DEALING WITH RISKS IN THE MANAGEMENT OF AGRICULTURAL FIRMS: AN EXTENSION/TEACHING VIEWPOINT

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INTRODUCTION

Several developments in recent years have focused the interest of extension and classroom educators on risk and uncertainty in agricultural production and marketing.[1] Developments causing current interest include variation in foreign demand for U.S. products, shortages of fuel and fertilizer, changes in agricultural government programs, and droughts in some of the major agricultural production areas of the U.S. In part it is a renewal of the emphasis placed on such management problems in the early 1950's [Thair, et al.]. Possibly the renewed interest has been kindled by the productivity of researchers interested in problems of decision making under uncertainty, such as represented in this Committee.

In order to assist the managers of agricultural firms as they deal with the problems of risk in production and marketing, it is necessary to have concepts and tools which are appropriate for analyzing the problems. The purpose of this paper is to (a) review such concepts and tools from the extension/teaching viewpoint, (b) describe how these concepts and tools are being used in educational programs to improve decision making under risk and (c) examine the accomplishments of W-149 relative to extension/teaching needs.

This paper has three parts. The first reviews the constructs of decision making under uncertainty. This overview provides a framework for the remainder of the paper. The second part of the paper reviews an extension project to develop methods and materials for teaching farmers to deal with risk in decision making. Finally, an analysis is provided of research accomplishments and needs in the area of risky decision making, from the perspective of a classroom teacher and an extension educator.

Decision Making Under Uncertainty: A Conceptual Framework

What is available in theory and models for use in developing educational programs? There are probably many ways to describe what is

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[1] The terms "risk" and "uncertainty" will be used synonomously. With the acceptance of subjective knowledge, the distinction between risk and uncertainty is irrelevant, and the terms are interchangeable.

available. Anderson (1976) did an excellent job in an earlier discussion. Figure 1 provides a starting place for achieving the objectives of this paper.

Data Flows and Organization

The upper major section of Figure 1 stresses the central role of data in decision making under uncertainty. Economic principles, strategic relationships, technology alternatives and production functions must all be used to organize the price, yield, and input-output data into a description of payoffs or outcomes for each alternative action-event combination. The payoff matrix provides a framework for accomplishing this organizational process. The payoff matrix forces definition of the relevant alternative actions, the significant events (or states of nature) that will affect the payoffs from these actions, and the units to be used in measuring the payoffs. An important conceptual issue here is the choice of the appropriate measure of performance--net farm income, return to management, income after taxes, return over variable cost, or net cash flow? Decision trees present a graphical alternative to the payoff matrix and are particularly useful for the presentation of sequential decision alternatives and events.

Before going too far into looking at Figure 1, it may be well to emphasize the audiences identified as targets for extension and teaching efforts. The audience includes farmers, creditors, resource owners (such as land owners), policy makers, input suppliers, and buyers of agricultural products. The audience includes not only people in the industry but those being trained to move into the industry in university classrooms, in vocational-technical training programs, and in other youth programs. As we will emphasize later, specific educational programs on decision making under certainty compete for time with other important alternatives. Resulting priorities must be considered in planning educational efforts in the classroom and field.

One possible function of an educational program is to provide data processed in the form of the payoff matrix or decision tree directly to the audiences for use as they see fit. The payoff matrices and/or decision trees contain useful management information, drawing on economic and strategic principles such as marginality conditions, flexibility, liquidity, diversification, insurance, etc. The payoff matrix and tree present price and production relationships under relevant states of nature and production alternatives. The direct information approach is illustrated as the first branch (1) in Figure 1 providing direct information to the audiences.

The Use of Subjective Knowledge

Expectations of the audience concerning levels of important variables also flow into the system (Figure 1). The argument for the acceptance of subjective knowledge assumes that it is impossible for the manager to know the alternative actions, the possible outcomes, and their consequences and yet be entirely ignorant of the probabilities associated with these outcomes. It is difficult to conceive of a decision situation in which the producer has no knowledge of the chances of various outcomes.

