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AN APPLICATION OF STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION: MEASURING THE RELATIONSHIP OF PRODUCER ATTRIBUTES TO RISK PREFERENCES

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AN APPLICATION OF STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION: MEASURING THE RELATIONSHIP OF PRODUCER ATTRIBUTES TO RISK PREFERENCES

By

Garth A. Carman

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ABSTRACT

AN APPLICATION OF STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION: MEASURING THE RELATIONSHIP OF PRODUCER ATTRIBUTES TO RISK PREFERENCES

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Garth A. Carman

Stochastic dominance with respect to a function is used to develop confidence intervals around risk preference measures for 30 farmers in South Central Michigan. The predictive power resulting from these interval measures are compared with the accuracy of a single-valued utility function and first and second degree stochastic dominance efficiency criteria. The relative merits of each decision tool are discussed.

After a justification for the use of this technique an empirical application is presented. In comparison with a single-valued utility function and first and second stochastic dominance, the interval measure of risk preference has a clear advantage because it allows for trade-offs between accuracy of predictive capabilities and ordering of action choices.

The interval measures of risk preference functions, are then used to establish a relationship between the risk preferences and producer attributes. Using discriminant analysis, producers can be classified into risk preference categories by their attributes at specific points on the risk preference interval. However, these attributes do not

remain consistent as movement occurs along the function. Finally, producer attributes are used to predict risk preferences and those risk preferences are used to predict action choices.

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CHAPTER I

INTRODUCTION

1.1 Study Background and Purpose

All agricultural producers must decide how to allocate their resources in a manner consistent with both their monetary and nonmonetary goals. The resources available to the operator are numerous and often are classified as either land, labor, or capital. The set of resource allocation alternatives available are defined as action choices. Typically, economists assume a certainty model. Within this model the production function, cost, and revenue curves are known. This assumption and the assumption of positive marginal utility for money allows for action choices to be accepted or rejected on the basis of a profit maximization model subject to resource constraints. Management's decision-making services no useful purpose under these assumptions of certainty. The economist could simply tell the producer what to produce and how to produce it. Consequently, the factors influencing the decision process, as well as the decision process itself, are not significant.

However, when the uncertainty, which exists in the "real world," is introduced non-uniqueness of decisions comes into existence. Resource price, and cost data are no longer the sole factors in solving for unique decisions. Instead, management and the manner in which it responds to an uncertain environment become crucial factors in the resource allocation and production process.

Within this framework two areas deserve attention. The first area is an analysis of the factors that influence the actual decision-making process. The second area deals with the decision-making process itself. While a great deal of attention has been focused on the latter, the former has received much less attention. These two areas, factors that influence the decision-making process and the actual process itself, allude agricultural economists in achieving a complete understanding. This is fortunate since a better understanding in these areas could lead to more complete knowledge of their implications on both a micro and macro level.

More specifically, in an uncertain world producers possess certain attributes. The attributes that may affect the decision-maker's selection of an action choice include: age, education, tenure, business size, wealth, income potential and action choice, etc. These attributes influence the risk preferences of producers. For example, an older operator nearing retirement may wish to "play it safe" and therefore may not desire to take risks that are necessary to generate additional income required for growth. On the other hand, a younger producer may have quite different risk preferences for just the opposite reasons. Similarly, a producer with a larger family and limited wealth may not be able to withstand fluctuating incomes as easily as a producer with a smaller family of greater wealth. As a result of such attributes, these individuals could very well possess different risk preferences.

The risk preferences of an individual may influence the manner in which he manages the production, marketing, and financial risks that exist in his particular environment. For example, given two producers, one risk-averse and one risk-loving, one might find that the risk-averse producer might utilize forward marketing, insurance, capital reserves, excess machinery capacity, etc., in a manner which either reduces or transfers marketing risks; while a more risk-loving operator may choose to carry these risks.

The success or failure of these management techniques, along with economies of scale, may influence the structural characteristics of the agricultural production sector.

The traditional analysis of farm size changes has focused on economies and diseconomies of size relying primarily on cost curve analysis. This has been done with hopes that changes in farm numbers and their associated sizes could be explained and predicted accurately in the future. For those who believe farming is a decreasing cost industry, concern is generated over the future of the small family farm operation in the coming years. However, Madden (1967) found after reviewing a number of studies of crop farming situations in various states that: "In most of these situations all of the economies of size could be achieved by modern and fully mechanized one-man or two-man farms."

The relative importance of risk and uncertainty in determining structural changes is not known. It is, however, recognized. French (1977) referred to risk and uncertainty in his summary of economies of scale. Heady (1952) perhaps best recognized the importance of risk and uncertainty in stating:

> "Continuance of the so-called family farm as the main structure of agriculture suggests, on the one hand that if size economies exist, they soon give way to diseconomies. Concurrently, the continuance of small farms suggest the hypothesis that economic dynamics of risk and uncertainty may be the final determinant of farm size in agriculture."

The structural changes that occur then influence the aggregate attribute makeup in subsequent periods. For example, suppose that small producers are more risk-loving and as a result do not utilize certain risk management tools. Given an unfavorable environment, it is possible that these small, risk-loving producers would be eliminated from the market place. Thus the next period would reflect an aggregate farm population of fewer small farmers. Similarly, this type of an example holds for other attributes.

At this time, it is unknown whether this dynamic framework or parts of it are valid. The testing of the possible relationships offers rewards for policy-makers at both the firm and aggregate level.

This research does not attempt to establish all of the previously discussed relationships. Rather, it proposes to study the relationships between producer's attributes and risk preferences. Currently, little is known about the relationship of producer attributes to risk preferences. If relationships can be established, further work can be suggested. If no relationship exists, this area of research can be eliminated in the future.

The need to recognize personal, business, and economic attributes has often been suggested. Barry and Baker (1977) state that "the need to test hypotheses on risk behavior is one area needing further study. For example, how do risk premiums required by primary producers vary with selected personal, business, and economic attributes." The Western Regional Research Committee (W-149) considered measuring utility functions for a large number of producers differentiated by selected attributes, Robison and King (1978). While critical of the methodology proposed by W-149, nonetheless, they recognized the need to consider the attributes. Although the Western Regional Committee recently rejected the idea, the rejection was based on the methodology proposed rather than the need to establish existing relationships. The need to identify these relationships, or lack thereof, between producer attributes and risk preferences is recognized. This research effort focuses on accomplishing this task.

Attributes of agricultural producers are often broken down into various categories. Barry and Baker (1977) classify attributes as either being personal, business, or economic.

The attributes of characteristics of the general agricultural production sector population have undergone many changes over the past century. Some of these changes have generated little concern, while others have been the focus of a great deal of attention.

French and Carman (1979) note that between 1945 and 1974 the average age of all farm operators increased from 48.7 to 51.7 years of age; meanwhile, the average age of operators for the largest farms was somewhat lower. Similarly, they note that the education level of farm operators has increased as it has for the general population as a whole.

Changes have also taken place with regard to other attributes. Changes in tenure have occurred over the past two decades. In 1954, 44.8 percent of the farms with over $2,500 of sales were operated by full-owners. In 1974 this number increased to 53.3 percent. For this same time period part-owners increased from 25.2 percent to 33.4 percent.

Tenants decreased from 29.1 percent in 1954 to 13.3 percent in 1974. The value of sales group distribution by tenure shows 45 percent of part-owners, 32 percent of tenant farms, and 17 percent of full-owner farmers had sales of over $40,000. In other words, full-owners tended to operate smaller farms than either tenant or part-owners.

Quite possibly, the most often discussed attribute related to the agricultural production sector is that of business size. The structure of the United States agricultural production sector has long been of interest to producers, policy-makers, and researchers. During the past three decades the U.S. agricultural sector has undergone tremendous growth in productivity and extensive structural change, both largely attributable to rapid technological change and the increasing degree of specialization that has accompanied it. In 1940 farm productivity, measured by the index of output per unit of input with 1960 as a base, was 60. In 1950, 1960, and 1970 this index increased to 73, 100, and 101, respectively. In 1974 this index had increased to 104.

During this time, and especially in the past decade, a great deal of interest has been focused on who <u>will</u> control agriculture, and, possibly more important, who <u>should</u> control agriculture. In his 1978 presidential address, B. F. Stanton discussed farm size. Stanton (1978) outlined four reasons why farm size issues have been the focus of concern for so many for so long. One reason is the poverty associated with rural incomes and the associated welfare implications. A second is related to business management aspects of an operation, i.e., finding production resource combinations and then taking this knowledge and applying it to individual farms. Closely related, the third has to do with realizing the most efficient combination of resources for individual farms and farms in general. Finally, the fourth is concerned with distributional issues, i.e., who controls the resources and how broadly or narrowly these resources are distributed among farmers and others.

In 1850 there were 1,449,073 farms in the United States averaging 202.6 acres in size. Farm numbers increased to 6,812,350 in 1935 while the average farm size decreased to 154.8 acres. Since that time the trend has reversed--the number of farms has declined while the average farm size has increased. In 1969 there were 2,730,250 farms averaging 389.5 acres. Similarly, the land devoted to agricultural production was 393,560,614 acres in 1850, increasing and reaching a peak in the 1950's and then declining to 1,063,346,489 acres in 1969. As this data suggests, the number of smaller farms has declined as larger farm numbers have increased.

Concurrently, there have been significant changes in economic attributes of farm producers. Leverage, as measured by the ratio of total debts to total assets of farms in the United States, has been changing. In 1960 the leverage ratio was 11.8, increasing to a peak of 16.8 in 1970 and 1972, and then decreasing to 15.6 in 1974. Net income, like leverage, has similarly increased since 1960. In 1960 average net income was $16,195, increasing to $47,510 in 1973, and declining to $37,857 in 1977.

1.2 Problem Setting and Statement

Risk and uncertainty permeate almost every aspect of the U.S. agricultural production sector. The degree of risk and uncertainty and the associated response have a great impact on all market participants. A model of the relationship between risk, producer attributes and responses to risk may be useful. The representation in Figure 1, although highly simplified, describes one view of the relationships.

In the initial stages there are a group of agricultural producers who all possess certain attributes such as those listed earlier. It is commonly recognized that these attributes have an influence on the producer's risk preference. The risk preference of an individual operating in a stochastic environment in turn has an influence on the manner in which producers manage or otherwise transfer production, financial, or marketing risks. These risk management strategies may, along with economies of scale, influence structural characteristics in the farming sector. Furthermore, structural characteristics influence what risk management strategies are available to the farm. Given the success or failure of these strategies, structural changes will impact upon the future attributes of the agricultural production sector and thus the process continues.

This research is concerned with measuring the relationship between producer attributes and risk preferences. As stated earlier, this relationship must be established before relationships between attributes and risk responses can be established. This research should provide some insights into the feasibility of further work in this area.

With these objectives in mind, this research will focus on two interrelated research areas. The first area will be an attempt to identify any systematic relationships that exist between personal, business, and economic attributes and risk preferences. That is, how does risk aversion vary by producer attributes? As will be discussed later, some work has been done in this area but this work needs improvement in two

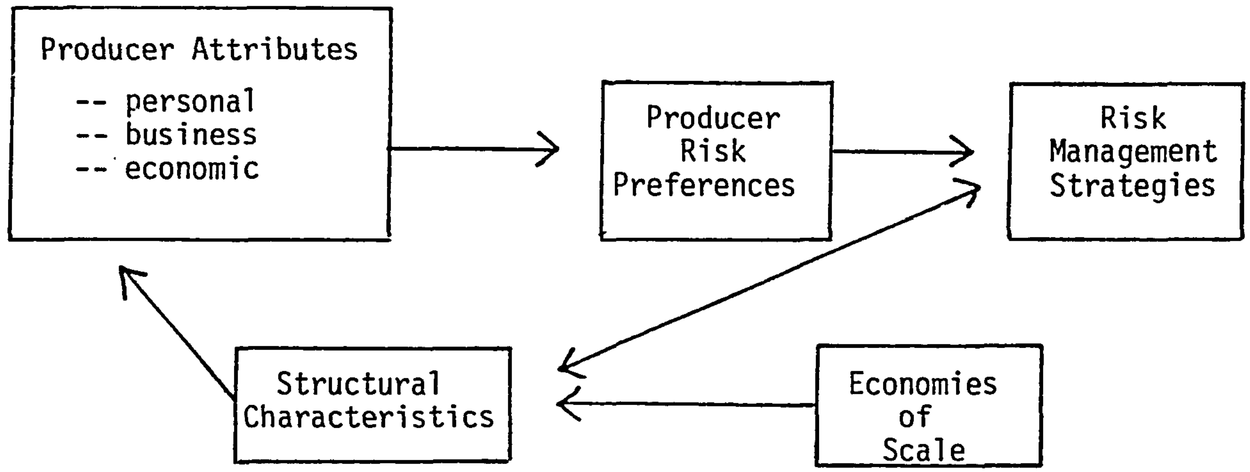

FIGURE 1.1

A Schematic Describing Relationships Between Producer Attributes, Risk Preferences, and Responses to Risk areas. First, more attributes deserve consideration. Second, the past efforts have relied on a methodology that is open to much criticism since the procedures used could have altered the results. Consequently, a new methodology is proposed, defended, and used for this analysis.

