Farmers attitudes toward and evaluation and use of insurance for income protection on Montana wheat farms
by Gordon E Rodewald

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Economics
Montana State University

Abstract:
This research problem was designed to examine and evaluate farmers' attitudes toward crop insurance and to test the adequacy of crop insurance and to test the adequacy of crop insurance as a means of alleviating the adverse effects of yield variability encountered in dryland grain farming. Crop insurance was defined as any insurance available for crop protection; in Montana this includes all-risk insurance and crop-hail insurance.

The hypotheses were: 1) that the use of crop insurance is more important in the short-run than in the long-run and; 2) that the farmer's use of crop insurance is influenced by his attitude toward and evaluation of crop insurance in relation to other methods of income protection. The tests were conducted with emphasis given to the beginning years for the farmer.

To test this hypothesis and the adequacy of crop insurance the farmers attitude toward planning his farming operation, his attitude toward crop insurance, his evaluation of hazards faced, and his evaluation of alternative methods of protecting his farm income were determined. These tests were conducted through the use of; 1) the Guttman scalogram technique for measuring attitudes, and 2) the paired comparisons technique for determining rank order and finding the scale separation between hazards and alternative methods of income protection. The results of this analysis were then compared to the results of budget analysis to determine the adequacy of crop insurance. This was done for two areas; the Triangle winter wheat and the Northeast spring wheat.

Four yield series compiled from state lease data were used. Two series from each area were used which were 17 to 20 years in length and in each case the average yield of the series approximated that of its respective area.

To determine the effectiveness of crop insurance it was necessary to consider, in addition to cash expenses, the cost of maintaining the farm household. With these expenses it was possible to determine the effect on farm income of yield variability both in the short and long-run, This was done for the farm using and not using insurance.

It was found in the study that farmers have a negative attitude toward the use of crop insurance. This was coupled with a low placing of crop insurance in relation to alternative methods of reducing the effects of low yields. In addition the budget analysis revealed that this appraisal by farmers may be accurate with respect to policies presently available.

FARMERS ATTITUDES TOWARD AND EVALUATION AND USE OF INSURANCE FOR INCOME PROTECTION ON MONTANA WHEAT FARMS

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Gordon E. Rodewald, Jr.

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ABSTRACT

This research problem was designed to examine and evaluate farmers' attitudes toward crop insurance and to test the adequacy of crop insurance and to test the adequacy of crop insurance as a means of alleviating the adverse effects of yield variability encountered in dryland grain farming. Crop insurance was defined as any insurance available for crop protection; in Montana this includes all-risk insurance and crop-hail insurance.

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CHAPTER I

INTRODUCTION

Risk and uncertainty in Great Plains agriculture arises from climatic factors, insects, disease, and fluctuations in prices paid and prices received. One way to alleviate the adverse effects of risk and uncertainty is to use crop insurance.

THE PROBLEM SITUATION

The uncertain situation faced by Great Plains farmers has led to the use of insurance as a managerial tool to reduce variability in farm income.

Agriculture on the Great Plains

The Great Plains farmer has always been faced with features which make farming difficult. Among these are great expanses of flat and treeless land and a variable semiarid climate. 1/ Only the climate has been a continuing problem, although the great expanses of level land certainly contribute in a causal way to the climate and to the damaging effects of some of the climatic phenomena. These include blizzards and chinook winds in winter and hailstorms and hot winds in summer.

1/ According to Web the flat, treeless land offers no obstructions for air movement. This results in constant movement of air which results in frequent winds of high velocity. Farmers were unfamiliar with this. See Walter Prescott Webb, The Great Plains, Ginn and Company, New York, 1931, pp. 3 and 6.

Average precipitation in a semiarid area is generally marginal for crop production. Even moderate variations below the average reduce yields sharply, and variations in this direction need not be large to bring complete crop failure. On the other hand modest variations above the mean increase yields significantly and the more extremely favorable weather patterns that have been experienced have demonstrated the physical capacity of the Plains to produce yields as high as any other area.

All of these cause considerable damage each year to growing crops and to the farmer their occurrence is uncertain. There will be years when rainfall is insufficient to produce a crop adequate to cover operating expenses. Montana Agricultural Statistics show that these events do not necessarily come one at a time but may indeed last several years. For example from 1933 to 1938 production in the Northeast Spring wheat counties ranged from 1.5 to 10 bushels per acre, averaging 4.95 bushels per acre. 2/ Hot dry winds are not limited to periods of drouth, but have much the same end result.

Hailstorms, blizzards, and chinooks, when they occur, do less general damage to crops during the year, but may destroy a crop for an individual farmer. Blizzards and chinook winds do this by winter killing or freezing the crop and hailstorms by knocking it down and threshing it during the late stages of development.

