in table 2. The question to which they relate is probably, of all those asked, the one most likely to be subject to interviewer bias.

Bartlett's test for homogeneity of variance, as outlined by Snedecor,[13] was applied to test whether the

[13] Snedecor, George. Statistical methods. Iowa State University Press. Ames, Iowa. 1947. p. 287.

TABLE 1. SUMMARY OF SELECTED CHARACTERISTCS DESCRIBING THE RESPONDENTS.

Characteristic	Unit	Mean: 77 farmers	Mean: 75 farmers[a]
Age	year	42.1	42.1
Dependents	number	3.6	3.6
Formal education	year	11.6	11.5
Land operated	acre	291.4	260.2
Capital	$1,000	133.6	108.5
Equity	percent	88.4	86.5

[a] Two farmers with extremely large farms excluded.

TABLE 2. NUMBER OF ALTERNATIVES IN CATTLE FEEDING CONSIDERED BY FARMERS AS DETERMINED BY EACH INTERVIEWER.

Interviewer	Number of alternatives considered	Number of farmers
A	1, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 3, 4, 4, 5	17
B	1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 4, 4, 5, 8	17
C	1, 1, 2, 2, 2, 2, 2, 2, 3, 3, 3, 3, 3, 4, 4, 5	16
D	1, 1, 1, 2, 2, 2, 2, 2, 3, 3, 3, 4, 5, 7	14
E	1, 1, 1, 2, 2, 2, 2, 3, 3, 4, 5, 5, 7	13

interviewing samples had the same population variance. This assumes a random distribution of respondents among interviewers—an assumption that was not fully satisfied with regard to the geographic locations of the respondents within Marshall County. It does appear to be satisfied for other attributes of the respondents. Bartlett's test was applied to a tranformation of the data. The transformation used was from x to $(x+1)^{1/2}$. This was done because counts of a discrete variable, such as the one considered here, tend to follow a Poisson distribution as Snedecor has noted. The test supported the hypothesis that the variances of the interviewer samples were not significantly different.

The data were also tested to see whether significant differences existed among the interviewers with regard to the mean number of alternatives elicited by each. As for the previous test, a transformation of the data to $(x+1)^{1/2}$ was carried out before applying analysis of variance. This test strongly supported the hypothesis that the means were the same.

THE FEEDER CATTLE PRE-PURCHASE DECISION PROBLEM IN RELATION TO GAME THEORETIC CRITERIA

The decision problem facing a farmer with respect to cattle feeding has two broad components: How large should the feeder operation be, and what types(s) of feeder program should he follow? For simplification these problems are considered as independent although this is not strictly true. For a given bundle of resources, the price relationships between the beef and other possible enterprises determine how large the feeder enterprise should be. The problem of what type(s) of feeder program to follow becomes a decision problem within the feeder enterprise. Under conditions of certainty, this dichotomy would be a false one. The feeder-cattle enterprise, however, is a risky one relative to other enterprises possible on Midwest farms. It is also an enterprise requiring specific managerial skills and a sizable fixed investment in cattle, housing, feedlots and equipment. For these reasons the separation of the decision problem into the two parts is a justifiable analytic simplification in an exploratory study such as this. In our analysis we consider only the decision problem within the feeder enterprise in a given season. Moreover, the analysis is restricted to the planning situation of the farmer. No consideration is given to the specific market situation he faces when he actually enters a buying or selling market where decisions, made with a minimum of reflection, may be forced upon him. The farmer must decide on the feeding program followed, the length of the fattening period or selling weight of the cattle and their quality when sold. Additional variables are the location of the buying and selling markets and the degree of personal entry into these markets. In selecting a feeder program, a decision has to be made as to which combination(s) of these variables would be best to use. The questions the farmer must pose for himself are: What type of feeder-cattle program should I follow in the coming season? If I should have a number of programs, what should their relative proportions be? These questions may be answered by default. Such would be the case for a farmer who followed some habitual feeder program.

Specification of the Model

We now outline a model of the feeder-cattle decision problem. It is inherently a normative model but incorporates some descriptive elements. This decision problem must be related to a decision model. Hence, we outline here a general model of the farmer's decision theory or process to be considered in relation to his choice of cattle feeding programs. The transformation process of concern is for the feeder-cattle input, a generic input. It may take a variety of specific forms in terms of cattle age, quality, breeding and previous management. The output is fat cattle and may take a variety of forms in terms of quality, weight and date of selling.

THE ECONOMIC HIERARCHY

The hierarchical groups relevant to the decision problem within the feeder enterprise may be specified as follows:

N' : the group of all farmers who may be expected to have a feeder-cattle enterprise. The order of N' is approximately 500,000.[14]

N'' : the set of economic decision makers above N' in the economic hierarchy relevant to feeder cattle. This set is composed of three broad groups. In ascending order they are meat packers,[15] retailers and consumers. While there are relatively few meat packers, there are thousands of retailers and millions of consumers.

N''' : the set of economic decision makers below N' in the economic hierarchy relevant to feeder cattle. This set is essentially composed of the ranchers who raise the feeder cattle. Its order is approximately 200,000.

Regarding cattle as the generic input and output, N', N'' and N''' satisfy the chain arrangement underlying our model. For all practical purposes, these three sets are disjunct.

NATURE'S ALTERNATIVES

Consider first the possible role of the meat packers and of the meat retailing and consumer groups. As the final link in the chain, it is the consumers who determine the demand for beef. Over a period of years, the most important factors influencing the aggregate demand schedule for beef are the number of consumers, their tastes and disposable incomes and the price of other meats. With respect to a given production season, the consuming population with its tastes is relatively fixed.

[14] Exact figures are not available. The figure given is based on: U. S. Census Bureau: 1954. Census of Agriculture. Vol. 2. 1956.

[15] In general, the meat packers act as wholesalers by selling direct to retailers.

Variations in the quantity of beef demanded, relevant to the short run of a single production period, are primarily related to changes in the price of beef and other meats. The dominant cause of changes in the month-to-month price of beef, however, is the supply of beef. Most beef is consumed within 2 weeks of slaughter. Within a given year, the current supply of beef, relevant to current demand, is a given or predetermined variable. Moreover, competition among the meat packers in supply marketing services forces them to accept the quantity of fat stock offered for sale at any particular time. Because of its perishable nature, the wholesale and retail prices of beef must be adjusted to this supply if it is excessive. A rather similar situation prevails for other meats.

In the short run, cattle supply is influenced little by the current action of packers, retailers or consumers. It is a function of the decisions made by the thousands of livestock producers—decisions made not so much under the influence of current circumstances as under the influence of conditions some months in the past and of prior expectations of current conditions. Thus the primary influences causing within-year variations in fat-cattle prices emanate from the supply side. The role of the meat packers *per se* and, likewise, of the retailing and consuming groups is negligible. It is the farmers who "deal the cards." Given the deal, the packers, retailers and consumers have to play accordingly. Producers of other types of livestock, as well as those producing fat cattle, affect fat-cattle prices. Hence they influence the payoffs facing the farmer in his feeder-cattle decision problem. Nonetheless, in the short run, the major influence on fat-cattle prices comes from the supply of fat cattle. We consider the feeder cattle pre-purchase decision problem as one faced from 4 to 14 months prior to the time when the fat cattle will be sold. The farmer, therefore, has ample time to adjust his feeding program to the expected effects of the producers of other types of livestock. Such adjustments could involve any of the selling specifications: weight, quality and date of sale. Given human capabilities, this is a reasonable approach to the decision problem at the pre-purchase stage. With a model specified in this fashion, it is the aggregated choices of the other farmers considering a feeder-cattle enterprise and of the feeder-cattle raisers that determine Nature's strategy. Recognition must also be given to weather at this point. It plays an important role through its effect on both grain and roughage production.

The set S of possible states of Nature thus consists of all possible combinations over the ranges of the aggregative maneuvers which might be followed by the feeder raisers in aggregate, all the other beef feeders in total and the weather. Obviously, Nature's strategy selection will affect the individual decision maker, but not *vice versa*.

Our model postulates that the decision maker effectively partitions this set S into subsets S_j, each subset being considered as a single broad alternative. The actual form of this partitioning will depend on the decision maker. The practical necessity for such a simplification of the problem is obvious; S is an infinite set since climatic effects may occur over some continuous range.

THE DECISION MAKER'S ALTERNATIVES

The set A of alternatives available to the cattle feeder is the set of all possible combinations of these variables, each taken over its range of possible values: sex, age, weight and quality of the cattle purchased, the feeding program followed, and the selling weight, quality and date of the fattened cattle. The set A is, therefore, of infinite order, some of the listed variables being continuous. Weight and age at purchase and weight and age at sale are such variables. Hence, the necessity for simplifying this set is apparent. A simplifying procedure leads to designation of a set of broad alternatives whose general element is designated by A_i. This set of broad alternatives, perceived by the decision maker and including only those which he considers from the infinite array, will vary among individuals. It is expected to be a set of alternatives with practical significance, being finite and containing feeder programs in the form and with the the implicit range of variation usually found in common reference to the feeder enterprise. Some subset, which we designate A°, of this set of broad alternatives will be considered by the farmer in his planning for the forthcoming production period. This subset may be delimited by the farmer on the basis of habit. More rationally it might be based on some detailed longer-run assessment of the situation in terms of trends in consumer demand, the risks involved and his personal goals and resource restrictions.

THE PAYOFFS

The model stipulates that the considered acts, A_i°, will be appraised in relation to the broad alternatives, S_j, available to Nature. This appraisal will be based upon the payoff element a_{ij} relevant to each act A_i° and state of Nature S_j. For a rational analysis of the problem, these payoff elements must be comparable. This could be achieved in the present context by considering as payoffs the expected annual net percent return accruing to an investment in each of the considered acts. This return is determined by the expected price of feeder cattle, the estimated cost of fattening the cattle and the expected price of fat cattle. Account must also be taken of the length of the feeding program and of alternative investment of the feeder enterprise capital when it is not invested in feeder cattle. The method of combining variables to derive comparable payoffs is illustrated in Appendix B.

Since cattle buying and selling prices and fattening costs vary over the possible states of Nature, the payoffs will, in general, vary over the payoff matrix. They will also differ from one decision maker to another because of varying specifications of the alternatives considered and of Nature's possible states, and because expectations will vary from one individual to another. By the implications of the general model constructed and shown to be capable of specification in terms of the feeder-cattle decision problem, the decision problem within the feeder-cattle enterprise is a problem under absolute uncertainty.

Assessment of the Model

It remains now to assess the normative model, attempting to see whether it has descriptive value. In other words, do farmers approach the decision problem within the feeder-cattle enterprise in some fashion akin to the model we have outlined? In making this appraisal, data are used from the 77 farmers described previously.

DISCERNMENT OF ALTERNATIVE ACTS

No attempt was made to ascertain the farmers' knowledge of the infinite set A of all possible feeder programs. It was obvious that all thought in terms of much broader alternatives than those that would constitute this set. Accordingly, the farmers' discernment of alternative acts was first considered systematically at the level of the broad alternatives, A_i. These are the alternatives that constitute a partitioning of the set A. Theoretically, this partitioning might be approached in two ways: in terms of the over-all programs or by way of the attributes specifying each program. As would be expected, preliminary discussion during the first-stage survey indicated that the program-by-program approach was impractical. The set of discerned alternatives is too large to be enumerated verbatim. The approach through the decision variables—age, type of cattle, purchase weight, feed program and selling weight, date and quality—was therefore adopted. The problem consists of determining at what levels of the various decision variables does a farmer discern one program as being distinct from another? In what fashion are the decision variables stratified, if at all?

