Working Paper Series

WORKING PAPER NO. 633

NOT JUST ANOTHER PAPER SHOWING VIOLATIONS
OF THE EXPECTED UTILITY MODEL:
HE EFFECTS OF ALTERNATIVE SIMILARITY ON RISKY CHOIC

by

DEPARTMENT OF AGRICULTURAL AND
RESOURCE ECONOMICS

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ABSTRACT

This paper explores the dependence of choice on the relative differences in the characteristics of the risky alternatives. The empirical results of our analysis show: 1) there is a strong effect on the degree of violations of Expected Utility from differences between the question pairs, 2) that the Expected Utility model holds for a particular and significant class of alternatives dependant on these relative differences, and 3) that the effects of the relative question differences result in a significant proportion of individuals having intransitive patterns of choice.

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Comments welcome, please contact the authors before quoting.

INTRODUCTION

The Expected Utility (EU) model, first given an axiomatic representation by von Neumann and Morgenstern, has broadly recognized normative and practical appeal among general economists for the analysis of behavior under risk. However, many controlled experiments have shown that individuals exhibit direct violations of the EU model, with choices violating the EU Independence Axiom of particular interest in this paper. For examples and a complete discussion of these violations, see MacCrimmon and Larsson; Kahneman and Tversky; Lichtenstein and Slovic; Grether and Plott; Camerer; and Battalio et alia.

The Generalized Expected Utility (GEU) models (see surveys by Camerer; Fishburn (88); and Machina (83,87)) weaken the EU axioms on preferences to allow for observed violations of EU in experiments. The GEU models are more difficult to use than the EU model is and their assumptions are much less intuitively appealing. Rubinstein likens the approach of these models to a "black box" that fits behavioral variations, but with the differences in these models' axioms from those for the EU model having little normative support. Furthermore, both Rubinstein and Luce (91) question the validity of the GEU models' approach of full rationality with costless evaluation and choice assumed in the GEU models and advocate exploration and development of alternative models of choice that account for the effects of evaluation effort.

Several authors have advanced alternative explanations of independence violations in the spirit of bounded rationality (March; Simon). Leland; Luce (56); Encarnacion; Ng; and Rubinstein develop models based on the arguement that the evaluation of alternatives is costly and that evaluation effort depends on the characteristics of the alternatives. In particular, they hypothesize that independence violations are more likely to occur when the alternatives are more similar. This paper develops and applies an experimental framework that tests the effect of similarity on choices among risky alternatives.

This paper addressess several aspects of the existing literature on risky choice. First, it statistically tests for and shows the significance of similarity on risky choice over questions of the form used to show EU independence violations. Two types of measures are used to show the effects of similarity on the validity of the EU model - objective (the distance between alternatives) and subjective (individuals' ranking of similarity perceptions) - these two measures are shown to be closely related. The experimental design that is required for this analysis consists of a more extensive set of risky choice alternatives than previous studies do.

Our experimental findings show three primary results. First, there is a strong effect on the occurrence of violations of Expected Utility from differences in the similarity between the risky alternatives. Second, the Expected Utility model holds for a particular and significant class of risky alternatives, the pairs that are dissimilar. Finally, our experimental results also demonstrate the significant occurrence of a pattern of intransitive choice, where this pattern is called for under the similarity model but that is inconsistent with the axiomatically based EU and GEU models.

The next section gives a brief discussion of the EU model, violations of EU and a limited review of the efforts made in the GEU and other models to allow for EU violations. Section II discusses some previously proposed similarity models and presents a reduced form model for a more general definition of question similarity. Section III discusses an empirical framework developed to test for these similarity effects and gives some initial empirical results. Sections IV and V present the results of a more in-depth discrete choice statistical analysis that tests for the effects of similarity on choices. Section VI gives evidence of intransitivities of choice consistent with the similarity model. A conclusion follows.

I. BACKGROUND.

A. The Expected Utility Model.

The EU model states that, under certain axioms, there is a cardinal representation u() for a preference pre ordering, $\succeq$, indicating weak preference ($\succ$ indicates strictly preference; ~ indicates indifference) over probability distributions. These probability measures are elements of a non-empty set P, $\{p,q\} \in P$, defined over a common n-dimensional outcome vector x, with the cardinal representation giving the result that:

> Under the necessary and sufficient axioms of EU on $\succ$, there exists a continuous function u() unique up to affine transformations on P such that:

$$p \succeq q \Leftrightarrow \sum_{i=1}^{n} u(x_i)p(x_i) \geq \sum_{i=1}^{n} u(x_i)q(x_i). \tag{1}$$

The three necessary and sufficient axioms (Jensen; Fishburn) on preferences that show the existence of a cardinal representation u() have a considerable degree of normative appeal among economists. Of primary interest in this paper is the Independence Axiom; this axiom states that the binary preference relation ($\succ$) over distributions p and q must be consistent over arbitrary linear combinations of p and q with any other distribution $r \in P$ through a scalar α:

$$\{p \succ q\} \Leftrightarrow \{\alpha p + (1-\alpha) r \succ \alpha q + (1-\alpha) r \text{ for any } \alpha \in [0,1]\}. \quad (2)$$

The remaining axioms in the EU model are 1) an ordering axiom, implying both completeness (comparability) among distributions and transitivity of preferences and 2) a continuity axiom that gives "denseness" of preferences over the probabilities. For a more complete discussion of these and more general sets of EU axioms giving a cardinal representation of preferences, see Fishburn (88).

Marshack initially and Machina later developed a graphical representation for attitudes over risk to illustrate models of risky choice for the case of three outcomes; most of the well-known violations of the EU model also are constructed using probability distributions defined over three outcomes. Figure 1 shows the implications of the EU model on choice for distributions over three outcomes where the outcomes are given in increasing order, $x_L < x_M < x_H$ as additions to the starting wealth level (W). Points in this two-dimensional simplex represent probability vectors over the three outcomes. The probability of receiving the smallest (highest) addition, x_L (x_H), to wealth ($P_L, P_H \in [0,1]$) is the value given on the horizontal (vertical) axis in this figure. The probability of receiving the medium addition, x_M, to wealth ($P_M \epsilon [0,1]$) is given implicitly in the diagram since $P_M = 1-P_L-P_H$. For example, the alternative in the figure represented by point 1 gives a lower probability for receiving both the lower and the higher outcome than does the alternative represented by point 2.

Individuals with monotonically increasing preferences would prefer movements to the "Northwest" in the probability triangle since the probability of the highest outcome increases as the probability of the lowest outcome decreases. As reviewed by Machina (82;87) and by Camerer, the indifference curves (Ia through Ig) in the interior of the figure must be both linear and parallel under the EU Independence Axiom. The slopes of these indifference curves show the individual's risk attitudes, with steeper slopes indicating greater risk aversion. In the figure, the riskier alternative represented in the figure by point 2 is preferred to that for the less risky point 1.

