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AN EXPLORATORY USE OF GROUP DECISION THEORIES IN EVALUATING FARM PLANNING PROGRAMMING MODELS

by

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ABSTRACT

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Farm management research has produced programming models capable of accurately simulating the interaction of physical, biological, and institutional factors and models of economic rationality. This precision has not resulted in significant farm usage. Normative assumptions implicit and explicit in these models may be major problems. If so, criteria reflecting the acceptability of normative assumptions should provide an effective means of model selection.

It is hypothesized that (a) it is possible to establish general criteria which distinguish normative propositions of programming models which will be usable in farm decision making from those that will not, and that (b) such criteria are implied by existing decision theory and research.

Working hypotheses were established regarding the nature of model normative assumptions. These served to guide a review of research in farm decision making which in turn implied general criteria of normative validity. Analysis of proposed planning models revealed a fundamental assumption of goal-directed maximizing behaviour by the

farm decision unit. Goals for the planning period are regarded as a static evaluative reference. They are assumed exhaustive in discriminating between alternatives and all significant goals are assumed to be quantifiable functions of measurable levels of economic goal achievement. Additional more specific assumptions operating within the scope of these fundamental assumptions are required by traditional analytical procedures or mathematical requirements.

A conceptual framework for group decision making established by rural sociology, group sociology, behavioural theory of the firm and diffusion theory suggests serious conflicts with modelled normative assumptions. Farm family goal formation and decision making are revealed as dynamic and simultaneous processes in which interpersonal goal-value conflicts play a major role. As a result hazy, ill-defined, and operational group goals are the normal case.

Although much research has been conducted on the importance, dynamic quality, and pervasiveness of group decision processes, no definitive theory exists which quantitatively describes the evolution of group goals and decision processes. Current farm management practice places the job of interpreting expressed goals and translating these intuitively into a mix of integrative and analytical tasks (and thus into resource allocations between integrative or harmonizing, and productive functions) in the hands of the decision unit and its advisors.

Research and theory reviewed indicate that the fundamental goal-directed maximizing assumption is representative of only a few short-run, technical decisions with globally accepted effects on income. More typically, expressed goals, values, and beliefs point not to ends for action but to needs for allocating resources between integrative and productive activities. Modelled goal structures must be explicitly recognized as conditional bases for intuitive allocations of resources between integrative and productive tasks.

Two strongly supported corollaries are possible. Firstly, the recognition that goal-directive maximizing behaviour is not possible indicates that model builders should focus on integrative requirements rather than normative exhaustiveness. No normative assumption is valid simply because it represents an expressed goal or value. Secondly, the large variety and dynamic nature of operational goals suggest that models should be capable of analysis conditioned on a wide range of firm goals. Weakly supported corollaries are possible in two additional areas. Firstly, utility functions are rejected for use in farm planning since they are part of an operational-goal oriented maximizing model and in addition focus on individual decision making. Secondly, extension agency objectives and techniques and diffusion theories imply that the conditioning base on which models should be built should be defined within the context of individual extension practices and objectives.

On the basis of the major criterion and its four corollaries it is concluded that the original hypothesis is acceptable. While no empirical test of the hypothesis was attemped it is notable that the criteria established are consistent with the degree of success encountered by existing farm planning programming models.

FOREWORD

The research on which this study is based has developed out of a concern that farm management research in the computer modeling era has grown out of touch with the human conditions surrounding farm decision making. While much effort in the farm management profession has been devoted to the building of normative models, farmers and extension workers have seldom found use for them in decision making. Is there something fundamentally wrong with the models? Do farmers and extension specialists not understand their potential? Are farm management researchers not sufficiently application-oriented?

As usual a considerable amount of time was spent developing and refining a concept of the problem. At first, it seemed that the problem was in large part mathematical, or at least had to do with cataloguing and weighing the characteristics of quantitative techniques potentially useful in farm planning. Could it be that farm management researchers had not yet developed models of farm planning within realistic decision environments? It appeared from a review of conceptual research into methods of modeling the farm decision environment (in all its stochastic, non-linear, lumpy and institutional complexities) that, in point of fact, models were available which could cope with the major tasks of environmental description. The further research along these lines continued, the more it became apparent that the problem was the absence of criteria capable of assessing the worth of farm management models, and this had more to do with the normative aspects of farm management than mathematical models per se. The problems of farm management did not appear sufficiently well understood that "the model", which adequately accounted for the normative aspects, could be recognized if in fact it did exist.

A first reaction in pursuing this line was that since planning models are normative and aimed at the satisfaction of decision makers, utility theory offered a sound framework for assessing the worth of farm management models. After some inquiry it became apparent that utility theory offered no sound basis for viewing the problem since the decisions in question were "small group" decisions, not the decisions of isolated decision makers. At this point, it appeared that a slightly different tack might prove useful. The theory of social welfare functions developed by Arrow [6] and enhanced by Fishburn and others [43] appeared to provide a framework for normative analysis of decision making in a group context. Further review revealed that this body of theory could not yet provide a foundation for assessing small group decision models. However the welfare function concept did point out a major problem in assessing normative decision models for use in group decision making.

Any theoretic base for purposive behaviour at the group level has to provide for the problems imposed by conflicts between individual objectives. At this point, it appeared necessary to abandon the familiar axiomatic bases provided by economic theory and to fall back on a more general base for developing a means of model assessment by basing a set of criteria on accepted theories of farm family group decision making. This was the point of departure for the thesis presented below.

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CHAPTER 1

THE PROBLEM

Farm management research has produced a large number of models each proposed for use in farm decision making. Farm management advisory personnel and farmers have the task of selecting from these models for use in farm planning. Development of selection criteria which can discriminate between models with a high potential for acceptance in farm decision making and those with a low potential is the central problem addressed by this study.

The appearance of complex farm management models has been associated with increasing sensitivity of economic rewards to management performance and increasing availability of complex operations research techniques. On the farm side, dependence on unstable international markets, increasing use of capital-intensive production techniques, decreasing equity positions, production specialization, dependence on off-farm suppliers, increasingly commercial oriented farm goal-value systems and increased competition for labour have contributed to the critical dependence of farm firms on decision making rather than tradition. On the other hand, models developed during the last two decades have proved adept in simulating the effects of increasingly complex production processes, business systems, and resource and institutional constraints on economic decision making. Linear programming (L-P) and increasing availability of electronic computers have permitted the evaluation of large numbers of farming alternatives [56,50,5,86]. Integer programming has provided an answer to non linearity problems such as lumpiness in assest acquistition, selection between either-or alternatives and selection of all-or-nothing alternatives [40]. Separable programming has allowed the representation on non-linear functions as linearly segmented functions [111, 112]. Stochastic programming formultions (L-P and quadratic programming) have been developed and they provide for selection between alternatives with stochastic: levels of achievement, resource levels, and production coefficients [92, 31, 91, 96].

In spite of extensive developments in farm management modeling, only a small number of specialized models has been used in farm decision making. The 1972 "Inventory of EDP Programs" [78] used in U.S.A. Agricultural extension Programs indicates extension oriented services having "highly usable reports" and over 50 recorded uses were in the following categories: ration formulation or nutritional analysis, technical simulations (eg. breeding programs), crop operations scheduling, debt analysis (eg. loan repayment), long-run and short-run budgeting, discounting, and tax calculation.

All services available to farmers treat the firm as a series of independent subsystems. No attempt is made to achieve an overall optimum. Most models are static and aimed at improving technical efficiency in a way that can only have favourable effects on farm income. Long-run planning is restricted either to a relatively minor use of long-run budgets which incorporate no selection process or to discounting models.

All models reporting extensive usage incorporated only weak consideration of farm goals and objectives within various farm firm subsystems. Information provided is directed at "what-if" questions or at universally acceptable goals rather than at generalized "what-should-I-do" questions. Feed formulation models (which make up about half of the above uses of planning models) are aimed at reducing feed costs, budgeting, and simulation models are aimed at testing the implications of farmer formulated plans. Reported long term planning models utilize traditional discounting concepts. No models incorporating the selection of optimal long run planning strategies in complex whole farm decision environments have reported significant numbers of uses.

As a result of adherence to static programming procedures which closely parallel the approach of traditional farm management extension, normative considerations are usually relegated to the pre-optimization (defining alternatives) and post-optimizing (interpreting model solution) stages in programming approaches to farm planning. For example, Tennessee's use of static linear programming in the "Rapid Farm Adjustment Program" [115] has aimed at suggesting adjustments necessary to maximize net returns to the operator, given available resources without regard to the size of the production unit. Adjustments are made to resulting plans on the basis of the planner's judgment and farmer's preferences. Major emphasis appears to have been on using L-P to arrive at a basis from which acceptable farm plans could be developed rather than explicitly introducing normative elements to arrive at the farm plan.

In Chapter IV of his thesis, which led to the Oklahoma L-P Farm Program,[1] Bitney [13] notes that the programming approaches to farm planning can only be successful as an integral part of an education program. Apparently, current educational (extension) programs are structured in such a way that normative elements enter the programming process in roughly the same way that they have traditionally entered budgeting-oriented farm planning, since in developing his area information system in a programming context, a normative content is not elaborated.

In contrast with the type of models in current use, research in the programming area has concentrated on the modeling of long run planning under complex decision environments and consequently on producing models with strong normative assumptions. Programming offers rapid calculation of a best possible solution from a wide range

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[1] L-P Farm is a static farm enterprise selection L-P model used in Oklahoma's farm management extension program.

of alternatives. As a necessary part of the processes, decision criteria are explicitly incorporated into the planning model. Decision makers are required to define best solutions before they can be calculated, rather than simply recognizing best solutions when they see them. Thus normative propositions are a required component of all programming models. In contrast with budgeting procedures, programming sacrifices active involvement in planning decisions in some measure in order to implement the optimizing concept.

The more complex the modelled decision environment, the more complex the set of normative propositions that are required to support choice between alternatives. For example, if the problem situation is the formulation of dairy rations given fixed nutrient requirements, feedstuff analysis and costs, a simple normative statement that cost should be minimized is sufficient to justify the use of a least-cost feed formulation model. Normative propositions in existing farm management use are of this type.

If, on the other hand, the problem situation is the determination of a mix of capital purchases required in a stochastic production process subject to stochastic resource constraints, more complex decision criteria are called for. At the very least, normative propositions are required to support choice between levels of achievement over time. Since levels of achievement are a function

function of production processes, choice between levels with varying probability distributions is required. Since the modelled production system has implications for a wide range of conceivable goals (eg., debt avoidance) choice between them must be supported by a prior normative proposition. Even the use of simple choice criteria in a complex decision environment does not reduce the complexity of underlying normative assumptions since they must in this case imply the insignificance of other more complex criteria.

Model acceptability in a farm planning setting can be pictured as having a normative and a technical component. A high level of technical acceptability has been achieved in many programming models. The limits of tractability are apparently sufficiently wide to permit accurate portrayal of the bounds imposed by the decision environment. Illustrations are in recent conceptual research in stochastic programming (eg. see Cocks [30] or Rae [112, 111] and in recent attempts at designing linear programming based decision systems (eg. Harter [56], Goldschmidt [50], Acton [5] and Marceau [86]. Normative acceptability is, however, an unknown quantity.

In general, model normative content has been defined <u>à priori</u> as a matter of expedience to allow illustration or use of other concepts. Those who have attempted to develop operational programming systems for farm management decision making have concentrated on the modeling of generally recognized elements in the decision environment or some aspect of such modeling.

Goldschmidt [50], for example, has concentrated on data acquisition techniques to provide information for a decision environment described by linear programming. Farms studied were generally large and had a relatively highly developed organizational structure within which profit maximization provided a reasonable objective function. Acton [5] has concentrated on the integer aspects of the decision environment while superimposing an admittedly hypothetical normative intent for illustrative purposes. Marceau [86][2] has used the general linear programming model to investigate the feasibility of a commercial short-run planning system using a cost reducing method of automatic generation of required program input. Profit maximization is assumed for illustrative purposes. Harter [56] has conducted a field study, incorporating data acquisition, problem formulation and solution interpretation elements in a linear programming based system. His major intent was to assess the generality and operationality of the linear programming approach in an actual extension setting. In the main, satisfaction with the system was expressed by both farmers and extension agents, but little attention was paid to feasibility of the role played by the profit maximizing choice function postulated in the model.

2/ Essentially the same research has been reported by Tongate [119].

Cocks [30] investigated the ability of linear programming and quadratic programming to accommodate stochastic elements in long-run decision making. Here again little attempt was made to reconcile normative propositions with firm decision processes.

In contrast with the *à priori* rationality assumptions in most programming models, it is interesting to note complex decision making patterns presented in sociology. Keefe and Burke [71] have noted that,

> "The family farm is a complex entity. It is composed of a great variety of expensive physical facilities and carries on a variety of production activities. But human beings are involved, tied together in a unique family relationship. In addition to the family and its individual members counted demographically, roles (father, son, mother, manager, parent, etc.), power relationships (head, subordinate), and interaction patterns, eg. autonomic, autocratic, syncratic, are also important components. All of these interact in varying degrees during decision making and planning situations, with the amount and quality of interaction influenced by personality and family characteristics."

Four points suggest that criteria of normative acceptability are required. Firstly, programming models which are potentially useful in farm planning are capable of incorporating wide range of normative concepts. Secondly, where normative elements in decision making are clear, their inclusion in a planning model can only render its search for solutions more efficient. Thirdly, it is to be expected that as new and more comprehensive models and data sources are brought to bear on increasingly complex farm decision situations, the volume of information available to decision makers will be increased to the point where a need for choice criteria will arise to limit the flow of information to a manageable level. Lastly, it appears that the farm decision processes with which programming models must interface, result in complex and dynamic normative standards as a result of continually adapting goals and "hands on" control of production and investment processes.

In summary, farm management research has produced many programming models capable of simulating in detail the effects of decision environments on variously defined models of economic rationality. Increasing precision in the simulation of physical, biological, institutional effects in the decision environment has not increased farm management use of these models. The normative assumptions implicit and explicit in these models may be a major factor in their apparent unacceptability for farm planning use. If this is the case, criteria reflecting the acceptability of model normative assumptions should provide a means of selecting models of potential use in farm planning.

CHAPTER 11

METHODOLOGY

The notion of "optimization"[1] is fundamental to farm management advisory services since it provides a means of determining the validity of normative propositions on which management recommendations are made. It is the intersection of a philosophical proposition and a convention or rule of prescriptive analysis. The convention of prescriptive analysis is that the prescriptor must continually seek an optimum. Even "better" plans are to be based on some conception of "best" or optimum". The philosophic position is that the something to be optimized must, to the greatest extent possible, come from within the individual decision unit. Simply stated, the principle of opimization is that individual farming units should try to achieve something inherent in their own social and psychological makeup. That wished-for something may be ill-defined, seldom achieved in practice, possibly inconsistent with physical reality and fleeting in its existence, but it must be the only standard by which alternative decision paths may be judged.

Decision making in a prescriptive sense may follow many non-optimizing patterns but it does not suit the

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1/ "Optimization" as used here explicityly includes the usual notion of less than universal optimality since a contextual framework is always implied.

normative approach of farm management to consider these. A convention of optimization gives direction to the search for better farm plans and is therefore a necessary start-

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2) It is often implied in farm management literature, (for example, see Strickland [130 Ch. 3], or Eisgruber [41 p. 127]) that simulation yields intrinsically more realistic solutions than programming because of its greater flexibility in describing behavioural processes as compared to the obvious optimizing context of programming (i.e. because other processes, not optimization, are observed in practice). This however, amounts to a confusion between "optimization" in the sense used above and optimization in the narrower sense imposed by individual programming models.