In varying degrees, the farmers did stratify the decision variables; the typical groupings made for each decision factor are shown in table 3. Purchase weight, for example, was commonly grouped by 50-pound intervals so that the average farmer distinguished five programs for steer calves with respect to the average purchase weight of the calves. While some farmers made finer distinctions and some broader ones, especially in relation to quality and feeder program alternatives, the pattern of simplification is clear. No farmer's discernment of alternatives was so different from the general assessment shown in table 3 as to be worthy of comment. Moreover, no farmer appeared to have difficulty in understanding the questions relevant to this discernment of alternatives. This is taken as evidence that the noted levels of stratification are indicative of the average farmer's train of thought.

TABLE 3. FARMERS DISCERNMENT OF ALTERNATIVES WITHIN THE FEEDER-CATTLE ENTERPRISE.

Decision factor	Commonly discerned alternatives within each decision factor	No. of alternatives within each decision factor
Age type	steer calves, heifer calves, yearlings, 2-year-olds	4
Purchase weight	by increments of 50 lbs.	
	steer calves: 300-550 lbs.	5
	heifer calves: 300-500 lbs.	4
	yearlings: 550-750 lbs.	4
	2-year-olds: 800-1,000 lbs.	4
Purchase quality	medium, good, choice, fancy	4
Purchase date	by months	5
Fattening period	by months	
	steer calves: 8-14 months	6
	heifer calves: 7-12 months	6
	yearlings: 6-11 months	5
	2-year-olds: 3-7 months	5
Feed program	drylot	2
	pasture	1
Selling quality	good, choice, high choice, prime	4

The pattern of simplification exhibited by the data of table 3 shows close correspondence to that typically used in newspaper and other farm-oriented reportings of the cattle market. Perhaps the farmers were merely reiterating these often-used distinctions, evidence that the set A is partitioned by farmers into some more practical and simpler set of alternatives as postulated by our model. Even with the level of stratification indicated in table 3, however, the set of all possible combinations among the decision factors is unmanageable. Indeed, from table 3 it should be possible to specify 22,560 alternative feeder-cattle programs that could be distinguished by the typical farmer interviewed. Obviously no farmer could consider so many alternatives in planning his feeder enterprise. Although he could discern that they differed, it would be impossible for a farmer to evaluate so many possibilities.

The evidence gathered indicates that this set of discernible alternatives is further reduced by two processes. First, a longer run decision appears to be made (sometimes by default) as to which of these alternatives will be considered over the shorter run of a year. Although no attempt was made to study this longer run decision, farmer comments indicated that it is greatly influenced by the farmer's risk feelings, experience and resource limitations. Thus, quite a few farmers indicated that they never considered 2-year-old feeder cattle because they were too risky. Others commented that they considered only calves because they were generally sure of "at least getting their money back from such an investment." The second method of reducing the number of alternatives to be considered consisted of a further broadening of the strata relevant to some of the decision variables. This applied especially to those factors relating to the selling specifications of the program.

That these processes were carried out by farmers was evidenced by their responses to the question: In planning your feeder-cattle enterprise, what alternative feeder programs do you normally give consideration to? These possible programs were specified in terms of the age type of feeders bought, their quality, weight and month(s) of purchase, the feed program to be followed and the grade, weight and month of sale. The essential feature of these responses is the number of alternative programs mentioned by each farmer and the level of stratification exhibited in these alternatives. Consider first the number of distinct alternatives mentioned by each respondent. Since these alternatives constitute the set A° of considered acts, their number is the order of A°. Table 4 gives, in frequency distribution form, the order of A° for each of the 77 farmers.

While the information in table 3 indicates that all farmers realized that an extremely large number of alternatives exist, table 4 shows that only 4 percent considered more than five alternatives in the short run. For the 17 percent who had only a single pro-

TABLE 4. FREQUENCY DISTRIBUTION OF NUMBER OF PRE-PURCHASE ALTERNATIVES CONSIDERED BY FARMERS.

Number of alternatives considered	Number of farmers
1	13
2	33
3	14
4	8
5	6
6	0
7	2
8	1
Total	77

TABLE 5. RANGES IN QUALITY, WEIGHT AND DATE OF BUYING AND SELLING CATTLE SPECIFIED IN CONSIDERED ALTERNATIVES; PERCENT OF FARMERS CONSIDERING.

Decision variable	Specified range of decision variable	Percent of considered alternatives falling in each range	
		Buying	Selling
Quality	single grade	80.5	82.9
	two grades	19.5	17.1
Weight	zero	73.6	35.6
	50 lbs.	9.8	7.8
	100 lbs.	15.1	46.8
	150 lbs.	0.5	4.4
	200 lbs.	1.0	4.4
	250 lbs.	0.0	1.0
Date	1 month	61.4	41.9
	2 months	21.5	30.2
	3 months	13.2	24.4
	4 months	2.4	3.5
	5 months	1.5	0.0

gram in mind, the short-run pre-purchase decision problem was trivial. Their selection was "habitual." The modal number of alternatives considered was 2, 43 percent of the farmers considering only a pair of alternatives. Compared with the order of the average discerned parent set implicit in the data of table 3, it is obvious that the subsets A° classified in table 4 are remarkably small.

Table 5 shows the extent to which the quality, weight and date of buying and selling were broadened by the farmers in specifying their considered alternatives. The feed-program variable is not referred to explicitly in the table. A range in the specification of weight, quality or date, however, implies a range in the feed program.

Table 5 indicates that weight and date of buying and selling were most frequently broadened, especially in specifying the selling characteristics of a program. Seemingly, farmers felt less sure about the selling environment than about the buying environment. Consequently, their considered alternatives in selling were more flexible than those of buying. Over-all, 205 considered acts were nominated. The following figures show the percentage of these considered programs that contained a broadening of at least one, two or three of the buying and selling decision factors listed in table 3:

No. of decision factors broadened	Buying factor (percent)	Selling factor (percent)
At least one	57	80
At least two	23	48
At least three	3	9

Of the 77 farmers, 70 specified a range of some decision variable in at least one of their considered alternatives. Fifty-six broadened at least one variable in each of their considered alternatives. There is, therefore, abundant evidence that the farmers simplified their decision problem, not only by abstracting some small number of discerned alternatives, but also by amalgamating a number of these alternatives in terms of the individual decision factors.

To gain some indication of the reliability of the farmers' statements of the composition of the set A° of considered acts, the alternatives mentioned were checked against a previous statement by each farmer of his plans for the current season. In only one case out of the 77 did the current plan include a program not specified in the subset of short-run alternatives. Further inquiry indicated that this plan entailed a prior commitment and was, in the current situation, a forced decision.

Thus, in terms of the way in which the farmers discerned and reacted to the acts available to them, they did so in a manner completely in agreement with that postulated by our normative model. At least in this regard, the model has descriptive value. Simon's hypothesis has been strongly substantiated. Our real-world decision makers did simplify a complex range of possible acts to a degree compatible with their capabilities.

DISCERNMENT OF NATURE'S ALTERNATIVES

What of the other aspect of our model, that of the states of Nature? In this regard, the first question to be considered is the extent to which the farmers conceived of Nature's strategies as being determined by the aggregative actions of all other beef feeders, the feeder-raiser group and the weather.

All of the 77 farmers recognized the weather as an important influence as suggested in table 6. This table shows the various ways in which the farmers conceived the pre-purchase situation in terms of other farmers as opponents in what might be called the "beef-feeder game." Each category of the table is

TABLE 6. FARMERS' CONCEPTION OF THEIR OPPONENTS IN THE BEEF-FEEDING GAME.

Conception of opponents in addition to the weather	No. of farmers
No conception	6
All other beef feeders individually	9
All other beef feeders as a group	7*
Meat packers as a coalition	4
Meat packers as a coalition sometimes	2
Meat packers as a coalition within markets	3
Feeder raisers as a group	2
All other feeders individually, feeder raisers as a group	2
All other feeders as a group, feeder raisers as a group	3*
Meat packers as a coalition within markets, feeder raisers as a group	1*
All other feeders individually, packers individually	3
All other feeders individually, packers in coalition sometimes	6
All other feeders individually, packers in coalition within markets	3
All other feeders grouped, packers individually	1*
All other feeders grouped, packers grouped	3*
All other feeders grouped, packers grouped sometimes	3*
All other feeders grouped, packers grouped within markets	3*
All other feeders individually, packers individually, feeder raisers grouped	2
All other feeders individually, packers in coalition, feeder raisers grouped	1
All other feeders individually, packers in coalition sometimes, feeder raisers grouped	3
All other feeders grouped, packers individually, feeder raisers grouped	2*
All other feeders grouped, packers in coalition, feeder raisers grouped	4*
All other feeders grouped, packers in coalition sometimes, feeder raisers grouped	2*
All other feeders grouped, packers in coalition within markets, feeder raisers grouped	2*
Total	77

* Farmers who had a conception of the situation not very different from our specification of the theoretical model.

exclusive. Summarization indicates that 71 of the farmers had some conception of an opposition—59 in a form involving some grouping and 12 in terms of individuals. The influence of other feeders in some fashion was recognized by 59 of the farmers; of meat packers by 48; and of the feeder raisers by 24 of the farmers. Not shown in table 6 is the fact that one farmer mentioned the consumer group as a segment of his opposition. Another specified all livestock producers as an opponent. This farmer is included among the three who may be said to have visualized the situation exactly in terms of the theoretical models specified. That is, a combination of the weather, a feeder-raiser group and a group of all other beef feeders constitutes the basic determinants of Nature's possible states. With some degree of subjectivity, 31 of the farmers had pictures of the situation approaching the normative model rather closely. These farmers are indicated by an asterisk in table 6.

The data of table 6 were obtained during the second-stage survey by letting the farmers read questions and lists of possible persons or individuals who were, in effect, engaged in decisions which represented acts or "strategies against them." There is no mention of feeder raisers, a purposeful omission designed to provide a check on the farmers' responses. If a farmer did not mention feeder raisers, he was asked about them after he had answered the listed questions. Nineteen farmers mentioned feeder raisers on their own initiative. An additional five suggested their influence when questioned specifically on their role.

To gain some idea of how operational these concepts of an opponent might be and to serve as an additional check on the original answers, the farmers were later asked an open-ended question as to which factors were most important in determining the type of feeder program they followed. As this was done in the third-stage survey, it is unlikely that answers were biased by memories of responses given to the related questions of the second-stage survey. The data in table 7 show the frequency with which each of the listed factors was mentioned either as a primary or secondary determinant of choice. Fifty-four farmers mentioned only a single factor; 23 nominating two factors. It is noteworthy that no farmer mentioned any other specific farmer as influencing his choice.

Nineteen of the farmers placed major emphasis on some aspect of their feed supply, the primary short-run determinant of which is the weather. Some aspect of expected cattle prices, either buying or selling,

TABLE 7. FACTORS NOMINATED BY FARMERS AS INFLUENCING THEIR CHOICE OF PROGRAMS WITHIN THEIR FEEDER-CATTLE ENTERPRISE.

Factor influencing choice	Number of times mentioned as	
	Primary factor	Secondary factor
Expected personal supply of grain and roughage	10	4
Expected personal supply of grain	1	0
Expected personal supply of roughage	8	4
Expected buying price of feeder cattle	14	3
Expected buying and selling prices of cattle	9	2
Expected selling price of fat cattle	5	2
Expected corn price	0	1
Feeder-cattle purchases of other farmers	1	1
Amount of risk involved	21	6
Force of habit	8	0
TOTAL	77	23

was given primary consideration by 28 of the farmers. One nominated the purchases made by other farmers with feeder programs. These responses are quite compatible with our conception of Nature since the main determinant of cattle buying and selling prices is the aggregate actions of the feeder raisers and the other farmers who buy feeders.