The second interrelated research area is to use the attribute-preference relationship to determine how accurately action choices can be predicted.

In accomplishing these goals this dissertation is divided into six chapters. This chapter has provided a brief introduction, a problem statement and framework of analysis. Chapter II reviews the literature and critiques work that has been performed in this area. In light of the deficiencies of previous research, Chapter III presents a newly-developed theoretical approach and methodology. Empirical evidence of this methodology's superiority is also presented and discussed. Chapter IV presents the questionnaire, survey design, and background on the sample chosen for observation. Chapter V presents the analysis of the data while Chapter VI focuses on the summary and conclusions of the dissertation.

CHAPTER II

LITERATURE REVIEW

We need a clearer understanding of how personal business, and economic attributes influence risk preferences. In other words, are there similarities in risk attitudes for decision makers who possess similar personal, business and economic attributes? By studying the correlation between producer attributes and risk preference, we can improve our ability to design policies and make recommendations for specific groups.

Some previous studies have dealt with the topic of this dissertation. The earliest work was by Halter (1956) as part of the interstate managerial study. He posed questions to producers about hypothetical gains and losses. In each case a producer was offered a possibility of a certain gain or loss and the possibility of getting out of the group (the one for which a possibility of a loss existed) or getting into a group (the one for which a possibility of a gain existed) for a cash payment. They found that the type of individual who answered yes (i.e., to get into or out of the group who faced the possibility of a gain or loss respectively) to all loss or gain questions had certain distinguishing characteristics. On the average this group were the oldest, had fewer dependents and more farming experience. They had high net worth and low debt positions. These results suggest the individuals were both risk-averse and risk-loving which is consistent with a Friedman-Savage utility function. However, this was as far as the research went. No effort was made to measure risk aversion over more areas of incomes and since gains and losses as well as probabilities were not varied, relative risk preferences were only established above and below two points (one at a loss and one at a gain). Certainly a more detailed examination would have been required to focus in on a point or area of risk aversion over several areas of income and then relate this to the discussed attributes. As it was, this risk preference was composed to two discrete risk aversion points (one above and one below) and then related to discrete attributes (e.g., older and younger). While this was perhaps appropriate given the state of the art at that time it is certainly lacking in precision given the state of the art today.

Halter also found that this group was willing to accept all unfair insurance schemes and unfair risk situations--a surprising conclusion. However Halter went on to state that this fact was more a reflection of the study's technique rather than the dispositions of the individuals. Interviewing procedures were also blamed.

More recently Dillon and Scandizzo (1978) recognized the need to examine socioeconomic characteristics as they relate to risk preferences. They used a sample of 130 small farmers who either owned or sharecropped in northeast Brazil. Using the expected utility approach they elicited the utility functions of these farmers in two cases. The first involved payoffs above subsistence levels, thus insuring subsistence; and the second included the possibility of not reaching subsistence levels of income. Each farmer was given a choice between a risky and safe project and the cash return was varied until, in most cases, the point of indifference was achieved. In the other cases assumptions were necessary to determine the certainty equivalent. On this basis the farmers were classified as risk-averse, risk-loving or risk-neutral. They then used linear, quadratic and exponential utility models to estimate risk attitude coefficients. With the exception of the exponential model, they found that on the average both owners and sharecroppers were more than risk-averse when subsistence was at risk than when it was assured. When subsistence was assured again, with the exception of the exponential model, owners appeared to be more risk-averse than sharecroppers. They also state with respect to the exponential utility model that no strong differences in risk attitudes exist. They go on to point out the need to consider the magnitudes of risk preferences rather than relying on classification of producers as either risk-averters or risk-preferers. They also note that conclusions about risk attitudes are highly contingent upon the type of functional form that is fitted to the utility function.

Further analysis by Dillon and Scandizzo suggests that socioeconomic characteristics may account for some of the variations in risk attitudes. They examined farmers' age, income, household size and ethical attitude toward betting. Using linear and quadratic models they estimated equations to determine the impact that these socioeconomic variables have on risk attitudes. Again conflicts arose between the linear and quadratic models, further evidence of the importance of selecting functional forms. They conclude that income level and perhaps other socioeconomic variables influence farmers' risk preferences.

While an attempt was made to examine the impact of attributes on risk preferences, Dillon and Scandizzo's effort did little to point out the critical nature of the assumptions of the functional forms of the utility function. Also of interest is that selection of socioeconomic variables was based primarily on easy accessibility. The ex-post nature of the analysis precluded the use of other attributes that could and possibly should have been used in the analysis. Again it is worth noting that a utility function approach was used in this study.

Halter and Mason (1978) provided one of the most recent studies on attribute preference relationships. They describe their recommended method of eliciting a utility function as such. By holding probabilities constant and varying income, points of indifference were obtained. Then, through subsequent questions, utility functions were constructed.

After they presented their single-valued utility function approach, they attempted to demonstrate that estimated decision-makers utility functions could be used to determine if risk attitudes are related to farm and producer characteristics. Their sample consisted of 11 grass seed farmers who operated farms in Willamette Valley, Oregon. They state that due to lack of precedence, there is little theoretical basis upon which to hypothesize relationships. Consequently they relied on regression models to sort out important characteristics in both a step-wise add and delete manner. The dependent variable used was the coefficient of absolute risk aversion which is defined as the negative ratio of the second derivative to the first derivative of the utility function evaluated at the respondents income level. After step-wise add and delete regression, the significant variables left were: percent of land owned, education level, and age. No mention is made of the other variables analyzed, so little is known about the comprehensiveness of the study.

Once the three significant variables were identified, linear and quadratic analysis were performed.

They found greater risk preference among higher educated farmers as percent of ownership increased. Lower educated farmers demonstrated greater risk aversion with increasing levels of ownership. They also found risk aversion increases with increasing age for higher educated farmers and decreases with lower education levels. When age and percent ownership are analyzed jointly, it was found that risk preferences increase with age for all levels of percent ownership with the exception of older farmers. In effect the Halter-Mason study found that age, education, and percentage of land owned, either separately or jointly, were statistically significant variables related to risk attitudes. They concluded that: "Finally, further empirical work needs to be done with respect to monetary losses and how to obtain the utility function and its implications across both gains and losses." It is worth noting that the absolute risk aversion coefficient utilized as the dependent variable in their analysis was at only one level, that being the farmers' level of income. No comparisons were made for negative income or losses nor was risk aversion examined at other levels of income, which given the stochastic nature of prices and production could easily be applicable. In other words, they used a risk aversion point rather than a risk aversion function.

Moscardi and de Janvry (1977) have also related behavior to risk with socioeconomic and structural variables by studying a sample of peasant households in Mexico. Rather than using the direct approach of directly eliciting utility functions, they present and utilize an indirect approach. This approach involves, given a production function and associated marginal value products, the comparison of actual fertilizer applications with those that are at an economic optimum. They then relate risk aversion to socioeconomic characteristics of peasant households. By using discriminant analysis and regression analysis they found that their results generated support for the hypothesis that risk bearing capacity of peasants could be explained by certain characteristics. They found land under control, off-farm income, and membership in a solidarity group were significant; however, age, schooling, and family size were not significant. The signs of the estimated relationship generally agreed with their hypotheses. The negative relationship between risk aversion and land under control and off-farm income are consistent with the hypothesis of decreasing absolute risk aversion with respect to wealth. They also found a negative relation with respect to risk and group membership.

A similar study by Binswanger (1978) examined the relationship of characteristics with risk preferences using a sample of peasant farmers in rural India. These results found that wealth had little effect on risk aversion while schooling tended to reduce aversion. Sex, progressiveness, dependency ratio, amount of land rented, and age had a less clear impact, if any, on risk preferences.

While these studies are interesting, several criticisms seem justified. First the work of Scandizzo and Dillon (1978), Moscardi and de Janvry (1977), and Binswanger (1978) were all performed in less developed countries with peasants comprising the samples. Given the vast differences that exist between the peasants' environment and that present in the U.S commercial agricultural sector, any generalizations between these environments would certainly require a great leap of faith.

The second criticism is that given the work necessary for each study, it would seem appropriate that as many attributes as possible should be recognized and analyzed. As discussed, some cases based selection of attributes to be considered on existing data.

The third and most important criticism is methodology employed. Previous research for the most part has relied on measuring utility functions and then deriving risk aversion measurements from the utility function. This technique was certainly justifiable given the state of the art. However, many researchers have noted the need to refine techniques in this area, and their concerns are quite valid. Hypothetical questions used to elicit utility functions quite possibly yield responses that will not agree with actual decisions.

As discussed, direct elicitation of utility functions by interview procedures are designed to determine points of indifference between a risky and a certain outcome. Once these points of indifference are determined the utility function is fitted by means of regression.

The methodology is criticized as a source of bias for several reasons. Some people have a real aversion to gambling. In other words, people, when given an option of a gamble and a sure income, may avoid the gamble in a hypothetical setting when, in fact, they undertake many gambles in real life. The von Neumann-Morgenstern model is such an example since it has a bias for the utility and disutility of gambling. Dillon and Scandizzo's work (1978) further emphasizes the need for correcting this shortcoming. In their sample of Brazil farmers 30 percent believed that gambling was immoral and 80 percent had never gambled.

With several methods the problems associated with distinguishing between probabilities exist. In other words, does a decision-maker change choices when probabilities are changed by small increments and, if so, at what point?

Selection of the proper functional form is also an area to open to criticism and often leads to undesirable implications (Lin and Chang , 1978). In some instances different functional forms lead to inconsistent results.

Finally, the direct elicitation of utility function approach is not only uninteresting for the respondent but it is difficult to conduct. Consequently many researchers use interview teams to elicit the information from the samples. As a result severe interview errors and interviewer bias may occur.

Most methods of eliciting utility functions from decision-makers have one or more of the previously mentioned weaknesses. Officer and Halter (1968) analyzed the von Neumann-Morgenstern model, a modified von Neumann-Morgenstern model and the Ramsey model. They compared each for its applicability to the real world and discuss the associated weaknesses of each model. They conclude that current criticisms will not be alleviated by generating new theories of utility analysis, but rather the more productive mode of operation is to further test existing theories.

Regardless of this fatalistic philosophy, there exists a need to develop a new technique in deriving risk preferences. The shortcomings of directly eliciting utility functions are too great to ignore. Given that few other methods existed as precedents, it is not difficult to understand why single-valued utility functions were used even in spite of criticisms. It also suggests a possible reason why additional work has not been conducted in the attribute-preference relationship. Researchers in this area were cognizant of the weaknesses and were apologetic regarding their methodology choice. Certainly others recognized the shortcomings of this approach and therefore shifted their research efforts to other areas. As suggested earlier, there appears to be an alternative to the direct elicitation of utility function methodology. That alternative methodology, as well as empirical evidence of its superiority, will be discussed in Chapter III.

CHAPTER III

THEORETICAL APPROACH AND METHODOLOGY

3.1 The Interval Method

As discussed in Chapter II, previous research in the attribute-preference area has ignored several attributes as well as relied upon establishing a utility function from which risk aversion was determined. Several criticisms are justified when dealing with a directly elicited, single-valued utility function. To alleviate these problems a new methodological approach was developed which directly measures the risk aversion function. This direct measurement of risk aversion functions was developed by King and Robison (1979). Not only does this approach have the advantage of directly measuring risk preferences, it also does so in a manner which constructs an interval for the range of risk aversion functions. When utility functions are used the risk aversion function is single-valued just as the utility function from which it is derived is.

There seldom is a perfect fit when estimating a utility function; however, the associated risk aversion function acts as if there is. The methodology used here allows for assigning an interval to the range of risk aversion functions.

King and Robison (1979) utilize stochastic dominance with respect to a function to order action choices of decision-makers. Rather than relying on utility functions, an efficiency criterion is used. The efficiency criterion that is used is stochastic dominance.