Behavioural theory supports the notion that firms do not always follow a single and logically consistent goal structure, that multiple and changing goal structures occur, and that inconsistency may persist over long periods. However, the empirical fact that firms apparently do not optimize in their decision processes does not imply that it is a wrong strategy for prescriptive analysts to try to optimize something in their decision processes. A principle of "optimization" states only that the prescriber should act as though there is something in the nature of human affairs to be optimized. It does not fail when that something is difficult to describe or does not permit analytical solutions. The principle is proposed as a grand strategy after the manner of a principle of causation in the logic of scientific discovery. It is acceptable not because of its own empirical validity, but because, only by pursuing it can it be assured of not moving away from better solutions (in terms of current ethical standards) if they exist. Since some solutions are preferred to others, we cannot go wrong by continually pursuing a "best" among these even though it may not be unique and it may be difficult or even impossible to identify. Optimization viewed in this manner implies that simulation models may in fact be better "optimizers" than mathematical optimizing models. This is however, not an intrinsic superiority. If optimization models do not optimize, it is because they are not, or cannot be, correctly specified, not because they are "optimizing" models.

ing point. This is not to imply that approaches employing non-optimizing (in a mathematical sense) models have no part to play in farm management. They too, may be a part of attempting to "optimize" in the sense given above.[2]

The adoption of optimization as a strategy for farm management is not ethically neutral. It rejects the notion that there exists what Arrow [6, p. 22] has called a "social good" which can be defined independently of individual desires. Rather, it adopts from the beginning the philosophic proposition that decision makers should act as though there exists something in the nature of human desires to be maximized.

In general, this proposition makes no empirical assumption beyond the existence of human desires and an ability of prescriptive analysts to derive some direction of purpose from these. It is not necessary, in the adoption of such a strategy, to postulate that some measurable funtion, subject to mathematical optimization procedures, actually exists since, as Arrow [6, p. 22] states, all that is required for an unambiguous choice to be made is that there exists weak ordering of preference on the set of alternatives being considered. However, in the context of the present study of programming feasibility this necessity is imposed. Some minimum mapping of decision space into preference levels is required by mathematical programming procedures.

A clear distinction between alternate approaches and optimization is required because of the strong tendency for farm planning models to evolve out of economic models of rational entrepreneurial behaviour (eg [36]). Several alternate philosophic positions are possible in lieu of a principle of optimization in prescriptive analysis. One could hold that an objective good quite apart from human preference exists and should be the goal of all human action. The difficulty of establishing such a universal rule is apparent given the unlikelihood of political concensus on one hand as a pragmatic vindication, and the certainty of infinite regress involved in argumentation basing such a rule on a higher order objective good on the other hand. Appeal to authority provides another inadequate basis for prescriptive analysis, for it leads to the possible dogmatic acceptance of rules which may be neither strategically efficient nor based on currently acceptable ethical standards. A variant of such a position is to appeal to the authority of tradition which has the same basic fault as other appeals to authority.

Optimization has been presented as the objective of farm management and thus the normative content in programming models. It has been presented as a philosophic and strategic proposition and is quite distinct from optimization in the narrower mathematical sense. Acceptance of optimization implies that the validity of normative elements can only be determined in an examination of the social and psychological makeup of farm decision groups. Other approaches have been rejected as being either strategically inefficient and/or founded on unacceptable philosophic propositions. To the extent that optimization has been practised, it can be regarded as having resulted in a number of proposed decision criteria for use by farm managers. It is equally likely that normative elements have not been generated by a concept of optimization but rather from more specific models of economic rationality.

During the last two decades, research in small group and farm decision making has developed a theoretical framework for decision making within the farm decision unit. Research in the sociology of small groups has developed an individual and group value based theory for action in situations where choice prevails [29]. Rural sociologists have studied farm goal holding and decision patterns which support and specialize generalized group decision theories [36,56]. Extension education and farm management research have studied the disemination of concepts among farm decision groups [120,118]. Behavioural theories of the firm have developed concurrently with group decision theories and explicitly integrate the role of individual value conflicts in firm decision processes [11,28].

It is hypothesized in this study that (a) it is possible to establish criteria which distinguish between the normative propositions of programming models which will be used in farm decision making and those which will not, and that (b) such criteria are implied by existing decision making theory and research. Part (b) of the hypothesis can be accepted only if part (a) is accepted and the criteria established are also implied by existing research results and theory. In the final analysis part (a) can only be accepted if empirical evidence indicates that models indicated as usable are in fact used. To the extent that criteria are implied by empirically validated theory and research both (a) and (b) are acceptable.

A hypothesized set of criteria could be verified directly by field testing available programming models and using the correspondence between the performance of these models and the degree of feasibility suggested by the hypothesized set of criteria as a test of validity.

However by its very nature, an empirically based study must become solution-oriented and thus can only deal tangentially with the problem of generating generalized criteria. An empirical study would have to focus on the normative validity of specific aspects of specific programming models for a small sample of potential users. For example an empirical study by Rades [110] has produced some criteria for the development of decision aids based on acceptability by a small sample of Indiana farmers who had used three versions of a corn production scheduling model. Although such studies are required to deal with details of implementing specific management services, they are less likely to produce the strategic model development generalizations required at this time.

An empirical test is not feasible for three additional reasons: (a) the number of potential models is large, (b) the field testing of individual models is time consuming and expensive and (c) the technical expertise necessary to carry out such a testing program is not likely to be available until after the need for such a test has passed. A valid set of criteria must then be a logical extension of existing farm decision making theory.

By requiring only a theoretical verification of proposed criteria the analysis can avoid becoming solution oriented and thus focus on the more general nature of the problem. To this extent, the approach taken is similar to that of Renborg [116] who has analyzed growth theories of the agricultural firm, "in terms of their possibilities for directing and controlling the growth process of an agricultural firm over time", though, as will become apparent, it is much more specialized in scope. The contrast here is provided by studies which attempt to catalogue and contrast elements of models in order to determine which among them contains the more favourable set of realistic elements. The emphasis here is basically problem not solution oriented.

To guide a review of research and theory related to farm decision making, working hypotheses regarding what comprises an operational or potentially operational programming farm decision model have been established and in turn indicate areas in which criteria are most critically required. This extensive development of working hypotheses is supported by the proposition that it is often useful at some point in hypothesis (criteria) formulation to decide that fruitful hypotheses will occur in a certain domain[3]. Whether or not developed criteria are valid does not depend on the validity of the working hypotheses made to assist in their creation. Developed criteria are to be considered sufficient for their purpose until they either conflict with more readily supportable[4] hypotheses or are the object of direct or indirect empirical falsification.

In reviewing models, considerable emphasis has been placed on operationality. Most programming models developed in agricultural economics have had a research orientation. Few farm management models have aimed at anything beyond conceptualizing a given problem situation in a particular programming framework, with the result that a vast number of very specialized planning models exist. Models considered below, however, are only the select few which have some claim to efficient algorithms,

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[3] See Kaplan [68, Chapter III] regarding the use of working hypotheses.

[4] See Margenau [87] on "regulative principles" for choosing between empirically validated hypotheses.

technically feasible data requirements and specifications, and sufficient conceptual clarity to permit extension use. In the usual case, they have been suggested either as general, systematic approaches to actual prescriptive analysis or as tools for the study of farm firm growth in various normative contexts.

A review of operational programming models allows the classification of underlying normative propositions. Certain normative propositions are explicit in all programming models. By analyzing the various dimensions of this normative content, implicit model assumptions are determined. These, in turn, imply basic normative assumptions relating to farm firm decision processes. After working hypotheses have been established, a review of research and theories of farm decision making is conducted to establish criteria for model evaluation.

Although it is not possible to develop generalized criteria and at the same time carry out a fully empirical test, it is possible to conduct a limited empirical test of validity. Since a limited number of programming models are currently being used in farm planning, developed criteria should be consistent with the degree of success which these have achieved. This provides a limited test of the ability of criteria to select useful models. It is not possible to test, even in a limited way, the ability of criteria to reject models unlikely to be acceptable since there is no way of knowing whether models are currently unused because they are unacceptable or simply untried.

Chapter 1 of this thesis has developed a problem situation which implies the need for generally accepted criteria for the evaluation of the normative content of mathematical programming models proposed for use in farm planning. This chapter has defined a methodology for the development of model evaluation criteria. The basis for this approach to developing evaluation criteria lies in a concept of optimization as a philosophic and strategic proposition which implies that the validity of normative elements can only be determined in an examination of the social and psychological makeup of farm decision groups. Since empirical studies are viewed as forcing solution oriented and thus narrow approaches, this examination takes place at a theoretical level. In order to provide direction to the examination of established theory, it is proposed to use currently operational planning models as indicators of significant areas for criteria development.

General Organization

At this point we have: a defined problem, a broad, general framework in which to analyze it, and some basic guidance as to which direction the search for solutions (evaluation criteria) should take. Chapter 111 narrows the search for evaluation criteria still further. An "operational" programming context is developed to illustrate the types of normative propositions required to support the normative content of programming models which have been proposed for use in farm planning.

The primary task of the first three chapters is to provide sufficient focus to the search for evaluation criteria to permit efficient examination of subject matters related to farm decision making. Chapter 1V begins the consideration of these relevant subject matters by developing a conceptual framework for group decision making. Since this is primarily a review of received theory which may not be generally familiar to agricultural economists, extensive use is made of expert opinion. Attention is paid to developing group decision concepts as well as theories which are necessary for Chapter V and following chapters' analysis of decision making in the farm firm.

Following Chapter 1V, available literature relating to normative elements in farm decision making is examined. Studies are reviewed which support, supplement and specialize concepts and theories from Chapter 1V. Where evidence warrants them, summary statements or generalizations are proposed as a base for establishing criteria for the evaluation of programming models. The concluding chapter V111 draws on reviewed decision theories in implying general criteria for the evaluation of programming models. A final chapter 1X suggests several areas in which further research is required.

CHAPTER III

NORMATIVE ELEMENTS OF THE FARM PLANNING PROCESS IN A PROGRAMMING CONTEXT

This chapter presents an "operational" programming context into which normative factors in farm firm decision making are forced by the use of programming models in farm planning. Since the intent of this chapter is to illustrate areas in which normative assumptions are being made no overall analysis of each model is attempted. Analysis is retricted to normative factors except to explain interactions between normative and environmental factors.[1]

In essence the chapter cites and in many cases illustrates the pervasive use of three fundamental precepts relating to the use of normative elements in operational programming models. Firstly, a set of normative standards which is known and specifiable in terms of the firms goals and objectives for the planning period exists at the planning date. Secondly, the exhaustive treatment of firm normative standards within planning models represents an ideal for model builders. Thirdly the normative decision base which exists as of the planning date is

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[1] No detailed explanation of either problem specification or solution techniques is given. However, an attempt is made to relate all discussion to familiar concepts from accessible farm management literature. It is anticipated that either the reader has a fairly extensive knowledge of operational programming models in the area of farm management or wishes to pursue the extensive references cited in appropriate instances.

complete in the sense that no gaps exist in goal areas within the scope of the decision environment (eg. both long run and short run goals are complete) and contains a number of particular characteristics which coincide with traditional economic rationality (eg. time preference, risk aversion, diminishing marginal propensity to consume, diminishing marginal utility). The reader who is willing to accept that these precepts are in fact pervasive may proceed to summary at the end of this chapter and read that brief discussion without loss of continuity. However, it is important to recognize that these are strong and pervasive normative assumptions in virtually all recent research attempts to develop programming models for farm planning in the face of complex, comprehensive decision environments.[2]

An introductory section reviews the general nature of programming models, establishes a working hypothesis regarding the admissability of various planning models in establishing a programming context and considers more specifically the mathematical nature of admissable models which have been most commonly used or proposed. Following this introductory section, several sections are

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2) Recent research into improving the efficiency of search techniques utilized in non-analytical decision models shows that strong normative assumptions are not restricted to programming models [18].

presented to illustrate the general nature of normative assumptions in a number of potentially operational programming models.

Within models discussed major emphasis is on what might be called their most limiting resources, where questions of feasibility are most acute. As noted by Hutton [59, pp 195], these would appear to "centre on the nature of the objective function, treatment of risk of error in coefficients and treatment of time associated variables". Unlike Hutton's treatment however, this study is specifically directed at normative elements of programming models.

Dimensions examined are clearly interdependent and in order of presentation are: The Time Dimension, The Financial Dimension, The Consumption Dimension, The Risk Dimension, and the Choice Dimension. By definition of normativity, one would expect elements of choice to be inherent in each of the dimensions above. It is useful, however, to consider a separate choice dimension to relate methods used in weighing the importance of other dimensions and reconciling them into a single choice criterion and a set of normative constraints. This procedure of necessity causes some duplication of discussion but results in a clearer presentation than a discussion of choice criteria within each of the other dimensions.

Introduction

The general mathematical programming problem can be stated as optimize $Z = f(X),\ X = x_1,\ldots,x_n$ (1)

subject to $g_i(X) \leq, \geq, = b_i,\ i=1,\ldots,m.$ (2)

As stated, the problem does not necessarily have an obtainable global optimum. However, the addition of restrictions on f and g has allowed mathematical programmers to develop algorithms for the solution of particular cases of the general programming problem. (See for example, Mangasarian [84], McMillan [95], Hadley [53]. In one of the most restrictive cases (linear programming), both f and g are required to be linear, continuous, and $X \geq 0$. Recent developments have indicated the conditions under which obtainable global optima exist for more generalized restrictions on f and g[3/] and algorithms for obtaining these solutions have been developed in many cases. Relatively few algorithms (notably linear programming and its variants integer programming, mixed integer programming, separable programming and quadratic programming) have reached a stage where they can be considered potentially usable in solving real world farm management problems for a number of reasons related to computational efficiency and problem specification.

Regardless of conditions of optimization and existence of solution algorithms, the general programming approach requires that criteria of choice between

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3/ For example, Bector [12] has investigated the properties of Quasi-Convex objective functions defined over a non-empty closed convex set in R^n.

admissable alternatives be single measurable magnitudes (i.e. a single function). In the case where multiple goals exist, a set of relations must be defined such that this single dimension objective exists. In the words of Charnes and Stedry (Johnsen [64, p. 186]):

> "It may be tautological, but nevertheless interesting that it is impossible to simultaneously optimize two functions: one can, at best, optimize one, placing a constraint on the other; or one can construct a superfunctional which is some function (perhaps a weighted sum) of the initial functions".

The above outlines, in a general way, show the programming context into which modeled normative factors in farm planning are being forced. To proceed farther in developing the programming context it is necessary to review recent farm management research to obtain information on the nature of potentially operational planning models. In doing so it is not necessary to dwell at length on the status of related research in mathematical programming since the development of criteria relates more directly to what must be portrayed rather than how, in a mathematical sense, it must be specified. Specification will be dictated by optimality requirements. Whether these are reasonable or not is part of what is to be judged by established criteria. To determine the normative assumptions of programming models it is necessary to include in the programming context only those models which have been seriously proposed either as normative tools in actual farm planning or as tools for investigating problems inherent in farm planning. Systems[4] approaches to farm planning such as those reported by Acton [5], Goldschmidt [50], Harter [56], Marceau [86], Cocks [30], Stonehouse [128], Bitney [13] and Ray and Hudson [115], are clearly included. As a general rule, these systems approaches have had a cursory normative content possibly because of their concentration on environmental matters and static models which limit the incorporation of dynamic normative concepts such as time horizon, time preference, and goal sequences. Many of the sytems approaches, particularly those currently being used (e.g. Roy [15], Bitney [13]) rely on pre-optimizing (e.g. selection of alternatives) and post optimizing (e.g. altering solutions to render them more acceptable) consideration of normative elements and thus seldom explicitly document normative considerations. However a considerable variety of explicitly incorporated normative elements usually based on a priori reasoning does appear in farm growth literature in models which are a direct generalization of the system approaches. These generalizations of currently operating models can be considered a preview of future operational planning models and contribute, in large part, to the programming context established below.