There were eight farmers who suggested they selected their programs on some habitual basis. Reference to their considered alternatives indicated that two of these farmers considered only a single feeder program, while five considered two alternatives. A check of these stated alternatives against the history of their feeder enterprise over the prior 2 years and their current plans showed that six of them did indeed have a common selection over the 3 years. For the other two, a habitual selection did not appear to have taken place. It seems most likely that these eight farmers did not think in terms of an opponent, at least in the short run.

Of the 21 respondents who mentioned risk as a major influence on their choice, seven considered only a single alternative, another seven, two alternatives and the remaining seven at least three possible programs. Excluding those with a single alternative, four considered only calf programs, seven gave some consideration to yearlings, and three included 2-year-old cattle as one of their alternatives.

Summarizing these results, we see that only 19 of the 77 farmers responded to the open-ended question on factors influencing their feeder choice by mentioning a primary determinant incompatible with the concept of Nature. These were the 8 mentioning habit or tradition and 11 of those mentioning risk. For the remaining 58, it seems that Nature probably did play some role, although perhaps not exactly as we have postulated. If account is taken of the secondary factors mentioned by some of the farmers, it would appear that only nine farmers did not place emphasis on some aspect of Nature.

To what extent did the responses tabulated in table 6 correspond to those shown in table 7? Main concern is with those farmers marked by an asterisk in table 6. They came closest to the conception of the situation postulated by the basic model of this study. Of these 31 farmers, only 1 was not among the 58 who mentioned a primary choice influencing a factor compatible with the model.

Equivalently, included among the 46 farmers not marked by an asterisk in table 6 were 18 of the 19 farmers who mentioned, as the primary influence on their feeder-program choice, a factor apparently incompatible with the theoretical concept of Nature. Thus, there are 28 farmers whose responses to the open-ended question on choice were compatible with the model while their formalized answers, as tabulated in table 6, were not. The most reasonable explanation for this discrepancy is probably that these farmers did not answer the formal questions correctly in terms of their normal way of thinking about the problem. Certainly the majority of the farmers had not previously thought explicitly in terms of an opponent. This was indicated by many of the side comments on the formal questions. At the same time, it was obvious that many of the farmers thought and acted intuitively in terms of an opponent. In a sense, they were "at war" but did not wish to "make a declaration of war."

Summarizing these comments on the data of tables 6 and 7, it appears that at least 30, and perhaps as many as 58, of the 77 farmers had conceptions of an opponent in fair agreement with the model. A more definite statement would be desirable but, given the data, not warranted.

DISCERNMENT OF STATES OF NATURE AND ASSOCIATED PAYOFFS

In attempting to assess farmer use of the payoff and state of Nature concepts, an oblique method of questioning was pursued. For each respondent, a game against Nature was constructed. Each farmer's set of considered alternatives was taken as his available acts. Four broad states of Nature were delimited. These consisted of the four combinations possible from two types of weather—good and bad in terms of grain production—and two levels of aggregate activity on the part of other farmers with feeders—mainly short feeding or mainly long feeding. Prior informal questioning indicated that the inclusion of all the postulated components of Nature would make the problem too complicated. Hence the feeder raisers were specified as behaving in an "average or normal fashion," a sufficiently meaningful concept to the farmers for construction of the game against Nature. Only two farmers questioned the meaning of the words "average or normal."

For each of his available acts, the farmer was asked his expectation of cattle buying and selling prices under each of Nature's four possible states. Two of the farmers found this formulation of the decision problem incomprehensible. Both of them were among the six farmers who are listed in table 6 as having no formal conception of an opposition. The 75 farmers who did comprehend were asked whether they normally considered their pre-purchase alternatives in some such way with payoffs varying according to the conditions that might prevail. Twenty-four said that they did in some fashion or other. In each of these cases, however, further questioning indicated that the states of Nature involved in such considerations were very broad. Two of these farmers apparently considered four states of Nature, more or less in line with those postulated in the constructed game. One of these farmers considered two alternative acts, the other three. All of the other 22 farmers specified only two states of Nature. Nine of these pairs of states were based on the possible feed situation, 11 on the possible aggregative buying actions of other feeder fatteners, two on the possible cattle-feeding programs of all other farmers and one on consumer demand for meat. Nineteen of these 24 farmers were included among the 31 marked with an asterisk in table 6. All 24 were among the 58 farmers who mentioned as a primary influence on their choice a factor compatible with the theoretical formulation of Nature.

Fifty-three farmers apparently did not follow some specific conception of multiple states of Nature. It would seem that they made their deliberations in terms of a single state of Nature, perhaps with payoffs formulated as expected values.

As a general assessment of the model, the farmers were asked whether they considered the constructed representation of the pre-purchase decision problem to be a good, fair or poor representation of the problem. The responses were as follows: good—38, fair—26 and poor—13.

This rating is a subjective one. Nonetheless, the figures indicate that the majority of the farmers considered the model reasonable in construction. Such a reaction is typical. As other writers have noted, once a normative mode of decision making has been pointed out to decision makers they will usually recognize it as such and often tend to consider the problem in such a manner in the future. It is interesting that all of the 31 farmers whose stated formal conception of an opposition approached that postulated by the model were included among the 64 who thought the constructed model either good or fair. In fact, 26 of them said that it was good. Twelve of the 13 who said that it was poor belonged to the group of 19 farmers who nominated as a primary influence on their choice a factor apparently incompatible with the model's conception of Nature.

THE EFFECT OF OUTLOOK INFORMATION

For a farmer considering feeder cattle as a possible enterprise, the crucial period for making plans and purchases is from July to December. During these months, outlook forecasts of feeder and fat cattle market conditions during the coming season are available. These predictions, emanating from official sources, are discussed and analyzed in many of the communication media used by farmers. Alternatively, by attending sales the farmer may make his own appraisal of the trend of events in determining what we have called Nature's strategy.

The fact that outlook information is available tends to overshadow the implication of our model that absolute uncertainty exists. If the information were pertinent and accurate and the forecasts made turned out to be correct, certainty would prevail. Such is not the case, however. One reason for this is a practical one. In principle, correct forecasts can be made, and it is not necessarily true that predictions always will be upset by reactions to the predictions. Allowance for these reactions can be made only if a continuous function describing the reaction of those concerned to a published prediction or forecast is available. Such a function is not available with respect to outlook forecasts relevant to the feeder and fat cattle markets. Evidence presented here shows that farmers do react to outlook forecasts. Therefore, such forecasts, insofar as they are quantified rather than simply directional, can only be correct by coincidence. Moreover, even directional forecasts will be upset if reaction to the forecast is strong enough.

There is little evidence available as to the reaction of Midwestern cattle feeders to outlook information and forecasts. Heer[16] studied the directional accuracy

[16] Heer, John F. Directional accuracy of farm price predictions in the Iowa farm outlook letter. Unpublished M. S. thesis. Iowa State University Library, Ames, Iowa. 1953.

of forecasts made in the Iowa Farm Outlook Letter, the primary source of the outlook information available to cattle feeders in Iowa. His 1953 study indicated that 73 percent of the predictions made therein about the beef-cattle market were correct. However, utilizing Heer's data, it appears that of predictions made for cattle in the crucial pre-purchase period of the year from July to September inclusive, only 55 percent were correct. For June to September inclusive, the figure was 62 percent. It is noteworthy that the greatest reaction to published forecasts probably occurs during these months. Such reaction was probably a significant factor causing the percentage of successful predictions to decline during this planning and purchasing period. Moreover, it is likely that reactions to such forecasts have become stronger since 1953, even to the extent that some farmers have become so subtle as to react to a forecast in the opposite direction to what would be expected. That this is so was evidenced by data collected in this study.

Before considering these data, an important feature of the published forecasts must be noted: The majority of forecasts are not pertinent in terms of the decision problem within the feeder-cattle enterprise. They do not, in general, consider a particular type of cattle versus another type. Not one out of the 65 predictions studied by Heer is couched in terms of specific types of cattle. Cattle are always referred to either as feeder cattle or fat cattle. Such information is of use mainly in deciding between the feeder-cattle enterprise and other enterprises, not for decisions within the feeder cattle enterprise. On the basis of the lack of specification in the forecasts, it could be argued that available outlook information does not negate the implication of the model; namely, that absolute uncertainty prevails in the situation studied.

Concerning the descriptive value of the model, the important point is whether the farmers considered such information to be useful and whether they used it. To this end, the farmers were asked whether, prior to making their own decision, they actively sought information on the kinds of feeders other farmers had already bought or were interested in buying. Thirty-six farmers said they did, and 41 said they did not. These responses can be checked against the farmer's statement of his conception of the role of the other farmers with feeders as given in table 6. Those who did seek such information should tend to consider other farmers with feeders as a group. The extent to which this was so is shown in table 8.

Half of those who sought information considered other farmers with feeders as a group. Approximately one-third of those who did not seek information considered other farmers as a group "working against themselves." As would be hoped in terms of the model, the majority of the respondents who did not mention

TABLE 8. CORRESPONDENCE BETWEEN FARMERS' SEEKING OF INFORMATION AND THEIR CONCEPTION OF OTHER FARMERS WITH FEEDERS.

Conception of other farmers with feeders	Number of farmers	
	Seeking information	Not seeking information
As a group	18	12
As individuals	13	16
Not mentioned	5	13
Total	36	41

other farmers with feeders as being important (line 3) were among the group who did not seek information.

Outlook information was thought to be helpful in their pre-purchase planning by 29 of the farmers. Of the remainder, 21 thought it harmful, and 27 thought it had no effect either way. All 29 of those who thought outlook information helpful were among the 36 who said that they actively sought such information. That 48 of the 77 farmers did not consider the information to be helpful is further evidence that outlook information does not eliminate uncertainty in pre-purchase decisions for the feeder enterprise.[17]

Consistency With Specified Model

The preceding analysis was aimed at assessing the descriptive value of the postulated normative model. Figure 1 summarizes the data by way of a tree diagram. Three types of branches may be distinguished in terms of agreement with the over-all set of postulates of the specific model. The farmers are stratified at five levels. The first relates to the hypothesis that the farmers simplify the decision problem by selecting for consideration some small number of acts from all those that are available. As the tree shows, all

[17] Two of the farmers who said that the outlook predictions were helpful commented that this was because they then knew it would be better to do the opposite! The 21 farmers who said outlook information was harmful were asked why they thought this was so. The reason given by 13 of them was that too many farmers followed the prediction, causing it to be wrong. Four said that the forecasts were based on inaccurate information. The remaining four based their opinion on historical grounds; they had followed a forecast that was unsuccessful.