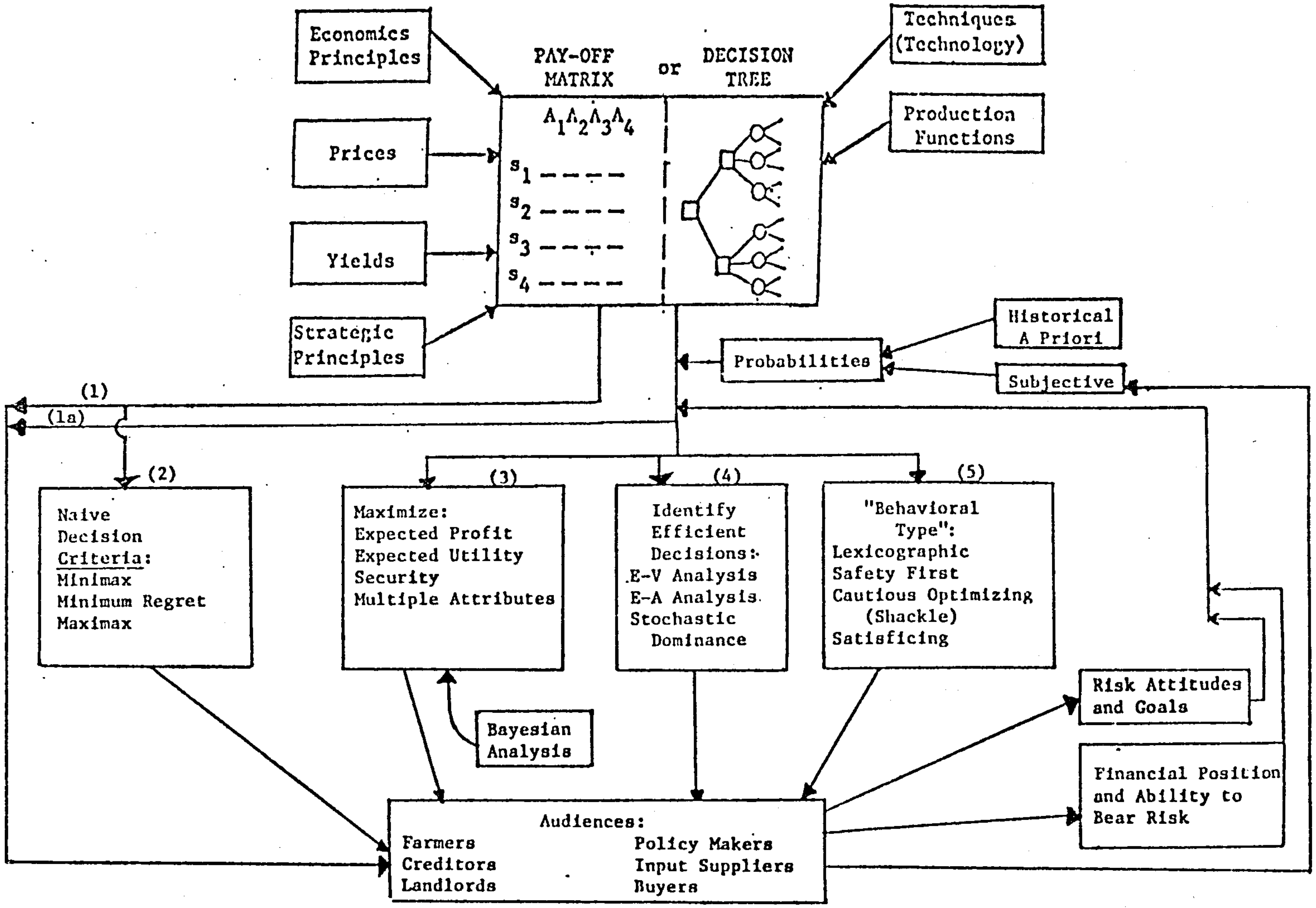

Figure 1. Needs and Alternatives in Decision Making Under Uncertainty

Probabilities, whether called subjective or personal probabilities, are numbers assigned to events which conform to the rules of probability calculus [Savage]. They reflect the decision maker's degree of belief that a particular event will occur. These beliefs may be based upon "objective" evidence such as historical observations, and input from outlook specialists, advisors, media, etc. However, to the extent that they are an expression of personal judgement, it is possible that two decision makers may assign different probabilities to the same event. Officer and Anderson [p. 13] argue, "if subjective probabilities are implied in a real behavior, then it is far better to make these explicit in a systematic manner--even if they may not be readily extractable."

The potential for using probabilities in a management context will depend on the ability of educators to teach the principles of probability manipulation, elicitation, and application. With this accomplished, probabilities based on historical (a priori) grounds might be developed by researchers and made available to decision makers directly as probability estimates, or indirectly as data to be processed and incorporated into the subjectively developed probabilities. These probabilities can then be combined with the payoff matrix information and presented in the educational program as a basis for decision making. This is illustrated as branch (1a) in Figure 1. With this approach the audience would have little basis for sorting out the information contained in these payoff-probability distributions. The frustration of risky decision making could be increased rather than decreased at this point. However, several alternative decision models are available, to help utilize this payoff and probability information.

Alternative Decision Models

General approaches for developing decision making models under uncertainty are listed in Figure 1, including the provision of data with explanations but no models.[2] Critics reject some models for decision making under uncertainty on the grounds that probabilities are used. They argue that (a) the arithmetic is too hard and the rules too complex, (b) decision makers seek simplification rather than complication. For example, they try to reduce the number of possibilities considered (e.g., use the mode) rather than increase them

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[2]Anderson (1976) and Roumasset (1976, 1977) were followed very closely in choosing the alternative models and examples in Figure 1. Anderson (1976) also reviews potential education/extension/research efforts in terms of normative, predictive and analytic efforts. Normative approaches provide suggestions about desirable and undesirable decision choices using any of the models in Figure 1. Conditionally normative effort is a customary function of extension. That is, if a model is descriptive of the decision maker's goals, it is used in working with him. Extension is frequently called on to be predictive concerning probable future actions of farmers as a group and the aggregate effects of such actions, (e.g. response to a farm program). Analytic effort is devoted to learning on the part of the scholar.

(e.g., look at the whole probability distribution), and (c) it is difficult to imagine such vital information as probabilities popping into a decision maker's head as if by magic.

As illustrated by branch (1), a possible approach is to simply provide the audience with the guidelines and data needed for the preparation of the payoff matrix and/or provide the matrix or tree outcomes. Alternative (1a) involves the presentation of the probability information along with the payoff matrix. Similarly, considerations relating to the decision-makers' risk attitudes and values, financial position, and ability to bear risk can be introduced by (1a). Another alternative (2) is to apply decision criteria such as maximin, minimax risk, pessimism-optimism index, or principle of insufficient reason [Eisgruber and Nielson]. However, the potential for these criteria is limited [Luce and Raiffa, Ch. 13].

The maximizing model (3) is sometimes referred to as a full optimality model in that it results in the best obtainable solution considering risk preferences (Roumasset, 1977). But this is accomplished without describing exactly how the decision process is carried out. This approach assumes that decision makers maximize the expected value of their utility functions. The modern form of the expected utility model was developed by von Neumann and Morgenstern. Critics of using utility functions say (a) some of the utility axioms aren't reasonable, (b) it is unnecessary to go beyond use of simpler measures of risk aversion, and (c) attitudes about risk are too difficult to measure, too individualistic and too changeable to be usefully measured. Proponents say (a) the axioms are very reasonable, (b) the results are more descriptive of how people act than those from profit maximizing models, and (c) they have successful applications to support their faith in the model (Anderson et al., 1977).

The fourth category of models involves ruling out some decision choices as less preferred than others. The remaining decisions, then, are described as "efficient." If the decision makers are concerned with expected returns and variability of returns, then their E-V efficiency frontier is useful to them and might be provided in educational programs. It delineates the alternatives that give the lowest variance for a given expected return or the greatest expected return for a given level of risk measured in terms of variance (Markowitz). Other measures of risk can be used as in the MOTAD model (Hazell). Several operational models are available (Anderson, 1976). The stochastic dominance model (Anderson, 1974) identifies preferred (efficient) alternatives under as few restricting assumptions about risk preference as possible.

Most approaches for deriving "efficient" decisions presuppose that decision makers are risk averters. However, utility functions differ among farmers. Halter and Mason found some farmers adverse to risk, some were risk neutral, and others displayed a preference for risk taking.

Roumasset (1977) identifies behavioral models (5) as those which stress the decision process and its costs rather than the result of choice. Nielson hypothesizes that decision makers have multiple goals. They are not motivated strictly by monetary outcomes. The farmer has several goals reflecting his situation and the desires of the farm family. The implication is that risk preference should be considered in the context of these multiple objectives.

The most important distinctive characteristic of this approach is the specification of a decision process. For example, one version of the lexicographic safety-first model is to choose the alternative that maximizes expected returns, given no more than an α chance of a return below a specified "catastrophic" level.[3] These concepts are analyzed by Day, Aigner, and Smith. Another way of accounting for risk is the concept of focus loss. Boussard and Petit incorporated this concept into a linear programming structure.

Decision makers may have their own individual ideas as to what is the important risk parameter. This is the difficulty inherent in quantifying all the dimensions of their various objectives [Lin, Dean, and Moore, p. 504]. Therefore, instead of attempting to maximize this function, the "satisficing" concept introduced by Simon might be considered. The approach used with the decision maker would be iterative in nature, as described by Candler and Boehlje. By successively generating solutions, evaluating whether goals are satisfied, and revising the solutions, the decision maker would identify improved farm plans. "In this way we can feel our way . . . without ever explicitly defining the decision maker's preference function" [Candler and Boehlje, p. 330].

There are a variety of alternative concepts, approaches, and models for analyzing risky decisions. This overview provides a framework for reviewing the extension project and analyzing research contributions and needs from a farm management education perspective.

Review of the Extension Project

This two year project, funded by a SEA-Extension special needs grant, was conducted jointly by Oregon State and Oklahoma State Universities. A need for the project was identified by the Wheat Industry Resource Committee, a joint effort of Extension and the National Association of Wheat Growers. The project involved the development of methods and materials for use by educators in teaching how to explicitly consider risk in making farm decisions.

The specific objectives were as follows:

1. Prepare publications to present, discuss, and illustrate principles of decision-making under risk and uncertainty.
2. Develop teaching materials and audio-visual materials for use by farm management specialists and area agents in pilot workshops for wheat farmers.
3. Test and evaluate the publications, materials, and methods in pilot workshops.
4. Distribute the materials and methods to farm management specialists in other States and instruct them in their use.