The literature on growth models is pertinent only on a selective basis since there is a grey area between

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4/ By systems approaches is meant any of the proposed or operational farm planning models which place decision making for the whole farm in one analytical framework.

normative growth models which are aimed at studying problems inherent in how a farm should grow in various normative contexts and positive models which are aimed at analysis of how, in fact, farms do grow. As Irwin and Eisgruber [61, p. 4] have noted:

> "A review of the rather extensive literature leaves one with the uneasy feeling that most of the work lies in limbo between optimization and prediction, between management of the firm and aggregate analysis, or between specific problem solving and generalization".

Growth models aimed at understanding the problems of growth, in particular normative contexts, such as those of Martin and Plexico [88], Baker [7 and 8], Duvick [39], Smith [126], and Johnson [67] have been included in establishing a programming context. Growth models more clearly aimed at positive description, however, are not included.

The majority of models which fall within the established operational designation can be classified as variants of linear programming, quadratic programming, integer programming, or separable programming. Separable programming allows strict linearity restrictions of f and the g_i to be relaxed in favour of a more general restriction of concavity and separability on f and convexity (concavity for constraints) and separability on the g_i [Hadley 53, Chapt. 4 or McMillan 95, Chapt. 6]. Stochastic linear programming and quadratic programming have allowed some considerations of non-linearities caused by stochastic elements in the constraints or objective function. Integer programming has permitted the accommodation of discontinuities in f and the g_i where the domain consists of intergral values only.

It should be noted that a number of mathematical and computational efficiency problems have prevented the development of a single all-inclusive generalization of the linear programming approach to farm management. Stochastic linear programming is hampered by computational efficiency problems (Cocks [31]). Computationaly efficient integer quadratic programming algorithms are not available, and separable programming poses computational efficiency problems particularly where a large number of non-linearities are approximated. Because of the above problems, programming approaches with any claim to operationality in farm planning have been restricted to minor deviations from the linear programming approach. Examination of a recent U.S.D.A. review [133] of U.S. Farm Management E.D.P. programs reveals that all of the reported 12 routinely available programming approaches to whole farm planning[5] were based on linear programming with the exception of one which incorporated quadratic programming as well. Additional noteworthy systems not reported in the survey, L-P Farm (Oklahoma State University) and Mascot (Imperial Chemical Industries) also used linear programming. The following sections enlarge

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5) Programming services were reported by University of Mass., University of Missouri, University of New Hamphire, University of North Carolina, Pennsylvania State University, University of Tennessee, Texas A & M. University, University of Vermont, Virginia Polytechnic Institute, Washington State University, West Virginia University and Oregon State University.

on the normative content of the most commonly used or proposed programming models.

The Time Dimension

Although normative assumptions made in operational model specification of the time dimension are normally implicit, two aspects of the time dimension have received attention in farm management literature. Length of planning horizon and dynamic relations between formulated goals have usually been based on à priori specification of rational behaviour. Intertemporal equivalence, the most often specified dynamic relation between goals, postulates standards of equivalence between goals specified over time. Length of time horizon is rationalized by a conception of goal formualtion and relations between formulated goals.

The Time Horizon

Operational programming models considering a time horizon greater than one year usually come to grips with the time horizon problem by incorporating multigoal decision functions. Essentially this is a result of the need to give some weight to the achievement of goals in both the current planning period and beyond. Planning periods beyond the current one cannot be considered extensively without in effect extending the planning horizon thus horizon[6] length is determined by specification of a point sufficiently distant that a given cursory treatment of future planning periods is acceptable to the decision unit. Most operational farm management models have adopted an implicit "going concern" principle in this respect. For example, in a situation in which profit maximization is deemed all important, it is usual to place some weight on variables such as terminal net worth to insure that the business will be maintained as a going concern past the current planning period.

Approaches to time horizon determination in farm management literature can be placed into one of two categories which, for want of better terminology, we can call the "pragmatic" approach, usually used in farm planning models, and the "turnpike" approach which appears in some conceptual farm growth models. Only the former has received any extensive use in operational farm planning hodels; however, its use has often implicitly presumed some elements of the latter approach. Both approaches are considered here in an attempt to determine fundamental normative assumptions.

Both approaches begin with the clearly appealing planning imperative that sooner or later a halt must be called to the expansion of the planning horizon.

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6) As pointed out by Boussard [22], the planning horizon may be considerably shorter than the period cited since the object of planning is specification of immediate action in the light of all available information, and under certain conditions optimal immediate actions are insensitive to the lengthening of the planning period beyond a certain point.

Boussard [23] has developed, in a farm growth context, Modigliani's notion that long run plans are not developed for their own sake but rather are to provide a means of incorporating all available information in the optimal determination of initial period actions. This being the case, it makes sense only to extend the time horizon as long as the information so incorporated has some effect on optimal initial period actions. As Boussard [23, p. 468] points out, in general, this does not necessarily imply the existence of a finite planning horizon. He gives as an illustration the maximization of classical time discounted consumption functions in linear programming models. Boussard [23] accepts as a definition of time horizon, "the time within which it is necessary to plan in order to make a decision for the first period". Since, as he notes, this does not place any restriction on the length of the horizon, the extra conditions that the planning horizon exist and be "not too long" are added.

In his development of the turnpike theorem in a farm planning linear programming context, Boussard has examined very general conditions which guarantee that a finite planning horizon exists. This formalistic approach to time horizon determination does however, make some strong normative assumptions. In effect, it redirects the specification of normative content from the point of view of the decision maker to the point of view of the model builder. Objectives of the decision unit must be constrained to permit an analytic guarantee of finite horizon legth. It is necessary to begin with the assumption that a goal structure, suffieciently clearly formulated for a time period long enough to permit the implication of a time horizon, exists as an expression of decision unit's intentions.

Given the existence of such a goal structure, further normative assumptions are made regarding its content. Boussard's model requires that: a linear consumption function exist for each time period, the decision unit desires to maximize terminal net worth,[7] and neither the decision unit nor the environment place any absolute constraints on alternative courses of action considered. In making these assumption, the model builder indirectly insures the existence of a finite planning horizon, whose length cannot be specified à priori.

In contrast with the turnpike approach, the pragmatic approach does not seek to guarantee in an analytic sense that the model developed will have a finite planning horizon, but achieves the same end in a more direct manner. It also begins with the assumption that a sufficiently complete goal structure exists, but the object of sufficiency is quite dirrerent. The goal structure is presumed to directly imply that decision

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[7] Boussard [23] has shown that these first two requirements are equivalent to the maximization of a weighted sum of yearly consumption.

periods beyond a given date are sufficiently inconsequential to the decision unit that they may be given a defined cursory treatment in establishing model normative content.[8] Defined cursory treatment will vary from decision unit to decision unit. For example in a given model, a going concern principle may be followed by either placing any one of a infinite number of weightings on various stocks of terminal wealth or placing constraints on terminal wealth.

Intertemporal Equivalence

The majority of multiperiod planning models incorporates some notion of intertemporal equivalence in their objective functions or constraint systems. In the usual case, the objectives are specified, following the Hicksian model[9] as the present value of a stream of values depicting annual goal achievement. (see for example, Johnson,

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8/ The implicit rational for supposing time periods beyond a point can be regarded as relatively inconsequential appears to be based on the empirical notions that (a) individuals have positive time preferences (that is they discount successive future goal achievements at higher rates) and thus distant periods add little to goal achievement; and that (b) individuals do often display definite planning horizons within their cognitive processes which reflect directly on their willingness to consider solutions as meaningful; and the analytical hope that (c) current period actions will be largely independent of distant time period specifications.

9/ For an illustration of commonly used Hicksian models see Cocks [29].

[67, Ch. 11]). Rationale for this approach is provided by an a priori model of rational behaviour in an environment characterized by: (1) perfect foresight (single valued expectations of all possible eventuations) and (2) perfect capital markets (in the sense of the classical perfectly competitive market). Rational behaviour is defined as preferring the stream, of say income, which has all elements ≥ to those of other streams. Given the above perfect capital market and perfect foresight, individuals are free to convert streams of income to current sums of money and vice versa. On this basis, it appears reasonalbe to make the further rationality assumption that the individual should be indifferent between a given future stream of income and the given current sum which is known to be capable of generating that stream. Since all streams have an equivalent current sum, these can be used to rank various investment projects.

If these notions of rationality are accepted and in addition, the decision environment provides an objective measure of marginal returns to investment, an objective equivalence between future streams of income and a current sum of money can be established by determining the sum required to generate the given stream at the prevailing marginal return to investment. Such a marginal rate prevails for the investor facing a certain future in the classical perfect capital market. This investor will continue to invest to the point where the costs of increased investment equal returns from increased investment.

As a result the prevailing cost of investment funds can be used as a proxy for marginal return to investment in discounting future income streams.[10]

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10 It will be noted that this entire presentation of the classical discounting concept is couched (as is most related literature) in terms of a stream of income flowing from a given investment which has positive elements only. In the more generalized case, where any element may be positive or negative, the present value concept (even given that the discount rate can be somehow justified) presents logical inconsistencies related to the Internal Rate of Return (IRR) versus Present Value (PV) controversy. Simply stated, the problem is that in cases where multiple solutions to the IRR exist, (I.E. PV=0 for more than one IRR), P V as a function of the interest rate is not monotonic (Teichroew, Robichek, Montalbano [131]. To illustrate, if the discount rate is interpreted as a marginal investment return, the PV model may yield the intuitively inconsistent implication that an increase in the market rate renders acceptable (i.e. $PV \geq 0$) a project not acceptable at a lower rate.

In such cases, Teichroew, Robichek and Montalbano [131], have established conditions which allow the decision maker to make consistent decisions (market rate < project acceptance level always produce a larger PV) using either IRR or D.P.V. in such a way that the firm will be assured of increasing its PV as classically described, i.e. PV=F (income stream and perfect competition market rate. In doing so, they have solved the inconsistency problem; however, they have not addressed the more fundamental problem of how to justify an objective discounting procedure, which is, of course, our primary concern, since it would presumably negate the need for specifying normative content regarding intertemporal equialence.

Real farm managers face a more complex environment where capital markets are not perfect (unlimited funds are not available at the market rate) and the future is not certain. As a result, the marginal return from investment is not likely to equal the market rate of interest and this objective external means of assessing marginal returns to investment ceases to exist [Mao 85 Chapter 7]).

Discrepancies inherent in externally justified objective discount rates lead to the search for an objective internally specified discount rate. The fundamental problem here is that such an opportunity cost cannot be known ahead of optimization, thus leading to a paradox since optimization cannot proceed unless a discount rate is known a priori [Baumol and Quant 9]. Recourse to the use of utility theory provides a way around the paradox [Gunn and Hardaker 52], but amounts to abandonment of the search for an objective choice criterion.

The realization that the assumptions of classical Hicksian discounting procedures are seldom realistic in a farm planning setting has led a large number of model builders to consider another means of theoretic support for discounting. In general, their approach is to consider the discount rate to be a subjective measure of time preference, thereby eliminating the need to assume perfect foresight and a perfect capital market. Virtually all models use some form of subjective discounting as an alternative to more complex utility functions, which are generally viewed as nonoperational in farm planning (see for example [52]).

In practice however, farm management personnel usually settle for some estimate of market rate or rate of return on investment. Indications are that the subjective concept is not taken seriously. In any case, standards of intertemporal equivalence are required to exist on the planning date, they must be quantifiable in the form of discount rates and they must be independent of eventuations in the decision environment.

Other Dynamic Relations Between Formulated Goals

In the usual case, farm management models do not make special provision for other dynamic relations between formulated goals such as those presented by a family life cycle. Dynamic models tend to be formulated as a series of similiar single period models with the addition of appropriate inter-period linkages and specification of a single objective function. Baker [8] however, has indicated that an allowance for the family life cycle can be made by specializing the constraint system and objective function to reflect known dynamic processes in the family goal structure. He suggests, in particular, that different activities be considered at various stages in the life cycle. It may be useful "to include more growth relevant alternatives in early years of a farm firm, and more financial alternatives, expecially with respect to estate management in later years".

To summarize, two approaches to the determination of time horizons, a turnpike approach and a pragmatic approach, were briefly discussed. The overall implication of discussion regarding time horizon is that it is useful to investigate available evidence and establish criteria relating to both the formulation of normative standards and the content of formulated normative standards. Further, it will be useful to investigate and establish criteria relating to more specific questions of empirical support for various elements of normative intent such as the nature of decision unit consumption functions and the nature of decision unit conceptions of tradeoffs between planning periods.

In the usual case, normative standards are modelled as the achievement of goals in one or more series of goals (each series consisting of corresponding goals defined over time). Within each series, it is necessary to determine some form of intertemporal equivalence. Current concensus in farm management literature favours the use of subjective discount rates, but since no readily apparent means of empirical determination is available, operational planning systems usually resort to market rate discounting. Clearly important implicit assumptions regarding the existence and magnitude of subjective discount rates are being made in using this expedient.

In addition, some conceptual studies have suggested the incorporation of other dynamic relations between goals in an L-P contex on the basis of family cycle relationships. It should be useful in this respect to examine research related to the nature of family goals over time.

In general the time dimension in programming models implies the existence of a set of normative standards within the farm decision group. These standards operate over a planning period in such a way as to either directly or indirectly imply its length. In the majority of models a going concern assumption is used to directly imply that goal achievement beyond a point is not significant. In addition, standards of intertemporal equivalence which have a number special properties are assumed to exist. Firstly they are quantifiable as discount rates. Secondly these discounting rates are established independently of the decision environment and thus related normative standards remain static over the time horizon. This assumption of a static normative base holds even where dynamic goal structures are modeled since their functional form must be fixed on the planning date. Thirdly although discount rates may vary from period to period they must exist in all periods. An assumption is therefore made about comprehensiveness of the underlying set of normative standards. Basic assumptions in the time dimension relate to the existence, dynamics, comprehensiveness, length of run, and functional form of group normative standards.

The Financial Dimension

Production and marketing aspects of farming have long been recognized as important dimensions of farm planning models. In recent years, a number of medels have been developed to accommodate the financial dimension. Previous comments regarding the absence of documented normative intent in operational farm planning are also applicable here. However, growth-oriented studies have revealed normative considerations in the financial dimension often as a by-product of the extensive development of other considerations in the financial dimension. A variety of means have been proposed for incorporating normative concepts such as debt avoidance, liquidity preference and equity requirements. Since, in general terms, normative aspects of the financial dimension revolve around the liquidity concept, this section focuses on liquidity[1] and specifically on the work of Baker [7, 8] who has been a major proponent of the need to expand consideration of the financial dimension in farm planning models.

Liquidity Preference

The rationale for incorporating the concept of liquidity reserves into farm planning models is that

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[1] "Liquidity" as used here refers to the convertability into liquid assets of fixed assets and debts under the firm's control. Liquidity preference is defined as a desire for certain levels of access to liquid assets.

planners are expected to require a contingency reserve against unforseen expense or opportunity. Liquidity is seen as an informal insurance policy. Opportunity costs of maintaining high levels of liquidity (that is, arranging contingency measures to accommodate virtually all possible eventualities) can be thought of as the cost of being able to plan under a situation approaching certainty. The decision maker's liquidity preference may then be looked at as an expression of preference for planning under certainty as opposed to uncertainty.