2/ Montana Agricultural Statistics, Volume V, Montana Department of Agriculture, Cooperating with the United States Department of Agriculture, Agricultural Marketing Service, Helena, Montana, December, 1954, pp. 57-100.

Improvements have been made in cultivation methods, varieties of seed, and management techniques, all of which tend to lessen the effect of drouth, insects, rust, and other diseases. Even with these improvements there is no physical method for protecting against the parching hot winds and hailstorms which destroy potentially good crops. For this reason farmers have turned to insurance as a means of combating these uncertainties and stabilizing their farm incomes.

Risk and Uncertainty Defined

Many definitions have been given for uncertainty and the associated risk, however for the purposes of this paper the definitions given by Frank Knight will be used. Knight states "risk is a measurable uncertainty, and uncertainty is an unmeasurable uncertainty. The practical difference between the two is that in risk the distribution of the outcome in a group of instances is known (either through calculations a priori or from statistics of past experience). In uncertainty it is, in general, impossible to form a group of instances, because the situation is in a high degree unique. If the distribution of different possible outcomes in a group of instances is known, it is possible to get rid of any real uncertainty by the expedient grouping of instances. That it is possible does not mean that this will be done and for the individual there is no difference between a measurable uncertainty and an unmeasurable uncertainty." 3/

3/ Frank H. Knight, Risk, Uncertainty, and Profit, Houghton Mifflin Company, New York, 1921, pp. 223-234.

Using Knight's definition we can say that factors such as climate and price fluctuations are unmeasurable uncertainties for the individual farmer. However, the income effects of most climatic factors such as hail, drouth, and wind are uncertainties which may be shifted to an insurance company which can group the instances and become the risk taker. To the extent that a farmer shifts the uncertainty through the use of insurance the impact of the event may be lessened. Unless the farmer takes insurance every year for these contingencies they are still uncertain to the farmer. Even if the farmer carries insurance every year an element of income uncertainty remains in the form of price and yield uncertainty which cannot be fully insured.

Use of Insurance in Agriculture

The first attempt to insure growing crops was against hail on Connecticut tobacco in 1880. By 1920 hail insurance sold by mutuals, stock companies and state hail departments was adopted by Great Plains farmers. 4/ The first attempt to insure crops for other than hail came in the form of a general crop insurance in 1899, followed again in 1917, 1919, 1931, and 1937. All of these were by private companies and all failed. 5/ In 1938 Congress passed the Federal Crop Insurance Act which

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4/ John C. Ellickson, Hail Insurance on Growing Crops, United States Department of Agriculture, Information Bulletin 56, processed June, 1951, pp. 10-11.

5/ William G. Murray, Agricultural Finance, Iowa State College Press, Ames, Iowa, 1953, p. 161.

now provides all-risk insurance for such crops as wheat, cotton, flax, corn, tobacco, beans, citrus, and combinations of crops.

Many people who chose farming as an occupation will have as their first goal survival of the farm firm and the farm household. This may be accomplished by maintaining a favorable net worth position and increasing his net worth over time until his survival goal is assured. This means the farmer needs "to manage production, inventories, cash reserves, and access to outside funds (through insurance and credit) so as to minimize the probability of a risk loss large enough to render the farmer insolvent". 6/ The insolvent position is defined to be where cash receipts fall short of meeting necessary production and family living expenses as well as debt and tax payments. In the Great Plains region this survival goal is not always easily attained because of the uncertainties previously mentioned and by the precarious capital position of beginning farmers. The second goal of many farmers will be capital accumulation. They will try to attain this after the survival goal has been reached. The survival goal of the farmer may be considered to be the short-run goal and capital accumulation the long-run goal.

With the advent of crop insurance the farmer was faced with the decision of whether or not to protect his income with insurance. He may make this decision each year or he may make the decision once.

6/ Rainer Schickele, "Farmer's Adaptations to Income Uncertainty", Journal of Farm Economics, Vol. XXXII, No. 3, August, 1950, p. 363.

There are many reasons why farmers faced with uncertainties choose to use or not to use insurance. Among these are attitudes toward insurance which may be affected by such factors as age, experience, the size of unit, net worth position or cost of insurance. A farmer may play hunches and buy all-risk or crop-hail insurance only once in a while, say one out of four years, thinking he can in this manner make insurance pay off for him, which it may actually do. In this case he may be calculating a priori the probability of an event such as a hail storm occurring. This type of calculation would be a subjective judgment on the part of the farmers. Some farmers may not use insurance because they consider the impact of the risk to be so slight as not to warrant its use. There may also be institutional reasons why farmers choose to use or not use insurance. These may stem from past experience with the insurance companies, for example, unsatisfactory adjustment of losses.