B. Violations of the Expected Utility Model

For all its normative appeal and ease of use, the EU model has been shown to be systematically violated in a large number of experimental studies[1]. Of particular interest here are those empirical violations that strongly challenge the validity of the Independence Axiom. In an experiment reported by Kahneman and Tversky, the choices made over the alternatives[2] given in Figure 2 show a pattern of violation of the EU model known as the Certainty Effect. Most of their respondents (80%) selected the certain alternative A over B, while 65% of the respondents selected the riskier alternative O over N for the second choice pair.

Figure 2 shows the approximate slope that the linear preference representations, "Indifference #1 and #2", should take to be consistent with the majority of the respondents' choices reported by Kahneman and Tversky; the key point is that these curves cannot be parallel to each other as called for by EU. These "Indifference Curves" can not be parallel since the probability distributions p,q defining the elements of the risky choice pair (N,O) can be written as linear combinations of probability distributions p^o,q^o defining the pair (A,B) with a common alternative ($0), where ($0) indicates a degenerate probability distribution for a lottery with a 100% chance of receiving $0:

$$p = .25^*p^o + .75^*(\$0) \qquad q = .25^*q^o + .75^*(\$0). \qquad (3)$$

Note that p^o,q^o defining the choice pair AB can be written in (3) with $\alpha = 1.0$. The Independence Axiom states that the choice between O and N, being linear combinations of A and B, should not depend on the common probability distribution ($0), nor on the factor (.25 or 1.0) defining the shares of the probabilities p^o,q^o in the choice pairs (NO or AB). Therefore, the individuals who selected A (over B) in the first pair and O (over N) in the second pair show an independence violation of EU. See Kahneman and Tversky or Camerer for a complete discussion of these independence violations.

A similar set of choice pairs constructed by Kahneman and Tversky shows an EU violation that is known as the Common Ratio Effect; these pairs are illustrated in Figure 3 as RS and XY with the probabilities defining X and Y constructed as linear combinations with those defining R and S. Most (86%) of their respondents selected the less risky alternative R over S, but 73% selected the riskier alternative Y over X, even though both choice pairs are defined as alternatives with equal expected values. The linear "Indifference #1,#2" curves corresponding with the majority of choices also cannot be parallel, giving a violation of EU in a similar direction as the Certainty Effect choice pairs do.

C. Models of Risky Behavior as Alternatives to EU.

The empirical violations of EU have been interpreted as quite damaging to its validity for modeling behavior under risk. As a result, considerable effort has been devoted to finding more positively accurate models for behavior under risk. See Camerer, Machina (87), and Fishburn (88) for an analysis of this group of axiomatic (GEU) models. There are also two relevant models addressing independence and other violations, one by Kahneman and Tversky called Cumulative Prospect Theory (CPT), and a like model by Luce (91) called Rank and Sign Dependent Linear Utility (RSDLU).

In a general sense, the GEU models weaken the EU model's Independence Axiom[3] just enough to allow for the well-known empirical examples giving violations of the EU model, but keeping as close to the axiomatic framework of EU as possible. The result of these models is that risky choices can be evaluated through the following form:

$$W(p) = \sum_{i=1}^{n} g_i(p)w(x_i). \tag{4}$$

In (4), the function w() on outcomes acts like the cardinal representation u() in the EU model defined in (1); g() is generally a non-linear weighting function on the probability distribution. These GEU models have the EU model as a special case, with variations from EU being defined through these models' functional forms. Both CPT and RSDLU were developed primarily as predictive models; they use functions over the outcome and the probabilities much like those in the GEU models. However these models hold that preferences over outcomes also depend on the sign (losses vs. gains) of the payoffs relative to the status quo.

The normative basis for the GEU models' weakening of EU axioms is not strong. In addition, new experimental results give examples (Camerer; Conlisk (89); Battalio et. al.) of systematic independence violations that are not explained by many of these models, raising questions regarding the nature of risky choice for alternative pairs that have not yet been tested for in experiments. The next section presents an alternative explanation of violations of EU through a specific reduced-form model that reflects factors of bounded rationality or costs of evaluation, where choices reflect both the underlying preferences and the costs of evaluation.

II. AN ALTERNATIVE EXPLANATION OF THE PARADOXES.

There are several researchers (Leland, D. Friedman, Viscusi, Rubinstein) who argue that the reason for EU violations is not primarily because of the decision makers underlying preference structure, but is due to limited capacity of individuals to assess the relevant tradeoffs between the alternatives' probabilities and outcomes. This argument embodies the spirit of the bounded rationality approach (Simon; March) that holds computations to be costly or that individuals have limited ability to distinguish between alike alternatives (Heiner; Conlisk). Because of these limitations, papers by Leland and by Rubinstein suggest that choice is dependent on the nature of the alternative pairs, and that EU violations may occur when choices over dissimilar pairs are compared with those over similar pairs.

These similarity models are related to somewhat more general models of choice with sensitivity or evaluation limits by Conery; Encarnacion; Luce (56); and Ng. The application of these bounded rationality models to address a long-standing empirical "irregularity" (with respect to the existing EU theory) in the similarity models is very much like the arguments of "Near Rationality" used by Akerloff and Yellen to address the rational occurrence of business cycles. A parallel view of decision making to the similarity models that has received recent emphasis in Psychology is found in models of Change of Process theories that are reviewed by Payne, with applications given in work by Mellers et al. and by Johnson et al.; in these models, the methods individuals use to evaluate risky alternatives differ due to the characteristics of the alternatives. This paper also has a common motivation with models of the effects of similarity in product attributes on choice; see Glazer and Nakamoto.

The present paper explores the nature of similarity, tests both its effects on choice and its value in explaining EU independence violations. This section builds a framework for viewing similarity; the following three sub-sections address questions of:

1. What is similarity for risky choice pairs and how can it be objectively defined?
2. How do the effects of similarity relate to the experimental violations of EU?
3. How can similarity be made operational and tested?

A. Objective Factors Used to Define Similarity

The similarity between the choice pairs that have been used to show independence violations, such as those for the Certainty Effect and the Common Ratio Effect, could be viewed simply through the scaler $\alpha \epsilon [0,1]$ and the probability distribution r used to define the pairs as in (3). Let the risky choice pairs be defined by $p_i = \alpha_i p_0 + (1-\alpha)r$ and $q_i = \alpha_i q_0 + (1-\alpha)r$; the larger the value of α_i, the more similar will be p_i and q_i as the common probability distribution r receives more weight. However, a workable definition of similarity as an explicit function of α is difficult to develop, since the risky alternatives are also defined through and similarity reflecting relevant costs and benefits of evaluation will likely also depend on r, p_o, q_o and the outcome vector x. either probability vectors or a distributions over the outcomes. This sub-section considers a definition of similarity that uses observable summary measures defined over both the probability distributions and the outcomes. This definition is followed in Sub-Section C by a reduced form model for testing the effects of the alternatives' similarity on choice.