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[3] Roumasset (1977) took special care to assure that the decision maker could use alternate rules if the previous one was not feasible.

These objectives place emphasis on preparing materials for use by extension staff and classroom educators. However, the ultimate audience of the project was visualized as being the operators of commerically viable family farms. Specific emphasis has been given to the management problems of wheat farmers but the concepts and methods were developed to be applicable to other farm audiences. The co-leaders of the project were Gene Nelson, at Oregon State University and Ted Nelson, at Oklahoma State University. A seven member advisory committee represented farm management and marketing extension and research in universities across the U.S.

The materials and methods developed were presented and reviewed at a national extension workshop held in Denver July 11-14, 1978. A total of 69 participants were in the workshop representing 36 states and 4 provinces of Canada. The predominate program responsibility of the participants was in farm management (two-thirds of the participants), but marketing, research, and teaching functions were represented as well. Doug Youg gave a progress report on the activities of W-149. Vernon Eidman and Odell Walker reported on experiences in teaching risky decision-making in the classroom.

Approach and Premises

Two preliminary activities performed soon after the project was initiated were important in influencing the direction of the project. These consisted of a review of literature and a survey of extension and classroom educators in farm management.

Review of Literature

The review of literature (Walker and Nelson) attempted to identify and interpret the literature relating to "risk and uncertainty" in agriculture, with particular emphasis on farm management. It took stock of the "state-of-the-arts" in farm decision making research at that time. This review of literature was conducted concurrent with the organization of the W-149 Project in 1975, thus the review could not benefit from these research contributions.

The volume of literature on "risk and uncertainty" is so large when viewed across disciplines and subdisciplines that all its dimensions could not be explored. Emphasis was placed on applied and illustrative empirical studies in agricultural economics. A computerized literature search system, a CRIS information retrival, and the survey of farm management instructors and extension specialists (discussed later) were used to identify the 215 items included in this review.

Survey of Educators

The other initial project effort was the survey of farm management instructors and extension specialists across the U.S.A. in Fall, 1975. Of necessity, this was an open-ended type of questionnaire, with limited capabilities for rigorous analysis. However, the responses are revealing [Walker].

Survey responses received from 14 states indicated the topics relating to decision making under uncertainty which were included in extension programs. Aggregative outlook analyses provided a background understanding of the sources of uncertainty for farmer audiences. Several states reported using special tools which facilitate evaluation of the effects of imperfect knowledge--for example, capital budgeting, using discounting for uncertainty, and linear programming or budgeting systems, which aid sensitivity analysis. Marketing strategy topics, particularly hedging and contracting, were most frequently mentioned. There appeared to be a definite lack of published materials dealing with decison making under uncertainty.

Responses from 29 states reported on risk and uncertainty topics covered in undergraduate farm management classes. The time reported spent on risk and uncertainty was modest, with decision making under uncertainty tending to be taught in higher, upper division courses. However, some orientation to sources of uncertainty and introduction to planning under uncertainty were frequently reported for the introductory courses. Strategies such as diversification, flexibility, and insurance were common topics. The survey may have missed some operations research, advanced marketing, and finance classes which contain decision theory material.

Overall, very little evidence was found of significant efforts in either classroom teaching or extension to apply the concepts of decision making under uncertainty to farm management. In particular, applications and examples were very limited.

Comparing the results of literature review with the responses from the survey, reveals a large "gap" between theory and practice in risky decision making. The purpose of the extension project was to bridge this gap.

Project Premises

To proceed with the development of educational materials and accomplish the objectives of the project, it was necessary to develop, at least implicitly, some key premises about how decision makers behave and to specify the components of the approach to be taken in the development of teaching materials. These evolved as the project proceeded. The survey and literature review were used as a starting point. Then they were tested in the field with farmers and in the classroom with students. Based on the evaluation of sessions they were modified.

Following are some of the key elements in this approach:

1. It was assumed that there is a human tendency to ignore risks and uncertainties (Hogarth, p. 273). The role of the educational program then should be to remind the audience of the various sources of risk that they face and to help them better understand and quantify these sources of risk.
2. Highest priority was given to the organizational phase of the decision process. It was assumed that the greatest potential for helping the farmer to improve the decision making process was through the use of payoff matrix and decision tree concepts. These bring out two key components in the decision making process:

listing the alternative actions that are available and identifying the various sources of the risk influencing the outcome of these decision alternatives. The payoff matrix and decision tree represent modest innovations on the traditional budgeting approaches used in the decision-making process. However they provide a framework which encourages the decision maker to consider all of the possibilities before narrowing them down to those deserving additional consideration. These concepts help to avoid the tendency to ignore risks. It was interesting to note in reviewing decision theory texts, research reports, and extension publications that very little attention has been given to how a payoff matrix or decison tree is constructed. For example, a recent text in this area [Anderson, Dillon and Hardacker] devotes no more than a page to this process.

3. Another premise for the development of educational materials was that decision makers can consider future events in terms of subjective probabilities and that it is possible to quantify these probabilities. Assuming that these subjective probabilities can be quantified, educational meterials should be developed to teach decision makers how to estimate their probabilities and use them to analyze their decision alternatives. Decision makers also need a data base for refining and revising these probability estimates.

4. No presumptions were made regarding the nature of individual farmers' risk attitudes. Specifically, they were not assumed to be risk averters which is the implicit assumption for some approaches to risky decision analysis. This is an empirical question and until evidence accumulates to the contrary it was believed that educational programs should be cautious not to make presumptions about the nature of the risk preferences held by individual farmers. It was assumed then that objectives differ among farmers and that a wide range of perferences exists from risk takers to risk avoiders.

   The estimation of individual utility was assumed to "futility" (using Dillon's word). Two concerns support this premise. The first is that the techniques for eliciting utility functions have not been proven to be efficient and accurate [Scandizzo and Dillon]. The second concern is that the process of eliciting utilities is a time-consuming one and that the cost involved would not be justified by the value of improved decision making. According to Halter and Dean [p. 139], it is generally impractical from the standpoint of time and cost to determine the utility function from individual decision makers. In developing an educational program, however, priority should be given to helping decision makers recognize and understand their attitudes regarding risk, including how they are influenced by their financial position.

5. Finally, some decision makers are seeking ways to control at least some of the risks affecting their farm operations. Examples of risk control practices or strategies are flexibility, diversification, and insurance which eliminate or ameliorate the impacts of risk. This assumption implies that the presentation of these risk control methods should be included in educational programs. Such practices or strategies guide selection of alternative actions for consideration in the payoff matrix and decision tree frameworks.

Methods and Materials Developed

The educational materials were developed in a modular format. This format provides maximum flexibility for combining one module with others, and with other materials to accomplish various instructional objectives. For example, the educator can easily incorporate special examples of local conditions to illustrate the application of the concepts.

Two types of modules were developed. They are the "general teaching" modules and "decision analysis" modules. The general teaching modules provide for introducing and understanding the concepts in a general sense using simplified examples. However, to understand the use and application of these concepts, it is important that they be enhanced by real-world examples which are meaningful to the audience. The decision analysis modules provide the worksheets, examples, computer programs, budget forms, etc., needed to facilitate the application of the concepts to specific decisions. As this was a national project the materials had to be adaptable to many different agricultural enterprises and conditions. The greatest emphasis was placed on the general teaching modules, but decision analysis modules were also developed to demonstrate how the concepts could be applied locally.

