MEASUREMENT AND MODELING OF FARMERS' GOALS: AN EVALUATION AND SUGGESTIONS

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Farmers and other business people commonly consider multiple goals or objectives in their decisions, especially investment or other long-run decisions. Various techniques, such as discussed by Keeney and Raiffa, have been developed to incorporate multiple goals or objectives in decision making. These techniques differ in how the decision-making process is viewed, empirical data required about goals, and solution algorithms. Considerable emphasis has been given to development of alternative models and solution algorithms, but problems (Willis and Perlack), of quantifying farmers' goals for use in these models have received relatively little attention.

We contend that the typical goal measurement techniques are inappropriate for many of the multiple goal models (MGMs) and suggest specific approaches to help overcome the problems inherent in currently used techniques. Three general ways of modeling multiple goals are reviewed in the first section to illustrate differences in the decision-making process assumed and type of empirical goal information required by the models. Then selected studies illustrating attempts to quantify farmers' goals are reviewed. The gap between the requirements of the MGMs and the information typically produced by these studies is highlighted. Four goal measurement procedures are described briefly and their correspondence to the demands of the various MGMs is evaluated.

MULTIPLE GOAL MODELS

A wide array of MGMs have been formulated.[1] The three general types of MGMs discussed here are representative of those used in agricultural economics and illustrate features of many MGMs. These models differ in their view of the decision-making process as well as the information they require about goals.

Lee and others have suggested a goal programming approach in which it is assumed that various goals can be ranked in order of importance. Satisficing or target levels of achievement are specified by the decision maker for each of the goals. A lexicographic utility function is embodied in the model when unique preemptive priority factors are assigned to each goal. This model may be represented as:

$$(1) \quad \text{Minimize } \Sigma\lambda_i^-\alpha_i^- + \Sigma\lambda_i^+\alpha_i^+$$

subject to

$$(2) \quad \Sigma G_{ij}X_j + \alpha_i^- - \alpha_i^+ = g_i \text{ for all } i$$

$$(3) \quad \sum_j a_{kj} X_j \leqslant b_k \text{ for all } k$$

$$(4) \quad X_j, \alpha_i^-, \alpha_i^- \geqslant 0$$

where λ_i^- and l_i^+ are the preemptive priority levels for negative and positive deviations for the goal i, α_i^- and α_i^+ are the negative and positive deviations from the target level of goal i, G_{ij} is the matrix of objective achievement per unit of the decision variable X_i, g_i is the target objective level, and equation 3 limits resource use to resource availability, b.[2]

This model is solved by a modified simplex technique which minimizes α_i^- for the first or highest priority goal and then switches to satisfying the second goal subject to the restriction that satisfaction with respect to the first goal does not decrease. As goals with the highest priorities are satisfied, or a point is reached beyond which further improvements cannot be achieved, successively less important goals are considered. No additional value or satisfaction is derived from overachievement of a goal and no substitutions or tradeoffs among goals are considered in this formulation.[3]

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[1]For a more general discussion of goal programming and multiple objective optimization, see Charnes and Cooper or Keeney and Raiffa. Cohon and Marks review and evaluate some multiobjective programming techniques. An alternative technique suggested for public decision making which does not involve articulation of the decision makers' preferences is discussed by Willis and Perlack.

[2]An empirical example using this general approach is Dobbins and Mapp's "ranked goal structure" model.

[3]As formulated, no deviation from the satisfaction level is allowed and dissatisfaction is associated with overachievement of a goal. Essentially, goal programming with this formulation becomes a search for an alternative optimum. The model could be reformulated with no dissatisfaction associated with overachievement of a goal or goals.

This "ranked MGM" views farmers' decision making as sequential—first goal A is satisfied and then goal B. Because only the relative priorities among goals are included in the model, measurement techniques yielding ordinal preferences are acceptable for ranking goals. The goals are assumed to be independent, but because of their sequential nature the preferability of a goal depends on the level of achievement of higher order goals. Essentially achievement of goal B has no value until goal A is satisfied. Because no tradeoffs are considered, goals that are not exactly of the same level of abstraction can be included.[4] Target levels for all of the goals must be expressed in precise, quantitative terms rather than as qualitative, global conditions.