Most of the previously suggested models of similarity are defined for choices over simple risky alternatives, called prospects by Kahneman and Tversky, where each of the alternatives has only one non-zero payoff. One of these pairs gives an outcome of x_1 with probability p (otherwise zero), while the other gives an outcome of x_2 with probability q (otherwise zero). For example, the pairs used in the Certainty Effect and the Common Ratio Effect are prospects. Objective similarity for prospects has been defined by Rubinstein to be a linear weighted function of the outcomes and the probability differences between the alternatives for scalar weights γ_1 and γ_2:

$$\text{similarity} \equiv f[(x_1-x_2),(p-q)] = \gamma_1|x_1-x_2| + \gamma_2|p-q| \qquad (6)$$

The scalar weights in (6) define the contribution of the outcome and the probability factors for an individual's similarity judgements and could in principle be empirically estimated.

The similarity measure in (6) is rather limited in its usefulness since it cannot define the similarity of risky alternatives with positive probability over more than two non-zero outcomes. Here, a more general measure of similarity is defined as a function of summary measures over the relative differences in the alternatives' probability vectors (p,q) and over the common outcome vector x given these probabilities as in equation (7):

$$\text{similarity} \equiv g[h_i(p,q),k_j(x;p,q)] \qquad (7)$$

The vector of functions $h_i()$ (i=1,...H) in (7) are based on relative characteristics of the probability vectors; the vector of functions $k_j()$ (j=1,...K) will be developed to capture the relevant outcome differences conditional on these distributions.

One such function in $h_1()$ gives the difference between the alternatives' probabilities is the metric[4] measure in the n-dimensional discrete outcome case. Again, the alternatives are defined by the probability vectors $\{p_1,p_2,...p_n\}$ and $\{q_1,q_2,...q_n\}$ over the common outcome vector $\{x_1,x_2,...x_n\}$:

$$metric(p,q) \equiv [\sum_{i=1}^{n} (p_i - q_i)^2]^{\frac{1}{2}}. \tag{8}$$

The metric measure can be generalized for probability distributions over continuous outcomes through a function of the normalized integral of the absolute differences between the cumulative distribution functions (CDFs) over the alternatives. This CDF measure is defined over the outcome space, where f(x) is the probability density function for the alternative, as:

$$Distance(CDF) \equiv \frac{\int_{RangeX} |CDF(z)_p - CDF(z)_q| dz}{Range\ X} \tag{9}$$

$$where:\ CDF(x) = \int_0^x f(z)dz\ and\ Range\ X = [supremum(X) - infimum(X)]$$

The CDF's for two continuous distributions p and q are shown in Figure 4. The CDF for distribution p [CDF(p)] compared with that for q [CDF(q)] shows a larger sum of the probability for outcomes below x_1, a smaller sum of the probability for outcomes above x_1 and below x_2, and a larger sum of the probability of occurrence for outcomes below x_3 and above x_2. Figure 4 shows that the CDF measure will include some relative outcome effects in addition to probability differences. The normalization in (9) by the range of outcomes removes the outcome scale effect from this probability distance measure, but relative outcome effects are still present.

In addition to the measurement of the similarity over the probabilities through the metric or CDF's, a measure on the relevant differences of the common outcome vector is needed. At first glance, a distance measure directly over the outcomes seems an appealing approach to this problem; however, we sought to remain within the standard risky choice framework where the probability distributions are defined over a common outcome vector x. Since the probability differences are accounted for by the metric or CDF-based distance measures[5] to a degree, functions based on the expected values of the alternatives should capture many of the relevant outcome differences for the risky alternatives used in our study. These functions will be further defined in Section IV.

B. General Model for the Effects of Question Similarity on Risky Choice

Consider two risky alternatives A^o and B^o, defined for a common outcome vector by their probability distributions p^o and q^o. In the commonly known risky choice examples used to show EU violations (such as for the pair AB in the Certainty Effect or the pair RS in the Common Ratio Effect), A^o is selected over B^o by a majority of the respondents; this pattern of choices[6] indicates that many individuals are risk averse for the pair, since the alternative B^o has a larger probability for both the lowest (x_L) and the highest (x_H) outcome than A^o does, with the expected values (EV) for the pair having the relationship of $EV(A^o) \leq EV(B^o)$.

Violations of EU have been shown for patterns of individual choices that violate EU through the choice between the base pair (A^o,B^o) and between another pair (A_1,B_1), where this pair was constructed to be comparable with the base pair under the EU model as a linear combination of the probabilities from the base pair with a common alternative throught the Independence Axiom (2). For example, in the Certainty Effect elicitation framework this new pair is NO, while in the Common Ratio Effect example it is XY.

The similarity model hypothesizes that choices between similar and dissimilar risky choice pairs will differ, hence independence violations of EU can be explained through a dichotomy between the two choice pairs' dissimilarity. The basis for the statistical analysis used in this paper is that the similarity of the risky alternatives is an independent variable from a reduced form equation that reflects the agents' selection of the evaluation effort level. This effort level is chosen on the basis of the anticpated costs and benefits of the evaluation, much like the model developed by Heiner. We test the hypothesis H_1 versus the null that similarity has no effect:

> H_1: The occurence of independence violations depends on the relative simalarity of the alternative pairs.
>
> Specifically, when compared with a dissimilar choice pair, the more similar the risky choice pair, the more likely are independence violations.

This required pattern under EU for risky choices allows testing for the effect of the similarity of the alternatives on the occurrence of violations in the series. Previous empirical findings such as for the Certainty Effect and Common Ratio Effect examples, has shown a significant degree of violations for such risky choice questions. The similarity model hypothesizes that these violations occur due to differences in the similarity of the risky alternatives (A_j,B_j) relative to the base pair (A^o,B^o). Under this similarity hypothesis, the agent's ability to evaluate (or benefits from this evaluation) the relative desirability of the pair (A_j,B_j) is reduced from that for the pair (A^o,B^o) through decreases in α_j.

The experimental design of the set of risky choice questions in this study here were substantially influenced by the frameworks used in recent work by Camerer and by Battalio et al.; these papers also extend the number of alternative choice pairs through a series of risky choice pairs. The empirical design used here differs from those in previous studies by having somewhat more extensive range in the risky choice questions with respect to the factors proposed to affect question dissimilarity.

C. A Statistical Model for Testing the Effects of Similarity on Choice

The similarity models are intuitively appealing and can be formulated to allow for many of the independence violations of EU for the fairly simple risky choices that are prospects. However, these models, like others of bounded rationality or costs of evaluation, are difficult to construct analytically through a specific formulation; this difficulty is further increased as the dimension of the alternatives increases. This paper abstracts from such an analytical effort and develops a reduced form statistical model to test the effects of similarity on choice. The dependent variable in this discrete choice model has a value of 1 if the more risky choice is selected over the less risky one.