Liquidity is available in many forms and has the potentiality of being used to insure against a variety of unforeseen expenditures. Feed grains may be held in excess of yearly feed requirements to either maintain production or to sell for cash in case of a crop failure. Cash may be withheld from operating capital to take advantage of a possible drop in feeder prices or to provide for a sudden outbreak of disease in a poultry flock. Life insurance may be purchased to prevent forced dissolution on the death of a partner or to use as collateral for unforeseen machine repairs. There are, of course, an almost limitless number of possible liquidity reserves that could be cited. However, the majority of those that have been developed fall within the more traditional financial areas (eg. savings, investment and credit acquisition).

The process of credit acquisition has been considered of fundamental importance in the growth of farm firms.

As a result of critical reliance of firm growth on credit availability and acquisition terms, growth models (eg. [39, 126, 134]), both normative and positive, have been developed which limit credit availability. However, as noted by Eisgruber and Irwin [61, pp. 11] "the usual models constrain borrowing capacity at specified interest rates and leverage ratios merely by the cash flow required to service long term debt." Recent research by Baker [7] and others has aimed at a more explicity consideration of the limitations on the firm's credit reserves and the relation of these reserves to the firm's liquidity preference.

Instead of simply restricting the amount of credit by type available in any one time period, Baker has gone further to consider the processes whereby credit reserves are generated and absorbed. He has developed the concepts of a credit reserve at each credit source and a lender's preference for various loan uses and sources. These are incorporated into a system of linear constraints as lender's "interaction coefficients" and "credit absorption rates" to achieve a more accurate portrayal of the credit market. Credit absorption rates relate the net rate at which each reserve is depleted by various credit uses while interaction coefficients relate the reaction of specific lenders to credit obtained from another [7].

Given this more precisely defined credit reserve, the firm must then determine an appropriate trade-off between the benefits of borrowing (leverage) and reduced liquidity due to reduced credit reserves. The firm's valuing of liquidity provided by credit reserves can be incorporated in a linear programming framework by assigning either positive weights to credit reserves or negative weights (not to be interpreted as credit charges which are also included as costs) to debts in the objective function. In the case where reserves are valued by the farmer at a constant marginal rate, only a single weight needs to be specified for each reserve. Where value is a non-linear function of reserve level, several weights must be specified for each reserve so that the function can be approximated by linear segments. Baker suggests that an opportunity cost principle be used in determining weightings (ie. what is a dollar's worth of liquidity from a particular credit reserve worth, relative to liquidity from other sources?) between various reserves. In this sense, a dollar's worth of credit based liquidity should be worth no more than a dollar's worth of cash withheld from productive actiities since, in fact, this forms a very general alternate source of liquidity.

In any case, returns to a liquidity reserve are difficult to determine and no operational procedure has been given. Various levels of liquidity from a given source of liquidity may "rationally" bear some relation to each other (liquidity preference functions are usually held to value increased reserves at decreasing marginal rates) but liquidity value weightings relating values obtained from other sources will be difficult to generalize on, even in a broad sense. It is possible to suppose however, as Baker [8] has suggested that certain flexible credit reserve sources such as banks, might "rationally" receive higher weightings than less flexible ones such as trade credit.

Smith [126] in using Baker's approach to credit reserve generation has defined a firm's debt aversion as a negative weighting less than 1.0 in the objective function (discussed in the section on the choice dimension). The relative weightings of other goals such as expected profits relative to liquidity reserves are another difficult and unresolved issue. Baker has reported some preliminary, but far from operational, attempts at determining weights involved in linear programming objective functions incorporating liquidity preference schedules by analyzing past firm performance.

Liquidity and Risk

Boussard [24] has also developed a technique, "focus of loss", for dealing with reserves maintained in the face of uncertainty. He has used the notion of liquidity as an antidote to uncertainty in an admittedly positive model of farmer's behaviour under uncertainty. His decision maker is allowed the luxury of planning under virtual certainty (negligible possibility of ruin) by including liquidity constraints in the form of a focus loss concept, on his current cash flow. The decision maker is viewed as focusing his decision making on a given disaster level of total disposable income sufficient to cover certain necessary expenditures.

Each activity is constrained to contributing no more than a given proportion 1/K to the disaster level. Maximum per unit activity contributions (a measure of individual riskiness) are considered individual foci of loss. In Boussard's study, disaster foci for various crops were consensus values given by various extension experts. Presumably a focus loss concept could be applied in a farm management application by simply obtaining the farmer's subjective estimates of total focus of loss, individual foci of loss and k.

In a normative context, the above approach presents the anomaly that a decision maker chooses to make plans as if certainty exists, provided focus loss constraints (a provision for uncertainty) on choice in the certain environment are obeyed.[12] Presumably, experience has taught him that he can do so. The basic question of how he would like to choose in the face of a stochastic environment is avoided by assuming that the decision unit is sufficiently conservative to constrain its alternatives to those which closely approximate a certain planning environment.

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12) In this sense the focus of loss concept is similar to the conservatism often displayed in farm planning L-P's which limit the acreage levels at which "risky" activities can enter L-P solutions so that planning can proceed under assumed certainty.

Other Financial Restrictions

The alternative to using a weighting system to express the desire for liquidity preference is to impose direct, borrower-imposed, limitations on sources and uses of credit reserves. Such restrictions may be the outgrowth of striving in the liquidity preference area, but may also reflect other normative functions not related directly to liquidity preference. Johnson [67], for example, has taken this approach by including borrower restraints on various types of credit use.

In summary, the financial dimension reveals a single concept, liquidity preference, of overriding importance in portraying the impact of normative intent on financial processes. Further, emphasis appears to be on the application of this concept to the more traditional financial aspects. However, a number of less elegant direct restrictions on credit use and sources have been included in planning models from time to time.

Normative elements presented are conceptualizations of financial preferences or objectives which are presumed known and measurable as of the planning date. Although measurement problems are recognized, it is assumed possible to quantify the relationship between these objectives and some overall objective such as profit maximization. The decision units liquidity preferences are considered static even though lendor's liquidity preferences are regarded as dynamic.

Known liquidity preferences or objectives generally relate to the holding of reserves, and primarily to insure against uncertainty. Non-risk oriented reasons for maintaining reserves are of course possible. However, from a risk point of view an underlying assumption appears to be that the decision unit desires to plan as though certainty exists (choice is not made on the basis of distributions confronted) provided certain reserves are maintained. An additional assumption which will reappear in many of the models reviewed concerns the assumed exhaustiveness of normative elements. Clearly the detailed treatment of liquidity suggested here implies an inadequate treatment of these elements by other prescriptive procedures.

The Consumption Dimension

The fundamental importance of the production-consumption interface in farm planning has been stressed in farm management literature since Heady's presentation of the Household-firm competitive interaction model [57, Ch. 14]. Acceptance of this model has led even those specifying model normative content in terms of non consumption goals (for example, growth goals such as net worth accumulation) to recognize the consumption dimension as an important normative modifying influence in choices between alternatives.

Farm family consumption functions act as constraints and drain off disposable income which could otherwise be made available for investment. Since their influence is through investment such constraints are often not found in static models which usually don't emphasize the investment process. Since virtually all farm planning models developed to date have been static, little attention has been directed to the consumption dimension. (see Marceau [86], Harter [56], Stonehouse [128]). The whole farm model developed by Acton [5] however, is dynamic and incorporates constraints and activities which force family consumption to a $5,000 minimum plus 40 per cent of disposable income in excess of $12,500. No empirical evidence is given to support the form of the function and no means is specified for quantification in actual application. Presumably, the farmer would simply be asked to state his consumption preferences in terms of a minimum acceptable consumption and a marginal propensity to consume.

The general approach in multiperiod farm planning models is to impose a consumption function, often exhibiting diminishing marginal propensity to consume, in each time period considered. Since a diminishing marginal propensity to consume implies the approximation of a concave function in the constraint system, a variety of means have been devised to meet the convexity requirements of programming models. A number of models reviewed have chosen to use a linear (Keynesian) consumption function which is both concave and convex. Many other models have used a constant consumption function for similar reasons. On a more complex level, L-P models have been developed which make consumption a linearly approximated concave function of income. Concavity problems are overcome by simply maximizing consumption in the objective function. Still further complexity has been added within an L-P framework by making consumption a function of additional variables such as past income levels and capital gains.

Farm growth (usually defined in terms of net worth) models are usually aimed at an understanding of the role of various aspects of investment. Since consumption places an obvious limit on investment in all periods, it is extensively treated in many growth models. A consumption function similar to that used by Acton was used by Boehlje and White [19] in a dynamic L-P model of firm growth ($3,000 minimum plus 50 per cent of disposable income above $3,000)[13] As before, neither the form of equations nor their means of quantification were specified. Baker [7,8] has investigated the use of consumption functions exhibiting diminishing marginal propensity to consume relative to current income and exhibiting linear relations to past income and capital gain.

Baker's model is presented below in some detail because it represents one of the most comprehensive attempts to build marginal propensity to consume into farm planning models. His formal model gives:

13/ This type of function is particularly common in growth literature. (For another example see Kay [70]).

consumption outlays = f_1 (current ordinary income +
1/4 current capital gain)
+ f_2 (past ordinary income)
+ f_3 (past capital gains)

where, with respect to the bracketed quantities:

f_1 is a discontinuous decreasing marginal propensity to consume schedule;

f_2 is a constant marginal propensity to consume schedule; and

f_3 is a constant marginal propensity to consume schedule.

The actual translation of these concepts into an L-P model has been specified by Baker [7,8,135]. This translation is not particularly important for our purposes except in illustrating that it requires that "consumption outlays" be a positive component of the objective function to be maximized. Baker's model maximizes a linear combination of yearly consumption outlays and terminal net worth with intertemporal weightings determined by conventional discounting procedures.

The model developed clearly illustrates that complex processes of choice between savings and consumption can be built into a L-P model. However, no means is given for the determination of f_1, f_2, or f_3, for a particular decision unit. It seems reasonable to assume non-increasing marginal propensities to consume and that both normative and positive elements will exist in the determination of necessary coefficients; but these are at best broad generalizations which are far removed from coefficient determination.

The consumption dimension reveals that it is possible to incorporate relatively complex consumption relationships in programming models. It is implicitly assumed that the necessary consumption relationships exist, are specifiable, and are necessary to the generation of useful solutions as of a given planning date. While it is true that some sort of normative consumption relationships exist as of the planning date, it is not necessarily true that they represent useful normative propositions for evaluating future periods. Even given that they are measurable, there remains the problem of validity over the planning period. As in other dimensions, there appears to be a tendency to think of the normative element (in this case consumption) as an input into the planning process rather than an output. It follows then that most model builders are inclined to include as many normative propositions as possible within the limitations of their ability to measure, specify, and pay the costs of analysis. Assuming that normative consumption standards are established over the period, it is of course, logically possible to include this process within the model, however the relative merit of this procedure versus other methods of accomodating normative propositions would come into play. Regarding the particular functions reviewed, two specific areas for criteria development are suggested. The first and most obvious relates to the relative importance attached to various consumption goals relative to other goals and to each other since weighting factors are clearly required to establish

MPC's. Secondly, convexity requirements place specific constraints on the specification of consumption functions.

The Risk Dimension

Up to this point, we have discussed a variety of dimensions of farm planning programming models. Explicit consideration of one essential dimension, however, has been omitted. This section considers the explicit incorporation of risk elements into farm planning models[14] in contrast to the more implicit risk accommodating elements which have been discussed in the time dimension and the financial dimension. In carrying out an examination of the risk dimention, it is useful to examine, first the role of utility concepts, and secondly their incorporation into risk planning models.

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[14] Incorporation of risk elements is taken here to be the development of: a constraint set which is feasible under all possible states of nature, and a choice criterion which reflects the preferences of the decision unit given the risky situation at hand. That is, environmental description must account for stochasticity while normative elements do not necessarily have to. Clearly quadratic programming and chance constraint programming are not included unless they incorporate a stochastic constraint system: focus loss programming is excluded because its constraint system contains infeasibilities for some states of nature. Where such models have been used without making provision for the risky nature of the decision environment, normative content appears to reflect the model builder's need to constrain the output from an inadequately specified model as much as it reflects the decision unit's intentions.

The risk dimension has only recently been incorporated into programming models in a manner approaching our definition of operationality (see Cocks [31], or Rae [111 and 112]. Cocks, in a major move toward systematic stochastic farm planning in a programming context, has developed what he calls the "linear programming theory of farming systems". This approach accounts for major elements of uncertainty in both the objective function and the constraint system. His approach is sufficiently general that it has been used extensively as a framework for this section on the risk dimension.[15]

In general, the aim of Cocks' discrete stochastic multi-stage approach is to provide a more accurate protrayal of the decision environment by including the concept of discretely stochastic elements in a linear constraint system. Models developed to date (by Cocks [31], and Rae [112, 111]) have focused normative content in the objective function which has been variously specified as a linear, linear-by-approximation, and quadratic function. Theoretic support for the specification of normative content in these, as in virtually all stochastic farm planning models is provided

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[15] A brief discussion of a more simplistic "FAT" approach which achieves the same purpose is also included.

by the maximization of expected utility maxim.[16] Thus before considering actual programming formulations, it is useful to briefly touch on the nature of utility concepts used in farm planning models.

At the opposite end of the model complexity scale a non utility oriented approach to risk in the decision environment has been reviewed in [31], and demonstrated in [91]. It is only briefly reviewed here. The "FAT" approach is essentially a formalization and more extreme version of the conservatism often practised by farm management specialists in evaluating farm alternatives. According to this model, the decision unit attempts to maximize the expected value of a given goal function subject to the additional normative constraint that the usual linear constraint system must be feasible in any foreseeable state of nature. This

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16/ The aim of this chapter is to provide a programming framework for the creation of useful evaluation criteria. Utility theory as such has played a minor role in models that can be termed operational in a farm planning sense. However, the effect of utility as a supportive concept and its more explicit use in some risk oriented objective functions makes it useful to include Appendix A to relate some broad generalizations inherent in utility theory which support the more narrowly based context established in this chapter. Many systems of axiomized rationality have been devised to allow operational development of utility functions and to support the use of utility based strategies. An excellent review of the utility concept may be found in Becker and McClintock [11]. More specialized presentations are in Fishburn [45, 46]. Farm management oriented treatments are given by Halter and Dean [54] and Dillon [36].

approach represents and ultimate degree of conservatism where the decision maker is willing to go to any length to ensure that he can effectively paln under certainty. Risk is rejected, rather than being considered a variable in making choices.

"Utility" in Farm Planning

In the following discussion of utility in stochastic farm planning models four points are illustrated:

1. Utility theory as used in farm planning models provides a prescription for individual action in a risky situation.
2. Utility models are based on axiomized rationality which may or may not be acceptable to the decision unit. However, acceptability is required if a utility function is to be derived and maximization of expected utility is to provide a reasonable strategy for group action.
3. The need for an acceptable rationality in utility models does not abate when the need for actual utility function derivation is removed via efficient set approaches.
4. Diminishing marginal utility is normally assumed.

Farm planning models incorporating utility concepts under non certainty have, in general, been non-commital about the nature of their intended decision group and thus the acceptability of axiomized rationality. In the usual case, they are as well non-commital regarding precisely which axiomatic system they propose to use in support of their use of utility. However, the notion of an individual decision maker's utility function, as an ideal choice criterion defined up to a linear transformation and on one or more goal achievement continuums appears to be implicit in reviewed models and farm management literature (eg. Scott and Baker [124], Gunn and Hardaker [52]).

The acceptance of any one of several systems of axiomized rationality permits the derivation of a utility function and supports the use of maximization of expected utility strategy in planning under non-certainty. The expected utility proposition has obvious appeal to farm planners who note on a strictly pragmatic basis, that other things being equal, farmers prefer alternatives with high expected returns, and that other thins being equal, they prefer more certainty to less. As illustrated in Figure 3.1 below, for a single goal utility function, the maximization of expected utility criteria is capable of coping with both of the above pragmatic notions.