A second MGM has the same basic mathematical formulation, but can be solved by the simplex algorithm. In this case, the λ_i^+ and λ_i^- in equation 1 are the weights attached to over- and underachievement of objective i instead of the preemptive priority levels.[5] Goals are not ranked, all are assumed to be of equal desirability or importance, and the decisionmaker can substitute achievement of one goal for that of another to increase the level of satisfaction.[6] Overachievement of one goal may compensate for underachievement of a different goal. Depending on the situation, a zero weight may be assigned to underachievement or overachievement for a specific goal.[7] The ratio of the weights of two goals represents the rate of substitution between them. Commonly, the rate of substitution between any two goals is constant for all levels of those goals and independent of the level of attainment of other goals, but these assumptions could be relaxed, for example, by using linear programming step functions.

This "substitution MGM" views farmers' decision making as involving tradeoffs. The fact that weights must be assigned to the underachievement and overachievement of goals implies measurement on a ratio scale. The underlying preference function is commonly assumed to be additive and the utility derived from a specific goal does not depend on the levels of the other goals, but multiplicative utility functions could be assumed. Because tradeoffs are possible, the goals must be similar in level of abstraction so that a decision maker can specify the relative weights or tradeoff ratio between them. As in the case of the ranked MGMs, target levels must be expressed in precise quantitative terms for the substitution MGMs.

A third way of modeling the multiple goals of farmers was used by Patrick and Eisgruber in their simulation study. They considered four goals, each assigned a weighting expressing its relative importance to farmers. Ratings for four different target levels of satisfaction with respect to each goal were developed. The overall level of satisfaction, S, associated with a particular farm plan can be expressed as:

$$(5) \quad S = \sum_{i=1}^{4} Z_i A_i$$

where Z_i is the weight assigned to goal i and A_i is the rating of the target level attained for goal i.[8] Both the weights and target levels may change as the socioeconomic characteristics of the decision maker and farm firm change.

Like the substitution MGM, the "satisficing MGM" views decision making as involving tradeoffs among goals, but the tradeoffs are in terms of satisfaction. The Z_i values must be on a ratio scale and are constrained to add to one. Additivity of satisfaction from alternative goals is assumed and substitutability of satisfaction from goals is possible. Linear correspondence between the scale ratings and subjectively determined target levels is not required. For example, a rating of 1 may be assigned to a plan which provides less than 90 percent of the planned family consumption goal, 2 to a plan providing 90 to 110 percent, 3 to a plan providing more than 110 percent to 140 percent, and 4 to a plan providing more than 140 percent of the goal level. Because tradeoffs of satisfaction rather than goal achievement occur, the goals in the model do not need to be of exactly the same level of abstraction. However, for the satisficing MGM, like the other MGMs, target levels must be expressed in precise quantitative terms. The factors affecting the relative weights and target levels of the goals also must be determined.[9]

STUDIES OF FARMERS' GOALS

Several studies of farmers' goals have been conducted in the U.S. and other countries. A selection of them can illustrate the principal alternative approaches to measuring goals.

Nielson asked Michigan farmers open-ended questions about their goals and found that they emphasized short-run or a mixture of short- and long-run goals. About one-third of the farmers did not clearly verbalize their

[4]Level of abstraction refers to exclusivity of a goal. Goal A may be viewed as a subset of the more inclusive goal B and an individual will have difficulty in visualizing them as alternative goals with tradeoffs. If goals are of the same level of abstraction, an individual is more likely to be able to visualize the possibility of tradeoffs.

[5]An alternative development of a similar formulation is provided by Candler and Boehlje.

[6]Dobbins and Mapp, Wheeler and Russell, and Barnett have used this approach for micro-level decisions in agricultural economics.

[7]Neely et al. examined the national economic development and environmental quality tradeoff effects on the selection of TVA projects. Vocke et al. varied the weights assigned to derive a tradeoff frontier between the cost of agricultural production and soil conservation.