Insurance Policies Presently Available

In Montana, Federal Crop Insurance is offered for wheat in 19 counties and for barley in six. As written in 1939 and revised in 1946 the Federal Crop Insurance Act states that the amount of the coverage offered per acre must be an amount lower than the per acre cost of producing the crop in the area and in no case shall it exceed 75 percent of the average yield.

As this is an all-risk type policy the indemnity may be collected if damage to the crop is from any natural cause and if the damage brings the average yield for the farm below the yield of coverage. This level of coverage varies between areas and between counties depending upon the

risk of the area. In the spring wheat counties the coverage varies from 4 to 9 bushels, for the winter wheat counties it varies from 4 to 12.6. The lower coverages are usually associated with fields where continuous cropping is practiced.

The premium rates charged vary according to the coverage and risk associated with the area from .85 bushels to 1.15 bushels in the spring wheat area and from .59 bushels to 1.50 bushels in the winter wheat area.

Reductions in premiums are available to the farmer who insures 200 acres or over. The reduction to him is 4 percent if his insured acreage is over 200 acres and 2 percent for each additional 100 acres. In addition reductions are available to every farmer; for each no-loss-year he will receive a reduction of 5 percent up to a maximum of 50 percent. If the farmer has five consecutive no-loss years and has a loss the sixth year his premium will then go back to a 15 percent reduction. This means that if a farmer carries it every year and can go four years without a loss his premium will be reduced at least 15 percent regardless of the losses experienced after that.

Hail insurance is less complicated than Federal Crop Insurance. It operates the same as fire insurance, automobile insurance, or any insurance where the indemnity is paid on the percent of damage.

There are about 43 stock hail insurance companies operating in Montana along with the State Hail Board insurance. The private companies all offer identical coverages and rates. The coverage offered for hail insurance by these companies is the amount of coverage the farmer feels

he needs, the coverage cannot exceed the expected value of the crop. The State Hail Board limits coverage to $12 an acre.

The Research Problem

The purpose of this research is to determine farmer's attitudes toward and evaluation of all-risk and crop-hail insurance in relation to alternative methods of protecting farm incomes. Farmers appraisal of the hazards faced will also be determined. A test of the adequacy of all-risk and crop-hail insurance as a means of reducing the effects of yield variability on the flow of farm incomes will be conducted in an effort to relate this to farmers attitudes and evaluations.

OBJECTIVES

The general objective of this study will be to appraise crop insurance from the viewpoint of both the farmers and the insurance companies and make suggestions for its improvement as a tool in the management of farms.

Specific objectives are:

1. to determine the farmer's evaluation of insurance as a managerial tool in relation to other means of combating risk and uncertainty.
2. to determine farmer's attitudes toward all-risk and crop-hail insurance as a means of stabilizing farm income.
3. to test the adequacy of present insurance to help farmers survive unfavorable weather conditions through budget analysis.

HYPOTHESIS

It is more important for Montana farmers with a low net worth than a high net worth to use all-risk and crop-hail insurance for stabilizing farm income and attaining the goal of survival.

Specific hypotheses are:

1. the farmer who uses all-risk and crop-hail insurance is less likely to experience years when farm income is not large enough to cover farming expenses than the farmer who does not.
2. the farmer's use of all-risk and crop-hail insurance is influenced by both his attitude toward and his evaluation of it as a managerial tool with respect to alternative methods of protection.

PLAN OF FOLLOWING CHAPTERS

The analytical methods will be described in Chapter II. An understanding of the methods are required for comprehension of the analysis which follows in the remaining chapters. The methods are; 1) Guttman scale, 2) Contingency tables, 3) Paired comparisons, and 4) Budgets.

The farmer's attitudes toward planning and insurance will be described in Chapter III. This includes testing attitudes for association with other factors.

In Chapter IV the farmers evaluations of crop insurance as a managerial tool for stabilizing farm income will be examined.

Chapter V will be devoted to budget analysis of capital accumulation in order to determine the suitability of crop insurance as a managerial tool.

Chapter VI will be devoted to implications and future research.

Chapter VII will be devoted to a summary of the study.

CHAPTER II

METHODOLOGY USED IN STUDY

The Study Area

Two of the major wheat producing regions of Montana, the Northeast spring wheat area and the Triangle winter wheat area were studied. Valley, Daniels, Sheridan, Roosevelt, Richland, and McCone counties represented the Northeast while Toole, Liberty, Hill, Chouteau, Fergus, Judith Basin, Teton, and Pondera counties represented the Triangle. These are shown in Figure 1.

Sample communities were randomly drawn from all of these counties, each designed to contain at least 15 farms, 10 of which were to be contacted. Farms were eliminated which did not have as their major enterprise small grain production. The information collected represented 24 communities and included 251 farmers.

