An Evaluation of Factors Affecting The Hierarchy of Multiple Goals

Wyatte L. Harman, Roy E. Hatch,
Vernon R. Eidman and P. L. Claypool

AGRICULTURAL EXPERIMENT STATION
OKLAHOMA STATE UNIVERSITY
and USDA

Technical Bulletin
T-134
June 1972

Abstract

A survey of South Central Plains farmers was conducted in 1970 to obtain farm operators' rankings of eight economically oriented goals and to determine the effect of operator and firm characteristics on the ranking of those goals. The paired-comparison technique was utilized to determine the hierarchy of goals for each respondent. The scalar values of each goal were then used as dependent variables in regression equations.

About 40 to 50 percent of the variation in the goal structure was explained by farm operator and farm firm characteristics. Some factors found to be most important in explaining differences in the ranking of goals were the operator's age, educational level, farming experience, number of dependents, level of assets, off-farm income, cropland acres and net worth.

The predictive ability of the equations was evaluated by applying the regression equations to additional observations not included in the randomly sampled control group. About 17 percent of the predicted hierarchies were found to be insignificantly different from the actual hierarchies.

A majority of the farmers did not select the same goal as most important. The three goals "making the most profit each year", "maintaining or increasing family living level" and "avoiding years of low profit" were ranked first by 32, 27 and 22 percent of the respondents, respectively. A majority of the farmers, 57 percent, did agree that "increase leisure time" was the lowest ranking of the eight goals. An additional 32 percent ranked "controlling more acres" last.

Oklahoma Agricultural Experiment Station
Oklahoma State University
in cooperation with
Farm Production Economics Division
Economic Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

TABLE OF CONTENTS

I. INTRODUCTION 5

II. THE PAIRED-COMPARISON TECHNIQUE 6
A. Hypothetical Example 8
B. Possible Violations of the Model 14

III. THE SELECTION OF GOALS 14

IV. RESPONSE EVALUATION 16
A. Individual Consistency of Judgment 16
B. Group Response Evaluation 17
C. Definition of Subgroups 18
D. Subgroup Response Evaluation 20

V. THE PREDICTIVE EQUATIONS 22
A. Control More Acres 23
B. Avoid Being Forced Out of Business 25
C. Maintain or Increase Family Living 25
D. Avoid Low Profits or Losses 25
E. Increase Leisure Time 25
F. Increase Net Worth 25
G. Reduce Borrowing Needs 26
H. Make Most Annual Profits 26
I. Summary of Significant Factors 26

VI. EVALUATING THE PREDICTIVE ABILITY OF THE EQUATIONS . . 26

VII. SUMMARY AND CONCLUSIONS 27

VIII. LIMITATIONS OF THE PAIRED-COMPARISON METHOD IN EVALUATING HIERARCHIES OF FARM GOALS 28

IX. BIBLIOGRAPHY 30

X. APPENDIX A — PAIRED-COMPARISON FORMAT 31
A. Enumerator Instructions to Respondent 31
B. Questionnaire 32

XI. APPENDIX B — DEVELOPMENT OF A HYPOTHETICAL PREFERENCE MATRIX AND TEST FOR INCONSISTENCY OF AN INDIVIDUAL'S RESPONSES TO FOUR COMPARATIVE JUDGMENTS 34
A. Hypothetical Responses to Items A, B, C and D 34
B. Preference Matrix Formulation 34

XII. APPENDIX C — DETERMINATION OF INDIVIDUAL RESPONSE CONSISTENCY 35

XIII. APPENDIX D — TESTING THE VALIDITY OF THE PAIRED-COMPARISON MODEL AND SCALING OF PREFERENCES . . . 37
A. Development of the Frequency Matrix 37
B. Development of the Proportion Matrix 38
C. Development of the Z-Matrix 38
D. Development of the Scale 39
E. Development of the Theoretical Z-Matrix 39
F. Development of the Theoretical Proportion Matrix . . 40
G. Development of Angular Transformation Matrices . . . 41
H. Development of Angular Deviations Matrix 42
I. Test for Validity of the Assumed Paired-Comparison Model 42
J. Summary of Common Scalar Values for Selected Characteristics: Derived by the Paired-Comparison Method 42

XIV. APPENDIX E — REGRESSION EQUATIONS AND CORRESPONDING COEFFICIENTS 45
A. Definition of Dependent Variables 45
B. Definition of Independent Variables 45

An Evaluation of Factors Affecting The Hierarchy of Multiple Goals

Wyatte L. Harman, Roy E. Hatch,
Vernon R. Eidman and P. L. Claypool*

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, pp. 295-310; 4, pp. 26-43], 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 [16, p. 494]. Some analyses have considered two or more of these goals by maximizing one subject to a constraint on another [6, 11]. In other cases, a utility function has been estimated for an individual farmer incorporating both expected income and variability of income [15].

Although these efforts have been useful, progress in using multiple goals has been inhibited by the difficulty of simultaneously incorporating several goals into analytical models and the inability to correctly specify these goals in ways that reflect their use in the actual decision-making process. The recent development of simulation routines for farm firm analyses provides an analytical procedure that is flexible enough to incorporate multiple goals [7, 16]. This development adds renewed impetus to the study of farmers' goals.

---

*Wyatte L. Harman and Roy E. Hatch are agricultural economists with Farm Production Economics Division, ERS, USDA stationed at Oklahoma State University, Stillwater, Oklahoma. Vernon R. Eidman and P. L. Claypool are professors of agricultural economics and statistics, respectively, at Oklahoma State University.
Research reported herein was conducted under Oklahoma Station Project No. 1497.

Simulation models designed to select the best combination of financial and production strategies for a farm firm over time require a detailed specification of the farmer's goals, how the goals are used in making decisions, and how the goals change over time. In many cases, this information is not stated explicitly, but it is implicit in the analysis. While it is probably impossible to provide all of the information that is needed concerning goals and their use in decision-making, additional information indicating the ranking or hierarchy 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.

The purpose of this bulletin is to illustrate a method that can be used to determine an operator's hierarchy of goals and to describe the effects of specified characteristics (such as age, experience, family size, and farm size) on the goal hierarchy. More specifically the objectives are:

1. To briefly discuss alternative ranking procedures and to illustrate the computational procedure for the paired-comparison technique;
2. To determine the preferences of a group of randomly sampled farmers with regard to eight economically oriented goals;
3. To estimate the effect of certain factors on the relative importance of each goal in the hierarchy; and
4. To develop means of predicting the effects of factors identified in objective 3 on the hierarchy of goals.

The Paired-Comparison Technique

Several methods of estimating attitudinal preferences have been advanced by leading individuals in various fields of endeavor. Two of the most popular and frequently used are the Guttman scale and Kendall's rank correlation methods [8, 9]. The work of L. L. Thurstone in 1927 which resulted in *the law of comparative judgment* [18] has provided the impetus for a number of analytical techniques which are collectively referred to as the Method of Paired Comparisons [2, 5].

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]. They viewed each method as a means of identifying attitudes and characteristics but they note the limitations of each method. Guttman's scale analysis only divides responses into favorable-unfavorable groups, i.e., farmers' and bankers' attitudes toward the use of credit. This method requires at least 100 respondents per group being evaluated and does not rank items in relation to each other.

Kendall's rank correlation analysis provides an ordinal ranking of items but does not indicate the relative position of one item to another, i.e., it only delineates a simple rank ordering of the items with no distinction between closely or widely ranked items. On the other hand, the paired-comparison technique not only provides an ordinal scale, but it also provides an estimate of each item's numerical position on the scale. A disadvantage of this technique is that the respondent must indicate the preferred item for all possible combinations of pairs making the enumeration and analysis more complicated than the rank correlation method.

In applying the procedures discussed above, Bostwick, et al., found that Guttman's scale analysis indicated farmers had a positive attitude toward using credit and that each of the other techniques could be used to develop a rank of the important characteristics for borrowing. The rank order developed by paired comparisons was judged to be more precise because it estimated the disparity and/or closeness of attributes in a scalar framework.

Krenz [10] used the paired-comparison method to determine the reasons for seeding cropland to grass in North Dakota. He found that the most important reasons were expectations of reducing income variability, higher expected net income and cattle feeding requirements. Fourthly, but some distance down on the scale of relative importance, was the uncertainty of future wheat programs. Reductions in wheat allotments and inadequate size of fields were of minor importance.

The superiority of the paired-comparison technique as a scaling device depends initially upon the actual instrument used to generate data. First, it is necessary to construct the items (attitude statements) according to a rigorous "checklist" of criteria [5, p. 13, 14]. Secondly, the number of items used must be such that the attention span of the respondent is not severely taxed by the length of the questionnaire. In addition, numerous comparisons tend to confuse the respondent because of his inherent desire to remain consistent in his preferences and of his inability to remember all of his previous choices.

The model to be presented here (also see [5,] [10] and [3]) is that formulated by Mosteller [12, 13]. Mosteller assumes:

1. The n items produce reactions (sensations) whose intensities may be located on a single subjective continuum.
2. The distribution of intensities of reactions to each item 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 and the intensity of reaction to a second item are equal for all pairs of items.
5. Each of the R randomly selected respondents states a preference of one item over the other for each of the n(n-1)/2 pairs of items.

Each of the assumptions as stated here is self-explanatory except for the first. Under this assumption, the respondent is able to locate the intensity of his reactions to each of the items on a mental scale which is so finely calibrated that the intensities of no two items occupy the same location. That is, the respondent is able to rank the relative intensity of reaction to the items from "most intense" to "least intense" even though he may be unable to assign a meaningful numerical measure of magnitude to any of the intensities. Also, an assumption of additivity of scale separations is embedded within these assumptions. That is, if D_{ij} is the distance (magnitude and direction) from item number i to item number j along the subjective scale and D_{jk} is the distance from item j to item k, then $D_{ik} = D_{ij} + D_{jk}$ is the distance from item i to item k for any three items i, j, and k.

Based on the assumption listed above, Mosteller develops a procedure for estimating the scale separations between any two of the items by arbitrarily assigning a scale value of zero to one of them. He later [14] proposes a goodness-of-fit test to determine how well the "fitted model" agrees with the data. A hypothetical example is presented to explain and illustrate the procedure for developing a scale, to clarify the null and alternative hypotheses being tested, and to illustrate the mechanics of the test procedure.

Hypothetical Example

Suppose it is desired to determine the relative importance farmers attach to the n = 3 goals (items): (a) to make the most profits, (b) to increase net worth, and (c) to increase leisure time. The paired-comparison model is assumed. Each of the R = 10 randomly selected farmers is asked to state which of two goals is more important to him for each of the n(n-1)/2 = 3 pairs of statements. The format for pairs of statements is illustrated in Appendix A.

The first step is to develop a frequency matrix (3X3) indicating the number of times any one goal was chosen over each of the other two goals.[1] For example, the entries in column 1 of Table 1 indicate

[1]Respondents are encouraged to select one item as preferred. However, if the respondent insists he cannot select one item as being preferred to the other, a score of .5 is placed in each cell of the frequency matrix for the corresponding pair of items.

Table 1. Frequency matrix—hypothetical example of ten respondents.

