AN ABSTRACT OF THE THESIS OF

John Randall Winter for the degree of Doctor of Philosophy in the Department of Agricultural and Resource Economics presented on December 6, 1985.

Title: An Investigation of the Measurement of Individual Risk Attitudes.

Abstract approved: _______________ (for Steven T. Buccola)

Two direct elicitation of utility (D.E.U.) techniques were used to estimate risk attitudes of a group of agricultural producers. The two elicitation techniques used in the study were 1) an error-in-response model using a modified Ramsey method, and 2) stochastic dominance with respect to a function (SDF). The primary objective of the study was to determine whether the two elicitation techniques yield consistent estimates of risk attitudes. A second major objective of the study was to provide additional information about the distribution of risk attitudes among agricultural producers.

The study confirmed the results of other research efforts that the majority of risk attitude parameters of agricultural producers lie within the range -.0001 and .001 with income measured in dollars [King and Robison, 1980]. The study also supports previous research results which indicate that a significant portion of decision makers exhibit risk preferring behavior, at least over some ranges of incomes.

The error-in-response model classified 38.1% of the respondents as risk preferring, 47.6% as risk neutral, and 14.3% as risk averse. With only one exception, the SDF technique elicited risk preferring attitudes for every respondent over some range of income values.

Individual and aggregate tests for decreasing (increasing) absolute risk aversion were conducted. No respondents were found to exhibit increasing or decreasing absolute risk aversion. The statistical comparison of the two elicitation techniques was inconclusive. A paired t-test failed to reject the null hypothesis of no difference in the estimated risk attitudes. However, the correlation between the two measures was virtually zero (-.046) suggesting that the two measures of risk attitudes are not closely related.

The two elicitation techniques were also compared on other grounds. Both elicitation techniques are designed to prevent certainty bias that has plagued other D.E.U. methods. The SDF technique is found to be superior in overcoming possible interviewer bias. Neither technique is superior in coping with probability bias.

The SDF technique is easier to implement but the error-in-response questionnaire is easier to formulate. The error-in-response model results in a specific estimate of the respondent's risk attitude when the negative exponential utilty function is used. Based on the comparisons made in the study, the SDF procedure is considered to be superior to the error-in-response model for eliciting risk attitudes.

An Investigation of the Measurement of Individual Risk Attitudes

by

John Randall Winter

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Doctor of Philosophy

Completed December 6, 1985

Commencement June 1986

APPROVED:

(for Steven T. Buccola)

Professor of Agricultural and Resource Economics
in charge of major

Head of Department of Agricultural and Resource Economics

Dean of Graduate School

Date thesis is presented December 6, 1985

ACKNOWLEDGMENTS

The author wishes to take this opportunity to thank some of the individuals who contributed to the successful completion of this thesis. I would like to thank the members of my committee for their helpful comments and suggestions: Steve Buccola, Gene Nelson, Wes Musser, Lu Eisgruber, Dan Brunk, Bob Mason, and Russell Hicks. Frank Conklin and Jim Whittaker also deserve credit for their guidance and encouragement in the early stages of the research.

I would also like to thank Dr. R.D. Henry, Chairperson of the Department of Agriculture at Illinois State University, for his support.

A special thanks goes to my parents who provided financial and moral support throughout my years of graduate study.

Finally, and most importantly, I wish to express my gratitude to my family--Carol, Valerie, Michael, and Stephanie. I am sorry for the many evenings and Saturdays when I could not be home. Thanks for your understanding and support. This paper could not have been completed without you.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

AN INVESTIGATION OF THE MEASUREMENT OF INDIVIDUAL RISK ATTITUDES

I: INTRODUCTION

The importance of risk in agriculture has long been recognized and in recent years a great deal of research effort has been devoted to the investigation of the impact of risk on farmers' decisions. Two major aspects of risk research are the estimation of individual utility functions and the determination of individual risk attitudes. One of the earliest attempts to elicit individual utility functions was conducted by Mosteller and Nogee [1951]. Since that time, many researchers have attempted to improve elicitation techniques. Some of the most widely known research efforts in the agricultural context include the work of Lin, Dean, and Moore [1974], Officer and Halter [1968], Halter and Mason [1978], and Binswanger [1980]. More recent examples of utility or risk attitude elicitation include King and Robison [1981], Wilson and Eidman [1983], and Musser, et.al. [1984]. One of the major shortcomings of these attempts to elicit utility functions is that a single elicitation technique is used in every case although Officer and Halter did contrast three variations of a single technique. No effort has been made to utilize two or more different elicitation techniques with the same set of respondents. As a result, it is difficult (if not impossible) to draw conclusions concerning the reliability of the various elicitation techniques. Consequently, one of the major objectives of the present study is to directly compare two elicitation techniques.

Conventional wisdom suggests that most decision-makers are risk averse. Most of the theoretical research incorporating risk in economic models assumes that economic agents are risk averse (See Newberry and Stiglitz [1981], Chapter 6 for a particularly good example). However, attempts to elicit risk attitudes to date have found a substantial number of individuals exhibiting risk neutral or risk preferring attitudes. Young, et.al. [1979] present a summary of several of the most well-known efforts of risk attitude elicitation. They conclude "...it is our judgment that the possibility of risk neutral or risk preferring attitudes ...among a significant fraction of agricultural producers ...cannot be excluded." One of the objectives of the present study is to provide additional information about the distribution of risk attitudes among agricultural producers.

A good deal of skepticism exists within the agricultural economics profession about researchers' ability to assess individual risk attitudes. This skepticism arises because of the inconsistent results of some studies and the possible introduction of some decision-making biases in the elicitation techniques that have been used. For example, Lin, Dean, and Moore [1974] compared three variations of the von Neumann-Morgenstern elicitation method and found different utility function estimates. The different estimates probably arise because of various types of decision-making biases. Whittaker and Winter [1980] compared attempts to elicit utility functions for the same set of respondents at two points in time. When regressing elicited risk attitudes against socio-economic variables, they found that nearly all signs were reversed from one time period to the other. Love and Robison [1984] found risk attitude classification reversals when comparing risk attitudes elicited at two different points in time. Binswanger [1982] discusses some of the problems that have been encountered in eliciting risk attitudes and makes a case for relying on experimental methods rather than direct elicitation of utility. By directly comparing two different elicitation techniques, the current study will attempt to provide some insights into the reliability of elicitation techniques and perhaps shed some light on the usefulness of continued research in the area of risk attitude elicitation.

The major objectives of the study are to:

1. Compare two different techniques for eliciting risk attitudes to determine if the resulting estimates of risk attitudes are consistent between techniques when the same sample of respondents is used;
2. Provide additional information about the distribution of

risk attitudes of agricultural producers; and

3. Provide insights concerning the fruitfulness of further research in the area of risk attitude elicitation.

PLAN OF THE STUDY

Chapter II presents the theoretical foundations of utility, including a brief history of the development of the idea of utility. Chapter III describes the error-in-response model using a modified Ramsey elicitation method. Chapter IV presents the details of the stochastic dominance with respect to a function elicitation technique. Chapter V presents the results of the elicitation procedures. Chapter VI deals with the relative merits of the two approaches of elicitation based on selected theoretical, statistical, and empirical grounds. Chapter VII concludes the study with a summary of the results and recommendations for future research.

II. THEORETICAL FOUNDATIONS OF UTILITY AND RISK ATTITUDE ELICITATION

This chapter presents the theoretical foundations of utility and risk attitude elicitation. The chapter provides a brief review of the development of utility in economics and discusses the relationship between neoclassical cardinal utility theory and von Neumann-Morgenstern cardinal utility.

This study assumes the existence of a von Neumann-Morgernstern (VNM) utility function. The proof of the expected utility theorem is included in the chapter; this proof provides the basis for assuming the existence of a VNM utility function.

UTILITY

Reference has been made to the elicitation of "utility functions" and "risk attitudes." It will be beneficial to briefly examine the history of the concept of utility and the development of the risk attitude parameter.

The original concept of "cardinal utility" is due to the neoclassical (marginal school of) economists such as Gossen, Jevons, Edgeworth, and Marshall [Whittaker, 1940; Stigler, 1950]. Neoclassical cardinal utility implied a high degree of measurability of utility where utility was synonymous with satisfaction or well-being of an individual. The neoclassical economists believed in a true science of pleasure or pain; that is, they believed that there existed a natural unit of utility that could (theoretically) be measured thus permitting interpersonal comparisons of utility. With the existence of a natural unit of utility, it was meaningful to say that some good provided twice as much (or half as much) utility as some other good. This was the sense of the word "cardinal" in the neoclassical utility theory. Neoclassical cardinal utility was accepted as the core of economic theory until the late 1930's. The neoclassical concept of cardinal utility was largely discredited by the end of the 1930's by the work of economists such as J. R. Hicks and R. G. D. Allen. Cardinal utility was supplanted by the less restrictive concept of ordinal utility and indifference curve analysis. With ordinal utility, it is recognized that numerical differences in utility are meaningless. All that counts is the ranking of utilities so that if U(X) is a utility function then any monotonically increasing transformation of U(X) will serve equally as well as U(X).

Von Neumann and Morgenstern revived the concept of "cardinal utility" with the publication of the second edition of The Theory of Games and Economic Behavior [1947]. Since the neoclassical concept of cardinal utility had been in such disrepute, von Neumann and Morgenstern's concept met a good deal of resistance. While VNM cardinal utility exhibits some of the properties of neoclassical cardinal utility, several important distinctions between the two concepts make them different. The present study assumes the existence of VNM cardinal utility. Therefore, it is important to understand the meaning of VNM cardinal utility and recognize the difference between VNM and neoclassical cardinal utility.

Von Neumann and Morgenstern [1947] utilized an axiomatic approach to utility theory. They stated a set of postulates or axioms about preference orderings that they assumed were reasonable. VNM then proved that in order to obey the axioms, one must always prefer the alternative with the highest expected utility. VNM utility theory incorporates a decision maker's preference structure for the object of the utility function (usually, but not restricted to, wealth or income) and the decision maker's beliefs about the likelihood of obtaining any particular outcome. The essential result of VNM cardinal utility is that a decision maker can rank various prospects (gambles or lotteries) based on the (mathematically calculated) "expected utility of the prospect."[1] Further, a VNM utility function is valid up to a positive, linear transformation; that is, if U(X) is a VNM utility function then any $V(X)=a+bU(X)$, $b>0$, is a strategically equivalent VNM utility function [Keeney and Raiffa, 1976]. Strategically equivalent means simply that U(X) and V(X) are interchangeable for the purpose of investigating the individual's preferences. The fact that utilities that are positive linear transformations of one another are strategically equivalent is the feature that leads to VNM being considered "cardinal." This characterisitic is opposed to the neoclassical idea of the existence of a natural unit of utility that could be measured.

Since VNM's development of the expected utility theorem, numerous other authors have essentially duplicated VNM's results with slightly different sets of axioms [Savage, 1954; Herstein and Milnor, 1953; Fishburn, 1970;

[1]This property results in VNM utility theory being alternatively known as expected utility theory.

and others]. The proof of the expected utility theorem is presented below. The proof follows the development of Baumol [1972] because of its relative simplicity. Begin with a statement of the theorem.

Expected utility theorem: If we ascribe to every prospect a utility value equal to the mathematical expectation of the utility values of its payoffs (which may be determinate or another prospect), the resulting utility rankings of these prospects will be such that those which receive higher utility values will be preferred to those that receive lower utility values, and any prospect preferred to another will have a higher utility value than the less preferred prospect.

The following notation is used. [A,B:P] represents a prospect ("gamble" or "lottery") that yields payoff A with probability P and payoff B with the complementary probability (1-P). Denote indifference between two prospects G_1 and G_2, as $G_1 \sim G_2$. G_1 preferred to G_2 will be represented by $G_1 > G_2$.

The proof of the expected utility theorem is derived from the following five axioms:

1. Complete ordering: For any two prospects G_1 and G_2, either $G_1 > G_2$, $G_1 \sim G_2$, or $G_2 > G_1$. As a corollary, preferences are transitive so that $G_1 \sim G_2$ and $G_2 \sim G_3$ implies that $G_1 \sim G_3$.

2. Continuity: Consider three payoffs A, B, and C such that $A>B>C$. Then there exists a probability P such that $0<P<1$ and B~[A,C:P].

3. Independence: Consider any three payoffs A, B, and C with A~B. Then [A,C:P]~[B,C:P] for any probability P.

4. Unequal probability: For any payoffs A and B and any probabilities P and P'; if $A>B$, then $[A,B:P]>[A,B:P']$ if and only if $P>P'$.

5. Compound probability: For any payoffs A and B and any probabilities P, Q, and R, [[A,B:Q],[A,B:R]:P]~[A,B:S] where S=PQ+(1-P)R.

Axiom 5 may be interpreted to say that decision makers evaluate a compound prospect in terms of the probabilities of winning the ultimate prizes. It is also assumed that the decision maker can correctly "compound" the probabilities; i.e., he does not make math errors.

BAUMOL'S PROOF OF THE EXPECTED UTILITY THEOREM

Consider two prospects G_1=[A,B:P] and G_2=[A',B':P']. By the continuity axiom, there exists a prospect [E,D:R] for which A~[E,D:R], assuming that E>A>D. Similarly, there exists a prospect such that B~[E,D:S] if E>B>D. By the independence axiom, [A,B:P]~[[E,D:R],[E,D:S]:P]. By the compound probability axiom, the compound lottery on the right hand side is indifferent to the prospect G_3=[E,D:T] where T=PR+(1-P)S.

Using the same procedure as above, generate a second compound lottery such that [A',B':P']~[[E,D:R'],[E,D:S']:P']. Again, the compound lottery can be reduced by the compound probability axiom to G_4=[E,D:T'] where T'=P'R'+(1-P')S'.

We now have G_1~G_3 and G_2~G_4, where G_3 and G_4 contain the identical payoffs E and D. Recall that E>D by assumption so, by the unequal probabililty axiom, G_3>G_4 iff T>T'.

Consider now the utility of the prospect G_1=[A,B:P]. According to the expected utility theorem, U([A,B:P])=P U(A) +(1-P) U(B) which, by virtue of equivalences stated above is equal to P U([E,D:r])+(1-P) U([E,D:S]). Invoking the expected utility theorem a second time indicates that this latter expression is equal to

P{R U(E)+(1-R) U(D)}+(1-P){S U(E)+(1-S) U(D)}

or, multiplying out and combining terms,

{PR+(1-P)S} U(E)+{P(1-R)+(1-P)(1-S)} U(D).

Further expansion of terms yields

$\{PR+(1-P)S\}\ U(E)+\{P-PR+1-P-S+PS\}\ U(D)$

which we recognize as

$T\ U(E)+(1-T)\ U(D)$.

Using the same procedure, we can show that

$U([A',B':P'])=T'\ U(E)+(1-T')\ U(D)$.

Since $U(E)>U(D)$ by assumption, $U(G_1)=T\ U(E)+(1-T)\ U(D)$ will be a larger number than $U(G_2)=T'\ U(E)+(1-T')\ U(D)$ only if $T>T'$. But we have shown previously that $T>T'$ is a necessary and sufficient condition for prospect $G_1=[A,B:P]$ to be preferred to $G_2=[A',B':P']$. Thus use of the expected utility theorem guarantees that the more preferred prospect will always have a higher utility value, and that the prospect having the higher utility value will always be the preferred prospect.

CARDINAL UTILITY

A topic that has led to a great deal of confusion is the relationship (if any) between neoclassical cardinal utility theory and VNM cardinal utility theory. "It is generally (though not universally) agreed that there is none --the two utility measures have nothing in common insofar as their cardinality is concerned." [Baumol, 1972, p. 547]

Neoclassical cardinal utility provided a measure of introspective pleasure intensity, permitted interpersonal utility comparisons, and dealt only with conditions of certainty. None of these statements are true with respect to VNM cardinal utility. The problem that arises and that has caused so much misunderstanding of VNM utility is that the word "cardinal" has been used to mean two entirely different things. The neoclassical concept deals with the absolute marginal pleasure measurement that permits interpersonal utility comparisons. The VNM concept is purely operational, referring to the mathematical property that two VNM utility functions are "strategically equivalent" [Keeney and Raiffa, 1976] if one function can be expressed as a linear transformation of the other. Indeed, to the strict neoclassical theorist, the VNM cardinal utility function is really only an ordinal measure in that it can only predict <u>rankings</u> among prospects. Differences in VNM utility levels ("marginal utilities") do not indicate successive increments of marginal satisfaction arising from an incremental change in the quantity of some item. "The (V)NM cardinal utility index is a confounded measure of risk-taking attitude and the intrinsic worth of the attribute." [Schoemaker, 1980, p. 16] This concept is not a cardinal measure in the neoclassical sense.

Pratt [1964] and, independently, Arrow [1965] developed a unique measure of risk aversion. Commonly called the Pratt coefficient, the measure is derived from the first and second derivatives of the VNM utility function. If $U(X)$ is a VNM utility function, the absolute risk aversion coefficient, $r(X)$, is equal to $-U''(X)/U'(X)$ where $U''(X)$ and $U'(X)$ are, respectively, the second and first derivatives of the utility function. A decision maker can be classified as risk averse, risk neutral, or risk preferring as $r(X)>0$, $r(X)=0$, or $r(X)<0$, respectively. Thus the risk aversion measure, being unrestricted in sign, does not preclude the existence of risk preference or risk neutrality. Henceforth, the more generic term "risk attitude parameter" is used to refer to $r(X)$. An important property of the risk attitude parameter is the uniqueness of $r(X)$. For a VNM utility function, $U(X)$, and any strategically equivalent VNM utility function, $V(X)= a+bU(X)$ $(b>0)$, the derived risk attitude parameters will be identical. In other words, even though an infinite number of VNM utility functions can serve to represent the preferences of an individual, all of these utility functions will result in the same risk attitude parameter.

Young, et.al. [1979] have described three popular approaches for eliciting information about individual VNM utility functions. The two techniques used in the current study fall within the direct elicitation of utility (D.E.U.) approach. D.E.U. uses interview procedures to determine preferences between certain outcomes and risky options involving hypothetical gains and losses. Under some variants the observed preferences of the respondent, as determined through the interview procedure, are used to estimate the respondent's utility function. The risk attitude parameter is then derived from the elicited utility function. Because of the uniqueness of the risk attitude parameter as discussed above, we do not have to be concerned with the fact that an infinite number of functions could replace the estimated utility function.

The most popular variations of the D.E.U. approach are referred to as the von Neumann-Morgenstern, modified von Neumann-Morgenstern, and Ramsey methods [Dillon, 1971]. Officer and Halter [1968] discuss and demonstrate the differences among these variations. Briefly, the three variations represent successive advances in elicitation techniques as researchers have sought to overcome some of the problems and shortcomings of D.E.U. methods. The two elicitation methods used in the present study represent further advancements in D.E.U. methods. The techniques are: 1) an error-in-response (ER) model combined with a modified Ramsey method [Ahmed,1979; Knowles,1980]; and 2) use of stochastic dominance with respect to a function (SDF) [King and Robison, 1981]. A significant difference between the two elicitation techniques is that the ER model requires that the functional form of the utility function be specified whereas the SDF model does not require a specific functional form. Before proceeding to a detailed development of the models, some basic definitions will be introduced.

DEFINITIONS

U(X) represents the VNM utility function for the attribute X.[2] Let [A,B:P] represent the prospect that yields payoff A with probability P and payoff B with probability (1-P). By the expected utility theorem, U([A,B:P])=P U(A)+(1-P) U(B); that is, the utility of a prospect is equal to the statistical expectation of the utilities of the outcomes.

The expected value of a prospect is the statistical concept of a probability-weighted average. For example, the expected value of the prospect [A,B:P] is P (A)+(1-P) (B). The expected value of the prospect G_1 will be denoted as $E(G_1)$.

The certainty equivalent of a risky prospect is that sure amount that yields the same utility as the risky prospect itself. Denote the certainty equivalent of a risky prospect G_1 as $CE(G_1)$. By definition, $U(CE(G_1))=U(G_1)$.

The risk premium of a prospect G_1 will be denoted $RP(G_1)$. The risk premium is defined as the difference between the expected value of a prospect and the certainty equivalent of the same prospect; that is,

$RP(G_1)=E(G_1)-CE(G_1)$.

[2]The attribute of the utility function is usually some measure of money such as wealth or income. However, other attributes can be accomodated by the expected utility theorem.

The relationship between the expected value of a prospect and the certainty equivalent of a prospect is derived by Pratt [1964] and Keeney and Raiffa [1976], among others. This relationship differs as an individual is risk averse, risk preferring, or risk neutral. The important characteristics are outlined below without proof.

For a risk averse decision maker, the risk premium of any non-degenerate prospect[3] is positive. Alternatively, we can say that the expected value of the prospect is greater than the certainty equivalent of the prospect. These relationships can be derived from the fact that a risk averse decision maker's utility function is concave. Figure 2.1 demonstrates these relationships for the risk averse decision maker faced with the prospect [A,B:0.5]. Point C is the certainty equivalent of the prospect and Point D is the expected value of the prospect. Note that D is greater than C, implying that the risk premium is positive.

For a risk preferring decision maker, the risk premium of any non-degenerate prospect is negative. We can also say that the certainty equivalent of the prospect exceeds the expected value of the prospect for a risk preferring individual. Figure 2.2 demonstrates these relationships for the risk preferring individual faced with the prospect [A,B:0.5]. Again, Point C represents the certainty equivalent of the

[3]A non-degenerate prospect is defined as any prospect in which no single outcome will occur with probability 1.0.

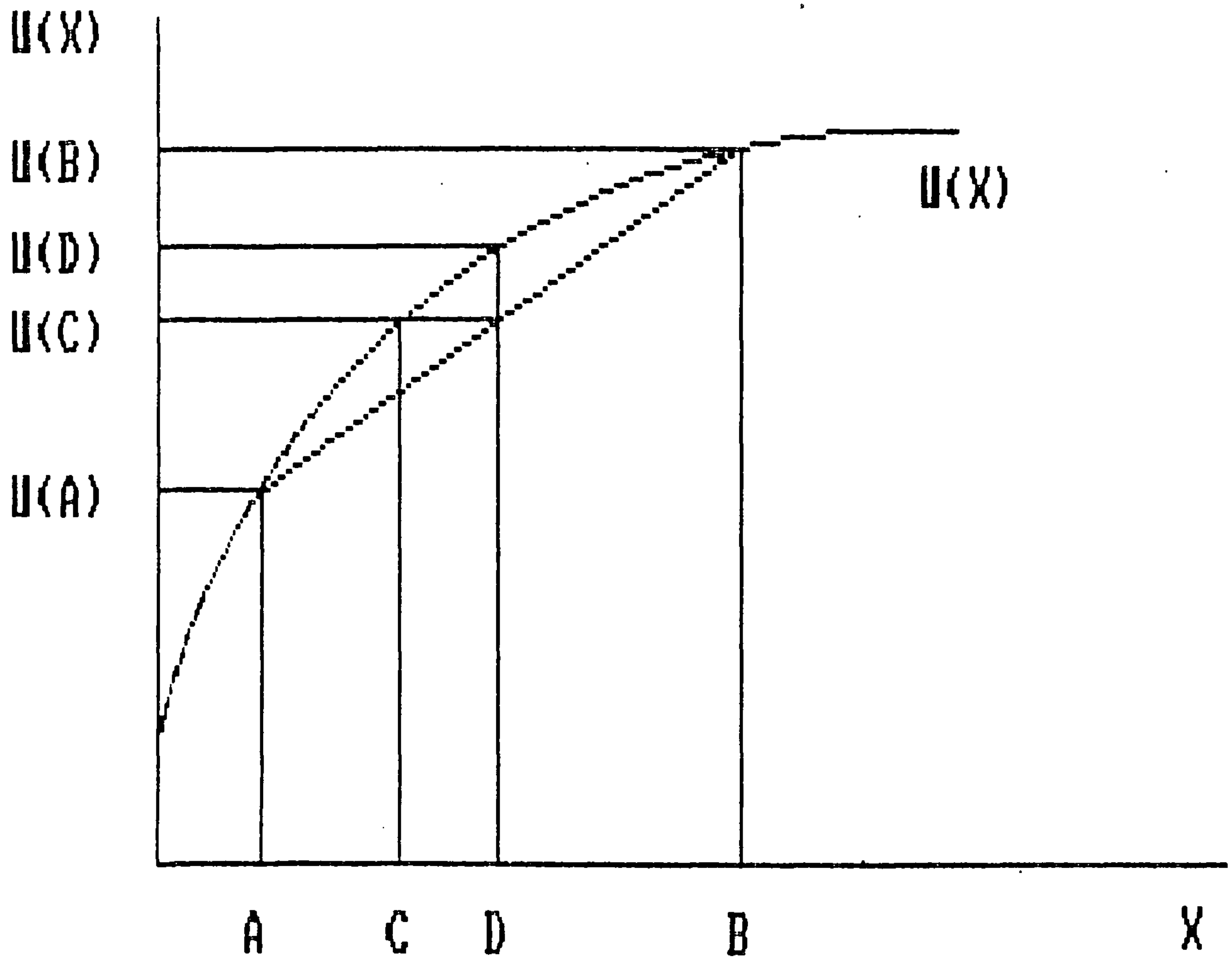


Figure 2.1: Relationship Between the Expected Value, D, and the Certainty Equivalent, C, of a Prospect (A,B:0.5) for a Risk Averse Individual

D > C ⇒ risk premium is positive

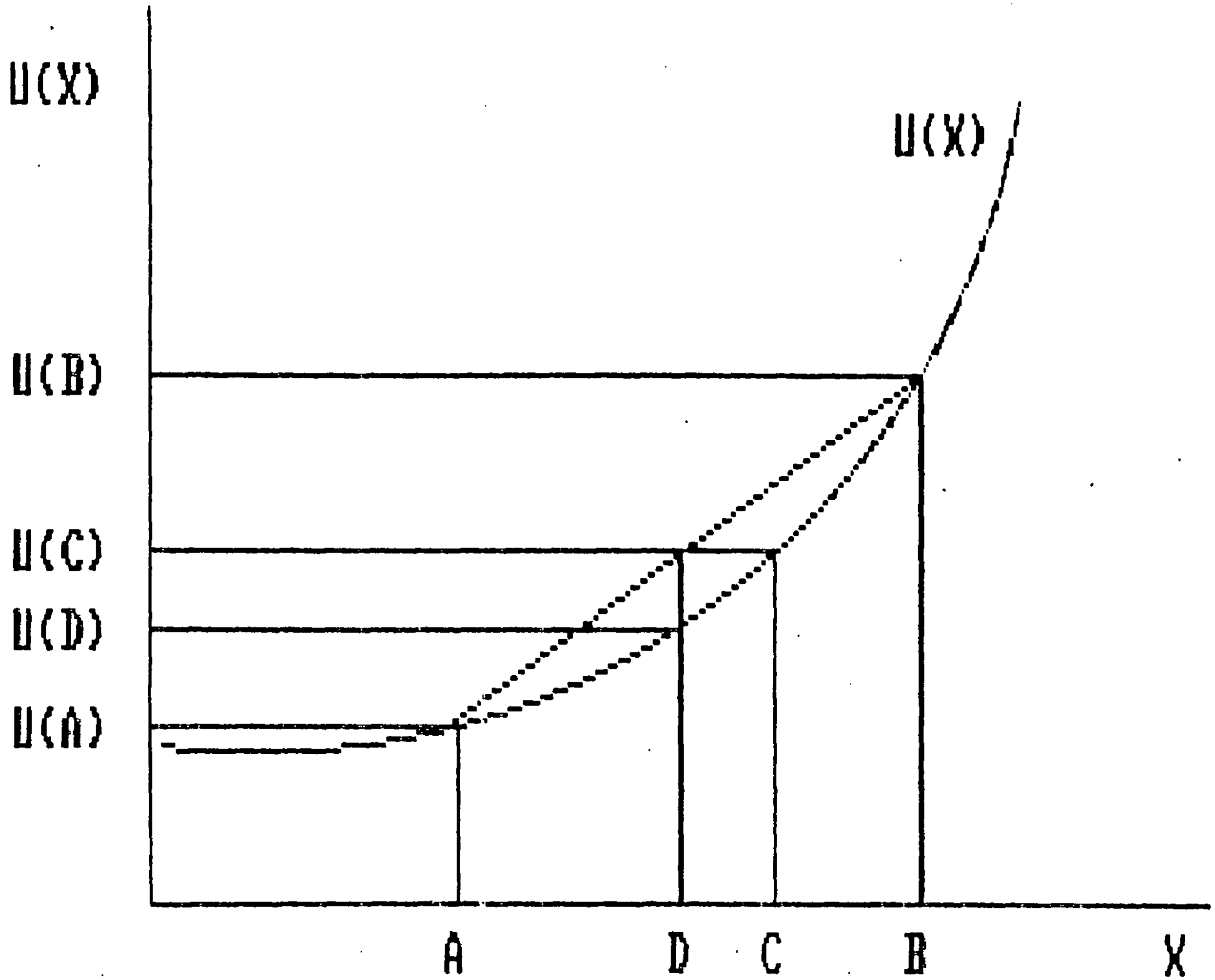


Figure 2.2: Relationship Between the Expected Value, D, and the Certainty Equivalent, C, of a Prospect (A,B:0.5) for a Risk Preferring Individual

D < C ⇒ risk premium is negative

prospect and Point D represents the expected value of the prospect. For the risk preferring individual, D<C and the risk premium is negative.