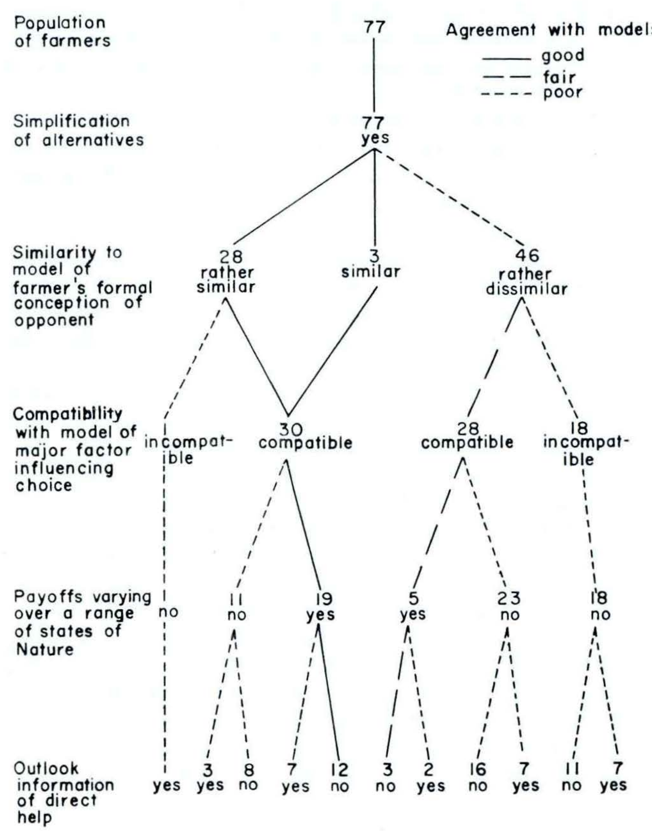

Fig. 1. Tree diagram assessing the descriptive value of the postulated normative model.

the farmers did carry out this simplification. The second level of stratification is based on the farmers' statements of their conception of an opposition. For 31 of the farmers, this statement was in close agreement with the model, although only three gave answers in exact agreement with the model. The third level of stratification hinges on the farmers' responses to an open-ended question asking the primary factor influencing their choice among alternative feeder-cattle programs. These responses were classified on the basis of whether or not the specified factor was compatible with the model. The fourth level of stratification is based on the farmers' statements as to whether or not they considered their alternative acts in terms of payoffs varying according to the conditions that might prevail. Those who said yes were, at least in this regard, acting in agreement with the model. The last stratification level is based on the farmer's assessment of outlook information taken on its face value, as being helpful or not helpful. Those who thought such information of no direct help were in agreement with the model.

The tree shows that of the 77 farmers, 12 could be said fairly certainly to consider the decision problem in the fashion postulated by the model. For another three, the model was probably descriptively correct. Some of the remaining 62 farmers may have considered the problem in the manner postulated by the model, but it is unlikely. In its entirety, the model therefore has descriptive value for only a small proportion of the population examined.

Nonetheless, a large proportion of the farmers apparently did behave in partial agreement with the model. Thus, all 77 farmers considered a simplified set of alternative acts; 58 specified as the primary factor influencing their choice a factor compatible with the model; 24 made allowances for payoff variations over various possible states of Nature; and 50, insofar as they thought outlook information to be of no direct help, probably considered the decision problem as one involving a high degree of uncertainty.

ASSESSMENT OF THE THEORIES OF CHOICE

A number of theories of choice (Wald, Laplace, etc.) applicable to decision making under absolute uncertainty were presented in an earlier section. The present section is devoted to an empirical appraisal of these several theories, based on the group of 77 farmers used in our appraisal of the specific model. In assessing the role played by the theories, we attempt to answer five questions. The answers given to these questions will not apply to all decision makers under absolute uncertainty.[18] Strictly speaking, the answers relate only to the 77 individuals studied. Nevertheless, the data also will be analyzed statistically as if the 77 farmers were a random sample from an over-all population of owner-operators between 30 and 50 years of age who had fed an average of at least 25 feeder cattle in each of the three feeding seasons prior to the survey.[19] The questions considered are: (1) To what extent do the theories have descriptive value? In other words, do the farmers tend to make decisions under absolute uncertainty by analyses of the situation similar to those postulated by the theories? (2) How stable is the decision maker's approach to decision making as the setting of the decision problem varies? (3) So far as the theories are descriptively true, what characteristics of a decision maker's background tend to be associated with the selection of a particular approach to the decision problem? (4) For those theories advanced as normative decision criteria, what value might they have in reducing *ex ante* resource misallocation? Equivalently, for the decision problems studied, do salient discrepancies exist between the farmers' solutions and the normative solutions? (5) Are there noteworthy differences between the various normative decision criteria in the degree to which they reduce *ex ante* resource misallocation in the situations studied?

Answers to these questions, so far as they can be given, will be based on the farmers' solutions to a number of decision problems under absolute uncertainty. These problems were of two types, some being completely hypothetical and some representing a practical problem within the feeder-cattle enterprise. To simplify the presentation, we first will consider these two sets of problems separately, drawing the analyses together later. We begin by considering the hypothetical decision problems.

Description of the Hypothetical Decision Problems

These problems were based on the payoff matrix used to illustrate the several decision theories explained earlier. For convenience, this matrix is reproduced here.

Decision maker's alternatives	States of Nature S_1	S_2	S_3	S_4
A_1	2,500	3,500	0	1,500
A_2	1,500	2,000	500	1,000
A_3	0	6,000	0	0
A_4	1,500	4,500	0	0

In posing the hypothetical problems to the farmers, the alternative acts A_1, A_2, A_3 and A_4 were described simply as four possible annual investments, each requiring the same amount of capital. The payoffs shown opposite each act were specified as the possible dollar net returns that might accrue over the investment year if that act were chosen. It was pointed out that for a given investment choice, the likelihood of receiving any particular payoff relevant to that choice was completely unknown; the decision maker could only be sure that he would receive one of the payoffs listed opposite whichever act he selected.

This basic problem was posed in four "once only" contexts. Two of these specified that the alternative selected was to be the only income source; the other

[18] Absolute uncertainty prevails when the decision maker has no objective knowledge of the likelihood of occurrence of the possible outcomes of the decision. He knows only what outcomes may occur.

[19] F tests based on analysis of variance and Chi-square tests will be the principal statistical procedures used. In using analysis of variance to make tests of significance, it will be assumed that the data fulfill the necessary assumptions, *viz.* that the various fixed effects and the error are additive and that the errors are noncorrelated and normally distributed.

two that a sure annual income of \$3,000 additional to that derived from the selected act was also available. For each of these income situations the farmer was asked which act he would choose when the selected investment (a) could only be made once and (b) had to be made in each of 20 consecutive years. It was stipulated that Nature's strategy might vary from year to year over these 20 years.

The farmers were asked to treat each problem as if it were a real-life decision that had to be made under their current circumstances. No attempt was made to specify the available acts as real-world alternatives. The net income figures used are realistic, however, compared with those commonly found throughout the survey area. For each solution nominated, the reason for that specific choice also was requested.

All the farmers were owner-operators with considerable resources at their disposal. Also, none of the alternative acts could lead to absolute losses. It is therefore reasonable to regard the 1-year setting of the problem as having only short-run effects and the 20-year setting being considered as having long-run repercussions on the decision maker. Thus, the four decision problems can be characterized as follows: (a) short-run with no sure income; (b) short-run with sure income; (c) long-run with no sure income; (d) long-run with sure income.

Descriptive Role of the Theories of Choice: Hypothetical Decision Problems

The frequencies with which each of the alternatives were chosen in each setting of the problem by the 77 farmers are listed in table 9. For convenience, the theories of choice compatible with the selection of each alternative are also noted in the table. Acts A_1 and A_2 were most frequently selected. With no sure income available, the majority of farmers chose A_2. With an additional sure income, the majority chose A_1. Only when an additional sure income was available did a significant proportion of the respondents choose A_3 or A_4.

Had the farmers made their selections in a random manner, in reference to each column, a distribution pattern with approximately 20 selecting each act would be expected. In no case do the listed distributions approach such a pattern. Moreover, as table 9 shows, there are quite distinct differences between the frequency patterns for each setting or column of the decision problem. *Ipso facto,* it is concluded that the farmers made their choices in an active way, and that credence may be given to their explanations of these choices. Assuming the 77 farmers to be a random sample, Chi-square tests strongly support the hypothesis that the farmers' selections were purposive. A Chi-square test for independence between the setting of the decision problem and the alternatives chosen, regarding the data matrix of table 9 as a contingency table, also led to rejection of the hypothesis that the choices made were independent of the problem setting.

TABLE 9. DECISION THEORIES COMPATIBLE WITH THE SELECTION OF EACH ALTERNATIVE AND THE NUMBER OF FARMERS SELECTING EACH ALTERNATIVE IN EACH HYPOTHETICAL DECISION PROBLEM.

Alternative selected	Compatible decision theories[a]	Setting of decision problem			
		No sure income		Additional sure income	
		Short run	Long run	Short run	Long run
A_1	Laplace;	22	32	41	44
A_2	Wald; Hurwicz;[b] Simon;[c] Shackle;	52	41	16	13
A_3	Hurwicz;[d] Shackle;	2	2	13	6
A_4	Savage;	1	2	7	14
	Total	77	77	77	77

[a] Simon's theory with a zero aspiration level is compatible with each alternative.
[b] With $\beta \geqslant 8/9$.
[c] With an aspiration level greater than zero.
[d] With $\beta \leqslant 8/9$.

Decision Procedures Followed

In all cases in which A_1 was chosen, the respondents gave as their reason that it had the highest average payoff or that its row total was the largest. Selection of A_1, therefore, always was based on the Laplace criterion. As was quite evident during the collection of the data, it was not based on the use of Simon's theory with a zero aspiration level. Selection of A_1 was always preceded by some numerical calculations on the part of the respondent, either of row totals or averages. Numerical calculations by the respondent never led to any choice other than A_1.

All farmers selecting A_2 indicated that they did so because it guaranteed a minimum return of \$500 under all possible states of Nature. Their reasoning is in agreement with the Wald criterion, the Hurwicz criterion with a zero degree of optimism, Simon's theory and the special case of Shackle's theory when it is equivalent to the Wald criterion. (We have already noted that the Hurwicz criterion with a zero level of optimism is equivalent to the Wald criterion.) Given the respondents' reasoning, it seems most probable that the selection of A_2 was generally based on a Wald maximin approach or the use of Simon's theory with a nonzero aspiration level, rather than on the special cases of the Shackle and Hurwicz theories. Moreover, in situations where the decision maker's aspiration level exceeds or equals the maximum minimum payoff, Simon's theory is equivalent to the Wald criterion. Thus, there is only a small chance of error in attributing the selection of A_2 to a Wald criterion type of approach. It was the approach most implicit in the farmers' reasons.

Farmers' explanations for the selection of A_3 emphasized a preference for gambling. They recognized the "riskiness" of A_3 relative to the other alternatives but were attracted by the possibility of receiving the maximum possible payoff of \$6,000—behavior inconsistent with the Simon theory as a basis for selection of A_3. A gambling motivation is, however, compatible with a Shackle or a Hurwicz approach.

A gambling motivation was generally given for the choice of A_4; many of the farmers suggesting that this investment alternative was chosen as a compromise between the relative "safeness" of A_1 or A_2 and the "riskiness" of A_3. Such reasoning is suggestive of the Savage regret approach, although no farmer came close to giving an explicit statement of this criterion as the basis for his selection of A_4. Over-all, it appears that only the Laplace and the Wald criteria have widespread descriptive value in explaining the farmers' choice. In choosing A_1, a large proportion of the respondents made a choice incompatible with Shackle's hypothesis.

STABILITY OF CHOICE

Inspection of table 9 shows that many changes in choice occurred as the setting of the hypothetical decision problem varied, otherwise each alternative would have been selected the same number of times in each of the four settings of the decision problem. Only a third of the farmers did not alter their choice as the problem's context varied. One farmer always chose A_4, one always A_3, 11 always A_2 and 13 always A_1. It is certain that the shifts in choice that occurred are a function of the particular payoffs and problem settings specified in the hypothetical problems. In consequence, the changes in choice will not be discussed in full detail. Only the general implications of the data will be considered. The most important fact is that two-thirds of the respondents varied their decision-making approach as the context of the decision problem altered. Of these changes, the majority related to the income setting of the problem and not the length of time over which the decision would be influential. This is revealed somewhat by the data of table 9 and more clearly by the data of tables 10 and 11.

