RELATING FARM AND OPERATOR CHARACTERISTICS TO MULTIPLE GOALS*

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INTRODUCTION

Economic analyses of firm behavior are typically based on the assumption of maximization or minimization of a single goal. While economists recognize that multiple goals are important in making business decisions [1, 4], a single goal, such as profit maximization, is used because it is operational and it provides an analytical approximation of firm behavior. However, the reduction of year-to-year income variability, providing an acceptable family living level, increasing net worth, additional leisure time, and many other goals have been suggested as being important to some farm firms [18]. Some analyses have considered two or more of these goals by maximizing one subject to a constraint on another [7, 13]. In other cases, a utility function has been estimated for an individual farmer incorporating both expected income and variability of income [17]. Although these efforts have been useful, progress towards incorporating multiple goals into empirical models has been inhibited by the inability to correctly specify important goals and the difficulty of incorporating several goals into frequently-used models. The recent development of simulation routines for farm firm analyses provides an analytical procedure that is sufficiently flexible to incorporate multiple goals [8, 18]. While it may be difficult to provide all of the information that is needed concerning goals and their use in decision making, additional information indicating the ranking of goals and the manner in which this hierarchy differs for farmers under alternative economic and noneconomic conditions provides a better basis for the selection of organizational and financial strategies.

This paper discusses the application of the paired-comparison technique to determine the ranking of eight economically-oriented goals by a group of randomly sampled farmers. Some of the personal and firm characteristics affecting the ranking are identified in the analysis and a means of predicting the hierarchy as a function of these factors is discussed.

THE PAIRED-COMPARISON TECHNIQUE

Several methods of estimating attitudinal preferences have been advanced. Two of the most popular and frequently used are the Guttman scale and Kendall's rank correlation methods [9, 11]. The work of L. L. Thurstone in 1927 which resulted in *the law of comparative judgment* [19] provided the impetus for a number of analytical techniques which are collectively referred to as the Method of Paired Comparisons [2, 6].

Bostwick, et al., conducted a comparative study of the Guttman scale, Kendall's rank correlation, and the paired-comparison technique in evaluating the attitudes of farmers and bankers with regard to essential borrower characteristics and attitudes toward borrowing [3]. The paired-comparison technique was found to be superior because it provided both an ordinal scale of attitudes and an estimate of each attitude's numerical position on a scale. Krenz [12] also found the technique suitable for identifying reasons for seeding cropland to grass in North Dakota.

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The paired-comparison model is used to develop an ordinal scale of farm operators' goals and provide an estimate of each goal's numerical position on the scale in this study.[1] The model applied is that formulated by Mosteller [14, 15, 16]. It has five major assumptions:

1. The n items (goals) produce reactions (sensations) whose intensities may be located on a single subjective continuum.
2. The distribution of intensities of reactions to each item (goal) for a population of individuals is normal.
3. The n normal distributions have equal standard deviations with possibly different means.
4. The correlations between the intensity of reaction to one item (goal) and the intensity of reaction to a second item (goal) are equal for all pairs of items.
5. Each of the R randomly selected respondents states a preference of one item (goal) over the other for each of the $n(n-1)/2$ pairs of items (with no indecisions allowed).

Each of the assumptions is self-explanatory except for the first. It indicates that the respondent is able to locate the intensity of his reactions to each of the goals on a single mental scale which is so finely calibrated that the intensities of no two goals occupy the same location. This assumption is critical to the conditions of unidimensionality and additivity which are embedded within all of the assumptions. That is, if D_{ij} is the distance in magnitude and direction from item i to item j along a subjective scale and D_{jk} is the distance from item j to item k along the same scale, then the distance, D_{ik}, is total distance from item i to item k.

Mosteller's model allows use of a chi-square goodness-of-fit test to determine if the assumptions have been met. The null hypothesis states that the assumptions have been met and the paired-comparison model is valid. Alternatively, rejection of the null hypothesis indicates the assumptions have not been met and the model is invalidated.[2] Mosteller discusses three principal ways that the assumptions of the model may be violated resulting in the rejection of the null hypothesis:

1. Lack of normality,
2. Lack of additivity among the scale separations, and
3. Failure of the n populations to have equal standard deviations.