Figure 2.3 shows the relationship between the expected value of a prospect and the certainty equivalent of the prospect for a risk neutral individual faced with the prospect [A,B:0.5]. Point C represents the certainty equivalent of the prospect and Point D represents the expected value of the prospect. Since a risk neutral individual's utility function is linear, the certainty equivalent and the expected value of the prospect are equal, implying that the risk premium is zero.

For a more complete development of the above relationships and accompanying proofs, the reader is referred to Keeney and Raiffa [1976].

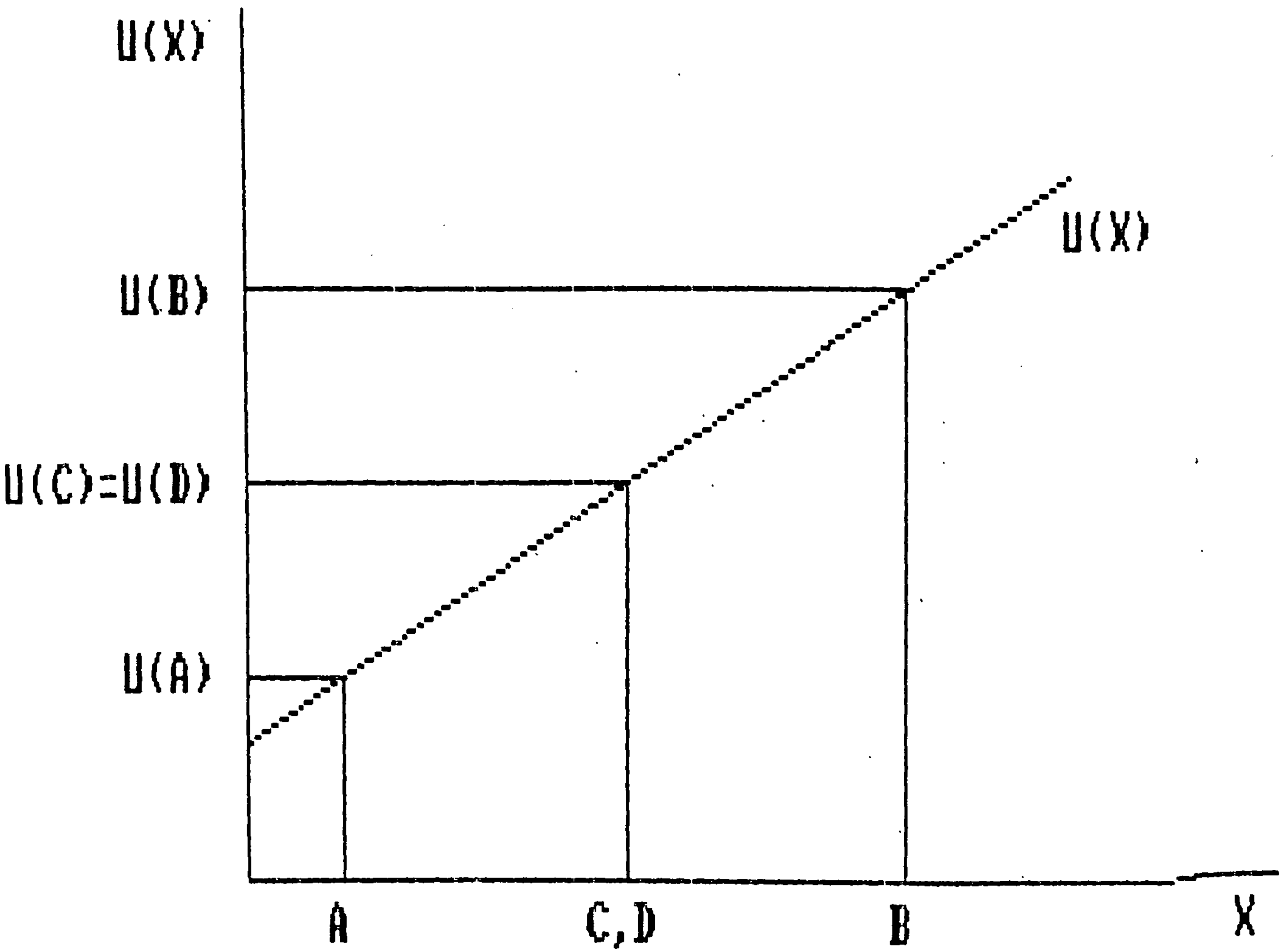


Figure 2.3: Relationship Between the Expected Value, D, and the Certainty Equivalent, C, of the Prospect (A,B:0.5) for a Risk Neutral Individual

D=C ⇒ risk premium is zero

III. THE ERROR-IN-RESPONSE MODEL USING A MODIFIED RAMSEY ELICITATION TECHNIQUE

D.E.U. METHODS

Some of the earliest attempts to estimate individual utility functions were based on the continuity axiom. For convenience the continuity axiom is repeated below: Consider three payoffs A, B, and C with $A>B>C$. Then there exists a probability P such that $0<P<1$ and $B\sim[A,C:P]$, where $B\sim[A,C:P]$ indicates indifference between the sure amount B and the prospect $[A,C:P]$.

By the expected utility theorem, we know that the utility of the prospect $[A,C:P]$ is equal to $P\ U(A)+(1-P)\ U(C)$. By the continuity axiom, therefore, there exists a probability P such that

(1) $U(B)=P\ U(A)+(1-P)\ U(C)$.

The von Neumann-Morgenstern (VNM) method of utility elicitation utilizes equation (1) to estimate utility functions by providing the three payoffs A, B, and C and eliciting the value of P that makes the respondent indifferent between the prospect $[A,C:P]$ and the certain payoff B. Since the VNM utility function contains two degrees of freedom (origin and scale),[4] arbitrary utility values can be assigned to two of the payoffs (say, A and C) and utility values can be derived for other payoffs in the manner described. For example, let A=100, B=50, and C=0. Assign U(A)=1 and U(C)=0 to fix the origin and scale of the utility function. Next, elicit the value of P for which the respondent claims indifference between [100,0:P] and 50.

Assume that the elicited value of P is 0.6. Then we have:

(2) U(50)=U([100,0:0.6])=0.6 U(100)+(1-0.6) U(0),

or, by substitution,

(3) U(50)=0.6 (1)+ 0.4 (0)=0.6

and an estimate of the utility value for 50 has been revealed. The elicitation procedure can be repeated as many times as desired to derive utility values for other payoffs and to provide consistency checks for the elicited values [Anderson, Dillon, and Hardaker, 1977].

The VNM approach to utility elicitation has been criticized on two grounds:

1. Probability bias. Bias may be introduced if the respondent has a preference for some probability levels,[5] and

[4]The two degrees of freedom referred to arise because utility lacks a unique scale and origin. Thus two utility values can be selected arbitrarily.

[5]Edwards [1953] has reported probability preferences in his research.

2. Gaming bias. The outcome may be distorted if the respondent has an aversion or preference for the gaming process itself since he is asked to compare a risky prospect with a sure amount.

The modified von Neumann-Morgenstern (MVNM) approach was developed to overcome the first criticism of the VNM method. MVNM[6] uses constant neutral probabilities $(P=(1-P)=0.5)$ in conjunction with the continuity axiom to elicit utility functions. Again, two of the payoffs (usually A and C) are provided along with the fixed probability $P=0.5$. The respondent is asked to provide the payoff B that would make him indifferent between the prospect [A,C:0.5] and B. Let $A=100$, $C=0$, $U(A)=1$, and $U(C)=0$. The respondent is asked to determine the value B that will make him indifferent to the prospect [100,0:0.5].[7] Suppose the elicited value is 40. Then

(4) $U(40)=0.5\ U(100)+0.5\ U(0)$, or by substitution,

(5) $U(40)=0.5\ (1)+0.5\ (0)= 0.5$

and a point on the respondent's utility function has been estimated. Again, the procedure can be repeated as often as desired to derive other utility-payoff combinations.

[6]The MVNM approach is the same as Anderson, Dillon, and Hardaker's [1977] Equally Likely Certainty Equivalent (ELCE) approach.

[7]The reader will recognize that the respondent's certainty equivalent has been elicited in the MVNM approach.

The MVNM approach handles the criticism of probability distortion in the VNM approach by using neutral probabilities but does not address the criticism of possible distortion due to the effects of "gaming" (Criticism #2, above). Consequently, most researchers have adopted the Ramsey method or a variation of the Ramsey method for eliciting utility functions. The Ramsey method is named for Frank Ramsey who proposed (but never used) the technique in his book, The Foundations of Mathematics [1931]. A detailed description of the Ramsey method is presented by Halter and Mason [1978]. The essential characteristics of the procedure are outlined below.

The respondent is presented with the choice between two risky prospects at each stage of the elicitation procedure. It is assumed that there are only two "states of the world," S_1 and S_2, each occuring with probability P=0.5. Thus there are four possible outcome values. At each stage of the elicitation procedure, three of the four values are provided and the respondent is asked to provide the fourth value that will result in indifference between the two risky options. The response to the first stage of the procedure is utilized to construct a second set of risky options that are then presented to the respondent. By carefully selecting the values that are presented to the respondent at each stage of the elicitation procedure, the interviewer can elicit points on the respondent's utility function. The procedure is repeated as often as desired to elicit additional points on the respondent's utility function. Table 3.1 presents an abbreviated version of the Ramsey method based on the procedures used by Halter and Mason [1978]. In the first stage of the interview, values for a, b, and d are provided and the respondent is asked to determine the value for c' that would make him indifferent between the two prospects.[8] The second stage of the interview is directly linked to the first stage by using the elicited value, c', and the original values of "a" and "d" to elicit another indifference value, c''. Stages 3 and 4 continue the process by eliciting indifference values a' and a'', respectively. This abbreviated version of the Ramsey method would result in the determination of five points on the respondent's utility function (two points that have assigned values, usually d and c'', and three points that have calculated values, c', a', and a''). Additional points can be determined by further extension of the procedure. For a more detailed description of the Ramsey method, the reader is referred to Halter and Mason [1978].

While the Ramsey method overcomes both criticisms (probability bias and gaming bias) leveled against the VNM approach, the Ramsey method can be criticized on other grounds. First of all, the Ramsey method is substantially

[8]Halter and Mason [1978] related the values in the first stage to the respondent's income level.

Table 3.1 Basic Framework of the Ramsey Method

STAGE 1

PROSPECTS	STATES S_1	S_2
P_1	b	c'
P_2	a	d

STAGE 2

	S_1	S_2
P_1	b	c''
P_2	a	c'

STAGE 3

	S_1	S_2
P_1	c''	c'
P_2	a'	d

STAGE 4

	S_1	S_2
P_1	a'	c''
P_2	a''	c'

more complicated to administer than the VNM or MVNM methods. Since the values used in constructing the risky options in the later stages of the Ramsey method are dependent upon the responses to the earlier stages, the interview cannot be entirely planned before the elicitation interview. Consequently, the interviewer must concentrate on properly constructing the risky options as the interview progresses. The need to "construct" the options while the interview is in progress may detract from the interview process and may lead to errors in constructing the options that could break the linkage between the stages of the interview and thereby render the results of the interview useless.

Knowles [1980, 1984] has described other criticisms of the Ramsey method. In particular, he points outs that there may be problems of "accumulating errors" as the interview progresses. The accumulation of errors arises because responses to earlier stages of the interview are used to develop the later options presented to the respondent and the responses at each stage of the procedure represent an estimate of the indifference value but may not actually be equal to the "true" indifference value. Knowles [1980, 1984] shows how the accumulation of errors can limit the confidence in the parameter estimates (of the utility function) because of autocorrelation and heteroscedasticity. He proposes an "error-in-response" model to overcome these criticisms.

THE ERROR-IN-RESPONSE MODEL

Consider the first stage of the Ramsey framework presented in table 3.1. There exists a value c* for which the respondent is indifferent between the two prospects. The value c' (not necessarily equal to c*) is elicited so that the respondent claims indifference between the two prospects.

The error-in-response model explicitly assumes that the subjectct responds with error, so that

(6) $c'=c^*+u$

where u represents a random error term.

By the expected utility theorem,

(7) $U(a)+U(d)=U(b)+U(c^*)$.

Rearranging terms and applying the inverse of the utility function yields

(8) $c^*=U^{-1}\{U(a)+U(d)-U(b)\}$.

Combining (6) and (8),

(9) $c'=U^{-1}\{U(a)+U(d)-U(b)\}+u$

Each stage of the elicitation procedure results in an equation like (9) with different values for a, b, c', and d. A least squares criterion can be used to estimate the parameter(s) of the utility function. With the error-in-response model the subsequent stages of the elicitation procedure do not need to be constructed from the responses from earlier stages of the interview. The interviewer is relieved of the necessity of constructing the options as the interview is in progress. Also, each subject in the study can be presented with the same set of options to provide greater ease in analyzing (assembling) the data. Since the error-in-response model removes the need to "link" the prospects presented to the respondent, we also are able to overcome the problems of autocorrelation and heteroscedasticity pointed out by Knowles [1980, 1984].

THE ERROR-IN-RESPONSE MODEL USING A MODIFIED RAMSEY METHOD AND THE NEGATIVE EXPONENTIAL UTILITY FUNCTION

The negative exponential utility function (hereafter, exponential utility function) is specified in (10) for risk averse individuals and (11) for risk preferring individuals (also see figure 3.4).

(10) $U(X)=K-Ae^{-BX}$; $A, B > 0$

(11) $U(X)=K+Ae^{-BX}$; $A > 0$, $B < 0$.

Figure 3.4 shows that the location and scale of the utility function are mutually determined by the constants K and A.

It is easily verified that the risk attitude parameter, $r(X)=-U''(X)/U'(X)$, is equal to B for both (10) and (11). Thus, the risk attitude parameter of the exponential utility function is a constant.

Another important property of the exponential utility function concerns the risk premium and certainty equivalent of prospects which differ by a fixed increment for each possible outcome. Consider $P_1=[A,B:R]$ and $P_2=[A+h,B+h:R]$, where h is a constant. If the certainty equivalent of P_1 is CE and utility is (10) or (11), then the certainty equivalent of P_2 is CE+h. An extension of this result is that the risk premiums for P_1 and P_2 will be equal. The importance of

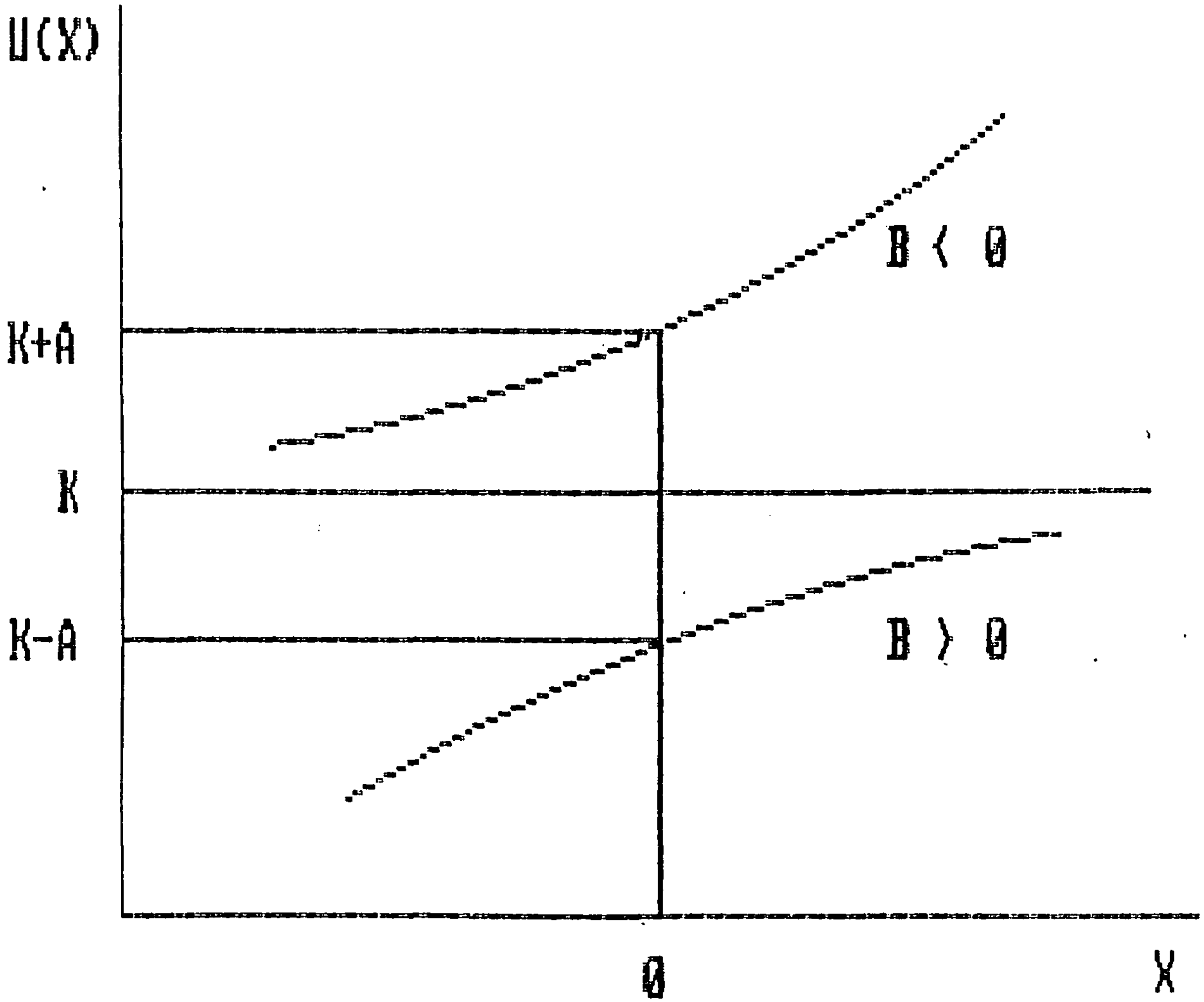


Figure 3.4: General Shape of Exponential Utility Function for Risk Preferring (B <0) and Risk Averse (B >0) Subjects

these relationships can be seen by considering two additional prospects, P_3=[C,0:1] (that is, a prospect that yields C for certain) and P_4=[C+h,0:1]. If an individual with an exponential utility function prefers (has a higher utility value for) P_1 to P_3, that individual will prefer P_2 to P_4. The complete development and proof of the relationships outlined above can be found in Keeney and Raiffa [1976].

Substantial debate has centered around the appropriate attribute to be measured in a VNM utility function with the two most widely used attributes being money wealth or money income. Because of the properties just cited, it does not matter whether wealth or income is used with the exponential utility function.

THE ESTIMATION PROCEDURE

The purpose of D.E.U. methods is to estimate respondents' utility functions so that we may determine their risk attitude. With the error-in-response model, we directly estimate the risk attitude parameter instead of deriving the risk attitude parameter from an estimated utility function. The procedure is outlined below for the exponential utility function and stage 1 of the Ramsey framework presented in table 3.1. The respondent is presented with the choice between two prospects, $P_1=[a,d:0.5]$ and $P_2=[b,c':0.5]$ where a, d, and b are constants provided by the interviewer. We seek the value for c' at which the respondent claims indifference between the two prospects. The error-in-response model assumes that the respondent's answer, c', differs from the true value, c*, by a random error term, u, so that c'=c*+u.

For the true value, c*, application of the expected utility theorem yields

(12) $U(a)+U(d)=U(b)+U(c^*)$.

Rearranging terms and substituting the assumed exponential utility function yields

(13) $K-Ae^{-B(c^*)}=K-Ae^{-B(a)}+K-Ae^{-B(d)}-K+Ae^{-B(b)}$.

Combining like terms and dividing both sides of the equation by (-A), yields

(14) $e^{-B(c^*)}=e^{-B(a)}+e^{-B(d)}-e^{-B(b)}$

and the arbitrary scale and origin parameters, A and K, have been removed.

Taking the natural logarithm[9] (denoted ln) of both sides of (14) and dividing through by (-B) gives

(15) $c^{*}=(-1/B)\ \ln\{e^{-B(a)}+e^{-B(d)}-e^{-B(b)}\}$.

Finally, combining the assumption that $c'=c^{*}+u$ with (15) yields

(16) $c'=(-1/B)\ \ln\{e^{-B(a)}+e^{-B(d)}-e^{-B(b)}\}+u$.

Each stage of the elicitation procedure results in an equation like (16) by substituting different values for a, b, and d. After several stages have been completed by the respondent, a least squares criterion with non-linear regression can be applied to derive an estimate of the risk attitude parameter B.

The questionnaire used to elicit risk attitudes with the error-in-response model is in Appendix I. The questionnaire consists of nine sections; each section is associated with a different base (average) income level. The different income levels associated with each section are presented in table 3.2. During the interview, each respondent was

[9]VNM utility functions are valid up to a linear transformation. Note that we are taking the natural logarithm of both sides of an equation, not utility functions. Therefore, we are not violating this principle. Also, see Knowles [1984].

Table 3.2: Base Income Levels Used in Error-in-Response Elicitation Procedure

Section	Base Income Level ($)
A	-10,000
B	- 5,000
C	-0-
D	10,000
E	20,000
F	30,000
G	40,000
H	50,000
I	60,000

presented with five of the nine sections. The sections presented to a particular respondent's farm size as measured by planted acreage (owned and rented combined). The objective of this approach was to keep the values presented to the respondents within the range of income levels normally experienced by the respon- dents. The delineation of farm size and income levels was determined in consultation with Mr. Hugh Hickerson, Linn County Oregon Agricultural Extension Agent. Based on Mr. Hickerson's experience and knowledge of the agricultural industry in the study area, farm sizes were identified as small, medium, or large in the following manner:

Small: less than or equal to 750 acres

Medium: more than 750 but less than 2,000 acres

Large: 2,000 acres or more.

The five sections presented to a respondent, as determined by farm size, were as follows (refer to table 3.2):

Small farm: sections B, C, D, E, G

Medium farm: sections A, C, D, F, G

Large farm: sections A, C, E, G, I.

The sample consisted of nine small farms, nine medium farms and three large farms according to the definitions above.

IV: ELICITING RISK ATTITUDES USING STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION

This chapter presents the details of a relatively new approach for eliciting risk attitudes. A general description of stochastic dominance with respect to a function is provided first, followed by the specific details of the elicitation procedure utilized in the current study.

The concept of stochastic efficiency was first formalized by Quirk and Saposnik [1962]. A mathematical treatment of the various concepts of stochastic dominance (complete with proofs) is presented by Hadar and Russell [1971]. A less rigorous and quite readable discussion of stochastic dominance is given by Anderson, Dillon and Hardaker [1977]. Meyer [1977] extends the idea of first- and second-degree stochastic dominance to encompass less restrictive behavioral assumptions (see below) in describing stochastic dominance with respect to a function. Meyer's basic results are utilized in this study to elicit producers' risk attitudes. It appears that the first widespread use of stochastic dominance with respect to a function to elicit risk attitudes was undertaken by King and Robison [1981]. This chapter draws heavily upon the work of King and Robison.

First-degree stochastic efficiency rests on the behavioral assumption that decision makers prefer more to less (i.e. the first derivative of the utility function is positive). First-degree stochastic dominance (FSD) can be used to identify probability distributions that are "not dominated" by any other probabilty distribution in the choice set and are thereby considered stochastically efficient in the first degree (FSE). This means simply that probability distributions that are not in the FSE set would not be preferred to any of the probability distributions in the FSE set by decision makers who prefer more to less.

Second-degree stochastic efficiency adds the assumption that decision makers are risk averse (i.e. the second derivative of the utility function is negative). Second-degree stochastic dominance (SSD) can be used to identify those probability distributions that are stochastically efficient in the second degree (SSE). Distributions that are not in the SSE set would not be preferred by a risk averse decision maker to any of the distributions that are in the SSE set.

Stochastic dominance with respect to a function (SDF) is an evaluative criterion that will identify the efficient set of distributions from a choice set for a decision maker whose risk attitude parameter, $r(X)=-U''(X)/U'(X)$, lies within specified upper and lower bounds. If the upper bound is $+\infty$ and the lower bound is $-\infty$, SDF is equivalent to FSD. If the upper bound is $+\infty$ and the lower bound is 0, SDF is equivalent to SSD. Thus SDF is a more flexible (or general) version of stochastic efficiency than either FSD or SSD.

Up to now the discussion of stochastic efficiency has been in the framework of identifying the efficient set of distributions where the efficient set is made up of all distributions that are not dominated by any other distribution in the choice set. This feature provides the usefulness of stochastic dominance in the area of portfolio selection (see, for example, Hadar and Russell [1971,1974]). One of the essential elements of portfolio selection is the elimination of some of the possible choices from the admissible set for a specified class of decision makers to make the selection of the preferred "portfolio" a simpler task. In this research stochastic efficiency has the converse use. Instead of specifying an upper and lower bound for the risk attitude parameter and then eliminating some portfolios as being inefficient, stated preferences between distributions will be observed and some values of the risk attitude parameter will be eliminated for being inconsistent with the stated preferences of the respondent.

The mathematical foundations for "eliciting" respondents' risk attitudes in the manner described above is found in Meyer [1977] and the operational considerations are explained in King and Robison [1981]. A numerical example will provide an understanding of the procedure. Suppose we are trying to elicit the risk attitude of a decision maker whose true (but unknown) utility function is $U(X)=1-e^{-.2X}$.

The decision maker is offered the choice between two simple prospects (say, F and G) where prospect F is $5 for certain and prospect G is an equal chance of $10 or $0. It is easily shown that all risk averse decision makers will prefer prospect F to prospect G. For our decision maker, U(F)=.6321 and U(G)=.4323 (see the proof of the expected utility theorem in chapter I for the details of calculating the utility of a prospect). Thus, the decision maker (DM) will reveal that F is preferred to G and the conclusion is that the DM is risk averse (at least within the range of monetary outcomes between $0 and $10).