Table 10 relates to the time setting of the hypothetical decision problem. In it, no account is taken of the income setting of the decision problem. The table entries were derived by adding the corresponding frequencies for each choice pair A_iA_j ($i = 1, 2, 3, 4$; $j = 1, 2, 3, 4$) in the two "no sure income" settings of the problem and in the two "additional sure income" settings of the problem, A_i and A_j referring to the choices made by each respondent in the short-run and long-run contexts of the problem, respectively. Since each farmer was asked to make two short-run and two long-run decisions, each respondent is recorded twice in table 10. Equivalently, the table relates to twice 77, or 154, choice pairs. Entries on the main diagonal of the table's "A_iA_j matrix" indicate the number of times out of 154 that the choice pair A_iA_j ($i=j$) occurred. Such pairs constitute 80 percent of the total number of choice pairs. In other words, 80 percent of the solutions given by the farmers relevant to the time setting of the problem show no change in choice (or change in the decision-making approach) as the time setting of the problem varied. Assuming the survey farmers to be a random sample, the 95-percent confidence interval for the percentage of choice pairs of the type A_iA_j ($i=j$) is from 71 to 87 percent.[20]

The frequencies of choice pairs of the type A_iA_j ($i \neq j$) are shown by the entires off the main diagonal of the "A_iA_j matrix" of table 10. Each such pair represents a shift in choice by a respondent between the short-run and long-run setting of the problem. Thirty-one such shifts in choice occurred. Of these, 17 were away from A_2 into A_1 as the time influence of the decision became greater. Remembering that the reasons for selecting A_2 generally suggested use of the Wald criterion, while those for A_1 corresponded to the Laplace criterion, it appears that the majority of the shifts in choice occasioned by the extension of the decision's time influence related to a change from a Wald to a Laplace approach. The converse change, indicated by the pair A_1A_2, occurred three times. The choice pair A_3A_4 occurred six times, indicating in these cases a change from a conservative to a less conservative approach as the time influence of the decision lengthened. Over-all, despite some conflicting tendencies, the data indicate that the farmers were least conservative in their long-run decisions, remembering, however, that the majority of the choice pairs indicate no change in the respondents' decision-making approach as the time setting of the problem varied.

Except that it relates to the income context of the hypothetical decision problems and takes no account of their time setting, table 11 is similar in construction to table 10. Mechanically, it may be read in the same fashion as table 10 and indicates that only 68 out of 154, or 44 percent, of the solutions given by the farmers relevant to the income setting of the problem showed no change in choice (or change in the decision-making approach) as the income setting of the decision problem varied.

Again assuming the survey panel to be a random sample, the 95-percent confidence interval for this estimate of 44 percent is from 34 to 54 percent. The figure of 44 percent contrasts markedly with the corresponding figure of 80 percent relative to the time setting of the problem. Obviously, within the range of time and income settings specified, the respondent's decision-making approach was generally far more responsive to variations in the income setting of the problem than to variations in the time setting. Inspection of table 11 reveals that altogether there were 86 shifts in choice between the two income contexts of the problem; 53 of these changes were away from

[20] Based on the assumption that the number of such choice pairs follows a binomial distribution.

TABLE 10. FREQUENCY OF OCCURRENCE OF PAIRS OF CHOICES AMONG THE ALTERNATIVES A_1, A_2, A_3 AND A_4 RELATIVE TO THE TIME SETTINGS OF THE HYPOTHETICAL DECISION PROBLEMS, AND FREQUENCY WITH WHICH EACH ALTERNATIVE WAS SELECTED IN EACH TIME SETTING.

Choice in short-run setting	Choice in long-run setting A_1	A_2	A_3	A_4	Total frequency
	(No.)	(No.)	(No.)	(No.)	(No.)
A_1	57	3	1	2	63
A_2	17	51	0	0	68
A_3	2	0	7	6	15
A_4	0	0	0	8	8
Total frequency	76	54	8	16	154

TABLE 11. FREQUENCY OF OCCURRENCE OF PAIRS OF CHOICES AMONG THE ALTERNATIVES A_1, A_2, A_3 AND A_4 RELATIVE TO THE INCOME SETTINGS OF THE HYPOTHETICAL DECISION PROBLEMS, AND FREQUENCY WITH WHICH EACH ALTERNATIVE WAS SELECTED IN EACH INCOME SETTING.

Choice in no sure income setting	Choice in additional sure income setting A_1	A_2	A_3	A_4	Total frequency
	(No.)	(No.)	(No.)	(No.)	(No.)
A_1	32	0	10	12	54
A_2	53	29	5	6	93
A_3	0	0	4	0	4
A_4	0	0	0	3	3
Total frequency	85	29	19	21	154

A_2 into A_1, implying a shift from a Wald to a Laplace approach, as the income uncertainty associated with the decision decreased. Indeed, the off-diagonal entries of table 11 show that every change in choice was either away from A_2 into A_1, A_3 or A_4, or from A_1 into A_3 or A_4 as income uncertainty decreased. Since the reasons given for selection of A_3 or A_4 invariably involved a gambling motivation, it is apparent that every shift in choice denoted the adoption of a less conservative decision-making approach as the income uncertainty inherent in the problem's context declined. Moreover, comparison of the choice frequencies given in table 9 for similar time settings of the problem reveals that a majority of the respondents changed their decision-making approach as the income setting of the problem varied. This is in contrast to the situation relative to variations in the time influence context of the problem. As table 9 also shows, only a minority of the respondents altered their approach to the problem as its time influence varied.

Comparing the solutions for the long-run and short-run problems with no sure income available, as listed in table 9, little difference in popularity between A_3 and A_4 is evident. Indeed, neither of these acts were very popular; apparently, with no additional sure income available, only a few of the farmers were prepared to gamble. With an additional sure income of $3,000 available, however, both A_3 and A_4 became far more popular. Also, inspection of table 9 shows that a distinct difference in popularity between A_3 and A_4 developed as the period of influence of the decision varied. In the short-run setting A_3 was by far the more popular of the two; in the long-run context, the position was reversed.[21] Since A_4 is intuitively a safer investment than A_3, it appears that most of those farmers who "gambled" in the sure income setting preferred to take greater risks in their short-run decisions than in their long-run decisions. This contrasts with the behavior of those who switched from a Wald type of approach to the Laplace algorithm as the time influence of the decision became greater. The latter tended to take greater risks in their long-run decisions. Numerically, the former group was more important.

ASSOCIATIONS BETWEEN PATTERNS OF CHOICE AND SELECTED CHARACTERISTICS OF THE RESPONDENTS

The respondents were asked to solve the hypothetical decision problems in terms of their current circumstances. Assuming that they did, we now consider these solutions against the respondents' backgrounds attempting to perceive what associations exist between the patterns of choice over the four problems posed and some basic attributes of the respondents. In doing this, we will exclude the two respondents who operated extremely large farms relative to the other 75 members of the population.

Table 12 lists the means of some characteristics of those farmers following each pattern of choice shown at the top of the table. Four choice patterns are delimited; intuitively, they are the most meaningful of all those that might have been listed. For both A_1 and A_2 there was a noteworthy number of farmers who chose this single act in each of the four settings of the hypothetical decision problem. These farmers are grouped separately in the table under the headings of "Always A_1" and "Always A_2." The 13 farmers who always selected A_1 used the Laplace criterion consistently. It is most likely that the 11 who always chose A_2 were following an approach of the Wald type. The remaining farmers are classified into two groups: those who changed their choice as the setting of the problem varied but always selected either A_1 or A_2 and those who selected either A_3 or A_4 at least once as a solution for one of the four problems posed. A_3 and A_4 are grouped together because, intuitively, they are the least safe of the alternative acts. Their selection, given the availability of A_1 or A_2, implies a tendency to gamble, or at least to take risks. Conversely, A_1 and A_2 are, relative to A_3 and A_4, conservative alternatives. In table 12, these four decision patterns are listed from left to right in their intuitive order of decreasing conservativeness.

Age. Those farmers who always selected A_2 tended to be the older members of the population. It seems reasonable that these older respondents should use a Wald type of approach. They probably place more emphasis on maintaining their current situation as a base for their retirement rather than on bettering their current status. The younger members of the group generally chose either A_1 or A_2, switching between the Laplace and Wald approaches as the context of the decision problem varied.

Education. On the average, those respondents who chose A_2 had the smallest number of years of formal education. To some extent, this may be correlated with the fact that these farmers tended to be the older ones; their opportunities to obtain education may not

[21] Assuming the population to be a random sample, the (adjusted) Chi-square test value for this difference in popularity is 3.6. This value is significant at the 6-percent level.

TABLE 12. AVERAGE OF SELECTED CHARACTERISTICS OF THOSE FARMERS WITHIN EACH DECISION PATTERN GROUP.[a]

Characteristic	Unit	Decision pattern over the four hypothetical decision problems: Always A_2 (11 farmers)	Either A_1 or A_2 (72 farmers)	Always A_1 (13 farmers)	Sometimes A_3 or A_4 (29 farmers)	Over-all average (75 farmers)
Age	year	45.2	40.2	42.4	42.1	42.1
Formal education	year	10.9	11.1	12.0	11.8	11.5
Dependents	number	2.8	3.6	3.4	3.9	3.6
Total capital invested	$1,000	91.0	121.2	127.5	96.8	108.5
Net worth	$1,000	84.6	107.2	104.6	82.3	93.9
Equity	percent	93.0	88.4	82.0	85.0	86.5
Feeder cattle purchased[b]	number	77.7	115.6	121.9	115.5	111.1
Calves	percent[c]	62.2	44.7	59.6	39.1	47.1
Yearlings	percent[c]	37.8	54.8	34.4	49.6	47.1
2-year-olds	percent[c]	0.0	0.5	6.0	11.3	5.8

[a] The two farmers with extremely large farms are excluded.
[b] Cattle purchased during the period July 1, 1956, to June 30, 1957.
[c] Percentage of number of feeder cattle purchased.

have been as great as those available to younger members of the population. Those who used the Laplace criterion, choosing A_1, had the most education.

Dependents. Perhaps unexpectedly, those who always chose A_2 had the smallest number of dependents, perhaps because they were, in majority, the older ones whose children were no longer classed as dependents. We would have expected conservative choices to be associated with a larger number of dependents, especially since business and family interests are closely associated in farming. Those respondents with a larger-than-average number of dependents, however, tended to choose the more risky, but possibly more remunerative, alternatives, A_3 and A_4, at least once.

Total capital invested. Quite large differences existed among the four groups in terms of their capital investment. Above average investment tended to be associated with consistent selection of A_1 or of either A_1 or A_2. On the other hand, those choosing A_2 had the smallest capital investment. Small capital investment, relative to the average investment of the overall group, was also associated with selection of A_3 or A_4.

Net worth. Those farmers with a smaller-than-average net worth tended to follow either the least conservative choice pattern, sometimes selecting A_3 or A_4, or else the most conservative pattern, always choosing A_2. Such contrasting decisions suggest that the decision maker's inherent psychological make-up may be the dominant influence affecting his choice.