There are three degrees of stochastic dominance. First degree stochastic dominance implies second degree stochastic dominance and third degree stochastic dominance. Second degree stochastic dominance implies third degree stochastic dominance. First degree stochastic dominance (FSD) implies the probability function f(y) dominates (or is preferred to) g(y) by FSD if, and only if:

$$F_1(y) \leq G_1(y) \text{ for all } y \in [a,b] \text{ with}$$

$$F_1(y) < G_1(y) \text{ for at least one value of } y.$$

FSD requires that the marginal utility of income plus wealth U(y) be positive.

$$U'(y) > 0.$$

Second degree stochastic dominance implies the probability function f(y) dominates (or is preferred to) g(y) by SSD if and only if:

$$\int_a^{y^*} F_2(y)dy \leq \int_a^{y^*} G_2(y)dy \quad \text{for all } y^* \in [a,b] \text{ with}$$

$$\int_a^{y^*} F_2(y)dy < \int_a^{y^*} G_2(y)dy \quad \text{for at least one value of } y.$$

SSD requires the decision-maker to be everywhere risk averse, that is:

$$U'(y) > 0 \text{ and } U''(y) < 0.$$

Third degree stochastic dominance (TSD) requires that $U'''(y) > 0$; i.e., decreasing risk aversion. TSD is not utilized in King's (1979) methodology as he finds FSD and SSD sufficient for his purposes.

FSD and SSD can be demonstrated graphically. FSD means that the cumulative density function of the preferred strategy lie in part to the right and no where to the left of the cumulative density function for the dominated prospect (Figure 3.1).

When the cumulative density functions for prospects intersect then SSD must be examined. For example, Figure 3.2 exhibits no FSD.

Since FSD condition failed we now test for SSD

$$\int_a^{y^*} F(y)dy - \int_a^{y^*} G(y)dy \leq 0$$

or in this case

$$[\int_a^c F(y)dy - \int_a^c G(y)dy] + [\int_c^{y_1} F(y)dy - \int_c^{y_1} G(y)dy] \leq 0.$$

With respect to Figure 3.2, the first term is the negative of area A with the second term equal to area B. In this instance, F(y) dominates G(y) by SSD since area A is greater than area B. Above y_1, F(y) is always below G(y), so the accumulated area under F(y) continues to be less than that under G(y). Since SSD requires diminishing marginal utility [U"(y) < 0] the utility gain from the reduced probability of low payoffs represented by area A must be less than the utility loss associated with the higher probability of intermediate outcomes represented by area B since A $\geq$ B and the marginal utility of y is greater in the interval [a,c] than the interval [c,y].

Two criticisms can be made against SSD (King, 1979). The first is that it requires decision-makers to be everywhere risk-averse, and second SSD is not always a discriminatory tool. With this in mind King (1979) attempted to eliminate these criticisms by utilizing stochastic dominance with respect to a function. With this technique lower and upper bounds are put on the risk aversion function r(y) defined as:

$$r(y) = \frac{-U''(y)}{U'(y)} .$$

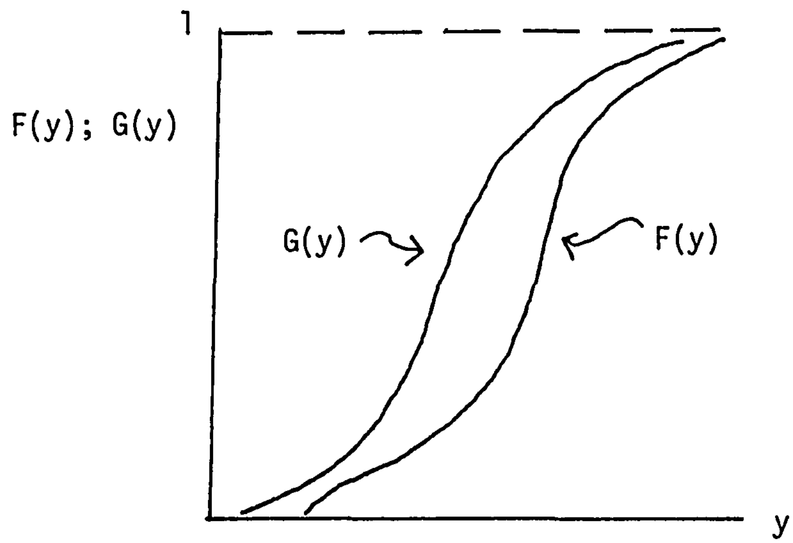

FIGURE 3.1

First Degree Stochastic Dominance of G(y) by F(y)

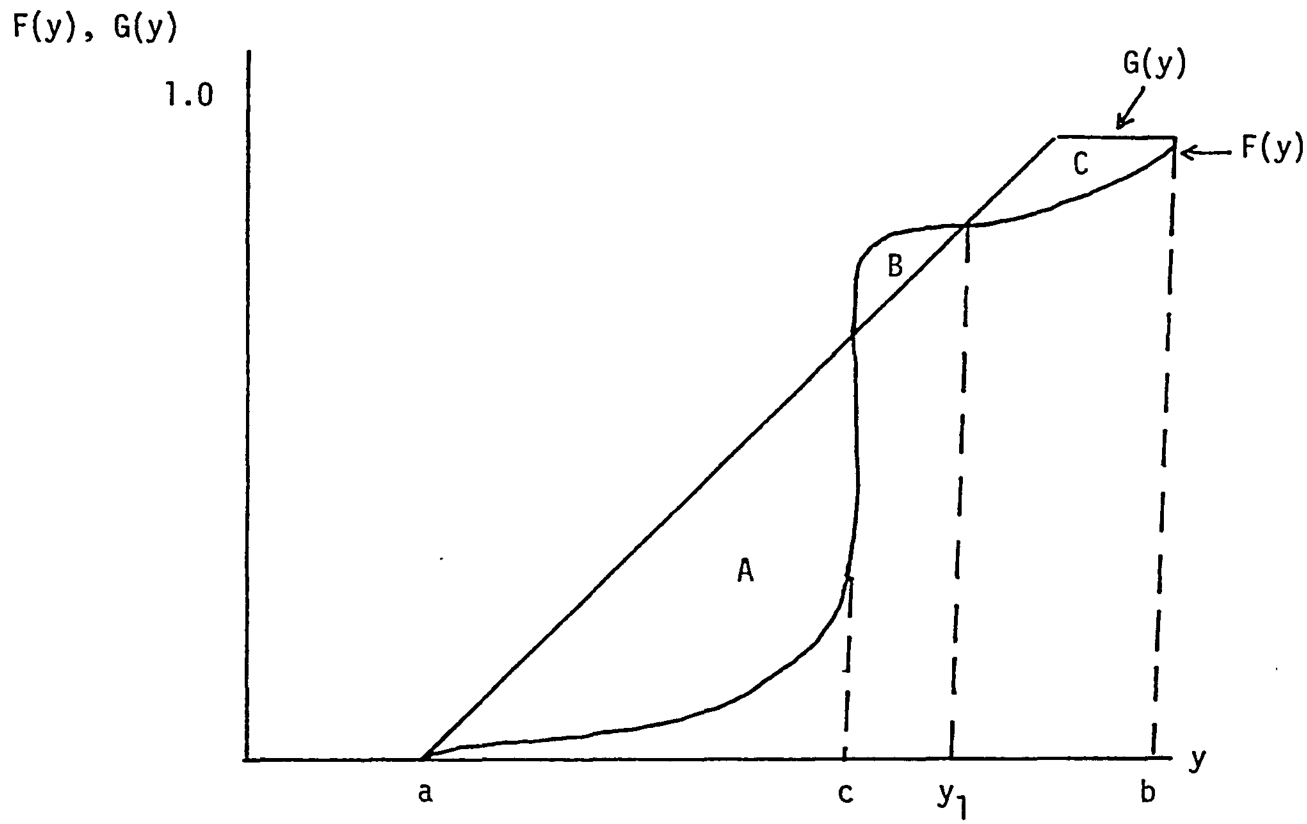

FIGURE 3.2

Intersecting Cumulative Distributions Which Violate First Degree Stochastic Dominance Requirements

FSD and SSD then become two special cases with $r_1(y) = -\infty$ and $r_2(y) = \infty$ for FSD and $r_1(y) = 0$ and $r_2(y) = \infty$ for SSD. By allowing the interval to take any shape the criticisms of the special cases are eliminated.

Stochastic dominance with respect to a function, as developed by Meyer (1977), is a much more powerful tool in ordinary action choices than either FSD or SSD. This technique orders uncertain action choices for a decision-maker who possesses a certain lower and upper bound, $r_1(y)$ and $r_2(y)$, on his absolute risk aversion function. These upper and lower bounds then define an interval measurement of risk preferences. The appealing feature of this interval measurement once obtained is that it allows us to order action choices. It imposes no assumptions on the shape of the function. Consequently it can be as narrow (precise) or wide (imprecise) as desired. Furthermore, this interval can take any shape and thus no restrictive assumptions about risk aversion are necessary. In other words, rather than assuming the shape of the function, the shape is determined by the decision-maker's preferences. As a result risk-loving [negative $r(y)$] as well as risk-averse [positive $r(y)$] behavior is accounted for.

This is done by identifying a utility function $U(y)$ which minimizes

$$\int_0^1 [G(y) - F(y)]\, U'(y)dy$$

subject to the constraint

$$r_1(y) \leq U''(y) \;/\; U'(y) \leq r_2(y);\; y \in [0,1].$$

In effect the difference in the expected utilities between $F(y)$ and $G(y)$ is minimized. If the minimum is zero, then $F(y)$ and $G(y)$ cannot be ordered and indifference is established. When the minimum is negative then preference cannot be established and

$$\int_0^1 [F(y) - G(y)]\ U'(y)dy$$

is minimized subject to the same constraint already mentioned. If this difference is positive, G(y) is preferred to F(y). If the difference is negative, ordering is not possible given the decision-maker's preferences.

By utilizing optimal control techniques Meyer developed a program to order action choices.[1] However, this assumed that decision-makers' intervals were known which is not the case. King (1979) then operationalized Meyer's program for his own needs. Given that a risk aversion interval will enable one to order action choices, King realized that comparisons and preference of action choices allow one to establish a risk aversion interval. With this in mind he developed several computer programs. The first program, NORGEN, generates a set of normal random sample distributions with a predetermined mean, variance, and number of elements. The second program, INTID, then takes these distributions and determines what specified set of intervals separate these plans. These two programs are necessary to establish the questionnaire that will be used to elicit the risk interval. Once this task is accomplished and the risk interval is known, this interval can be fed into the third program, UFUNC, which generates the utility function of the decision-maker. Using this function in the fourth program, NSTDO, the action choices under consideration can be ordered.

Consequently, generation of sample distributions is the first step. The user of NORGEN must specify the mean, standard error, number of

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[1]For a complete explanation, see King (1979).

distributions desired, and number of elements in each distribution. The second step, which involves the separation of distributions by risk intervals, requires the specification of interval measurements. The measurement grid used will be discussed later. After this task is accomplished the construction of the questionnaire can proceed.

The approach is an iterative one. By using an iterative approach the risk aversion interval can be constructed by comparisons of those carefully selected pairs of distributions. Construction of the interval measurements of decision-makers' absolute risk aversion function is based on the premise that a choice between distributions divides risk aversion between two spaces: one consistent with the choice and one inconsistent with it. Since the properties of the distributions define the two regions, the level of risk aversion depends solely on the two distributions being compared. By repeatedly comparing distributions the size of the interval can be reduced. With each choice a portion of the absolute risk aversion interval established in the previous comparison is eliminated, since it is inconsistent with the decision-maker's revealed preferences. This procedure continues until the desired level of precision is attained. This is done at each of the relevant income levels and then by connecting known portions of the upper and lower bounds the entire risk aversion function can be constructed.