The DM is next offered a choice between the prospect G and a new prospect H which is $4 for certain. To simplify the example, assume that the DM has an exponential utility function, $U(X)=K-Ae^{-BX}$. A unique value of B at which the DM is indifferent between G and H exists. However, the value of B that would indicate indifference between the two prospects cannot be identified with a closed form equation. Instead, the expected utilities of the two gambles are compared as a specific interval of risk attitudes is examined, say from $r_L(X)$ to $r_U(X)$ where $r_L(X)$ is a lower bound and $r_U(X)$ is an upper bound for r(X). One of Meyer's [1977] fundamental results is that the expected utilities of the two prospects need only be compared at the endpoints of the interval of risk attitudes under consideration, $r_L(X)$ and $r_U(X)$. Comparing the expected utilities of the two prospects at the endpoints will reveal one of two relationships: (1) one of the prospects (either G or H) will be preferred at both values of the risk attitude parameter, $r_L(X)$ and $r_U(X)$, or (2) one gamble will be preferred when the risk attitude parameter is $r_L(X)$ and the other gamble will be preferred when the risk attitude parameter is $r_U(X)$. In implementing SDF, the interval $(r_L(X),r_U(X))$ is varied until condition (2) above holds. When condition (2) holds, the unique value of B at which the DM is indifferent between G and H is within the interval $(r_L(X),r_U(X))$. Based on this knowledge concerning B and the observed preference of the DM, further limitations can be placed on the DM's risk attitude.

To continue the example, let $r_L(X)=.05$ and $r_U(X)=.10$. When B=.05, U(G)=.1968 and U(H)=.1813; G is preferred. When B=.10, U(G)=.3161 and U(H)=.3297; H is preferred and condition (2) holds. For our DM (B=.2), U(G)=.4324 and U(H)=.5507. When presented with the choice between G and H, the DM will reveal his preference for H. Based on his stated preference for H, the concusion is reached that the DM's risk attitude is greater than the lower bound of .05. Values for the risk attitude parameter between 0 and .05 have then been eliminated. By repeating the comparison of carefully selected prospects, further limits can be placed on the range of risk attitudes that are consistent with the DM's stated preferences. Note that, in the example above, we cannot conclude that the DM's risk attitude is greater than

.1 at this time since neither of the gambles (G nor H) is preferred by all DM's with risk attitudes between .05 and .1.

OPERATIONAL CONSIDERATIONS

A number of operational considerations must be addressed in order to elicit risk attitude parameters through the use of stochastic dominance with respect to a function. The elements that must be determined include the appropriate values of the risk attitude parameter to use in the elicitation process, the number of values of the risk attitude parameter to use, and the "richness" of probability distributions to offer to the respondents. King and Robison [1981] have studied and discussed these and other issues in implementing stochastic dominance. Their recommendations were used heavily in structuring the questionnaire used in this study.

The number of values of risk attitude parameters required by the elicitation process is determined by the number of distribution comparisons that each respondent will be asked to make. King and Robison developed the relationship between the structure of the questionnaire (number of distibution comparisons) and the number of values of risk attitude parameters that must be specified. They show that the number of values needed is 2^N where N is the number of distribution comparisons that the respondent will make in the elicitation process. In the present study, each respondent will be asked to make three pair-wise comparisons of distibutions requiring the specification of eight values of risk attitude parameters.

King and Robison [1981] recommend that the focus of the measurement scale should be concentrated in the risk attitude parameter interval between -.0001 and .001 since most previously elicited risk attitudes fall within this range. In reviewing the results of previous elicitation attempts by Officer and Halter [1968], Lin, Dean, and Moore [1974], Halter and Mason [1978], and Wilson and Eidman [1983] conclude that elicited risk attitudes have ranged from -.0002 to .0012. Musser, et.al. [1984], estimated risk attitudes in the range of -.00014 to .00325. The eight values of risk attitude parameters that are used in the present study are -.0005, -.0001, 0.0, .0001, .0003, .0006, .001, and .005. These values were chosen in an effort to concentrate attention within the range of previously elicited values. It should be noted at this time that the value of the risk attitude parameter is dependent upon the corresponding measure of money included in the utility function. In particular, for any specified income level, the product of income and the risk attitude parameter is a constant. Therefore, if the measure of income is changed from dollars to thousand dollars (i.e., multiplied by 1000), the corresponding risk attitude parameter will be divided by 1000. All values of risk attitude parameters discussed above assumes income measured in dollars.

Once the measurement scale for the risk attitude parameter has been specified, sample distributions that will serve as the basis for the choices to reveal the respondents' risk atitudes must be generated. King and Robison [1981] have written a computer program that generates normal probability distributions using parameters specified by the user (mean and standard deviation). The user must also specify the number of income values to include in each of the distributions. King and Robison have tested varying numbers of income values and have concluded that six values per distribution seem to work quite well. Their recommendation is based on the desire to present choices between distributions that are "rich" enough to be interesting to the respondent without making it unduly difficult to choose (specify preference) between any two distributions. After any (user-specified) number of distributions have been generated, the program tests each pair of distributions to determine which distributions are efficient in the sense of stochastic dominance with respect to a function. The information generated by the computer program can then be used to develop the questionnaire to be used to elicit individual risk attitudes. For greater detail about the procedure for generating the questionnaire, the reader is referred to King and Robison [1981].

The specific structure of the questionnaire used in this study is presented in Figure 4.1. The letters A-N

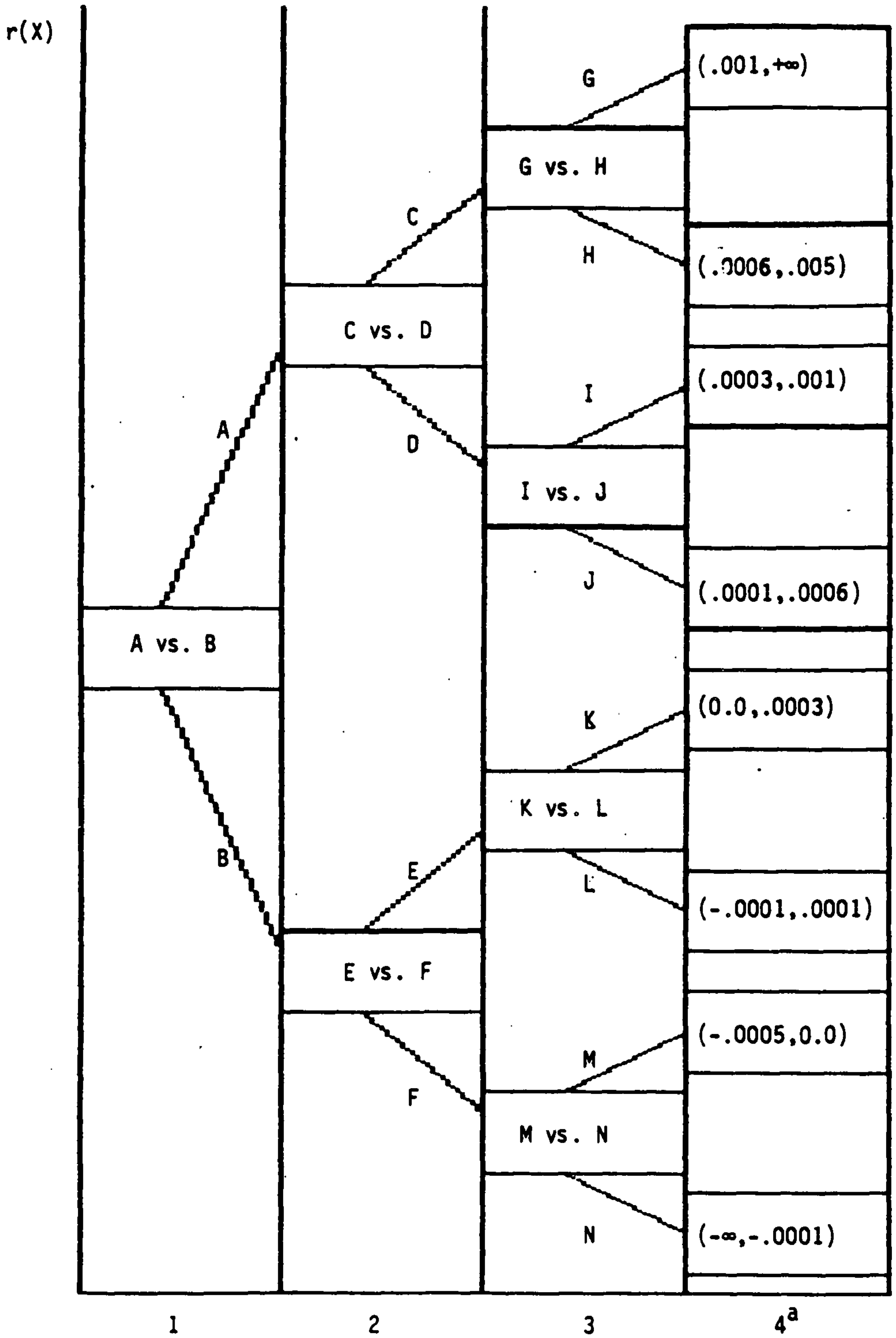


Figure 4.1 Structure of SDF Framework.
[a]Consistency Check

represent the distributions that are presented to the respondents. The procedure that is followed during the interview is similar to a programmed text where the path that is followed is determined by the choices made by the respondent. Even though each stage of the questionnaire is comprised of fifteen pairs of distributions, each respondent will be asked to make only four comparisons. The result of the first three choices is to place the respondent's risk attitude in one of the eight intervals specified in figure 4.1. Based on the exhibited preferences of the respondent, we conclude that his risk attitude parameter lies somewhere within the indicated interval. The final (fourth) comparison of distributions is a consistency check. Once a respondent's risk attitude is determined to lie within a specified range, prediction can be concerning the respondent's preference between other carefully chosen distributions. The fourth comparison provides a test of the ability to predict the respondent's preference by comparing the stated preference with the preference implied by the results of the first three (3) comparisons of distributions.

A copy of the questionnaire that was used in this study to elicit risk attitudes is found in Appendix I. The portion of the questionnaire dealing with stochastic dominance with respect to a function consists of nine different sections; each of the nine sections is associated with a different base level of income. Each respondent is presented with five of the nine sections during the interview. The five sections presented to a respondent are based on the size of the respondent's farm as outlined in Chapter 3 above. The SDF procedure assumes that the risk attitude parameter is a constant within the range of values presented in the distribution comparisons. By repeating the elicitation procedure at differing base income levels, the risk attitude parameter is allowed to vary as the income level changes. The respondent's true utility function is approximated by several different segments with each segment having a constant value for the risk attitude parameter. The procedure outlined above provides the opportunity to test whether there is a significant relationship between the risk attitude parameter and the level of income.

Table 4.1 shows the nine base income levels used in the questionnaire. All of the distributions used in the questionnaire were generated using the respective base income levels as the mean of a normal distribution. The standard deviations were chosen so that the coefficient of variation (standard deviation divided by mean) remained constant at a value of 0.1. The only exception to this guideline is the section with a mean of zero. The standard deviation for that section was set to 500, the same level as the section with a mean of -5,000. The same procedure was used to generate the questionnaire for the error-in-response model described in the previous chapter.

Table 4.1: Base Income Levels Used in the SDF Elicitation Procedure.

Section	Base Income ($)	Standard Deviation
A	-10,000	1,000
B	- 5,000	500
C	-0-	500
D	10,000	1,000
E	20,000	2,000
F	30,000	3,000
G	40,000	4,000
H	50,000	5,000
I	60,000	6,000

V: RESULTS

The elicitation methods described in the two previous chapters were used to elicit the risk attitude parameters of a sample of grass-seed producers in the Willamette Valley in western Oregon. The producers who cooperated in the study are a subset of the producers who previously cooperated in studies by Halter and Mason [1978] and Ahmed [1979]. Through retirements, deaths, and other causes, the number of individuals in the sample has decreased. Halter and Mason began with forty-four respondents in 1974. The sample was reduced to thirty-seven by 1976 for Ahmed's study. In completing the survey for the current study in 1979, only twenty-six individuals could be contacted. Two of these individuals refused to cooperate in the study. Twenty respondents successfully completed all portions of the questionnaire. One more respondent completed only the error-in-response portion and three more completed only the SDF portion.

THE ERROR-IN-RESPONSE MODEL

The second section of the questionnaire contains the modified-Ramsey elicitation procedure. As explained in Chapter III above, nine different income levels (Parts A-I) are included. For any one respondent, five of the nine sections are used. The particular sections that are used for any respondent are determined by the size of the respondent's farming operation as measured by total tilled acres (both owned and rented). As the questionnaire was originally designed, three indifference points would be elicited in each of the five parts, resulting in fifteen elicited points to fit the least squares estimate of the utility function. After several interviews were completed, it became apparent that the respondent's patience was being taxed.[10] Consequently, one of the points at each income level was deleted, resulting in ten elicited points for fitting the utility functions for each respondent.

[10]Respondents' impatience for playing "games" with hypothetical gains and losses has long been recognized as one of the problems associated with D.E.U. methods.

In addition to the problem of taxing respondents' patience with hypothetical situations, other problems arose in implementing the modified-Ramsey method. Some respondents had difficulty in understanding the framework. This misunderstanding seemed to be exacerbated when working with negative values. Some respondents disliked the simple, two-outcome framework because of lack of realism: "I never make decisions that way." Some individuals found it difficult to accept that they could not influence the probabilities. In this vein, some respondents felt that their managerial capabilities could be applied to make the more favorable outcome more likely to occur. Thus, in some cases there may have been probability distortions. While the interviewer can spend additional time trying to handle these difficulties as they arise, determination of how much impact these problems may have on the final, elicited values is impossible. These types of problems are the primary reason for utilizing the error-in-response model. The error-in-response model is designed to minimize the impact of these types of problems between stages of the elicitation procedure [Knowles, 1980, 1984].

Non-linear regression was used to estimate the individual risk attitude parameters. Since the exponential utility function does not permit risk neutrality, per se', each respondent's utility function was tested for risk neutrality prior to attempting to estimate the risk attitude parameters. A simple regression approach was devised to perform this test.

Recall the Ramsey framework described in Chapter III and presented in Table 3.1. The values a, b, and d are provided and c' is elicited so that the respondent claims indifference between the two alternative prospects, P_1 and P_2. If the respondent is risk neutral, the utility function is linear and may be specified as U(X)=X. Assuming indifference between the prospects and applying the expected utility theorem, it is easy to show that

(17) $a+d=b+c'$

or,

(18) $c'=a+d-b$,

when the individual is risk neutral.

Letting $s=a+d-b$, $c'=s$ for a risk neutral individual. Risk neutrality can be tested using simple linear regression by estimating β in equation 19.

(19) $c'_i=\beta * s_i + e_i; \; i=1,2,3,...,n$

where n is equal to the number of games presented to the respondent. If the respondent is risk neutral, $\beta=1.0$. Note that the appropriate regression equation does not contain a constant, i.e., the equation is forced through the origin. Testing the hypothesis, H_0: $\beta=1.0$, provides a simple test of risk neutrality. If H_0 is rejected, the conclusion is that the respondent is not risk neutral. Furthermore, carefully structuring the values a, b, and d allows the magnitude of β to provide additional information. If $a>b>d$, then $\beta>1$ implies risk preference and $\beta<1$ implies risk aversion. Because of no a priori basis for assuming that a respondent's risk attitude falls into any particular classification, the appropriate test of H_0 is the two-tailed t-test.

The results of the procedure outlined above are summarized in Table 5.1. According to this simple test of risk attitude classification, six respondents are risk preferring (28.6%), three respondents are risk averse (14.3%), and twelve respondents are risk neutral (57.1%). The regression procedure does not directly estimate the magnitude of the risk attitude parameter but by providing information pertaining to the risk attitude classification of respondents, the procedure provides a type of validity test for the error-in-response model.

TABLE 5.1. Results of a Regression Test for Risk Neutrality.

ID	ß	t-value	Classification[a]
1101	1.007120	1.71	N
1116	0.930345	-8.02	A
1124	1.039630	2.929	P
1125	1.000050	0.1839	N
1204	1.046840	5.673	P
1205	1.017500	3.217	P
1309	1.000000	0.0	N[b]
1314	1.047520	4.24	P
1317	1.004280	0.6328	N
1410	0.883974	-9.948	A
1411	1.046200	4.676	P
2502	1.022990	4.545	P
3108	0.997240	-0.635	N
3112	1.003990	0.409	N
3113	1.001090	0.415	N
3121	1.009920	0.4699	N
3206	0.999639	-0.2395	N
3319	1.008530	1.21	N
4115	0.946670	-3.669	A
4218	1.033320	1.898	N
4420	0.985424	-0.843	N

[a]N=Neutral, A=Averse, P=Preferring; Significance level=.05.

[b]Respondent gave exact risk neutral response in every instance.

RESULTS OF THE ERROR-IN-RESPONSE MODEL

The NLIN (Non-linear regression) procedure of SAS (Statistical Analysis System) was used to estimate B in equation 16, reproduced below for convenience.

(20) $c' = (-1/B)\ \ln\{e^{-B(a)} + e^{-B(d)} - e^{-B(b)}\} + u.$

The non-linear regression procedure uses an iterative procedure to find the value of the unknown parameter (B) that minimizes the sum of squared errors. The estimated risk attitude parameters are given in Table 5.2. The classification of respondents into the three categories of risk averse, risk neutral, and risk preferring correspond exactly with the results of the simple linear test presented in Table 5.1 with only two exceptions. The error-in-response model showed respondents 1101 and 4218 to be risk preferring. The linear regression approach of classification showed these two respondents to be risk neutral. Note that the t-values for the linear test (see Table 5.1) were relatively large (and positive) for both of these respondents; both respondents would have been classified as risk preferring with a significance level of .10.

TABLE 5.2. Estimated Risk Attitude Parameters from the Error-in-Response Model.

ID	B[a]	t-value	Classification[b]
1101	-0.021211	-2.64	P
1116	0.105691	5.22	A
1124	-0.061129	-9.13	P
1125	-0.000004	-0.01	N
1204	-0.108420	-10.66	P
1205	-0.048940	-3.71	P
1309	0.0	NA	N[c]
1314	-0.063215	-3.07	P
1317	-0.002690	-0.36	N
1410	0.222709	6.27	A
1411	-0.075997	-9.02	P
2502	-0.037515	-5.42	P
3108	0.001800	0.15	N
3112	-0.038790	-1.73	N
3113	-0.005340	-1.05	N
3121	-0.043330	-1.99	N
3206	-0.000560	-0.19	N
3319	-0.005174	-0.63	N
4115	0.081780	3.52	A
4218	-0.066898	-2.96	P
4420	0.009448	0.76	N

[a]Estimated risk attitude with money measured in $1,000.

[b]N=Neutral; A=Averse; P=Preferring; Significance level=.05.

[c]Respondent gave exact risk neutral response in every instance. Exponential utility function is not applicable.

The error-in-response model classifies eight respondents (38.1%) as risk preferring, ten respondents (47.6%) as risk neutral, and three respondents (14.3%) as risk averse. Young, et.al. [1979], has reported the results of other attempts to elicit risk attitudes. The results of the present study are not greatly dissimilar from previous studies. In particular, a significant portion of respondents are found to exhibit risk preferring behavior.

RESULTS OF THE STOCHASTIC DOMINANCE WITH RESPECT TO A FUNCTION ELICITATION PROCEDURE

Part III of the questionnaire (see Appendix I) consists of nine parts (A-I). As in the case of the error-in-response model, each respondent was presented with only five of the nine parts based on the size of their farming operation. Each part of the questionnaire proceeds like a programmed text. Although there are fifteen binary comparisons for each part of the questionnaire, the respondent made only four actual comparisons. After making four binary comparisons for each part of the questionnaire, the respondent's risk attitude was elicited so as to fall within a specified upper and lower boundary of risk attitude parameters.

As the respondent moves from part to part of the questionnaire during the interview, the elicited range of their risk attitude can (and often does) vary. Connecting the elicited risk attitude ranges with linear segments results in a graph like that in figure 5.1. The graphs that resulted from eliciting risk attitudes of twenty-one respondents using the SDF procedure are presented in Appendix II. It is interesting to note that all but four of the respondents (ID numbers 3112, 3121, 3203, and 4218) had elicited risk attitude parameter ranges that encompassed both positive and negative values. King and Robison's [1981] findings closely

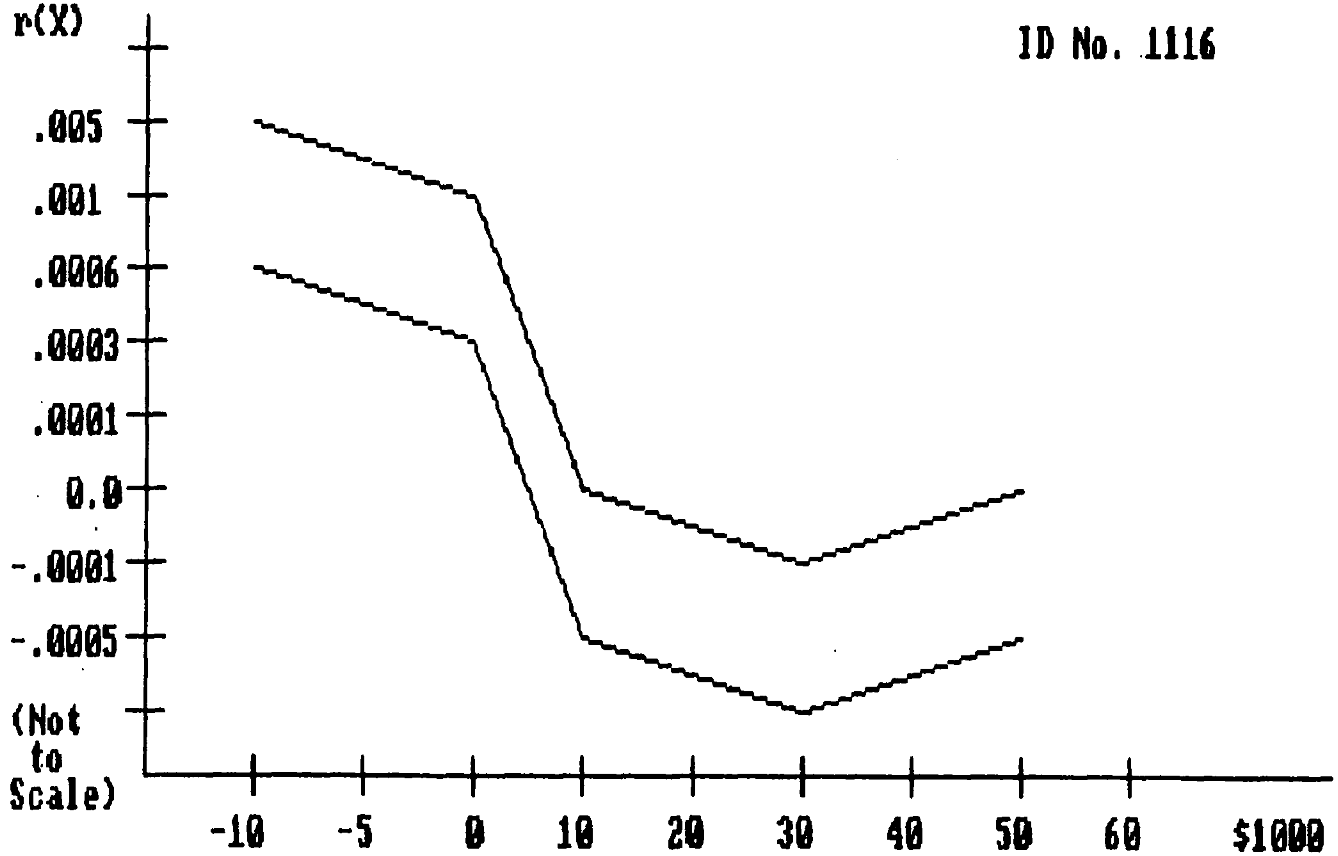


Figure 5.1: Example of Results of SDF Elicitation Procedure

paralleled these results, casting doubts on the appropriateness of eliciting single-valued utility functions that restrict the risk attitude to be non-negative and on the applicability of a criterion such as second-degree stochastic dominance which holds only for decision makers who are risk averse at all income levels.

One of the by-products of the SDF elicitation procedure is the opportunity to test for a relationship between the elicited ranges of the risk attitude parameter and the income levels. Thus we can test for increasing or decreasing risk attitudes as income levels increase.

Arrow [1974] argues in favor of the hypothesis of decreasing (absolute) risk aversion. Decreasing absolute risk aversion implies that an individual's willingness to accept a "bet" of a fixed size will increase as that individual's wealth increases. Stated another way, the individual's risk attitude parameter will decrease (that is, become less risk averse or more risk preferring) as wealth increases. Arrow's support for the stated hypothesis is on intuitive grounds rather than theoretical or empirical. As a by-product of the SDF elicitation procedure, we have empirical data to provide a test of the hypothesis of decreasing absolute risk aversion. Each respondent has an elicited range of risk attitude parameters for five different income levels. Simple linear regression can be used to test whether the elicited range of risk attitudes varies systematically with the income levels. In order to accomplish the regression test, it is necessary to associate a single value of the risk attitude parameter (rather than a range of values) with each of the five income levels. While any procedure for reducing a range of parameters to a single value will be somewhat arbitrary, it seems logical to use the midpoint of the range as a representative indicator. A problem arises with using the midpoint of the range of elicited values when the elicited range of risk attitide parameters is at one of the endpoints of the risk attitude spectrum (see Figure 4.1) since the endpoints are unbounded on one side. When the elicited range was at one of the ends of the risk attitude spectrum, the final finite value within the elicited range was used as the single value of the risk attitude parameter for the associated level of income (i.e., .005 at the upper end and -.0005 at the lower end). Thus for Respondent 1116 (figure 5.1) the five values used to represent the elicited ranges of risk attitude parameters were .0028, .00065, -.00025, -.0005, and -.00025. These five values were regressed against the corresponding average income levels (measured in $1,000) to determine if there was a significant linear association between the risk attitude parameter and the level of income. There did not exist a significant (p=.05) relationship between these variables for any respondent. We must keep in mind, however, that there are only five observations to use in the regression analysis. Nonetheless, we cannot conclude that the risk attitude parameters varied systematically with the level of income, i.e., the respondents did not exhibit either increasing or decreasing absolute risk aversion.

Another approach to testing for decreasing (increasing) absolute risk aversion is to pool the data across respondents. In this manner, many more observations are available to increase the statistical reliability of the results. The problem that needs to be considered is off-setting behavior among individuals. In other words, if one respondent exhibits increasing absolute risk aversion and another exhibits decreasing absolute risk aversion, observations from these two respondents may "wash out" and result in a conclusion of constant absolute risk aversion. Despite this potential problem, the test of decreasing (increasing) absolute risk aversion over the entire sample was conducted. The conclusion of constant absolute risk aversion was borne out since the coefficient for income was not significant.

The final topic to be discussed in this chapter is the effectiveness of the SDF elicitation procedure in measuring respondents' preferences. When evaluating the effectiveness of an elicitation technique, we need to be concerned with two different aspects--discrimination and accuracy. Discrimination refers to the ability to eliminate some of the possible choices without eliminating the preferred alternative. Obviously it is beneficial to be able to eliminate "inefficient" or inferior alternatives from the choice set. First- and second-degree stochastic dominance have been found to be rather weak with respect to this criteria [King and Robison, 1981; Porter and Gaumnitz, 1972]. Accuracy refers to the ability to correctly predict a respondent's preferred choice from among the admissible set. King and Robison [1981] discuss and demonstrate the direct tradeoff that exists between discrimination and accuracy of alternative preference measures including SDF, first- and second-degree stochastic dominance, and single-valued utility functions.

One of the advantages of stochastic dominance with respect to a function is the user's ability to determine the "width" of the risk attitude ranges used for the elicitation process. The wider the range the less discriminating the procedure will be. However, accuracy (in the sense of not eliminating preferred choices) will be increased. Therefore, the user can take into account the direct tradeoff between accuracy and discrimination in structuring the questionnaire. King and Robison [1981] have empirically tested the tradeoff between accuracy and discrimination. Based on their results, a reasonable tradeoff between accuracy and discrimination appears to be achieved when the questionnaire consists of three or four binary comparisons. Experience to date also suggests that respondents do not find this number of comparisons to be unduly taxing of their patience and willingness to participate in the interview.