Equity. The lower an entrepreneur's equity ratio, the greater the risk he is taking, *ceteris paribus.* To a degree, therefore, an entrepreneur's equity ratio is an indication of his willingness to take risks. This is borne out by the equity data of table 12. Those respondents with a higher-than-average percentage equity either always chose A_2 or chose either A_1 or A_2. As previously mentioned, these are the two most conservative choice patterns among the four patterns delimited. Indeed, those choosing A_2, which corresponds to a Wald type of approach to the decision problem, had a very high percentage equity on the average. Conversely, those who used the Laplace approach or tended to gamble by sometimes choosing either A_3 or A_4 had relatively low equity ratios.

Feeder cattle purchased. Compared with other enterprises possible on Midwest farms, the feeder-cattle enterprise is "risky." Hence, to some extent, the size of a farmer's feeder enterprise is an indication of his tendency to take risks. The total number of cattle, or any other unweighted aggregate index, however, is only a rough indication of the risk taken. Such measures do not take into account the differences in risk between the various age types of cattle—differences that are quite substantial. Least risky are calves, while 2-year-olds are extremely risky. Yearlings have an intermediate level of associated risk. Against this background, we now consider the cattle data listed in table 12.

As expected, those farmers who used a Wald type of approach, always choosing A_2, tended to have smaller feeder-cattle enterprises. Moreover, their feeder operation contained the greatest proportion of calves of any of the groups listed and the smallest proportion of 2-year-olds. Conversely, those who tended to gamble by sometimes selecting A_3 or A_4 had the largest proportion of 2-year-olds and the smallest proportion of calves. Since 2-year-olds are the most risky type of cattle to fatten, it is not surprising that the proportion of 2-year-olds increases across the table as the conservatism of the decision pattern decreases.

From an economic viewpoint, a more interesting measure of the relative importance of the decision pattern groups is their role in terms of production. A satisfactory index is the relative weight of feeder beef purchased and fat beef sold by each group. Such figures are listed in table 13 for the 1956-57 season. It is noteworthy that those who changed their decision-making approach, as the setting of the hypothetical decision problem varied, handled nearly three-quarters of all the beef fed.

TABLE 13. PERCENTAGE OF FEEDER BEEF BOUGHT AND OF FAT BEEF SOLD, IN 1956-57 BY THE SURVEY PANEL, HANDLED BY EACH DECISION PATTERN GROUP.

Decision pattern group	Percentage of all feeder beef bought	Percentage of all feeder beef sold
Always A_2	9.3	10.0
Either A_1 or A_2	30.1	30.4
Always A_1	17.9	18.8
Sometimes A_3 or A_4	42.7	40.8

Normative Role of the Theories of Choice: Hypothetical Decision Problems

No normative implications of "real-world" decisions can be drawn from analysis of the farmers' solutions of the hypothetical problems analyzed. Hence, we now turn to a consideration of more practical or "real-world" problems and farmers' reactions to them. These problems were constructed from data supplied by the farmers. They relate to pre-purchase planning within the feeder-cattle enterprise. Each farmer's set of considered feeder programs was taken as his alternative acts. For each of these possible programs, the farmer was asked to give his expectation of the most probable buying and selling price of cattle under four possible states of Nature. Two farmers could not do this. Formulation of the decision problem in such terms was beyond them. Consequently, the major part of the analysis of the practical problems refers to 75 respondents. The specified states of Nature were the four combinations possible between two mutually exclusive weather possibilities and two mutually exclusive aggregate fattening policies on the part of all other farmers with a feeder-cattle enterprise. The feeder-raiser group was specified as behaving in "average or normal fashion," the reason for this simplification being that discussed previously.

Weather was specified in terms of the magnitude of the national corn crop. The two alternatives were a large national corn crop, leading to an average corn price of $1.10 per bushel through the fattening season, or a small corn crop, giving rise to an average price of $1.30 per bushel. By using this mode of expression, the possible effects of the weather were defined in a manner meaningful to the farmers. The alternatives open to all other cattle feeders were taken as their planning to produce mainly short-fed cattle to be sold from March to June or mainly long-fed cattle to be sold from June to September. The four combinations among these alternatives will be designated as follows: S_1, good cropping weather and marketings mainly March to June; S_2, good cropping weather and marketings mainly June to September; S_3, poor cropping weather and marketings mainly March to June; S_4, poor cropping weather and marketings mainly June to September.

Each farmer specified his price expectations for each state of Nature. He then was asked which alternative feeding program he would select and the number of cattle to be fed under each program. From these data, the proportion of the farmer's feeder enterprise resources that would be devoted to each alternative was calculated. As in the real-world situation, the respondent was allowed to select the null alternative of having no feeder cattle if he desired. The problem was posed under the following three possible circumstances: either good or poor weather possible; good weather certain; poor weather assured. For each of these problems it was specified that absolute uncertainty prevailed over Nature's possible states.

Normative payoff matrices were constructed from the price expectation and cattle feeding data supplied by the respondents.[22] In these matrices, the payoff elements were expressed as the expected percentage net return on each act, allowance being made for the length of the investment. Constant returns to scale were presumed to prevail in each alternative. Solutions to the practical decision problems were obtained by applying the theoretical procedures illustrated in the section explaining the several theories of choice under absolute uncertainty.

Descriptive Role of the Theories of Choice: Practical Decision Problems

We now examine the farmers' solutions of these practical decision problems in relation to the questions posed at the outset of this section. We first consider the descriptive role of the theories of choice. We can consider the descriptive role of only the Laplace equiprobability, Wald maximin and Savage regret theories of decision making under absolute uncertainty. The theories of Hurwicz, Simon and Shackle cannot be appraised because the respondents' pessimism-optimism indices, aspiration levels and gambling indifference maps are unknown. The Wald maximin and Savage regret criteria will not be considered with only pure strategies permitted; mixed strategies are feasible in the practical problems, and it would be irrational to consider these procedures only in terms of pure strategies. The main procedure in analyzing the descriptive role of the decision theories is as follows: First, the empirical solutions to the decision theories will be constructed as normative specifications. Next, the actual choices made by farmers as descriptive actions will be compared with the empirical solutions.

[22] The construction of the payoff matrices is explained in Appendix B.

The theoretical solutions of the practical problems can be divided into two main classes: If the payoff martix contains a dominant row, all three of the Laplace, Wald and Savage theories select as optimal the act corresponding to that row; all three answers to the problem are then identical. Such occurrences constitute the first grouping of the theoretical solutions. If the payoff matrix does not contain a dominant row, the theories will not suggest identical solutions. Such occurences constitute the second class of solutions. The relative importance of these two groupings of the solutions is shown in table 14 for each problem setting.

TABLE 14. CLASSIFICATION OF THEORETICAL SOLUTIONS TO THE PRACTICAL DECISION PROBLEMS.

Problem setting	Number of problems in which the Laplace, Wald and Savage solutions were: Identical	Not identical
Good weather certain	60[a]	15
Poor weather certain	66	9
Either good or poor weather	52[a]	23

[a] Including one problem whose solutions, for all practical purposes, were identical.

Thus, of the 225 problems constructed, 178 contained a dominant alternative which was automatically selected by each of the theoretical decision procedures. That so many dominant acts existed is partly because of the small number of alternatives present in each problem. It also reflects the feelings of those respondents who did not attach strong differential effects to some or all of Nature's possible states.

Assuming the survey panel to be a random sample, a Chi-square contingency test value of 8.0 for the data of table 14 indicates that there is less than one chance out of 100 that the occurrence of idential solutions is not independent of the setting of the practical decision problems. Moreover, as the following discussion outlines, a reasonable explanation can be given for the pattern of the data in terms of our theoretical model.

Dominant alternatives tended to occur most frequently when poor weather was specified as certain. This is possibly a reflection of the fact that with poor weather assured, fewer cattle would be fed and fewer farmers would feed cattle. Under such circumstances there would be fewer aggregative maneuvers possible by those other farmers feeding cattle, a phenomenon most likely leading to a smaller range of possible variation in fat cattle prices and, concomitantly, a greater chance that a dominant alternative might exist. Conversely, with either good or poor weather possible, it might be expected that there would be least chance of a dominant alternative occurring. As the preceding figures show, dominant alternatives were least frequent when the weather was not specified.

We will first examine the farmers' solutions for those problems containing a dominant alternative.

All Theoretical Solutions Identical

Table 15 gives a qualitative classification of the farmers' solutions for those 178 problems with a dominant alternative. The classification is in terms of the agreement between the farmer and theoretical

TABLE 15. CORRESPONDENCE BETWEEN FARMER AND THEORETICAL SOLUTIONS TO THE PRACTICAL DECISION PROBLEMS IN THOSE CASES WHERE ALL THEORETICAL SOLUTIONS WERE IDENTICAL.

Number of alternatives considered	Number of cases in which the farmer and the theoretical solutions were identical			Number of cases in which the farmer's solution overlapped the theoretical solution			Number of cases in which the farmer and theoretical solutions were disjunct			Total number of cases in which all theoretical solutions were identical		
	G[a]	P[b]	E[c]	G	P	E	G	P	E	G	P	E
1	12	13	13	0	0	0	1	0	0	13	13	13
2	6	11	5	12	10	10	4	5	4	22	26	19
3	4	5	3	6	6	6	3	2	1	13	13	10
4	0	0	0	7	6	5	0	0	0	7	6	5
5	0	0	0	3	6	3	0	0	0	3	6	3
7	0	1	0	1	0	1	1	1	1	2	2	2
8	0	0	0	0	0	0	0	0	0	0	0	0
Total	22	30	21	29	28	25	9	8	6	60	66	52
Percent	37	45	40	48	42	48	15	13	12	100	100	100

[a] G denotes the problem setting with good weather certain.
[b] P denotes the problem setting with poor weather certain.
[c] E denotes the problem setting with either good or poor weather possible.

solutions. As previously mentioned, the theoretical solutions were obtained by applying the relevant decision criteria to the normative payoff matrix of each problem. For each problem setting, the total number of farmers within each solution classification is shown at the bottom of table 15. These totals are also given as a percentage of the total number of problems in each setting. Comparison of these percentages within each qualitative grouping indicates that little variation existed between problem settings. The reason for this is that, in most cases, a farmer's solutions for all three problem settings fell into the same qualitative class.

Averaged over each problem setting, 41 percent of the farmers' solutions coincided exactly with the theoretical solution; in addition, 46 percent of the farmers' solutions overlapped the theoretical solution. These were cases where the farmer selected a mixed strategy that included the optimal act as a component. For only 13 percent of the problems were the farmer and theoretical solutions disjunct. Obviously, the respondents tended to select, at least as a part of their program, the alternative suggested by the theoretical procedures. But, as the following discussion of table 15 indicates, this does not imply that the theories played any extensive descriptive role.

Of the 155 farmer solutions that coincided with the theoretical solution, 24 percent were necessarily correct because they related to "problems" involving only a single feeder program. Another 35 percent of these 155 farmer solutions related to farmers who considered only two alternatives. Only in one case out of the 36 in which more than three acts were considered was a strategy corresponding exactly to the theoretical solution chosen. Moreover, in the majority of those cases where the farmer's solution overlapped the theoretical solution, the optimal act was only of minor importance in the farmer's solution. Nor was there any significant correspondence evident between the farmers' approaches to the short-run hypothetical decision problems (which correspond best in time influence to the practical problems) and the classification of the farmers' solutions in table 15. Also, the solutions of those 24 farmers who considered more than one state of Nature did not correspond to the theoretical solutions to any greater extent than was evident for the other members of the panel. Purposive selection by the respondents, based on calculations akin to those involved in our construction of the payoff matrices and application of the decision algorithms, appears unlikely. As is shown in the following paragraphs, a similar conclusion must be drawn from analysis of those problems not containing a dominant act. Also, for both solution groups, this conclusion remains true when the Wald and Savage approach solutions based on only pure strategy selection are allowed.