In Figure 3.1 M is a measure of goal achievement and U is a measure of utility. The probability of M[P(M)] and the probability of its utility [P(U(M))] are equal probability measures since there is a one to one correspondence between levels of U and M. The expected utility of goal achievement distribution #i is denoted $E(U(M_i))$. Among alternatives with equal expected payoffs, Max. E(U) will favour narrower dispersion over wider. Among alternatives with similar distributions, Max E(U) will favour the one with the highest expected payoff.

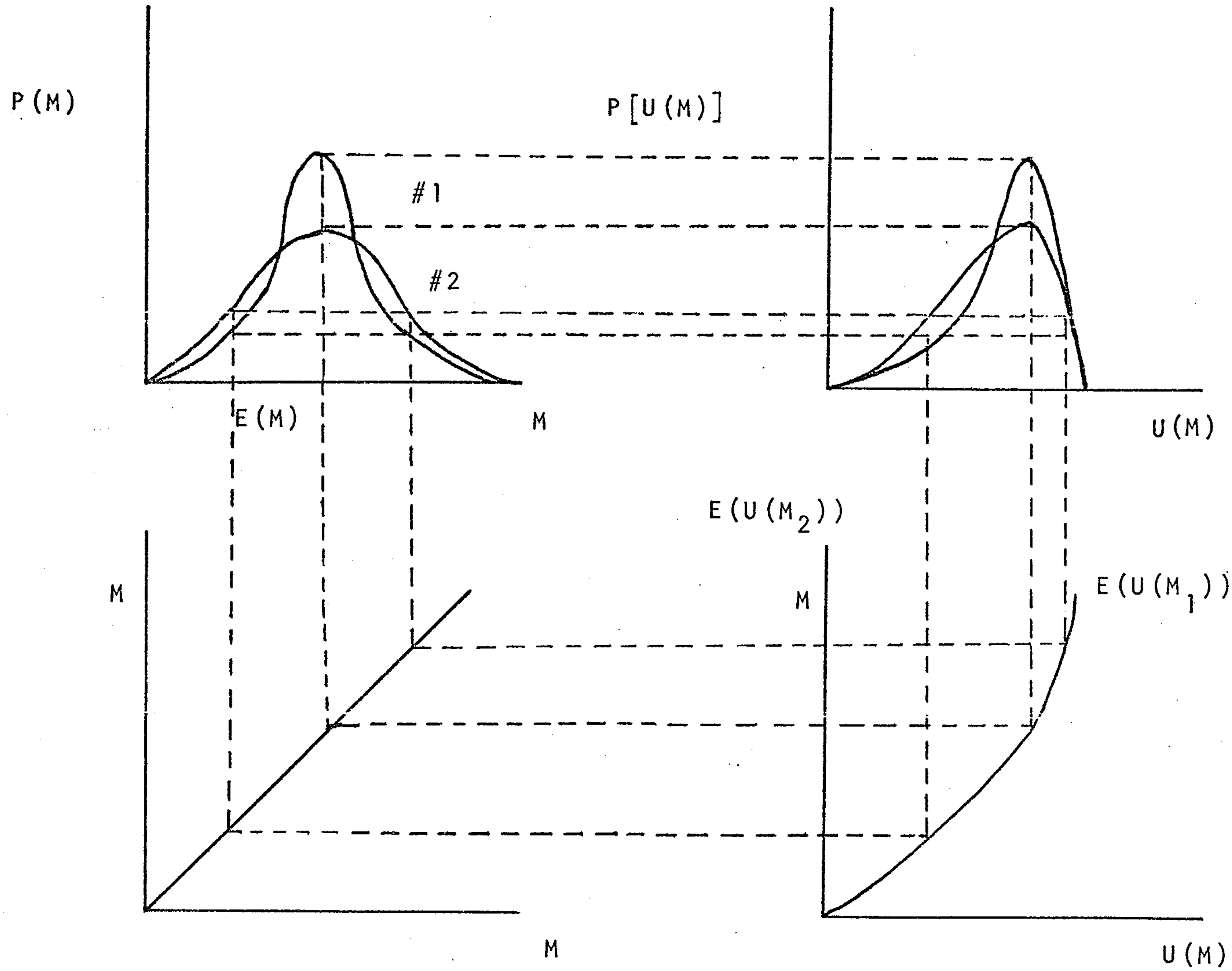

Figure 3.1 Maximization of Expected Utility and Expectation - Variance Tradeoffs.

However despite its pragmatic appeal the utility concept is fundamentally a model of individual rationality. The additional assumption that it is equally valid for the farm firm decision units is required to support its use in farm planning. The tendency to assume that a single maximizing preference function exists on the decision date has already been cited in the financial and consumption dimensions. Since the utility concept provides the only tested procedure for developing such functions it is important to note that it places the same normative limits on farm decision units as it does on individuals. To permit the use of a utility function the function itself must be static over the planning horizon. That is it must not contain exogenous variables. Even, more fundamental are requirements that a preference function exists, that it is exhaustive in its ability to evaluate alternatives and that it be quantifiable. [17/]

For a large subset of stochastic farm planning models (Quadratic Programming Models), no explicit derivation of a utility function is required (Eg.[124]) . Rather, parametric variation of a risk aversion coefficient is used to solve several different problems each with a different objective function. For example, we can consider the single goal quadratic objective function;

17/ A more exhaustive examination utility axioms is in Appendix A.

$$Z = \bar{c}\,x - \lambda xAx \quad (3)$$

where $\bar{c}$ is a vector of expected payoffs associated with a vector of controlled variables (x), $\bar{c}\,x$ is total expected payoff and xAx is the total payoff variance. A Taylor's series expansion of the utility function U(Y) abount the mean $U(\bar{Y})$ where

$$Y = cx \quad (4)$$

shows that the above objective function closely approximates a large number of concave expected utility functions.

Taylor's Series gives:

$$U(Y) = U(\bar{Y}) + U'(\bar{Y})\,(Y-\bar{Y})/1 + U''(\bar{Y})\,(Y-\bar{Y})^2\,/2 + \ldots \quad (5)$$

Applying the Expectation Operator yields:

$$E[U(Y)] = U(\bar{Y}) + U'(\bar{Y})\,E\,(Y-\bar{Y}) + U''(\bar{Y})\,E\,(Y-\bar{Y})^2\,/2 \quad (6)$$

$$= U\,(E[Y]) + \lambda V[Y] + \ldots\ ) \quad (7)$$

Since $\lambda < 0$ by assumed concavity of U, since terms beyond the third may be assumed negligible, and since U is assumed an order preserving transformation it follow that:[18]

$$\text{Max } E[Y] + \lambda V[Y] \equiv \text{MAX } U(E[Y]) + \lambda V[Y] \approx \text{MAX } E[U(Y)] \quad (8)$$

Parametric variation of λ generates an "efficient set" of programming solutions in the sense that for given values of λ, no higher value of E(Y) and/or lower value of V(Y) exists, which generates a higher expected utility for the approximate utility function. In choosing from the resulting

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18/ $\equiv$ implies equivalence, $\approx$ implies approximate equality.

"efficient set", the decision unit is assumed to be choosing the correct risk aversion coefficient and thus the correct utility function. Even in efficient set approaches however, the planning strategy is maximization of expected utility and is not normally [19] justified other than by reference to one or several systems of axiomized individual rationality.

The use of utility in planning models (as in the above example) also generally requires the assumption of a concave (risk averse) utility function for either the efficient set or given utility function approach. This mathematical requirement, although serious reservations have been voiced [69] is normally not assumed to limit problem specification.

Risk and Utility

Rae's elaboration of Cocks' multiperiod farm planning model incorporates the most general description of the decision environment of any model reviewed. [20] Although its primary contribution is to accurate portrayal of environmental information constraints a brief review is presented to show that the model is capable of coping with decision environments in which normative consideration of uncertainty is mandatory.

19/ It is possible that the use of efficient set approaches may be justified by other than utility grounds. The normal approach however has been to use such a justification.

20/ A concise review of various possible approaches to stochastic programming in farm planning is given in [31].

The basic approach is to build on the base established by non stochastic multiperiod linear constraint systems. By allowing discrete stochasticity of up to all coefficients in the constraints, the decision unit plans at decision date "t" only on the basis of a knowledge of coefficient eventuations in t-i, t-i-1, t-i-2 (i=o,1,2,..). Future coefficients at each decision date within the time horizon are know probabilistically. The recognition and specification in a linear constraint system of this fundamental characteristic of information flow is the major contibution of the model. The addition of information constraints in stochastic framework ensures that the firm's "actions must be such that if two different environments are the same up to a given date, then his actions must be the same up to that date" [31, p. 93]. A more detailed explanation of constraint specification for i-0 can be found in [31] and for i-1 in [112, 111].

The above model shares with other less general stochastic models the need to consider a risk dimension in the objective function. The clearly established stochastic nature of the environment yields outcomes (levels of goal achievement) which are probability distributions rather than fixed points. Choice is between strategies or alternatives with associated outcome distributions rather than point outcomes. The virtually universal means for operational and theoretic support of farm management choice criteria in such situations has been provided by the maximization of expected utility.

In Cocks' illustrative model [31, Ch. IV, V], two expected utility-maximizing objective functions defined on a single goal are used. In the first case, utility is considered to be linear in $\bar{Z}$. Therefore,

$$\text{MAX } E(U) = \text{MAX } (\bar{Z}). \tag{9}$$

In the second case,

$$U = f\ (\bar{Z}). \tag{10}$$

Since f is concave; this implies that E(U) is closely approximated by a quadratic objective function,

$$E\ (\bar{Z})\ -\emptyset V(\bar{Z}). \tag{11}$$

Since in this particular model,

$Z=(C,T)\ (1,\alpha)'$ we have in the first case (12)

$\text{Max}E(U)=E[Z]=E[C+T]$ and in the second case (13)

$$\text{Max}E(U)=E\ (\bar{Z})\ -\ \emptyset V(\bar{Z})\ =\ E[C\ +\ T]\ -\ \emptyset V[C+\alpha T], \tag{14}$$

where $\bar{Z}$ is a relevant measure of goal achievement defined on the various outcomes specified for the decision environment,

C is consumption in period number 1,

T is terminal net worth,

$\emptyset$ is a constant coefficient of risk aversion derived from f,

E is the expectation operator and

V is the variance operator.

Over the two year horizon, terminal net worth is weighted in the "goal function" by a subjective discount of 10 per cent relative to year one consumption. That is,

$$Z = C_1 + \frac{1}{1.1} T. \tag{15}$$

In the second case where risk aversion is a significant factor in normative content,

$$E(U) = E(C_1 + \frac{1}{1.1}T) - \emptyset V \quad (C_1 + \frac{1}{1.1}T). \tag{16}$$

The level of risk inherent in any solution is assumed to be given by the variance in the level of achievement indicated by the decision unit's "goal function". Although the subjective weighting within the "goal function" is fixed (no operational means of specification is given), it is suggested that the relative E-V weighting, $\emptyset$, be determined by parametric programming on $\emptyset$, and the decision unit's choice between alternate solutions, each of which has a unique $\emptyset_k$ (k=1,2,....).

Rae [112] has used a linearly approximated (separable programming) non linear utility function in conjunction with a discrete stochastic linear constraint system incorporating known constraint coefficients in t-1, t-2,... and probabilistic knowledge only in t, t+1,..... Since the problem situation involved three stages within a one-year time horizon, goals incorporated were short-run and time discounting was considered unnecessary. The farmer expressed a desire to achieve an annual income of $6,000, a desire to avoid income variability from year to year and a desire to produce quality products. The first and second goals are introduced into the model by way of an estimate of the farmer's utility function.[21] Estimation revealed a utility function that was steeply sloped up to about $6,000 annual income where it levelled off and was also concave (risk averse) over the entire range of positive net incomes. Thus both goals were incorporated by maximizing expected utility.

Rae [11] has also suggested that this use of the utility concept can be extended to multigoal cases, where the farmer's preferences are expressed in terms of several goals, for example, net income and terminal net worth. In such a case, he suggests that one utility function be derived for each goal and that a linear combination of the two utility functions be maximized using subjective weighting factors which could be varied parametrically rather than estimated à priori.

A different approach to the normative consideration of risk in farm planning via linear programming has been suggested by Boisvert [21 55]. Rather than incorporating a risk oriented utility function as a choice criterion he suggests that normative content should focus on the ability to ward off disaster income levels. The programming model

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21/ To see this more clearly with respect to the risk avoidance goal, consider any concave utility function and two alternatives, (a) a 50-50 chance of .5x and 1.5x and (b) a certain 1.0x. Since the utility gain of an increased .5x (relative to the certain 1.0x) is less than the utility loss from a loss of .5x, the certain 1.0X will always have the highest utility as long as the function is strictly concave. If the function is linear, risk aversion is not exhibited since $U[E(X)] = E[U(X)]$.

developed incorporates the notion of chance constraints and uses a profit-maximizing objective function. In effect the decision maker is viewed as having a lexicographic utility function of the form,

$$U = g(I,\ 1-P) \tag{17}$$

where I = income and 1-P is the probability with which less than given resource use levels are assured.

In addition it is assumed that

(a) $g/I > 0$

(b) $g/(1-P) > 0$ and

(c) I substitutes for 1-P at a diminishing rate.

The programming problem formulated is

$$\text{Max.} \quad \sum_{1}^{n} C_j \quad X_j \tag{18}$$

$$\text{subject to} \quad Pr\left[\sum_{1}^{n} a_{ij} \; x_j \leq b_i\right] \leq P \tag{19}$$

$$x_j \geq 0, \; i=1,\ldots,m, \; j=1,\ldots,n \tag{20}$$

or[22]

$$\text{subject to} \quad \sum_{1}^{n} a_{ij} \; x_j \leq b_i \tag{21}$$

$$X_j \quad 0, \; i=1,\ldots,m, \; j=1,\ldots,n, \tag{22}$$

where b_i' is a constant such that b_i' is exceeded with probability $\leq P$.

Based on the assumptions made regarding the decision maker's utility function an efficient set approach is elaborated since the above utility assumptions suggest an I-versus-P trade-off. Profit maximizing solutions are calculated for different levels of P (the probability of exceeding resource requirements). In Boisvert's model [21] the only resource level concerned is "available field operating time". The decision unit's choice of a solution from the efficient set generated implies a level P (a measure of security desire) given the validity of underlying utility assumptions. It should be noted here, as in the focus-loss model previously mentioned, that the decision maker does not choose to evaluate risky alternatives, but rather to outline a set of conditions under which he is willing to pretend risk does not exist.

As have previous dimensions the risk dimension suggests the existence and measurability of a comprehensive, exhaustive normative base for decision making on the planning date. However, in the risk dimension the assumed need for exhaustive treatment of normative content within the programming model is shown more clearly through the use of utility theory. The demands of utility on the make up and goal structure of the decision unit (see also Appendix III A)

22/ An alternate formulation [96] where stochastic elements are concentrated in the technical coefficients has

$E[a_{i*}]\ x - d_i\ (x\ B_i x)^{1/2} \leq b_i$ where a_{i*} is the i'th row of

technical coefficients, B is a variance-covariance matrix for a_{i*} and d_i is the normal deviate associated with P.

suggest that decsiion units possess very unified, identifiable and consistent goal structures. Even the efficient set approaches suggest that a goal structure sufficient to imply appropriate trade-offs and the selection of a correct solution from the set is in existence. Utility theory is quite specific in assuming that the decision unit is an individual and all normative assumptions are vested in a measurable utility function. At a still more specific level individual utility models reviewed make assumptions about relevant measures on which utility should be based, continuous versus lexicographic functions, and the degree of approximation achieved by efficient-set approaches.