This study extends the framework for the analysis of choice by creating an extensive series of risky pairs that are comparable to (A^o,B^o) through the EU model. That is, pairs $(A_z,B_z;\ z \in \{1,...m\})$ in this series are defined through their probability distributions

(p_z, q_z) that are constructed as linear combinations of (p^o, q^o) with another distribution r_j (over the same outcomes as (p^o, q^o) are) through a scalar $\alpha_j \in [0,1]$:

$$\begin{aligned} p_z &= \alpha_z p^o + (1 - \alpha_z) r_z \\ q_z &= \alpha_z q^o + (1 - \alpha_z) r_z \end{aligned} \tag{5}$$

For example and as defined in (3), the distributions p_1, q_1 that correspond with the choice pairs NO are given through the linear combination defined in (5), with $p^o = (0, 1.0, 0)$, $q^o = (.2, 0, .8)$, $r_1 = (1.0, 0, 0)$ and $\alpha_1 = .25$. The alternative B_z is defined to be more "risky" than the alternative A_z is, indicated by $EV(A_z) \leq EV(B_z)$; that is, the expected value relationship between the base pair is preserved for pairs within the series.

Under EU, individuals' choices between the series of risky alternative pairs must follow a regular pattern. If the individual selected the riskier (less risky) alternative B^o (A^o) in the base pair, the individual should also select the riskier (less risky) alternative B_z (A_z) in each of the pairs for the entire series of choices under EU. Therefore, if choices deviate from this pattern for any pair, there is a violation of EU for choices between (A^o, B^o) and (A_z, B_z)[7].

In the series of risky choice pairs used in this study, choice is modeled so that the riskier alternative B_j has a probability of being selected over the less risky A_j, dependant on summary measures over the characteristics of the alternatives and the individual. These summary measures were selected to reflect the costs and benefits of the evaluation of the alternatives.

Through the reponses from the set of risky choice questions discussed above, a measure of the dissimilarity (δ_j) between the alternatives will be empirically developed as a function of the relative differences between measures on the alternatives' probabilities and their outcomes. The similarity function will be a function of the metric or CDF based distance measure on the probabilities, a vector of measures (υ_j) that are functions of the alternatives' expected values, plus other variables:

$$P(B_{ij} \text{ over } A_{ij} / \beta_i) = \phi(\delta_j, \upsilon_j, \eta_i, \beta_i, \lambda_i, \varepsilon_{ij}) \tag{10}$$

The base choice variable (β_i) is the individual's choice, $\beta_i \epsilon \{0,1\}$, for the base pair (A^o,B^o) defined for each EU-comparable sub-group in the set of risky choice questions; this measure equals 1 if the more risky alternative B^o were selected over A^o. Elements of the vector υ_j also enter into the choice probability function directly in addition to their effects on the perceived dissimilarity. The term η_i defines a vector of individual i's personal characteristics. The variable λ_i reflects the effects on choice of the elicitation process through question attenuation or learning. The random term ε_{ij} is the realization of a draw from a logistic cumulative distribution function; this distribution is identical for all agents and over all choice pairs.

The interpretation of equation (10) for choices with respect to EU will depend on the individual's choice for the base pair. If the riskier alternative B^o is chosen (base choice=1), the function $\phi()$ giving the probability of choice for the riskier B_j over A_j is interpreted as the probability that choice will be consistent with EU; if the less risky alternative A^o is chosen (base choice=0), $\phi()$ gives the probability of an EU violation for the more risky choice of B_j over A_j.

Under the independent and identically distributed logistic distributional assumption for the random term ε_{ij}, and with a linear in the parameters (γ) model for the effect of the explanatory variables, $z_{ij}=(\delta_j,\upsilon_j,\eta_i^*,\beta_i,\lambda_i)$, the estimated probability of the riskier choice for the m questions and the n individuals is given by the value of the CDF at $[z_{ij}'\gamma]$:

$$[P(B_{ij}\ over\ A_{ij}/\beta_i)]_{mn\ by\ 1} = [f(z_{ij},\gamma)]_{mnby1} = \left[\frac{1}{1+\exp(-z_{ij}'\gamma)}\right]_{mn\ by\ 1} \qquad (11)$$

The goal of the empirical analysis is to estimate and test the coefficient vector γ in (11), with the estimation of the coefficient for the similarity varible of particular interest.

III. EMPIRICAL STUDY OF THE EFFECTS OF SIMILARITY ON RISKY CHOICE

A. Survey Design

1. Risky Choice Pairs

The specific risky choice questions used in the study were extensions of the Certainty Effect (Figure 2) and the Common Ratio Effect (Figure 3) examples; the pairs in this study cover a larger range of probabilities and outcomes than the original questions and are given in Tables 1A through 1D. This experimental base was used because of the familiarity of most researchers with the Certainty Effect and Common Ratio Effect examples and because the outcomes are comparable to those regularly faced by individuals. The first two alterative pairs {(AB,NO),(RS,XY)} in Tables 1A and 1D, respectively, give choices with the identical probabilities as used in Kahneman and Tversky, with most of the remaining pairs being comparable to them through EU. In addition, one question pair (#39) used an outcome vector of ($0,$3000,$5800) with the same probabilities as the pair XY (#34) to allow a test the validity of expected value maximization under similarity.

The pairs given in 1B and 1C used more varied outcome ranges for the risky choice pairs than those in 1A. Pairs in Table 1B give choices over alternatives with four dimensions for two sets of outcomes ($0,$3000,$3800,$4000) and ($0,$200,$3000,$4000). The probabilities of these pairs over the new outcome vectors are linear combinations of those in the pair CD (#4) in Table 1A with distributions over the new outcomes of ($200 and $3800) and can be compared with choices made for the pairs in Table 1A regarding the validity of the EU model. Pairs in Table 1C use the identical probabilities that were used by Kahneman and Tversky to show the Certainty Effect (questions 1 and 2 in Table 1A), but with different outcome levels. Adjustments for inflation and for the exchange rate[8] would show Kahneman and Tversky's payoff levels being bracketed by the {$0,$750,$800} payoff set in the first two pairs (#29 and #31 in Table 1C) and the {$0,$3000,$4000) payoff set used in the alternative pairs (#1 and #2 given in both Table 1A and Table 1C).

2. Question Format

The survey included two forms of questions, with the practice questions of each type as shown in Table 2. The first question type (Practice Question 1) corresponds with previous studies and asks respondents to select their preferred alternative from the pair of risky choices. Twenty-four questions of this first type were given randomly to each participant. Eight randomly selected questions of the second type (Practice Question 2) were given as a block of questions in the surveys, with respondents asked to first give their preferences between the two alternatives and then to indicate their perceptions of the dissimilarity between the alternatives and their strength of preference[9] between the choices. These dissimilarity and strength of preference judgements were given on a continuous and bounded scale from 1 to 9, with qualitative terms {Similar, Somewhat Dissimilar, Dissimilar, Very Dissimilar} and {Indifferent, Somewhat Strong, Strong, Very Strong} given to the respondents to aid in their point selection. Subjects were urged to consider points other than integers for the dissimilarity and strength of preference judgements in both written and verbal instructions.