Forty-seven of the 225 problems had payoff matrices such that the Laplace, Wald and Savage criteria solutions were not identical. The farmers' solutions to these problems are classified in terms of their agreement with the theoretical solutions in table 16. In making this tabulation, the farmer's solution was regarded as coinciding with the theoretical if it included the acts of the normative solution in proportions within the range $y_i \pm 0.10$, where y_i is the fraction of resources that should be devoted to the *ith* act. The range $\pm$ 0.10 allows for possible errors of estimation in both farmer and normative solutions—errors deriving from possible inaccuracies in the data used to calculate production costs. While the range of $\pm$ 0.10 is arbitrary, it is considered reasonable.

TABLE 16. CORRESPONDENCE BETWEEN FARMERS AND THEORETICAL SOLUTIONS TO THE PRACTICAL DECISION PROBLEMS IN THOSE CASES WHERE ALL THEORETICAL SOLUTIONS WERE NOT IDENTICAL.

Number of alternatives considered	Number of cases in which farmer's solution in agreement with: Laplace solution			Wald solution			Savage solution			None of the theoretical solutions			Total number of cases in which all theoretical solutions were not identical		
	G[a]	P[b]	E[c]	G	P	E	G	P	E	G	P	E	G	P	E
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	2	0	1	2	1	4	1[d]	2[d]	1[d]	5	3	7	9	5	12
3	0	0	0	0	0	0	0	0	2	1	1	2	1	1	4
4	0	0	0	0	0	0	0	0	0	1	2	3	1	2	3
5	0	0	0	0	0	0	0	0	0	3	0	3	3	0	3
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
Total	2	0	1	2	1	4	1[d]	2[d]	3[d]	11	7	16	15	9	23

[a] G denotes the problem setting with good weather certain.
[b] P denotes the problem setting with poor weather certain.
[c] E denotes the problem setting with either good or poor weather possible.
[d] Including one problem already listed under agreement with the Wald solution.

Inspection of table 16 reveals that only 16 of the 47 farmer solutions or descriptive actions coincided with a normative solution of the theoretical criteria detailed in a previous section. Fourteen of these instances were for problems involving only two acts. Of these 14 problems, 12 had theoretical solutions involving both alternatives in approximately equal proportions. The farmers may have tended to allocate their resources in smiliar proportions as a simple compromise between the two alternatives. The normative solutions to the other four of the 16 problems involved only pure acts. Coincidence between the farmer selections and the theoretical solutions could again have been due to chance. Given the data of table 16, this seems most likely. Also, no significant correspondence existed between the farmers' solutions to the hypothetical short-run decision problems and their solutions to the practical problems. This supports the contention that the farmers' analyses of the practical problems were not based on considerations akin to those used in deriving the normative solutions.

ALTERNATIVE HYPOTHESES

We cannot say that the Laplace, Wald and Savage theories played any significant descriptive role in relation to the normative payoff matrices for the practical problems. This contrasts with the fact that in the hypothetical decision problems a majority of the farmers did tend to use a Laplace or Wald type of approach. Probably a multitude of factors contribute to this discrepancy. Only the three possible causes hypothesized as the most important will be discussed here, however.

Profit maximization. Profit maximization has been assumed to dominate the decision maker's appraisal of his problem. Perhaps this assumption is too strong. For instance, some of the decision makers may have preferences between alternative acts based on non-monetary characteristics of the acts. Others may gamble for its own sake.

Strangeness of the model. As shown previously, only a minor proportion of the farmers approached the decision problem in a manner similar to that postulated by the normative model. The "strangeness" of the constructed decision problem with its implicit use of the model may have confused some of the respondents.

Calculation difficulties. Normative payoff matrices were used in the comparisons. As shown in Appendix B, the development of these matrices involved a series of cumbersome calculations. Implicitly, we assumed that the respondents could also make these calculations, or rule-of-thumb approximations of them, or know intuitively from previous experience the adjustments that had to be made. This is an extremely strong assumption. Its lack of fulfillment is probably the major cause for the high degree of irrationality suggested in the farmers' solutions. The fact that the farmers did not make the transformations from expected prices to expected profits correctly, however, does not necessarily vitiate the descriptive role of the theories. The farmers may have been using the theories, not in relation to the normative payoff matrices, but in terms of some naive set of payoffs.

Naive payoffs. The simplest such hypothesis is that the farmers made their choices simply in terms of the expected buying and selling prices of the cattle—taking no account of intermediate production costs. To test this hypothesis, payoff matrices were constructed for each problem in terms of the margins between expected buying and selling prices for each alternative. The farmers' solutions were checked against the theoretical solutions for this naive formulation of the decision problems. Again no significant correspondence was found between the theoretical and farmer solutions, nor between the farmer's solutions to the practical problems and their decision-making approach to the short-run hypothetical problems. Hence, the hypothesis must be dismissed.

Habitual selection. An alternative hypothesis is that the farmers did not solve the constructed problem in an active way. Perhaps they had a rather fixed feeder-cattle operation from year to year which they nominated as their solution to the problem. As a test of this hypothesis, the farmers' solutions to the practical problems were checked against the history of their feeder enterprises during two previous years. The 13 farmers who considered only a single alternative were excluded from this phase of the analysis. Of the remaining 62 farmers, 21 percent had solutions to the practical problems coinciding either exactly or very closely with their actual feeder programs over the two previous years. They apparently made their feeder-cattle decisions on a habitual basis; when confronted with the practical decision problem they had probably reiterated the habitual solution. It appears certain that for these 13 farmers, and for the 13 who considered only a single alternative, the decision theories on which we have elaborated played no descriptive role in the short run of a single season. It may be that the theories played some role over the longer run for these farmers in initially determining their habitual decision; more likely, though, their original longer run decision was based on an aspiration level approach of the Simon type. Perhaps they found a feeder-enterprise pattern that was initially satisfactory and simply maintained this same pattern, without seeking better alternatives.

The 49 respondents whose feeder operation varied within the two prior seasons in general nominated solutions that (a) varied over the three problem settings and (b) were, in consequence, usually different from either of their two historical selections. These farmers, therefore, probably approached the practical problems in an active manner. Moreover, they constitute the bulk of population. On these grounds, we cannot dismiss the theories as playing no role with respect to the practical problems.

NORMATIVE ROLE OF THE THEORIES OF CHOICE: PRACTICAL DECISION PROBLEMS

The average expected annual percent net returns from the farmer, Laplace, Wald and Savage solutions for each state of Nature in each problem setting are shown in table 17. Inspection of the table reveals that these returns differ little from state to state within each solution. Also, only relatively small differences exist between the average payoffs for the Laplace, Wald and Savage solutions. Given the prevalence of dominant alternatives, this is not unexpected. The outstanding feature of the data is the difference between the farmer and normative solutions. For every state of Nature in every problem setting, the average expected payoff from the farmer solution is markedly smaller than that from any of the three normative solutions.

Assuming the survey panel to be a random sample, F tests based on analysis of variance (using designed comparisons among the means of table 17) indicated that the differences between the farmer and theoretical solution means were highly significant, also that significant differences did not exist among the theoretical solution means.

Table 18 lists the magnitude of the average discrepancies between the farmer and normative solution payoffs. The percentage increase in net return that would be expected if the normative strategy had been selected rather than the farmers' nominated solution is shown in table 19. Obviously the decision theories examined do have practical normative import *ex ante*. Nothing can be said of their role in reducing *ex post* resource misallocation. The extent to which they did so would depend on the correctness of the farmers' price expectations.

Table 19 also suggests that the three normative theories do not differ greatly in the extent to which they reduce resource misallocation *ex ante*, as would be expected given the data of table 17. Some noteworthy differences do exist, however. In the problem setting with specification of good weather certain, the average expected payoffs from the Wald and Savage solutions are dominated by those from the Laplace solutions. With poor weather assured, the Wald approach is dominated. On the other hand, with weather unspecified, the Savage approach is inferior to the Laplace and Wald algorithms. That the Laplace solutions are never dominated, while the Wald and Savage are, is not surprising because the latter are conservative approaches.

The data of table 19 can also be interpreted as an indication of the extent to which the survey farmers tended to be irrational, assuming profit maximization as their goal. Table 20 gives a better indication of the degree of irrationality that prevailed. It presents frequency distributions of the discrepancies between the farmer and Laplace criterion solutions under each state of Nature. Had they used the Laplace criterion, 17 percent of the farmers would, on the average, have increased their expected net return by 10 or more percentage points; 6 percent of the farmers would have decreased their net return. Because the frequencies for the Wald and Savage criteria follow essentially the same pattern, they are not presented.

TABLE 17. AVERAGE EXPECTED ANNUAL PERCENT NET RETURN UNDER EACH STATE OF NATURE FOR THE FARMER, LAPLACE, WALD AND SAVAGE SOLUTIONS OF THE PRACTICAL DECISION PROBLEMS.[a]

Solution	Good weather certain		Poor weather certain		Either good or poor weather possible			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Farmer	20.5	19.0	18.0	18.9	20.1	19.9	18.1	18.1
Laplace	25.4	23.8	23.5	22.9	24.9	23.8	23.4	22.9
Wald	25.2	23.8	23.0	23.0	24.8	23.9	23.0	22.8
Savage	25.2	23.8	23.3	23.0	24.8	23.8	22.9	22.5

[a] Percent net return on purchase price of cattle and feed required to finish them.

TABLE 18. AVERAGE GAIN IN EXPECTED ANNUAL PERCENT NET RETURN UNDER EACH STATE OF NATURE THAT WOULD OCCUR IF THE FARMERS USED THE LAPLACE, WALD OR SAVAGE CRITERIA.

Criterion	Good weather certain		Poor weather certain		Either good or poor weather possible			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Laplace	4.9	4.8	5.5	4.0	4.8	3.9	5.3	4.8
Wald	4.7	4.8	5.0	4.1	4.7	4.0	4.9	4.7
Savage	4.7	4.8	5.3	4.1	4.7	3.9	4.8	4.4

TABLE 19. AVERAGE PERCENTAGE INCREASE IN EXPECTED ANNUAL PERCENT NET RETURN UNDER EACH STATE OF NATURE THAT WOULD OCCUR IF THE FARMERS USED THE LAPLACE, WALD OR SAVAGE CRITERIA.

Criterion	Good weather certain		Poor weather certain		Either good or poor weather possible			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
Laplace	23.9	25.3	30.5	21.2	23.9	19.6	29.3	26.5
Wald	22.9	25.3	27.8	21.7	23.4	20.1	27.0	26.0
Savage	22.9	25.3	29.4	21.7	23.4	19.6	26.5	24.3

TABLE 20. FREQUENCY DISTRIBUTIONS OF THE CHANGE IN EXPECTED ANNUAL PERCENT NET RETURN THAT WOULD OCCUR IF THE FARMERS USED THE LAPLACE CRITERION.

Interval	Good weather certain		Poor weather certain		Either good or poor weather possible			
	S_1	S_2	S_3	S_4	S_1	S_2	S_3	S_4
−15.0 to −10.1	..	..	..	.	1	..	..	..
−10.0 to −5.1	.			1	1		..	..
−5.0 to −0.1	2	6	1	4	3	10	2	5
0.0 to 4.9	40	43	43	47	40	42	41	43
5.0 to 9.9	15	10	17	13	17	14	19	19
10.0 to 14.9	13	10	7	4	6	3	6	1
15.0 to 19.9	3	1	3	3	2	2	4	3
20.0 to 24.9	2	4	1	2	4	4	1	2
25.0 to 29.9	..	1	1	1	1	..	.	1
30.0 to 34.9	..	..	1	..	..	..	2	1
35.0 to 39.9	..	..	.	..	..	..	..	..
40.0 to 44.9		.	1	.		.	..	..