The highly specific nature of normative concepts in risk models has been illustrated. In addition these models tend to build risk concepts on top of concepts from other dimensions resulting in even more complex normative models. The "FAT" model, the chance contrained model and the utility model are examples of radically different and very specific approaches to normative content. Chance constraints define probablistic conditions under which the decision unit is willing to plan with certainty, utility approaches assume that risk itself is valued while the "FAT" approach assumes risk must be avoided at all costs. This specificity of normative concepts combined with the size of matricies involved (eg.[31]) suggests the additional assumption that group normative standards related to risk evaluation are few and quite specific.

Suggested areas of inquiry appear to include the makeup of typical farm decision units, the consistency and exhaustiveness of existing goal structures, the measureability of normative decision standards, the development of goal structures, risk sensitive areas of goal holding and existing procedures for accommodating risk-oriented normative standards.

The Choice Dimension

All of the model dimensions discussed above cut across the choice dimension as a result of their normative focus. For this reason, discussion of certain broad issues in the coice dimension has been reserved to avoid unnecessary duplication and to permit a drawing together of similarities in normative elements from a variety of dimensions.

Two polar approaches to the development of choice criteria, each associated with a school of thought in utility theory appear in the literature. On one hand, it is argued that a super function, incorporating levels of goal achievement and appropriate trade offs for all significant goals, can be defined and maximized. This approach is suggestive of the use of a multidimension utility model (See Appendix A). On the other hand, it is often argued that a hierarchy of firm goals of varying importance exists. Only an acceptable level of achievement with respect to the most important goal will permit the second most important goal to be considered, and so on. There is no possibility of trade off between goals. In programming terms, this amounts to a planning process of starting by doing as well as possible with respect to achievement levels of the least important goal under consideration, given specified levels of achievement for more important goals. If no feasible solution exists, the second least important replaces the least important as an object of maximization and the least important goal is dropped. The process continues until an acceptable solution is reached. In a utility setting, this approach is known as a lexicographic utility model [54, Ch. 3].

In the following discussion of choice criteria, discussion is restricted to the function to be maximized without regard for its status with respect to the two above fundamental approaches. In doing so the possibility of goal constraints which decisively limit the range of the criterion function is acknowledged, but these have previously been discussed in connection with various model dimensions. The purpose here is to take a closer look at methods of specifying such trade-offs as are deemed necessary in the objective function. The objective functions reviewed may have one or several goal variables and one or several sub-goal variables and appropriate methods of allowing for appropriate trade-offs between and within goal areas. In the usual case, some trade-offs are established within the objective functions and qualifying goal constraints exist as well. Most cases reviewed fall somewhere between the two polar cases cited above.

The general approach to developing trade-offs appears to have been to define (1) goal function(s) for each time period, then (2) to aggregate similar goal achievements over time using time discounting, and lastly (3) to weight discounted values related to each goal achievement series. The general scheme followed is outlined in Figure 3.2.

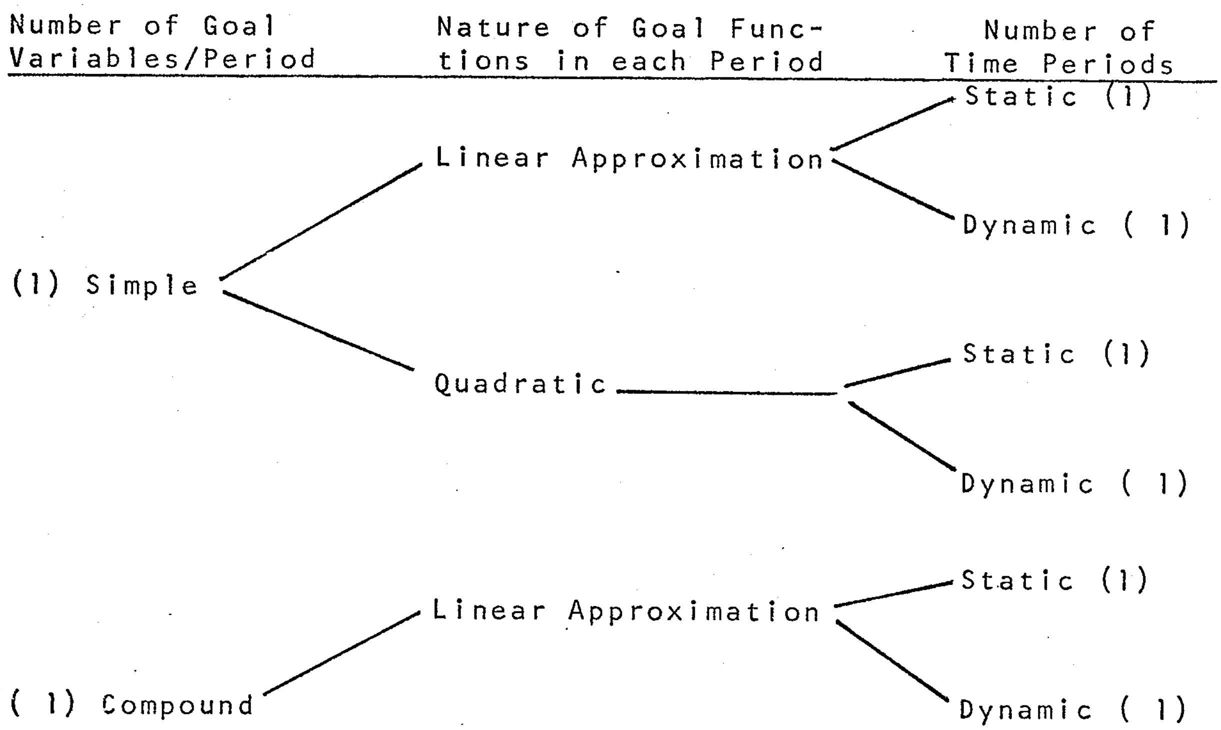

Figure 3.2 Choice Functions of Current Operational Significance

Choice functions of current operational significance appear to fall into six broad categories which are not intended to be exhaustive.

(a) A simple static linear approximation is a concave function, of a single level of achievement, which has been approximated by linear segments (may be only one segment).

(b) A simple dynamic linear approximation is a linear combination (with weights given by time preference discounting) of concave functions of a single level of achievement over time, each of which has been approximated by linear segments.

(c) A compound static linear approximation is simply a linear combination of simple static linear appoximations, with weights determined by the decision maker's preference between goals.

(d) A compound dynamic linear approximation is simply a linear combination of simple dynamic linear approximations, with weights determined by the decision maker's preference between goals.

(e) A simple static quadratic function is a quadratic function of a single level of achievement.

(f) A simple dynamic quadratic function is a linear combination (with weights given by time preference) of quadratic functions of a single level of achievement over time.

The whole farm approaches of Marceau [86], Goldschmidt [50], Harter [56], Stonehouse [128], and numerous others working with static farm planning models have used single planning period profit maximization, variously but similarly defined, as a choice function. Dynamic elements such as capital investment enter only via their effect on the single period profits. Other elements of personal preference have not usually been considered in the choice functions of these studies. The choice of some form of profit maximization in these cases is normally justified in one of three ways.

1. The model has a sufficiently specific area of application or a sufficiently short horizon that profit maximization reasonably represents the firm's preference within the given context.
2. The firm being modelled is large enough to have a rather formalistic set of objectives among which profit maximization is the dominant goal.
3. The choice of objective function is not critical, and facilitates the examination of environmental problems.

Marceau, Stonehouse and Harter have developed short run static models for which profit maximization has a reported relevance in the farmer's view. (See Stonehouse [128, pp 161-164], or Harter [56, Ch. 8]). Goldschmidt has analyzed decision making on comparitively large Israeli farms with relatively formalistic goal structures favouring the use of profit maximization preference functions. In other cases, the use of profit maximization has been justified by the fact that other plausible functions produced similar solutions.

The process of farm planning is conceived of as a more wholistic approach than that envisioned in the static whole farm approaches above and normally does not operate in the context of formal organization goals. Therefore it is necessary to examine other more complex choice functions in dynamic farm growth and planning models. In general the normative aspects of such models are of a non-empirical nature, but do illustrate the types of approaches which are technically feasible. Acton [5] following Candler and Boehlje [28] has used a mixed integer linear programming planning model to maximize a compound dynamic linear approximation. This weighted sum of terminal free cash balances, terminal assets and terminal debts is maximized subject to annual family consumption constraints. He suggests that weights be established on the basis of the firm's preference. Revision of weights is suggested if the initial solution is not satisfactory. No technique for deriving weights is specified, but reference is made to an iterative estimating technique suggested by Candler and Boehlje [28] which is discussed later in this chapter.

Martin and Plexico [88] and Martin [89] have defined several simple dynamic linear approximation objective functions in the process of studying the phenomena related to farm firm growth. They considered maximization of: (1) undiscounted gross sales, (2) the present worth of net returns, (3) the present value of land ownership, (4) acres farmed over the planning period, (5) discounted gross sales, (6) acres operated in the last production period, (7) undiscounted net returns, (8) owned capital at the end of the planning period, and (9) the present value of consumption. All are linear functions of specific yearly outcomes, most of which are directly related to net income, the remainder are income dependent. In discussing the results of their analysis, they point out that apparently dissimilar objectives often yield optimal solutions that are strikingly similar. For example, maximizing the present value of consumption over the planning period and maximizing the present value of profits (or any of 5,7,8,6,4, from the nine objective functions above) result in similar capital accumulation profiles for their test situation. Martin [89, p. 46] concludes that since most of the objective functions give similar capital accumulation results, "the objective function subject to the restrictuions of the model used in this analysis is not a sensitive variable". It should, however, be noted that sensitivity in this context refers to farm growth.

Duvick [39] has used an unweighted sum of the present value of yearly consumption and terminal net worth (another compound dynamic linear approximation) in a multiperiod study of the financial aspects of farm growth. He compared the resulting solutions with those obtained by maximization of either of two simply dynamic linear approximations, specifically maximization of terminal net worth and maximization of the present value of yearly consumption. Duvick [39, p. 92] concluded that, "increases in consumption and net worth are dependent on a high level of income and it appears that maximizing both goals will give a result near to that obtained when maximizing net worth alone and at little expense to consumption". Maximization of consumption alone, on the other hand, led to a significant decrease in terminal net worth. Considerable contrast was apparent between solutions obtained by maximizing terminal net worth and the present value of yearly consumption separately.

Smith [126] has used another compound dynamic linear approximation objective function to study the financial aspects of growth in a linear programming model of an Illinois grain farm. The objective function used is present value of terminal assets plus present value of yearly consumption above a minimum minus 1.25 times the terminal real estate debts minus terminal non real estate debts. He also used two similar function: one with the real estate weight changed to 1.0 and the other with a debt aversion weighting in each model period. No empirical justifications are given for the form of the objective function.

Cocks and Carter [32] have developed (using elements of theory of the firm and utility theory) seven, wealth-consumption oriented simple and compound dynamic linear approximation goal functions to represent possible choice functions in a multiperiod linear programming context which includes a variety of possible enterprise choices. Among choice criteria considered are:

1) Maximization of the present value[23] of future yearly consumption where yearly consumption is discounted according to timing to reflect time preference and quantity of reflect diminishing marginal utility.
2) Maximization of the present value[23] of yearly profits subject to profits being reinvested.
3) Maximization of the present value[23] of yearly profits subject to profits being withdrawn.
4) Maximization of the present value of cash flow (i.e. cash generated yearly for consumption use and terminal net worth).
5) Maximization of terminal net worth.
6) Maximization of the present value of a linear combination of (1) and terminal net worth for each of several weighting factors. (The firm is allowed to choose the weight which it feels most appropriate.
7) Maximization of the internal rate of return where return consists of the consumption flow plus terminal net worth.

They suggest a parametric treatment of wealth-consumption weights to give solutions from which the firm can apply its own preference functions. In general, they draw the conclusion "that plans are sensitive to goals and that, in setting up wealth consumption goals, choice of weightings

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23/ The discount rate used was 10 per cent.

is likely to be critical" [32, p. 408].[24] Similar results were obtained by Boehlje and White [19] who investigated the maximization of the present value of annual disposable income and the maximization of terminal net worth in a multi-period linear programming model, emphasizing production and financial processes.

The above results are not entirely inconsistent with those of others who have not found similar objective functions sensitive, since they normally have only referred to the effect on growth in citing insensitivity. The Cocks-Carter and Boehlje-White models have a greater ability to display differences between objective functions because they incorporate enterprise selection which the Martin model (previously discussed) in particular does not.

Baker [8] has illustrated a linear programming formulation which allows diminsihing marginal propensity to consume and liquidity preference to be built into the objective function. In general, the liquidity preference procedure is to place subjectively determined reservation prices which increase as reserves are depleted, on variously classified (e.g. by source or use) liquidity reserves. Diminishing

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24/ In addition they note that the maximum-internal-rate-of-return criterion forces time preference to discount at the maximum internal rate and that in view of the unique nature of the terminal state in any planning model (i.e. it is the beginning state in the next planning period), it is concluded that some weight will likely be given to this state in choosing alternatives.

marginal propensity to consume is accommodated by placing decreasing weights (MPC's) on disposable income used in consumption, as the level of consumption increases. "Consumption response to current income" is determined by applying MPC's to income from productive sources and capital gain. In addition, Baker's model makes a provision for "consumption response to the past year's income" and "consumption response to the previous year's capital gain" to be linearly determined by the income and capital gain of the previous year. "Consumption outlay" in any one year is the sum of the cited functions of current income and capital gain, the past year's income and the past year's capital gains. A weighted sum of yearly consumption outlay and terminal net worth is included in the objective function. Intertemporal equivalence is established by applying conventional discounting procedures to consumption "outlays" in each year. No operational procedure is given for the determination of weights relating decreasing marginal propensity to consume, increasing liquidity preference, the relative importance attached to liquidity, consumption and other goals, intertemporal preference or the linear influence of past income or capital gain on consumption. It is established that such weightings are within the capabilities of a linear programming formulation. However, no evidence is submitted to the effect that normative standards in these areas may be expressed in this way.

The capacity of programming formulations to permit subjective weightings of various farm goals has been noted. However these madels normally use "reasonable" weightings for illustrative purposes and no operational procedure for estimation of weights is indicated. Candler and Boehlje [28] have detailed an adaptive process of weight determination for both money and non-money goals in linear programming capital accumulation models. The procedure partially avoids à priori mapping of goals into a single preference dimension.

Their approach begins by defining a goal function for each conceivable goal. Individual goal functions are defined such that arbitrary relative values, associated with the given goals from various alternatives, are additive. That is, they give a total amount of achievement from all sources with respect to the given goal by direct summation. It is implicitly assumed here that the decision unit can agree on the extent to which each source of goal achievement contributes to a scale relating total achievement of that goal. This assumption is naturally more perilous when goals for which no standard of measure exists (for example, togetherness or pollution) and scaling is more arbitrary. If agreement cannot be reached on the specification of certain goal functions, it is suggested that the problem may be shifted from the goal function specification stage to the weight determination stage. This is possible by either breaking down goals into sub goals to yield a larger number of goal functions for which scaling procedures may be agreed upon, or by including more than one scaling procedure for given goal (i.e. by effectively defining additional goal functions) with the hope that agreement may more easily be reached in following stages in which weights associated with each goal function are determined. Once all contributions to each goal have been reduced to a single additive dimension and appropriate scaling procedures are determined, the problem of reconciling conflicting goals can begin. First, arbitrary weights (λj) to be applied to each goal achievement level are determined by or for the decision unit. The resulting choice function is then used in optimizing a linear programming problem.