For the overall sample of respondents who participated in the current study, 72.5% (74 out of 102) of the consistency checks were accurately predicted based on the elicited risk attitudes. Predicting the preferred distribution can be thought of as a binomial experiment. The appropriate test is whether more than fifty percent of the choices can be predicted. The expected number of correct predictions under the null hypothesis is 51 with a variance of 25.5 (standard deviation of 5.05) with a normal distribution. The actual result (74) lies 4.55 standard deviations from the mean. The conclusion is that the SDF procedure was able to predict significantly more than 50 percent of the preferred distributions. Only two of the twenty-three respondents who completed the questionnaires resulted in prediction accuracy below 50%. There was no test of the discriminatory power of SDF in the current study.

VI: COMPARISON OF THE TWO ELICITATION TECHNIQUES

As indicated previously, individual producer's risk attitudes were estimated using two different elicitation techniques. The primary objective of the study was to determine if the two different elicitation techniques would yield consistent estimates of risk attitudes for the same individual.

A paired t-test is one method of statistically testing whether the two elicitation techniques yield the same estimates for each individual. The paired t-test is appropriate since the elicitation techniques are applied to the same individual. Thus we wish to test whether the average of the differences between the two measures for each individual is zero rather than testing whether the difference of the averages of the two measures is zero.

The error-in-response model described in Chapter II yields a single estimate of the respondent's risk attitude. The stochastic dominance with respect to a function (SDF) technique does not yield a single estimate of the respondent's risk attitude but rather a range of values. In order to apply the paired t-test, it is necessary to condense the elicited range of risk attitudes from the SDF procedure to a single value.

In the previous chapter a regression approach was used to test for increasing or decreasing absolute risk aversion.

The regression results suggested that none of the individuals exhibited increasing or decreasing absolute risk aversion. For this study the mean value of the respondent's risk attitude estimates was used as the most appropriate single-valued estimate of the individual's risk attitude. The risk attitudes that result from the procedure described above are presented in table 6.1 along with the point estimates that resulted from the error-in-response elicitation technique.

The paired t-test to determine if the average difference between the pairs is equal to zero was conducted. The resulting t-value was -.847 with nineteen degrees of freedom. The null hypothesis of no difference between the elicited values from the two techniques could not be rejected at any reasonable level of significance. The level of significance of a statistical test is the probability of making a Type I error (rejecting a hypothesis that is in fact true). The concern that arises when the paired t-test fails to reject the null hypothesis is the power of the test. The power of a test is equal to one minus the probability of making a Type II error (failure to reject a false null hypothesis). The power function of a test is the probability that the test will reject the null hypothesis when in fact the alternative hypothesis is true. The simple correlation between the two elicited estimates of individual

Table 6.1: Comparison of Error-in-Response and SDF Elicitation Techniques.

ID [a]	Error-in-Response	SDF
1101	-.000021	.00074
1116	.000106	.00049
1124	-.000061	-.00023
1125	-0-	-.00018
1204	-.000108	.00061
1205	-.000049	-.00022
1309	-0-	-.00030
1314	-.000063	-.00092
1317	-.000003	-.00025
1411	-.000076	-.00020
2502	-.000038	-.00008
3108	.000002	-.00012
3112	-.000039	-.00050
3113	-.000005	-.00007
3121	-.000043	.00500
3206	-.000001	.00001
3319	-.000005	.00093
4115	.000082	.00003
4218	-.000067	-.00040
4420	.000009	-.00017

Note: Income is measured in dollars.

[a] Includes only respondents who successfully completed both elicitation techniques.

risk attitudes is -.046. The fact that the simple correlation is negative would indicate that the power of the paired t-test is not large. One would expect a large, positive correlation between the elicited values if in fact the two techniques did give consistent estimates of individual risk attitudes. The conclusion that results from the statistical comparison of the two elicitation techniques is mixed. On the one hand, the paired t-test failed to reject the hypothesis that the average difference between the measures is zero. The negative correlation, on the other hand, would suggest that the two elicitation techniques do not yield similar estimates. Therefore, the results of the statistical comparison are inconclusive.

A number of other points should be discussed. Seventeen of the respondents' risk attitude ranges elicited through the SDF procedure went off of the specified range (-.0005,.005) for at least one income level. This observation suggests that the specified range of risk attitudes used in the SDF procedure was too narrow. A larger range of values may have in fact resulted in different point estimates for the SDF procedure which in turn may have affected the correlation between the two measures. Future research using the SDF procedure should heed this result.

In addition to statistical tests, there are other criteria for comparing the two elicitation techniques. One of these criteria is interviewer bias. Binswanger [1980] has discussed the issue of interviewer bias as it applies to DEU methods. In summarizing research of Dillon and Scandizzo [1978], Binswanger shows that elicited risk attitudes of respondents can change significantly as a result of different interviewers. This interviewer bias may be related to the decision making bias known as anchoring [Musser and Musser, 1984]. Anchoring occurs when an initial value (either given or computed) serves as a starting point for evaluation and the basis for additional judgements. While adjustments are made, they generally prove to be insufficient and the final result is then biased toward the "anchor" or starting point [Tversky and Kahneman, 1974]. Thus, if one interviewer is very risk averse, in eliciting others' utility functions he will probably supply risk averse values as an anchor and bias the elicited risk attitude parameters toward risk aversion. The opposite effect would arise if the interviewer were risk preferring. The anchoring bias is most likely to arise in elicitation methods that require or permit the interviewer to suggest values for consideration such as in the Ramsey technique or any of its variations. The SDF elicitation procedure does not require the interviewer to elicit indifference values; the respondent is presented with a comparison of distributions and asked to state his preference. Thus, little opportunity is available for the interviewer to influence the results. In fact, King and Robison [1981] have had success with the SDF procedure through mail surveys without the direct interaction of an interviewer and the respondent. On the grounds of the anchoring bias, SDF is superior to the Ramsey method.

A criticism that is often levied against DEU methods is lack of realism. This criticism generally pertains to the context of the problem as it is presented to the respondent and the fact that the elicitation procedure uses hypothetical gains and losses. Binswanger [1980, 1982] has been especially critical of DEU methods because of a lack of realism. Neither of the two elicitiation techniques used receive high marks in dealing with this criticism. The interviewer can cast the distributions in terms of alternative income levels that will be achieved under different, uncontrollable states of the world to try to put the problem in a context that the respondent can understand. Since the problem does not relate to a specific decision faced by the respondent, it is still difficult to argue that the problem is presented in a realistic framework. Indeed, one of the criticisms raised by the respondents during the interview process was the lack of realism of the problems. The difficulty with presenting a "realistic" problem setting is the required detail and complexity that arises. The increasing complexity will most likely outweigh any advantages that arise from casting the problem in a more realistic setting. One of the objectives of DEU methods is to be able to measure individual risk attitudes in a simple setting and then extend the results to more realistic settings. In addition, casting the problem in some sort of realistic setting may in turn introduce new biases that arise from the respondents familiarity with the problem as it is casted. Thus the respondent's stated preferences may reflect decisions that have been made in the past rather than a careful consideration of the choices that are presented.

Another means for selecting between the two elicitation methods is the ease of administering the procedure. Respondents seem to have a more difficult time in specifying indifference levels like those required in the Ramsey model than in identifying a preference between two distributions required in the SDF procedure. The SDF procedure is also much easier for the interviewer to administer. Based on the criteria of ease of administration, the SDF model appears to be superior to the Ramsey model.

Some of the earliest attempts to elicit individual risk attitudes (using the von Neumann-Morgenstern or modified von Neumann-Morgenstern methods) were criticized for possible biases arising from the certainty effect [Tversky and Kahneman, 1974] and possible probability preferences. As discussed in previous chapters, both of the techniques utilized in this study have been modified to overcome these criticisms. No grounds for preferring one of the techniques over the other can be based on these two points.

One possible advantage of the Ramsey model is that it results in a specific estimate of the respondent's risk attitude or utility function. Consequently, each respondent will be uniquely classified as either risk averse, risk neutral, or risk preferring at a specified income level. The SDF procedure does not necessarily result in such clear cut classifications as evidenced by the figures in Appendix III. Recall that all but four of the respondents had elicited risk attitude ranges that encompassed both negative and positive values for the risk attitude parameter. Even though the Ramsey method will provide a definitive classification of an individual's risk attitude at any specified income level, it should be noted that Musser, et.al. [1984] found classification reversals when they estimated different functional forms of the utility function. The apparent superiority of the Ramsey method in classifying risk attitudes may be illusory.

A particular disadvantage of the SDF procedure is the construction of the questionnaire. The SDF procedure requires the ability to generate many possible distributions and the ability to determine the stochastic dominance rankings of the distributions as different ranges of risk attitudes are considered. King and Robison [1980] have written a computer program to assist in the task of constructing the questionnaire but the job is still formidable. Furthermore, if a fairly narrow range of risk attitudes is desired, several binary comparisons will be required to gain the desired precision. The difficulty of constructing the questionnaire grows exponentially with the number of comparisons that are required. However, once the questionnaire is constructed, the rest of the elicitation procedure is quite easy to complete.

Based on the criteria discussed above for comparing the two elicitation techniques used in this study, the SDF appears to be a superior technique for eliciting individual risk attitudes. While the SDF procedure is not without its problems, the problems associated with the SDF procedure are primarily operational in nature. The Ramsey method on the other hand seems much more likely to introduce interviewer bias that may substantially alter the elicited risk attitudes.

VII: SUMMARY AND CONCLUSIONS

SUMMARY

Two different direct elicitation of utility (D.E.U.) techniques were used to elicit the risk attitudes of a group of agricultural producers. The major objective of the study was to determine if consistent estimates of a respondent's risk attitude parameter could be obtained from two different elicitation techniques.

Chapter I introduces the study. Chapter II continues with a discussion of the basic idea of von Neumann-Morgenstern (VNM) utility and the relationship between VNM utility and the neoclassical concept of cardinal utility. The important differences between these two types of utility are often over-looked or misunderstood, resulting in confusion and skepticism regarding VNM utility based on well-founded criticisms of neoclassical cardinal utility.

Chapter III presents the error-in-response model using a modified Ramsey elicitation technique. Some of the shortcomings of earlier attempts to elicit individual utility functions are discussed. The error-in-response model is introduced as one means for overcoming some of these shortcomings.

Chapter IV presents the stochastic dominance with respect to a function (SDF) elicitation technique. The SDF elicitation technique is relatively new but seems to be gathering fairly wide acceptance as a reasonable alternative to some of the earlier elicitation methods.

Chapter V shows the results obtained from using the two different elicitation techniques for the same sample of agricultural producers. Chapter VI provides a comparison of the elicitation results. The paired t-test was used to test whether the elicitation techniques yielded consistent estimates of individual risk attitudes. The hypothesis that the two elicitation techniques yielded the same estimates could not be rejected at the 10% confidence level. However, the virtually zero correlation between the elicited values suggests that the methods did not yield consistent estimates of individual risk attitudes.

Ideally, the next step to be pursued in validating the results of the elicitation techniques would be to integrate the elicitated risk attitudes with research that identifies specific actions that should be preferred by selected classes of decision makers. An excellent example of this type of research is the study by Kramer and Pope [1981] that relates participation in government programs to risk aversion levels. By observing the actual economic behavior of respondents, we can then test whether predicted actions (based on elicited risk attitudes) parallel actual choices. Research of this type might lead to a more definite conclusion concerning the validity of the two elicitation techniques by showing which method resulted in elicited risk attitudes that indicated choices that more nearly paralled actual economic behavior. Even in this case, though, we must consider the role of utility theory. In particular, is utility theory prescriptive or predicitive? There is not universal agreement on the answer to this question. Some [Raiffa, 1968 for example] feel that the theory is prescriptive--that is, the theory suggests which decision should be made based on the decision makers risk attitude rather than being a good device for predicting which decision will be made. In this case, checking predicted choices with actual decisions may not necessarily be a good method of validating elicited risk attitudes. Here we must heed the warning of Musser and Musser [1984] that utility functions or risk attitudes that are elicited from generalized elicitation methods will not be very useful (or accurate) in predicting behavior in a specific managerial setting. If VNM utility theory cannot predict choices, the question might arise as to the usefulness of the theory. As a prescriptive theory, the usefulness lies in its capability of being a decision aid--helping managers make rational decisions based on their risk attitude when confronted with complex decisions. Indeed, Kramer and Pope [1981] have used the theory in just this way--to identify superior choices for managers based on a stated risk aversion level. The most famous example of using expected utility theory in a prescriptive nature is Savage who, when presented with the Allais' paradox, changed his preferred choice based on an inconsistency between his stated preference and expected utility theory. For a more complete discussion of the role of utility theory, see Swalm [1966].

CONCLUSIONS

One of the noteable results of the elicitation techniques was that a large portion of respondents exhibited risk preferring behavior over at least some levels of income. This result parallels the findings of several other attempts to elicit individual risk attitudes which are summarized by Young, et. al., [1979]. Many studies in agricultural economics assume that producers are risk averse. The common assumption of risk aversion should be reconsidered in light of the results of this and other studies eliciting individual risk attitudes.

A test of decreasing (or increasing) absolute risk aversion was undertaken. None of the respondents' risk attitudes showed a statistically significant relation between income and risk attitude. Since very few other formal tests of the relationship between income and risk attitude exist, the result of the test should be of interest to researchers. An implication of this result is that the exponential utility function is an appropriate representation of individual utility functions since the exponential utility function exhibits constant absolute risk aversion. Musser, et. al. [1984] have shown the importance of selecting an appropriate functional form for the utility function. The results of the current research provide support for the exponential utility function. An equally important contribution of the current research is evidence that the exponential utility function can be estimated without undue difficulty by using the error-in-response model.

Since the statistical tests comparing the two elicitation models was inconclusive, the models were compared on other grounds to determine if one of the models was superior. In particular, some of the common biases that have been observed in decision making under uncertainty were investigated to determine if one of the elicitation techniques was better suited to avoid or overcome the biases. In addition to possible biases that would influence the results of the elicitation procedures, other difficulties that may arise in the elicitation process were discussed.

The biases that were discussed included bias attributed to the interviewer, bias arising from the certainty effect, and probability bias. The SDF procedure was found to be superior for coping with possible interviewer bias. Both elicitation methods were designed to overcome possible bias arising from the certainty effect. Neither method is superior in dealing with bias that may arise from probability preferences.

Other criteria used for comparing the two elicitation techniques included the level of realism of decision choices, ease of administering the elicitation technique, difficulties in constructing the elicitation questionnaire, and type of output that results from the elicitation methods.

Neither elicitation method used in this study appears to be superior on grounds of realism. SDF is superior to the error-in-response model on the basis of ease of administration. However, the error-in-response model is superior to the SDF model on the grounds of ease of questionnnaire construction. The error-in-response model is potentially superior because of the ability to derive a single-valued function for the risk attitude parameter.

SHORTCOMINGS OF THE STUDY AND RECOMMENDATIONS FOR FUTURE RESEARCH

Alfred Marshall has been quoted as saying that every short statement about economics is misleading [Samuelson, 1973]. An extension of this thought would be that every study in economics has some shortcomings. Some of the shortcomings or deficiencies of the current study will now be discussed.

Upon completion of the elicitation procedure, twenty useable questionnaires were available for comparing the two elicitation techniques. In order for the questionnaire to be useable, the respondent had to complete both portions (SDF and error-in-response) of the questionnaire. In some cases, interviews were terminated prematurely if a respondent completely lost his patience and willingness to further cooperate in the study. Obviously, statistical comparisons of the two techniques would be better if more observations were available. One of the common problems with D.E.U. methods is the difficulty in deriving estimated utility functions (or risk attitude parameters) for a large number of respondents. Consequently, a small number of respondents is a very common shortcoming of D.E.U. studies. The current study is no exception.

A second (but related) shortcoming of the current study is the use of five different income levels in the elicitation techniques. Again it would have been better if more observations could have been derived. The number of observations for testing the SDF procedure for decreasing (increasing) absolute risk aversion levels is limited to the number of income levels used in the elicitation process. Obviously, five observations is barely acceptable for regression analysis. Nonetheless, it must be stressed that elicitation methods tax the patience of most respondents and increasing the number of income levels would necessarily increase the length of the questionnaire. Practical considerations make it difficult to increase the questionnaire to include many more levels of income.

An extension of the problem just discussed can be made to the error-in-response model. Practical considerations led to limiting the number of indifference points elicited to ten for each respondent. Consequently, the non-linear regression used to estimate the risk attitude parameter had only ten observations available. Again, additional data are desirable from the statistical viewpoint but not easily obtained without unduly taxing respondents' patience and willingness to participate.

A large number of respondents expressed preferences between distributions in the SDF procedure such that the elicited risk attitude range was at the extremes of the presented values. In retrospect, it would have been desirable to expand the presented range beyond the (-.0005,.005) range used to construct the questionnaire. An expansion of the range used to construct the SDF questionnaire could also alleviate some of the problems that were encountered when trying to condense the SDF elicited ranges to a single value. Recall that one of the primary difficulties that arose was in assigning a single value to an interval that was unbounded either above or below. Expanding the range of parameters used to construct the questionnaire would likely reduce the number of instances in which an elicited risk attitude range would result in an unbounded interval.

Despite the shortcomings cited above, the study led to several significant conclusions. Two D.E.U. methods that are quite different in nature were compared to determine if the methods would yield consistent estimates of individual risk attitudes. Very little research has been completed that contrasts different elicitation techniques so this is a significant contribution even though the comparison was somewhat inconclusive. A large percentage of individuals exhibited risk preferring behavior over some ranges of income levels. This is not a novel result but does lend support to other D.E.U. studies that have reached similar conclusions. A test of decreasing (increasing) absolute risk aversion was included in the study. None of the respondents in the study were found to have either increasing or decreasing absolute risk aversion. An implication of this result is that the negative exponential utility function is appropriate for these respondents. Substantial debate has centered on the appropriate utility function to use when eliciting risk attitudes. Researchers planning to continue research in the area of risk attitude elicitation should be cognizant of the results of this study. While we cannot conclude that the negative exponential utility function will serve as "everyone's utility function," we do now have some concrete evidence that the negative exponential utility function may be an acceptable alternative to other utility forms without some of the shortcomings that have been well documented in the literature.

BIBLIOGRAPHY

Ahmed, A. An Econometric Analysis of Risk Attitudes Among Grass Seed Producers in the Willamette Valley. Unpublished M.S. thesis, Oregon State University, 1979.

Anderson, J.R., J.L. Dillon, and J.B. Hardaker. Agricultural Decision Analysis. Ames, Iowa: The Iowa State University Press, 1977.

Arrow, K.J. Aspects of the Theory of Risk Bearing. Helsinki: Academic Book Store, 1965.

Arrow, K.J. Essays in the Theory of Risk Bearing. New York: North Holland Publishing/American Elsevier Publishing, 1974.

Baumol, W.J. Economic Theory and Operations Analysis, 3rd ed. Englewood Cliffs: Prentice-Hall, 1972.

Binswanger, H. "Attitudes Towards Risk: Experimental Measurements in Rural India." Amer. J. Agr. Econ. 62:3 (August 1980), 395-407.

Binswanger, H. "Empirical Estimation and Use of Risk Preferences: Discussion." Amer. J. Agr. Econ. 64:2 (May 1982), 391-393.

Dillon, J.L. "An Expository Review of Bernoullian Decision Theory." Rev. of Mktg. and Agric. Econ. 39:1 (March 1971), 3-80.

Dillon, J.L., and P.L. Scandizzo. "Risk Attitudes of Subsistence Farmers in Northeast Brazil: A Sampling Approach." Amer. J. Agr. Econ. 60:3 (August 1978), 425-435.

Edwards, W. "Probability-preferences in Gambling." Amer. J. Agr. Econ. LXVI:3 (July 1953), 349-364.

Fishburn, P.C. Utility Theory for Decision Making. New York: Wiley, 1970.

Hadar, J., and W.R. Russell. "Stochastic Dominance and Diversification." J. Econ. Theory. 3 (1971): 288-305.

Hadar, J., and W.R. Russell. "Diversification and Interdependent Prospects." J. Econ. Theory. 7 (1974): 231-240.

Halter, A.N., and R. Mason. "Utility Measurement for Those Who Need to Know." Western J. Agr. Econ. 3:2 (December 1978), 99-110.

Herstein, I.N., and J. Milnor. "An Axiomatic Approach to Measurable Utility." Econometrica. 21:2 (April 1953), 291-297.

Keeney, R.L., and H. Raiffa. Decisions with Multiple Objectives: Preferences and Value Tradeoffs. New York: Wiley, 1976.

King, R.P., and L.J. Robison. "Implementation of the Interval Approach to the Measurement of Decision Maker Preference." Unpublished. 1980.

King, R.P., and L.J. Robison. "An Interval Approach to Measuring Decision Maker Preferences." Amer. J. Agric. Econ. 63:3 (August 1981), 510-520.

Knowles, G.J. "Estimating Utility Functions." in Risk Analysis in Agriculture: Research and Educational Developments. Agricultural Experiment Station, Univ. of Illinois, AE-4492, June 1980.

Knowles, G.J. "Some Econometric Problems in the Measurement of Utility." Amer. J. Agric. Econ. 66:4 (November 1984), 505-510.

Kramer, R.A., and R.D. Pope. "Participation in Farm Commodity Programs: A Stochastic Dominance Analysis." Amer. J. Agr. Econ. 63:1 (February 1981), 119-128.

Lin, W., G.W. Dean, and C.V. Moore. "An Empirical Test of Utility vs. Profit Maximization in Agricultural Production." Amer. J. Agric. Econ. 56:3 (August 1974), 497-508.

Love, R.O., and L.J. Robison. "An Empirical Analysis of the Intertemporal Stability of Risk Preference." South. J. Agr. Econ. 16:1 (July 1984), 159-165.

Meyer, J. "Second Degree Stochastic Dominance with Respect to a Function." Inter. Econ. Rev. 18:2 (June 1977), 477-487.

Mosteller, F., and P. Nogee. "An Experimental Measurement of Utility." J. Pol. Econ. 59:5 (October 1951), 371-404.

Musser, W.N., and L.M. Musser. "Psychological Perspectives on Risk Analysis." Risk Management in Agriculture. ed. P.J. Barry, 82-92. Ames, Iowa: Iowa State University Press, 1984.

Musser, W.N., M.E. Wetzstein, S.Y. Reece, L.M. Musser, P.E. Varca, and C.C.J. Chou. "Classification of Risk Preferences with Elicited Utility Data: Does Functional Form Matter?" Western J. Agr. Econ. 9:2 (December 1984), 322-328.

Newbery, D.M.G., and J.E. Stiglitz. The Theory of Commodity Price Stabilization: A Study in the Economics of Risk. Oxford: Clarendon Press, 1981.

Officer, R.R., and A.N. Halter. "Utility Analysis in a Practical Setting." Amer. J. Agric. Econ. 50:2 (May 1968), 257-277.

Porter, R.B., and J.E. Gaumnitz. "Stochastic Dominance vs. Mean-Variance Portfolio Analysis: An Empirical Evaluation." Amer. Econ. Rev. 62:3 (June 1972), 438-446.

Pratt, J.W. "Risk Aversion in the Small and in the Large." Econometrica. 32:1-2 (January-April, 1964), 122-136.

Quirk, J.P., and R. Saposnik. "Admissibility and Measurable Utility Functions." Rev. Econ. Stud. 29:2 (1962), 140-146.

Raiffa, H. Decision Analysis. Reading: Addison-Wesley, 1968.

Ramsey, F.P. The Foundations of Mathematics. New York: Harcourt Brace, 1931.

Samuelson, P. Economics. 9th ed. New York, McGraw-Hill Book Company, 1973.

Savage, L.J. Foundations of Statistics. New York: Wiley, 1954.

Schoemaker, P.J.H. Experiments on Decisions Under Risk: The Expected Utility Hypothesis. Boston: Martinus Nyhoff Publishing, 1980.

Stigler, G.J. "The Development of Utility Theory: Parts 1 and 2." J. Pol. Econ. LVIII:4-5 (August-October 1950), 307-326, 373-396.

Swalm, R.O. "Insights into Risk Taking." Chapter 26 in Serraino, W.J., S.S. Singhvi, and R.M. Soldofsky, ed. Frontiers of Financial Management. Cincinnati: South-Western Publishing, 1971.

Tversky, A., and D. Kahneman. "Judgement Under Uncertainty: Heuristics and Biases." Science. 185 (September 1974), 1124-1131.

von Neumann, J., and O. Morgenstern. Theory of Games and Economic Behavior. 2nd ed. Princeton: Princeton Univ. Press, 1947.

Whittaker, E. A History of Economic Ideas. New York: Longmans, Green, and Co., 1940.

Whittaker, J.K., and J.R. Winter. "Risk Preferences of Farmers: An Empirical Example, Some Questions, and Suggestions for Future Research." in Risk Analysis in Agriculture: Research and Educational Developments. Agricultural Experiment Station, Univ. of Illinois, AE-4492, June 1980.

Wilson, P., and V. Eidman. "An Empirical Test of the Interval Approach for Estimating Risk Preferences." Western J. Agr. Econ. 8:2 (December 1983), 170-182.

Young, D., W. Lin, R. Pope, L. Robison, and R. Selley. "Risk Preferences of Agricultural Producers: Their Measurement and Use." in Risk Management in Agriculture: Behavioral, Managerial, and Policy Issues. Agricultural Experiment Station, Univ. of Illinois, AE-4478, July 1979.

APPENDICES

APPENDIX I

THE ELICITATION QUESTIONNAIRE

Appendix I contains a copy of the questionnaire that was used to elicit risk attitudes. The questionnaire consists of three separate parts. The first part of the questionnaire solicits various socio-economic data of the respondent. The second part of the questionnaire consists of the framework for eliciting risk attitudes using the modified Ramsey method and the error-in-response model. The final part of the questionnaire consists of the distributions that were used to elicit risk attitudes using stochastic dominance with respect to a function.

PART A:	-10,000
PART B:	- 5,000
PART C:	-0-
PART D:	10,000
PART E:	20,000
PART F:	30,000
PART G:	40,000
PART H:	50,000
PART I:	60,000

FARM SIZE	PARTS
Less than or equal to 750 acres	B,C,D,E,G
Between 750 and 2000 acres	A,C,D,F,H
Greater than 2000 acres	A,C,E,G,I

SOCIO-ECONOMIC INFORMATION

I.D. Number________

Legal Form of Farm Ownership________________________________

Age of Principal D-M________________________________

Years of Formal Schooling________________________________

Number of Dependents (including self)______________________

OFF-FARM EMPLOYMENT

Name (Relationship to D-M)	Full-Time Month Equivalents	Approx. Annual Net Income
____________________	__________	__________
____________________	__________	__________
____________________	__________	__________
____________________	__________	__________

Acres Under Your Control

1979-80 Owned ____________ (or being purchased) Leased__________ Type of Lease________________

1980-81 Owned ____________ (or being purchased) Leased__________ Type of Lease________________

What percent of total farm sales were made using each of the following pricing arrangements?

	1979-80	1978-79
Forward Contracting	________	________
Cash Market, 1 or 2 Sales	________	________
Cash Market, 2 - 5 Sales	________	________
Cash Market, 6 or more sales	________	________
Deferred Pricing*	________	________
Futures Hedging	________	________
Other ______________	________	________

*Deferred pricing refers to storing grain (seed) at an elevator for sale at a future date).

PART II: ERROR-IN-RESPONSE MODEL

In this section, you are asked to identify the outcome level that will make you indifferent between two alternative actions. The outcomes can be considered as possible returns above cash production costs for a portion of your farm business. The outcomes are to be considered equally likely for each alternative and completely beyond your influence.

There are no right or wrong answers. Your responses should reflect your own preference.