This procedure is demonstrated in Figure 3.3. Suppose an individual was given a choice between Distribution A and Distribution B. If A is selected than r(y) lies below point x. Depending on the first response the individual is asked to choose between two more distributions, C and D. If C is chosen, then r(y) upper and lower are points x and s respectively. If D is chosen t becomes the new upper bound and the process

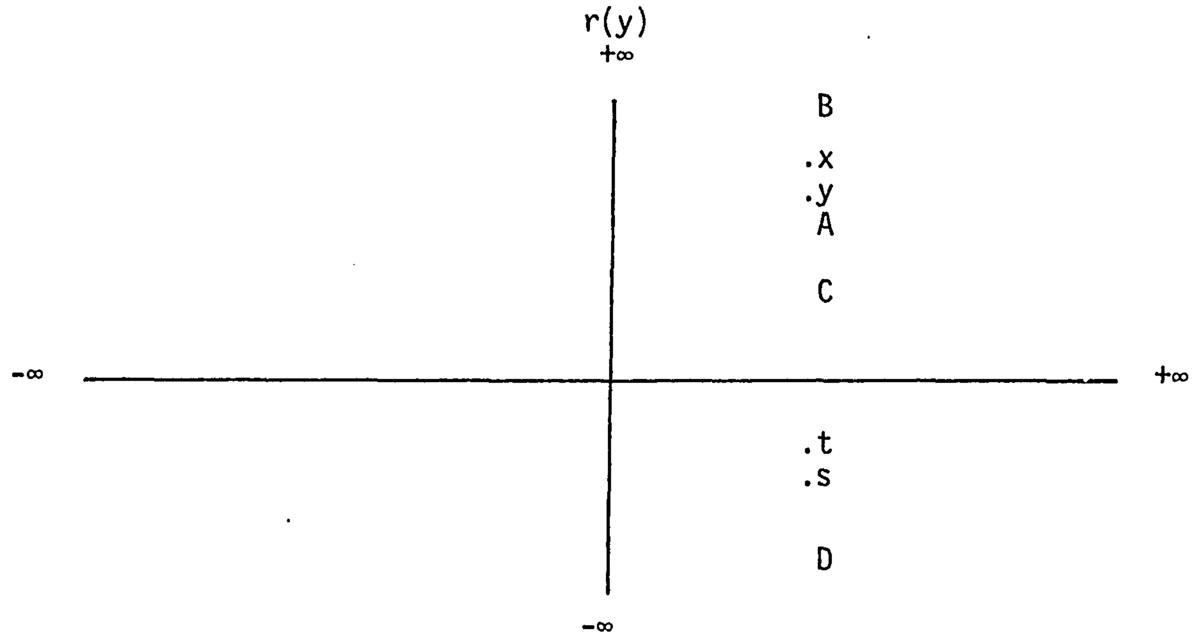

FIGURE 3.3

Reduction of Interval Size

continues to establish the bounds. Then by changing the values of the distribution and thus moving along the horizontal axis the process continues. By connecting the points on the upper and lower bounds horizontally the absolute risk interval function is established.

Once these bounds have been established they can then be used to predict which action choices will be followed. Each individual is assigned a range and these ranges usually differ from one individual to the next. The decision-maker's preferences determine the level and shape of this interval function and thus no assumptions about decision-maker preferences are required.

3.2 Empirical Test of Interval Approach

In the previous chapter a literature review was provided summarizing work done in the preference-attribute relationship area. The major criticism of these studies was the use of a single-valued utility function approach. The need for a new methodology was recognized and discussed and the interval methods just presented was offered as a superior technique. In light of the criticisms leveled at the methodologies employed in previous studies and the development of the interval method as a superior alternative, it seems only reasonable that an empirical justification follow.

3.3 Experimental Design

Ten graduate students from the Department of Agricultural Economics at Michigan State University (MSU) were sampled. These students were chosen on the basis of their knowledge of the theory. Since several courses taught at MSU deal with risk and uncertainty and stochastic dominance, an attempt was made to select students with little or no exposure to these concepts.

In setting up this experiment two tasks were necessary. The first was to determine the income range over which risk aversion should be measured. While any number of income ranges can be selected, it was found that three income levels were sufficient. Since the sample was composed of graduate students, the income ranges were: \$2,000-\$4,000, \$9,000-\$11,000, and \$16,000-\$18,000. The first two levels were chosen since they represent a one-quarter, one-half, or three-quarter time graduate assistant appointment. All people in the sample were receiving one form of this funding. The third level was selected to represent the income level of these individuals if they were to enter the job market, i.e., their opportunity cost, Consequently, these three levels of annaul income reflected income most consistent with the individuals' lifestyles and thus were easy for them to relate to.

The second task to be accomplished prior to conducting this experiment was to set up the measurement grid. This grid establishes the risk aversion interval to be determined for each individual at each of the three income levels. The grid that was selected is presented in Table 3.1.

This grid is both precise and complete in that the extreme values are very risk-loving and risk-averse--so much so that the risk premium as approximated by

$$\pi = \sigma^2 \frac{\lambda}{2}$$

becomes unrealistically high, suggesting that few if any would fall out of this range.

TABLE 3.1

Absolute Risk Aversion Levels Defining Measurement Grid

.010000
.005000
.002500
.001500
.001000
.000800
.000600
.000400
.000300
.000200
.000100
0.000000
-.000100
-.000250
-.000500
-.001000

Once this task was completed 40 Monte Carlo distributions were generated, with $\overline{x} = 0$ and $\sigma^2 = 500$. Then, by utilizing the previously discussed stochastic dominance with respect to a function, each of these distributions were separated from one another by an interval. In other words a decision-maker, making pair-wise comparisons, who preferred one distribution would lie above the lower bound of the interval while a decision-maker who selected the other distribution would lie below the upper bound. Using the previously discussed iterative approach this allowed a narrowing of this interval, thus achieving any desired level of preciseness.

Prior to making any comparisons all that is known is that the risk aversion coefficient is bounded by negative or positive infinity. After the first comparison a new upper or lower bound can be established. Thus, after one question decision-makers fall into one of two intervals. Subsequent questions allow placement of the interval in one of four, eight, or sixteen intervals.

Each respondent was asked to complete a five-part questionnaire. The first three sections contained fifteen questions each, and respondents were instructed to respond to four questions in each section. In an iterative process these three parts narrowed in on the risk aversion interval at each of the three previously discussed income levels. The fourth section of the questionnaire was a direct elicitation of the individual's utility function, a methodology similar to previous studies in the area of preference-attribute relationships. The fifth part asked each respondent to make six pair-wise comparisons of income levels over the entire range of incomes, i.e., \$2,000-\$18,000. This was done in such a way that each respondent chose the one income distribution level that they most preferred.

An attempt was made to get the respondents to relate this to their own circumstances. In each pair-wise comparison the distribution contained six elements representing six different income levels. Each element was equally likely to occur; thus it was equivalent to rolling a die to determine an individual's annual income level. In completing these questionnaires each respondent was informed that one element of the chosen distribution would be his/her income level for a year. They were asked to consider what they would do if they received a "good" or "bad" outcome. "Bad" outcomes would necessitate borrowing, liquidating assets, or drawing on savings. "Good" outcomes would allow for the purchase of additional assets, saving, or liquidation debts. In other words each respondent was asked to consider what they would do, thus drawing a relationship between this experiment and the individual's own circumstances.

3.4 Analysis

Of the ten questionnaires, nine were properly completed and returned. This allowed the prediction of 54 action choices with both the risk interval method and the single-valued utility function.

The first part of the analysis was to use the interval established earlier to predict which action choices would be selected over the entire income range. Similarly, the same task was completed with the single-valued utility function. The results shown in Table 3.2 offer some interesting insights.

TABLE 3.2

Empirical Results of Action Choice Predictions
Using Interval Risk Measures and a Utility Function

Number of Questions	1	2	3	4	Utility Function
Percent of Incorrect Predictions	2%	12%	22%	28%	35%
Percent Un-Ordered	90.7%	50%	16.7%	9.3%	0%
Percent Ordered	9.3%	50%	83.3%	90.7%	100%

As seen in Table 3.2, the utility function is 65 percent accurate in its predictive power while it is able to order all distributions. The interval method is 98, 88, 78 and 72 percent accurate in its predictive power after one, two, three and four questions, respectively. In other words as we narrowed the intervals to a higher level of precision, accuracy was given up in the predictive capabilities. Also of interest is that as the number of questions used to define the interval increased, thus decreasing the width of the interval, the number of distributions that could be ordered increased. As discussed earlier, the interval allows us to separate distributions into three groups: those unanimously preferred, those dominated, and those which fall within the interval and thus cannot be ordered. The percent of action choices unordered decreases as the interval is narrowed.

Several points are worth noting. First, the distributions used for predictions were very similar and thus choices between distributions were very difficult for many. None of the seven distributions could be eliminated with first degree stochastic dominance. Also, second degree stochastic dominance which assumes an interval between zero and infinity could order only 7.4 percent.

Further comparisons of the interval method with second degree stochastic dominance yielded interesting insights. SSD yielded a 98 percent accuracy rate while only ordering 7.4 percent of these distributions--inferior results to those obtained after only one question with the interval method. Of those distributions ordered, SSD was in error 25 percent of the time while the error percentage for one and two questions for the same comparisons was 20 and 19 percent, respectively. Obviously this is an example of the problem confronted when making the assumption that there is decreasing absolute risk aversion over wealth.

With regard to this point it was found that the individual's risk aversion intervals took no particular shape. As stated SSD assumes decreasing absolute risk aversion over wealth and different functional forms of utility functions suggest constant increasing or decreasing absolute risk aversion. Our results do not demonstrate this. Every interval was different and there was no consistent shape--some had increasing then decreasing, decreasing then increasing, increasing, decreasing, and constant absolute risk aversion over wealth. Obviously one of the attractive features of the interval method is that it does not make any assumptions about the shape of the interval; rather, it lets the interval take whatever shape is consistent with the decision-makers' preferences.

Robison and King (1978) discussed the similarities between single-valued utility and production functions. Just and Pope (1978) suggested an unwillingness to assume that production responses are described by a single-valued function. Robison and King made similar inferences to utility functions and suggested the interval method as a superior technique. They justified this interval method superiority on the basis of the higher degree of realism associated with an interval as opposed to a single-valued function.

One would hypothesize that as the level of precision in measuring preferences increases, thus decreasing the width of the interval, that the accuracy decreases. Also, as the precision is increased, the number of orderings would increase since the distributions are less likely to fall within the interval. These empirical results support these hypotheses.

At this point it should be clear that the interval method is a more realistic tool. However it is unclear whether it is a superior tool to single-valued utility functions where complete orderings are desired. In other words, the utility function was less accurate, but it ordered every choice. To test which tool was better given identical conditions, a comparison was made of the accuracy rate for the distributions that were ordered. To accomplish this goal the pairs that were ordered after each question were examined and then compared with the results obtained using the utility function. The results of placing the interval and utility function on the same level are presented in Table 3.3.

In four of the five cases tested, the interval approach was superior in accuracy with respect to choosing among action choices. After one question both the utility function and interval method were equivalent. Consequently, these empirical results suggest the interval method is not only a more realistic tool for elicitation of risk preferences, but a superior tool as well.

This consideration is magnified when one considers the elicitation process itself. To establish the utility function the respondents had to complete nine questions. Three, six, nine and twelve questions were necessary for the interval method for one, two, three and four questions, respectively. Most respondents complained about the difficulty of completing the utility questionnaire while they enjoyed the interval method since they perceived it as more realistic.

As demonstrated, there exists a trade-off between accuracy and the number of orderings that exist. This trade-off needs further investigation, but it is similar to recognizing the trade-offs between type I and type II errors in statistical analysis. As Manderscheid (1965) suggested,

TABLE 3.3

Accuracy of Interval Compared
to Utility Function Approach

Question	1	2	3	4
(Percent Correct)				
Interval	80%	81.5%	73.3%	67.4%
Utility Function	80%	74.0%	60.0%	61.0%

the losses associated with those errors, as well as their probabilities, need to be recognized when determining where to set significance levels. A similar type of analysis is appropriate here. In other words, if a high level of ordering is desired and the costs associated with eliminating a preferred choice is small, then a very precise measurement is called for. On the other hand, if accuracy is very important and ordering is not, then a less precise interval measurement is necessary.

The interval method allows a great deal of flexibility. Regardless of the level of accuracy desired this method greatly reduces the number or action choices consistent with decision-makers preferences. Given the design of this experiment, a low ordering occurred with high accuracy. In a practical setting it is very likely that a higher percentage of orderings will occur with the same level of accuracy.

CHAPTER IV

QUESTIONNAIRE AND SAMPLE DESIGN

In an attempt to establish relationships that might exist between producer attributes and risk preferences and then to use that relationship in predicting action choices, two prior steps must be accomplished. The first is constructing the questionnaire. The second is selecting and questioning the sample.

4.1 Questionnaire Design

Designing a questionnaire requires much time and planning. While an example was given in the previous chapter, it should prove beneficial to outline the questionnaire design procedure since the questionnaire is the primary basis for this research effort.

The first step is the generation of sample distributions to be used. In order to do this, one must first decide on five factors and then enter these five factors into the program NORGEN.[1] The program NORGEN generates sample distributions from an underlying normal distribution.

The first factor specified is NE, which is the number of distributions to be generated. While this number can vary greatly, depending on the make-up of the questionnaire, for this study's purpose 40 distributions proved sufficient. Generation of less than 40, given the

[1]For a listing of NORGEN and INTIDPROG, see King and Robison (1981).

measurement grid to be used, runs the risk of not having distributions separated by all of the specified risk aversion levels on the measurement scale. Any more than 40 is redundant.