Goal	Make the most profits (1)	Increase net worth (2)	Increase leisure time (3)	Total
Make the most profits	---	7	4	11
Increase net worth	3	---	2	5
Increase leisure time	6	8	---	14
Total	9	15	6	30
Rank order	2	1	3	---

three of the respondents preferred "make the most profits" to "increase net worth" and six preferred the same goal to "increase leisure time". In column 2, the other seven respondents preferred "increase net worth" over "making the most profits" and eight preferred the net worth goal over "increase leisure time". Four individuals chose "increase leisure time" over "making the most profits" and two over "increase net worth" in column 3. In the column totals, 30 responses (three items and ten respondents) were evaluated and nine preferred "make the most profits"; fifteen "increase net worth"; and six "increase leisure time" over the respective alternatives. The bottom row gives the rank order of the three goals based on the number of observed preferences.

Having obtained the rank order, rearrange the matrix (Table 1) such that the least preferred goal (increase leisure time) is in the first column and the most preferred goal (increase net worth) is in the last or right column. The rows should also be rearranged placing the least preferred goal in the top row and the most preferred goal in the last row. With a matrix as small as a 3X3, this rearrangement can be completed mentally and is not shown as a separate table.

The second step is to develop the proportion matrix indicating the proportion of respondents preferring one goal to each of the others. This is accomplished by dividing each entry in the frequency matrix by R, the number of respondents. Since $R = 10$ in our example, simply place a decimal in front of each entry as shown in Table 2.

Thirdly, each proportion, p_{ij}, in the proportion matrix is transformed to a z_{ij} value by using the "Table of Normal Deviates Z, Corresponding to Proportions P, of a Dichotomized Unit Normal Distribution" [5, p. 246]. If this table is not readily accessable, the table of the cumulative standardized (unit) normal distribution, which is found in most introductory statistics books, may be used. The desired quantity, z_{ij}, is a value of the standardized normal random variable Z such that $Pr(Z < z_{ij}) = p_{ij}$. The z_{ij}'s are recorded in Table 3. For example, from

Table 2. Frequency matrix rearranged according to the reverse rank order of preferences and converted to a proportion matrix, P.[1]

Goal	Increase leisure time	Make the most profits	Increase net worth
Rank order	3	2	1
Increase leisure time	----	.6	.8
Make the most profits	.4	----	.7
Increase net worth	.2	.3	----

[1]Hypothetical data.

Table 3. Z matrix corresponding to the proportion matrix.[1]

Goal	Increase leisure time	Make the most profits	Increase net worth
Increase leisure time	----	.253	.842
Make the most profits	—.253	----	.524
Increase net worth	—.842	—.524	----
Total	—1.095	—0.271	1.366
Average	—0.365	—0.090	0.455
Scalar value	0.000	0.275	0.820
Common scale	0.000	0.335	1.000

[1]Hypothetical data.

row 2, column 1 of Table 2 $p_{21} = .400$ which corresponds to $z_{21} = -.253$ since $Pr(Z < -.253) = .400$. Thus, the quantity $-.253$ is entered in row 2, column 1 of the Z matrix. The z values are positive when the proportion is greater than .500 and negative when less. After completing the Z matrix, sum the columns including a value of zero for the diagonal element and average each column keeping the sign.

To develop the scalar value (sixth row of Table 3), change the sign of the most negative "average" value (—0.365 in column 1, row 5) and add the result to each of the average values, including itself to develop an origin of zero. The resulting scale values are 0.000 for the goal "increase leisure time"; 0.275 for "make the most profits"; and 0.820 for "increase net worth". Note that the scale is not on a zero-one basis but that it can be converted by dividing each of the scalar values by the largest value. This common scale can then be used to compare the ranking for groups of individuals stratified on a specific characteristic.

Once the estimated scale values have been obtained, one may retrace the above procedure to obtain the normal deviates (z values) fitted to the assumed model and with the help of the standardized normal tables obtain the fitted proportions p'_{ij}. The objective is to determine how well the fitted p'_{ij} quantities agree with the corresponding observed p_{ij} quantities. The null hypothesis to be tested is that the model assumed above is valid (that is, the assumptions of the model are not violated). The alternative hypothesis is merely that the null hypothesis is not correct (that is, one or more of the assumptions are not met).

The scalar values in row 5 of Table 3 (not the common scalar values in row 6) are used to form a matrix of theoretical z values, Table 4. The column and row headings of Table 4 are identical to Table 3. The first column of Table 4 is obtained by multiplying each scalar value by negative one and listing them in order. In this example, $z_{11} = 0$, $z_{21} = -0.275$, and $z_{31} = -0.820$. Column 2 is developed by subtracting the first nonzero value in column 1 (z_{21}) from all others in column 1 and entering each value in the respective cell in column 2. Succeeding columns are calculated in a similar manner. In the example: $z_{22} = -0.275 - (-0.275) = 0.00$; $z_{32} = -0.820 - (-0.275) = -0.545$; and $z_{33} = -0.545 - (-0.545) = 0.00$. Generally, for column 2: $z_{31} - z_{21} = z_{32}$; $z_{41} - z_{21} = z_{42}$; . . . ; $z_{n1} - z_{21} = z_{n2}$; for column 3: $z_{42} - z_{32} = z_{43}$; $z_{52} - z_{32} = z_{53}$; . . . ; $z_{n2} - z_{32} = z_{n3}$; and so on for succeeding columns.

The theoretical z values of Table 4 are converted to theoretical proportions (p'_{ij}) by using the "table of normal deviates" in the reverse manner explained previously. For instance, the theoretical proportion for $z_{21}(-0.275)$ is 0.392. The theoretical proportion for $z_{31}(-0.820)$ and $z_{32}(-0.545)$ are 0.206 and 0.293, respectively (Table 5).

Since the distribution of probabilities for the population of possible observed proportions for cell (i, j) is not known, it will be approximated using the inverse sine transformation developed by R. A. Fisher in 1922 (see Mosteller [14]). For this discussion, the approximation may be stated as follows: "If a proportion p is observed from a binomial sample

Table 4. Theoretical Z matrix developed from the scalar values of Table 3.[1]

Goal	Increase leisure time	Make the most profits	Increase net worth
Increase leisure time	----		
Make the most profits	—.275	----	
Increase net worth	—.820	—.545	----

[1]Hypothetical data.

of size R from a population with a true proportion of success p*, then

$$(1) \qquad \theta = \arcsin \sqrt{p}$$

is approximately normally distributed with mean $\theta^* = \arcsin \sqrt{p^*}$ and variance 821/R where θ and θ^* are measured in degrees." Define

$$(2) \qquad \begin{aligned} \theta_{ij} &= \arcsin \sqrt{p_{ij}} \\ \theta'_{ij} &= \arcsin \sqrt{p'_{ij}} \end{aligned}$$

where p_{ij} are the observed proportions and p'_{ij} are the theoretical proportions below the main diagonal in the respective proportion matrices (that is, for $i > j$). Assuming the null hypothesis that the paired-comparison model is valid, the true proportion of success for cell (i, j) in the fitted model is p'_{ij}. The test statistic for testing the null hypothesis is then

$$(3) \qquad \chi^2 = R \sum_{i=2}^{n} \sum_{j=1}^{i-1} (\theta_{ij} - \theta'_{ij})^2/821$$

which has approximately a chi-square distribution with $(n-1)(n-2)/2$ degrees of freedom. The null hypothesis is rejected if the calculated value of χ^2 exceeds the tabulated chi-square critical value corresponding to a right-hand tail area of α and the appropriate number of degrees of freedom. Otherwise, the null hypothesis is not rejected.

To determine the deviation of the expected proportions, p′, from the observed proportions, p, each cell value is changed to a percentage (by multiplying by 100) and converted to angles by using a "Table of Angular Transformation of Percentages to Degrees" [5, p. 248]. Using only the lower diagonal elements of the observed proportion matrix (Table 2), Table 6 is developed. Table 7 is developed by using the theoretical proportions shown in Table 5. For example, converting the proportion .4 in row 2, column 1 of Table 2 to 40.0 percent and reading the angle in the "table of angular transformations" gives 39.23 degrees. This process is continued until all θ_{ij} and θ'_{ij} below the main diagonal of Tables 6 and 7 are completed. If such a transformation table is not readily available, a table of natural trigonometric functions may be used. For example, using the proportion .4 above, $\sqrt{.4} = .6325$ and the angle

Table 5. Theoretical proportions matrix, P′, corresponding to the theoretical Z values.[1]

Goal	Increase leisure time	Make the most profits	Increase net worth
Increase leisure time	----		
Make the most profits	.392	----	
Increase net worth	.206	.293	----

[1]Hypothetical data.

Table 6. Angular transformation matrix, θ, based on observed proportions.[1]

Goal	Increase leisure time	Make the most profits	Increase net worth
Increase leisure time	----		
Make the most profits	39.23	----	
Increase net worth	26.56	33.21	----

[1]Angular transformation of observed proportions shown in Table 2 based on hypothetical data.

Table 7. Angular transformation matrix, θ', based on theoretical proportions.[1]

Goal	Increase leisure time	Make the most profits	Increase net worth
Increase leisure time	----		
Make the most profits	38.76	----	
Increase net worth	26.99	32.77	----

[1]Angular transformation of theoretical proportions shown in Table 5 based on hypothetical data.

whose sine is .6325 is 39 degrees and 14 minutes or $39 + 14/60 = 39.23$ degrees.

The table of deviations, $\theta - \theta'$, is formed by subtracting each element θ'_{ij} from the corresponding θ_{ij}. For example, $\theta_{21} = 39.23$ and $\theta'_{21} = 38.76$. By subtraction $\theta_{21} - \theta'_{21} = 0.47$ in Table 8. Continue the process until all $(\theta_{ij} - \theta'_{ij})$ coefficients are calculated. For our hypothetical example with the number of respondents, R, equal to ten and the number of choices, n, equal to three, the calculated χ^2 value, using equation (3) is 0.0073. This value is less than the tabular value of 3.841 at the $\alpha = .05$ level of significance with one degree of freedom. Therefore, the null hypothesis that "the model assumed is valid" is not re-

Table 8. Angular deviations matrix, θ-θ'.[1]

Goal	Increase leisure time	Make the most profits	Increase net worth
Increase leisure time	----		
Make the most profits	.47	----	
Increase net worth	—.43	.44	----

[1]Elements are calculated by subtracting elements in Table 7 from their respective elements in Table 6.

jected. If the calculated χ^2 value is greater than the tabular value, the null hypothesis is rejected, and the scale separations and rank order in Table 3 are nullified. Bostwick [3], Edwards [5], and Krenz [10] discuss additional procedures that may be used to eliminate choices and rescale if the null hypothesis is rejected.

Possible Violations of the Model

Mosteller [13] discusses three principal ways that the assumptions of the model may be violated resulting in the rejection of the null hypothesis. These ways are:

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. Krenz [10] evaluates the third in detail.

The basic assumptions, calculations and tests of significance associated with the paired-comparison method were used to estimate a hierarchy of goals for farm operators in a specific study area. Personal interviews with randomly selected farm operators furnish the basic data used in the analysis. The following sections discuss the results of the analysis.