[8]For a discussion of this procedure and implications with respect to the utility function, see W. Edwards.

[9]Patrick indicates the effects that alternative relative weights and target levels can have on farm firm growth.

goals. Even when presented with a specific list of possible goals, farmers differed substantially in the ranking of the goals. Because of the variety of answers to the questions, Nielson grouped responses into very general and abstract categories of security, high level of living, farm production, success or prestige, average level of living, and farming as a way of life. Gasson developed four types of value orientations. Farmers with an instrumental orientation view farming as a means of obtaining income and security, those with a social orientation farm for the interpersonal relations, those with an expressive orientation view farming as a means of self-expression, and those with intrinsic orientation value farming as an activity in its own right. Gasson found that farmers who differed in their value orientations had differences in their personal characteristics and resources controlled, but whether they differed in their economic behavior is not known.

A second, somewhat more quantitative, approach to measurement of the importance of different goals is exemplified by Hesselbach and Eisgruber's study. They considered goals of living standard, farming as a way of life, farm ownership, nurture of children, realization of standards, retirement, work as a goal, risk aversion, and decision-making readiness. Farmers were asked whether they would agree, disagree, or be undecided with respect to a series of statements in each goal area and whether it was very important, important, or unimportant. Goal scores were developed for each of the nine goals which represented an individual farmer's agreement and degree of importance as a percentage of the total possible score on a goal.

Patrick and Eisgruber considered goals of living standard, net worth accumulation, risk aversion, and leisure-children. On the basis of the Hesselbach and Eisgruber data, goal score equations were estimated to adjust the goal weights as characteristics of the farmers and farm firms changed. However, the initial weights and target levels of the goals were assumed in the simulation model.

In a third approach a paired comparison technique is used to elicit preferences among goals and then a preference score is derived for each goal by Thurstone procedures. Harman et al. used this approach to determine the goal hierarchy and factors affecting goals for use in a simulation model.[10] Farmers indicated their preference between the 28 combinations of the eight goals taken two at a time. The paired comparison procedure provides an ordinal scale of ranking of the goals. Estimates of each goal's numerical position on an interval scale can be derived under certain assumptions.

Hatch et al. included goals of control more acreage, avoid being forced out of business, maintain or improve living standard, avoid years of low income, increase leisure, increase net worth, reduce borrowing, and make the most profit in their model of firm growth with no tradeoffs among goals. They found the dominant goals changed frequently and concluded that tradeoffs should be included. Dobbins and Mapp modified this model and found that with tradeoffs permitted production plans tended to be more stable and net worth accumulation greater than with the ranked goal structure.

A fourth approach to measuring farmers' goals was used by Barnett in his goal programming study of West African farmers. He considered goals of subsistence food production, revenue, leisure, and both under/overspending credit limits. Farmers ranked the goals by the method of paired comparisons and Barnett later analyzed the paired comparison data by using multidimensional preference scaling (MDS). This technique allows farmers to have a ranking or hierarchy of preferences from one perspective which is different from their ranking on another perspective. The goal scores obtained from MDS are assumed to be on a ratio scale. Although Barnett had difficulty in developing acceptable goal weights and had to make some additional assumptions, the goal programming model explained resource allocation better than income maximization alone.

Some of the studies cited were not designed to provide information directly for models of decision making, but they do indicate some of the problems involved in the definition and measurement of farmers' goals. Four problems stand out. First, many of the goals considered previously are very general and may have little or no influence on a particular decision made by a farmer. Decisions on the quantities of various crops to plant could be affected by goals very different from those influencing whether an individual will farm as a career. Clearly it is important to specify and measure the goals relevant to the specific types of decisions being studied. The researcher must make this evaluation on the basis of the specific situation being analyzed.