The second variable that must be specified is ND, which is the number of elements in each distribution. Any number from three to six appears acceptable. More than six makes comparisons between distributions both less realistic and more uninteresting. Also, selection of the number of distributions should be guided by ability of the researcher to relate distributions to real world events as well as probabilities. For the purpose of this analysis, the number of distributions was set at six. This was done primarily to reflect the probability of outcomes similar to the tossing of a die. In other words, farmers could be told that the six elements of a distribution was printed on one of the six sides of a die. When making comparisons between distributions a farmer could be told that he must choose which of the two dice to roll with the outcome being realized income.

The third variable that must be determined is YMEAN, which is the mean of the underlying distributions. To do this it must be decided over what income range one wishes to measure risk aversion, and at how many points. Since each element of the distribution was to represent after-tax farm profit, the range of income used for this analysis was $-1,000 to $50,000. This range seems realistic for the farmers who would be sampled. In deciding how many levels to measure risk aversion, a trade-off exists. Naturally it is preferable to measure risk aversion at as many points as possible; however, the more points chosen increases the number of comparisons that must be made by a multiplicative factor. In this case four points seemed optimal. Consequently YMEAN was set at $0,

$10,000, $25,000, and $45,000 for the four different runs that were necessary. This, in conjunction with setting the standard deviation of distributions, made the range of income over which risk aversion was measured $-1,000 to $50,000.

The fourth variable that needs to be specified is STD, which is the standard deviation of each of the underlying distributions. In doing this care must be taken not to assume that risk aversion is constant over too large an income range. This is especially critical with low levels of income. Prior to this analysis STD was usually set at 500, as was the case with the example given in the previous chapter. However, as income gets greater, one could argue that risk aversion is constant over longer ranges. Also comparisons between distributions becomes less interesting when the mean of distributions are increased and the standard deviation remains small. In other words, the difference of $500 means much less when comparing hundreds of thousands of dollars than it does when comparing thousands of dollars. Consequently it was assumed that constant absolute risk aversion held for greater dollar increments as the mean of the distributions increase. As a result for YMEAN equal to $-5,000, $10,000, $25,000, and $45,000, STD was set at 500, 500, 2500, and 2500, respectively. In effect, constant absolute risk aversion was assumed between $-1,000 and $1,000; $9,000 and $11,000; $22,000 and $28,000; and $40,000 and $50,000. This method is both more interesting and valid than previous work.

It should be noted, however, that by increasing the width as income increases differences in the discriminant analysis results at various income levels cannot be attributed solely to changes in risk preferences.

It may be that the assumption of constant risk aversion influences the results and biases the test of the hypothesis. Further research is necessary to determine if this is a problem and if so how significant is the problem.

Finally, it is necessary to specify IROUND, which is a rounding factor for each element of each distribution. Many numbers have been used but experience suggests that IROUND = 100 is the most ideal. Using a smaller rounding factor makes comparisons tedious, while using a larger factor is not realistic in this given case.

Using these values NORGEN was run four times, once for each income level. This data was then stored and used for input on the next program, INTID.

INTID is a program which takes the distributions and identifies a boundary interval for pairs of distributions. Inputs necessary for this program include NE and ND as discussed in Chapter III. Similarly NAME and R, which are the arrays used to describe sample distributions, are read from catalogued NORGEN output so this input involves very little effort.

Factors that must be determined are NG, which is the number of levels on the measurement grid, and RA, which is the array of values themself. As stated earlier, a very good grid was found. NG is equal to 16 and the values of RA are listed in Table 4.1. This grid is both complete and detailed. It is complete in that it contains a range of risk aversion coefficients that most are likely to fall within. It is detailed in that the 16 values allow for small incremental changes.

TABLE 4.1

Absolute Risk Aversion Levels
Defining Measurement Grid

.010000
.005000
.002500
.001000
.000800
.000600
.000400
.000200
.000100
0.000000
-.000100
-.000250
-.000500
-.001000

The output of this program details which plans are preferred above and below specified risk aversion points. With this information the process of completing the questionnaire could continue.

The next step necessary is that of sequencing questions. As discussed earlier, the upper and lower bounds of the risk aversion function are necessarily assumed positive and negative infinity prior to questioning. By using an iterative process this space can be reduced to as narrow an interval as desired or deemed necessary. The same question design was used here as in the previously discussed example since the measurement grid was the same. However, in reviewing the questionnaire it was decided to use only three questions rather than four. The loss of accuracy and ordering capability were offset by the benefits received by reducing the questionnaire size.

As can be seen by examining the questionnaire (see Appendix), there are seven questions to a section, to which each person responded to three. With four questions the total number in each section increases to fifteen even though each respondent makes only one additional comparison. It was believed that this added length might reduce the response rate and therefore not be worth it. Also, the analysis in the previous chapter had low ordering because the comparison between those distributions was so difficult. As will be discussed, an attempt to alleviate this problem was made so that the loss of ordering power and accuracy by moving to only three questions would not be realized.

The questioning sequence scheme is presented in Figure 4.1. Starting at the top, the first questions compare two distributions that are separated by the measurement levels of .0003 and .0004. Depending on

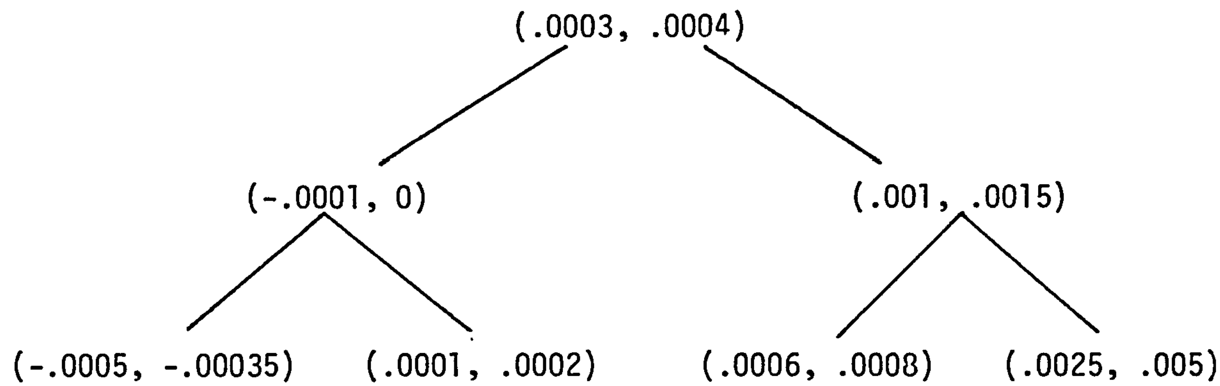

FIGURE 4.1

Iterative Process Used in Questionnaire Design which distribution is selected, the decision-maker will either establish a new upper bound of .0004 or a lower bound of .0003. Thus the new interval will be $(-\infty, .0004)$ or $(.0003, +\infty)$ depending on the choice of the comparison. A similar analysis takes place for any subsequent number of questions desired. Consequently for this work three questions yielded eight intervals into which a particular decision-maker could fall. The intervals into which a decision-maker could fall for each question are listed in Table 4.2. The first number in the brackets represents the lower bound, while the second represents the upper bound for the absolute risk aversion interval.

The above described procedure was followed four times, once for each income level. The results of this work are Sections I, II, III, and IV of the questionnaire as shown in the Appendix. As is apparent, this is both the most complex and time-consuming portion of the questionnaire construction.

The first four sections of the questionnaire establish a risk aversion interval for each decision maker. Using that interval it is possible to predict which action choices will be selected and Section V is used for such predictive purposes. The distributions used should span the range over which the function has been established. Care should be taken to insure that no distribution is dominated by first degree stochastic dominance since these comparisons are not interesting. In other words, no one who has positive utility for wealth would select a plan dominated by first degree stochastic dominance.

TABLE 4.2

Correspondence Between Questions Asked and Risk Intervals Identified

Number of Questions	Possible Intervals							
0	(-∞, +∞)							
1	(-∞, .0004)	(.0003, +∞)						
2	(-∞, 0)	(-.0001, .0004)	(.0003, .0015)	(.001, ∞)				
3	(-∞, -.00025)	(.0005, 0)	(-.0001, .0002)	(.0001, .0004)	(.0003, .0008)	(.0006, .0015)	(.0001, .005)	(.0025, ∞)

The manner in which distributions are compared is innovative. Other studies have not allowed for contradiction of the transitivity axiom; however, this procedure will allow for testing the extent of this occurrence.

Finally, section VI is used to elicit information about personal, business, and economic attributes. This information was not readily available by other sources and will be discussed later. Also contained in this section are six questions used to determine personality traits. Work has been done to examine the relationship of personality traits to job preference, grade point average, as well as many other factors (Roberts and Lee, 1977; Myers, 1962).

With this in mind six faculty members in the Agricultural Economics Department at MSU were asked to fill out the interval measurement questionnaire and provide their Myers-Briggs scores. Then an analysis was done to see which, if any, factors were related to their risk aversion. Of the four personality traits two showed promise; introvert-extrovert and judgement-perception. Obviously the small sample size precludes reporting results since any conclusions cannot provide a strong basis for including the Myers-Briggs questions. However, the additional information was obtained at a low cost and might prove worthwhile in the future. The six questions used were based on questions in the Myers-Briggs tests (Briggs and Myers, 1976). The first three questions classify decision-makers as either an introvert or extrovert, while the last three seek to establish whether judgement or perception is present. Basically an introvert exists and relates to his own inner-world while an extrovert works in the outer-world. The judgers like to organize and plan while the percepters are less organized and have trouble making decisions.

It is also worth noting that composing the questionnaire instructions required much work. Clear, concise instructions are necessary for correct completion of the questionnaire; however, they must also be short so as to avoid reducing the response rate. After several drafts and reviews the final wording of the instructions was selected.

4.2 Pre-Test

Seven farmers were sent the questionnaire as a pre-test. Five questionnaires were returned, but one of these questionnaires was not completed since the respondent indicated concerns about the purpose of the study.

Once the questionnaires were returned, the five respondents were contacted by telephone in an attempt to discern whether they understood the instructions. For the most part the instructions were clear; however, the farmer who returned the blank questionnaire indicated a statement of the study's purpose would facilitate a higher response rate. These suggestions and criticisms were acknowledged and several changes were made to alleviate perceived problems. The pre-test was certainly a worthwhile task which improved the final result.

4.3 Sample Selection

In any study the selection of a sample is a difficult task. Obviously the way in which the results are to be used should guide the selection process. Factors such as representativeness, ease of acquiring data, response rate, etc., must all be examined. For this study it was determined that the sample population should come from Telfarm participants at Michigan State University. Telfarm is a voluntary record-keeping system that the Agricultural Economics Department provides to interested Michigan farmers for a specified fee. The disadvantages of using these participants as a sample include lack of representativeness, inability to get wide dispersion of size, as well as other shortcomings of a non-random sample. Obviously the results will be only generalizable to the sample itself.

While the disadvantages are significant, the advantages appear to dominate. Given that personal, business, and economic attributes will be used in the analysis, the use of Telfarm records will provide significant amounts of detailed and sensitive information at a low cost. Not only will exclusion of this information from a questionnaire reduce the size of the questionnaire, thus possibly increasing the response rate, but it will also be much easier and less time-consuming to collect. Also, Telfarm participants historically have been cooperative study participants, again increasing the response rate.

Of the Telfarm participants, it was decided to examine three enterprise types: dairy, cattle feeding, and cash crop. This selection was made to determine if any recognizable differences existed in risk preferences. In addition to Telfarm membership, the participants had to be included in the 1979 Business analysis. This further requirement had two purposes--first, it insured that these individuals were specialized in each particular enterprise, and second, it insured complete records.

4.4 Sample

The sample used for this study consisted of 37 dairy farmers, 17 cattle feeders, and 26 Saginaw Valley cash crop producers, for a sample total of 80. Since Telfarm classified by county, individuals were selected primarily by counties with a large number of qualifiers in each county.

4.5 Data Acquisition

Once the questionnaire and sample selection had been completed, it was necessary to determine the best strategy for questionnaire completion. The two methods considered were: a mail survey or a personal interview campaign. A mail survey had the disadvantages of lower response rates and possibly less accuracy; however, this method was both less costly and time-consuming. Given the large sample size and their geographical distributions around the state of Michigan, the time and cost factors associated with personal interviews made that alternative prohibitive. Thus the questionnaires were mailed to the sample population. Two weeks after the first mailing, non-respondents were sent a follow-up letter. After an additional two weeks, non-respondents were contacted by telephone in an attempt to increase the response rate.