The Selection of Goals

Goals considered in this study were obtained from previous research efforts and consultations with individual farmers and extension specialists in the study area. The resulting list included sociological, economic and production goals. The original list was reduced by eliminating goals that could not be quantified in simulation analyses of firm growth and those judged to be of lesser importance. In some cases, similar goals were combined into one statement. This process and pretesting with farmers resulted in the following eight goal statements (items) used in this study:

1. Control more acreage by renting or buying;
2. Avoid being forced out of business;
3. Maintain or improve 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 are primarily economic in nature and can be quantified for use in firm growth studies.

The questionnaire used to obtain operators' preferences with the paired-comparison technique must contain all possible combinations of the items to be ranked taken two at a time. The number of paired statements required is n(n—1)/2, where n is the number of items being ranked. In the case of ranking eight items, 28 pairs of statements are required. Appendix A shows the paired statements and their randomly selected order. Each pair of statements was placed on a card, and the 28 cards were handed to the respondent at the time of the interview. The enumerator recorded answers as the respondent stated his preference between each pair of statements listed on the individual cards. This procedure aided in disassociating questions and, thus, minimized biasing answers toward previous choices. The respondent was encouraged to select only one statement from each pair. If the respondent was insistent, indifference between statements was allowed.

A survey of 149 randomly selected farms was conducted in a 21-county area which included parts of northern Texas, northwestern Oklahoma, southwestern Kansas, and southeastern Colorado (Figure 1). From

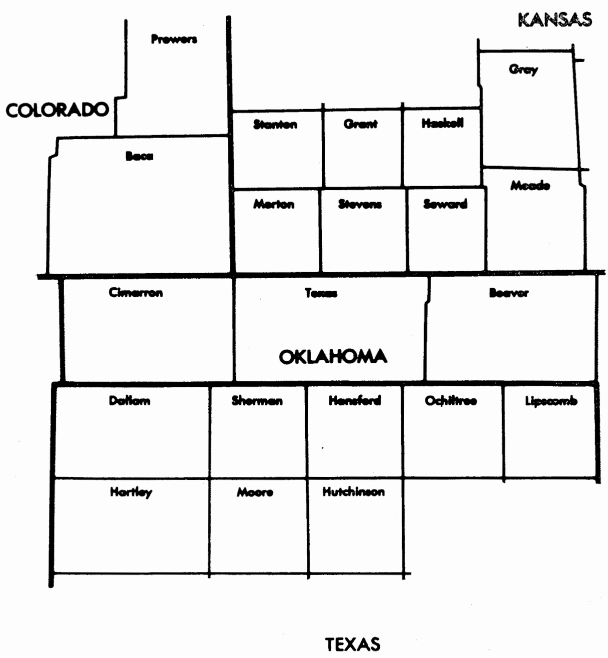

Figure 1. Map of the study area

these 149 interviews, 129 complete questionnaires were obtained. Information concerning farm and operator characteristics and the operator's responses to the 28 paired-comparison statements were recorded. Operator characteristics included age, educational level, farming experience, tenure and the number of dependents. Farm characteristics included the size and type of operation, acres owned and rented, number of head for each cattle enterprise, farm sales, farm income, off-farm income, assets, debts, allotments, and labor force data. A later section discusses the relationship of these characteristics to the hierarchy of goals.

Response Evaluation

Individual Consistency of Judgment

The preferences of each respondent were recorded and tested for consistency of judgment. Inconsistencies may occur because of lack of interest, similarity of choices or the inability of a respondent to comprehend all of the choices and simultaneously remain consistent in his judgments.

An inconsistency exists if choice A is preferred to choice B and B to C, but C is preferred to A rather than the consistent preference of A to C. An inconsistency of choice is termed a circular triad. A coefficient of consistency can be developed and statistically tested to determine if an excessive number of circular triads has been committed. The procedure used to compute and test the number of circular triads in a set of responses is given in Appendix B.

Application of the formula in Appendix B indicates the maximum number of circular triads an individual can commit in ranking eight items (the number of items in this study) is 20. The number of circular triads is referred to as the "d" statistic. Any individual who commits no more than 9 circular triads (d=9) provides a basis to reject the null hypothesis that he made random choices at the 10 percent level of significance. From Kendall's table of probabilities, the probability of "d" being less than or equal to 9 for an individual making random choices is 0.094, which is less than 0.10; the probability of "d" being less than or equal to 10 is 0.153 [9, p. 193]. An explanation of how to use Kendall's table and an approximate test based on the χ^2 distribution are given in Appendix C.

Table 9 indicates the number and percentage of the respondents committing a specified number of circular triads (inconsistencies of judgment). Only 11 of 129 respondents (about 8.5 percent) committed 10 or more circular triads with none committing over 14. Further analysis is based on the 118 respondents having no more than 9 circular triads.

Table 9. Distribution of respondents by the number of circular triads committed.

Number of circular triads committed	Number of respondents	Percent of respondents	Cumulative percentage
0	14	10.9	10.9
1	9	7.0	17.9
2	19	14.7	32.6
3	15	11.6	44.2
4	14	10.9	55.1
5	11	8.5	63.6
6	13	10.1	73.7
7	8	6.2	79.9
8	6	4.6	84.5
9	9	7.0	91.5
10	4	3.1	94.6
11	0	0	94.6
12	3	2.3	96.9
13	3	2.3	99.2
14	1	.8	100.0
15-21	0	0	100.0
Total	129[1]	100.0	-----

[1]These 129 respondents represent approximately 87 percent of the questionnaires.

Group Response Evaluation

The percentage of respondents ranking each goal last and the percentage ranking each goal first is given in Table 10. The results indicate that two goals, "control more acres" and "increase leisure time", were the last choices of 32 and 57 percent of the respondents, respectively.[2] Each of the other six goals were preferred as last choice by less than 10 percent. The total percentages shown in Table 10 exceed 100 because some respondents indicated the same intensity (equal preference) for two or more goals.

There is less agreement on the most preferred goals than on the least preferred goals. "Making the most annual profits", "maintaining or increasing family living", and "avoiding years of low profits or losses" were each selected as the most important goals by only 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.

[2]The authors recognize that the choice of words may bias the results. The wording used for the leisure time goal was "increase time off from farming (leisure time)." This wording was selected to reduce any undesirable connotation respondents may attach to the word leisure because of the "work ethic". Efforts were made during the pretesting of the questionnaire to eliminate such bias. However, available resources did not permit inclusion of procedures to test for bias due to the choice of words in either this or other goal statements.

Table 10. Respondents ranking goals first and last.[1]

Goal	Respondents preferring goal the least		Respondents preferring goal the most	
	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

[1]Percentages accumulate in excess of 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.

A question arises concerning the high percentage of respondents who indicated "control of more acreage by renting or buying" as least important when general pressures are toward enlarging the operation. The sample farms averaged more than 2,200 acres of which over half is cropland. Considering the modal size of 1,280 to 1,600 acres and the shortage of available labor in the area, it is conceivable that "controlling more acres" is of lesser importance than the other choices. In addition, expansion may occur due to unexpected opportunities to enlarge rather than the conscious pursuit of such a goal.

These results indicate a large proportion of the respondents ranked one or two of the choices low, but there was little agreement on either one important goal or one common hierarchy. Consequently, a statistically significant hierarchy could not be developed based on the entire sample. However, stratifying the respondents into groups based on age, farm size, or other factors may disclose more uniformity in the selection of a hierarchy.

Definition of Subgroups

It was hypothesized that certain personal and psychological characteristics of the farm operator, as well as characteristics of the farm firm, affect the hierarchy of goals. The survey included information on four personal characteristics: age, education, agricultural experience, and the number of dependents. Agricultural experience was divided into four categories: total farming experience, livestock experience and irrigated and dryland crop experience.

In addition to personal characteristics, debt level, asset level, off-farm income, acres of total land, acres of cropland, net worth level, type of cattle enterprises, total farm income, and the desired minimum vacation time were recorded for each farm in the sample. These factors provide the basis for stratifying the sample into subgroups for the remainder of the analysis. The subgroups and the number of respondents in each are shown in Table 11. No attempt was made to measure psychological characteristics in this study because of the additional time and expense required.

Table 11. Computed test statistics for the paired-comparison model and number of respondents for specified subgroups of randomly sampled farm operators.

Group characteristic	Subgroup definition	Number of respondents	Computed X^2 value[2]	Probability of a larger X^2 value[3]
				(percent)
Age	Under 30	11	40.20	1.0
	30-39	21	38.49	1.0
	40-49	30	31.06	7.5
	50-59	33	41.95	0.5
	60 and over	23	23.18	35.0
Educational level	Less than high school	40	32.31	5.0
	Less than 2 yrs. of college	56	46.99	0.5
	2 yrs. or more of college	22	33.98	3.5
Farming experience	10 yrs. or less	23	32.65	5.0
	11-20 yrs.	19	52.86	0.5
	21-30 yrs.	41	31.50	7.0
	More than 30 yrs.	35	34.69	3.5
Number of dependents	Less than 2	45	37.55	1.5
	2	16	36.44	2.0
	3	29	29.42	10.0
	4	16	57.37	0.5
	More than 4	12	32.70	5.0
Debt level[1]	Less than $25,000	51	44.92	0.5
	$25,000-$49,999	21	27.43	17.5
	$50,000 or more	39	47.92	0.5
Asset level[1]	Less than $100,000	39	37.51	1.5
	$100,000-$249,999	33	38.80	1.0
	$250,000 or more	37	45.03	0.5
Off-farm income[1]	Less than $1,000	59	80.05	0.5
	$1,000-$4,999	26	31.59	7.0
	$5,000-$9,999	21	38.26	1.0
	$10,000 or more	7	10.11	97.5
Acres of land	640 or less	19	26.81	20.0
	641-1,280	37	40.58	0.7
	1,281-2,560	32	44.55	0.5
	2,561-5,120	20	18.19	62.5
	Over 5,120	10	10.30	97.5
Net worth level[1]	$1-$99,999	51	57.01	0.5
	$100,000-$249,999	33	45.02	0.5
	$250,000 and over	21	33.02	4.5

(continued)

Table 11. Computed test statistics for the paired-comparison model and number of respondents for specified subgroups of randomly sampled farm operators. (continued)

Group characteristic	Subgroup definition	Number of respondents	Computed X^2 value[2]	Probability of a larger X^2 value[3]
				(percent)
Acres of cropland	640 or less	37	27.88	17.0
	641-1,280	37	36.88	1.5
	1,281-2,560	29	53.23	0.5
	Over 2,560	15	18.60	62.0
Type of cattle operations	Cow-calf only	60	51.06	0.5
	Stockers	36	33.22	5.0
	Cow-calf and stockers	22	29.23	10.5
Minimum vacation time desired	7 days or less	70	60.30	0.5
	8-14	38	43.57	0.5
	Over 14	10	10.29	97.5
Livestock production experience	5 yrs. or less	32	24.37	50.0
	6-10	13	12.84	95.0
	11-20	20	34.56	5.0
	Over 20	53	42.36	0.5
Irrigation experience	none (dryland)	53	29.64	10.5
	1-5 years	25	28.11	11.5
	6-10 years	19	28.34	11.5
	11-15 years	11	62.95	0.5
	Over 15 years	10	26.12	20.5
Total farm income[1]	Less than $20,000	35	34.88	3.5
	$20,000-$39,999	20	17.42	61.5
	$40,000-$69,999	25	38.51	1.5
	$70,000-$139,999	22	34.51	3.5
	$140,000 and over	11	26.74	20.0

[1]Nonrespondents were excluded.