Procedure of Analysis

Four analytical techniques are used in this study; 1) scalogram analysis, to determine the farmers' attitude toward crop insurance and toward planning in general, 2) paired comparisons, to determine the farmers' evaluations of crop and crop-hail insurance in relation to alternative methods of stabilizing farm income, 3) contingency tables, to evaluate the farmers' attitudes toward insurance and planning, and 4) budget studies, to determine the adequacy of crop insurance in helping farmers attain their goals. Each of these will be explained

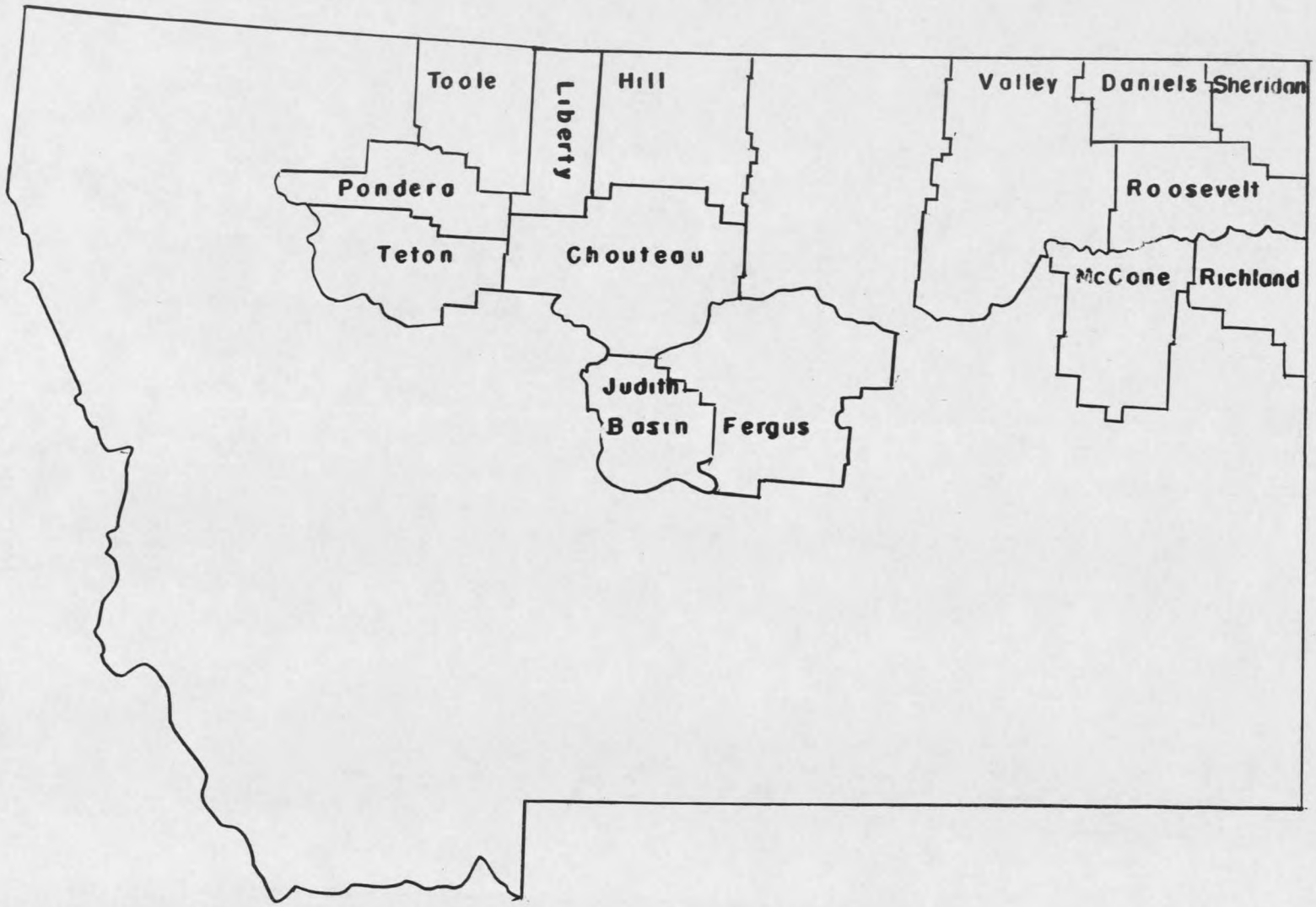

Figure 1. Map of Counties in Study Area.

in this chapter in order that the reader will have an elementary understanding of their application to this study.

The farm sizes are: 1) small farms ranging from 95 to 580 crop acres, averaging 384 crop acres, 2) medium farms ranging from 600 to 1,095 crop acres, averaging 830 crop acres, 3) medium large farms ranging from 1,100 to 1,360 crop acres, averaging 1,200 crop acres, and 4) large farms ranging from 1,400 to 2,400 crop acres, averaging 1,700 crop acres.