Second, goals must be of a level of abstraction that will permit a target level or levels to be specified. Generally the more specific the goals, the easier it will be to determine the tradeoffs or weights associated with the deviations from the target level. Relevancy of the goals and target levels is of concern for all of

[10]Instead of using the traditional approach of obtaining an individual's preference score from paired comparisons (A. L. Edwards), Harman et al. developed a "respondent's common scalar value" (p. 22) as the dependent variable in their regressions. This value is the number of times a particular goal was selected as the preferred goal expressed as a percentage of the comparisons involving that goal. This value does not correspond directly to the group or subgroup scalar value derived by group paired comparison analysis.

the MGMs discussed.

Third, goal preferences must be measured in the appropriate metric for each of the MGMs discussed. For the ranked MGM, ordinal scaling of the goals is sufficient, but the substitution MGM with tradeoffs requires that the preferences be measured on a ratio scale. The satisficing MGM requires at least interval and preferably ratio scale measures.[11]

Finally, the assumed relationship among the goals in a given MGM should be made explicit and verified empirically. Although this procedure may be fairly straightforward for the ranked MGM, it may be more problematic for the others. In the satisficing MGM, overall satisfaction is modeled as a strict additive combination of the satisfaction with respect to each goal weighted by the importance of that goal. However, the overall satisfaction of farmers may not be additive. The importance given a goal by the farmer may vary with the target level attained of that goal or may vary with the levels of the other goals associated with an alternative (Willis and Perlack).[12] to the extent that MGMs seek to reflect the actual decision process of farmers, the measurement technique used should permit analyses of these assumptions. The substitution MGM is subject to similar considerations.

QUANTIFYING FARMERS' GOALS

In any attempt to quantify farmers' goals, one should select and define goals in a manner appropriate for an MGM. Abstract and nonquantifiable goals such as good health cannot be included directly in the model. Goals that can be measured should be expressed as specific target levels such as an income of $12,500, rather than in general terms such as higher income. Although there are long-run and short-run goals, the goals considered should be over time periods relevant to the particular set of decisions being made. In addition to defining goals in an appropriate manner, the researcher should measure them by a suitable technique.

The four measurement techniques suggested for quantifying farmers' goals are described briefly and emphasis is given to their suitability for use with various MGMs. References for the statistical background and empirical applications are provided. These procedures are all based on questionnaire, self-report farmer interviews. The self-report approaches have various inherent problems because they are based on an individual's ability to describe his/her preferences and goals, but their flexibility of use and relatively low cost are advantages.[13]

The classic paired comparison method developed by Thurstone has been used by Harman et al. and others.[14] An individual is presented with pairs of alternative goals and is instructed to select the one preferred in each pair. The frequency of selection is used to derive a hierachy of goal preferences. The method has an advantage over a simple rank ordering of goals in that a zeta coefficient (A. L. Edwards) can be derived to verify the consistency of the individual's preferences. The Mosteller chi-square test measures the degree of consistency among individuals within a group.

The ordinal ranking derived from paired comparisons can then be transformed into a scale with interval properties if a normal distribution of judgments is assumed. Further, although it has not been done previously, the procedure can be extended to goals that are defined in terms of specific target levels. As indicated previously, however, ratio scales rather than interval scales are required for satisficing and substitution MGMs so the paired comparison procedure results are most suitable for the ranked-goal MGM. The paired comparison approach yields a set of goal scores that typify a group of individuals and the scores may not reflect the preferences of a given individual within the group. This feature may limit the usefulness of the technique in deriving an individual farmer's goal preferences.

Magnitude estimation is a more direct approach for obtaining ratio scaled preferences.[15] Basically, a farmer is asked to assign "points" to specific goals in comparison with a fixed standard. For example, the farmer could be asked, "If the goal of leisure is given 100 points, how many points would you assign to goal A?" If a farmer thinks goal A is twice as important as the leisure goal, he would give 200 points to goal A. However, if goal A is only half as desirable as the base goal leisure, he would assign only 50 points to A. In an alternative procedure (constant sum), the farmer is asked to distribute a fixed number of points among the various goals in proportion to their importance and these weights are used to compute tradeoff values. These ratio scaling procedures should be repeated with other goals as the base or standard to check for consistency.[16]

[11]See Coombs for a further discussion of the properties of various scaling techniques.