The materials developed and available include the report on the review of literature already discussed. A mini-text was also prepared, entitled MAKING FARM DECISIONS IN A RISKY WORLD: A GUIDE BOOK. It provides a comprehensive review of the principles and techniques for making risky decisions and serves as a basic reference for instructors and advanced students. The material, presented in simplified language, was distilled from the literature reviewed and augmented by the project experience.

The five "general teaching" modules, self-contained packages of educational materials, were designed to teach the general concepts of risky decision making. They are in a slide-tape format with printed support materials such as workbooks and handouts. This format offers flexibility in the repeated delivery of the same or slightly modified information. To effectively convey the abstract concepts involved, high quality artwork and photographs were used. This slide-tape format also allows for developing methods to encourage participation and feedback and enchance comprehension and retention of the concepts. The titles of these presentations are as follows:

"Dealing with Risk in Making Farm Decisions: Introduction" (12 min.)
"Guiding Risky Decisions with a Payoff Matrix" (22 min.)
"Using Probabilities in Making Farm Decisions" (90 min.)
"Considering Your Attitudes in Making Risky Decisions" (18 min.)
"Controlling Risk in a Farm Business" (49 min.)

The "decision analysis" modules apply the decision making concepts to specific situations. An example is the computerized decision aid developed and field tested by Anderson and Holt. It analyzes the production and marketing risks associated with the decision to graze stocker cattle on wheat using probability estimates for prices, yields, and gains. The decision choices are evaluated in terms of expected values, income ranges, and cumulative probabilities. Used interactively with a portable computer terminal, the program allows individual farmers to enter different assumptions for analysis. The module includes (a) a description of the model and example problems, (b) the source listing and documentation for the PL 1 program, and (c) a slide presentation and script that introduces the use of decision trees for this decision.

Examples of other decision analysis modules deal with adjusting fertilizer rates for variable weather, making land investment decisions under uncertainty, purchasing crop insurance, and analyzing forward contracting alternatives for crops. A complete listing of the materials developed and available is included in Appendix A.

Accomplishments and Evaluation

Evaluating a project whose objective is to develop and disseminate educational materials is not a simple task. As economists we are particularly sensitive to the problems of measuring those intangible benefits of motivation and "better" decision making. It is possible, however, to describe the results of preliminary testing, enumerate some of the continuing activities, and indicate the general impact of the project.

Preliminary Testing

The materials were tested at farmer meetings, agent training sessions, meetings of the Western Farm Management Extension Committee, and a farm management staff training session held in Alberta, Canada. These preliminary evaluations were very important in influencing the nature of the educational materials developed. Reactions were generally favorable and modifications were made in response to the feedback received. There were very few complaints that the material presented was <u>too</u> simple for the target audience, justifying the assumption of a minimum of prior knowledge. All respondents indicated that the presentation provides information useful to farmers, and most felt that the rationale for using the concepts in decision making was clearly stated.

An example of the modifications made in response to the evaluations is the additional emphasis in the payoff matrix module given to narrowing down the alternative choices to those most promising and eliminating those events which are less critical. It was found that the challenging aspect of developing the payoff matrix was to limit it to practical dimensions when applying it to a specific decision problem.

In discussing the concept of probabilities, farmers in both Oregon and Oklahoma responded positively to assigning probabilities to future events for decision making purposes. In a post-workshop mail survey in Oregon, 91 percent of the 44 responding farmers indicated that probability information would be useful to them. Of 61 farmers completing evaluation forms in Oklahoma, 64 percent felt that the joint probabilities were the "strongest point of the program." Only 3 respondents "didn't understand joint probabilities" [Holt and Anderson].

The educational materials also emphasized helping the audience understand why it is important for them to consider their attitudes and what influences these attitudes, with particular emphasis on their financial structure. The use of examples and "what-if" situations, where members of the audience are asked to put themselves in the place of the decision maker, were found to be effective in presenting these ideas.

The educational module on controlling risks met with a favorable response from both educators and farmer audiences. This presentation is a checklist of the various methods which might be used to control the different sources of risk. It also presents some of the advantages and disadvantages associated with each. This module appeared to be favored for presentations where time was limited. Several evaluators felt more comfortable with this material because it is more traditional compared to concepts like the payoff matrix, probabilities, and risk attitudes.

The project and its evaluation culminated in the National Extension Workshop held in Denver during July of 1978. The purpose of the project was to present the materials developed and to provide training in the use of materials in farmer-oriented extension programs. The evaluation of the workshop was very positive. On a scale of one through five (1 = waste of time, 5 = outstanding), 30 percent of the participants gave the workshop an overall rating of five, 62 percent a four, and 8 percent a three. Other responses indicated that the workshop was motivating, focused on needs, and stimulated discussion. The participants also indicated they were more confident and committed to incorporating risk considerations and concepts in their extension programs.

Continuing Activities

Activities following the conclusion of the project provide some basis for assessing its impact. The printed materials were distributed to the participants in the Denver workshop and at least one complete set has been sent to each of the 50 states. Requests for additional copies of these materials continue to be received. So far, a total of 169 slide presentations, sold for the cost of reproduction, have been distribtued to 21 states and Canada.

The potential of the project materials in teaching undergraduate farm management courses was described in a paper presented at the ADC/RTN farm management teaching workshop in Michigan during April 1977 (Walker, 1977). Also, a paper describing the rational and content of the instructional package dealing with the use of probabilities in farm decision making (Nelson and Harris) was presented at the "Innovations in Undergraduate and Extension Teaching" session at the 1978 AAEA meetins in Blacksburg.

Another outgrowth of the project has been the exploration of risk applications in extension marketing programs. A meeting was held October 31 and November 1, 1978, at Michigan State University with representatives from the Northcentral extension marketing group. The meeting was called by Sharon Hoobler, SEA-Extension. A similar meeting was held with representatives from the Western Extension Marketing Committee in Corvallis, April 23-24, 1979, followed by a workshop at the Committee's annual meeting at San Diego, January 8, 1980.

To provide follow-up to the project, Roy Black of Michigan State University organized the symposium on "Teaching Decision Making Under Risk and Uncertainty" at the 1978 AAEA meetings at Washington State University. At the symposium there was a report on a limited survey regarding the use of the materials developed and other activities relating to teaching risky decision making. Information was obtained from eleven colleagues at land grant schools who had attended the Denver workshop. Seven indicated they were using the slides in both extension and classroom teaching. One respondent observed that people not trained in agricultural economics were very receptive to the materials. Some respondents indicated they had some trouble teaching probabilities, but others were using the probability presentation particularly because it is put together to do the complete teaching job. It appears from this limited information that interest was stimulated in teaching activities relating to this problem area.

There have also been several special requests from presentation of these materials. The material developed as part of the project has been presented at the annual meeting of the American Society of Farm Managers and Rural Appraisers in 1978 in New Orleans and at the National Agricultural Bankers Conference of the American Bankers Association at Salt Lake City in 1979.

General Impact

Evaluation of the impact of an educational program is always difficult, but it does appear that this project has influenced the teaching of concepts relating to decision making under uncertainty, both in the classroom and in the field. Much remains to be learned about teaching the concepts of risky decision making to farmers. There is a need for additional training and follow-up. A comment from one of the participants in the Denver workshop was that an update should be considered every two to three years.