It will be assumed throughout the study that the prices paid and prices received by farmers are those paid and received in 1959. The cost information used in the budgets are from a study currently being conducted by the Farm Economics Research Division. 1/

Crop insurance will be defined as insurance for income protection and will include both crop-hail and all-risk crop insurance. The premium rates and policies of the insurance companies are those available to farmers in 1959.

ATTITUDE SCALES

An attitude may be defined as "the degree of positive or negative affect associated with some psychological object". 2/ This psychological

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1/ Study in progress, Supply Response to Wheat on Dryland Crop Farms in Montana, conducted by LeRoy C. Rude, Agricultural Economist, Farm Economics Research Division, Agricultural Research Service, United States Department of Agriculture.

2/ A. L. Edwards, Techniques of Attitude Scale Construction, Appleton-Century-Croft, Inc., New York, 1957, p. 2.

object may be a symbol, phrase, slogan, person, institution, ideal or idea toward which people may differ with respect to positive or negative "affect". In this study the psychological objects were crop insurance and planning.

Determining Attitudes

The individuals' attitude toward an object is determined through his positive or negative response to each of a series of appropriate statements. In order for these statements to be effective it is necessary that a few basic requirements be met; 1) statements which refer to the past rather than the present should be avoided, 2) factual statements should be avoided, 3) use statements which refer to the psychological object, 4) select statements that are believed to cover the entire range of the effective scale of interest, 5) avoid statements that are likely to be agreed or disagreed with by almost every one, 6) keep the language of the statements simple, clear, and direct, 7) each statement should contain only one complete thought, and 8) avoid ambiguous statements, and words that may not be understood by everyone. 3/ If these criteria are met the statements should have the same meaning to all respondents, with a common frame of reference to the object.

There are several methods of using these statements to obtain the attitude of the respondent, and from among them the method called the Scalogram was chosen for this study. This method, developed by L. A.

3/ Ibid., pp. 13-14.

Guttman in the 1940's and in 1950, is commonly called the Guttman scale and will be referred to as such throughout the study. 4/ In order for a set of statements with a common content to constitute a Guttman scale the individual with a higher score than another individual must rank as high or higher on every statement in the set. If this happens the statements are said to constitute an unidimensional scale. In the unidimensional scale the statements establish a continuum ranging from least to most favorable with respect to the psychological statement (insurance in this case). In general the continuum would mean that every person who had a scale score of three agreed to the same three statements, those who had a score of four agreed to the same three as those with a score of three plus one more statement, and those who had a score of five agreed with those who had a score of four plus one more statement and so on. It is the purpose of the Guttman scale to tell us what the scale score is for each individual.

If the number of statements is relatively small and there are only a few respondents the scaling may be done manually. If the number of respondents is large this will be more readily done by the use of a sorter and a reproducing punch after the information or answers to the statements have been punched on cards. The latter method was used in this study as the number of respondents was 251.

4/ Ibid., p. 172.

One method for scaling the statements by the machine method was developed by Carol L. Stone 5/ using Robert H. Ford's procedure of weighting the statements. The method employed by both Robert Ford and Carol Stone is that the weights will increase in modified geometric progression. Each geometric score may be attained in only one way. In an eight-statement scale a respondent with a perfect negative response to all eight statements would have a geometric score of 0. This would be the only way this geometric score could be attained. If a respondent had a perfect positive response to the eight statements his geometric score would be 255. Between 0 and 255 there are 254 possible combinations of response patterns, scores 0, 1, 3, 7, 15, 31, 63, 127, and 255, are perfect geometric scores and will contain no errors, all others will. The geometric score is obtained by adding the weights of the statements answered positively. For example, statement one has a weight of one, and two a weight of two. This gives a geometric score of three. The errors are recorded and distributed according to item. Table I illustrates some response patterns. For example respondent H had a geometric score of 191, he could obtain this score only by answering positively to all but the seventh statement in a series of eight, had he answered positively to this question he would have had a perfect score of 255. This is obtained by adding the weights (1 + 2 + 4 + 8 + 16 + 32 + 128) or $\Sigma 2^n$ for all positive responses.

5/ Carol L. Stone, Machine Method for Scaling Twelve Dichotomies, State College of Washington, pp. 1-13.