PART A

CHANCES OF OCCURRING	**ALTERNATIVES** 1	2	3	4	5	6
1/2	- 9,000					
1/2	-11,000	-10,500	-10,500	-10,500	-10,500	-10,500

	1	2	3	4	5	6
1/2	- 8,000					
1/2	-12,000	-10,500	-10,500	-10,500	-10,500	-10,500

	1	2	3	4	5	6
1/2	- 7,500					
1/2	-10,500	-10,000	-10,000	-10,000	-10,000	-10,000

PART B

CHANCES OF OCCURRING — **ALTERNATIVES**

	1	2	3	4	5	6
1/2	-4,500					
1/2	-5,500	-5,250	-5,250	-5,250	-5,250	-5,250

	1	2	3	4	5	6
1/2	-4,000					
1/2	-6,000	-5,250	-5,250	-5,250	-5,250	-5,250

	1	2	3	4	5	6
1/2	-3,750					
1/2	-5,250	-5,000	-5,000	-5,000	-5,000	-5,000

PART C

CHANCES OF OCCURRING	ALTERNATIVES					
	1	2	3	4	5	6
1/2	500					
1/2	- 500	-250	-250	-250	-250	-250

	1	2	3	4	5	6
1/2	1,000					
1/2	-1,000	-250	-250	-250	-250	-250

	1	2	3	4	5	6
1/2	1,250					
1/2	- 250	0	0	0	0	0

PART D

CHANCES OF OCCURRING | **ALTERNATIVES**

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	11,000					
1/2	9,000	9,500	9,500	9,500	9,500	9,500

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	12,000					
1/2	8,000	9,500	9,500	9,500	9,500	9,500

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	12,500					
1/2	9,500	10,000	10,000	10,000	10,000	10,000

PART E

CHANCES OF OCCURRING

ALTERNATIVES

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	22,000					
1/2	18,000	19,000	19,000	19,000	19,000	19,000

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	24,000					
1/2	16,000	19,000	19,000	19,000	19,000	19,000

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	25,000					
1/2	19,000	20,000	20,000	20,000	20,000	20,000

PART F

CHANCES OF OCCURRING	ALTERNATIVES 1	2	3	4	5	6
1/2	33,000					
1/2	27,000	28,500	28,500	28,500	28,500	28,500

	1	2	3	4	5	6
1/2	36,000					
1/2	24,000	28,500	28,500	28,500	28,500	28,500

	1	2	3	4	5	6
1/2	37,500					
1/2	28,500	30,000	30,000	30,000	30,000	30,000

PART G

CHANCES OF OCCURRING

ALTERNATIVES

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	44,000					
1/2	36,000	38,000	38,000	38,000	38,000	38,000

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	48,000					
1/2	32,000	38,000	38,000	38,000	38,000	38,000

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	50,000					
1/2	38,000	40,000	40,000	40,000	40,000	40,000

PART H

CHANCES OF OCCURRING	ALTERNATIVES 1	2	3	4	5	6
1/2	55,000					
1/2	45,000	47,500	47,500	47,500	47,500	47,500

	1	2	3	4	5	6
1/2	60,000					
1/2	50,000	47,500	47,500	47,500	47,500	47,500

	1	2	3	4	5	6
1/2	62,500					
1/2	47,500	50,000	50,000	50,000	50,000	50,000

PART I

CHANCES OF OCCURRING | **ALTERNATIVES**

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	66,000					
1/2	54,000	57,000	57,000	57,000	57,000	57,000

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	72,000					
1/2	48,000	57,000	57,000	57,000	57,000	57,000

CHANCES OF OCCURRING	1	2	3	4	5	6
1/2	75,000					
1/2	57,000	60,000	60,000	60,000	60,000	60,000

PART III: SDF ELICITATION PROCEDURE

In this section, you are asked to compare distributions of numbers and indicate which you prefer. The numbers represent levels of return over cash costs that may be returned from your farming operation. The distributions should be thought of as ranges of possible outcomes that can occur under particular management strategies and environmental situations. Six levels are listed for each distribution and each level is considered to have one chance in six of occuring for the particular distribution. In each part you will answer only four questions.

Your choices should reflect your own attitudes and preferences. As before, there are no right or wrong answers.

PART A

1. Compare:

A	B
-10,900	-11,500
-10,600	-10,800
-10,400	-10,700
- 9,900	- 9,900
- 9,800	- 9,700
- 9,600	- 8,000

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
-10,600	-11,100
-10,500	-10,000
-10,200	-10,000
- 9,100	- 9,200
- 9,100	- 8,700
- 8,800	- 7,800

If you chose C, go to question 4.
If you chose D, go to question 5.

3. Compare:

E	F
-11,200	-11,500
-11,000	-11,400
-10,500	-10,800
-10,200	- 9,400
- 9,100	- 9,200
- 9,000	- 8,800

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
-11,300	-11,400
-11,100	-11,100
-10,900	-10,200
-10,600	-10,100
- 9,700	- 9,100
- 9,400	- 9,000

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
-11,200	-11,300
-10,300	-10,900
-10,200	-10,700
-10,200	-10,100
- 9,900	- 8,900
- 9,700	- 8,800

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
-10,900	-12,000
-10,800	-10,400
- 9,700	-10,000
- 9,400	- 9,800
- 9,300	- 8,800
- 9,100	- 7,900

If you chose K, go to question 12.
If you chose L, go to question 13

7. Compare:

M	N
-11,000	-12,000
-10,000	-10,900
-10,000	-10,300
- 9,500	- 9,200
- 9,300	- 9,100
- 8,700	- 7,800

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
-12,000	-11,900
-10,900	-10,100
-10,300	-10,000
- 9,200	- 9,900
- 9,100	- 9,700
- 7,800	- 9,600

Go to next part.

9. Compare:

Q	R
-11,200	-11,300
-10,300	-10,900
-10,200	-10,700
-10,200	-10,100
- 9,900	- 8,900
- 9,700	- 8,800

Go to next part.

10. Compare:

S	T
-11,300	-11,400
-11,100	-11,100
-10,900	-10,200
-10,600	-10,100
- 9,700	- 9,100
- 9,400	- 9,000

Go to next part.

11. Compare:

U	V
-12,000	-11,900
-10,900	-10,100
-10,300	-10,000
- 9,200	- 9,900
- 9,100	- 9,700
- 7,800	- 9,600

Go to next part.

12. Compare:

W	X
-11,200	-12,000
-10,300	-11,900
-10,200	-11,700
-10,200	-10,000
- 9,900	- 8,600
- 9,700	- 7,800

Go to next part.

13. Compare:

Y	Z
-11,000	-12,000
-10,000	-10,900
-10,000	-10,300
- 9,500	- 9,200
- 9,300	- 9,100
- 8,700	- 7,800

Go to next part.

14. Compare:

aa	bb
-10,900	-12,000
-10,800	-10,400
- 9,700	-10,000
- 9,400	- 9,800
- 9,300	- 8,800
- 9,100	- 7,900

Go to next part.

15. Compare:

cc	dd
-11,200	-12,000
-10,300	-11,900
-10,200	-11,700
-10,200	-10,000
- 9,900	- 8,600
- 9,700	- 7,800

PART B

1. Compare:

A	B
- 5,950	- 6,000
- 5,550	- 5,950
- 5,100	- 5,850
- 5,050	- 5,000
- 4,950	- 4,300
- 4,550	- 3,900

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
- 5,350	- 5,750
- 5,150	- 5,100
- 5,150	- 4,900
- 4,900	- 4,850
- 4,750	- 4,750
- 4,500	- 3,950

If you chose C, go to question 4.
If you chose D, go to question 5.

3. Compare:

E	F
- 5,450	- 6,000
- 5,400	- 5,450
- 4,850	- 5,150
- 4,700	- 4,600
- 4,650	- 4,550
- 4,550	- 3,900

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
- 5,300	- 5,550
- 5,150	- 5,000
- 5,050	- 5,000
- 4,650	- 4,600
- 4,600	- 4,350
- 4,200	- 3,900

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
- 5,600	- 5,950
- 5,150	- 5,050
- 5,100	- 5,000
- 5,100	- 4,950
- 4,950	- 4,850
- 4,850	- 4,800

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
- 5,450	- 5,750
- 5,300	- 5,700
- 5,200	- 5,400
- 4,950	- 4,700
- 4,900	- 4,600
- 4,800	- 4,400

If you chose K, go to question 12.
If you chose L, go to question 13.

7. Compare:

M	N
- 5,750	- 5,150
- 5,100	- 4,900
- 5,050	- 4,750
- 4,300	- 4,600
- 4,200	- 4,500
- 4,150	- 4,350

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
- 5,750	- 5,600
- 5,400	- 5,500
- 5,350	- 5,250
- 4,950	- 5,100
- 4,850	- 4,550
- 4,000	- 4,500

Go to next part.

9. **Compare:**

Q	R
- 5,600	- 5,950
- 5,150	- 5,050
- 5,100	- 5,000
- 5,100	- 4,950
- 4,950	- 4,850
- 4,850	- 4,800

Go to next part.

10. **Compare:**

S	T
- 5,300	- 5,550
- 5,150	- 5,000
- 5,050	- 5,000
- 4,650	- 4,600
- 4,600	- 4,350
- 4,200	- 3,900

Go to next part.

11. **Compare:**

U	V
- 5,750	- 5,600
- 5,400	- 5,500
- 5,350	- 5,250
- 4,950	- 5,100
- 4,850	- 4,550
- 4,000	- 4,500

Go to next part.

12. **Compare:**

W	X
- 6,000	- 5,450
- 5,200	- 5,250
- 5,000	- 5,150
- 4,900	- 4,750
- 4,400	- 4,700
- 3,950	- 4,100

Go to next part.

13. **Compare:**

Y	Z
- 5,750	- 5,150
- 5,100	- 4,900
- 5,050	- 4,750
- 4,300	- 4,600
- 4,200	- 4,500
- 4,150	- 4,350

Go to next part.

14. **Compare:**

aa	bb
- 5,450	- 5,750
- 5,300	- 5,700
- 5,200	- 5,400
- 4,950	- 4,700
- 4,900	- 4,600
- 4,800	- 4,400

Go to next part.

15. **Compare:**

cc	dd
- 6,000	- 5,450
- 5,200	- 5,250
- 5,000	- 5,150
- 4,900	- 4,750
- 4,400	- 4,700
- 3,950	- 4,100

PART C

1. Compare:

A	B
-950	-1,000
-550	- 950
-100	- 850
- 50	0
50	700
450	1,100

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
-350	- 750
-150	- 100
-150	100
100	150
250	250
500	1,050

If you chose C, go to question 4.
If you chose O, go to question 5.

3. Compare:

E	F
-450	-1,000
-400	- 450
150	- 150
300	400
350	450
450	1,100

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
-300	- 550
-150	0
- 50	0
350	400
400	650
800	1,100

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
-600	-950
-150	- 50
-100	0
-100	50
50	150
150	200

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
-450	-750
-300	-700
-200	-400
50	300
100	400
200	600

If you chose K, go to question 12.
If you chose L, go to question 13.

7. Compare:

M	N
-750	-150
-100	100
- 50	250
700	400
800	500
850	650

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
-750	-600
-400	-500
-350	-250
50	-100
150	450
1,000	500

Go to next part.

9. Compare:

Q	R
-600	-950
-150	- 50
-100	0
-100	50
50	150
150	200

Go to next part.

10. Compare:

S	T
-300	-550
-150	0
- 50	0
350	400
400	650
800	1,100

Go to next part.

11. Compare:

U	V
-750	-600
-400	-500
-350	-250
50	-100
150	450
1,000	500

Go to next part.

12. Compare:

W	X
-1,000	-450
- 200	-250
0	-150
100	250
600	300
1,050	900

Go to next part.

13. Compare:

Y	Z
-750	-150
-100	100
- 50	250
700	400
800	500
850	650

Go to next part.

14. Compare:

aa	bb
-450	-750
-300	-700
-200	-400
50	300
100	400
200	600

Go to next part.

15. Compare:

cc	dd
-1,000	-450
- 200	-250
0	-150
100	250
600	300
1,050	900

PART O

1. Compare:

A	B
9,100	8,500
9,400	9,200
9,600	9,300
10,100	10,100
10,200	10,300
10,400	12,000

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
9,400	8,900
9,500	10,000
9,800	10,000
10,900	10,800
10,900	11,300
11,200	12,200

If you chose C, go to question 4.
If you chose D, go to question 5.

3. Compare:

E	F
8,800	8,500
9,000	8,600
9,500	9,200
9,800	10,600
10,900	10,800
11,000	11,200

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
8,700	8,600
8,900	8,900
9,100	9,800
9,400	9,900
10,300	10,900
10,600	11,000

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
8,800	8,700
9,700	9,100
9,800	9,300
9,800	9,900
10,100	11,100
10,300	11,200

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
9,100	8,000
9,200	9,600
10,300	10,000
10,600	10,200
10,700	11,200
10,900	12,100

If you chose K, go to question 12.
If you chose L, go to question 13.

7. Compare:

M	N
9,000	8,000
10,000	9,100
10,000	9,700
10,500	10,800
10,700	10,900
11,300	12,200

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
8,000	8,100
9,100	9,900
9,700	10,000
10,800	10,100
10,900	10,300
12,200	10,400

Go to next part.

9. Compare:

Q	R
8,800	8,700
9,700	9,100
9,800	9,300
9,800	9,900
10,100	11,100
10,300	11,200

Go to next part.

10. Compare:

S	T
8,700	8,600
8,900	8,900
9,100	9,800
9,400	9,900
10,300	10,900
10,600	11,000

Go to next part.

11. Compare:

U	V
8,000	8,100
9,100	9,900
9,700	10,000
10,800	10,100
10,900	10,300
12,200	10,400

Go to next part.

12. Compare:

W	X
8,800	8,000
9,700	8,100
9,800	8,300
9,800	10,000
10,100	11,400
10,300	12,200

Go to next part.

13. Compare:

Y	Z
9,000	8,000
10,000	9,100
10,000	9,700
10,500	10,800
10,700	10,900
11,300	12,200

Go to next part.

14. Compare:

aa	bb
9,100	8,000
9,200	9,600
10,300	10,000
10,600	10,200
10,700	11,200
10,900	12,100

Go to next part.

15. Compare:

cc	dd
8,800	8,000
9,700	8,100
9,800	8,300
9,800	10,000
10,100	11,400
10,300	12,200

PART E

1. Compare:

A	B
17,200	16,100
18,200	18,800
18,600	19,600
19,300	19,700
19,500	20,300
20,600	21,900

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
18,200	17,700
19,000	19,900
19,300	20,100
21,000	21,600
21,200	22,600
23,600	24,400

If you chose C, go to question 4.
If you chose D, go to question 5.

3. Compare:

E	F
16,100	15,900
19,700	16,200
19,900	16,600
20,200	20,000
20,600	22,900
20,800	24,500

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
17,300	17,100
17,800	17,800
18,200	19,600
18,800	19,800
20,600	21,800
21,300	22,000

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
18,200	17,000
18,800	19,600
19,100	20,400
20,200	20,600
20,500	21,000
20,900	24,300

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
17,500	16,900
19,400	17,200
19,500	18,300
19,500	21,200
20,200	21,700
20,600	22,500

If you chose K, go to question 12.
If you chose L, go to question 13

7. Compare:

M	N
18,800	16,000
19,300	18,100
19,800	19,300
21,400	21,600
21,600	21,800
23,300	24,400

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
17,100	16,200
17,200	17,600
18,300	18,900
18,400	20,100
18,800	20,400
18,900	20,700

Go to next part.

9. Compare:

Q	R
18,200	17,000
18,800	19,600
19,100	20,400
20,200	20,600
20,500	21,000
20,900	24,300

Go to next part.

10. Compare:

S	T
17,300	17,100
17,800	17,800
18,200	19,600
18,800	19,800
20,600	21,800
21,300	22,000

Go to next part.

11. Compare:

U	V
17,100	16,200
17,200	17,600
18,300	18,900
18,400	20,100
18,800	20,400
18,900	20,700

Go to next part.

12. Compare:

W	X
17,300	18,100
18,600	18,300
19,900	20,700
21,000	21,200
22,200	21,400
22,400	21,900

Go to next part.

13. Compare:

Y	Z
18,800	16,000
19,300	18,100
19,800	19,300
21,400	21,600
21,600	21,800
23,300	24,400

Go to next part.

14. Compare:

aa	bb
17,500	16,900
19,400	17,200
19,500	18,300
19,500	21,200
20,200	21,700
20,600	22,500

Go to next part.

15. Compare:

cc	dd
17,300	18,100
18,600	18,300
19,900	20,700
21,000	21,200
22,200	21,400
22,400	21,900

PART F

1. Compare:

A	B
27,300	24,000
28,200	27,100
28,600	28,900
30,300	32,400
30,700	32,800
31,400	36,600

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
27,100	26,600
27,500	29,800
31,100	30,200
31,800	32,500
32,100	33,900
32,900	36,600

If you chose C, go to question 4.
If you chose D, go to question 5.

3. Compare:

E	F
25,900	23,800
27,300	24,300
27,700	24,900
29,600	30,000
33,400	34,400
33,700	36,800

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
26,000	25,500
26,700	29,400
27,200	30,600
28,200	31,000
31,000	31,600
32,000	36,500

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
25,700	24,200
25,700	26,700
27,400	29,400
27,600	29,600
28,200	30,500
28,300	32,800

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
27,900	25,900
29,000	27,900
29,100	29,900
30,700	31,500
31,600	33,300
33,200	33,600

If you chose K, go to question 12.
If you chose L, go to question 13

7. Compare:

M	N
28,100	25,500
28,400	27,500
29,400	27,900
32,900	30,400
32,900	31,000
33,700	36,000

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
25,500	26,200
29,400	26,800
29,500	28,400
34,400	29,200
35,000	32,900
35,200	33,000

Go to next part.

9. Compare:

Q	R
25,700	24,200
25,700	26,700
27,400	29,400
27,600	29,600
28,200	30,500
28,300	32,800

Go to next part.

10. Compare:

S	T
26,000	25,500
26,700	29,400
27,200	30,600
28,200	31,000
31,000	31,600
32,000	36,500

Go to next part.

11. Compare:

U	V
25,500	26,200
29,400	26,800
29,500	28,400
34,400	29,200
35,000	32,900
35,200	33,000

Go to next part.

12. Compare:

W	X
23,800	26,800
28,700	30,000
29,800	30,100
30,700	31,500
33,700	32,200
36,500	34,100

Go to next part.

13. Compare:

Y	Z
28,100	25,500
28,400	27,500
29,400	27,900
32,900	30,400
32,900	31,000
33,700	36,000

Go to next part.

14. Compare:

aa	bb
27,900	25,900
29,000	27,900
29,100	29,900
30,700	31,500
31,600	33,300
33,200	33,600

Go to next part.

15. Compare:

cc	dd
23,800	26,800
28,700	30,000
29,800	30,100
30,700	31,500
33,700	32,200
36,500	34,100

PART G

1. Compare:

A	B
37,500	35,400
38,500	39,800
39,500	40,300
42,900	43,300
43,200	45,200
46,600	48,800

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
36,400	35,800
37,600	40,000
38,200	40,200
40,400	42,000
41,000	22,900
41,900	45,500

If you chose C, go to question 4.
If you chose D, go to question 5.

3. Compare:

E	F
37,100	33,900
38,600	36,700
38,700	37,200
41,000	40,600
42,200	41,300
44,300	48,000

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
34,600	34,500
35,600	36,300
36,300	37,000
37,600	39,500
41,300	44,600
42,700	44,900

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
32,200	32,000
35,600	36,100
39,200	38,500
39,400	43,200
40,700	43,700
43,800	48,800

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
32,300	31,800
35,100	32,400
37,800	33,200
40,300	40,000
40,900	45,900
41,400	49,000

If you chose K, go to question 12.
If you chose L, go to question 13

7. Compare:

M	N
36,100	34,500
36,600	36,300
41,500	37,000
42,400	39,500
42,800	44,600
43,900	44,900

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
34,900	34,500
35,800	37,200
37,900	39,800
38,900	42,000
43,800	44,400
44,100	44,800

Go to next part.

9. Compare:

Q	R
32,200	32,000
35,600	36,100
39,200	38,500
39,400	43,200
40,700	43,700
43,800	48,800

Go to next part.

10. Compare:

S	T
34,600	34,500
35,600	36,300
36,300	37,000
37,600	39,500
41,300	44,600
42,700	44,900

Go to next part.

11. Compare:

U	V
34,900	34,500
35,800	37,200
37,900	39,800
38,900	42,000
43,800	44,400
44,100	44,800

Go to next part.

12. Compare:

W	X
37,500	31,700
37,900	38,200
39,200	39,800
43,900	40,900
43,900	44,900
45,000	48,700

Go to next part.

13. Compare:

Y	Z
36,100	34,500
36,600	36,300
41,500	37,000
42,400	39,000
42,800	44,600
43,900	44,900

Go to next part.

14. Compare:

aa	bb
32,300	31,800
35,100	32,400
37,800	33,200
40,300	40,000
40,900	45,900
41,400	49,000

Go to next part.

15. Compare:

cc	dd
37,500	31,700
37,900	38,200
39,200	39,800
43,900	40,900
43,900	44,900
45,000	48,700

PART H

1. Compare:

A	B
43,800	39,800
48,400	47,800
48,800	49,800
48,800	51,000
50,400	56,200
51,600	60,800

If you chose A, go to question 2.
If you chose B, go to question 3.

2. Compare:

C	D
43,600	43,200
44,800	46,600
47,400	49,800
48,600	52,400
54,800	55,400
55,000	56,000

If you chose C, go to question 4.
If you chose D, go to question 5.

3. Compare:

E	F
44,800	39,800
50,000	40,600
50,200	41,400
52,400	50,000
53,600	57,400
56,800	61,200

If you chose E, go to question 6.
If you chose F, go to question 7.

4. Compare:

G	H
43,400	43,200
44,600	45,400
45,400	46,200
47,000	49,400
51,600	55,800
53,400	56,000

If you chose G, go to question 8.
If you chose H, go to question 9.

5. Compare:

I	J
45,200	44,200
45,800	49,800
51,800	50,400
53,000	54,200
53,400	56,400
54,800	61,000

If you chose I, go to question 10.
If you chose J, go to question 11.

6. Compare:

K	L
43,600	42,400
44,800	43,000
47,400	45,800
48,600	53,200
54,800	54,200
55,000	56,400

If you chose K, go to question 12.
If you chose L, go to question 13

7. Compare:

M	N
48,400	42,600
51,000	49,000
52,600	51,000
54,400	51,600
55,200	52,600
56,600	60,800

If you chose M, go to question 14.
If you chose N, go to question 15.

8. Compare:

O	P
42,600	43,000
49,000	45,600
49,200	46,400
57,400	48,400
58,200	48,800
58,800	51,600

Go to next part.

9. Compare:

Q	R
45,200	44,200
45,800	49,800
51,800	50,400
53,000	54,200
53,400	56,400
54,800	61,000

Go to next part.

10. Compare:

S	T
43,400	43,200
44,600	45,400
45,400	46,200
47,000	49,400
51,600	55,800
53,400	56,000

Go to next part.

11. Compare:

U	V
42,600	43,000
49,000	45,600
49,200	46,400
57,400	48,400
58,200	48,800
58,800	51,600

Go to next part.

12. Compare:

W	X
40,000	46,800
45,200	48,200
48,200	49,400
54,000	53,600
54,600	54,000
61,000	58,200

Go to next part.

13. Compare:

Y	Z
48,400	42,600
51,000	49,000
52,600	51,000
54,400	51,600
55,200	52,600
56,600	60,800

Go to next part.

14. Compare:

aa	bb
43,600	42,400
44,800	43,000
47,400	45,800
48,600	53,200
54,800	54,200
55,000	56,400

Go to next part.

15. Compare:

cc	dd
40,000	46,800
45,200	48,200
48,200	49,400
54,000	53,600
54,600	54,000
61,000	58,200

PART I

1. **Compare:**

A	B
52,400	51,000
58,200	58,800
58,600	61,200
58,600	62,000
60,600	63,200
62,000	73,000

If you chose A, go to question 2.
If you chose B, go to question 3.

2. **Compare:**

C	O
54,600	54,400
56,400	57,000
57,200	58,000
60,600	63,200
61,400	63,800
62,800	70,800

If you chose C, go to question 4.
If you chose O, go to question 5.

3. **Compare:**

E	F
52,400	48,400
58,200	53,400
58,600	58,800
58,600	59,200
60,600	61,000
62,000	65,600

If you chose E, go to question 6.
If you chose F, go to question 7.

4. **Compare:**

G	H
51,400	51,000
51,400	55,000
54,800	55,800
55,200	60,800
56,400	62,000
56,600	72,000

If you chose G, go to question 8.
If you chose H, go to question 9.

5. **Compare:**

I	J
52,000	51,000
53,400	58,800
54,400	59,000
56,400	68,800
62,000	70,000
64,000	70,400

If you chose I, go to question 10.
If you chose J, go to question 11.

6. **Compare:**

K	L
48,600	47,600
52,600	48,600
56,800	49,800
60,400	60,000
61,400	68,800
62,000	73,600

If you chose K, go to question 12.
If you chose L, go to question 13

7. **Compare:**

M	N
55,800	50,800
58,000	51,600
58,200	55,000
61,400	63,800
63,200	65,000
66,400	67,600

If you chose M, go to question 14.
If you chose N, go to question 15.

8. **Compare:**

O	P
51,800	52,400
55,800	53,600
59,800	56,800
63,000	58,400
66,600	65,800
67,200	66,000

Go to next part.

9. Compare:

Q	R
52,000	51,000
53,400	58,800
54,400	59,000
56,400	68,800
62,000	70,000
64,000	70,400

Go to next part.

10. Compare:

S	T
51,400	51,000
51,400	55,000
54,800	55,800
55,200	60,800
56,400	62,000
56,600	72,000

Go to next part.

11. Compare:

U	V
51,800	52,400
55,800	53,600
59,800	56,800
63,000	58,400
66,600	65,800
67,200	66,000

Go to next part.

12. Compare:

W	X
48,000	56,200
54,200	57,800
57,800	59,200
64,800	64,400
65,600	64,800
73,200	70,000

Go to next part.

13. Compare:

Y	Z
55,800	50,800
58,000	51,600
58,200	55,000
61,400	63,800
63,200	65,000
66,400	67,600

Go to next part.

14. Compare:

aa	bb
48,600	47,600
52,600	48,600
56,800	49,800
60,400	60,000
61,400	68,800
62,000	73,600

Go to next part.