[2]A critical value of $\alpha = .05$ was selected for this study. The X^2 value at $\alpha = .05$ with 21 degrees of freedom is 32.67. Therefore, the null hypothesis (the paired-comparison model is valid) is rejected if greater than 32.67.

[3]Using a critical value of $\alpha = .05$ or 5 percent, the null hypothesis (the paired-comparison model is valid) is rejected when the probability of a larger X^2 value is less than or equal to 5.0 percent. Alternatively, the value in this column can be used to determine whether the null hypothesis would be rejected for other levels of α.

Subgroup Response Evaluation

A ranking of the eight goals was developed for each subgroup listed in Table 11 using the paired-comparison procedure discussed above. An example of the computations for one subgroup, respondents of age 40 to 49, is given in Appendix D. The common scale values for each subgroup are also presented in Appendix D for the interested reader.

Having developed the scale for each subgroup, the first consideration is to test the null hypothesis that the paired-comparison model assumed is valid. A table of deviations $(\theta_{ij} - \theta'_{ij})$ and the associated χ^2 value was calculated for each subgroup. The computed χ^2 value and the approximate probability of obtaining a larger χ^2 value (providing the model is valid) are shown in Table 11 for each subgroup. Only a few of the computed χ^2 values are less than the tabular value of 32.67 at the $\alpha = .05$ level of significance with 21 degrees of freedom. Therefore, the null hypothesis is rejected for all but a few subgroups. This indicates that one or more of the assumptions of the model are violated.

Bock and Jones [2, pp. 208-211] present a procedure that can be used to test for differences between subgroups even though the assumptions of the paired-comparison model are violated. The null hypothesis here is that the response probabilities for each pair of choices are equal for all m subgroups, i.e., $P_{ij1} = P_{ij2} = \ldots = P_{ijm}$. 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:

$$(4) \qquad \chi^2_{ijm} = \sum_{\substack{i,j=1 \\ i>j}}^{n} \sum_{k=1}^{m} \frac{N_{ijk}(p_{ijk} - p_{ij\cdot})^2}{p_{ij\cdot}(1 - p_{ij\cdot})}$$

with $[\binom{n}{2} - 1]$ (m—1) degrees of freedom, where

N_{ijk} = total number of respondents in the k^{th} group preferring the i^{th} to the j^{th} choice,

p_{ijk} = the observed proportion of the respondents in the k^{th} group preferring the i^{th} to the j^{th} choice,

$p_{ij\cdot} = \sum_{k=1}^{m} N_{ijk}/N$; i.e., total number of respondents preferring i to j divided by the total number of respondents.

The summation for i, j=1, . . . , n refers to summing over all comparative judgments where i>j.

Table 12 shows the number of subgroups, the calculated χ^2 value, the degrees of freedom, and the probability of a larger χ^2 value for each of the group characteristics used in stratifying the sample. 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 hierarchial differences. Assets, net worth, acres of land, and years of livestock production experience are less significant but still may be important as casual factors.

A problem concerning interpretation of the above test is that the procedure assumes sample strata are identified initially, and random samples are drawn within each stratum. The observations in this study were obtained in a single random sample that was later stratified, causing the reader to question if this test can be used to indicate factors that might account for different goal hierarchies. The authors feel that bias introduced by sampling prior to stratifying will not be grossly misleading in identifying casual factors. However, the correct sampling proce-

Table 12. **Probabilities of significantly different hierarchies between subgroups.**

Group characteristic	Number of subgroups	Calculated X^2 value	Degrees of freedom	Probability of a larger X^2 value[1]
				(percent)
Age	5	181.13	108	0.5
Educational 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 time desired	3	56.48	54	50.0

[1]Using a critical value of $\alpha = .05$ or 5 percent, the rankings by subgroups are judged to differ significantly when the probability of a larger X^2 value is less than or equal to 5 percent. Alternatively, the values in this column can be used to determine whether the null hypothesis would be rejected for other levels of α the reader may prefer.

dure will minimize the sample variance and possibly change the mean of each group. The practical limitations of the correct sampling procedure are: (1) casual factors must be known in advance so that strata can be defined, (2) such a sampling procedure is likely to result in higher survey costs, especially as the number of stratifications is increased and (3) if one is dealing with factors similar to those shown in Table 12, a complete identification of the population associated with each characteristic is extremely difficult.

The Predictive Equations

The final objective of the analysis is to develop a means of summarizing the effect of specified characteristics of the operator and firm on the hierarchy of goals. Regression equations are estimated to predict the scalar value of each goal as a function of these characteristics. The equations provide a basis for estimating the goal hierarchy for farmers in the study area which were not included in the sample. Also, they provide a predictive framework for estimating changes in the hierarchy over time. The latter is particularly important in firm growth analyses.

An equation was developed for each of the eight goals with the respondent's common scalar value having a value from 0 to 100 as the dependent variable. The more significant factors in Table 12 and others (see Appendix E) are considered independent. Linear, quadratic and linear cross-product forms are considered where the specific forms are hypothesized to be relevant. A step-down regression procedure was used to exclude insignificant variables at the 5 percent level. The equations and explanation of variable notation are given in Appendix E.

The coefficient of multiple determination, standard error of the estimate, equation F-value and number of significant variables are given in Table 13 for each equation. About 37 to 56 percent of the variation is accounted for by the explanatory variables in six of the equations. The coefficients of determination are lower for the goals "reduce borrowing needs" and "avoid being forced out of business."

A further attempt to reduce the standard error of the estimates involved the use of principal components analysis. Three proxy variables, each composed of a combination of two or more of the original explanatory variables, were developed and considered in the analysis. However, none of these variables significantly improved the predictability of the regression equations.

Some of the factors which are particularly useful in explaining the relative importance of each goal in the hierarchy are given in Table 14. A detailed discussion of the relationship between the explanatory variable and the scalar value of each goal is not attempted here. A lengthy discussion would be required to explain all of the interaction terms included in the equations. The following briefly summarizes a few of the more important relationships.

Control More Acres

Controlling more acres by renting or buying diminishes in importance as the operator's age, level of education, number of dependents,

Table 13. Statistics of regression equations.

Goal	Equation	No. of terms	F-value of the equation	Std. error of the estimate	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.

Table 14. Summary of significant explanatory variables in the hierarchy of farmer goals.[1]

Operator or firm characteristic	Variable	Goals: Control more acres	Avoid being forced out of business	Maintain or increase family living	Avoid low profits or losses	Increase leisure time	Increase net worth	Reduce borrowing needs	Make most annual profits
		Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8
Age	X_1	S	S	S	S		S		
Tenure of operator	X_3	S		S	S	S	S		S
Education level	X_4	S	S	S		S	S		
Farming experience	X_2					S	S		
Number of dependents	X_{11}	S		S	S		S		S
Asset level	X_9	S	S	S	S	S	S		S
Debt-asset ratio	X_{16}			S	S	S	S		
Net worth	X_{15}	S		S	S	S		S	
Off-farm income	X_8	S		S		S	S	S	S
Acres of land	X_6	S			S		S	S	
Acres of cropland	X_5	S	S			S	S	S	
Owned acres of land	X_{12}	S		S	S			S	S
Prpt'n of land owned	X_{17}	S			S	S	S	S	S
Prpt'n of cropland owned	X_{18}		S			S	S		S

[1]"S" indicates significance at the 5 percent level in either linear, quadratic or cross-product form.

net worth and the acres of owned land increase. Alternatively, as the size of operation (acres of land) and proportion of land owned increase, the predicted scalar value increases. A positive coefficient for the level of assets is offset by two negative cross-products with off-farm income and acres of owned land.

Avoid Being Forced Out of Business

As age, assets and acres of cropland operated increase, the scalar value of "avoid being forced out of business" declines. The proportion of cropland owned increases the value but is offset by a negative cross-product with education levels.

Maintain or Increase Family Living

The importance of maintaining or increasing family living standards diminishes as net worth, off-farm income, acres of owned land and the debt-asset ratio increase. A negative cross-product term involving tenure and assets tends to offset the positive relation of asset levels.

Avoid Low Profits or Losses

Avoiding years of low profits or losses becomes less important as the operator's tenure changes from renter to owner. As the number of dependents, debt-asset ratio, net worth, acres of owned land and proportion of total land owned increase, the scalar value increases. A negative relation of asset levels is offset by positive cross-products of assets with total acres operated, number of dependents and net worth.

Increase Leisure Time

As farming experience and assets increase, the importance of leisure time increases at a decreasing rate. However, as the operator's tenure changes from renter to owner and as acres of cropland and the proportion of land owned increase the relative importance of more leisure decreases at a decreasing rate.

Increase in Net Worth

The predicted scalar value for increasing net worth declines as age, debt-asset ratio and off-farm income increases. It increases as education, farming experience, total acres operated and the proportion of cropland owned increase. Negative relationships of age and debt-asset ratio tend to be offset by a positive cross-product of the two variables.

Reduce Borrowing Needs

Reducing the need for borrowing becomes less important as net worth, off-farm income, total acres operated and the proportion of land owned increase. In contrast, as acres of cropland and total acres owned increase, reducing borrowing needs becomes more important.

Make Most Annual Profits

As the number of dependents and proportion of land owned increase, the scalar value for making the most profits declines. However, making profits becomes more important as tenure changes from renter to owner and as the total acres owned and proportion of cropland owned increase. Cross-products between off-farm income and the proportions of land and cropland owned offset their previous effects and another cross-product between the two proportions is negative.

Summary of Significant Factors

Some of the more interesting explanatory variables (previously indicated as significant casual factors in Table 12) are: (a) age of the operator is important in five of the equations; (b) educational attainment in five; (c) farming experience in two; (d) number of dependents in five; (e) assets in seven; (f) off-farm income in six and (g) cropland acres operated in five. Other variables significant in at least four of the equations, are tenure of the operator, total land operated, total acres owned, net worth, debt-asset ratio, the proportions of land and cropland owned. The coefficients and standard errors are given in Appendix Table XII.

Evaluating the Predictive Ability of the Equations

The primary concern in developing the equations was to provide a means of predicting the hierarchy of goals. The ability to predict the actual scalar value of each goal is of secondary importance if the ranking or hierarchy can be predicted by using the eight equations simultaneously. If similar ranks can be predicted for individuals not in the sample, the relative importance of the goals can be used in a decision-making framework.

At the same time that the randomly sampled farm operators were interviewed, other farmers in the study were also being interviewed to obtain additional information concerning irrigation practices and associated costs. Although this group of irrigation farmers was not randomly sampled with regard to the entire study area, they were dispersed throughout the area, and they do provide additional observations that can be used to test the predictive ability of the eight equations.