CHAPTER V

ANALYSIS OF DATA

5.1 Response Rate

Of the 80 questionnaires that were mailed to Michigan farmers, a total of 39 were returned for a response rate of 48.75%. By using the postmark dates it was determined that 17 or 44% of the returned questionnaires were returned after the first mailing. An additional 9, or 23%, were returned after the follow-up letter while 13, or 33%, of the returned questionnaires followed the phone call.

While a 49% response rate is acceptable, it would likely have been higher if the mailing had not occurred when farmers were trying to get their crops planted. In the telephone follow-up many of the producers mentioned how busy they were and stated that the questionnaire would receive attention if their time constraints allowed. In several cases they could not find the time to complete the questionnaire.

The response rates between dairy, cash crop, and beef feeders were reasonably consistent with 49% of the dairy producers, 42% of the cash crops, and 59% of the cattle feeders responding to the survey.

Only 31 of the 39 returned questionnaires were acceptable for use in the analysis. Prior to distribution of the surveys it was hoped that there would be at least 30 questionnaires to analyze and this hope was satisfied.

5.2 Ordering Based on Risk Interval

Once the questionnaires had been returned, each was analyzed to determine the appropriate risk aversion function for each individual. The risk aversion function was determined after one, two, and three questions. This information was then used to predict the action choices selected in Section V of the questionnaire in the same manner as was done earlier. Again the results were encouraging as can be seen in Table 5.1.

As can be seen these results are similar to those obtained earlier. Again, there exists a trade-off between the accuracy of ordering and the level of ordering that occurs. As suggested, the trade-offs between accuracy and failure to predict an action choice must be carefully weighed. Also the need to take into consideration the difficulty of comparing action choices is the primary determinant of choosing the correct number of questions to be used in this analysis. In other words, when choices are relatively easy a wider interval will suffice while with more difficult choices it is necessary to obtain a narrower interval.

Again we emphasize that the risk preference intervals which were elicited from the producers were all unique. In other words, any general assumption about risk preferences for all producers is not supported by this study's findings.

Basically, there appears to be two key factors that should become evident from this work. The first is that there exists a trade-off between accuracy of ordering and the ordering of action choices. If a high level of ordering is desired then a higher error rate in ordering will occur. If a small error rate in ordering is desired then a smaller level of

TABLE 5.1

Ordering and Accuracy of Interval Approach

Number of Questions	Incorrect Predictions (percent)	Correct Predictions (percent)	Choices Unordered (percent)	Choices Ordered (percent)
0	0	100	100	0
1	0	100	97	3
2	6.5	93.5	78.1	21.9
3	16	84	52	48
FSD	0	100	100	0
SSD	11	89	70	30

ordering must be accepted. Certainly the appropriate trade-off must be determined when using the interval method as an actual aid to producers for decision-making. The costs and probabilities of error are of primary importance in this respect. While no work has been done in this area it is only because of the newness of the technique, rather than its lack of importance. Future research should address these trade-offs.

The second lesson worth reiterating is that the interval method offers a superior technique to any arbitrary assumption about risk preference functions. In the past, assumptions have been made and analyses have been completed based on these assumptions. This research has demonstrated that individuals possess all different shapes of risk aversion functions and as a result if the interval is practical, the results of any research predicting action choices would likely be superior to those where the interval or risk preference is assumed.

5.3 Discriminant Analysis

After the ordering portion of the analysis was completed, it was then necessary to determine if any systematic relationship existed between risk preferences and producer attributes. To do this discriminant analysis was performed at each of the four levels of income that risk preferences were measured. At each level of income the producers were separated into three near evenly divided groups based on risk preferences. A discriminant function was then derived to separate as many of the producers into their correct classifications as possible. Variables were eliminated if they added nothing to the correctness of this classification scheme. The variables used in this analysis were for 1978 and are as follows:

V_1 = marital status (0 = single, 1 = married)

V_2 = age (years)

V_3 = number of children

V_4 = education level (number of grades completed)

V_5 = years living on farm

V_6 = years managing farm

V_7 = percent of income from farm

V_8 = percent of farm income yours

V_9 = acres owned

V_{10} = acres rented

V_{12} = introvert-extrovert (Measured +3 to -3 with higher value indicating higher degree of introvert and lower value extrovert. Zero indicates neutrality.)

V_{13} = perception-judging (Measured the same with higher value for judging, lower for perception.)

V_{14} = net worth (dollars)

V_{15} = net cash income (dollars)

V_{16} = net worth/assets (percent)

Where necessary the units of measurement are included.

To assist in providing information on the general characteristics of the sample, the variables, their means, standard deviations and ranges are also provided as follows:

Variables	High Value	Low Value	Mean	Standard Deviation
V_1	1	0	.93	.24
V_2	61	20	45.26	11.71
V_3	09	0	3.29	2.23
V_4	16	10	12.39	1.66
V_5	61	20	44.00	12.34
V_6	40	1	22.52	11.94
V_7	100	50	.90	.15
V_8	100	33	.75	.25
V_9	1,100	0	321.77	241.03
V_{10}	700	0	239.84	188.82
V_{12}	3	-3	1.35	2.04
V_{13}	3	-3	-1.06	1.72
V_{14}	1,002,800	-415,157	366,803.00	283,867.00
V_{15}	136,368	-197,454	43,335.20	57,839.70
V_{16}	100.00	24.53	.66	.68

5.4 Results at $0

For risk preferences measured at zero income levels, respondents were separated into three groups. The first group had an interval of (-.01, -.00025). The second group had an interval of (-.0005, 0) and the third group had an interval of (-.0001, .0002) or larger.

The results of the standardized discriminant function can be seen in Table 5.2. Those variables with the largest absolute values are the ones which are the most important in the classification scheme. Consequently age, years on farm, years managing farm, and net worth were of primary importance in classification.

TABLE 5.2

Discriminant Function at Zero Income Level

	Standardized Discriminant Function Coefficients 1	2
V_2	.85028	2.19746
V_3	- .88473	- .16746
V_4	.08774	- .49067
V_5	-2.04446	.03079
V_6	2.14624	-2.12725
V_7	- .11255	- .03732
V_8	.90806	- .21596
V_9	- .67952	- .22689
V_{10}	.26481	- .44742
V_{12}	.48395	.51225
V_{13}	.79638	.03752
V_{14}	1.22467	.15993
V_{15}	- .14345	- .37445
V_{16}	-1.06328	- .65862
Centroids of Groups in Reduced Space		
Group 1	-2.19848	.03311
Group 2	1.00343	-1.22477
Group 3	1.26060	.28343

The predictive ability of the discriminant function was also generated and the results are presented in Table 5.3. As can be seen this function correctly classified 84% of the producers. Also worth noting is that only two people were incorrectly classified into an extreme group. In other words, only two individuals were selected for a group that was two groups away from where they actually belonged.

5.5 Results at $10,000

A similar analysis was conducted at the $10,000 level of income. Here Groups 1, 2 and 3 were those with intervals of (0.01, 0), (-.0001, .0004), and (.0003, .0008) and larger respectively. Again an attempt was made to separate producers into three evenly divided groups based on risk preferences. This was done for efficiency since no obvious clustering pattern existed. The results of this analysis can be seen in Tables 5.4 and 5.5.

At this income level number of children, acres owned, net worth, and net cash income were the most important variables in the classification scheme.

Again this function classified 84% of the producers into the correct group, only this time no one was mis-classified to an extreme. Also this function utilized all 15 variables where the previous function eliminated marital status as a non-contributing factor.

5.6 Results at $25,000

Producers were classified here into three groups also. Those with an interval of (-.01, -.00025) formed Group 1 while those with an interval of either (-.0003, 0.0) or (-.0001, .0002) formed Group 2. Anyone

TABLE 5.3

Discriminant Function's Predictive Ability, Zero Income Level

Actual Group Name	Code	Number of Cases	Predicted Group Membership Group 1	Group 2	Group 3
Group 1	2	11	10. 90.9%	0. 0%	1. 9.1%
Group 2	3	4	0. 0%	4. 100.0%	0. 0%
Group 3	4	16	1. 6.3%	3. 18.8%	12. 75.0%

83.9% of Known Cases Correctly Classified

Chi-Square = 35.629 Significance = .000

TABLE 5.4

Discriminant Function at $10,000 Income Level

Standardized Discriminant Function Coefficients	1	2
V_1	-1.25845	.12082
V_2	.19637	-1.00134
V_3	1.62285	- .41860
V_4	- .45847	- .15178
V_5	.17034	.65933
V_6	- .80688	1.27414
V_7	1.32675	.01316
V_8	-1.37030	- .71373
V_9	1.69500	- .20420
V_{10}	- .80147	- .49913
V_{12}	1.14935	.16294
V_{13}	- .34766	.28638
V_{14}	-1.53637	- .00809
V_{15}	-1.44442	- .30078
V_{16}	.78975	- .56384
<u>Centroids of Groups in Reduced Space</u>		
Group 1	-1.73775	.58390
Group 2	- .24506	- .80137
Group 3	2.75699	.39920

TABLE 5.5

Discriminant Function's Predictive Ability, $10,000 Income Level

Actual Group Name	Code	Number of Cases	Predicted Group Membership Group 1	Group 2	Group 3
Group 1	2	11	9. 81.8%	2. 18.2%	0. 0%
Group 2	3	12	3. 25.0%	9. 75.0%	0. 0%
Group 3	4	8	0. 0%	0. 0%	8. 100.0%

83.9% of Known Cases Correctly Classified

Chi-Square = 35.629 Significance = .000

with an interval of (.0001, .0004) formed Group 3. Results of the discriminant analysis can be seen in Tables 5.6 and 5.7.

At this income level age, percent of farm income yours, acres rented, and net worth were the most important variables in the classification scheme.

Here classification was 77.4 percent accurate. Again all variables were included in the analysis. Also, no extreme misclassification took place.

5.7 Results at $45,000

Producers were classified into three groups here also. The first had a risk interval of (-.01, 0.00025) or (-.0005, .00) while the second had an interval of (-.0001, .0002) or (.0001, .0004). Finally the third group consisted of those producers with an interval of (.0003, .0008) or larger. The same analysis was conducted here with the results reported in Tables 5.8 and 5.9.

In this case years managing a farm, acres rented, age, and years living on a farm were the most important variables in the classification scheme.

In this case 74 percent of the producers were correctly classified by their attributes. Here three producers were misclassified to extreme categories. Again, all variables were included.

5.8 Interpretation of Results

There are two interrelated statistics provided with the discriminant analysis results that are worth discussion, those being the chi-square statistic and the significance level. These statistics answer the question could these results have been obtained if the groupings were in fact

TABLE 5.6

Discriminant Function at $25,000 Income Level

Standardized Discriminant Function Coefficients	1	2
V_1	- .22988	.19375
V_2	-1.63521	- .58505
V_3	.68701	- .58228
V_4	- .44701	.44583
V_5	.38311	.91488
V_6	.21969	- .10659
V_7	- .12150	- .21414
V_8	-1.40130	.10541
V_9	.50581	.78900
V_{10}	-1.51630	.14400
V_{12}	.50259	.09913
V_{13}	.85489	- .65913
V_{14}	.92993	.03030
V_{15}	- .89838	- .02147
V_{16}	- .73326	- .59558
<u>Centroids of Groups in Reduced Space</u>		
Group 1	-1.13733	- .75454
Group 2	- .66602	.61140
Group 3	2.09935	- .12860

TABLE 5.7

Discriminant Function's Predictive Ability, $25,000 Income Level

Name	Code	Cases	Group 1	Group 2	Group 3
Group 1	2	9	7. 77.8%	2. 22.2%	0 0%
Group 2	3	13	3. 23.1%	9. 69.2%	1. 7.7%
Group 3	4	9	0 0%	1. 11.1%	8. 88.9%

77.4 Percent of Known Cases Correctly Classified

Chi-Square = 27.113 Significance = .000

TABLE 5.8

Discriminant Function at $45,000 Income Level

	Standardized Discriminant Function Coefficients 1	2
V_1	.16772	- .23096
V_2	- .40000	1.20345
V_3	- .58839	.42323
V_4	- .24545	.13167
V_5	- .19480	-2.36374
V_6	.84495	.99286
V_7	.38387	- .13944
V_8	.78077	.17677
V_9	- .45983	.59130
V_{10}	1.09601	- .19480
V_{12}	- .32667	.06263
V_{13}	.19436	.49412
V_{14}	- .22369	.22091
V_{15}	.40643	.47012
V_{16}	.20904	- .47189
Centroids of Groups in Reduced Space		
Group 1	.26761	- .66118
Group 2	-1.27620	.32080
Group 3	.96741	.79617

TABLE 5.9

Discriminant Function's Predictive Ability, $45,000 Income Level

Name	Code	Cases	Group 1	Group 2	Group 3
Group 1	2	14	10. 71.4%	3. 21.4%	1. 7.1%
Group 2	3	9	1. 11.1%	8. 88.9%	0 0%
Group 3	4	6	2. 25.0%	1. 12.5%	5. 52.5%

74.2 Percent of Known Cases Correctly Classified

Chi-Square = 23.290 Significance = .000

a random occurrence? At each income level, given the chi-square statistic, the significance level of zero indicates that there is a zero probability of these groupings occurring randomly.