Given these weights, the linear programming solution obtained gives the highest possible level of achievement of each goal that can be obtained without reducing the level of achievement with respect to other goals. In all likelihood, the resulting "efficient set" of goal achievement levels will prove unsatisfactory to some group members who are now in a better position to resume negotiations on the relative importance that can be attached to various goals. After negotiation the weights may be revised (taking note of the direction in which weight change is warranted) and the process is repeated. It is suggested that this renegotiation of weights stage may be aided by using parametric programming methods on the λj. When an acceptable efficient set of goal achievement levels is obtained, the process terminates and an "optimal" set of weights will have been obtained.

The primary focus of the choice dimension is the determination of relative weights for various farm firm goals. Plans developed appear to be critically dependent on the relative weights assigned to goals. Although many weighting procedures have been proposed, they appear to be based on three major normative propositions.

Firstly, all models reviewed based their goal selection and weighting procedure for the planning period on whatever normative standards existed at the planning date. No model incorporated an adaptive mechanism in which normative standards themselves interacted with the decision environment over time.

Secondly, normative standards existing as of the planning date are assumed to be exhaustive in the sense that they are capable of evaluating all alterntives in each time period. Some studies have shown that for a particular purpose (maximizing some specific concept of growth) a large number of simple normative propositions is equally effective. In general, however, this is not true and as a result the assumption that existing normative standards can usefully discriminate over the entire planning horizon can not be taken lightly.

Thirdly, the development of complex and often unmeasureable weighting schemes suggests and underlying assumption that all normative standards should be internalized in the model. With the exception of one model [26] no model was seriously concerned with the problem of determining intra goal, iner temporal and inter goal weights. The normal procedure appears to be establishing inter-temporal equivalences between like types of goal achievement over time and then subjectively weighting these functions. The efficient set approach proposed by Candler and Boehlje [28] suggests that a choice exists between confronting decision groups with a large number of "efficient" solutions and in effect internalizing normative standards within the model. Although this interactive model is aimed primarily at overcoming measurement problems, it does suggest that a trade off exists between internal and external treatment of normative standards.

The choice dimension has reinforced the case for a fundamental assumption of maximizing behaviour and in addition to assumptions regarding the existence and comprehensiveness of normative standards makes an additional but related assumption. Acceptance of a maximizing framework involving economic goal suggests that major problems fall in the area of relative weight determination. The existence of relatively static normative standards which imply clear, consistent and comprehensive goals and relations between goals would support this concentration on the measurement problem. The absence of these conditions would suggest that more fundamental problems regarding the nature of goals must be solved first. For example, it may be that only by utilizing goals of the economic type, subjective elements can be forced into the choice of weighting factors. In this case the assumption that significant goals are related to economic outcomes places very definite a priori restrictions on the selection procedure. Nonetheless a major concern with most models is not the basic nature of goals but which of the consumption, net worth, asset holding, debt, or other economic goals is the most important.

Three responses to the measurement problem are apparent. Firstly, it has been suggested that within relatively wide limits the choice of an objective function is not critical. This suggests that the normative standards on which they are based are not critical. However, insensitivity of model results has been seriously questioned even given goal directed maximizing behaviour. A second suggestion is that the measurement of weights in the objective function can be reduced to an iterative interactive process between the decision group and the decision model. A third approach, closely related to the first, is to assume that the weights themselves have some sort of intuitive meaning and are clear to model users. Regardless of the specific assumptions made a major normative assumption in the choice dimension is that the selection of weights is the major problem in the specification of normative standards. Whether this assumption is valid or not depends on the dynamics of group normative standards, the relations between various goals and the comprehensiveness of goal holding.

The entire area of goal selection and weighting suggests that it will be useful to examine actual family goal-value structures, to establish any uniformities which may exist in farm family goal holding and also to establish whether any sound basis for relative weight determination exists. In addition, it would be useful to examine the practices involved in various potential farm management delivery systems, since these will be responsible for putting problems in an effective quantitative form.

Other Dimensions in the Programming Context

A treatment of the virtually limitless number of ways in which normative elements have entered farm planning, programming models must be selective. In emphasizing five major dimensions, it is recognized that cursory attention has been paid to many others which have not often been treated in the literature. For instance some space could have been devoted to a technical dimension within which goal-value structures interact with the specification of modeled technical processes or to a leisure dimension within which leisure time goals are reflected. However, since these areas are not extensively developed in farm management literature and since exhaustive treatment of model dimensions is not the objective these are not considered.

Summary of the Programming Context

In Chapter III, we have illustrated several normative dimensions of farm planning programming models. As shown in Figure 3.3, the programming context has pointed to some logical connections between model portrayal of normative standards and a normative black box. The remaining chapters of this thesis are concerned with the nature and significance of the black box.

To the extent that relevant research and theory in the area of farm group decision making are available it should be possible to establish general criteria for the evaluation of the normative content of programming models.

The farm planning process in a programming context is fundamentally a goal-directed maximizing procedure. Although reference is made to abstract, and noneconomic goal virtually all model goals are measureable and economic. Planning solutions in Figure 3.3 are generated by developing a series of equations which represent the firm's preference function solely in terms of firm goals and objectives. The pervasive pursuit of models which incorporate every "conceivable" goal suggests that maximal firm goal achievement is, in some sense, an ideal for both model builders and firms. For the firm, the goal maximizing assumption implies that farm firms are motivated to maximize some function of their expressed goals. For the model builder, the assumption has one additional facet. In addition to assuming goal maximizing behaviour, it is suggested that such behaviour must be internalized into the model (exhaustiveness). This latter aspect is borne out by the fact that justifications for including given goal structures are based solely on the significance of the goals in relation to the firm and the sensitivity of solutions. Support is not generally in terms of the deficiencies of other techniques for incorporating goals into the planning process.

The maximizing assumption underlying the operational programming models does not however, imply that model solutions are always expected to achieve this objective. The presentation of solutions is in the main, accompanied by cautions arising out of inabilities to identify and quantify the relationships between modelled goals. Since weighting factors in particular are notoriously tentative, efficient set approaches and iterative goal-establishment procedures have been suggested. This does not, however, represent any weakening of the maximizing assumptions. Even the iterative weight-determination procedure suggest by Candler, although clearly cast in a goal determination as well as a weight evaluation mode, assumes the desireability of maximizing some function of achievements relative to current firm goals.

The assumption that some sort of maximizing behaviour is at play has an interesting parallel in utility theory. The minimum requirement for a utility theory approach to decision making is that each decision maker must be capable of reducing all aspects of given alternatives to a single dimension, utility, which has the characteristics (a) that it establishes a weak ordering of all alternatives, and (b) that it permits no intransitivities [119]. In both the utility and programming cases, the assumption is that all diversity can be reduced to a single dimension reflecting worth to the decision unit.

The overriding assumption of maximizing behaviour is reflected in a number of subsidiary, and in most cases implicit, assumptions. Maximization of some function of firm goals is only possible if they are regarded as a static evaluative reference. Goals must exist on the decision date and they must be valid over the decision period. For example, if a given consumption goal of spending 50 per cent of disposable income on consumer goods in year four is included in the planning model, solutions generated will be conditioned on the assumed static character of this goal. The point here is that the goal formation procedure is assumed to be complete on the decision date. Psychic and social processes which generate goals are assumed to have either terminated or reached a stable equilibrium.

A second subsidiary assumption is that firm goals existing on the decision date are comprehensive in the sense that they permit the evaluation of all possible alternatives over the palnning period. This implies that there are no impediments to the generating of goals in any area which is of significance in selecting between alternatives confronted. In general goals included in planning models are of the operational type; this implies that the firm is able to establish a comprehensive set of operational goals without precise knowledge of the environments in which they will function.

In general models go farther than requiring measureability of firm goals. Model convexity requirements force a more rigorous set of constraints on model specification. In the consumption area, it was noted that consumption functions are maximized in models rather than used in constraints, while another function is maximized because of convesity requirements.

Another assumption required to support the maximizing objective is that the degree of overall goal achievement must be measureable. Models reviewed have restricted goals to quantitative economic goals in response to relative weighting schemes which have been preposed to reconcile risk, consumption, time, liquidity and other goals.

In terms of figure 3.3, maximizing behaviour is assumed to proceed on the basis of known, exhaustive, and measureable goals and interrelationships. Given the additional assumption that the required mathematical representations are tractable in programming terms, the set of normative constraints and the choice criterion can be defined and solutions can be generated and made available to the decision unit. No feedback mechanism which would relate the decision taking process to the generation of firm normative standards is specified as indicated by the dashed line in the illustration.

Figure 3.4 further clarifies the presentation of normative assumptions implicit in the programming context. Three levels of abstraction are reviewed. As indicated by the arrows at the top of the page, specific normative

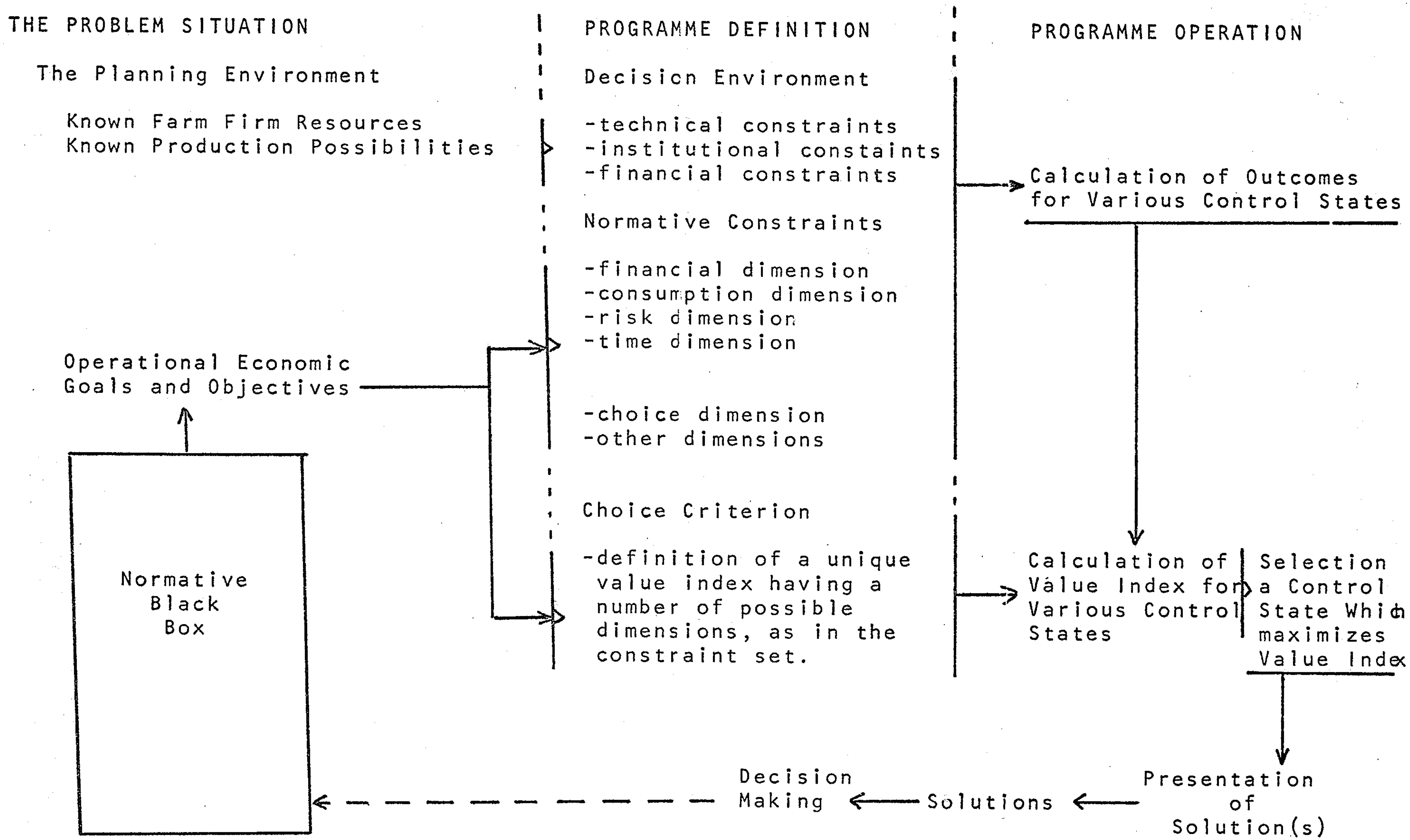

Figure 3.3 Normative Elements of the Farm Planning Process In An Operational Programming Context

propositions which have been discussed under five separate model dimensions collectively imply more general and implicit model assumptions which in turn imply a number of implicit assumptions regarding group normative standards. The assumptions in the main body of the figure show that assumptions made at each of levels ll and lll are, in turn, supported by or complemented by more abstract assumptions.

The following groups of questions relating to mdelled normative propositions are indicative of the areas in which existing theory and research in farm decision making can contribute to the development of evaluation criteria. No indication that theory or research sufficient to provide answers for all is intended. As will become apparent, many require detailed explanations in areas for which little or no data are available.

(a) The Nature of Group Normative Standards

1. Do group normative standards relevant to selection between farm planning alternatives normally exist on a planning date?
2. Can existing group normative standards be identified and measured?
3. It it possible that existing group normative standards relate more to the selection of decision making alternatives than to the selection of farm plans?

Level of Assumption	I Group Normative Standards	II Model Normative Propositions (General)	III Model Normative Propositions (Specific)
Assumptions	-Imply that all significant dimensions of alternatives can be reduced to a Value Index to be maximized. -Exist or can be made to exist in the form of firm goals -formation processes are static or in equilibrium -Form a comprehensive evaluative reference for alternatives faced -no impediments to goal formation exist -Can be identified and measured	-Quantifiable in terms of economic goals -tractable -Exhaustive evaluation of goal achievement is necessary	-Specific Normative Propositions -Choice dimension -time dimension -consumption dimension -financial dimension -risk dimension

Figure 3.4 Normative Assumptions Implicit in the Programming Context

4. Do existing group normative standards comprise a comprehensive base for decision making for the farm firm or any of its sub sets?
5. Are there common areas of group goal holding? If so, what are they?
6. Whose normative standards are relevant in farm planning situations? What are the relationships between individual and group standards?
7. Are there significant areas of non goal holding?
8. Is maximizing behaviour possible?

(b) <u>The Nature of Model Normative Propositions (General)</u>

1. How many major goal holding standards can be quantified? How credible is the quantification process?
2. Are the results of research on goal holding inter relationships consistent with the tractability requirements of programming models?
3. Is it necessary to include normative propositions in a formal analytical procedure? If so, to what degree?
4. How are normative propositions handled in existing farm management analysis procedures?
5. Do standards of equivalence between goals exist within the decision group.

(c) <u>The Nature of Model Normative Propositions (Specific)</u>

1. What time horizons are involved in group goal holding? Are group goals long run, short run, both?

2. Are there cyclical changes in goal holding?
3. What are the determinants of individual and group time preferences? Can they be quantified?
4. How is risk accomodated in existing decision processes? Can risk preferences by expressed in terms of "risk coefficients"?
5. In what decision areas are risk oriented goals important?
6. How widespread are liquidity goals? Can these be expressed as liquidity preference functions? Are liquidity goals independent of risk-oriented goals?
7. What are the major determinants of consumption relationships? Can meaningful marginal propensities to consume be determined?
8. Can standards of equivalence between goals be quantified in terms of weighting factors?

CHAPTER 1V

A CONCEPTUAL FRAMEWORK FOR FARM FIRM DECISION MAKING

Introduction

The acceptance of a principle of optimization in Chapter 11 implies that the planning process should, to the fullest extent possible, optimize something inherent in the socio-psychological makeup of the decision unit. In Chapter V, V1, V11, the concept of normative standards for farm firm decision making is developed to provide a base for evaluating normative elements in programming models.