The dissimilarity scale perceptions aided in the selection of objective factors characterizing dissimilarity and in the determination of the correspondence between the previous theoretical (and somewhat narrowly defined) models of "dissimilarity" with the actual perceptions of the individuals who face risky choices. We will show that this subjective measure does rather well in capturing the objective question characteristics that influence choice. This measure of similarity perceptions is particularly valuable since so little prior information is known about the objective factors determining similarity effects.

3. Further Survey Design Issues

The risky choice pairs given in Tables 1A-1D were broken into two groups (priority and secondary) in the elicitation for 160 of the 202 respondents[10] to give a large number of observations for the priority pairs that are of particular interest. These priority pairs were members of a set defined to allow tests of particular patterns of choice, with their question numbers from the Tables:

Table 1A: {1,2,4,5,6,7,14,16,17,18,19,20,21,23,}
Table 1C: {29,30,31,32}

The selected group in Table 1A included pairs that allowed for tests of a specific pattern of violations of EU. The specially selected pairs from Table 1C were included to evaluate the occurrence of paradoxes for the probabilities as used in Kahneman and Tversky's original examples, but defined over more varied outcomes. These 18 priority questions were given in random order in each respondent's survey. A random ordering of 14 of the 21 remaining secondary questions was used to complete the 32 question survey; thus, not all of the alterative pairs were faced by each respondent, but all questions were faced in random orderings by some of the population.

The survey population was further differentiated by altering the pattern of the questions faced by respondents. Three test population groups were developed to allow tests for survey effects; it was hypothesized that respondents might become accustomed to making choices among the alternatives to a degree dependent on the relative similarity of the questions they previously faced (context effect). For the surveys given to Test Group 1, a random sample of 18 priority and 13 secondary questions with low metric measures, e.g. pair EF in Figure 5 and VW in Figure 6, were randomly given to the respondents first, followed by a randomly selected question from the 8 high metric ("dissimilar") priority questions. Test Group 2 received a random ordering from among the 18 priority questions and the 8 high metric secondary first, followed by a random ordering of 6 questions from among the 13 low metric measure secondary questions. Finally, a control group received a random ordering first over the 18 priority questions and then over a subset of 14 of the 21 secondary questions, with no distinction based on the metric measures of the questions.

B. Initial Empirical Results

In all, 202 responses to the risk survey were obtained from 1) undergraduate[11] students (27%), 2) an academic population of either a) graduate students at the University of California at Berkeley's Department of Agricultural and Resource Economics or b) faculty in economics and agricultural economics (52%), and 3) members of the general (non-academic) population (21%). Survey administration took place over a four month period from November, 1991 to February, 1992[12]. The faculty and graduate student population had a high percentage of individuals who had previously modeled risky choice problems and had likely been familiar with both the EU model and the better-known examples showing its violation.

The mean dissimilarity judgments and the mean proportion of respondents selecting the riskier choice for each of the 39 questions are listed in Table 1A-1D and summarized graphically in Figure 7. This figure reflects the primary relationship (correlation -.67) between the two factors. In contrast, the metric measure's correlation with this mean proportion of the riskier choice is -.50. Therefore, this subjective dissimilarity measure captures a primary relationship of the question characteristics that affect individuals' choices over risky alternatives and gives additional information on factors affecting dissimilarity beyond the metric measure of distance.

As asserted in the similarity models and of particular interest, the positive relationship between low dissimilarity and a high proportion of risky choice is strong for those questions with the same probabilities as those used to show early examples of EU violations by Kahneman and Tversky (AB and NO in Table 1A, RS and XY in Table 1D); a higher proportion of individuals selected the riskier alternative for the questions with low metric measures and low mean dissimilarity judgements (NO;XY) than for those with high dissimilarity judgments (AB; RS). The similarity effects for risky choice pairs in Table 1A are quite evident for the large distance measure pairs such as AB (# 1) and CB (# 14) versus those for the lower distance pairs such as NO (# 2) and EF (# 5). The primary dimensional effect on dissimilarity is evident for pairs such as AC (3) and KL (12) where one alternative has a zero probability of the lowest outcome, here referred to as pseudo-certainty.

The results in Table 1B show the effects of changing the relative outcome vectors on both the mean dissimilarity judgements and on the population proportion selecting the riskier alternative. Relative to those for the pair CD (#4) in Table 1A, the alteration of the choice pair through a linear combination of a common degenerate distribution giving an outcome ($3800 or $200) substantially increased the percentage of riskier choices from those for the pair CD when the new pair was more similar and the distribution over the new outcome was dominant, e.g. when the probability of receiving the new outcome ($3800 or $200) was .75 in pair #25 and #27. The proportion of individuals selecting the riskier choice under both the linear combinations (.25 and .75) were somewhat higher for the distribution over outcomes of $3800 than those over the outcomes of $200, reflecting outcome effects.

Table 1C gives the population proportion selecting the riskier alternative for the pairs with the same probabilities but with different outcomes than the questions with the probabilities identical to those used to show the Certainty Effect. The proportion of respondents selecting the riskier pairs under the {$0,$750,$800} outcome framework compares in magnitude to but is somewhat smaller than the riskier choice proportions from the questions given by Kahneman and Tversky to Israeli undergraduate students and faculty (of unspecified proportions) in the late 1970's, indicating somewhat more risk aversion in our population[13] than in theirs.

The risky choice percentage and mean dissimilarity judgments in question #39 show some difference from those reported for #34 in Table 1D, the risky choice pair with like probabilities over equal expected values. There may be some individuals who follow expected value maximization for similar alternatives, but many individuals did not follow such a rule in our experimental population.

These initial mean population proportion results point to the need for a more in-depth analysis of the effects on choice of the dissimilarity between alternatives. The next section reports the results of rigorous tests of the effects of some of these factors for choices under risk and to assess their influence on the degree of violations of the EU model. Further, the results in Table 1A-1D indicate a large degree of empirical violations of not only the EU model, but also for many of the alternative GEU models. Section VI of this paper will give evidence showing that the alternative GEU models, CPT and RSDLU also are significantly violated when choice patterns for a wider set of question pairs are considered.

IV. ESTIMATING DISSIMILARITY JUDGEMENTS

A. Generalized Least Squares Regression Model.

The reported perceptions of dissimilarity were fitted as functions of objective and observable characteristics of the risky alternatives and of the individuals. There are two dissimilarity models of interest depending on the measure used for the differences in the probabilities; one model uses the metric measures between the alternatives over the probability space in (8) and the other uses the CDF-based measure given in (9). The other question characteristics used for both linear regression models are given in Table 3. This table includes both quantitative measures such as the distance measures (metric or CDF based) and discrete terms such as the indicators for dimensional effects. One of these dimensional variables is an indicator taking the value 1 if one of the risky alternatives has a zero probability of occurrence for the lowest outcome ($p_L = 0$ or $q_L = 0$); another is an indicator with the value 1 if both alternatives have non-zero probabilities over the same outcomes (equi-dimensional support). A limited set of observable discrete and continuous variables that were used to give personal factors affecting dissimilarity perceptions are also given in Table 3. Differences in the effects of the question characteristics for the undergraduate and non-academic populations were allowed through the interaction terms given in Table 3.