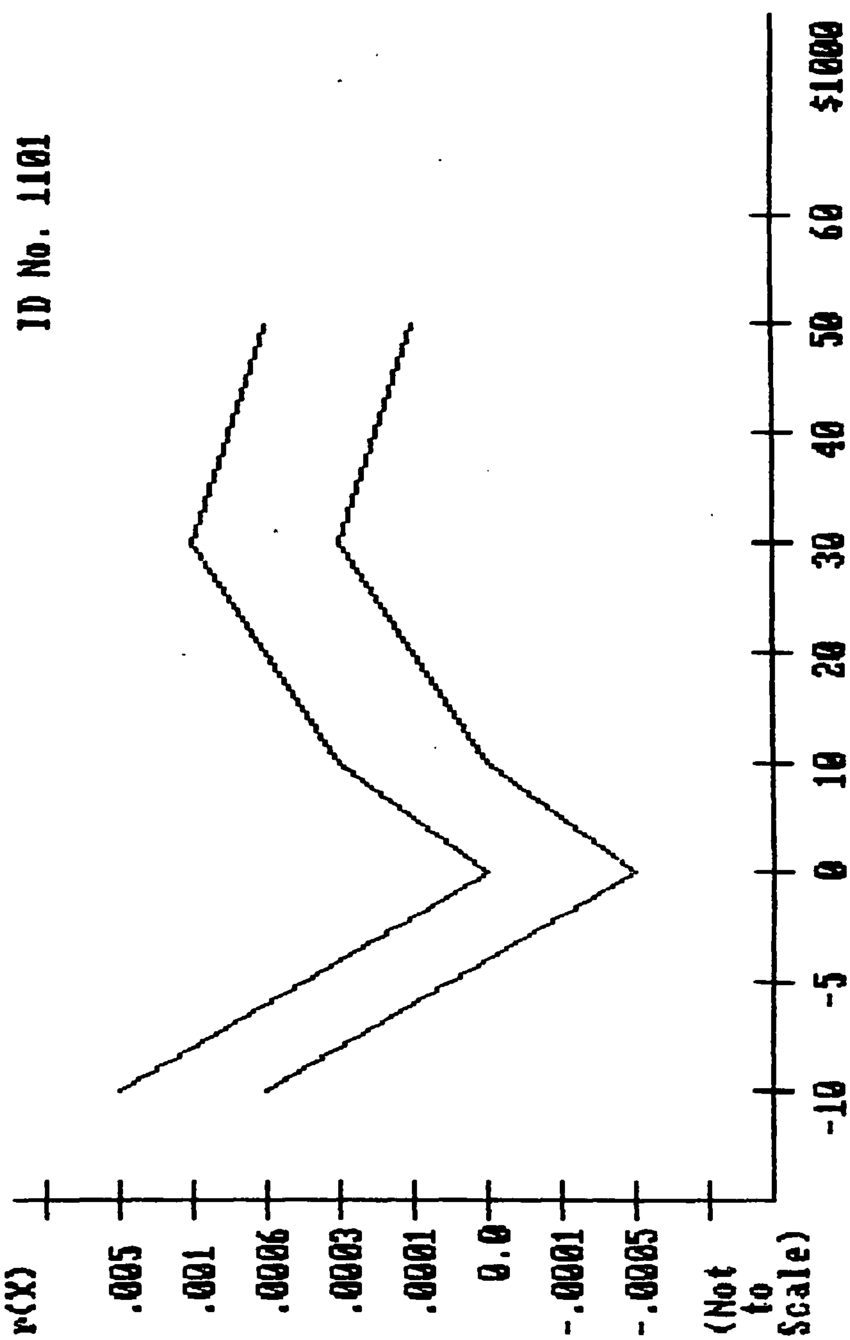
15. Compare:

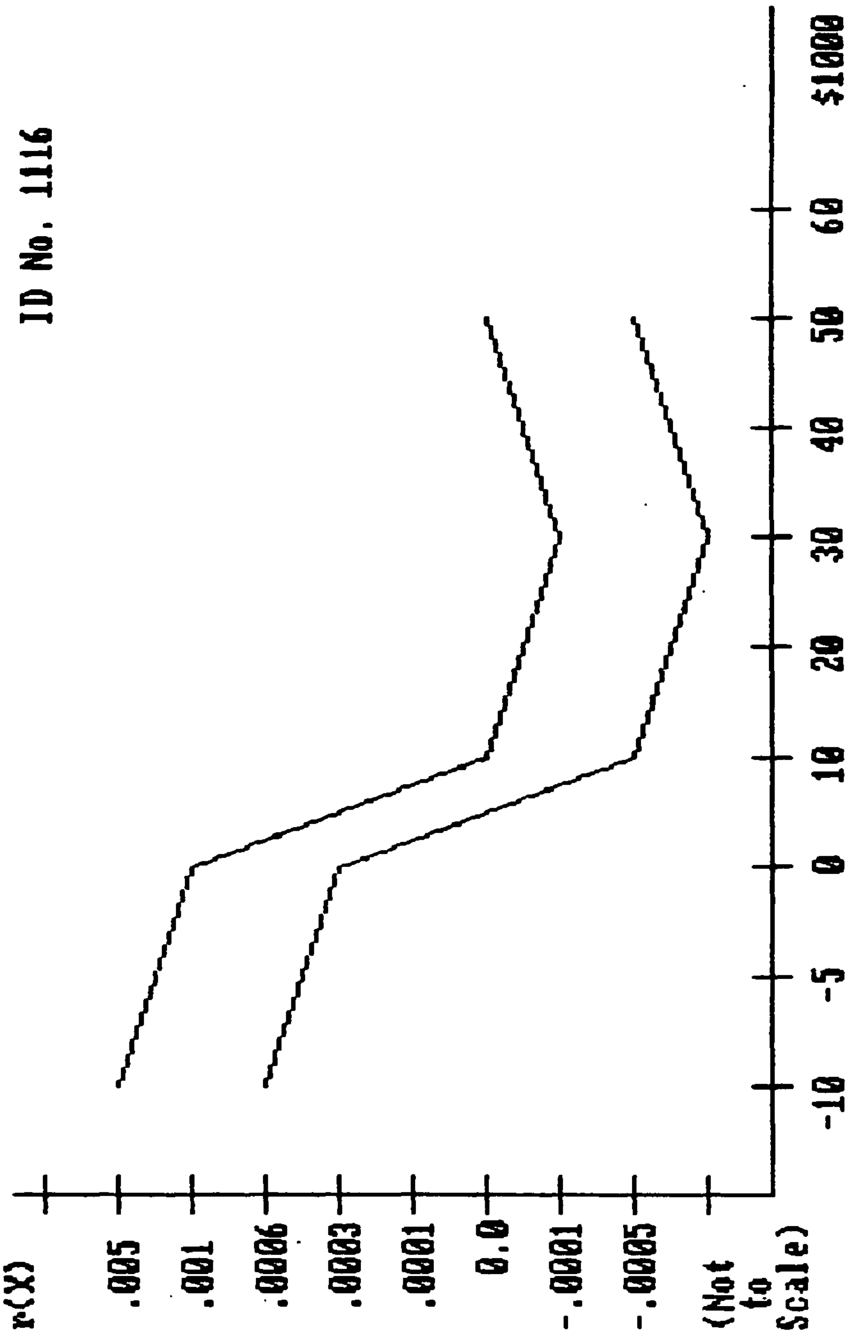
cc	dd
48,000	56,200
54,200	57,800
57,800	59,200
64,800	64,400
65,600	64,800
73,200	70,000

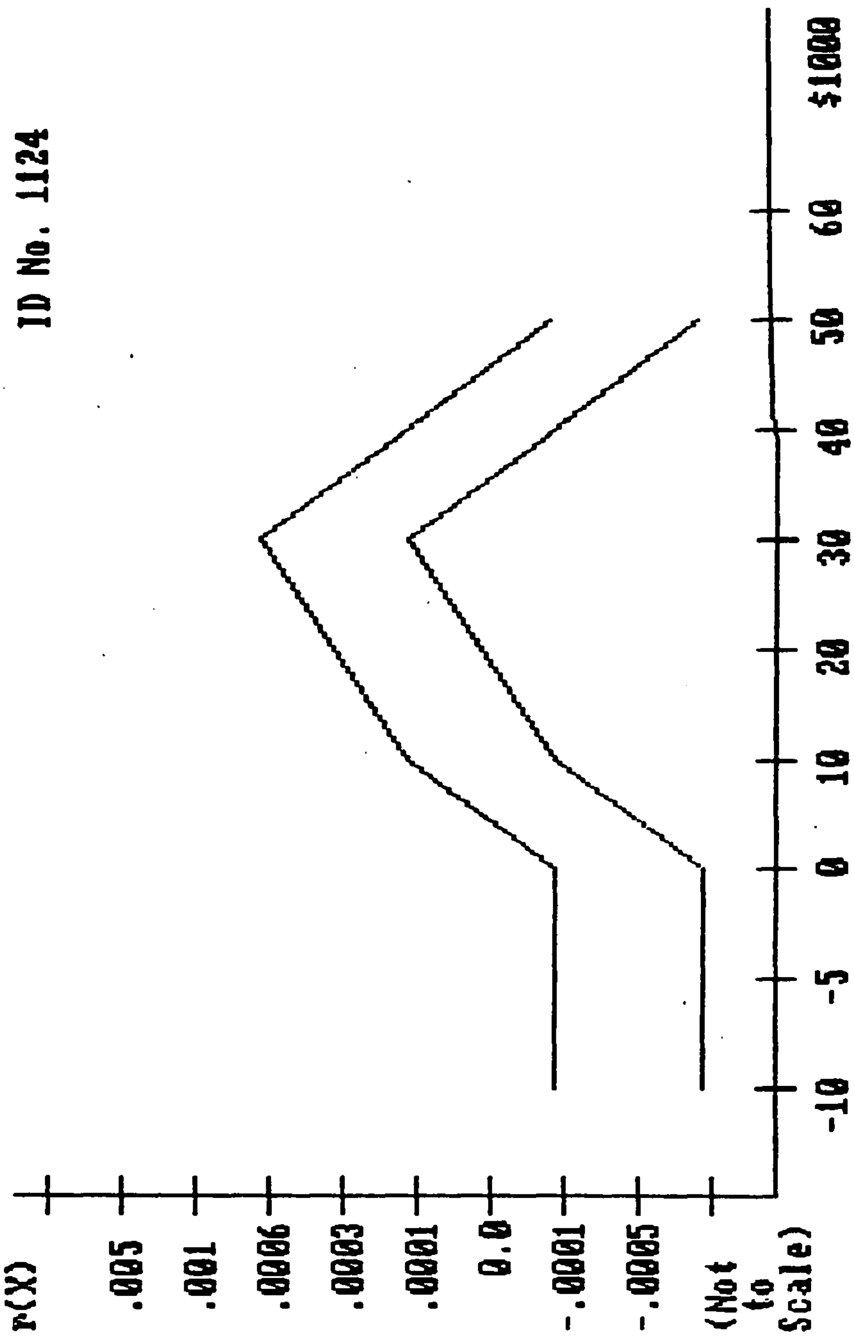
APPENDIX II

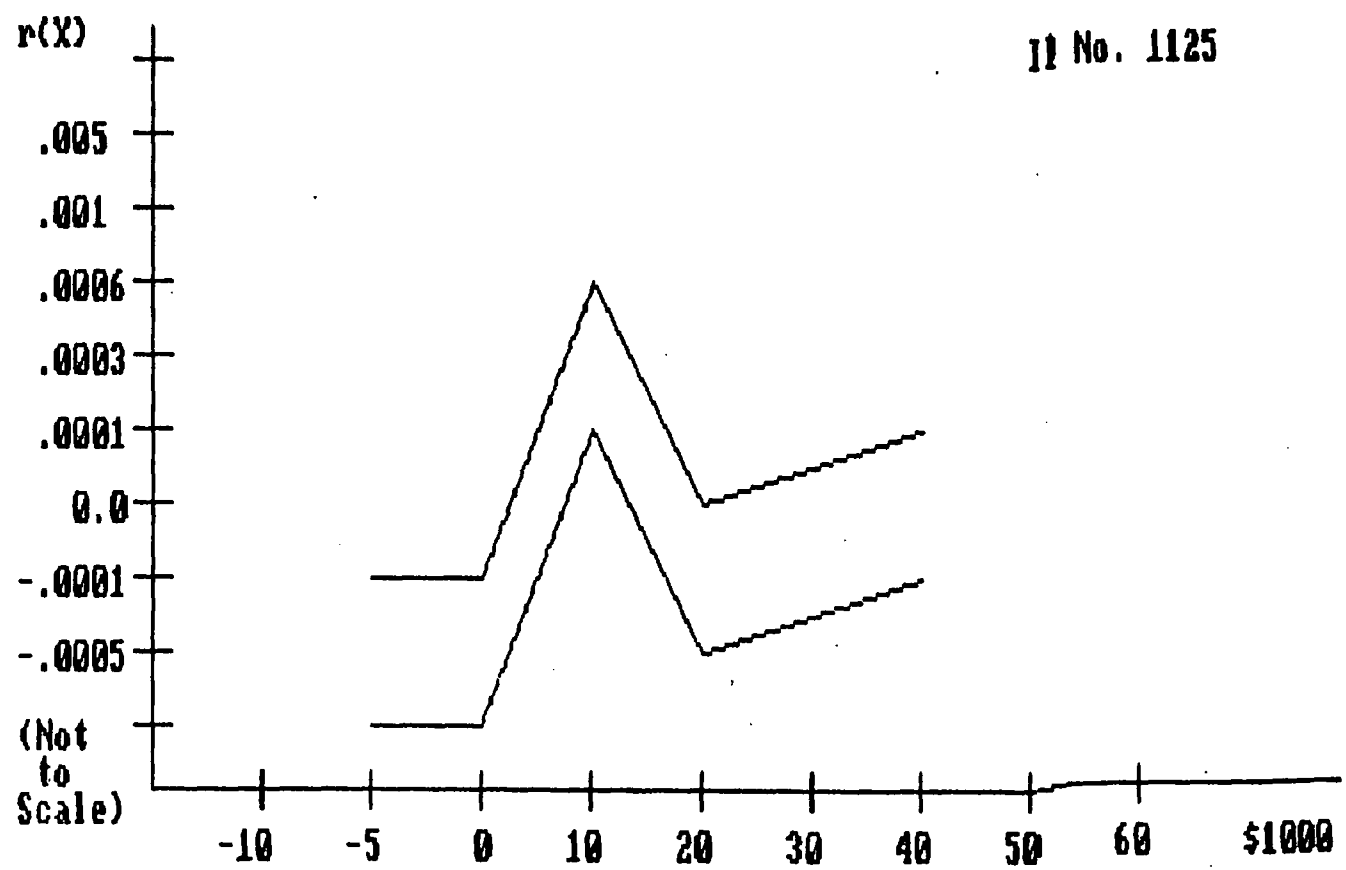
RESULTS OF THE SDF ELICITATION PROCEDURE

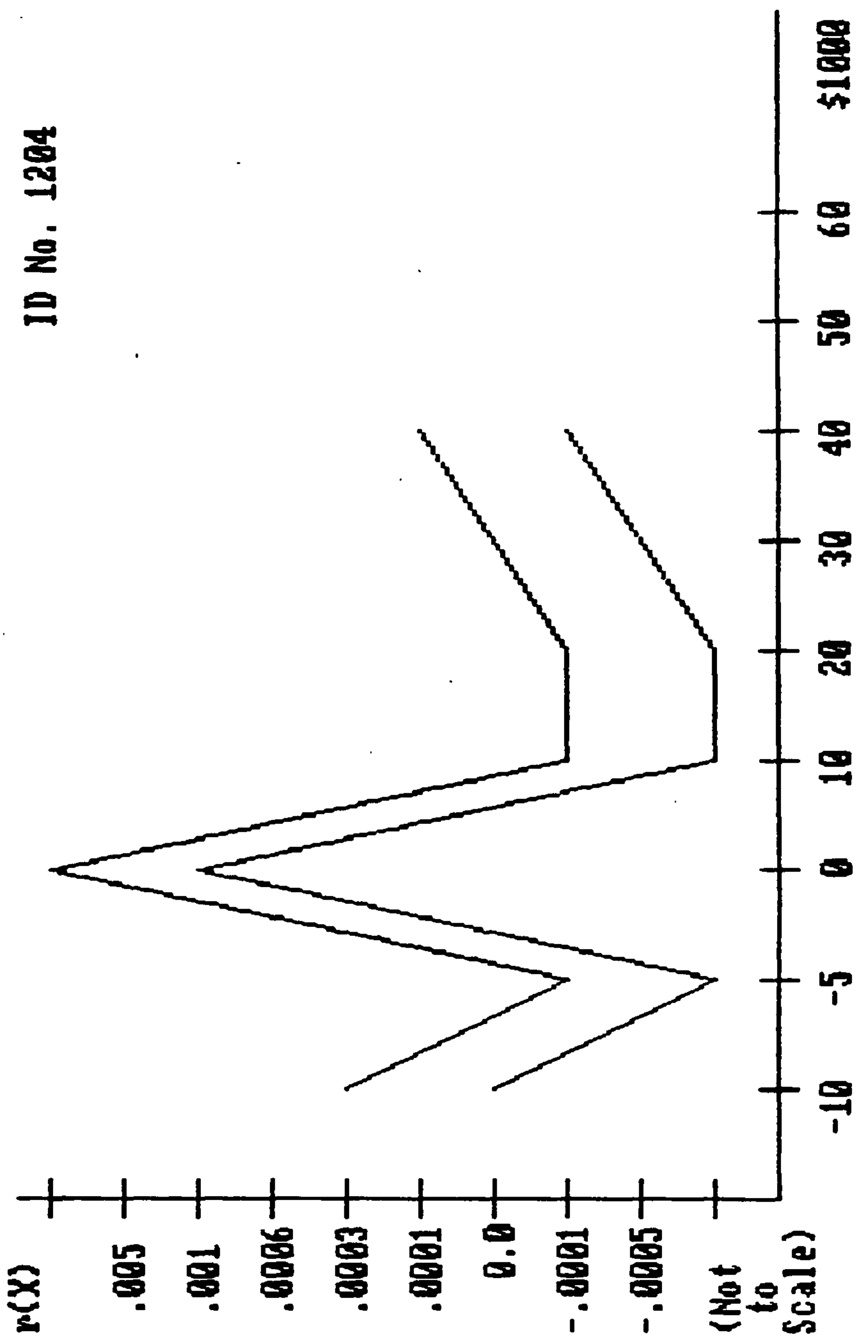
Appendix II contains graphical representations of the results of the SDF elicitation procedure.