As new educational methods and materials are developed, the need for research back-up is becoming more apparent.[4] The following sections outline what we feel are the critical research needs from the perspective of educators interested in teaching risky decision making to the present and future managers of agricultural businesses.

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[4]Roy Black in the closing discussion of the Denver Workshop pointed out that 1) we as educators are always calling for relevant research 2) thus we ought to delineate fairly carefully specific and important researchable topics and 3) these must be carefully defined and circulated to researchers like those involved in W-149. He also emphasized the importance of developing mechanisms for sharing materials and experiences in this area.

Some New and Emerging Risk Research Contributions

The following sections, organized according to the major components of the conceptual framework in Figure 1, review new research contributions with particular emphasis on W-149 from the perspective of a classroom teacher and an extension educator. The review is based on the progress reports for 1977 and 1978 and the two excellent publications from seminars at the annual meetings. The authors also have a close association with the project and colleagues working in the separate states.

It will be convenient to refer to the following objectives of W-149 in the discussion.

1. To identify factors affecting variability of prices for feed and food grains, oil seeds, and livestock and livestock products and to measure the effects of recent changes in price variability on the perception of price and income risks by primary agricultural producers.
2. To estimate risk premiums required by primary producers and associate these estimates with personal, business and economic attributes of primary producers (e.g., age, education, tenure, enterprises, business size and organization, location).
3. To identify and evaluate the effects of methods and instruments with which primary producers transfer market risks to firms in farm-related commodity and financial markets.
4. To identify and evaluate the effects of methods and instruments with which primary producers retain the risk bearing function within their firm.
5. To estimate the value of qualitative changes in flows of market and financial information that affect the capacity and willingness of primary producers to manage market risks.
6. To evaluate how changes in market risks and methods of risk management affect and are affected by selected structural features in agricultural production and in farm-related commodity and financial markets.
7. To estimate the welfare effects on producers, market firms, and consumers of public policies designed to stabilize agricultural prices and/or product supplies.

Payoff Matrices and Decision Trees

Topics relating to data, procedures and outcomes for payoff matrices or decision trees are included under this heading. Probability components are left for the following section. As suggested in earlier discussion, concepts associated with organizing information and building payoff matrices or decison tree are fundamental to decision making under uncertainty. The paper by Young, et al., on strategies for research and education on risk, reviewed alternative approaches and concluded that building decision trees and payoff matrices is high priority for working with farmers. For the policy audience, they suggested using econometric techniques rather than building from micro preference functions. Again for the farmer audience, they suggested using simple ways of identifying risk attitudes and models which do not require the more limiting assumptions of utility analysis. The thoughtful and careful study by Young's committee is very helpful and consistent with conclusions from the Extension Project.

In assisting a farmer to use the payoff matrix, the challenging aspect is to limit it to practical dimensions when applied to a specific decision problem. The decison maker needs to define the more promising alternative actions and the most significant events and measure the payoffs appropriately for the decision criterion or criteria to be used. For most real-life farm management decisions, a wide variety of phenomena, all subject to uncertainty, affect the payoffs. The researcher, educator and decision maker must isolate those that are most significant and eliminate those that are not.

Objectives 3, 4 and 5 are expected to provide results which will aid in application of payoff matrix/decision tree approaches. Several cooperators are developing procedures for evaluating a wide range of risk management techniques. The strategies being evaluated form the basis for developing actions for a payoff matrix or decision tree. Actions are hypotheses about reasonable ways to operate, given the possible events. Hopefully, the W-149 research will provide empirical and theoretical results relating to the potential of alternative strategies for transferring or living with risk which will provide guidance to extension and examples for university teaching.

Cooperators in W-149 are also working on financial strategies. For the lender audience, they are studying the effect of changes in farm lending risks on lender performance and evaluating innovations in lending arrangements. Researchers are also looking at different ways of evaluating credit under risk and ways of handling loan pricing under risk.

Once the alternative actions and events have been specified, the next step in constructing a payoff matrix or decision tree is to choose the appropriate measure for the payoffs and to compute them. What measure of performance is appropriate for budgeting the payoffs? Net farm income, return to management, return over variable cost, and other measures are possibilities, depending on the decision being analyzed. However, the explicit introduction of uncertainty into the decision process may lead to the consideration of other performance measures, such as net cash flow, to assess the risk that the action-event combination would not generate sufficient cash to meet commitments. Research is needed to evaluate the appropriateness of alternative performance measures. This is discussed further under alternative decision models below.

To construct the payoff matrix requires preparing a budget or a linear programming solution for each action-event combination in the matrix. This emphasizes the need for automated budgeting procedures using computer terminals or programmable calculators (McGrann and Edwards) to reduce the computational burden associated with payoff matrix analysis. In very complex multivariate problems, simulation may be the tool used to generate outcomes for alternative action-event combinations.

We have not seen evidence of plans in any of the W-149 contributing projects to assist in developing computer sofware that would facilitate this step. Candler, et al., argue that the software needs of extension are more demanding than the corresponding needs for research. Extension software must have the characteristics of clarity, speed, and reliability. In terms of payoff, this appears to be a promising area of work because decision making under uncertainty must be timely and it involves consideration of many variables.

Decision problems are so individualistic for a particular manager and farm that they are not directly amenable to fact finding research. That is, it is difficult to develop a payoff matrix which is useful to more than one farmer. Thus efforts are needed on teaching how to obtain or interpret the raw data needed, process it by budgeting or LP or by special software developed for that purpose, and place it in a matrix or decision tree framework. There is also a challenge to maintain the kind of data needed to support the analyses that must be made periodically.

Subjective Probabilities

This section deals with provision of information on probabilities of events, development of expectations and subjective probabilities, and their revision and value.

Eliciting Probabilities

Probability elicitation is reviewed by Hogarth. He argues that because man is "a selective sequential information processing system with limited capacity, he is ill equipped for assessing probability distribution." The concerns or qualifications expressed by Hogarth indicate the need for a very deliberate and studied approach to the development of procedures and techniques for eliciting probabilites. While the general observation is that people are not good at eliciting probabilities, careful guidance can improve this considerably. Research testing of alternative approaches for eliciting probabilities so that they can be used explicitly in decision making is needed. Four possible methods of eliciting probabilities have been identified: (1) direct estimation, (2) a cumulative distribution approach, (3) using the triangular probability function, and (4) assigning "weights" measuring strengths of conviction.

The direct estimation of subjective probabilities is a trial and error process. Checking to see that the probabilities add to one, and then revising, can become frustrating. A visual variation on this method was used by Francisco and Anderson. Respondents were asked to distribute a total of 25 counters over the different events, according to their beliefs.

The cumulative distribution approach suggested by Raiffa starts with the determination of the median event. Next, the respondent is asked to specify the lowest and highest event that will occur. Then to complete the specification of this cumulative probability distribution, the events corresponding to the lower and upper quartiles are specified. This approach offers possibilities when the events represent a continuous variant, but is somewhat complicated.

Triangular probability distributions (Cassidy, et al.) can be quantified by defining three parameters, the lowest possible event, highest possible, and most likely event. The approach provides an efficient and easily learned means of eliciting respondent's beliefs. However, accuracy may be lost due to the rigidity of the form of the distribution.