Interpersonal heteroskedasticity was suspected for the individual's reported perceptions of dissimilarity. This heteroskedasticity would have a straightforward interpretation since the "spread" of the dissimilarity scale judgements may well differ between each individual in the population. Asymptotic unbiasedness of the coefficient estimator may not be guaranteed and the bias in the covariance matrix might not be effectively improved in this response framework by increasing the number of respondents, since each new survey gives eight new similarity judgements with the potential for an unique spread for each individual. A Generalized Least Squares (GLS) model was used because of this heteroskedasticity.

B. Results.

Tables 4A and 4B report the results of a GLS model using the metric (8) and CDF (9) based measures to model distance effects, respectively. The estimated diagonal covariance matrix used in this GLS had the average of the squared errors for each individual on the diagonals as estimators for σ_i^2 where each individual's variance is allowed to differ; this GLS model can also be viewed as a weighted regression model. The large number of observations allows favorable degrees of freedom (1171)[14] for significance tests in these models. The primary findings from our efforts to model dissimilarity will be discussed below, with the secondary findings evident in the tables.

In Table 4A, the cubic relationship on the metric measure on the probabilities shows dissimilarity judgements increasing at a decreasing rate, with the combined effect from the three terms and their coefficient estimates being positive throughout since the metric measures are near enough to one throughout the risky choice pairs. Pairs where one alternative is pseudo-certain are judged to be significantly more dissimilar, with the null hypothesis giving this coefficient a value of zero. Alternatives with equi-dimensional support were judged to be significantly (null gives a coefficient of zero) less dissimilar; the equi-dimensional support indicator variable is 1 if both of the alternatives have non-zero probabilities for the same outcomes. Increases in the relative expected value differences (the ratios of the absolute difference of the expected values over the minimum of the expected values) give significant decreases in the dissimilarity judgements. Question order (a variable reflecting learning or attenuation) was not significantly different from zero for dissimilarity judgements.

There are two sets of personal charateristic variables of primary interest. Non-academics and undergraduates saw the risky choice alternatives as being significantly more dissimilar than the base academic population did. Individuals in both Test Groups 1 and 2 had significantly (moderately significant for Test Group 2) higher dissimilarity judgments than did the base group, with Group 1 having a significantly larger dissimilarity judgements than Group 2; thus, the experimental design in this elicitation had significant (versus the null of a zero coefficient) effects on perceptual judgements of dissimilarity.

The coefficient estimate on both of the interaction terms that are products of the metric measure with either the undergraduate indicator or with the non-academic indicator are significantly different from zero. These groups have dissimilarity judgements that are less affected by distance measures than the base population does, although the overall effects of the distance measures on dissimilarity judgements are still significantly different from zero for all groups. A general measure of model fit for the dissimilarity GLS regression using the metric measures in Table 4A is given by an R^2 measure of .61 and adjusted R^2 of .60.

The fit and coefficient estimates for the GLS regression of dissimilarity using the CDF based distance measure (Table 4B) were quite like those for the model using the metric measures. The metric measure model has some advantages in simplicity, while the CDF based distance measure is more general as it applies to continuous distributions, but both models fit dissimilarity perceptions rather alike.

V. TESTING THE EFFECTS OF DISSIMILARITY ON CHOICE

A. Logit Regression Model 1: Fitted Dissimilarity

1. The Model

We test the hypothesis that the dissimilarity between the alternatives affects choices under risk through a logit regression for the probability for a particular individual to choose the riskier alternative (observed dependent variable = 1) over the less risky in the choice pair for the model given in (11). A list of the variables used in these regressions is given in Table 5. Logit Model 1 used the fitted dissimilarity from the GLS regression in Table 4A, the metric measure model.

Functions over the expected values of the alternatives were also included as separate explanatory variables in the discrete choice regression in addition to their effects on dissimilarity. Some of the personal characteristic variables (age, education, and etc.) and interaction terms for undergraduates and the nonacademic population over the question characteristic variables were included directly in this model and in the GLS model of dissimilarity judgments. Because of these variables' "double effects" the interpretation of some of the personal characteristic variables is a bit complicated. Another logit model (Logit Model 2) will give more interpretable coefficient estimates on these personal information variables.

The base choice variable uses as an explanatory variable the choice for a risky pair for the sub-group that allows comparisons via EU. The coefficient on this variable will indicate the probability[15] for the individual to choose the riskier alternative provided that the riskier alternative was chosen for the base pair. The base choice pairs that were selected for alternative with relatively large metric or CDF measures, but that did not include a pseudo-certain alternative. For the pairs derived as variants of the Certainty Effect example, one of the pairs {(CB), (CD)} in Table 1A and Figure 5 were used. If the individual was given the choice between the pair (CB), that response was used for the base rate value; if the choice between the pair (CB) were not elicited, the alternative selected for the pair (CD) was used as the base. For the pairs that were constructed as variants of the Common Ratio Effect, the choice between the pair (RS) in Figure 6 that is #33 in Table 1D was used as the base choice. Risky choices for question #31 in Table 1C used question #29 in the table as the base; choices for question #32 in Table 1C used question #30 as the base.

2. Results

The coefficient estimators, standard errors and asymptotic t-values for the logit regression model for the propensity to choose the riskier alternative are given in Table 6. The log-likelihood ratio for this regression and its test statistics were quite favorable regarding the overall model fit. The percentage of correct predictions was 69%, with an 81% success rate for estimating the less risky choice (dependent variable=0) and 52% success rate for estimation of the more risky choice (dependent variable=1). The value of the probability density function at the means was $f(z'\gamma)$ = -.405, with the function f(()

defined as in (11). The primary results of the model's coefficient estimates are reported below.

The coefficient estimate for the fitted similarity is significantly different from zero and of the hypothesized sign; as this measure of dissimilarity among the pairs increases, the probability of an individual choosing the riskier alternative decreases. The absolute difference between the expected values was also significantly different from zero and of the expected negative sign, with this effect on choice given in addition to the variable's effect on the similarity judgements; respondents were less likely to select the riskier alternative as the stakes involved in the choice increased. These coefficient estimates give strong support for the similarity models' assertion of the dependence of choice on the relative characteristics of the alternatives.

The significant (versus the zero under the null) coefficient on the base choice rate term indicates strong support for of the EU hypotheses when other factors are accounted for. Individuals in the non-academic population were significantly (against a null hypothesis of zero) more likely to take risks (after accounting for the base choice effect) than those in the base academic population were. None of the coefficient estimates on the interaction variable terms was significantly different from zero. Note that there were significant differences for the undergraduate and non-academic populations from the base academic group in the GLS models fitting dissimilarity judgements, so some caution should be taken in the interpretation of the coefficient estimates in this model.

B. Logit Model 2: Direct Incorporation of Question Characteristics for Risky Choice.

1. The Model.

We constructed another model for discrete risky choice that *directly* uses as independent variables those question characteristic terms with explanatory power in the original GLS regression for dissimilarity judgements using the metric measures. The terms in this reduced form model are given in Table 7.