When examining the standardized discriminant function it is worth noting that the absolute values of the coefficients tells us how important each variable is in the classification process. The greater the absolute value the more important that variable is. As can be seen from the results a particular variable may be very important in separating group 1 from group 2 while of little importance in dividing group 2 from group 3.

Structural coefficients were not obtained in this analysis. These coefficients have an advantage over the standardized coefficient in that they are not affected by relationships with other variables. Standardized coefficients utilize the simultaneous contributions of all the other variables in the analysis. Consequently, the standardized coefficients may not reflect the appropriate weight of a particular variable due to a high correlation with another variable. However, this does not appear to pose a problem in this analysis since each variable utilized is not highly correlated with the remaining variables. If high correlation exists, structural coefficients should be included in the analysis.

5.9 Summary of Results

After completing the discriminant analysis, regression analysis was performed on the same data. The dependent variables were the upper and lower bounds of the risk aversion functions at each income level with the independent variables being those attributes used in the discriminant analysis. Since the primary difference in the two methodologies is that the regression analysis relies on a continuous risk variable and the discriminant analysis utilizes discrete risk variables, it can be expected that the results would be quite similar. As expected, they were.

Several factors appear worth noting based on the previous analysis. Based on attributes, discriminant analysis did a reasonably good job of classifying producers by risk preferences at all four income levels. However, no set of variables was consistently the most influential in that classification process. Using the results of the discriminant analysis which are closely repeated with the regression results, a comparison of the most influential variables in the classification scheme can be seen and compared in Table 5.10. Also contained in this table is the most influential variables over all income levels based on regression analysis.

While these results demonstrate that it is possible to classify producers into risk preference groups by attributes with a reasonable degree of accuracy at particular income levels, classification over the complete risk aversion function measured over all income levels was much less successful. The following section will devote attention to risk intervals over all income levels and use these results to predict action choices.

5.10 Using Attributes to Predict Action Choices

After completing the discriminant analysis further work was done to see how well risk preference functions over all levels of relevant income could be predicted. To accomplish this, the upper and lower bounds of the risk aversion function were used separately as the dependent variable, with the attributes previously mentioned serving as independent

TABLE 5.10

Most Influential Variables in Classification Process

Income Level	Regression Analysis 0-45,000	Discriminant Analysis 0	10,000	25,000	45,000
V	V_0	V_2	V_3	V_2	V_6
A R	V_2	V_5	V_9	V_8	V_{10}
I	V_4	V_6	V_{14}	V_{10}	V_2
A	V_9	V_{14}	V_{15}	V_{14}	V_5
B L	V_{10}				
E					
S					

variables. Since the function was measured at four levels there were four observations per individual producer. Unfortunately the results were not as good as hoped for. After using a step-wise process for adding and deleting variables, two equations remained. Equation 5.1 is the estimated equation for the lower bound on absolute risk aversion, and Equation 5.2 is the equation for the upper bound.

$$(5.1)\quad R_L = \underset{(-1.81)}{-.00005158}\ V_2 + \underset{(3.048)}{.00000512}\ V_9 - \underset{(-.1598)}{.000155}\ V_4$$

$$R^2 = .08$$

$$(5.2)\quad R_U = \underset{(2.88)}{.00157} + \underset{(1.68)}{.000000012}\ V_0 - \underset{(-2.55)}{.0000262}\ V_2 - \underset{(-1.55)}{.00000099}\ V_{10}$$

$$R^2 = .08$$

Where:

V_0 = income

V_2 = age

V_4 = education

V_9 = acres owned

V_{10} = acres rented

R_L = lower bound on risk aversion

R_U = upper bound on risk aversion

and t values are under the coefficients.

Obviously only a small percentage of the variation is explained (R^2 = .08). The variables are significant and the signs for the most part follow accepted theories. The negative relationship between age and risk aversion is consistent with decreasing absolute risk aversion with respect to wealth. As you get older, you get more wealthy and less risk averse. Decreasing absolute risk aversion with education is also expected. However, the signs on V_0 and V_9, income and acres owned are the reverse of what we would expect.

Naturally a better set of equations would have been described in predicting action choices based on attributes. However, since these were the best that were obtained, they must suffice.

In order to predict action choices, five producers were separated from the rest. The five producers' characteristics were then plugged into the above equation to predict an upper and lower bound on their risk aversion interval. These estimated intervals were then run to predict action choices of each of the producers. These predictions were then compared with the actual choices. This model was able to predict eight right, three wrong, while not ordering 39. Consequently, 22 percent were ordered and the error rate was 6 percent.

While these results appear good, caution is advised. The intervals are only as good as the model that generates them. Obviously the regression model generated here is lacking in most respects. The fact it worked well in five cases certainly doesn't insure it will do so in 20 or 50 cases.

CHAPTER VI

CONCLUSIONS AND FUTURE RESEARCH

6.1 Conclusions

The objectives of this research can be classified into three areas. Those three areas and the results obtained will now be summarized.

The first objective was to examine the interval method and its usefulness in predicting action choices. As discussed, the previous methods of analyzing and utilizing risk preferences have shortcomings. The interval method is a new tool and its superiority has not, until now, been demonstrated. Certainly this work has shown that producers possess different risk preference functions and these functions take all different shapes. The interval method, when its use is justified, allows for that to be taken into consideration. The interval method also demonstrated its greater flexibility and accuracy than a single-valued function. Finally, the use of the interval method to predict action choices provided results that are very encouraging for further work in this area. Not only does the interval method provide for a higher degree of accuracy than a single-valued function, it has the added feature of allowing for trade-offs of accuracy and ordering action choices.

The second objective of this research was to establish a relationship between the risk interval and producer attributes. The results showed that it is possible to use producer attributes to correctly classify a large percent of producers into their correct risk preference category at a particular income level. However, when using the entire risk preference functions, the relationship between risk preference and attributes is much less successful. This is a result of the fact that attributes that classify at each income level follow no consistent pattern over all income levels.

Finally, the third objective was to examine whether the attributes could be used to predict the producer's risk preference and then use this interval to predict action choices. The results in this area were disappointing. This was a result of the fact that no set of consistent attributes were found over all income levels.

6.2 Areas of Further Research

While this research has answered many questions, it has, in the process, created many more unanswered questions that deserve further attention.

In regards to the interval method, probably the one area that needs further analysis is the trade-offs between ordering of action choices and the accuracy associated with that ordering. As was demonstrated with both the graduate students and the farmers, an obvious trade-off exists. Additional research is needed on what exactly this trade-off is and how, given the costs and probabilities of errors, to make the correct trade-offs. Before the interval method is a viable decision-making tool, this question must be resolved.

Other areas of research deserving attention are numerous. Several are mentioned here. Does the risk interval of a producer change over time and if so, is it related to producer attributes. This research was cross-sectional over producers. Time-series research over a particular set of producers would be very interesting.

Finally, how well does the interval method perform when used in the actual decision-making environment rather than the hypothetical example used in the questionniare? Is it possible to obtain a risk interval based on actual marketing, management, and other business decisions? Obviously the list goes on.

Obviously many questions are left unanswered, some which are mentioned here. Further efforts are needed before the potential of the risk preference interval method as a new analytical tool even begins to be exploited.

APPENDICES

APPENDIX A

COVER LETTER

APPENDIX A

COVER LETTER

October 10, 1979

Dear Sir:

You, of course, know that farmers differ in the amount of risk they are willing to bear. This willingness to bear risk influences the farm management decisions they make. Currently, little is known about what determines particular risk attitudes. It is because of this lack of knowledge that the Department of Agricultural Economics at Michigan State is sponsoring research to determine what factors influence producer attitudes toward risk. A better understanding in this area should enable the University to provide better farm management advice to you and farm managers like you in the future.

Would you be willing to participate in this study by completing the enclosed questionnaire which should take less than 45 minutes. Although the questionnaire appears long, you are only asked to complete a portion of it. To help you complete the questionnaire each section begins with a set of instructions. The person who has primary responsibility for managing the farm should answer the questions, completing each section as accurately as possible. Once you have completed the questionnaire, please return it in the enclosed envelope as soon as possible. Naturally, all information that you provide is kept confidential.

Let me thank you in advance for your cooperation. Your participation will assure you a copy of the research results once they are completed.

Sincerely,

Garth Carman
Research Assistant in
Agricultural Economics

/law

Enc.

APPENDIX B

QUESTIONNAIRE

APPENDIX B

QUESTIONNAIRE

INSTRUCTIONS FOR COMPLETING SECTIONS I - IV

This part of the questionnaire is designed to measure your attitude towards risk. Each question asks you to make a comparison between two plans. Below each plan are listed six numbers, which represent levels of after-tax farm profit. One of the six income levels will be realized but assume you don't know which one at the time you select a farm plan. To illustrate, assume each of the farm income levels were printed on the face of the die. Each plan would be printed on a different die so that you would choose the die, then roll it with the outcome being your realized farm income.

This is similar to choosing between two crops knowing that six different prices and weather situations would occur. Suppose you could plant Crop A and Crop B and your after-tax farm profit is that listed under each state of nature.

	STATE OF NATURE	CROP A	CROP B
(1)	Poor prices, poor weather	-5,000	5,000
(2)	Poor prices, average weather	5,000	10,000
(3)	Average prices, poor weather	6,000	12,000
(4)	Average prices, good weather	15,000	13,000
(5)	Good prices, average weather	20,000	14,000
(6)	Good prices, good weather	25,000	15,000

You don't know what the weather will be like nor do you know what prices will be, but you still must decide which crop you are going to produce. Again, you must decide if you are willing to plant Crop A with lower levels of income for bad outcomes so that you could realize higher income levels if good outcomes occurred or whether you would produce Crop B giving up a chance of high income levels so you won't have to take a chance with low income levels. More importantly this decision is based on the difference in income levels between the two crops for each state of nature. In other words how much are you willing to give up for a chance of being better off to avoid a chance of being worse off? This is the analysis you should make.

There are several factors to keep in mind as you complete this questionnaire.

(1) There are no right or wrong answers. Everyone has different attitudes towards taking chances as opposed to playing it safe.

(2) Try to relate this experiment to your own situation. Assume that at the beginning of the year there were the two farm plans available to you and that you had to choose one for that year.

(3) Assume each income level represents your after-tax farm profit for the entire year. With this in mind think about what you would do if a good outcome occurred (good prices and weather) and you took the plan with the higher income level. On the other hand, think about what you would do if a bad outcome occurred (poor prices and weather) and you took the plan with the lower income level.

(4) The "-" sign preceding the income level means income losses.

In each section you are asked to make a comparison and based on which plan you select, you are asked to go to another question. As a result, you are only asked to respond to three of the seven questions in each section.

Each section examines different income levels. In the first section there are negative income levels (or losses). Assume that if you didn't take one of these plans your losses would be even greater. In each of the following sections the income levels increase.

With these instructions in mind, please complete Sections I, II, III, and IV.

SECTION I

1. If you were required to choose between PLAN 17 and PLAN 3, put a check in the box to the right of the one you would select.

PLAN 17 ☐	PLAN 3 ☐
$- 950	$- 650
$- 550	$- 550
$- 100	$- 450
$- 50	$- 300
$ 50	$ 150
$ 450	$ 300

If you prefer PLAN 17, go to Question 3.
If you prefer PLAN 3, go to Question 2.

2. If you were required to choose between PLAN 7 and PLAN 3, put a check in the box to the right of the one you would select.

PLAN 7 ☐	PLAN 3 ☐
$-1,000	$- 650
$- 450	$- 550
$- 150	$- 450
$ 400	$- 300
$ 450	$ 150
$ 1,100	$ 300

If you prefer PLAN 7, go to Question 5.
If you prefer PLAN 3, go to Question 4.

3. If you were required to choose between PLAN 8 and PLAN 4, put a check in the box to the right of the one you would select.