He further points out that the lack of normality is not critical to the method of paired-comparisons since this assumption "is more in the nature of a computational device than anything else." Thus the latter two are of primary importance.

GOAL SELECTION AND SURVEY

Eight goals, obtained from previous research and consultation with farmers and extension specialists in the study area, were included in the analysis. They are:

1. Control more acreage by renting or buying;
2. Avoid being forced out of business;
3. Maintain or improve the family's standard of living;
4. Avoid years of low profits or losses;
5. Increase time off from farming (leisure time);
6. Increase net worth from farm or off-farm investments;
7. Reduce borrowing needs; and
8. Make the most profit each year (net above farm costs).

These eight goals were selected because they are primarily economic in nature and can be quantified for use in firm growth studies.

A personal interview survey of 149 ramdonly selected farms was conducted in a 21-county area which included parts of northern Texas, northwestern Oklahoma, southwestern Kansas, and southeastern Colorado. Complete information concerning farm and operator characteristics and consistent responses to the 28 paired-comparison statements were obtained from 118 operators.

ANALYSIS AND RESULTS

Group Response Evaluation

The percentage of respondents ranking each goal first and the percentage ranking each goal last is given in table 1. The results indicate that two goals, "control more acres" and "increase leisure time," were the last choices of 32 and 57 percent of the

[1] The method for developing scales can be found in [3, 6 or 10].

[2] The paired-comparison method is based on a random sample of population prior to stratification. Another method of testing for differences in ranking of items is based on stratifying prior to sampling. Although the sampling procedure in this study does not strictly adhere to this procedure, the inability to obtain statistically significant hierarchies ultimately requires its use.

Table 1. RESPONDENTS RANKING SPECIFIC GOALS FIRST AND LAST IN THEIR RESPECTIVE HIERARCHIES [a]

Goal	Respondents ranking goal Last		Respondents ranking goal First	
	(Number)	(Percent)	(Number)	(Percent)
Control more acres	38	32.2	12	10.2
Avoid being forced out of business	9	7.6	21	17.8
Maintain or increase family living	3	2.5	32	27.1
Avoid years of low profits or losses	4	3.4	26	22.0
Increase leisure time	67	56.8	6	5.1
Increase net worth	5	4.2	16	13.6
Reduce borrowing needs	11	9.3	18	15.3
Make most annual profits	3	2.5	38	32.2
Total	140	118.5	169	143.3

[a] Percentages sum to more than 100 percent due to the designation of equally preferred goals by some of the 118 respondents. In terms of the most preferred goals, respondents indicated 32 two-way ties, 8 three-way ties, and 1 four-way tie. Respondents indicated 9 two-way ties, 5, three-way ties, and 1 four-way tie for the least preferred goals.

respondents, respectively. Each of the other six goals were ranked last by less than 10 percent of the respondents.

There is less agreement on the most preferred goal than on the least perferred goal. "Making the most annual profits," "maintaining or increasing family living," and "avoiding years of low profits or losses" were each ranked first by 20 to 30 percent of the respondents. Each of the other goals, with the exception of "increasing leisure time," was ranked first by 10 to 20 percent of the individuals. Only about five percent ranked "increasing leisure time" first.

Definition of subgroups

Certain operator and farm firm characteristics were hypothesized to significantly affect the ranking of the eight goals. The questionnaire included information on four personal charactistics: age, education, agricultural experience, and the number of dependents. Agricultural experience was divided into four categories: total farming experience, dryland and irrigated cropping experience, and livestock production experience. In addition to personal characteristics, the levels of assets, debts, farm and off-farm income, acres of cropland and total land, type of cattle enterprises, and the minimum desired vacation time were recorded for each farm in the sample. These factors provide a basis for stratifying the sample into subgroups in the remainder of this paper.

Subgroup Response Evaluation

A ranking of the eight goals was developed for each subgroup. Having developed the hierarchy of each subgroup, the first consideration was to test the null hypothesis that the paired-comparison model was valid. Only a few of the computed χ^2 values were less than the tabular value at the five percent level of significance [10, table 11].[3] Therefore, the null hypothesis was rejected for all but a few subgroups, indicating that one or more of the previous assumptions was not met.