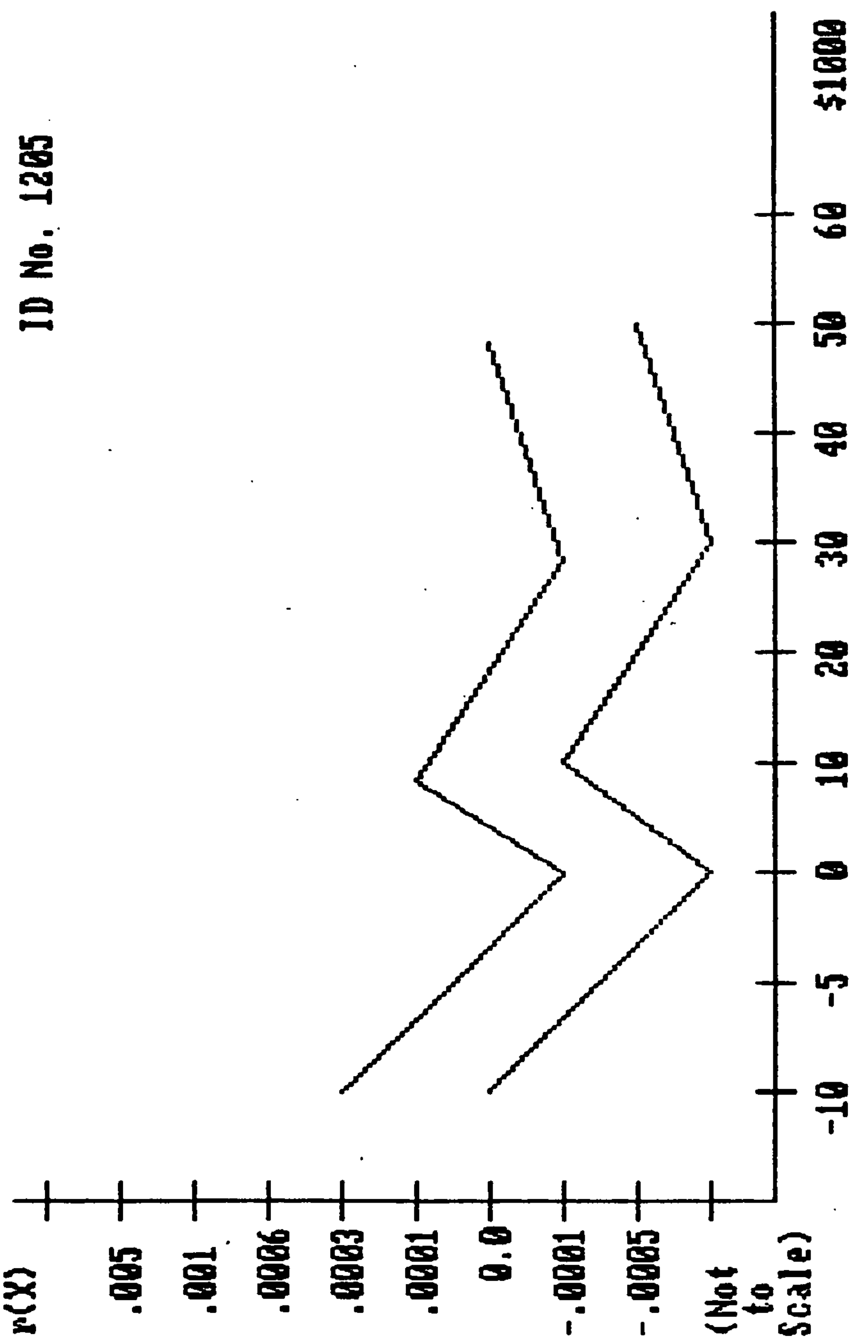

ID No. 1101
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

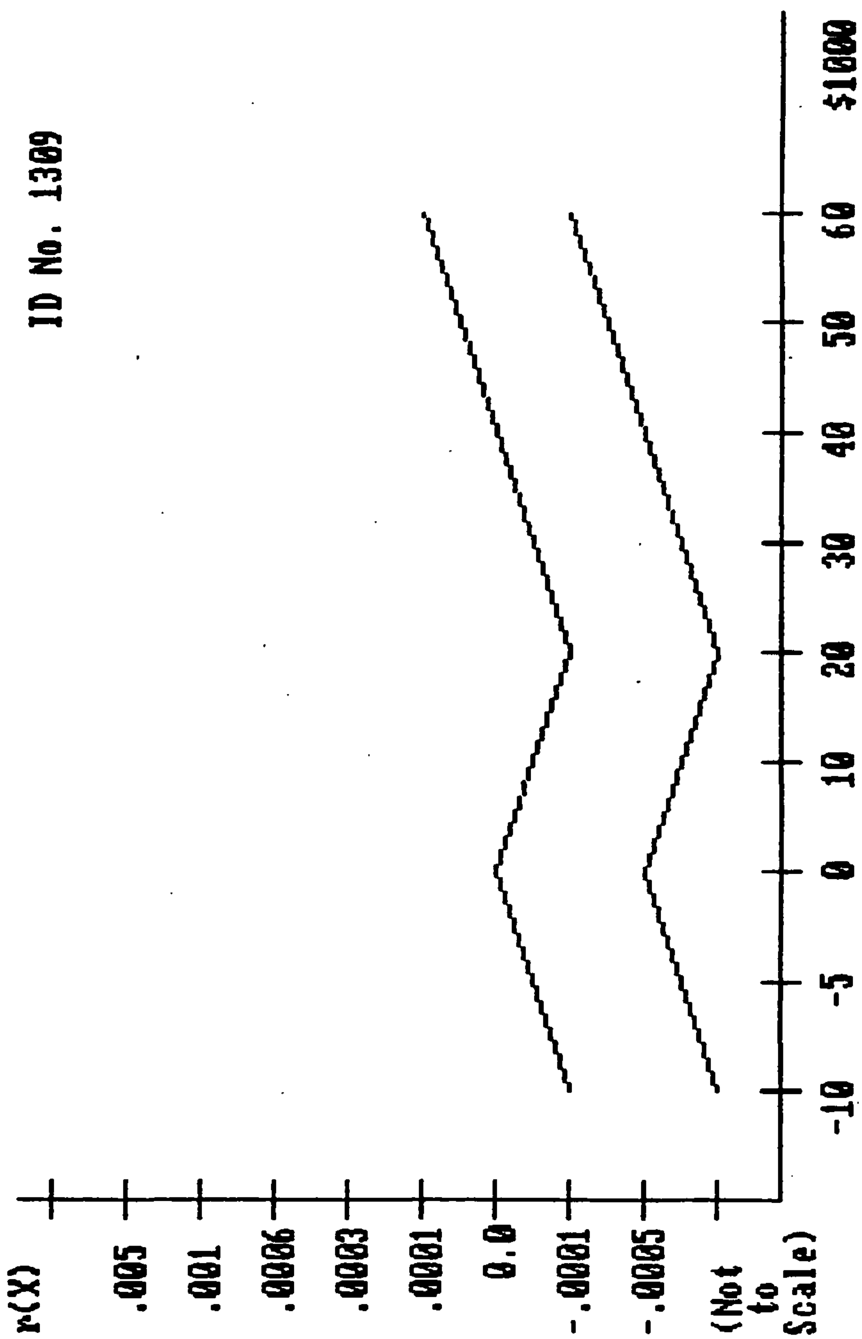

ID No. 1116
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

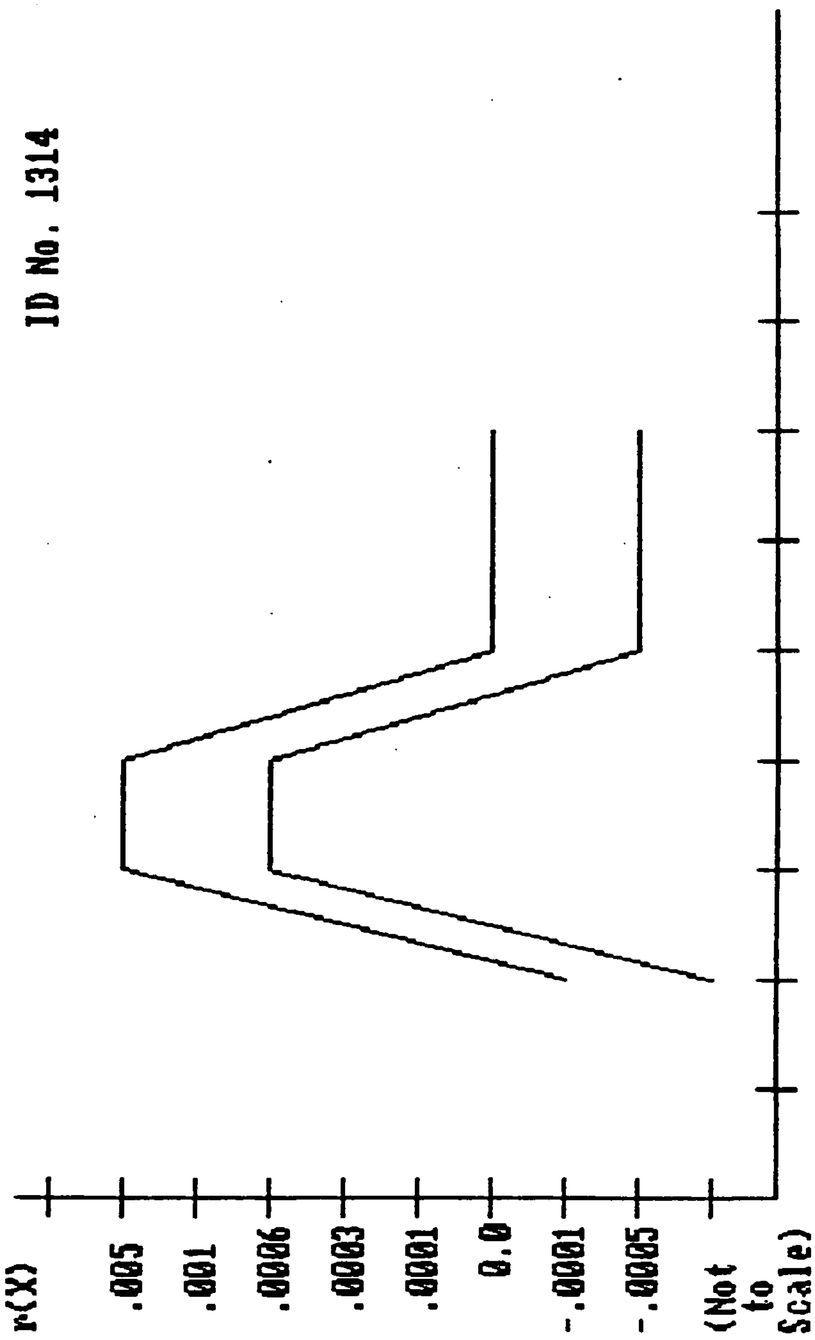

ID No. 1124
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

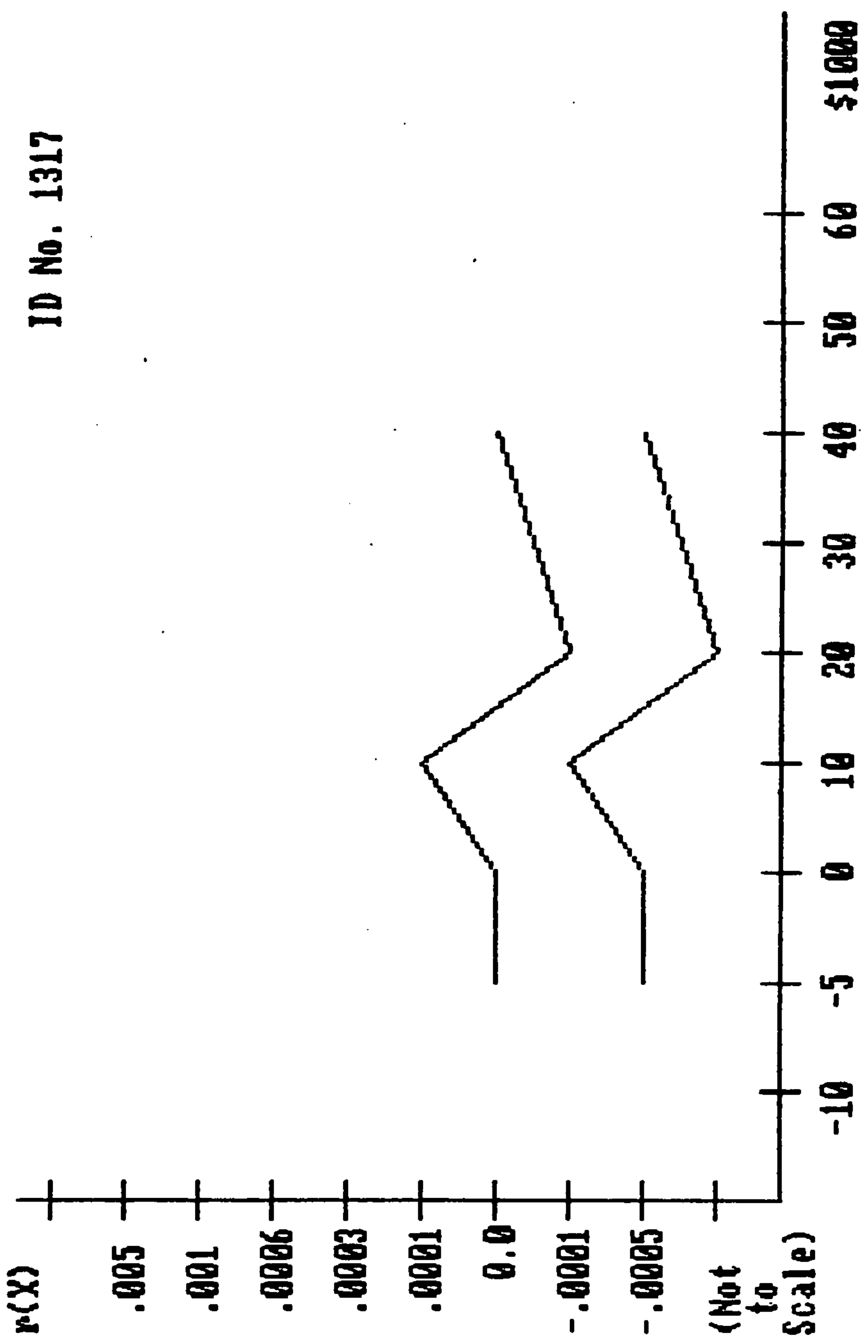

r(X)
II No. 1125
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

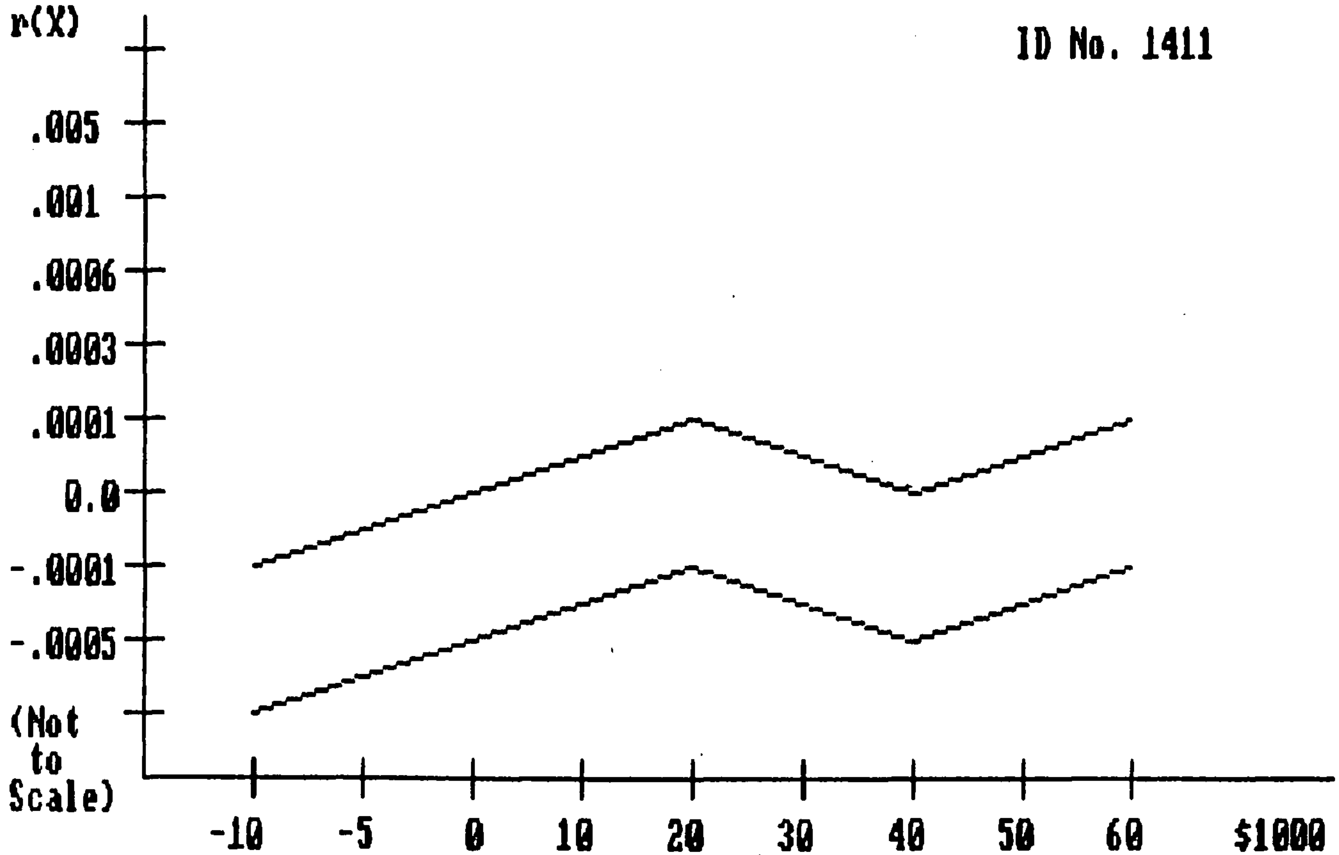

ID No. 1204
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

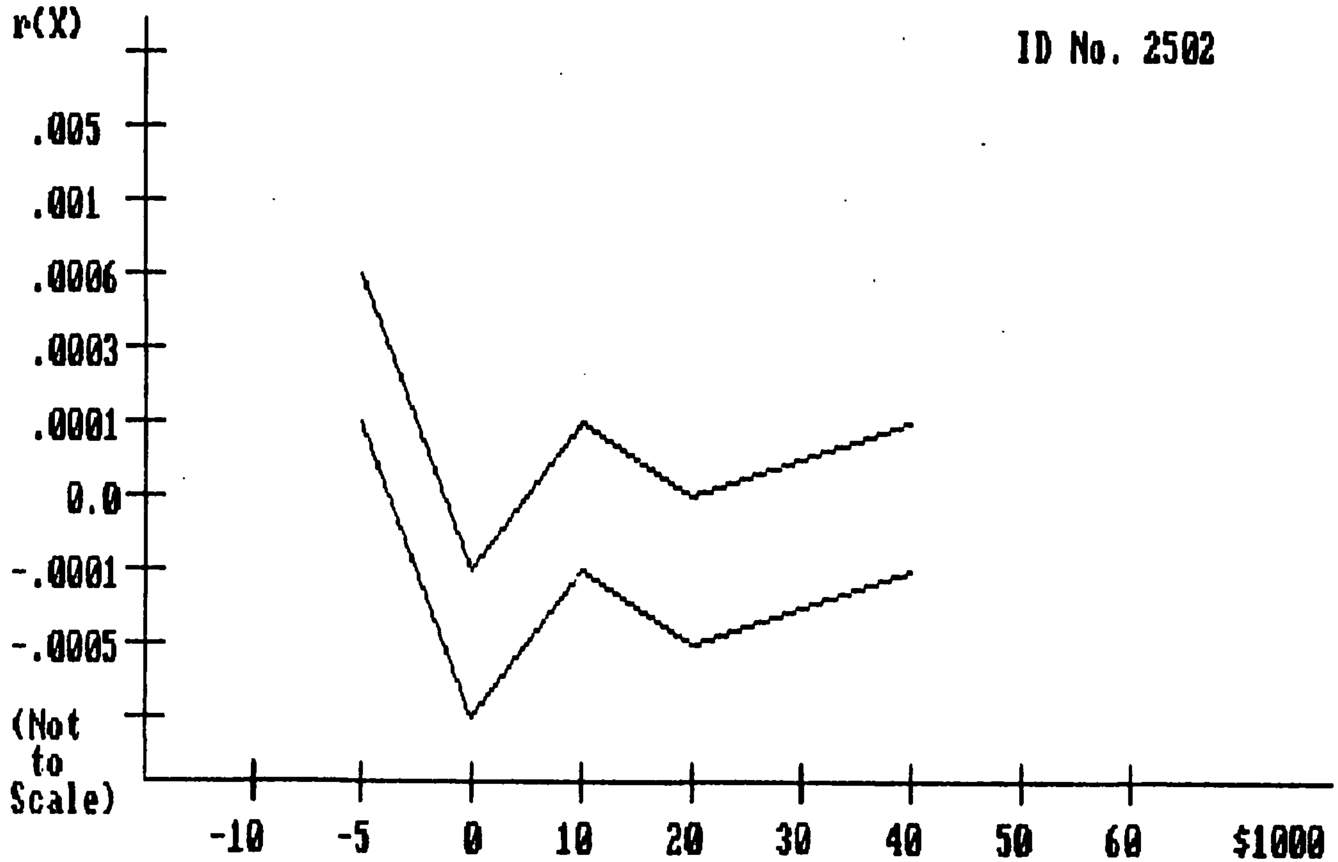

ID No. 1205
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

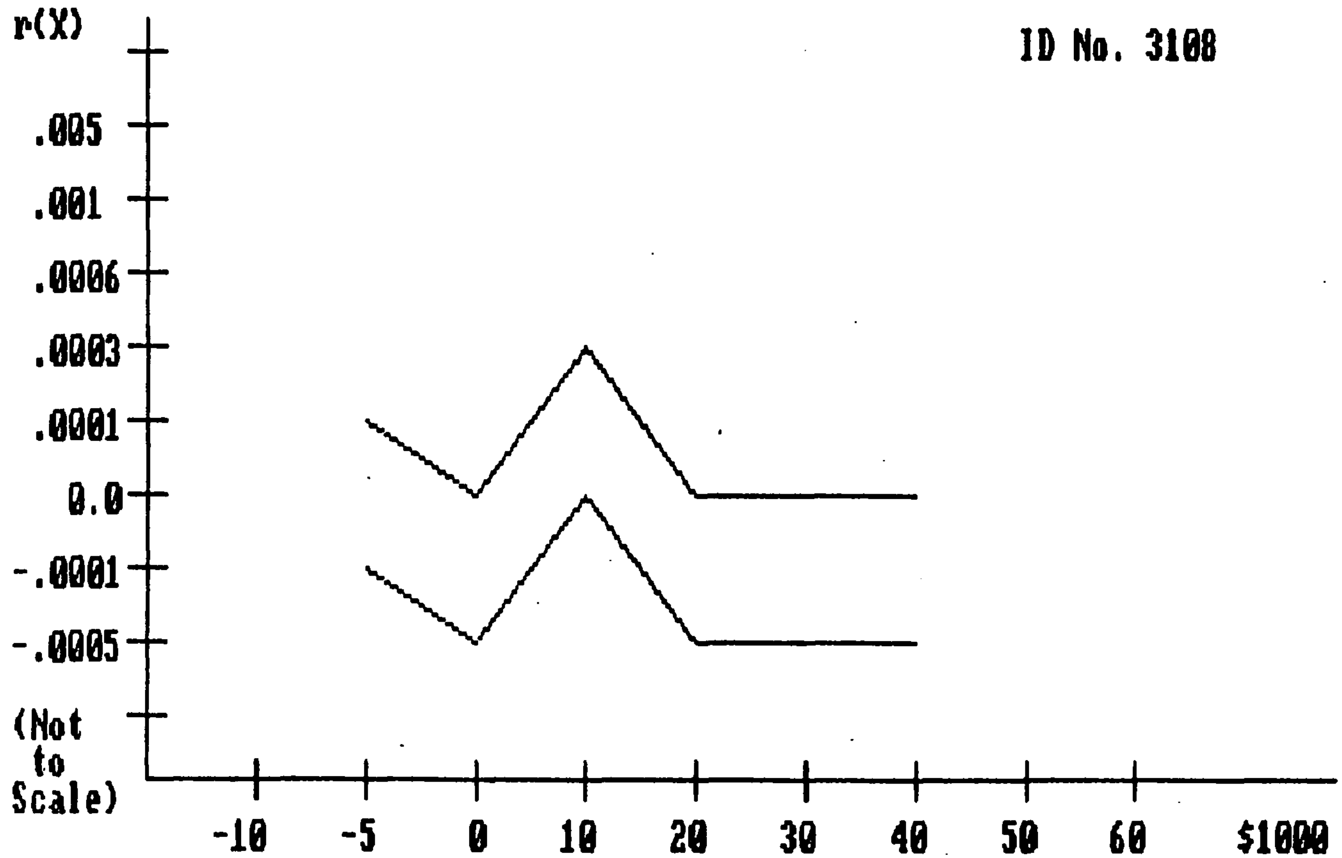

ID No. 1309
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

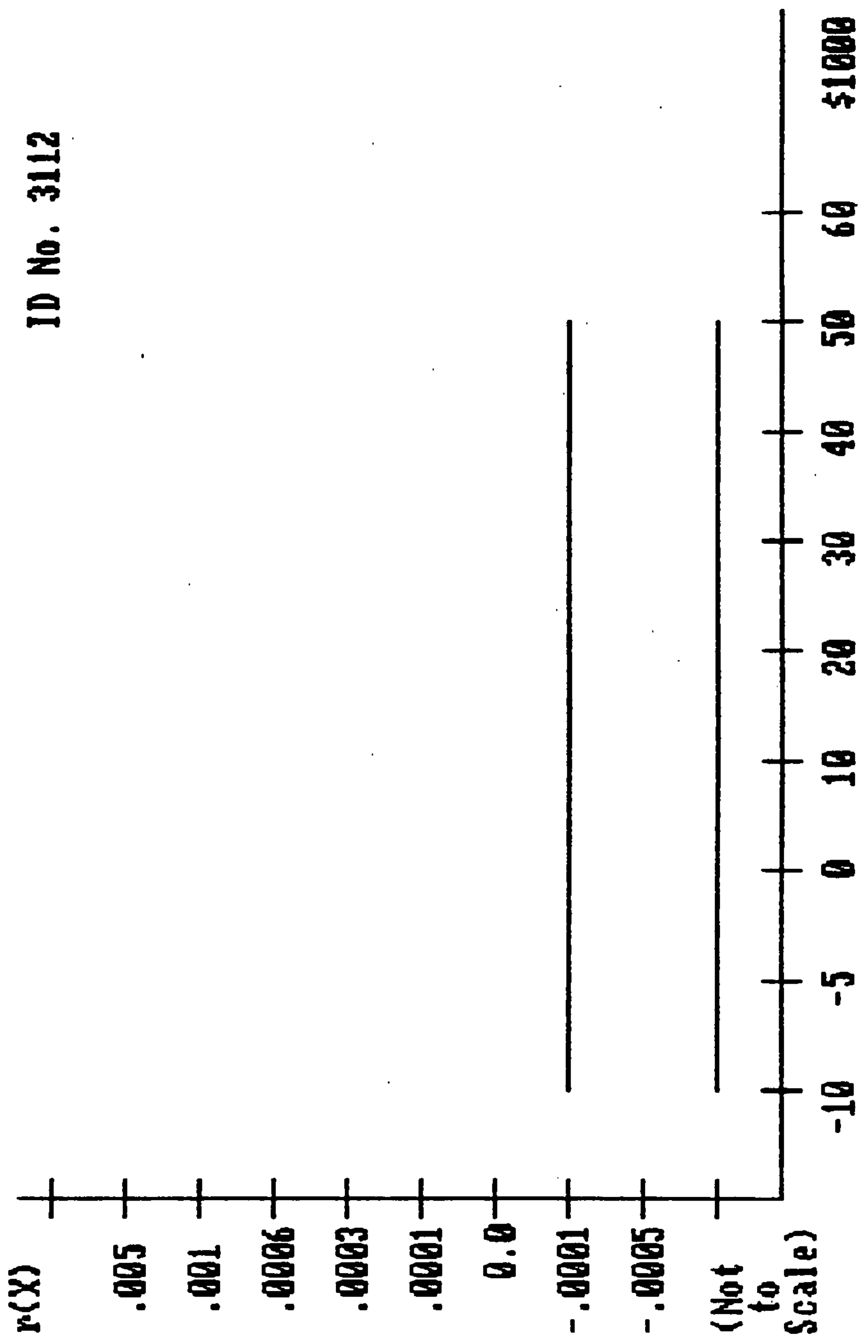

ID No. 1314
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

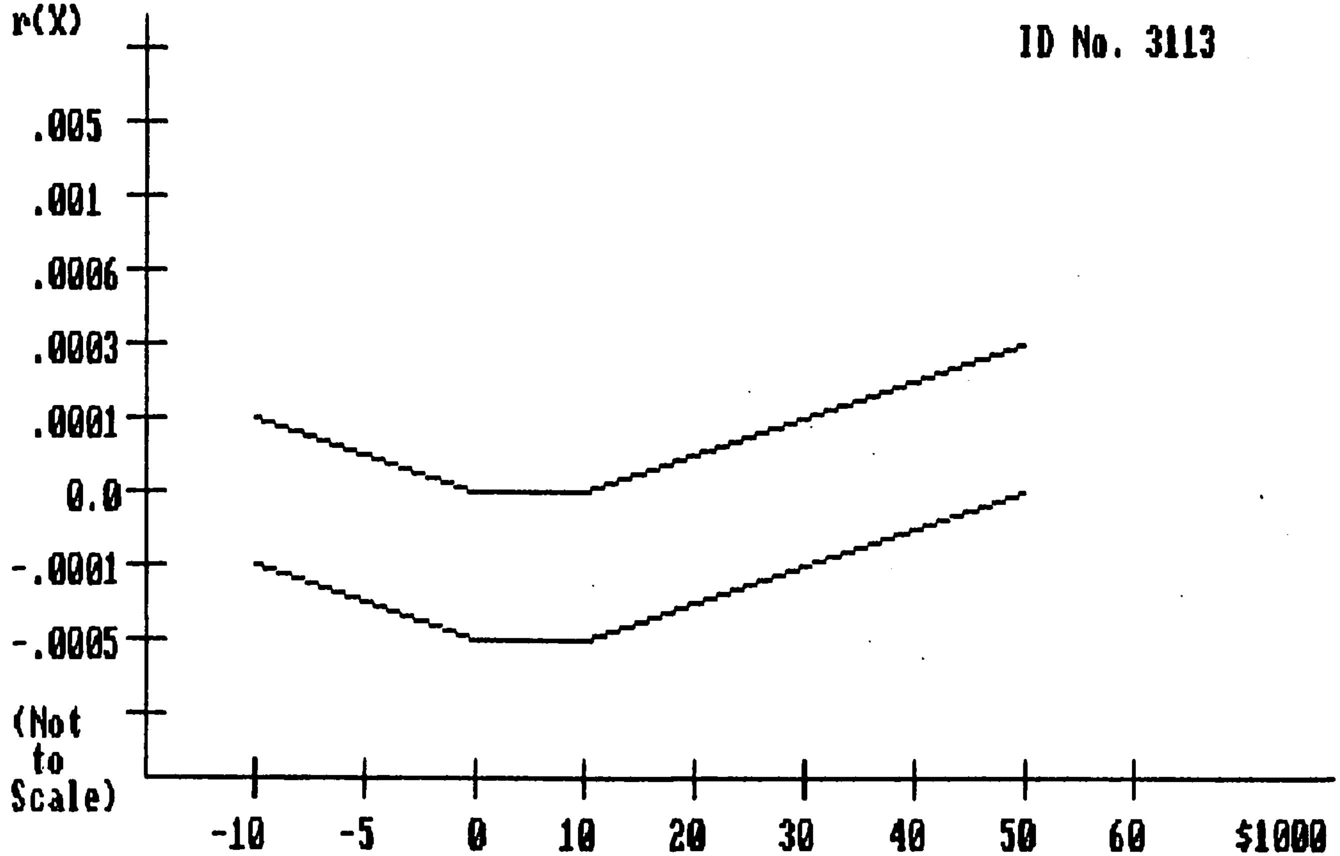

ID No. 1317
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000


r(X)
ID No. 1411
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not
to
Scale)
-10
-5
0
10
20
30
40
50
60
$1000