PLAN 8 ☐	PLAN 4 ☐
$- 950	$- 450
$- 50	$- 300
$ 0	$- 200
$ 50	$ 50
$ 150	$ 100
$ 200	$ 200

If you prefer PLAN 8, go to Question 7.
If you prefer PLAN 4, go to Question 6.

4. If you were required to choose between PLAN 2 and PLAN 12, put a check in the box to the right of the one you would select.

PLAN 2 ☐	PLAN 12 ☐
$- 550	$- 350
$ 0	$- 150
$ 0	$- 150
$ 400	$ 100
$ 650	$ 250
$ 1,100	$ 500

Stop and go to Section II.

5. If you were required to choose between PLAN 7 and PLAN 4, put a check in the box to the right of the one you would select.

PLAN 7 ☐	PLAN 4 ☐
$-1,000	$- 450
$- 450	$- 300
$- 150	$- 200
$ 400	$ 50
$ 450	$ 100
$ 1,100	$ 200

Stop and go to Section II.

6. If you were required to choose between PLAN 26 and PLAN 5, put a check in the box to the right of the one you would select.

PLAN 26 ☐	PLAN 5 ☐
$- 950	$- 600
$- 500	$- 150
$- 150	$- 100
$ 250	$- 100
$ 250	$ 50
$ 450	$ 150

Stop and go to Section II.

7. If you were required to choose between PLAN 29 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 29 ☐	PLAN 1 ☐
$-1,000	$- 300
$- 200	$- 250
$ 0	$- 100
$ 100	$ 450
$ 600	$ 450
$ 1,050	$ 600

Stop and go to Section II.

S E C T I O N I I

1. If you were required to choose between PLAN 3 and PLAN 17, put a check in the box to the right of the one you would select.

PLAN 17 ☐	PLAN 3 ☐
\$ 9,000	\$ 9,350
\$ 9,050	\$ 9,450
\$ 9,150	\$ 9,550
\$10,000	\$ 9,700
\$10,700	\$10,150
\$11,100	\$10,300

If you prefer PLAN 17, go to Question 2.
If you prefer PLAN 3, go to Question 3.

2. If you were required to choose between PLAN 8 and PLAN 4, put a check in the box to the right of the one you would select.

PLAN 8 ☐	PLAN 4 ☐
\$ 9,050	\$ 9,550
\$ 9,950	\$ 9,700
\$10,000	\$ 9,800
\$10,050	\$10,050
\$10,150	\$10,100
\$10,200	\$10,200

If you prefer PLAN 8, go to Question 4.
If you prefer PLAN 4, go to Question 5.

3. If you were required to choose between PLAN 2 and PLAN 13, put a check in the box to the right of the one you would select.

PLAN 2 ☐	PLAN 13 ☐
\$ 9,450	\$ 9,700
\$10,000	\$ 9,850
\$10,000	\$ 9,950
\$10,400	\$10,350
\$10,650	\$10,400
\$11,100	\$10,800

If you prefer PLAN 2, go to Question 6.
If you prefer PLAN 13, to to Question 7.

4. If you were required to choose between PLAN 29 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 29 ☐	PLAN 1 ☐
$ 9,000	$ 9,700
$ 9,800	$ 9,750
$10,000	$ 9,900
$10,100	$10,450
$10,600	$10,450
$11,050	$10,600

Stop and go to Section III.

5. If you were required to choose between PLAN 6 and PLAN 40, put a check in the box to the right of the one you would select.

PLAN 40 ☐	PLAN 6 ☐
$ 9,150	$ 9,350
$ 9,400	$ 9,550
$ 9,750	$ 9,650
$10,200	$ 9,950
$10,600	$10,550
$10,600	$10,600

Stop and go to Section III.

6. If you were required to choose between PLAN 7 and PLAN 4, put a check in the box to the right of the one you would select.

PLAN 7 ☐	PLAN 4 ☐
$ 9,000	$ 9,550
$ 9,550	$ 9,700
$ 9,850	$ 9,800
$10,400	$10,050
$10,450	$10,100
$11,100	$10,200

Stop and go to Section III.

7. If you were required to choose between PLAN 1 and PLAN 38, put a check in the box to the right of the one you would select.

PLAN 1 ☐	PLAN 38 ☐
$ 9,700	$ 9,700
$ 9,750	$ 9,900
$ 9,900	$10,000
$10,450	$10,050
$10,450	$10,250
$10,600	$10,450

Stop and go to Section III.

SECTION III

1. If you were required to choose between PLAN 29 and PLAN 4, put a check in the box to the right of the one you would select.

PLAN 29 ☐	PLAN 4 ☐
$21,900	$23,650
$24,350	$24,100
$24,900	$24,300
$25,350	$25,150
$26,850	$25,350
$28,250	$25,700

If you prefer PLAN 29, go to Question 3.
If you prefer PLAN 4, go to Question 2.

2. If you were required to choose between PLAN 2 and PLAN 11, put a check in the box to the right of the one you would select.

PLAN 2 ☐	PLAN 11 ☐
$23,300	$23,600
$24,900	$24,250
$25,100	$24,500
$26,250	$25,800
$26,950	$25,950
$28,300	$27,700

If you prefer PLAN 2, go to Question 5.
If you prefer PLAN 11, go to Question 4.

3. If you were required to choose between PLAN 17 and PLAN 4, put a check in the box to the right of the one you would select.

PLAN 17 ☐	PLAN 4 ☐
$21,900	$23,650
$22,150	$24,100
$22,450	$24,300
$25,000	$25,150
$27,200	$25,350
$28,400	$25,700

If you prefer PLAN 17, go to Question 7.
If you prefer PLAN 4, go to Question 6.

4. If you were required to choose between PLAN 6 and PLAN 3, put a check in the box to the right of the one you would select.

PLAN 6 ☐	PLAN 3 ☐
$22,950	$23,000
$23,650	$23,350
$23,850	$23,600
$24,800	$24,100
$26,700	$25,500
$26,850	$26,000

Stop and go to Section IV.

5. If you were required to choose between PLAN 2 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 2 ☐	PLAN 1 ☐
$23,300	$24,050
$24,900	$24,200
$25,100	$24,700
$26,250	$26,450
$26,950	$26,450
$28,300	$26,850

Stop and go to Section IV.

6. If you were required to choose between PLAN 6 and PLAN 4, put a check in the box to the right of the one you would select.

PLAN 6 ☐	PLAN 4 ☐
$22,950	$23,650
$23,650	$24,100
$23,850	$24,300
$24,800	$25,150
$26,700	$25,350
$26,850	$25,700

Stop and go to Section IV.

7. If you were required to choose between PLAN 17 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 17 ☐	PLAN 1 ☐
$21,900	$24,050
$22,150	$24,200
$22,450	$24,700
$25,000	$26,450
$27,200	$26,450
$28,400	$26,850

Stop and go to Section IV.

SECTION IV

1. If you were required to choose between PLAN 2 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 2 ☐	PLAN 1 ☐
$42,100	$43,450
$44,850	$43,650
$45,200	$44,500
$47,100	$47,450
$48,250	$47,450
$50,550	$48,100

If you prefer PLAN 2, go to Question 2.
If you prefer PLAN 1, go to Question 3.

2. If you were required to choose between PLAN 19 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 19 ☐	PLAN 1 ☐
$41,250	$43,450
$44,500	$43,650
$45,500	$44,500
$45,800	$47,450
$46,350	$47,450
$50,450	$48,100

If you prefer PLAN 19, go to Question 5.
If you prefer PLAN 1, go to Question 4.

3. If you were required to choose between PLAN 14 and PLAN 3, put a check in the box to the right of the one you would select.

PLAN 14 ☐	PLAN 3 ☐
$41,350	$41,650
$42,200	$42,250
$44,400	$42,650
$44,700	$43,500
$47,250	$45,850
$47,500	$46,700

If you prefer PLAN 14, go to Question 6.
If you prefer PLAN 3, go to Question 7.

4. If you were required to choose between PLAN 28 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 28 ☐	PLAN 1 ☐
$41,250	$43,450
$44,500	$43,650
$44,550	$44,500
$48,700	$47,450
$49,150	$47,450
$49,400	$48,100

Stop and go to Section V.

5. If you were required to choose between PLAN 9 and PLAN 1, put a check in the box to the right of the one you would select.

PLAN 9 ☐	PLAN 1 ☐
$41,200	$43,450
$42,900	$43,650
$43,250	$44,500
$45,400	$47,450
$45,850	$47,450
$50,000	$48,100

Stop and go to Section V.

6. If you were required to choose between PLAN 2 and PLAN 11, put a check in the box to the right of the one you would select.

PLAN 2 ☐	PLAN 11 ☐
$42,100	$42,700
$44,850	$43,750
$45,200	$44,100
$47,100	$46,300
$48,250	$46,550
$50,550	$49,500

Stop and go to Section V.

SECTION V

In this section you are asked to make the same type of comparisons you just made in Sections I-IV only over a wider range of possible income levels. Listed below are five plans:

PLAN 1	PLAN 2	PLAN 3	PLAN 4	PLAN 5
$-1,100	$ 5,000	$10,000	$- ,800	$- ,200
$ 3,000	$11,000	$15,000	$ 2,000	$10,000
$18,000	$19,000	$20,000	$11,000	$22,000
$35,000	$26,000	$25,000	$25,000	$25,000
$45,000	$32,000	$28,000	$40,000	$35,000
$50,000	$37,000	$30,000	$48,000	$40,000

Compare each set of plans listed below and put a check in the box to the right of the one you prefer:

PLAN 1	☐	OR	PLAN 2	☐
PLAN 1	☐	OR	PLAN 3	☐
PLAN 1	☐	OR	PLAN 4	☐
PLAN 1	☐	OR	PLAN 5	☐
PLAN 2	☐	OR	PLAN 3	☐
PLAN 2	☐	OR	PLAN 4	☐
PLAN 2	☐	OR	PLAN 5	☐
PLAN 3	☐	OR	PLAN 4	☐
PLAN 3	☐	OR	PLAN 5	☐
PLAN 4	☐	OR	PLAN 5	☐

Go to section VI.

SECTION VI

In this section we wish to find out some of the characteristics about you and your family operation. The information that is needed is listed below. Please check or fill in the appropriate blanks:

(1) Marital status ☐ Married ☐ Single

(2) Age ☐

(3) Number of children ☐

(4) Last grade of school you completed ☐

(5) How many years have you spent

☐ living on a farm?

☐ managing a farm?

(6) What % of your total family income is from the farm?

☐ %

(7) What % of your farm income is your share?

☐ %

(8) How many acres do you

☐ own?

☐ rent?

(9) How many cows do you own?

☐

(10) If you had an important farm management decision to make, would you:

☐ Feel more confident about it if you have other people's advice; <u>OR</u>

☐ Feel that nobody else is in as good a position to judge as you are.

(11) For entertainment would you rather

☐ Be around friends (like going to a party) <u>OR</u>

☐ Be more to yourself (like going to a movie).

(12) Are you usually a

☐ Good mixer <u>OR</u>

☐ Quiet and reserved.

(13) When you make a decision do you usually

☐ Make it right away <u>OR</u>

☐ Wait as long as you reasonably can before deciding.

(14) Do you prefer to

☐ Organize your schedule well in advance <u>OR</u>

☐ Be free to do whatever looks best when the time comes.

(15) When you make a decision do you

☐ Tend to be satisfied <u>OR</u>

☐ Tend to be curious and look for new light on the subject.

You have now completed the questionnaire. Thank you for your cooperation.

APPENDIX C

FOLLOW-UP LETTER

APPENCIX C

FOLLOW-UP LETTER

October 22, 1979

Dear Sir:

Currently little is known about producers' attitudes toward risk. These attitudes toward risk are important in determining both farm and nonfarm investment decisions that farmers make. Furthermore, even less is known about how these risk attitudes are related to the characteristics of the farmer and his farming operation. This lack of knowledge limits the effectiveness of the farm management advice that the University provides to decision-makers such as yourself.

About two weeks ago you received a questionnaire in the mail which was designed to gain a better understanding about the relationship between your risk attitude and the characteristics of your farm operation. The results of your questionnaire will be used, along with other farmers who received the questionnaire, to gain a better understanding about farmers' attitudes toward risk and the manner in which these attitudes are related to characteristics of the farming operation.

If you have already returned the completed questionnaire, please accept my thanks. If you have not yet done so, please return the completed questionnaire as soon as possible.

After the questionnaires are returned, they will be analyzed and you will receive a copy of the research results.

Sincerely,

Garth Carman
Research Assistant in
Agricultural Economics

GC/law

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