The characteristics of these 54 farm operators and the eight equations were used to predict their hierarchy of goals. Each respondent's "observed hierarchy" was then compared to the "predicted hierarchy" using Spearman's rank correlation coefficient, r_s [17, pp. 202-213]. The null hypothesis is that there is no positive correlation between the two hierarchies. Failure to reject the null hypothesis indicates that the "observed" differs from the "predicted" hierarchy. The alternative hypothesis is that the two hierarchies are positively correlated. Since values of r_s are contained in the interval -1 to $+1$, inclusive, the null hypothesis is rejected for positive values of r_s which are "large". Table 15 indicates the values of r_s obtained for the 54 irrigation farmers. For $n = 8$ items, the null hypothesis is rejected for $r_s \geqslant 0.643$ at the 5 percent level of significance [17, p. 284]. Only 9 of the 54 pairs of "predicted" and "observed" hierarchies exhibited sufficient agreement to reject the null hypothesis.

Though the analysis has shortcomings due to some bias from the irrigation factor and nonrandom sampling, it is unlikely that the significant differences in ranks could be entirely attributed to the sampling error. Consequently, the simultaneous use of the equations in a decision-making framework must be approached with caution.

Summary and Conclusions

The purpose of this study was to obtain farm operators' rankings of eight economic goals and to determine the effect of several operator and firm characteristics on the ranking of those goals. The operator's age, educational level, farming experience, number of dependents, level of assets, off-farm income, cropland acres, and net worth were eight factors found to significantly affect the ranking of operators' goals. Regression equations including these characteristics and others of the farming operation as explanatory variables accounted for about 40 to 50 per-

Table 15. Summary of rank correlations between "predicted" and "observed" hierarchies of nonrandomly sampled respondents.

Range of r_s	Number observed	Percent	Accumulative percent
Less than 0	13	24.1	24.1
0 to .2	9	16.7	40.8
.2 to .4	10	18.5	59.3
.4 to .642	13	24.1	83.4
.643 to .832*	8	14.8	98.2
Over .832**	1	1.8	100.0

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

cent of the variation. The predictive ability of the eight equations was evaluated by predicting the hierarchy of goals for each of 54 farmers not included in the original random sample and comparing the predicted with the observed hierarchy. About 17 percent of the predicted hierarchies did not differ significantly from the observed hierarchies.

The primary conclusion of this study is that a majority of the farmers interviewed did not agree on one primary goal. However, a relatively strong preference was indicated for a least preferred goal; "increasing leisure time" was ranked last by nearly 57 percent of the respondents. "Controlling more acreage" was chosen as a least preferred goal by 32 percent of the respondents. These distinct preferences are a function of the intensive type of agriculture, the large size of farms, labor costs and labor availability in the area. In addition, expansion may occur due to unexpected opportunities to enlarge rather than a conscious pursuit of such a goal.

Although no single goal was a predominant selection as the primary goal of the farm firm, "making the most annual profit" was ranked first by 32 percent of the respondents, while "maintaining or increasing family living levels", and "avoiding years of low profits or losses" were ranked first by 27 and 22 percent, respectively. Only 5 percent of the respondents indicated a preference for "increasing leisure time" as their primary goal.

Limitations of the Paired-Comparison Method in Evaluating Hierarchies of Farm Goals

The analysis was based on sample survey data obtained during the summer of 1970. As a result, the effect of the general economic conditions, weather conditions, and other items of changing annual influence could not be identified. A series of surveys taken over a period of years could possibly identify a more complete set of items influencing the hierarchy. Another general limitation is that the choice of criteria for subgroup classification was somewhat arbitrary. Different stratifications (subgroups) of the basic characteristics might improve the ability to scale the goals but, on the other hand, the chances are just as likely there would be no improvement. In addition, stratification into an increased number of subclasses could conceivably reduce the variation in responses and result in improved scaling ability.

The important and more controllable limitations of the study involve encroachments of two basic assumptions of the Method of Paired Comparisons: (1) the additivity of scale separations and (2) the occurrence of equal standard deviations. Complete compliance is crucial in developing acceptable scales for comparing hierarchies.

The additivity of scale separations implies the respondent can mentally determine a preference between two or more items. Implicitly, the ability to scale items 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 item i is a function of items j and k, at least two dimensions are involved. Edwards [5, p. 54] states "In practice, the test of significance is . . . primarily sensitive to lack of unidimensionality". Mosteller [14, p. 208] indicates that "this additive property will usually not hold" if unidimensionality is absent. Conscientious efforts were made by pretesting and counseling with experienced personnel to choose goals both relevant to the farmer and relatively independent but the high incidence of tests (Table 11) rejecting the null hypothesis that the paired-comparison model was valid indicate these efforts were only partially successful.

Violation of the second assumption of equal 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.[3] This procedure was not pursued in the analysis because there is no guarantee that the same items will remain in all hierarchies being compared for various subgroups. Consequently, the procedure delineated by Bock and Jones [2] was used only to indicate the causal factors of hierarchial differences but no attempt was made towards a comparative analysis of the scales between subgroups given in Appendix D.

Future studies should construct the items of choice so that they are clearly independent to alleviate difficulties encountered in the present study. Defining independent goals is difficult at best and may be impossible. An alternative is to seek the voluntary suggestions of relevant goals by the respondents. Self-expression of goals might reduce the interdependence encountered in this analysis. Regardless of whether goals are specified or self-expressed, procedures allowing all respondents to clearly distinguish between the statements used should aid in avoiding scaling problems resulting from interdependence.

Finally, the analysis only relates farm operator and farm firm characteristics to the hierarchy of multiple goals. It does not indicate the methods or procedures employed by farm operators in 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 the 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 over time.

[3]This situation can be analyzed using Thurstone's Case III model. Refer to Edwards [5, pp. 59-66] for the computational procedures and Krenz [10, pp. 1222-1223] for the results of eliminating widely dispersed items.

Bibliography

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

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

[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, October, 1961.

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

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

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

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

[8] Guttman, L. A. "A Basis for Scaling Qualitative Data." *American Sociological Review,* 9 (April, 1944), pp. 139-150.

[9] Kendall, M. G. *Rank Correlation Methods,* 3rd Edition. New York, Hafner, 1962.

[10] Krenz, Ronald D. "Paired Comparisons as Applied to Seeding Cropland to Grass." *Journal of Farm Economics,* Vol. 46, No. 5 (December, 1964), pp. 1219-1226.

[11] 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, September, 1967.

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

[13] 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 (1951a), pp. 203-206.

[14] 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 (1951b), pp. 207-218.

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

[16] 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,* Vol. 50, No. 3 (August, 1968), pp. 491-506.

[17] Siegel, Sidney. *Nonparametric Statistics.* New York: McGraw-Hill Book Company, 1956.

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

APPENDIX A

Paired-Comparison Format

The following questionnaire was used to obtain farm operator's preferences for the eight goals in this study. The order of presentation of statements within each pair was selected at random. The order in which the 28 pairs were presented was also selected at random. However, all respondents received the statements in the same order — the order shown below. Each pair of statements was typed on a card and the 28 cards were handed to the respondent at the start of the interview. The enumerator recorded answers as the respondent stated his preference between each pair of statements listed on the individual cards. This procedure helped to disassociate pairs of statements and, therefore, minimize biasing answers toward previous choices. The respondent was encouraged to select only one statement from each pair. However, if the respondent insisted he could not rank one goal over the other, indifference (or equal preference) between statements was allowed.

Enumerator Instructions to Respondent

Indicate your choice to the enumerator by the letter (a or b) beside the statement you prefer. The order of choices listed does not reflect importance. You need not be concerned with contradicting yourself since each pair of statements is included only once.

Questionnaire

You would prefer to:

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

15. a. ________ Control more acreage by renting or buying or
b. ________ Reduce borrowing needs

16. a. ________ Increase net worth from farm or off-farm investments or
b. ________ Increase time off from farming (leisure time)

17. a. ________ Increase time off from farming (leisure time) or
b. ________ Avoid years of low profits or losses

18. a. ________ Make the most profit each year (net above total farm costs) or
b. ________ Control more acreage by renting or buying

19. a. ________ Make the most profit each year (net above total farm costs) or
b. ________ Maintain or improve family's standard of living

20. a. ________ Avoid years of low profits or losses or
b. ________ Maintain or improve family's standard of living

21. a. ________ Avoid being forced out of business or
b. ________ Increase time off from farming (leisure time)

22. a. ________ Avoid being forced out of business or
b. ________ Reduce borrowing needs

23. a. ________ Make the most profit each year (net above total farm costs) or
b. ________ Increase time off from farming (leisure time)

24. a. ________ Reduce borrowing needs or
b. ________ Increase time off from farming (leisure time)

25. a. ________ Control more acreage by renting or buying or
b. ________ Avoid years of low profits or losses

26. a. ________ Reduce borrowing needs or
b. ________ Make the most profit each year (net above total farm costs)

27. a. ________ Avoid years of low profits or losses or
b. ________ Increase net worth from farm or off-farm investments

28. a. ________ Avoid being forced out of business or
b. ________ Increase net worth from farm or off-farm investments

APPENDIX B

Development of a Hypothetical Preference Matrix and Test for Inconsistency of an Individual's Responses to Four Comparative Judgments

Hypothetical Responses to Items A, B, C and D

A. Response 1—A is preferred to B
B. Response 2—C is preferred to D
C. Response 3—B is preferred to C
D. Response 4—A is preferred to C
E. Response 5—B is preferred to D
F. Response 6—A is preferred to D

Preference Matrix Formulation

Appendix Table I. Preference matrix.

	Columns	1	2	3	4
Rows	Items	A	B	C	D
1	A	---	0	0(1)	0(1)
2	B	1	---	0	0(1)
3	C	1(0)	1	---	0
4	D	1(0)	1(0)	1	---
5	a	3(1)	2(1)	1(2)	0(2)
6	a^2	9(1)	4(1)	1(4)	0(4)

The matrix is developed by recording the number one (1) for each column preference over the corresponding row as in response 1, A was preferred to B so one is recorded in column 1 and row 2; response 2, C was preferred to D so one is recorded in column 3 and row 4, etc. (Ignore the numbers in parentheses.) The summation of each column, a, in row five is squared in row six, and used for determining the number of circular triads (referred to as the d statistic). In this case where the number of items n = 4, no circular triads were committed (d=0) since:

$$d = (1/12)\,(n)\,(n-1)\,(2n-1) - 1/2 \sum_{i=1}^{n} a^2$$
$$= (1/12)\,(4)\,(3)\,(7) - 1/2\,(9+4+1+0)$$
$$= 0$$

and the respondent was perfectly consistent in his judgments.

To exemplify a case of inconsistency, let responses 4, 5 and 6 be reversed, and let the preference matrix values be those shown in parentheses. In this case the fourth response is C over A and D is preferred to both B and A in the fifth and sixth responses respectively. The $\sum_{i=1}^{n} a^2$ for the preference matrix is now 10 and d = 2. In checking, A was preferred to B in response 1 and B to C in response 3 but C was preferred to A in the revised response 4, resulting in one circular triad. Secondly, C was preferred to D in response 2 and D was preferred to B in the revised response 5 but in response 3, B was preferred to C. If the number of items, n, is even, Kendall [9, p. 146] indicates that the maximum num-- ber of circular triads is given by $(n^3—4n)/24$. If n is odd, the maximum is given by $(n^3—n)/24$. In this hypothetical example where n = 4, a maximum of two circular triads could be committed.