The question characteristic variables included a cubic metric term, the pseudo certainty and equi-dimensional support indicators, the three terms as functions of the expected values as in Logit Model 1 and the question order. The personal characteristic variables are identical to those in Logit Model 1. The interaction terms include undergraduate/non-academic indicators interacted with the metric, the base choice, the pseudo-certainty indicator and with the three functions of the expected values.

B. Results.

The model fit shown in Table 8 is comparable to that using the fitted dissimilarity judgements in Logit Model 1. Risky decisions are significantly (versus the hypothesized null gives a coefficient value of zero) less likely to be selected for alternatives with larger metric terms at a generally decreasing rate. The pseudo-certainty indicator is also significantly different from zero with a negative sign; if one of the alternatives has a zero probability of the lowest (zero) outcome, respondents are quite likely to select it. The positive and significant (coefficient value under the null is zero) sign on the relative absolute expected value difference shows some willingness to take risks if there is a large enough gain in relative expected value; the probability to select the riskier alternative is reduced (moderately significantly different from zero) by an increase in the minimum of the two alternatives' expected value.

The base choice variable giving the alternative selected for relatively dissimilar pairs is again quite strong for risky choice, supporting the strength of the Expected Utility model for risky choice. Elicitation effects were evident for the group (Test Group 2) that received relatively more high metric measure pairs initially were more likely to take risk than either the control group or Test Group 1.

There were no significant direct nor interactive differences beyond those captured by the base choice model for the undergraduate and the non-academic populations relative to the academic group in this logit model.

VI. INTRANSITIVITY PATTERNS SUPPORTING THE DISSIMILARITY MODEL

Particular patterns of violations of the complete and transitive ordering of the alternatives would be called for under a model where dissimilarity affects choice. Consider again the risky choice alternatives located on the loci of points between A and B in Figure 5; if, as shown by our logit regression results, individuals are more prone to select the risky alternative when the choices are similar, a pattern of choice with $E \succ C$, $F \succ E$, $D \succ F$, $B \succ D$ could arise, since dissimilarity depends primarily on the distance between these alternatives. However, when faced with a choice between C and B, the relative dissimilarity between the alternatives could lead the individuals to select C over

B, giving a violation of a transitive and complete ordering when coupled with the choice pattern over the less dissimilar alternatives. Such intransitivities would be predicted under effects of dissimilarity on the evaluation and subsequent choice between alternatives but would violate all of the GEU models, CPT and RSDLU.

We constructed tests of two particular patterns of intransitivity that were called for by the dissimilarity model, where a particular randomly presented array of relatively similar choices was compared with one dissimilar choice for pair. Intransitivity pattern 1 used those pairs in the example discussed above, so choices were made over the low metric measure (similar) pairs {(CE),(EF),(FD),(DB)} and over the larger metric measure (dissimilar) pair (CB). Intransitivity pattern 2 used some of the same pairs, with choices over the similar pairs {(EF),(FD),(DB)} and over the relatively dissimilar pair (EB).

The population statistics for the occurrence of these intransitivity patterns are given in Table 9, where the individuals satisfying these patterns selected the more risky alternative for the similar choices and the less risky for the dissimilar choices. Eleven (9.4%;9.6%) individuals showed Pattern 1 and Pattern 2 of intransitivity, respectively, of the 117 and 115 individuals who faced such pairs (six individuals showed both patterns). These population proportions were significantly different from zero through a t-test for both of the patterns, with the intransitivity proportion in Pattern 1 also being significantly different from that expected from choice under pure chance.

These findings of intransitive choice support the hypothesis that the evaluation method used by individuals depends on the dissimilarity between the alternatives and cast doubt on the validity of models set forth as alternatives to EU such as Kahneman and Tversky's CPT, Luce's RSDLU and the GEU models as completely accurate positive models of choice under risk. These results do support some alternative positive models of risky choice that do allow for intransitivities, e.g. Loomes and Sudgen's and Bell's Regret Theory models and Fishburn's (88) Skew-Symmetric Bi-linear model.

CONCLUSIONS

This analysis offers a substantial contribution to the study of behavior under risk. It yields a predictive model of the effect of dissimilarity on choice, where dissimilarity is defined over observable characteristics of the alternatives. The paper's empirical findings support further efforts toward the development of an analytical model of choice that explicitly includes the effects of the costs of or bounds on evaluation, where these costs are taken to depend primarily on the dissimilarity of the alternatives.

This paper makes operational and tests the effects of the similarity between question pairs for a wide class of risky alternatives. The theoretical basis for this analysis is from models suggested by Leland; Encarnacion; D. Friedman; Ng; and Rubinstein. The experimental design developed here extends the knowledge of choice under risk by expanding the risky choice pairs from two well-known question pairs used by Kahneman and Tversky to show independence violations. The dissimilarity between alternatives is fitted in a GLS regression framework using observable characteristics of the alternatives, personal variables of the individual respondents and interaction terms for the survey population. A significant difference in the likelihood of agents to select the riskier of two alternatives is shown in a logit regression analysis between question pairs that are perceived to be similar relative to those that are perceived to be dissimilar.

We found empirical support for the effects of similarity on choice from both the respondents' subjectively reported perceptions and from subsequent models where dissimilarity was defined over objective characteristics of the questions. There is a strong connection between the previously hypothesized objective definitions of dissimilarity and the individual's perceptions. Also, while the empirical independence violations of the EU model occur for a class of questions, the EU model is well supported for the class of decisions that are perceived as being dissimilar. In addition, empirical results showed a significant intransitivity of choice in the direction predicted by the similarity model, but that violates EU and many of its alternatives.

This analysis found mixed evidence for direct or indirect effects on risky choice among three population groups of undergraduate students, graduate students and faculty in economics and a group from the general population. The discrete choice model directly incorporating objective factors affecting dissimilarity showed no significant differences among these populations. The results of this and previous studies of choice under risk using undergraduate students should be robust for more general populations of interest. There were also significant effects of the elicitation framework in our results.

There is a wide class of problems for which the EU model holds, and another wide class for which violations of the EU model are prevalent. Further, the probability of occurrence of these violations can be predicted by a model using objective characteristics of the questions. These objective characteristics further correspond with notions of dissimilarity (Leland; D. Friedman; Ng; Encarnacion; and Rubinstein) and relate to models of evaluation costs or bounds (Conery; Conlisk; Heiner; Lipman; March; and Simon). The findings described in this paper offer a step toward a model of risky choice based on first principles of behavior called for by Luce (92), giving an empirical challenge for additional effort in this direction.

IMPLICATIONS

When both of the pairs of risky alternatives are dissimilar, the EU model fits rather well; the EU model lacks predictive power when one of the pairs of alternatives is similar and the other is dissimilar. Examination of the choices for the population in this study shows potential worth of a model for choice over similar alternatives, where the method of evaluation for similar risky alternatives differs from that used for dissimilar alternatives. Differences among the population in the similarity "thresholds" that trigger this dichotomy of choice would give differences in choice proportions for the risky alternatives. We conjecture that individuals' evaluation and subsequent choice reflects tradeoffs between the costs and benefits of evaluation effort for the alternatives, with the evaluation of similar alternatives being carried out to a lesser degree than that for the dissimilar alternatives. Future work will explore the validity of this conjectured model for choices under risk.