TABLE I.--RESPONSE PATTERN BY QUESTION AND RESPONDENT

Respondent	Response pattern to questions								Geometric score	Scale score	Number of errors
	1	2	3	4	5	6	7	8			
A	0	0	0	0	0	0	0	0	0	0	0
B	0	1	0	0	0	0	0	0	2	2	1
C	1	1	1	0	0	0	0	0	7	3	0
D	1	1	1	0	0	0	0	1	135	3	1
E	1	1	0	1	0	1	0	0	43	4	2
F	1	1	1	1	0	0	0	0	15	4	0
G	1	1	1	1	1	0	0	0	31	5	0
H	1	1	1	1	1	1	0	1	191	6	1
I	1	1	1	1	1	0	1	1	223	8	1
J	1	1	1	1	1	1	1	1	255	8	0
Weight	1	2	4	8	16	32	66	128			

In addition to the geometric score the respondent is given a scale score which corresponds to the response category he belongs in. In the case of the respondent who answered positively to all but the seventh question, in a series of eight, his scale score would be eight, the same as if he'd answered all eight positively, but with one negative error. The reason for this classification is that he most resembles that group. A respondent with a geometric score of two may be classified either with the zero group or the group with a scale score of two, in either case he will receive an error of one. According to the rules set up by Ford he will be put in the group with a scale score of two and he will receive a negative error of one. A respondent with a geometric score of 135 would have answered positively to the first three items, in a series of eight, negative to the next four and positive to the last one. This puts him in the group with a scale score of three with one positive error, the

error coming from the last question which he answered positively. In instances where the respondent has an error, and it is uncertain whether it should be a positive or negative error, the error will be split and one half will be negative and one half positive. For example, if the respondent answered all questions negatively except the second one his error would be split half and half. If there are two errors, and there is doubt about which group he belongs to, the error will be split two-thirds negative, two-thirds positive, one-third negative, and two-thirds positive in that order for the four responses involved.

Validity of Scale Scores and Justification of Use

There are three criteria to establish the validity of a scale in the Guttman sense; 1) the coefficient of reproducibility must be .90 or over. The coefficient is calculated by totaling the number of errors and dividing this by the number of respondents multiplied by the number of statements, all subtracted from 1 or: 6/

$$\text{Coefficient of reproducibility} = 1 - \frac{\text{Total number of errors}}{\text{Number of respondents x number of items}}$$

It has a possible range from zero to one. 2) No item in the scale has a total positive or negative error which is more than 50 percent of the positive response (for the positive error) or negative response (for the negative error). 3) That the total number of errors for any item is no more than 15 percent of the total number of responses for that item.

6/ Ibid., p. 10.

That these qualifications are met may be determined from a table such as Table II, which shows the number of positive responses and their errors, the number of negative responses and their errors, total errors and percent of errors for each item.

TABLE II.--GUTTMAN SCALE ANALYSIS FOR PLANNING ATTITUDES

Schedule question	Positive		Negative		Errors	
	Responses	Errors	Responses	Errors	Total	Total
	Number	Number	Number	Number	Number	Percent
4	246	0.00	5	4.50	4.50	1.79
2	240	.50	11	8.00	8.50	3.38
8	239	1.00	12	7.17	8.17	3.25
6	219	.83	32	24.72	25.55	10.17
7	167	9.28	84	18.17	27.45	10.93
5	127	12.93	124	10.28	23.21	9.24
3	91	26.72	160	4.66	31.38	12.50
1	51	26.34	200	0.00	26.34	10.49
Total	---	---	---	---	155.00	---

Coefficient of reproducibility = $1 - \frac{155}{251 \times 8} = 92.3\ \%$

To obtain the table the number of negative and positive responses are counted for each question along with their respective errors. This is done from the tabulated sheet obtained by listing the cards used for the machine method of scaling. The machine may be used to count the total errors, total negative errors and total positive errors so the researcher need not go through this counting process by hand.

In Table II the criterion that no item have more than 50 percent error is not met. After observing that two of the criteria had been met, the response pattern of all respondents was studied and it was decided that these items should not be rescaled as would be suggested by the criterion.

This conclusion was reached because in instances where there are more than a 50 percent error it will be noticed that there are very few respondents, most of which answered incorrectly. This suggests that judgment should be used in application of the criteria.

Although attitudes alone cannot be considered as determinants of farmer's action, their use in agricultural economics research may lead to insights into the solutions of problems considered important by the farmers themselves. This point is illustrated more fully in Chapter III.

CONTINGENCY TABLES

After the scale score has been determined for each respondent and we know the degree of favorableness or unfavorableness the next step is to determine what factors influence the respondent's attitude toward crop insurance. To do this contingency tables were constructed to compare scale scores to other factors that appeared to be appropriate. A list of the factors tested are in Chapter III. Interviews with farmers suggested that these factors may affect the farmer's attitudes.

Table III is an example of a contingency table. In this table the scale scores appear on one side and farm size appears on the top. The table then shows how many times the scale score 0-4 was associated with each farm size group. For example, scale score 0-4 was associated with the group under 600 crop acres 29 times, with the 600-1,099 group 24 times, with the 1,100-1,399 group 8 times, and with the 1,400-2,499 group 20 times.