An analysis of the assumptions indicated that two are critical to this study: (1) the lack of additivity among scale separations in a single dimension and (2) the lack of equal standard deviations between the goals. The additivity of scale separations implies the respondent can mentally determine a preference between two or more goals. Implicity, the ability to scale goals depends upon their appearing in only one dimension. That is, if there is a functional relationship or a degree of interdependence in the respondent's mind such that goal i is a function of goals j and k, at least two dimensions are involved. Edwards [6, p. 54] states "in practice, the test of significance is . . . primarily

[3] The tabular χ^2 value with 21 degrees of freedom is 32.67.

sensitive to lack of unidimensionality." Mosteller [16, p. 208] indicates that "this additive property will usually not hold" if unidimensionality is absent. Although the authors counseled with experienced personnel and pretested the questionnaire to choose goals both relevant to the farmer and relatively independent, the efforts apparently were only partially successful. The high incidence of tests rejecting the validity of the paired-comparison model indicates the respondents viewed one or more goals as a function of other goals.

The second assumption of unequal standard deviations can also lead to rejection of the null hypothesis. Proper adjustments in the model allow for elimination of the widely dispersed ($\sigma > 1$) items (goals) in accordance with another of Thurstone's models (case III).[4] These adjustments are not pursued in the analysis since there is no guarantee that the same goals will remain in the hierarchy for all subgroups being compared.

Bock and Jones [2] present a procedure that can be used to test for differences between subgroups even though the paired-comparison model is rejected. The null hypothesis here is that the response probabilities for each pair of choices are equal for all m subgroups, i.e., $P_{jk1} = P_{jk2} = P_{jkm}$. For our purposes, this hypothesis simply means that there is no difference in the ranking of the eight goals between subgroups. The test statistic has the following form:

$$X^2_{jkm} = \sum_{i=1}^{\binom{n}{2}} \sum_{\ell=1}^{m} \frac{N_{jk\ell}\,(P_{jk\ell} - P_{jk.})^2}{P_{jk.}\,(1 - P_{jk.})}$$

with $[\binom{n}{2} - 1]\,(m - 1)$ degrees of freedom. The value, $P_{jk\ell}$ is the observed proportion of all respondents, $N_{jk\ell}$ in the ℓ^{th} group which preferred the j^{th} to the k^{th} choice and $P_{jk.}$ is the proportion of respondents preferring j to k of the total number of respondents in all groups. The summation for i=1, ... $\binom{n}{2}$ refers to summing over all comparative judgments of items (goals). Table 2 shows the selected stratifications, number of subgroups in each, the calculated χ^2 value, the degrees of freedom and the probability of a larger χ^2 value for each of the group characteristics. These results indicate that age, educational level, years of farming experience, number of dependents, off-farm income, and acres of cropland are highly significant factors in causing hierarchal differences. Assets, net worth, farm size, and years of livestock production experience are less significant but still may be important as causal factors.

However, it should be noted that this procedure requires that sample strata be identified initially and that random samples be drawn within each stratum. This study is based on a single random sample that was later stratified. Because the test is only used to indicate factors that might account for different goal hierarchies, it is felt the bias introduced by the sampling procedure will not adversely affect the results of this study.

THE PREDICTIVE EQUATIONS

The final objective of the analysis is to develop a means of summarizing the effect of specified operator and firm characteristics on the hierarchy of goals.

Table 2. PROBABILITIES OF SIGNIFICANTLY DIFFERENT HIERARCHIES BETWEEN SUBGROUPS

Group characteristic	Number of subgroups	Calculated χ^2 value	Degrees of freedom	Probability of a larger χ^2 value [a]
				(percent)
Age	5	181.13	108	0.5
Education level	3	95.37	54	0.5
Farming experience	4	128.78	81	0.5
Number of dependents	5	185.99	108	0.5
Debt level	3	55.89	54	50.0
Asset level	3	67.03	54	10.0
Off-farm income	4	144.24	81	0.5
Acres of land	5	119.55	108	25.0
Acres of cropland	4	142.79	81	0.5
Net worth level	4	95.09	81	25.0
Livestock experience	4	96.32	81	25.0
Type of cattle operations	3	52.61	54	75.0
Total farm income	5	99.34	108	75.0
Minimum vacation desired	3	56.48	54	50.0

[a]Using a critical value of $\alpha = .05$, the ranking by subgroups are judged to differ significantly when the probability of a larger χ^2 value is less than or equal to 5 percent.