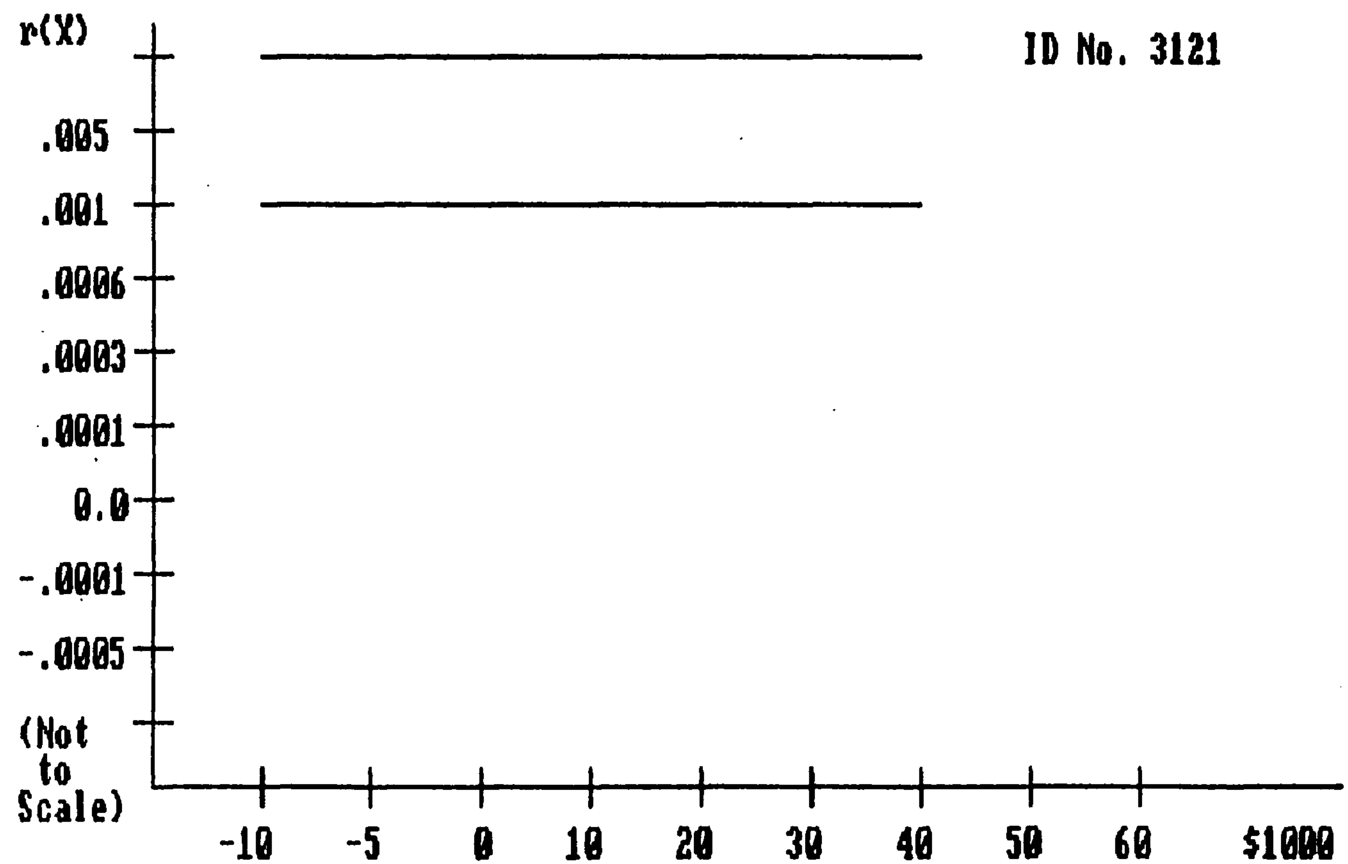

ID No. 2502
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

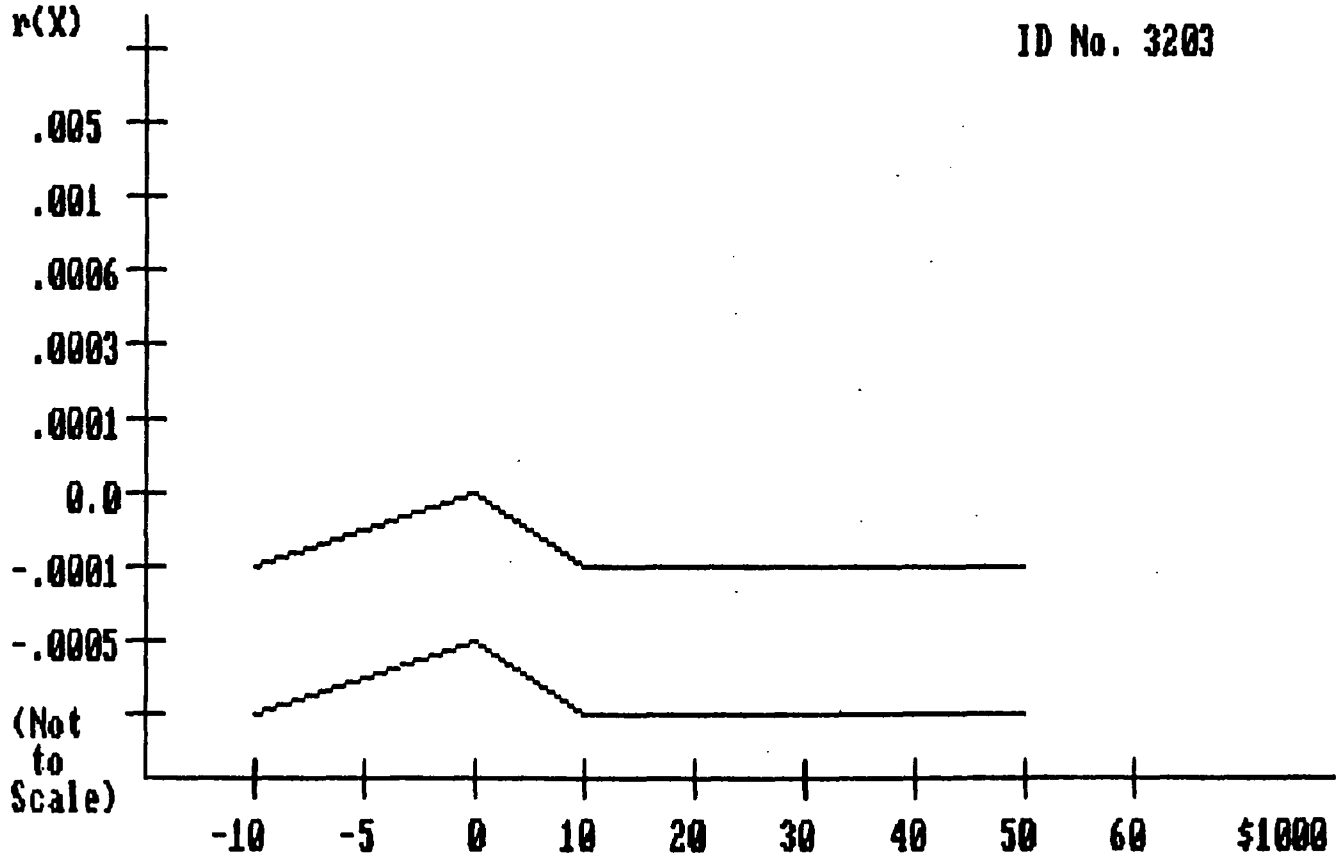

ID No. 3108
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

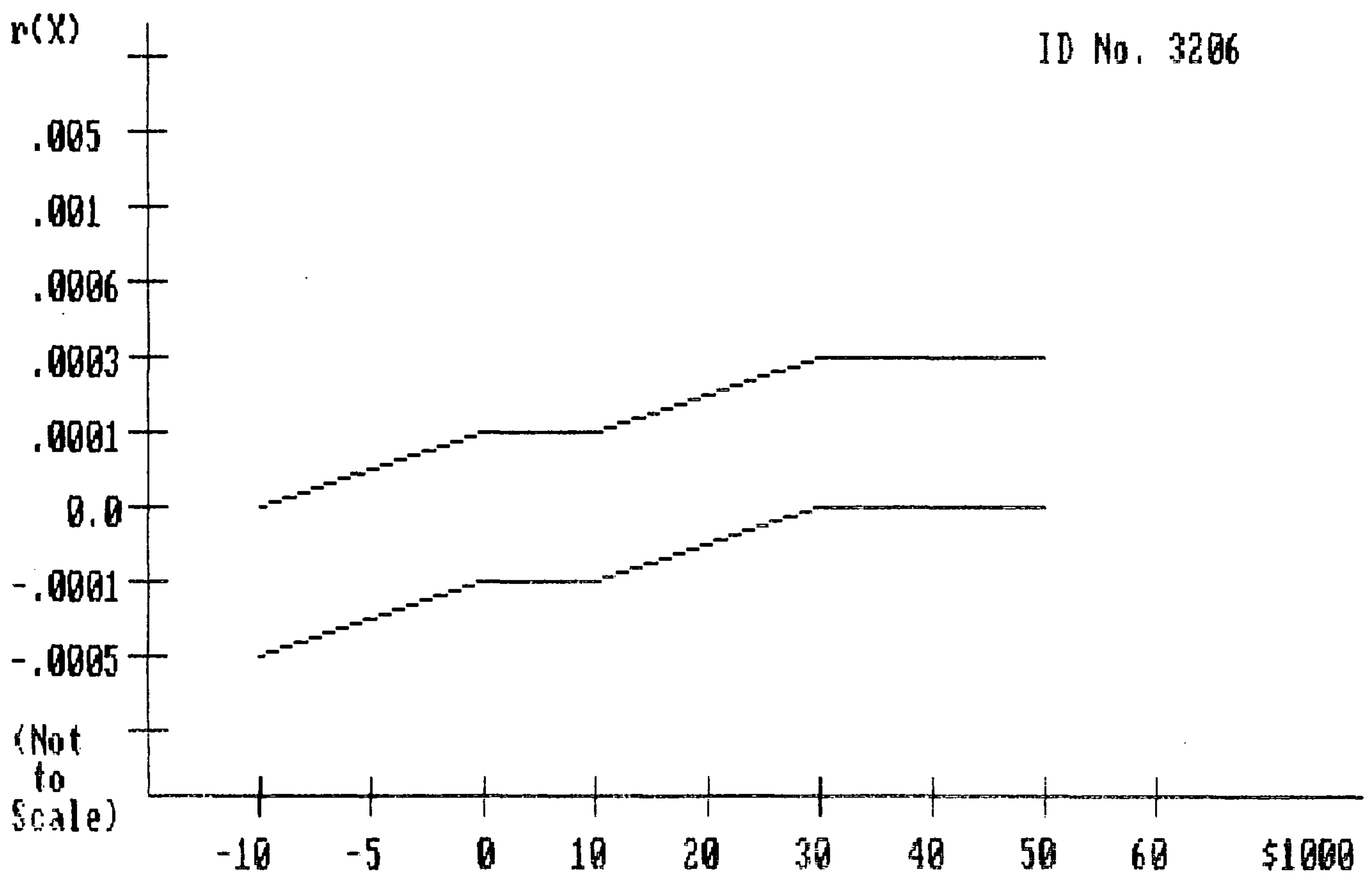

ID No. 3112
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

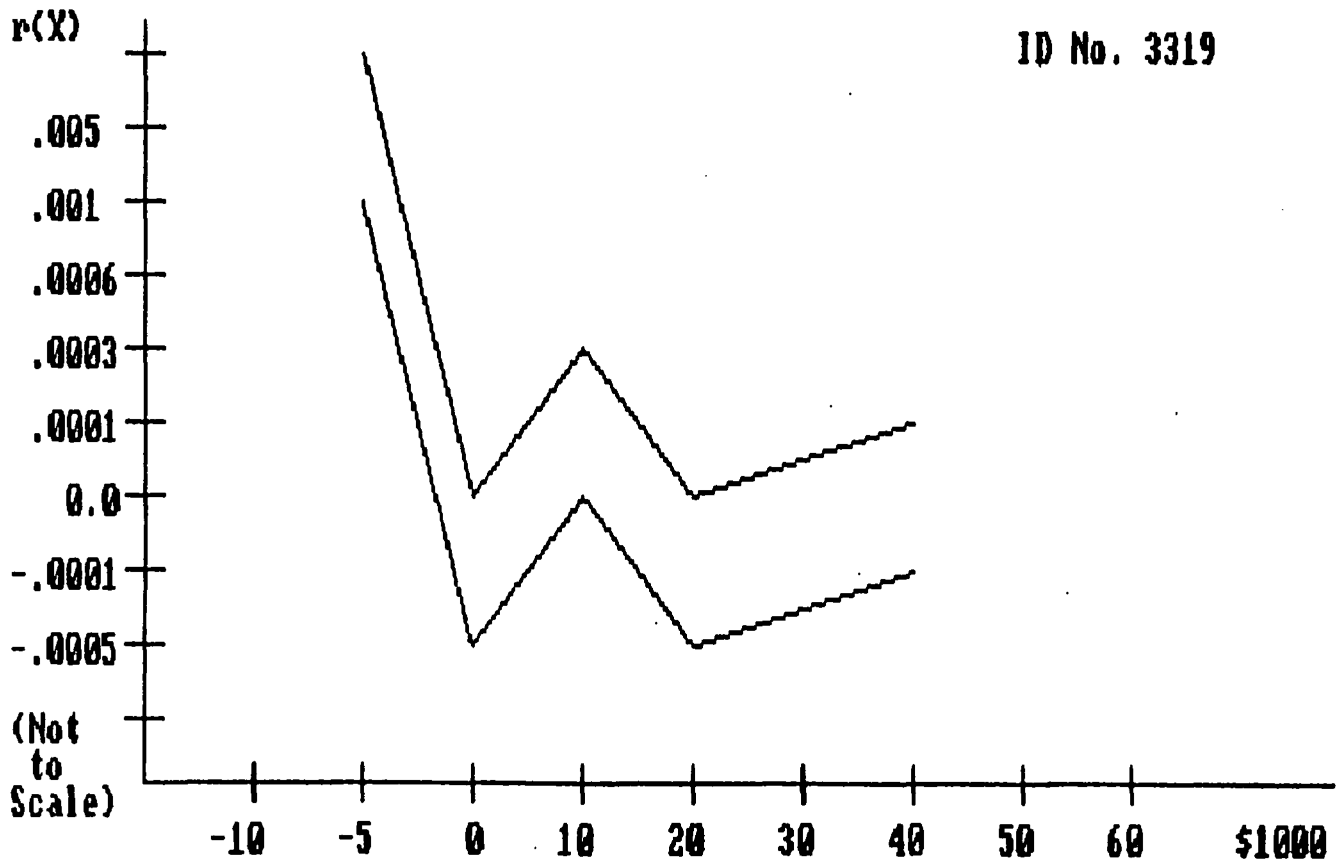


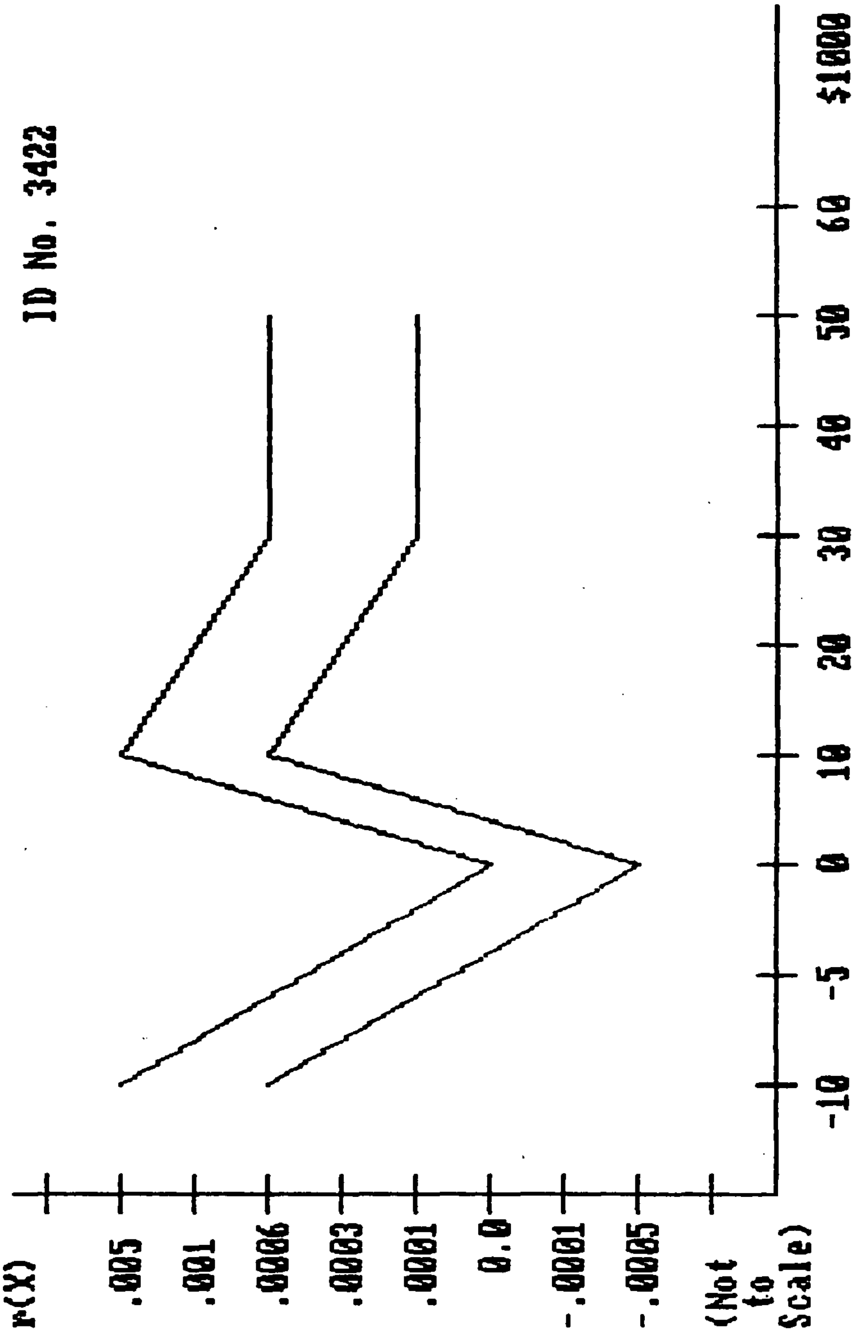
ID No. 3113
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

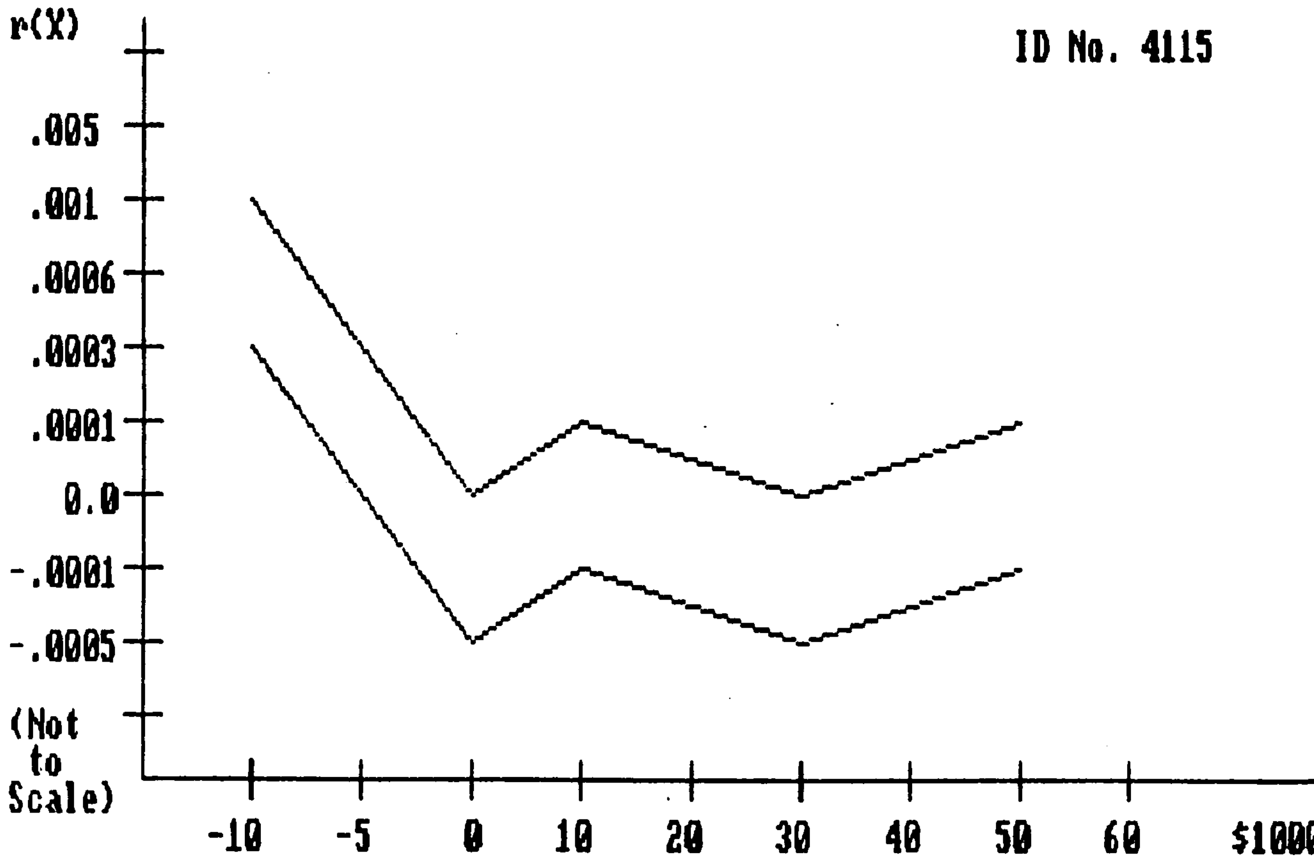

r(X)
ID No. 3121
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

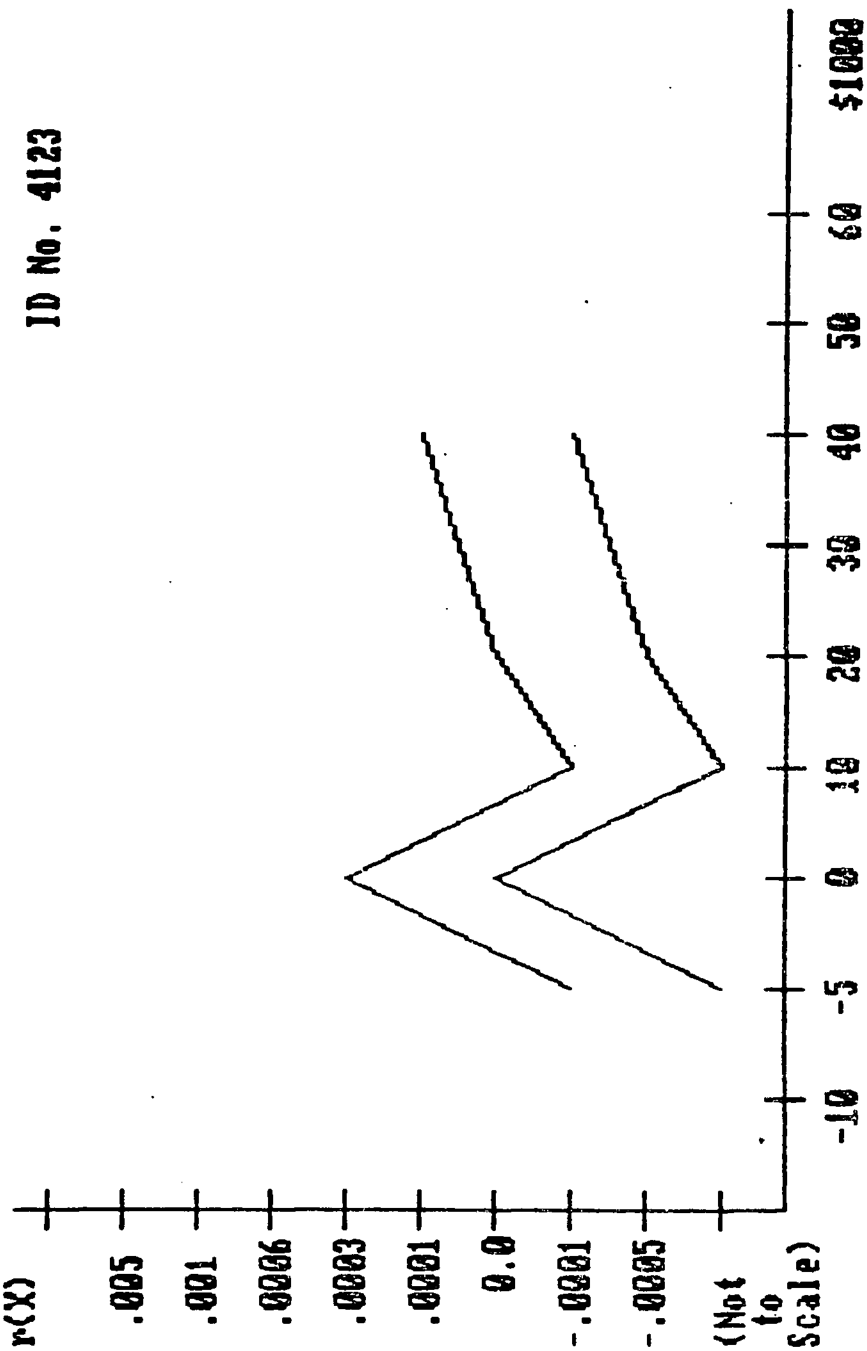

ID No. 3203
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000

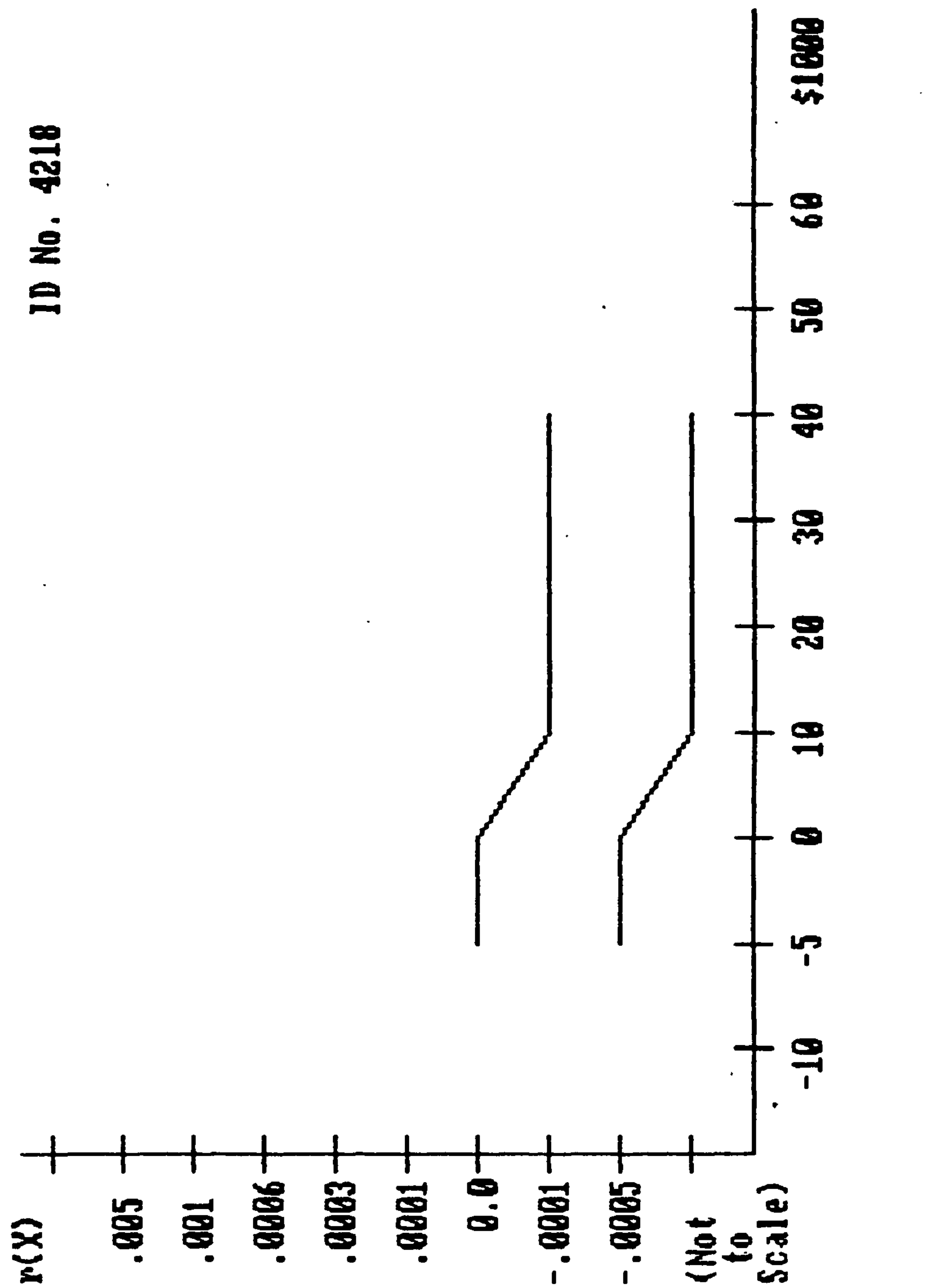

r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000
ID No. 3206

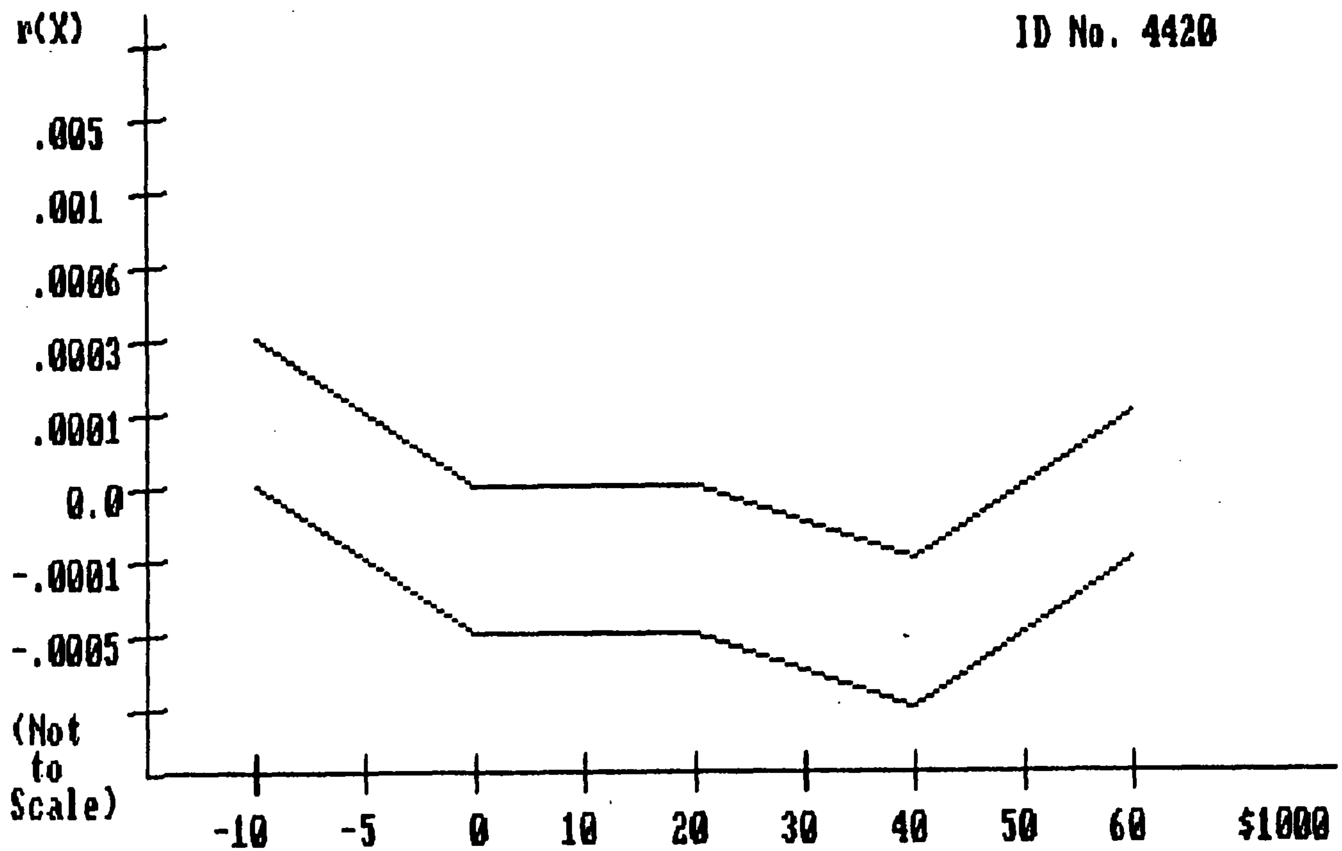

ID No. 3319
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000


ID No. 3422
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000


r(X)
ID No. 4115
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000


ID No. 4123
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000


ID No. 4218
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000


ID No. 4420
r(X)
.005
.001
.0006
.0003
.0001
0.0
-.0001
-.0005
(Not to Scale)
-10
-5
0
10
20
30
40
50
60
$1000