APPENDIX C

Determination of Individual Response Consistency

If a large number of circular triads is committed by an individual, there is reason to suspect that his preferences are merely random choices. Therefore, it is of interest to test the null hypothesis that the individual's choices are random. The one-sided alternative hypothesis states that an individual uses a fixed rationale for making his choices which results in a small number of triads. There is a great deal of confusion associated with testing the null and alternative hypotheses as evidenced by the fact that Edwards [5. p. 72] reached an erroneous conclusion to his example. This was primarily due to his failure to state explicitly the null and alternative hypotheses being tested.

Having stated the hypotheses, it is clear that if the number of circular triads is "small", the sample evidence tends to support the alternative hypothesis rather than the null hypothesis. Thus, if "d" is such that the probability of observing "d" or *less* circular triads is less than or equal to the significance level, α, the null hypothesis will be rejected; i.e., "d" is judged to be small. Since Kendall's table [9, p. 193] gives the probability of observing d or *more* circular triads, we must compute 1-P where P is the entry in the "P-column" corresponding to d+1 in order to obtain the probability of obtaining d or *less* circular triads.

If the parameters of Kendall's table are exceeded or if the table is unavailable, the following test statistic may be used (see Kendall [9], p. 157).

$$\chi_d^2 = \frac{8}{n-4}\left[\tfrac{1}{4}\binom{n}{3} - (d+1) + \tfrac{1}{2}\right] + v$$

where n = the number of items,

$\binom{n}{3}$ = The number of combinations of n things taken 3 at a time; also denoted by ${}_nC_3$

= $n!/[3!\,(n\text{-}3)!]$,

and v = the degrees of freedom associated with χ_d^2

$$= \frac{n(n-1)(n-2)}{(n-4)^2}$$

Since the value of χ_d^2 increases as the value of d decreases, the null hypothesis will be rejected whenever the calculated value of χ_d^2 exceeds the critical value in the χ^2 table corresponding to v degrees of freedom and a significance level of α. If the quantity of d+1 in the above formula is replaced by d, as indicated by Kendall and Edwards, then an approximation to the probability that the number of triads is less than or equal to d—1 is obtained and this alone does not determine whether or not d, the actual number of triads observed, is sufficiently small to reject the null hypothesis.

Example: Suppose it is desired to test the above null and alternative hypotheses at the 10 percent level of significance for an individual who committed $d = 9$ circular triads in stating preferences within each pairing of $n = 8$ items. From Kendall's table [9, p. 193], we find that $\Pr(d \geqq 10) = 0.906$ which implies that the probability of $d \leqq 9$ is equal to $1 - 0.906 = 0.094$ which is less than 0.10. Therefore, we reject the null hypothesis that the individual made random choices at the 10 percent level.

If we use the χ^2 approximation, $v = 8(7)(6)/(4)^2 = 21$ and

$$\chi_d^2 = 8/4\left[1/4\ (56) - 10 + 1/2\right] + 21 = 30.0$$

From a χ^2 table, the critical value corresponding to 21 degrees of freedom and significance level of 0.10 is given as 29.62 (when rounded to two decimal places). Since this value is less than the calculated value (30.0) of χ_d^2, we are again led to reject the null hypothesis. In fact, it is true that $d = 9$ is the largest number of observed triads for which the null hypothesis would be rejected at the 10 percent level of significance for $n = 8$.

APPENDIX D

Testing the Validity of the Paired-Comparison Model and Scaling of Preferences

This example follows the same steps outlined for the hypothetical example in the text. However, it is constructed from the survey data obtained from the respondents (a total of 30 operators) in the 40 to 49 years of age subgroup. The complete procedure is necessary to test the null hypothesis that the paired-comparison model assumed is valid and to estimate scale values associated with the choices of this particular age group.

Development of the Frequency Matrix

By recording the preferences (column preferred to row) of all individuals in the subgroup, the following frequency matrix was developed:

Appendix Table II. Frequency matrix for respondents of age 40 to 49.

Item:	Control more acres	Avoid being forced out of business	Maintain or increase family living	Avoid years of low profits	Increase leisure time	Increase net worth	Reduce borrowing needs	Make most annual profit	Total
Row									
1	--	15	18	20	13	20	18.5	19	123.5
2	15	--	26	24.5	5	14	12	20	116.5
3	12	4	--	16	6	12	13	12.5	75.5
4	10	5.5	14	--	6	16	9	18.5	79
5	17	25	24	24	--	23.5	25	25	163.5
6	10	16	18	14	6.5	--	16	17	97.5
7	11.5	18	17	21	5	14	--	22	108.5
8	11	10	17.5	11.5	5	13	8	--	76
Total	86.5	93.5	134.5	131	46.5	112.5	101.5	134	840
Rank order	7	6	1	3	8	4	5	2	

The matrix cells a_{ij}, where $i \neq j$, are interpreted as the number of individuals in the group which preferred the j^{th} item (indicated by the column heading) to the i^{th} item (indicated by the row heading). For example, of the 30 individuals, 15 preferred controlling more acres (first column) over avoiding being forced out of business (second row); 12 respondents preferred controlling more acres over maintaining or increasing family living (third row).

Similar statements can be made for the remainder of the values in the first column. Conversely, the number of respondents preferring other items over controlling more acres are represented by the values in the first row. For example, 20 individuals preferred to avoid years of low profits over controlling more acres. By adding the number observed in the two corresponding cells of each pair of choices (e.g., $a_{12} + a_{21}$), the total number of respondents in the subgroup is obtained; this procedure performs a check to insure that all responses are recorded. If a respondent has expressed indifference or equal preferences between a pair of choices, a score of .5 is placed in each cell of that pair of items (a_{71} and a_{17}).

The column totals indicate the relative importance, frequency-wise, of each choice. A rank order, last row, is developed from the column totals for purposes of rearranging the columns in the matrix from least to most important goal (left to right). Rows are also arranged from least to most important (top to bottom). This rank order will be used for goal identification in the tables throughout this appendix section.

Development of the Proportion Matrix

By rearranging the frequency matrix by the rank ordering and dividing each cell by the total number of respondents in the subgroup, a proportion matrix is developed.

Appendix Table III. Proportion matrix for respondents of age 40 to 49.

Rank order	8	7	6	5	4	3	2	1
8	---	.567	.833	.833	.783	.800	.833	.800
7	.433	---	.500	.617	.667	.667	.633	.600
6	.167	.500	---	.400	.467	.817	.667	.867
5	.167	.383	.600	---	.467	.700	.733	.567
4	.217	.333	.533	.533	---	.467	.567	.600
3	.200	.333	.183	.300	.533	---	.617	.467
2	.167	.367	.333	.267	.433	.383	---	.583
1	.200	.400	.133	.433	.400	.533	.417	---

Development of the Z matrix

The Z values are developed from the proportions by the use of a "Table of Normal Deviates Corresponding to the Proportions of a Dichotomized Unit Normal Distribution" [5, pp. 246-247]. If the number of respondents is less than 200 and some of the proportions are outside the range of .02 to .98, an alternative procedure is delineated by Edwards [5, p. 43].

Appendix Table IV. Z matrix for respondents of age 40 to 49.

Rank order	8	7	6	5	4	3	2	1
8	---	.169	.966	.966	.782	.842	.966	.842
7	—.169	---	.000	.298	.432	.432	.340	.253
6	—.966	.000	---	—.253	—.083	.904	.432	1.112
5	—.966	—.298	.253	---	—.083	.524	.622	.169
4	—.782	—.432	.083	.083	---	—.083	.169	.253
3	—.842	—.432	—.904	—.524	.083	---	.298	—.083
2	—.966	—.340	—.432	—.622	—.169	—.298	---	.210
1	—.842	—.253	—1.112	—.169	—.253	.083	—.210	---

Development of the Scale

A scale of the items can be derived by summing the columns of the Z matrix, including the diagonal elements as zero, and finding the mean value of each column. The mean may be positive or negative and should advance from the most negative to the most positive according to the rank order (from left to right).

The scale is found by first creating an origin of zero for the least preferred item. Change the sign of the mean coefficient of that item (which should be the first column) from a negative to a positive and add it to each of the mean values including itself. If comparative scales between groups are desired, the original scale can be converted to a common scale of zero to one by dividing each of the scalar values by the largest scalar value.

The following table indicates the scalar values and relative position of the preferences according to a common scale.

Appendix Table V. Scalar values and relative scalar preferences of respondents of age 40 to 49.

	Rank order							
Item	8	7	6	5	4	3	2	1
Sum of columns	—5.533	—1.586	—1.146	—.221	.709	2.404	2.617	2.756
Mean	—.692	—.198	—.143	—.028	.089	.301	.327	.344
Scalar value	0	.494	.549	.664	.781	.993	1.019	1.036
Common scale	0	.477	.530	.641	.754	.957	.984	1.000

Development of the Theoretical Z Matrix

A theoretical Z matrix is built from the scalar values of Appendix Table V, row 3. The procedure is to change the sign of each scalar value to a negative and transform the row of scalar values to the left column (8) in the theoretical Z matrix. To develop successive columns, subtract the first value encountered such as row 7, column 8 from each value in all other rows of the same column and enter the answer in the next column of the corresponding row. For example, to develop column 7, subtract —.494 (first value encountered in column 8 of row 7) from —.549 in row 6 to get —.055 and record it in column 7 row 6. Then subtract —.494 from —.664 in row 5 to obtain —.170 and record it in column 7 row 5. Continue this process until column 7 is completed and repeat the procedure using column 7 values to develop column 6. Continue until all elements below the main diagonal are calculated.

Appendix Table VI. Theoretical Z matrix for respondents of age 40 to 49.

	Column:							
Row	8	7	6	5	4	3	2	1
8	---							
7	—.494	---						
6	—.549	—.055	---					
5	—.664	—.170	—.115	---				
4	—.781	—.287	—.232	—.117	---			
3	—.993	—.498	—.443	—.328	—.211	---		
2	—1.019	—.525	—.470	—.355	—.238	—.027	---	
1	—1.036	—.542	—.487	—.372	—.255	—.044	—.017	---

Development of the Theoretical Proportion Matrix

By utilizing the "Table of Normal Deviates Corresponding to Proportions of a Dichotomized Unit Normal Distribution", the lower left hand portion of the matrix of theoretical proportions can be de-

Appendix Table VII. Theoretical proportion matrix for respondents of age 40 to 49.

	Column							
Row	8	7	6	5	4	3	2	1
8	---							
7	.311	---						
6	.292	.478	---					
5	.253	.432	.454	---				
4	.217	.387	.408	.454	---			
3	.161	.309	.329	.372	.417	---		
2	.154	.300	.319	.361	.406	.489	---	
1	.150	.294	.313	.355	.399	.483	.493	---

veloped. Locate each nonzero value of the theoretical Z matrix in the "Table of Normal Deviates Corresponding to Proportions of a Dichotomized Unit Normal Distribution". Read the corresponding proportion and record it in the same p_{ij} cell in the proportion matrix as the z_{ij} coefficient was in the Z matrix.