A procedure developed as part of the extension project involves assigning weights which measure the strengths of the respondent's conviction that particular events will occur. This method has been informally tested using a variety of audiences with success. Briefly, the approach can be summarized as follows:

1. Discrete events are defined, using a total of 8 to 12 to describe the phenomenon.
2. The respondents are asked to identify the lowest and highest events thought possible. All events outside these extremes are assigned weights of zero.
3. They are then asked to consider the general shape of their probability distributions, e.g., uniform, normal, skewed right, etc.
4. They assign a weight of 100 to the most likely event, and weights of 1 to 100 to the remaining events, consistent with their information and beliefs.
5. The weights for each individual event are divided by the total of all the weights to calculate the probability for each event.

This approach is readily teachable. However, additional work is needed to compare this approach with other alternatives to determine how well this approach reflects the respondent's true beliefs. For a more thorough treatment of the various methods for eliciting probabilities, see Spetzler and Stael von Holstein. They recommend a structured interview process and various techniques to reduce biases in quantifying the subjective probabilities.

There are a few examples of the estimation of probabilities in business management such as the one in banking (Kabus). The most extensive body of experience relating to the elicitation of probabilities is in the area of weather forecasting. Since 1965, probability of precipitation forecasts have been formulated by the National Weather Service and routinely disseminated to the general public. Extensive evaluations of these forecasts have been conducted and the results indicate that the forecasters have been skillful in making reliable probability forecasts (Murphy and Winkler).

All work by contributors to W-149 (objectives 1 and 2) on developing probability estimates objectively or on eliciting probabilities has not been published. Work by Bessler at California relates to elicitation of probabilities. Some of the work suggests that the form of the mechanism for generating expectations varies among crops. In a Texas study the kinds of producer expectations found reflect lower market efficiency than is suggested by marketing research (Barry and Moberly).

Historical Data

Data needs for improving the quality of the decision makers' probabilistic information must be identified. Probabilities by no means preclude the use of data analysis, including econometric models and time series techniques, in outlook forecasting. In fact, the demand for data analysis may increase as the full potential of the probability concept is exploited. The data needs can be classified in three categories: historical data, forecast data, and value of information. Each will be discussed in turn.

Several studies of price, yield and income variability are available, but most were done in the early 1960's. A recent example is the Yahya and Adams study for Wyoming crops. They suggest that such information provides a useful perspective to the farmer because farmers often use a biased-sample of yearly crop outcomes i.e., those of recent years which are most easily remembered. In doing so, they say farmers may bias their crop income expecation, given that recent crop years may not be typical of longer time series. Just and Pope suggest some reasonable econometric procedures for estimating "objective" probabilities.

In the classroom situation, such estimates of price/income variability are especially helpful in illustrating the effects of management strategies such as diversification. Of course, they may be used directly under certain assumptions to estimate the prior probabilities for a payoff matrix or a decision tree. Simulation studies which use estimates of variability would benefit from direct estimates of crop yield and income variability.

W-149 promises in objective 1 to develop data on the variability of important variables and also study effects of changes in perception of price and income risk as a result of changes in the agricultural production environment. It also promises to work on developing statistical techniques for measuring risks associated with the prices of major products.

Forecast Data

Forecast or outlook data are needed to update and revise the historical or a priori probabilities. Black argues that it is important to characterize not only the expected value of the forecast but meaningful measures of its dispersion as well. He describes the procedure used by the Michigan State University agricultural economists in estimating the odds of 1975-76 corn and soybean prices as "quick and dirty" and limited by budget and time constraints. More sophisticated methods are available and Black suggests a careful review of the literature.

Just and Rausser evaluated the accuracy of outlook forecasts by the major econometric forecasting organizations over the past two years. None of these sources were found to be consistently, significantly better than the futures market in forecasting prices up to a year in advance. Brandt and Bessler recently compared the forecasts from econometric structural models, time series analysis, and expert forecasts with actual monthly prices for hogs, cattle, and broilers. None of the three forecasting methods consistently performed the best, but a composite forecast appeared to offer greater accuracy.

Probabilistic outlook information could be provided to decision makers through the use of an "expert" panel. Scoring rules (Bessler and Moore) are available for aggregating the probability information provided by each panel member generated by some variant of the Delphi technique. Nelson outlines the components of a proposed program for developing and disseminating probabilistic outlook information.

With greater emphasis on probabilistic information, consideration must also be given to the revision of these probabilities as new data becomes available, such as by using Bayes' Theorem. Francisco and Anderson found managers tend to be conservative in revising probabilities i.e., they do not extract as much information from the new message as they should.

To apply Bayes' Theorem requires information to allow assessment of the accuracy of the forecast used. An example is provided by Smith and Schrader. They analyzed past crop reports for corn and soybean to provide an indication of the accuracy of these official crop forecasts. They conclude that the production forecasts were reasonably accurate for 1966-75. More importantly, they provide users of this information with a measure of the magnitude of these errors.

Value of Probabilistic Information

Information comes at a cost. Its value in various decision-making situations should be considered in the design of future educational programs. Using a gaming approach incorporating key decisions in corn and soybean production, Debertin *et al.* (1975) found a significant positive return to both research information and learning from feedback. The "managers" were students in a senior farm management course for this initial experiment. A later experiment (Debertin *et al.*, 1976) used experienced farmers as participants. While the return to information was substantially less, it was positive and significant. Baquet *et al.*, estimated the value of weather forecasts, specifically frost, for growers making orchard-heating decisions.

If Objective 5 of W-149 is acheived, extension and university educators will have an idea of the potential payoff of information that they might convey. They will also be able to predict the effect of information on the capacity and willingness of producers to manage market risk. Progress on this objective is not reported in W-149 publications to date.

Information Dissemination Systems

Consideration must also be given not only to *what* information is presented but also *how* it is presented. Conrath reveals that the format in which the information is presented influences decision-making. Payne (p. 440) argues, based on psychological studies, that "the way in which sources of information are displayed affects their utilization."

Evaluating systems for disseminating information to farmers is not a part of W-149. But it is important that farmers' needs to assess the risk inherent in their decisions be recognized as results are reported. The content and forms of the messages presented should be such that the information can be used as a basis for farmers to derive their own probability estimates.

Measuring Risk Aversion

The literature relating to utility function estimation is well described in Young et al., and elsewhere (e.g. Dillon; Anderson et al.). Young et al. say that, if the decision model used requires risk aversion parameters, they must be simple enough that farmers can provide them. This rules out direct application of utility functions. The W-149 Subcommittee (Young et al.) also suggests that objectively measurable variables such as financial ability to bear risk or other objective measures of risk preference be used, such as farm size, legal form of ownership and financial measures.

With respect to research needs we would like to second the suggestion made by the Young et al. paper regarding research on objective measures of risk aversion, such as risk bearing ability. Research assistance in identifying such measures will be welcomed. There is a need for better understanding of relationships between an individual's financial position, measured in terms of debt-equity ratio and cash flow requirement, and how that individual reacts to risky decisions. By starting with these objective financial variables, it is possible to make explicit the context in which the decision-maker's risk attitudes are formed.

The second need is for methods which allow decision makers to discover for themselves their own individual attitudes towards risk taking. These preferences could possibly be revealed informally through the exploration of "what if" situations. The explicit consideration of the fiancial position would facilitate the development and implementation of approaches which allow decision-makers to more explicitly consider their attitudes toward risk in their decision choices. They would, thus, develop a better understanding of their decision processes.