TABLE III.--OBSERVED CONTINGENCY TABLE FOR SCALE SCORE AND FARM SIZE

Scale score	Farm size in crop acres				
	Under 600	600-1,099	1,100-1,399	1,400-2,499	Marginal totals
0 - 4	29	24	8	20	81
5	13	21	12	14	60
6	7	24	8	14	53
7 - 8	7	21	4	25	57
Marginal totals	56	90	32	73	251

To test the basis of classification in the table a chi-square test is used. This chi-square is designed to test for independence or dependence in the classification so the hypothesis tested is that "the two criteria, scale score and farm size, are independent". The chi-square formula for this test is:

$$\text{Chi-square} = \Sigma \frac{(O_{ij} - E_{ij})^2}{E_{ij}} \qquad 7/$$

Where: O_{ij} = observed number of the ijth cell,

E_{ij} = expected number in the ijth cell,

$$= \frac{R_i C_j}{n}$$

and $R_i = \Sigma O_{ij}$ = total observed number in the ith row,

$C_j = \Sigma O_{ij}$ = total observed number in the jth column.

n = the total number of observations.

7/ Bernard Ostle, Statistics in Research, Iowa State College Press, Ames, Iowa, 1956, p. 70.

$(r - 1)(c - 1)$ = the degrees of freedom.

r = the number of rows

c = the number of columns

The calculations of the expected number for each cell yields a table such as Table IV. Using the formula for calculating expected values the value 18.071 in cell 0-4, under 600 was obtained by (81 x 56)/251. The value of the cell 0-4, 600-1,099 = 29.043 = (81 x 90)/251.

TABLE IV.--EXPECTED VALUE FOR SCALE SCORE AND FARM SIZE

Scale score	Farm size in crop acres			
	Under 600	600-1,099	1,100-1,399	1,400-2,499
0 - 4	18.071	29.043	10.326	23.557
5	13.386	21.513	7.649	17.450
6	11.825	19.003	6.757	15.414
7 - 8	12.717	20.438	7.266	16.577

The chi-square for Table III was equal to $23.75 = (18.071 - 29)^2/18.071 + (29.043 - 24)^2/29.043 + \ldots + (16.577 - 25)^2/16.577$.

Using this chi-square the hypothesis is rejected if the calculated chi-square is greater than the tabulated chi-square at the .05 significance level with $(r - 1)(c - 1)$ degrees of freedom. For this example the hypothesis is rejected since the calculated chi-square = 23.75 which is greater than the tabulated chi-square of 12.592 at the .05 significance level with 9 degrees of freedom.

PAIRED COMPARISONS

The paired comparisons method is an alternative way to obtain a rank order for a set of objects. However, paired comparisons enable us to rank not only the objects but find the scale separations between the objects as well. For this study two short sets of paired comparisons were used, one to measure types of hazards and one to measure alternative methods of protection available to farmers. A schedule of the pairs is in Appendix B.

The following are definitions of the items used for the pairs. The first group comprises the main hazards faced by farmers.

Drouth--damage caused by lack of moisture sufficient to significantly affect the yield.

Hail--damaged by a hail storm sufficient to cut the yield.

Wind and flooding--damage caused by high winds and sufficient flooding to impair the crop growth or seeding.

Insect and disease--damage caused by insects and disease such as grasshoppers and rust.

Winter kill--damage caused by failure of the winter wheat to survive the winter.

All risks--this would include all the above.

The second group comprises seven alternative methods of protection.

All-risk or crop-hail insurance--refers to insurance which can be used as a managerial tool to protect farmers against loss of income arising from partial or complete crop failure, which is due to adverse weather conditions or other conditions which are beyond the control of the farmer.

Stored grain and feed--refers to the storage of grain and feed for purposes of offsetting low yields of these grains and feeds. This is a managerial tool similar to insurance, in this case the farmer carries his own insurance in the form of stored grain and feed.

Short-term credit--refers to money borrowed for production purposes, supplies obtained from merchants or dealers on a charge account, and loans not over three years in length. The loan can be for operating expenses, machinery, motor vehicles or trucks, or for family living expenses.

Off-farm jobs--refers to taking a job off the farm to compensate for loss of income on the farm following one or more poor crop years.

Belt tightening--refers to cutting expenses that would normally be incurred but which may be eliminated during a period of poor crop years.

Cash, stocks and bonds--refers to money in the bank, savings accounts and to corporate stocks and bonds such as city, state, federal or corporate. These are all considered equally liquid for our purposes and readily convertible into cash.

Diversified farming--this refers to a grain farmer who diversifies his operation for purposes of stabilizing farm income. This could be in the form of a feeding operation, raising hogs, etc.

When paired comparisons are used we assume; 1) that the items in the pairs can be ranked, 2) that the rank may be tested for statistical validity, 3) that the items are non-random and 4) that the errors are distributed approximately as chi-square.