[4]Refer to Edwards [6] for the computational procedures and Krenz [12] for the results of eliminating widely dispersed items.

Regression equations are estimated to predict the scalar value of each goal as a function of these characteristics. They provide a basis for estimating the goal hierarchy for farmers in the study area which were not included in the sample and a method to estimate changes in an individual operator's hierarchy over time. The latter is particularly important in firm growth analyses.

An equation was developed for each of the eight goals. Lack of space does not allow delineation of the equations, but they may be found in Appendix E of the publication entitled "An Evaluation of Factors Affecting the Hierarchy of Multiple Goals"[10]. The respondent's common scalar value having a value from 0 to 100 was the dependent variable.[5] Previously mentioned significant factors (table 2) and others were included as explanatory variables. Linear, quadratic and linear cross-product forms were considered where the specific forms were hypothesized to be relevant. A step-down regression procedure[6] was used to exclude insignificant variables at the 5-percent level.

The coefficient of multiple determination, standard error of estimate, equation F-value, and number of significant variables are given in table 3. About 37 to 56 percent of the variation is accounted for by the explanatory variables in six of the equations. The coefficients of multiple determination are lower for the goals "reduce borrowing needs" and "avoid being forced out of business."

The resulting equations indicate some knowledge as to which factors significantly influence the relative position of the goals on the hierarchy. In four or more equations, the significant explanatory variables are age and tenure of the operator, educational attainment, number of dependents, assets, net worth, debt-asset ratio, off-farm income, total land and cropland in the operation, total acres owned, and the proportions of land and cropland owned. Farming experience is highly correlated with age and, consequently, does not appear frequently in the equations.

Table 3. STATISTICS OF REGRESSION EQUATIONS

Goal	Equation	No. of terms	F-value	Std. error	R^2
Control more acres	Y_1	18	6.25**	24.75	.561
Avoid being forced out of business	Y_2	6	3.89**	28.60	.189
Maintain or increase family living	Y_3	11	5.00**	25.60	.367
Avoid low profits or losses	Y_4	18	3.44**	21.62	.413
Increase leisure time	Y_5	18	4.22**	23.31	.463
Increase net worth	Y_6	18	3.96**	22.17	.447
Reduce borrowing needs	Y_7	7	2.96*	29.90	.173
Make most annual profits	Y_8	14	4.24**	22.25	.392

*Significant at the 5 percent level.
**Significant at the 1 percent level.

LIMITATIONS OF THE PROCEDURE

Three general limitations of the procedure should be noted. The analysis was based on a cross-sectional survey, making it impossible to estimate the effect of external factors such as the general economic and weather conditions on the ranking of goals. Obtaining observations at several points over time may provide a basis to identify a more complete set of factors influencing the hierarchy. Second, stratification of the observations into more subgroups for each of the characteristics might improve the ability to scale the goals. However, the analysis did not indicate that definition of alternative subgroups would reduce the variation in subgroup responses and result in improved scaling. Third, the goals were prespecified

[5]The method of deriving common scalar values by the paired-comparison technique is given in [10, pp. 3-9]. The common values represent the hierarchy of each respondent's preferences on a subjective scale from zero to one. For purposes of regression, they were rescaled from zero to 100.

[6]Otherwise known as the backward elimination procedure [5, pp. 167-169]. This procedure begins with all independent variables in the first iteration and eliminates the insignificant variables until all remaining variables are significant at the prescribed level.

rather than letting the respondent state his own set of goals. Self-expression of goals might reduce the difficulties of interdependence encountered in this analysis.

A more important and, to some extent, controllable limitation of the study involves encroachment of two basic assumptions of the Method of Paired Comparisons: (1) the additivity of scale separations and (2) the occurrence of unequal standard deviations. Future studies can minimize this difficulty by developing goal statements which respondents comprehend as being clearly independent of each other. The ability to predict changes in the hierarchy should improve as compliance with the basic assumptions of the paired-comparison model improves. Strict compliance with the two assumptions is crucial to developing acceptable scales for comparing hierarchies.