Following some significant and promising earlier studies [Johnson et al.], the decision-making process has not been a fashionable area of study. Several hypotheses have been suggested by Nielson, and are still in need of testing. Do decision makers behave "as if" they maximize some function? In an educational context, the decision process must be understood if it is to be influenced and improved. More research regarding farmers' decision-making behavior would benefit the development of extension and teaching programs. This enters the realm of the psychologist. According to Payne, the psychological study of risky decision behavior has just begun to move any from the influence of the efforts made by mathematicians and economists. The implication is that this is a positive development.

We do not wish to be misunderstood regarding our appraisal of the usefulness of the utility function concept. This paradigm provides a logical point of departure for exploring more practical approaches. We are not saying that the utility function concept should be discarded but rather that approaches should be developed to allow for its application in the decision making process.

Alternative Models for Decision Making

Figure 1 reflects the understanding of the authors concerning alternative analytical models that are available. To date the productivity of W-149 does not include the evaluation of alternative analytical models as such. However the contribution by Young *et al*. and the excellent discussion by Musser are very helpful. Musser makes the argument that theory of the firm on which many of the models are based is not very predictive or descriptive for individual firm cases, although it is very useful for the aggregate case in predicting how a group of farmers would act. Since an important component of W-149 is orientated to aggregate policy implications, we may find emphasis on use of theory of the firm in the project, whereas the results may not carry over to use in work with individual farmers. Musser's very thoughtful comments will assist people in the profession to think about the usefulness and role of theory in different situations.

The advice from the Young *et al*. paper is to provide more and better information on alternative decision options and objective outcome probabilities. This would follow model (1a) in Figure 1. It is also suggested that more effort be devoted to teaching principles of decision making and information utilization which is consistent with branch (5).

According to the survey of extension specialists reported earlier, linear programming (LP) is still the most commonly used analytical technique, other than budgeting, in extension education. Attempts have been made to modify LP to improve its effectiveness in a risky world consistent with branch (4) in Figure 1. For example, Brink and McCarl recently reported on research to incoporate Hazell's MOTAD approach into a crop-planning LP model. Their research then compared actual farmer behavior with the model results. They observed that a large diversity of individual risk aversion coefficients was found. However, using this particular model, they found it difficult to explain observed farmer crop acreage allocations.

Quadratic programming has had many research applications in agricultural economics. It specifies a set of plans that are efficient in terms of minimizing income variance for given levels of expected income. The application of quadratic programming analysis to farm planning is being explored by Wyoming researchers participating in W-149.

Several contributors of W-149 appear to believe stochastic dominance offers promise for applications. Research examples of applications of that model would be welcome.

Emphasis on "behavior type" models (branch 5 in Figure 1) provides a different orientation regarding the analytical techniques to be applied as aids to making risky decisions. Simulation techniques offer potential for evaluating the probabilities of payoffs associated with alternate decisions [Eidman *et al*.]. Results from W-149 show that simulation provides a feasible method for comparing alternatives when the relationships are complex and involve multiple objectives [Patrick]. It can be used to evaluate strategies and test decision rules [Helmers]. Simulation has also been applied to investment analysis decisions [Walker and Hardin].

An important observation regarding analytical techniques incorporating risk considerations is that there are very few examples of their use to support educational programs for farmers. We see this as the ultimate test of the usefulness of model development work. But the responsibility is one that should be shared by researchers and educators. There is a need for close cooperation if these efforts are to be successful.

Driver and Stackhouse offer a good example of research on decision making under risk which is carried through to practical application. They used a risk simulator in conjunction with a linear programming farm planning model to generate a set of alternative plans for given farm situations. The farmers could then choose the plan consistent with their goals and attitudes within their individual decision making frameworks. Driver and Stackhouse (p. 19) indicate that "this is best accomplished through a research program that includes collaboration with extension personnel." W-149 can provide the impetus toward this closer collaboration between researchers and educators.

Summary and Conclusions

The following are impressions concerning important contributions of W-149 to needs of audiences of primary concern to farm management extension and teaching. As the list indicates, the research now in progress will fill major gaps. Additional research needs are also suggested for consideration of the committee. Some have already been suggested in W-149 reports to date.

Contributions of W-149

a. Evaluation of alternative models for use with decision makers (e.g. Young et al.).

b. Evaluation of alternative management strategies (e.g. product pricing techniques, financing methods, decision rules, diversification, insurance, etc.).

c. Direct data for decision making (e.g. enterprise variability, action-event payoffs, etc.).

d. Increased understanding of producer expectations for important variables (e.g. price expectations).

e. Impacts of policy alternatives on producer behavior in the aggregate.

Other Research Needs

a. Determine the relative importance of various sources of risk for use as a guide to firm decision makers, educators and policy makers in resource allocation.

b. Computational software for extension use suited to the uncertain decision setting and analytical tools available.

c. Evaluation of various probability elicitation techniques.

d. Development and application of improved techniques for obtaining objective probability information and forecasts.

e. Improving techniques for helping decision makers consider risk taking preferences, and developing objective measures of risk taking ability.

Concluding Remarks

All interested in decision making under uncertainty are quick to unite in advocating attention to the dynamic and stochastic as opposed to the static framework of theory of the firm. However, extension workers and classroom teachers must decide whether scarce resources could be better spent on general static answers rather than the specific, resource consuming approximations under uncertainty. The results of W-149 are very promising for use in extension and classroom resource allocation. First it appears that the project will provide results indicating concepts and strategies that work. Hopefully by gaining information about what does and doesn't work well, priorities for educational programs can be developed based on the probable level of educational impacts and the chance of success. Attention to identifying important problems for which the tools for decision making under uncertainty pay highest dividends is needed. For example, risk should be considered when making decisions on those problems which are key determinants of economic success by farmers. The latter may include major capital investment and decisions dealing with factors affecting price and yield variability on major farm enterprises.

The product of W-149 hopefully will meet the needs of the farm business teaching environment. The spirit in which the Young et al. paper was written recognized not only the possible payoff from research but what would be useful when considered as a product delivered to the student or the farmer. Several desirable characteristics of the research product can be suggested. The nature of the extension and classroom teaching environment requires that the models and data provided have accuracy, completeness, timeliness, cost effectiveness, believability, and understandability characteristics. Accuracy, completeness, timeliness, and cost may be attributes for which there are internal trade-offs. In a decision situation in which timing is the most limiting constraint, the decision approach used may be more expensive, less accurate and less complete than might otherwise be desired. The decision maker must balance learning-decision costs against potential returns of improved decisions.

Believability and understandability are important in extension and in the classroom. They relate to psychological, pedagogical, and communication factors associated with teaching and learning. Even the most experienced researcher finds it difficult to share the results of a research colleague which are from a complicated probabilistic simulation model with which he is not familiar. Most like to check the data, the model and the results, particularly if their own dollars or reputation are at stake. The decision maker may have the same barrier to accepting results from a model that he can't understand and doesn't have the opportunity to evaluate. Results from a simple or a familiar static model may be more timely, understandable and believeable even though less accurate and complete. To entice the decision maker to spend sufficient time on the dynamic stochastic analysis, the problem must be important enough so that the learning-decision costs are out weighed by potential return.