Development of Angular Transformation Matrices

Using a "Table of Angular Transformations of Percentages to Degrees" [5, p. 248], the deviations of the observed from the expected responses of each pair of choices can be calculated and statistically tested. The first matrix of angular transformations, θ, is derived from the observed proportions (Appendix Table III) and the second, θ', from the theoretical proportion matrix (Appendix Table VII). Use only the elements below the main diagonal of each matrix and convert the proportions to percentages by multiplying by 100.

Appendix Table VIII. Angular transformation matrix, θ, from observed proportions matrix, Appendix Table III.

Rank order	8	7	6	5	4	3	2	1
8	----							
7	41.15	----						
6	24.12	45.00	----					
5	24.12	38.23	50.77	----				
4	27.76	35.24	46.89	46.89	----			
3	26.56	35.24	25.33	33.21	46.89	----		
2	24.12	37.29	35.24	31.11	41.15	38.23	----	
1	26.56	39.23	21.39	41.15	39.23	46.89	40.22	----

Appendix Table IX. Angular transformation matrix, θ', from theoretical proportions matrix, Appendix Table VII.

Rank order	8	7	6	5	4	3	2	1
8	----							
7	33.89	----						
6	32.71	43.74	----					
5	30.20	41.09	42.36	----				
4	27.76	38.47	39.70	42.36	----			
3	23.66	33.77	35.00	37.58	40.22	----		
2	23.11	33.21	34.39	36.93	39.58	44.37	----	
1	22.79	32.83	34.02	36.57	39.17	44.03	44.60	----

Development of Angular Deviations Matrix

Subtract each θ'_{ij} from each θ_{ij} to develop the angular deviations matrix and record the answers in the corresponding $(\theta_{ij} - \theta'_{ij})$ cell in Appendix Table X.

Appendix Table X. Angular deviations matrix, θ-θ', of respondents of age 40 to 49.

Rank order	8	7	6	5	4	3	2	1
8	----							
7	7.29	----						
6	—8.59	1.26	----					
5	—6.08	—2.86	8.41	----				
4	0	—3.23	7.19	4.53	----			
3	2.90	1.47	9.67	—4.37	6.67	----		
2	1.01	4.08	.85	—5.82	1.57	—6.14	----	
1	3.77	6.40	—12.63	4.58	.06	2.86	—4.38	----

Test for Validity of the Assumed Paired-Comparison Model

The test statistic for testing the null hypothesis is

$$\chi^2 = R \sum_{i=2}^{n} \sum_{j=1}^{i-1} (\theta_{ij} - \theta'_{ij})^2/821 \qquad (3)$$

where R is the number of respondents and n is the number of items. The test statistic has approximately a chi-square distribution with $[(n-1)(n-2)]/2$ degrees of freedom. The null hypothesis, the paired-comparison model is valid, is rejected at a given significance level, α, if the calculated value of χ^2 exceeds the tabulated chi-square. Otherwise, the null hypothesis is not rejected. In this example, with $R=30$ and $n=8$, the calculated χ^2 value is 31.1, and the appropriate number of degrees of freedom is 21. The tabulated χ^2 value at the .05 level of significance with 21 degrees of freedom is 32.67. Thus, the null hypothesis is not rejected and we accept the validity of the paired-comparison model.

Summary of Common Scalar Values for Selected Characteristics: Derived by the Paired-Comparison Method

The following table indicates the common scalar values derived by the paired-comparison technique. Refer to Table 11 in the text for the specific subgroup χ^2 value and probability of a larger value occurring. The rejection of the paired-comparison model by most of the subgroup analyses precludes making valid comparisons. The results are only presented as a means of communicating the relevance and flexibility of the technique under more suitable conditions, i.e., acceptance of the paired-comparison model.

Appendix Table XI Common scalar values and rank order of goals based on specified stratifications of selected farmer characteristics.

Group characteristic	Subgroup definition	No. of respond-ents	Make most profit	Avoid low profits	Maintain family living	Avoid being forced out of business	Increase net worth	Reduce borrowing needs	Control more acres	Increase leisure time
			Common scalar value and rank							
Age	<30	11	1.000(1)	.944(3)	.952(2)	.678(7)	.910(4)	.746(6)	.890(5)	0(8)
	30-39	21	.968(3)	1.000(1)	.945(5)	.952(4)	.977(2)	.795(6)	.683(7)	0(8)
	40-49*	30	.984(2)	.957(3)	1.000(1)	.530(6)	.754(4)	.641(5)	.477(7)	0(8)
	50-59	33	1.000(1)	.922(2)	.614(5)	.473(6)	.718(3)	.627(4)	.306(7)	0(8)
	≧60*	23	1.000(1)	.848(2)	.765(4.5)	.811(3)	.586(6)	.765(4.5)	0(8)	.414(7)
Farming experience	≦10	23	.993(2)	1.000(1)	.915(3)	.782(5)	.865(4)	.704(6)	.661(7)	0(8)
	11-20	19	.777(5)	1.000(1)	.836(3)	.704(7)	.917(2)	.831(4)	.705(6)	0(8)
	21-30*	41	1.000(1)	.901(2)	.752(3)	.431(6)	.706(4)	.637(5)	.303(7)	0(8)
	>30	35	1.000(1)	.773(2)	.677(3)	.656(4)	.575(5)	.571(6)	0(8)	.123(7)
Education level	<high school	40	1.000(1)	.811(2)	.671(3.5)	.671(3.5)	.473(6)	.567(5)	.121(7)	0(8)
	<2 yrs. of col.	56	.916(2)	1.000(1)	.869(3)	.591(6)	.849(4)	.783(5)	.454(7)	0(8)
	≧2 yrs. of col.	22	1.000(1)	.891(4)	.898(3)	.740(5)	.927(2)	.663(6)	.636(7)	0(8)
Number of dependents	<2	45	1.000(1)	.673(2)	.566(4)	.528(6)	.604(3)	.548(5)	.075(7)	0(8)
	2	16	.854(2)	1.000(1)	.659(4)	.546(6)	.819(3)	.587(5)	.500(7)	0(8)
	3*	29	.991(2)	1.000(1)	.960(3)	.714(5)	.850(4)	.709(6)	.647(7)	0(8)
	4	16	1.000(1)	.954(3)	.937(4)	.577(7)	.864(5)	.997(2)	.769(6)	0(8)
	≧5	12	.698(3)	1.000(1)	.929(2)	.696(4)	.332(6)	.498(5)	0(8)	.008(7)
Acres of cropland	≦640*	37	1.000(1)	.949(2)	.892(4)	.921(3)	.872(5)	.637(6)	.544(7)	0(8)
	641-1,280	37	1.000(1)	.898(2)	.757(3)	.565(6)	.723(5)	.732(4)	.301(7)	0(8)
	1,281-2,560	29	1.000(1)	.906(2)	.765(3)	.677(5)	.726(4)	.620(6)	.499(7)	0(8)
	>2,560*	15	.870(3)	1.000(1)	.823(4)	.307(6)	.584(5)	.982(2)	0(8)	.139(7)
Off-farm income[1]	<$1,000	59	1.000(1)	.945(2)	.840(3)	.391(7)	.825(4)	.726(5)	.547(6)	0(8)
	$1,000-$4,999	26	1.000(1)	.809(3)	.827(2)	.569(6)	.605(5)	.657(4)	.150(7)	0(8)
	$5,000-$9,999	21	.961(3)	1.000(1)	.858(6)	.982(2)	.951(4)	.912(5)	.791(7)	0(8)
	≧$10,000*	7	.826(2)	1.000(1)	.257(6)	.736(3)	.506(4)	0(8)	.245(7)	.467(5)
Asset level[1]	<$100,000	39	1.000(1)	.958(3)	.942(4)	.971(2)	.815(6)	.882(5)	.530(7)	0(8)
	$100,000-249,999	33	1.000(1)	.862(2)	.640(4)	.387(6)	.670(3)	.534(5)	.267(7)	0(8)
	≧$250,000	37	1.000(1)	.963(2)	.866(3)	.398(6)	.850(4)	.686(5)	.386(7)	0(8)
Debt level[1]	<$25,000	51	1.000(1)	.989(2)	.795(4)	.828(3)	.781(5)	.671(6)	.436(7)	0(8)
	$25,000-49,999*	21	1.000(1)	.852(2)	.778(3)	.453(6)	.600(5)	.749(4)	.080(7)	0(8)
	≧$50,000	39	1.000(1)	.930(2)	.914(3)	.523(6)	.868(4)	.761(5)	.481(7)	0(8)

Appendix Table XI Common scalar values and rank order of goals based on specified stratifications of selected farmer characteristics. (continued)

Group characteristic	Subgroup definition	No. of respond-ents	Make most profit	Avoid low profits	Maintain family living	Avoid being forced out of business	Increase net worth	Reduce borrowing needs	Control more acres	Increase leisure time
			Common scalar value and rank							
Type of cattle operations	Cow-calf only	60	1.000(1)	.873(2)	.742(3)	.658(4)	.647(5)	.568(6)	.220(7)	0(8)
	Stockers	36	.898(2)	1.000(1)	.657(5)	.585(6)	.762(3)	.685(4)	.468(7)	0(8)
	Cow-calf and stockers*	22	.928(2)	.734(5)	1.000(1)	.622(6)	.776(3)	.743(4)	.395(7)	0(8)
Minimum vacation time desired	≦7 days	70	1.000(1)	.925(2)	.894(3)	.746(5)	.800(4)	.690(6)	.543(7)	0(8)
	8-14 days	38	1.000(1)	.982(2)	.671(5)	.643(6)	.729(3)	.706(4)	.115(7)	0(8)
	>14 days*	10	1.000(1)	.834(2)	.645(5)	.311(6)	.652(4)	.680(3)	.110(7)	0(8)
Acres of land	≦640 acres*	19	.831(4)	.984(3)	.996(2)	1.000(1)	.792(5)	.725(6)	.457(7)	0(8)
	641-1,280	37	1.000(1)	.738(2)	.700(3)	.502(6)	.630(4)	.602(5)	.290(7)	0(8)
	1,281-2,560	32	.923(2)	1.000(1)	.792(3)	.692(5)	.730(4)	.597(6)	.453(7)	0(8)
	2,561-5,120*	20	1.000(1)	.754(2)	.705(5)	.606(6)	.711(4)	.732(3)	.437(7)	0(8)
	>5,120 acres*	10	.776(3)	1.000(1)	.467(5)	0(8)	.824(2)	.689(4)	.055(7)	.144(6)
Net worth level[1]	$1-$99,999	51	1.000(1)	.966(2)	.950(3)	.859(4)	.821(5)	.667(6)	.538(7)	0(8)
	$100,000-249,999	33	1.000(1)	.949(2)	.776(3)	.516(6)	.571(5)	.691(4)	.255(7)	0(8)
	≧$250,000	21	.886(2)	1.000(1)	.553(4)	.271(7)	.863(3)	.454(5)	.366(6)	0(8)
Livestock production experience	≦5 years*	32	1.000(1)	.870(2)	.771(3)	.716(5)	.756(4)	.582(6)	.451(7)	0(8)
	6-10 years*	13	1.000(1)	.849(2)	.621(5)	.325(7)	.790(3)	.647(4)	.590(6)	0(8)
	11-20 years	20	.779(4)	1.000(1)	.972(2)	.753(5)	.705(6)	.842(3)	.469(7)	0(8)
	>20 years	53	1.000(1)	.853(2)	.681(3)	.509(6)	.645(4)	.560(5)	.112(7)	0(8)
Irrigation experience	none*	53	1.000(1)	.958(2)	.736(3)	.714(4)	.687(5)	.664(6)	.417(7)	0(8)
	1-5 years*	25	1.000(1)	.961(2)	.828(3)	.490(6)	.817(4)	.627(5)	.366(7)	0(8)
	6-10 years*	19	1.000(1)	.797(4)	.955(2)	.756(6)	.862(3)	.770(5)	.456(7)	0(8)
	11-15 years	11	.722(3)	1.000(1)	.734(2)	.448(6)	.666(4)	.632(5)	.372(7)	0(8)
	>15 years*	10	1.000(1)	.932(2)	.788(3)	.653(6)	.686(4)	.679(5)	0(8)	.154(7)
Total farm income[1]	<$20,000	35	1.000(1)	.862(4)	.914(2)	.909(3)	.689(6)	.742(5)	.389(7)	0(8)
	$20,000-39,999*	20	1.000(1)	.954(2)	.595(5)	.506(6)	.799(3)	.701(4)	.485(7)	0(8)
	$40,000-69,999	25	.969(2)	1.000(1)	.742(4)	.479(6)	.785(3)	.708(5)	.395(7)	0(8)
	$70,000-139,999	22	1.000(1)	.921(4)	.928(2)	.432(6)	.925(3)	.603(5)	.338(7)	0(8)
	≧$140,000*	11	1.000(1)	.783(4)	.839(3)	.606(6)	.854(2)	.724(5)	.413(7)	0(8)