Finally, the analysis only relates farm operator and farm firm characteristics to the hierarchy of multiple goals. It does not indicate the procedures employed or trade-offs required when using multiple goals in the decision-making process. Further identification of the managerial process might reveal that only a few goals are of primary importance in the short run and that secondary long-run objectives are being simultaneously pursued as time evolves. This, in itself, gives credence for additional studies of farm operators to determine changes in the hierarchy of goals over time.

REFERENCES

[1] Baumol, William J. *Economic Theory and Operations Analysis,* 2nd Edition. New Jersey: Prentice-Hall, 1965, pp. 295-310.

[2] Bock, R. Darrell, and Lyle V. Jones. *The Measurement and Prediction of Judgment and Choice.* San Francisco: Holden-Day, 1968, pp. 208-211.

[3] Bostwick, Don, James Esmay, and Gordon Rodewald. *Attitudinal Research Relating to Farmers' Use of Short-Term Credit.* U.S. Dept. of Agriculture, Economic Research Service, ERS-25, Oct., 1961.

[4] Cyert, R.M. and J.G. March, *A Behavorial Theory of the Firm,* Englewood Cliffs: Prentice-Hall, Inc., 1963, pp. 26-43.

[5] Draper, N.R. and H. Smith. *Applied Regression Analysis,* New York: John Wiley & Sons, Inc., 1966.

[6] Edwards, A.L. *Techniques of Attitude Scale Construction.* New York 1957, pp. 19-82.

[7] Eidman, Vernon R., Harold O. Carter and Gerald W. Dean. *Decision Models for California Turkey Growers.* Giannini Foundation Monograph No. 21, July, 1968.

[8] Eidman, V.R., "Incorporating Decision Rules," *Agricultural Production Systems Simulation* edited by V.R. Eidman, Oklahoma State University, May, 1971, pp. 79-85.

[9] Guttman, L.A. "A Basis for Scaling Qualitative Data." *American Sociological Review,* 9: 135-150, April 1964.

[10] Harman, Wyatte L., Roy E. Hacht, Vernon R. Eidman and P.L. Claypool, "An Evaluation of Factors Affecting the Hierarchy of Multiple Goals," manuscript in review process to be published as an Oklahoma State Experiment Station publication in cooperation with USDA, ERS, FPED.

[11] Kendall, M. G. *Rank Correlation Methods,* 3rd. Edition, New York: Hafner, 1962, pp. 144-161.

[12] Krenz, Ronald D., "Paired Comparisons As Applied to Seeding Cropland to Grass," *Journal of Farm Economics,* 46: 1219-1226, Dec. 1971.

[13] Martin, J.R. and J.S. Plaxico. *Polyperiod Analysis of Growth and Capital Accumulation of Farms in the Rolling Plains of Oklahoma and Texas.* USDA Technical Bulletin 1381, Sept. 1967.

[14] Mosteller, F., "Remarks on the Method of Paired-Comparisons: I. The Least Squares Solution Assuming Equal Standard Deviations and Equal Correlations," *Psychometrika,* 16:3-9, 1951.

[15] Mosteller, F., "Remarks on the Method of Paired-Comparisons: II. The Effect of an Abberrant Standard Deviation When Equal Standard Deviations and Equal Correlations are Assumed," *Psychometrika,* 16:203-206, 1951a.

[16] Mosteller, F., "Remarks on the Method of Paired-Comparisons: III. A Test of Significance for Paired-Comparisons When Equal Standard Deviations and Equal Correlations are Assumed," *Psychometrika,* 16:207-208, 1951b.

[17] Officer, R.R. and A.N. Halter, "Utility Analysis in a Practical Setting," *American Journal of Agricultural Economics,* 50:257-277, 1968.

[18] Patrick, George F. and Ludwig M. Eisgruber. "The Impact of Managerial Ability and Capital Structure on Growth of the Farm Firm." *American Journal of Agricultural Economics,* 50:491-506, August 1968.

[19] Thurstone, L.L. and Clave, E.J. *The Measurement of Attitude.* Chicago: University of Chicago Press, 1929.