Particular interest is in the nature of normative standards at a point in time and their generation over time. In addition, interest is in implications regarding the degree and manner in which normative standards should be internalized into formal planning models. Since the socio-psychological functioning of individuals in a group decision situation is the basis for acceptability of normative standards for group decision making and remaining chapters examines research related to individual and group operates in the context of an extension service, an examination of the impact of extension involvement on group goals, values and their formation is also conducted.

A conceptual framework for farm firm decision making based on concepts and theories from a diverse group of disciplines is presented in Chapter 1V. The framework is presented in four parts. In the first, Goals and Values basic goal-value concepts are presented at both the group and individual level. The second section, Conflict Resolution, presents the process of joint decision making or integration. A third section, The Family As A Decision Making Group, specializes the framework developed in the two previous sections by presenting certain idiosyncratic information on the family group. The fourth section, Farm Planning Decision Making, specializes the framework still further by integrating the role of extension personnel.

Goals and Values

Early in life each individual develops an abstract set or normative standards for action called values, which are continually changing in the long run, but stable in the short run. Goals, on the other hand, are desired ends resulting from individual values and beliefs. That is they are the ends set for action in the light of a perception of what is true in the decision environment.

Goals may also result from the compulsion of external pressures or motivational forces, both inate and learned. Katona [69] has pointed out that non problem oriented action directives are in fact the normal case in everyday behaviour. Habitual behaviour for example is the most usual occurence. However, since they reflect action directives involving little or no possibility of choice, it is not necessary to consider such goal sources in a framework for normative standards except to the extent that they interact with values in goal formulation. For instance, impulse motivations are translated into normative standards through the process of socialization.

It is important to distinguish between the concept of a goal as simply an end implied by a value in a given existential contex and what may be called an operational goal (this is similar to March and Simon's terminology; see Cartwright and Zander [29, pp. 409]) which is a goal of sufficiently low level abstraction to be used in determining degree of success in actual decision making.[1] Action is likely to be directed at operational goals. In the sense used in this thesis, all values imply goals or ends in some existential context, although they may not be of operational significance. A given high level value may imply any number, including zero, of lower order goals since as Neilsen 101 states,

> "an individual's values might indicate that something was desireable but he would not set it up as a goal to work for if his perception of circumstances led him to the conclusion that the object was unattainable". (Underline mine) [2]

For our purpose, a value system can be defined as an individual, abstract set of long standing standards relating to the preferability of possible actions. J.D. Schlater [123] defines values and lists additional definitions as follows:

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1) In general usage, "goal" is equivalent to an operational goal leading often to the conclusion that goals are to be distinguished from values via their lower level of abstraction.

2) This distinction between operational goals and more basic standards of value is particularly significant as a result of the heavy reliance of model builders on operational goals in developing choice criteria.

> "Values are conceptions of the desireable which affect an individual's choice among possible courses of action. Accordingly, values are abstractions, organizing principles or normative standards which have a regulatory effect on behaviour.
>
> This definition of values is in close alignment with those developed by Jacob and Flink, Kluckholm and Smith. Jacob and Flink identify values as 'normative standards by which human beings are influenced in their choice among the alternative courses of action which they perceive.'
>
> According to Kluckholm, a value is a 'conception, explicit or implicit, distinctive of an individual or characteristic of a group of the desireable which influences the selection from available modes, means and ends of action.' For Smith, values are 'conceptions of the desireable that are relevant to selective behaviour.'"

The above definitions clearly establish a cathetic[3] dimension as a primary distinguishing characteristic of values.

As is often the case in defining complex social concepts, additional precision can be obtained by specifying what values are not. They are distinct from a number of physiologically founded and/or learned motivations of an impulsive type, which influence action without regard to the individual's conception of reality (examples are biological drives and certain psychological needs), as well as attitudes and opinions.

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3) Cathexis is defined by Parsons and Shils [106, pp.5] as "the attachment to objects which are gratifying and rejection of those which are noxious". The difference between cathexis and valuing can be clarified by distinguishing between the desired and the desireable. Many things may be desired by a conception of social and physical reality (e.g. a social sanction) may prevent outward expression of this desire. Cathexis is a relation between motivation-drive, need, wish, impulse- and an object [106, pp.69].

Values do not include motivations of any type which allows little or no room for individual choice. Choice is the basis of value theory. In the words of Jacob and Flink [62]

> "Homo sapiens is physiologically capable unlike other species of a wide variety of mutually exclusive responses to given stimuli. This capacity for choice is the essential physio-psychological basis for the development of what we identify as "values", namely, standards of the desireable which men apply in making choices". (underline mine)

Values are to be distinguished from the attitudes through which they are often studied. Sargent and Williams (McGuiness [85] have stated that, "Attitudes are treated (by psychologists) as fairly consistent and lasting tendencies to behave in certain ways - primarily positively or negatively - toward persons, activities, events and objects". In this sense, attitudes are tendencies emanating from value orientations (see Parson and Shils [106, pp.358, 423, 453]).

Values[4] are not necessarily part of the individual's conscious personality, but may be held subconsciously. Those which are explicit in the sense that they incorporate some elements of belief, and provide a general systematic approach to the individual's environment may be termed value

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4] It should be noted at this point that there is no single, scientifically accepted concept of "value". Rather, several concepts which are scientifically valid in their own rights are recurrent in behavioural literature. For a quick review, see P.E. Jacob and J. J. Flink [62]. Value concepts used in this thesis are those proposed for use in decision situations similar to those presented in farm management.

orientations. Kluckholm [106, pp. 411] states, "a value orientation may be defined as a general and organized conception, influencing behaviour, of nature, of man's place in it, of man's reaction to man and of the desireable and non desireable as they may relate to man-environment and interhuman relations". This belief-value structure or value orientation, is shaped in large part by a socialization process during which the individual comes to hold certain role expectations for himself and others.

The distiction between values and value orientations has often been made, the latter having a distinct existential dimension. It should be noted, however, that this distinction relies heavily on a static conception of "value" given currency by long-run stability of certain elements of belief structures. In a larger sense, however, even values have an existential content. As Kluckholm [106, pp.392] has stated, "Values themselves are constrained within the framework of what is taken as given by nature." Values themselves exist in both the cathetic and cognitive domains. In this sense then, the distinction between values and value orientations becomes one of temporal stability of the existential propositions involved, values having relatively stable existential elements, and value orientations having less stable existential elements.

While this study is primarily concerned with the cathectic domain, it must be focused clearly in the light of information states of the cognitive domain. Individual values cannot be abstracted from the cognitive domain no matter what length of run is considered. What emerges then, is a cognitive hierarchical structure of values having various existential contents. We can speak of abstract values with little existential content and, at the other extreme, of operational values with a heavy existential content. The hierarchical structure is, however, not of a straight-forward type; ultimate values do not each imply a series of operational values. A complex psychological process of interations involving beliefs and values results in an operational individual value structure.

In the sense of this cognitive hierarchy, there exists an infinite number of values. Considerable evidence is available, however, to support the notion that a relatively few values reflecting modes of conduct and end states of existence (that is highly cathectic values) and applying across objects and situations, exist as a base on which less stable value orientations are built [119, Chapter 7 , 122, Chapter V]. If this is true, we can expect to find operational goal-value structures in farm families which are relatively poor indicators of relevant normative standards when environmental factors are relatively unstable, as in major planning situations. Fundamental values should provide a more relevant base because of their relative stability.

In terms of the programming context presented in the last chapter, the operational nature of the goal structures developed in programming models implies the existence of a special class of situation dependent values, described here as operational, on the planning date. The existential content of operational values existing on farm firms is therefore an important question in determining the validity of normative standards used in planning.

At the group level, individual values are at the basis of social interaction. As noted by C. K. Kluckholm [106] a stable and to some extent common value system is required by individuals in any social system to provide a basis for group existence in addition to providing a base for individual action. In an abstract sense, we can refer to this commonality as a group value system. The degree of commonality is thus a dimension of group values. As Kluckholm [106] says:

> "...it is possible and useful to describe the actual tendencies (of value holding) abstractly and to impute them to the group rather than the individuals". (brackets mine) (See also Cyert and March [34, Ch. 3].)

The above should not be taken to imply that a group is simply a collection of individuals and that group values are simply a collection of individual values, although this is partly true. Golembiewski [51, pp. 23] states: "A person's very conception of himself and the preservation of that self-conception, indeed are very often group products." While group values reflect a commonality of individual values, those values involved will be affected by the individual's membership in the group [51, ch. 2].

Values[5] have several important dimensions in addition to the cognitive, cathectic, and group distribution dimension discussed above. These dimensions also result in structures reminiscent of hierarchies with stratification by levels of the several dimensions. Values which reflect individual intent by relating to the achievement of means for further ends are called instrumental values, while goals or ultimate values are related directly to ultimate ends. It is possible for an ultimate value in one time period to be an instrumental one in a larger perspective. Paralleling the above user's-intention classification is one of situational classification or generality. Some values relate to very specific situations, while others are quite general, applying to a wider class of situations. Values are held with varying degrees of intensity. Some will be adhered to with great fervour while others receive little more than lip service.

As previously mentioned, values may not be consciously held. A continuum of explicitness ranging from easily verbalized to indirectly inferred values is possible. Values can also be classified with respect to

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5] The following discussion draws heavily on Kluckholm's discussion of dimensions of values in Parsons and Shils [106, pp. 44, Ch. 2].

their consistency. For example, they may be entirely independent of others, part of an inter-locking and entirely consistent system, or they may be entirely or partly inconsistent with others.

Conflict Resolution

Groups do not have values in the sense that individuals do, however groups do from time to time formulate goals toward which action is directed. In group conflict resolution we are faced with two basic problems. First, how does the group resolve individual goals into group goals? Second, failing resolution, how does the group accommodate apparent inconsistencies between individual goals? Conflict resolution is the group of processes involved in group goal formation and goal accomodation. Group goal formation involves a complete process of resolution. The other group of closely related processes, resulting in a quasi resolution of conflict, consists of accommodation procedures which stop short of group goal formation. Conflict resolution is discussed below in three broad areas, roughly, the nature of interaction between group members, quasi resolution of goal conflicts and resolution of goal conflicts.

As Jacob and Flink [62] state, an individual's orientation toward action is influenced by his values, beliefs and impulses. It is unlikely in any given situation that these determinants will be entirely consistent in their implied magnitude and direction of influence. In such a situation, internal resolution of conflict is required before effective action can be taken. In farm management, we are particularly interested in the interface of this internal conflict of interest and more obvious interpersonal conflicts of interest and the way in which this process translates itself into actual farm firm decisions.

Conflict among individual goals in a group situation will be the normal course of events. Kelley and Thibaut [72] [6] suggest a classification of three distributional conflicts regarding information, outcomes, and response which are inherent in individual problem solving in a group context.

They conclude after an exhaustive review of literature that even in situations where other group members are entirely passive in the decision process, that:

> "Research by social psychologists has shown that the aquisition and exercise of those various skills, (distinguishing of and discriminating between alternatives, a perceptual skill; responding in a discriminable manner, a behavioural skill; understanding alternative-outcome relationships, a cognitive process), is affected by the sheer presence of other persons". (Brackets, mine) Kelley and Thibaut, [72, pp 2-3]

In farm planning however, we can confine ourselves to the more pronounced case where there exists some degree of active involvement by more than one group member and where social interaction is clearly important.

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[6] This entire section on group problem solving draws heavily on the compendium presented by Kelley and Thibaut [72]

At the individual level, Kelley and Thibaut [72, pp 8-15] suggest that individuals focus on a certain information state regarding particular states of their environment and on a certain level of particular outcomes. Outcome levels below a focal point initiate information-gathering activities which in turn initiate response when a focal information state is reached. Group decision making requires certain outcome distributions.

In group problem solving, the outcomes achieved by one individual will be partly determined by others. When maximum outcome levels for each one are consistent, we may speak of perfect outcome correspondence; otherwise, we may speak of non-correspondence or conflict of interest and resulting outcome distribution problems and negotiations. In similiar manner, conflicts may arise in the distribution of information. Individual information states (at the minimum, information or others' preferences is required) will be partly determined by other members of the group. Except in the case where information is completely ubiquitous, individuals will be able to exercise power over others by negotiating the transfer of vital information. Response distribution may also result in conflict as a result of the need to coordinate activities to produce a new solution. Individuals may exert power by way of the importance attached to their responses. In short, the extent to which any one individual's goals will translate themselves into group goals will be determined by the resolution of group outcome, information, and response distribution problems.

This group conflict resolution situation bears a remarkable resemblance to that described by Cyert and March[7] [34] in their organization theory approach. Within the organization presented by modern corporations, they theorize a coalition of members (groups and individuals) having different goals.[8] In this context, they portray a "quasi resolution of conflict" in which they argue that "most organizations most of the time exist and thrive with considerable latent conflict of goals". This approach is contrasted with the classic resolution which "is to posit an exchange of money from some members of the coalition to other members as a way of inducing conformity

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7) Two major schools of thought regarding the psychological and social foundations of economic decision making are considered in this thesis. Utility theory has been rejected for the purposes of this study due to its failure to incorporate gorup decision processes. Behaviourist approaches on the other hand, provide an alternate psychological and social base which doe not necessitate the assumption that something is being maximized. By describing the actions of individuals and groups as they move from one decision to another (for example 100 Chapter 1)a decision process which has conflict resolution at its core is developed.

8) Despite the obvious differences of collectivity size, and homogeneity of individual purpose imposed by their organization theory approach, the similarity of the goal conflict situation in an entrepreneurial framework makes their analysis of significance.

to a single, consistent set of goals - the organizational objective" [34, pp. 117].

Within the context of the farm firm, we can think of the decision unit (in the usual case, a family farm) as a family coalition. Family goals become conditions of coalition emanating from a dynamic process of bargaining carried out largely in the context of everyday social interaction. The collective aim is to achieve satisfactory levels of social, psychological and economic achievement for each of the individuals concerned. Each individual to some degree is successful in maximizing his individual satisfaction. That is, he must curb his individual desires if the coalition is to survive and prosper. In such an environment of conflict resolution, it is not logically necessary for bargaining to produce goals composing logically consistent set capable of reduction to a common dimension.

Cyert and March [34] describe a process of conflict accommodation which allows the organization to proceed in the face of less-than-consistent set of organizational goals by way of "local rationality", "acceptable-level" decision rules and "sequential attention" to goals [34, pp. 117]. This conflict accommodation serves the purpose of providing individual members with sufficient inducement to maintain their membership in the coalition. "Local rationality" allows some members to directly impose their own goals in decisions of particular importance to them. The acceptance of "acceptable level decision rules" requires only a weak consistency (i.e. decision need only be based on goals which are globally acceptable levels) between local decisions." Sequential attention to goals" allows apparently conflicting goals to be pursued by agreeing on the expedient of pursuing only one at a time.

To the extent that processes of accommodation are a deep seated fact of group existence, they are not subject to prescriptive analysis. It is pointless to argue that collectivities should resolve conflicts in a certain manner if in fact they exist by way of accommodating them otherwise. The important point to be noted here is that the introduction of the concept of quasi resolution brings with it limitations on the group's ability to plan, since the group may be effectively barred from establishing goals in some areas and manners.

Throughout this section on conflict resolution, the emphasis has been on the interaction of individuals in the generation of group goals and decisions. It can hardly be expected that individual goal-value structures will remain stable through the process. At the same time the decision unit is working toward a decision, individual goal-value structures are continually shifting as a result of changing beliefs in a manner which facilitates the continued existence of the group.

Little is understood about the dynamics of individual goal-value structures [29, pp. 406, 139]. Some