[12]Alternative formulations could be developed for the satisficing MGM which would allow other forms of the implied utility function.

[13]See Young for a discussion of the difficulties in eliciting utility functions and risk preferences of farmers.

[14]The procedure is discussed in detail by Green and Tull and by Bock and Jones. Harman et al. illustrate the application of the procedure in detail to an analysis of farmers' goals and objectives.

[15]Magnitude estimation is developed most extensively by Stevens. Empirical applications with farmers' goals include those of Kliebenstein et al. and Patrick et al.

[16]The Spearman rho coefficient of rank correlation can be calculated to test for consistency of scoring by respondents with alternative base goals.

The statistical assumptions are relatively simple and straightforward (Stevens) and the technique can be used to find target levels of specific goals. Unlike paired comparisons, magnitude estimation yields scores which represent the individual farmer's goal hierarchy. Because of the assumed ratio scale properties, goal scores are comparable across individuals and scalar transformation of these scores is permitted. The goal information derived from magnitude estimation is suitable for substitution and satisficing MGMs.

Multidimensional preference scaling techniques (MDS) are another way of analyzing goals ranked in order of preference or the derived rankings from paired comparisons.[17] MDS includes several checks on internal consistency and clearly specifies the differences among subgroups. It is very heuristic in that it estimates the perspectives or dimensions that farmers use to evaluate goals and estimates the type of "ideal" that a farmer group would find most desirable from these perspectives. MDS does not assume, like the previously discussed techniques, that all goals can be ordered on a single continuum which holds for all subgroups. However, MDS techniques are sensitive to deviations from their assumptions and may not pertain to all decision contexts. Because goals scaled by the principal MDS techniques are typically assumed to have ratio properties, goal scores obtained by this approach are suitable for all three classes of MGMs.

In conjoint analysis, individuals rank order bundles or clusters of goals in order of preference.[18] For example, a high level of goal A combined with a low level of goal B and a moderate level of goal C is compared with another combination of goal levels. The analysis indicates the relative preference for each goal, for each level of a goal, and for combinations of goals. This feature makes possible the testing of whether the utility derived from a goal is independent of other goals and their levels, and whether the substitution rate among goals is constant. As typically used, this analysis-of-variance-based procedure yields preference scores that typify a group rather than an individual decision maker. Conjoint analysis does have checks on internal consistency and is farily easy to administer. However, it is intended to yield interval rather than ratio scaled data. Thus conjoint analysis results, like those of paired comparison procedures, may be more suitable for the ranked MGM rather than the substitution or satisficing MGMs. Further, the necessity of presenting combinations of goals to farmers limits the number of goals that can be considered in a given study.[19]

CONCLUSION

We suggest four problem areas in the measurement and modeling of farmers' goals for incorporation into MGMs. First, the selection and specification of goals relevant to particular farmer decisions must be done by the analyst. Second, the goals must be defined by the analyst at a level of abstraction that permits the target levels and weights to be specified. Third, the metric properties of many of the goal measures developed do not correspond to the data requirements of the MGMs. Fourth, the assumed relationships among goals should be explicit and empirically verified. We show that several measurement techniques have metric properties that appear to be appropriate for the measurement of farmers' goals for use in MGMs. Furthermore, these techniques permit testing of the assumed relationships among goals. Unless appropriate techniques are used to index farmers' goals for inclusion in the MGMs, the full potential value of these models may not be realized.

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[17]The statistical procedure is discussed by Kruskal and Wish and by Green and Wind. Blake et al. applied the procedure in agricultural market analysis and Barnett used it in analyzing goals of farmers in Senegal.

[18]Green and Tull provide a discussion of conjoint analysis and procedures as well as a product design example. Schrader et al. use conjoint analysis for a price-performance tradeoff.

[19]Various experimental designs could be used to reduce the combinations of goals presented to farmers, but these designs could preclude testing of certain main or interaction effects.

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