Data for use in developing alternative actions, alternative events and probabilities are needed. Most of these variables are unique to different farming areas represented in the project. This suggests that separate state level publications will be needed for applied research results from W-149. These state rather than national publications can emphasize local features of agriculture such as physical resources, climate, particular enterprises, technology, financial markets, etc. Hopefully the researchers can collaborate with extension workers to relate results to problems and approaches currently in the field. Results from the study that would reflect needed changes in procedures, for example those used in forecasting prices and yields, would be welcomed. Likewise additions to the body of knowledge that can be used in teaching decision making under uncertainty are needed.

The project has not yet shown emphasis on developing computerized, on line, flexible and general tools for ready use in the field utilizing the data developed and the concepts and models appropriate to decision making under uncertainty. Perhaps later in the project or in a follow up project further development of these tools will be considered. The potential payoff from such tools is attractive partly because decision making under uncertainty requires consideration of so many variables, uses so much data, and involves the interactions of many random variables. Problems use different data but are very similar with respect to their decision model structure. Thus, computer tools appear feasible. Timeliness is an important factor and it will be difficult to get decision makers to use all the power of the analytical techniques at their disposal, unless they have some computer assistance.

A teaching/extension/research cooperative effort may be needed toward the end of the W-149 project. Such a group could develop a publication aimed particularly at the extension and, ultimately, the farmer audience. It would have the advantage of focusing the attention of more than the research audience on the results from the project.

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APPENDIX A

EDUCATIONAL MATERIALS AVAILABLE FOR DEALING WITH RISK IN FARM DECISION MAKING[a]

Publications

MAKING FARM DECISIONS IN A RISKY WORLD: A GUIDEBOOK. (G. Nelson, Casler, Walker.)

This mini-text provides a comprehensive overview of the principles and techniques for making risky decisions. It serves as a basic reference for use by instructors. The material is selected from an extensive review of current literature to be useful in a farm management context. 97 p.

AGRICULTURAL RESEARCH AND EDUCATION RELATED TO DECISION-MAKING UNDER UNCERTAINTY: AN INTERPRETIVE REVIEW OF LITERATURE. (Walker and G. Nelson).

A survey of literature relating to risk and uncertainty in agriculture citing 215 references. Oklahoma St. U. Research Report P-747. 38 p.

Slide Tape Packages

G-1: DEALING WITH RISK IN MAKING FARM DECISIONS: AN INTRODUCTION. (Harris and G. Nelson). Number of slides: 56 Presentation time: 12 minutes.

This slide presentation is appropriate for use in a variety of situations, for students, or any audience interested in modern farm management problems and approaches. The objectives of this program are: (1) to provide an overview of the risky environment in which farm decisions are made, (2) to introduce new decision making concepts and techniques, and (3) to indicate some management strategies for controlling risk in the farm business.

G-2: GUIDING RISKY DECISIONS WITH A PAYOFF MATRIX. (Harris and G. Nelson). Number of slides: 77 Presentation time: 22 minutes.

The objectives of this program are: (1) to present the steps involved in making farm decisions using a payoff matrix, and (2) to demonstrate the nature of a payoff matrix and how it helps in making risky decisions. A handout is included which summarizes the content and offers another example.

G-3: USING PROBABILITIES IN MAKING FARM DECISIONS. (Harris and G. Nelson). Number of slides: 167 Presentation time: 90 minutes.

This slide program is designed with built-in audience participation and feedback. The workbook that accompanies this program is intended for use by each participant as the program proceeds. Participants should be able to: (1) understand the concept of "personal probabilities," (2) follow procedures to estimate their personal probabilities regarding a particular set of events, (3) compute the "expected value" for a set of events, (4) compute "cumulative" probabilities, and (5) interpret this probability information in the context of a specific decision choice.

G-4: CONSIDERING YOUR ATTITUDES IN MAKING RISKY DECISIONS. (Harris and G. Nelson). Number of slides: 68 Presentation time: 18 minutes.

The objectives here are: (1) to help the audience understand why it is important for them to consider their attitudes when making risky decisions, (2) to demonstrate how their risk attitudes are formed and influenced by thier overall objectives, financial position, and the size of the possible gains and losses, and (3) to present the important factors in determining their financial ability to assume risk (net worth, debt to net worth ratio, and cash flow needs).

G-5: CONTROLLING RISK IN YOUR FARM BUSINESS. (Harris and G. Nelson). Number of slides: 110 Presentation time: 49 minutes.

This program consists of two distinct segments. Part one is a tour of an actual wheat and cattle operation, which demonstrates the integration of a variety of risk control measures into an overall farm management plan. Part two provides a summary of risk control measures according to the source of risk being controlled. The objectives of this program are: (1) to provide a summary of a variety of risk control measures that can be used to control risk on the farm, and (2) to demonstrate their application in an actual farm operation.

D-3: DECISION TREES: A GUIDE TO RISKY DECISIONS. (Holt and Anderson). Number of slides: 32 Presentation time: 6 minutes.

Introduces use of decision trees for wheat harvest and stocker-grazing decisions.

<u>Other Materials</u>

D-1: A MODEL FOR INCORPORATING RISK INTO CROP AND GRAZING DECISIONS. (Anderson and Holt).

Description of model and example problems, 26 p.

D-2: TEACHING DECISION MAKING UNDER RISK AND UNCERTAINTY TO FARMER. (Holt and Anderson).

Reprint of article appearing in <u>Am. J. Agr. Econ.</u> May 1978, 5 p.

D-4: HARVEST-GRAZE DECISION PROGRAM. (T. Nelson).

Source listing and documentation for PL 1 program using Decision-Tree approach to compute joint and cumulative probabilities. 6 p.

D-5: COMPUTATIONAL AIDS FOR UNCERTAIN FARM DECISIONS. (T. Nelson). Source listings, program documentation and sample problems for fertilizer use, government program participation, grain storage, and machinery costs. 24 p.

D-6: ADJUSTING FERTILIZER RATES FOR VARIABLE WEATHER. (T. Nelson and Tucker). Okla. St. U. Ext. Facts 2215, 4 p.

D-7: WEATHER INFORMATION: WHAT AND WHERE IT IS. (Anderson and Holt) Okla. St. U. Ext. Facts 9418. 4 p.

D-8: AN OLD AND NEW APPROACH TO THE LAND PURCHASE DECISION. (Holt).

Contrasts the Lee/Rask model with repayment ability approach; includes computer source listing. 12 p.

D-9: CAPITAL INVESTMENT ANALYSIS IN AN UNCERTAIN WORLD. (Hardin). Description of land investment simulation model. 31 p.

D-10: WHAT CAN I PAY FOR FARMLAND. (Willett).

Outlines procedure for analyzing financial feasibility of land investment. 12 p.

D-11: EVALUATING FINANCIAL RISK IN LAND INVESTMENT DECISIONS. (G. Nelson).

A simplified approach to risk assessment using a triangular probability distribution. 9 p.

D-12: CROP INSURANCE TO REDUCE RISK: USING A PAYOFF MATRIX TO AID IN THE PURCHASE DECISION. (Casler).

Presents budgeting procedures and worksheets for analyzing the crop insurance decision. 32 p.

D-13: CROP CONTRACTING DECISION PROGRAM. (G. Nelson, Faus, and Powers).

Documentation and source listing. 20 p.

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[a] Order materials from: Farm Management Extension
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Oregon State University
Corvallis, OR 97331