Establishing a Rank Order and Testing the Rank for Agreement

Using this method each respondent is asked to choose the item he feels is most important from each pair. The number of pairs for the group is n factors taken two at a time or $\binom{n}{2}=\frac{1}{2}n(n-1)$, where n equals the number of factors being ranked. For example, for the first group there are six factors which yields 15 pairs $\left[\frac{1}{2}6(6-1)\right]$. In this analysis a matrix, such as the F Matrix, Table V, is used to compare the items. The matrix will show the number of times each item was chosen over every other one in the aggregate. For example, in the F Matrix, reading across the table

TABLE V.--F MATRIX, JUDGMENTS OF 251 FARMERS ON ALTERNATIVE METHODS OF PROTECTION USED BY FARMERS

		F value for alternatives					
Alternatives	Rank	6	5	4	3	2	1
Off-farm jobs	6	----	142.5	135.5	160.0	151.5	211.5
Short-term credit	5	108.5	----	131.0	144.5	156.5	191.0
Belt tightening	4	115.5	120.0	----	133.0	148.0	196.0
Crop insurance	3	91.0	106.5	118.0	----	139.5	174.5
Cash, stocks and bonds	2	99.5	94.5	103.0	111.5	----	193.0
Stored grain and feed	1	39.5	60.0	55.0	76.5	58.0	----
TOTALS		454.0	523.0	542.5	625.5	653.5	996.0

on row 6, short-term credit was chosen over off-farm jobs 142.5 times, belt tightening was chosen over off-farm jobs 135.5 times. After summing across the rows a rank order may be established by rearranging the matrix. The factor with the smallest sum is the factor in first place. In the F Matrix this was stored grain and feed and was placed on the bottom to facilitate the scaling process. If a respondent fails to show a preference for one of the factors in a pair one half of each of his response is placed in the corresponding cells. This yields a half of a response as shown in the cell (6 - 5).

We may test for coefficient of agreement among the respondents by the formula: 8/

$$\mathcal{U} = \frac{2\Sigma}{\binom{m}{2}\binom{n}{2}} - 1 \qquad 1)$$

8/ M. G. Kendall, Rank Correlation Methods, Hafner Publishing Co., New York, 1955, 2nd edition, pp. 107-109.

where: u = the coefficient of agreement which varies from a maximum of 1 for perfect agreement to a minimum of $-1/(m-1)$ if m is even of $-1/m$ if m is odd.

m = number of respondents

n = number of items being ranked

$\binom{m}{2} = \frac{1}{2}m(m-1)$

where the summation occurs for values below the diagonal:

$$\Sigma = \Sigma(\gamma)^2 - m\Sigma(\gamma) + \binom{m}{2}\binom{n}{2} \qquad 2)$$

where: γ is the value of each cell in the matrix.

This provides a means of determining the extent to which a group of respondents agree in their comparative judgments.

The significance test for the coefficient of agreement indicates whether or not the level of agreement calculated could be attained if the comparative judgments of the respondents were random. The formula Kendall uses for this test is: 9/

$$\chi^2 = \frac{4}{m-2}\left\{ \Sigma - \frac{1}{2}\binom{n}{2}\binom{m}{2}\frac{m-3}{m-2} \right\} \qquad 3)$$

where: Σ = the value obtained by formula 2

m = the number of judges

n = the number of items

The degrees of freedom for chi-square is given by the formula:

$$\nu = \binom{n}{2}\frac{m(m-1)}{(m-2)^2}$$

9/ Ibid., p. 107.

Scale Values for the Rank Order

Thurstones "Law of Comparative Judgments" is used to find the scale values of the paired comparisons. 10/ This law provides a rationale for ordering the items along a psychological continuum.

The law assumes; 1) for a given stimulus there is associated a most frequently aroused or modal discriminal process on a psychological continuum, 11/ and 2) all discriminal processes aroused by a stimulus are normally distributed about this modal discriminal process. With this assumption in mind it is possible to say that there is a mean which is the same as the mode and median discriminal process, as would be the case in a normal distribution. This mean is the scale value of the stimulus. The standard deviation of the discriminal process is referred to as the discriminal dispersion. 12/

Thurstones law is stated in equation form as: 13/

$$R_j - R_k = Z_{jk} \sqrt{\sigma_j^2 + \sigma_k^2 - 2r_{jk}\sigma_j \sigma_k}$$

10/ A. L. Edwards, op. cit., p. 20.

11/ A discriminal process is a theoretical concept and represents the experience or reaction of an individual when asked to make a comparison or judgment of some attribute. As the stimulus will not always evoke the same discriminal process there will be a modal one which will be the one most frequently appearing.

12/ Edwards, op. cit., p. 21.

13/ J. P. Guilford, Psychometric Methods, McGraw-Hill Book Company, Inc., New York, 1954, pp. 155-156.