[1]Nonrespondents were excluded.

NOTE: < means "less than" and > means "more than".

*Indicates acceptance of the paired-comparison model for significant scaling.

APPENDIX E

Regression Equations and Corresponding Coefficients

This appendix includes the set of equations estimated for predicting the scalar values of each goal. An equation was estimated for each of the eight goals. Only linear and quadratic forms were considered, and cross-products were limited to linear forms. All beta coefficients were required to be significant at the 5 percent level. Definitions of the variables, the estimated equations and standard errors of the coefficients are shown below.

Definition of dependent variables

Y_1 = Control more acres.
Y_2 = Avoid being forced out of business.
Y_3 = Maintain or increase family living.
Y_4 = Avoid low profits or losses.
Y_5 = Increase leisure time.
Y_6 = Increase net worth.
Y_7 = Reduce borrowing needs.
Y_8 = Make most annual profits.

Definition of independent variables

X_1 = Age in years.
X_2 = Farming experience in years.
X_3 = Tenure of operator where 1 = owner operator, 2 = partial owner-renter and 3 = renter only.
X_4 = Educational level where 0 = incomplete high school and vocational school, 1 = incomplete high school and complete vocational school, 2 = completed high school only, 3 = completed high school and vocational school, 4 = completed one year of college, 5 = two years of college, 6 = three years of college, 7 = four years of college and 8 = more than four years of college.
X_5 = Acres of cropland in operation.
X_6 = Acres of land in operation.
X_7 = Total farm income where 0 = less than \$1,000, 1 = \$1,000 to \$4,999, 2 = \$5,000 to \$9,999, 3 = \$10,000 to \$19,999, 4 = \$20,000 to \$39,999, 5 = \$40,000 to \$69,999, 6 = \$70,000 to \$99,999, 7 = \$100,000 to \$139,999, 8 = \$140,000 to \$179,999 and 9 = \$180,000 and over.
X_8 = Net off-farm income coded like X_7.

X_9 = Assets in hundred dollars.
X_{10} = Debts in hundred dollars.
X_{11} = Number of dependents.
X_{12} = Acres of owned land.
X_{13} = Acres of owned cropland.
X_{15} = Net worth in hundred dollars; $X_9 - X_{10}$
X_{16} = Debt-asset ratio; X_{10}/X_9.
X_{17} = Proportion of land owned (not percentage); X_{12}/X_6.
X_{18} = Proportion of cropland owned (not percentage); X_{13}/X_5.

Appendix Table XII. Regression coefficients and corresponding standard errors.[1]

Independent variables	Form	Dependent variables $\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
Intercept	Linear	23.603 (12.724)	73.334 (8.190)	74.379 (4.572)	—43.445 (19.862)	—202.690 (47.083)	85.985 (23.796)	69.207 (5.903)	158.330 (20.150)
X_1	Linear						—1.321 (—.626)		
	Quad.	—.009 (.003)	—.007 (.003)						
X_2	Linear					3.673 (.947)	1.490 (.626)		
	Quad.					—.045 (.018)			
X_3	Linear				25.327 (6.643)	148.216 (43.233)			—38.380 (9.078)
	Quad.					—30.859 (10.168)			
X_4	Linear						19.512 (4.742)		
	Quad.	—1.079 (.259)					—1.191 (.507)		
X_5	Linear		—.008 (.003)			—.033 (.009)			
	Quad.					7.69×10^{-6} (1.76×10^{-6})		2.08×10^{-6} ($.85 \times 10^{-6}$)	
X_6	Linear	.012 (.004)					.009 (.003)	—.010 (.003)	

Appendix Table XII Continued.

Independent variables	Form	Dependent variables							
		$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
X_7	Linear					12.498 (5.362)			
	Quad.					—1.361 (.510)			—1.340 (.363)
X_8	Linear			—26.667 (8.783)					
	Quad.						—1.311 (.425)	—2.293 (1.134)	
X_9	Linear	(.038) (.008)		(.045) (.011)	—.027 (.014)	.008 (.003)			
	Quad.		-1.6×10^{-7} $(.7\times10^{-7})$			-4.100×10^{-7} (2.000×10^{-7})			
X_{10}	Quad.				9.69×10^{-6} (4.03×10^{-6})				
X_{11}	Linear				12.741 (3.626)				—13.950) (3.289)
	Quad.	—1.850 (.407)			—.745 (.329)				1.300 (.331)
X_{12}	Linear	—.033 (.007)		—.060 (.018)	.074 (.017)			.018 (.005)	
	Quad.			1.8×10^{-6} (6.4×10^{-7})					5.23×10^{-6} (1.08×10^{-6})
X_{13}	Linear				—.100 (.028)				

Appendix Table XII Continued.

Independent variables	Form	$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
		Dependent variables							
X_{15}	Linear	—.036 (.010)		—.031 (.007)	.052 (.017)			—.005 (.002)	
X_{16}	Linear				48.258 (15.545)		—216.732 (62.179)		
	Quad.			—19.801 (7.898)			55.888 (16.990)		
X_{17}	Linear				60.600 (15.227)	—97.646 (48.805)			—208.47 (52.977)
	Quad.	39.162 (11.804)				112.092 (49.263)		—28.392 (10.907)	232.41 (58.40)
X_{18}	Linear								158.66 (43.499)
	Quad.		23.839 (8.253)				16.139 (7.375)		
X_1X_8	Linear			.510 (.166)					
X_1X_{11}	Linear						—.221 (.058)		
X_1X_{12}	Linear				.002 ($.35 \times 10^{-3}$)				

Appendix Table XII Continued.

Independent variables	Form	Dependent variables							
		$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
X_1X_{13}	Linear				.002				
					$(.5 \times 10^{-3})$				
X_1X_{16}	Linear						5.956		
							(1.907)		
X_2X_5	Linear						5.056×10^{-4}		
							(2.0×10^{-4})		
X_2X_6	Linear						-4.322×10^{-4}		
							(1.0×10^{-4})		
X_2X_9	Linear						1.906×10^{-4}		
							$(.6 \times 10^{-4})$		
X_2X_{16}	Linear					—2.210	—6.029		
						(.816)	(1.876)		
X_3X_4	Linear						—3.755		
							(1.538)		
X_3X_7	Linear								6.210
									(1.656)
X_3X_8	Linear	—5.037							
		(2.451)							

Appendix Table XII Continued.

Independent variables	Form	Dependent variables							
		$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
X_3X_9	Linear			—.012 (.004)					
X_3X_{11}	Linear	8.325 (1.749)					2.786 (1.123)		
X_3X_{12}	Linear			.020 (.008)					
X_4X_8	Linear	4.170 (1.171)							
X_4X_{12}	Linear			.002 $(.8 \times 10^{-3})$					
X_4X_{17}	Linear					11.067 (4.211)			
X_4X_{18}	Linear		—5.531 (2.382)			—8.852 (3.852)			
X_5X_8	Linear		.002 $(.8 \times 10^{-3})$						
X_5X_{11}	Linear	—.006 (.002)							

Appendix Table XII Continued.

Independent variables	Form	Dependent variables							
		$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
X_5X_{13}	Linear				1.098×10^{-5} $(.4 \times 10^{-5})$				
X_5X_{17}	Linear						—.029 (.006)		
X_6X_8	Linear							.004 (.002)	
X_6X_9	Linear				4.19×10^{-6} (1.0×10^{-6})				
X_6X_{13}	Linear				6.34×10^{-6} (2.1×10^{-6})				
X_6X_{16}	Linear				.012 (.004)				
X_7X_{16}	Linear					7.593 (3.210)			
X_8X_9	Linear	—.016 (.004)							
X_8X_{11}	Linear	3.445 (1.313)							

Appendix Table XII Continued.

Independent variables	Form	Dependent variables							
		$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
X_8X_{15}	Linear	.019							
		(.004)							
X_8X_{17}	Linear								45.100
									(18.182)
X_8X_{18}	Linear								—47.680
									(15.984)
X_9X_{11}	Linear				.003				
					(.001)				
X_9X_{12}	Linear	-9.79×10^{-6}							2.23×10^{-6}
		(2.24×10^{-6})							$(.5\times10^{-6})$
X_9X_{15}	Linear				4.19×10^{-6}				
					$(.9\times10^{-6})$				
X_9X_{17}	Linear					—.015			
						(.004)			
$X_{11}X_{12}$	Linear	.004							.004
		(.001)							(.001)

Independent variables	Form	Dependent variables							
		$\hat{Y}_1$	$\hat{Y}_2$	$\hat{Y}_3$	$\hat{Y}_4$	$\hat{Y}_5$	$\hat{Y}_6$	$\hat{Y}_7$	$\hat{Y}_8$
$X_{11}X_{13}$	Linear			.004 (.002)					
$X_{12}X_{15}$	Linear	1.23×10^{-5} $(.3 \times 10^{-5})$							
$X_{15}X_{18}$	Linear					.014 (.004)			
$X_{17}X_{18}$	Linear								—213.350 (53.800)

[1]Standard errors are indicated in parentheses.

0672/1.15M