SUMMARY AND LIMITATIONS

This study refers to decisions made with respect to cattle feeding by a group of Iowa farmers. It represents an attempt to evaluate certain decision models and theories as they either (a) explain the procedures which farmers do use in making decisions under uncertainty or (b) provide procedures which farmers should use in decision making under certain problem settings involving uncertainty and relative to the end of profit attainment. In economic terminology, (a) refers to the possible descriptive role, the explanation of actual actions taken by farmers, of the various theories; (b) refers to the normative role, the actions farmers should take relative to particular goals, of the theories.

Real-world economic decisions are clouded by uncertainty about the future. This study has been concerned with decisions made under uncertainty, the decision maker having no objective knowledge of the likelihood of occurrence of the possible outcomes of his decision. He knows only what outcomes may occur.

Assuming an economic hierarchy of the type and magnitude generally found in the real-world, several general game theoretic models of the production decision problem facing an entrepreneur appeared unsatisfactory. By considering a situation involving a large number of entrepreneurs whose production decisions interact and all of whom have only human capabilities for solving problems, however, a more satisfactory specific model was derived. Essentially, this model was normative, being postulated as the most rational way for the entrepreneur to view his production decision problem. It corresponded to the real-world situation by assuming that the decision maker simplifies his choice problem to a degree compatible with his mental capabilities, appraising only some subset of his available acts and confining his attention to a small number of states of Nature. (Nature, as here used, is explained in the text.) These states of Nature were specified as broad aggregative maneuvers possible on the part of his opponents considered in aggregate. This model is one of absolute uncertainty where opponents are so numerous that their individual actions cannot be assessed.

Using the constructed model, an empirical assessment of the normative and descriptive roles of the several theories of choice relevant to uncertainty was made. Theories which are primarily normative include those of Laplace, Wald, Savage and Hurwicz. Since they represent simple algorithms, however, it is not implausible that these theories might have descriptive value or actual use by farmers. The theories of Simon and Shackle are purely descriptive and have no normative connotation. These theories are examined relative to decisions and choices specified by farmers to determine whether they are descriptive in the sense of typifying procedures which farmers do use.

For this empirical analysis, data were collected during 1956-57 by way of a four-stage personal interview panel survey. The panel was composed of a population of 77 respondents, all of whom: (1) were farming in Marshall County, Iowa; (2) were between 30 and 50 years of age in June 1957; (3) had owned and operated at least 80 acres of farmland during the 3 years prior to June 1957; (4) had fed an average of at least 25 feeder cattle in each of the three feeding seasons prior to the survey; and (5) had cooperated in all stages of the survey.

These restrictions were used to ensure having a group of respondents familiar with the cattle-feeding enterprise, the empirical analysis being based upon the decision problem facing a farmer within the feeder-cattle enterprise at the pre-purchase planning stage of a given season. This decision problem could be incorporated in the postulated normative model mentioned earlier. In the first stage of the empirical analysis, however, the comparison of farmer choices with the characteristics or elements of the model, examination of the farmers' responses revealed that only 12 out of the 77 could be said fairly certainly to consider the decision problem in the exact fashion postulated by the specified model. For another three farmers, the model was probably descriptively correct. In its entirety, therefore, the model had exact or complete descriptive value for only a small proportion of the population. But a majority of the farmers did behave in partial agreement with the model. All considered some simplified subset of the alternatives available to them; 58 specified as a primary factor influencing their choice a factor compatible with the theoretical specification of the model; 24 of the respondents made allowances for outcome variations over two or more states of Nature.

In the second stage of the empirical analysis, designed to assess the possible normative and descriptive roles of the several decision theories, the respondents were asked to solve two sets of decision problems under absolute uncertainty. The first of these sets consisted of four hypothetical problems. The farmers' solutions to these problems, together with reasons for their choices, indicated that probably only the Wald and Laplace theories had significant descriptive value. Only a minority of the farmers consistently used the same approach for solutions to each of the hypothetical decision problems. Evidently the decision approach used and, consequently, the choice made depend to a large extent on the setting of the decision problem. In this regard, income was more important than the time influence in determining the decision approach to be used or suggested. Consistent use of a Wald type of approach tended to be associated with farmers having a low level of total capital investment and a high equity ratio. On the average, respondents using the Wald approach were also the older and least educated members of the population. Those who always used the Laplace algorithm generally had the most years of formal education, a relatively high net worth and a low equity ratio. In contrast to farmers using only a Wald or a Laplace approach were those who switched between these two procedures as the setting of the decision problem varied. Generally, they were younger, employed more capital and had more dependents. They were numerically more important than either of the groups using only a Wald or a Laplace approach.

The other set of problems analyzed in the second stage of the empirical analysis was practical. These problems related to a real-world, rather than a hypothetical, situation. Each respondent was asked for data relevant to his pre-purchase decision problem within the feeder-cattle enterprise. Given this data, the farmer was asked for his solutions to this problem when it was posed in three different contexts. Again, from comparison of the farmers solutions and the solutions for the theoretic approaches to these practical problems, nothing could be said of a general descriptive role of the theories *per se*. It was apparent that the theories played no descriptive role in terms of the normative model underlying the construction of these practical problems. In contrast, however, the theories appeared to have important normative implications for decisions on cattle feeding. Within the setting of the practical problems, the respondents would have been able to increase their expected profits by at least 21 percent, as an average, if they had used the Laplace, Wald or Savage procedures.

Several limitations of the empirical analysis of farmers' decisions in relation to decision models and game theories presented here should be noted. First, profit maximization was assumed to be the dominant goal. Ideally, utility maximization would have been a more relevant assumption, but its measurement also would have been impractical. Second, the empirical analysis assumed that the respondent's solution to a constructed decision problem corresponded exactly with the decision and resultant action he would have taken if faced with the same problem in real life. This correspondence may not always be true. Third, the respondents were only asked to solve each decision problem once. Had they been asked to solve the problems at other points in time they may have given different answers. Fourth, the empirical analysis related, in strict terms, only to a population of 77 farmers. Moreover, much of the study revolved around but one of the many production decision problems faced by these entrepreneurs.

APPENDIX A:
CHARACTERISTICS OF THE POPULATION

The mean and range of some selected attributes of the survey farmers are shown in the accompanying tables. Personal characteristics are summarized in table A-1, financial data in table A-2 and farm organization characteristics in table A-3.

A wide range is evident for a majority of the characteristics. With the exception of equity, which has a slightly negatively skewed distribution, all of the attributes listed in tables A-2 and A-3 have a frequency distribution that is strongly positively skewed. Typical is the distribution of operated acres. It is as follows:

Acres operated	*Number of farmers*
80-99	3
100-199	24
200-299	21
300-399	17
400-499	7
500-599	3
1,100	1
1,820	1

TABLE A-1. SELECTED PERSONAL CHARACTERISTICS OF THE POPULATION: MEAN AND RANGE.

Item	Unit	Mean	Range	
			Low	High
Age	year	42.1	31	50
Dependents	number	3.6	0	7
Education: School	year	11.0	4	12
College	year	0.6	0	5
Total	year	11.6	4	17
Other experience: Nonfarm	year	2.0	0	25
Farm laborer	year	4.8	0	16
Tenant	year	5.7	0	26
Experience as owner-operator	year	11.4	3	27

TABLE A-2. SELECTED FINANCIAL CHARACTERISTICS OF THE POPULATION: MEAN AND RANGE.

Item	Unit	Mean	Range	
			Low	High
Invested capital:				
Land and buildings	$1,000	72.8	5.0	450.0
Machinery	$1,000	11.1	1.0	50.0
Livestock	$1,000	18.2	0.0	140.0
Other capital	$1,000	31.5	0.3	805.0
Total capital investment	$1,000	133.6	20.1	1,300.0
Borrowed capital:				
Land, buildings and machinery	$1,000	9.5	0.0	56.0
Livestock	$1,000	3.2	0.0	26.0
Other (Unsecured capital)	$1,000	2.8	0.0	30.0
Total borrowed capital	$1,000	15.5	0.0	102.0
Equity ratio	percent	88.4	52.6	100.0
Gross farm income	$1,000	41.9	8.0	442.0

TABLE A-3. CROP AND LIVESTOCK PROGRAMS FOLLOWED BY THE POPULATION: MEAN AND RANGE.

Item	Unit	Mean	Range	
			Low	High
Land operated	acre	291.4	80	1,820
Owned	acre	239.3	80	1,820
Rented	acre	52.1	0	335
Land use:				
Grain	acre	145.5	0	900
Soybeans	acre	8.4	0	63
Silage	acre	8.7	0	200
Hay	acre	43.1	0	200
Rotation pasture	acre	24.9	0	500
Permanent pasture	acre	24.1	0	285
Homesteads, lots and waste	acre	11.8	2	110
Total	acre	266.6	80	1,820
Livestock:				
Pig litters	number	32.4	0	100
Feeder cattle purchased	number	137.4	9	1,200
Calves	number	67.3	0	900
Yearlings	number	63.6	0	817
2-year-olds	number	6.5	0	140
Beef cows	number	6.9	0	57
Milking cows	number	2.6	0	40

APPENDIX B:

DERIVATION OF NORMATIVE PAYOFF MATRICES FOR THE PRACTICAL DECISION PROBLEMS

As pointed out in the text, rational analysis of the decision problem necessitates that the elements of the payoff matrix be comparable. Comparability was achieved by using as payoff elements the annual percent net return expected from each of the considered feeder program alternatives under each possible state of Nature. These percent returns were calculated for each farmer as follows:

Denote by:

a_{ij} : the expected annual percent net return on investment in alternative A_i° if the state of Nature S_j should prevail.

P_{ij} : the farmer's expected selling price at the farm in cents per pound liveweight of fat cattle from A_i° if S_j occurs.

c_{ij} : the estimated cost of production in cents per pound liveweight of fat cattle from A_i° if S_j occurs.

e_i : the farmer's proportionate equity in the capital invested in A_i° if A_i^c is selected. This figure could not be ascertained precisely. As an approximation, the farmer's estimate of his year-to-year average equity ratio for his feeder-cattle enterprise was used.

r : the maximum annual percent net return which the farmer felt certain of receiving from alternative investment of his feeder-enterprise capital during the period of the year when it is free for investment elsewhere.

s : the proportion of the farmer's equity in his feeder-enterprise capital that he normally invests elsewhere when it is not invested in feeder cattle.

t_i : the fraction of the year during which the farmer's feeder-enterprise capital is free for investment elsewhere.

m_i : the length of feeder program A_i° in months.

The payoff elements were then calculated for each farmer by the following formulas:

$$a_{ij} = \frac{p_{ij} - c_{ij}}{c_{ij}} \cdot \frac{12}{m_i} \frac{100}{1} \qquad \text{if } m_i \geqslant 12,$$

$$a_{ij} = \frac{p_{ij} - c_{ij} + c_{ij}e_irst_i}{c_{ij}} \cdot \frac{100}{1} \qquad \text{if } m_i < 12.$$

While reinvestment of the farmer's personal capital in the off-feeder season was common, only one farmer reinvested borrowed capital. The net return from this investment was included in the calculation of his payoff matrix.