Economists may be quite interested in evaluating individuals risk preferences through direct elicitation. This paper should offer both confidence and caution to researchers seeking to use the EU model for risky decisions. The pitfalls of choice elicitation shown be the independence violations may well be avoided through survey design that excludes risk pairs perceived to be similar, or that acts to increase this perceived dissimilarity.

ENDNOTES

1.There remain important questions concerning how these results correspond with non-experimental behavior of economic interest; see the review paper by Smith. We take the view that much can be learned about behavior under risk through controlled experiments, despite questions of their correspondence with everyday market behavior, and that additional understanding of the basic factors affecting such results is needed.

2.The outcomes in Kahneman and Tversky's experiments were made using late 1970's Israeli pounds, rather than the 1991/92 U.S. dollar outcomes used in this paper.

3.With the appropriate adjustments on the remaining axioms, if required.

4. The metric is a special case of a k-norm measure given below. Another interesting distance measure is the 1-norm (k=1), known as the "city block" metric (Glazer and Nakamoto). The k-norm(p,q) = $[\sum_{i=1}^{n} (p_i - q_i)^k]^{\frac{1}{k}}$.

5.Another approach to summarizing the outcome effects for similarity would be to select a particular functional representation for EU, such as an exponential utility function, and define a function of the differences in the alternatives' EU values.

6.The probability distributions used in these examples are defined over three outcomes, but in general could be defined for higher dimensions.

7.In addition, the EU model requires that this pattern of choice hold for arbitrary comparisons of pairs within the series, not only for comparisons with the base pair; empirical testing of choices for these comparisons will be the subject of a forthcoming paper.

8.The period of the late 1970's was a particularly difficult one for finding accurate applicable exchange rate measures for Israeli pounds to dollars.

9.Not analyzed in this paper.

10.The remainder of the subjects received a random ordering of the 39 questions in an earlier version of the survey.

11.The undergraduates were taken from the Political Economy of Natural Resources (PENR) courses at UC-Berkeley. These students included freshmen (roughly 30%) through seniors (roughly 20%). The major has a focus on applied micro-economics; the students have received course work comparable with those for students of similar class years in an economics or business major.

12.The undergraduates were given the surveys in their course lecture periods for immediate in-class completion near the beginning of the semester; these students took approximately 30 minutes to complete the survey. The graduate students, faculty and general population respondents were given the survey with both written and verbal instructions and allowed to complete it at their leisure; turnaround time for this group was on average about one week.

13.The difference between the relative proportions here and those of Kahneman and Tversky may be explained by the more diverse population (undergraduates, graduate students and faculty, and non-academics) used in this study, or by differences between the population of late 1970's Israeli students and faculty and this population of respondents from early 1990's Californians.

14.The degrees of freedom count is not adjusted for the estimation of the covariance matrix.

15. This probability is given when the coefficient is multiplied by the value of the density function at the mean values for the explanatory variables [$f(x'\gamma)=.24$] as in (11).

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FIGURE 1: Probability Triangle for EU Preferences.

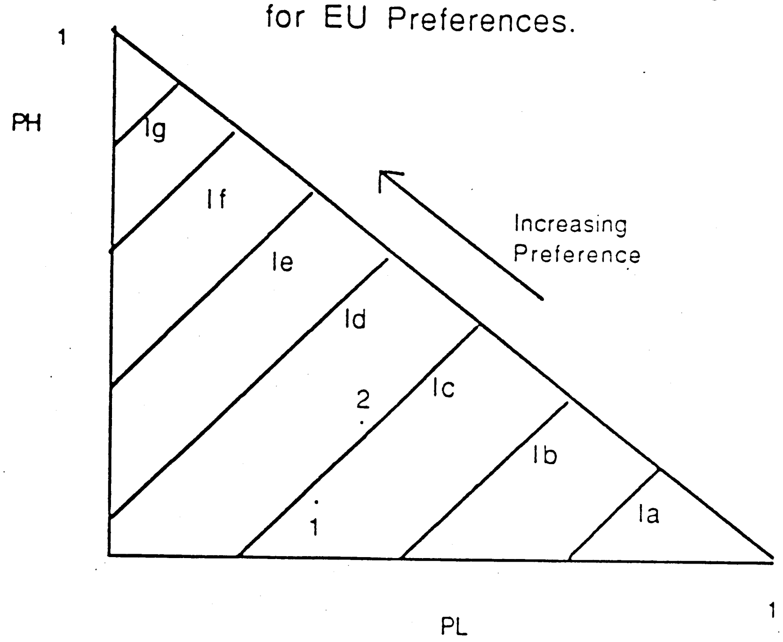
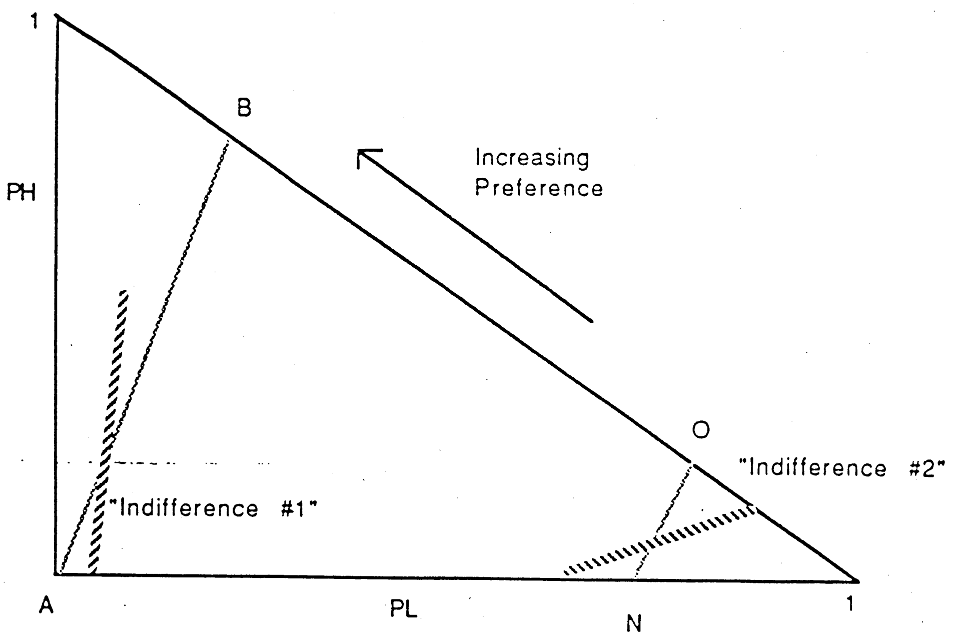


Figure 2: CERTAINTY EFFECT



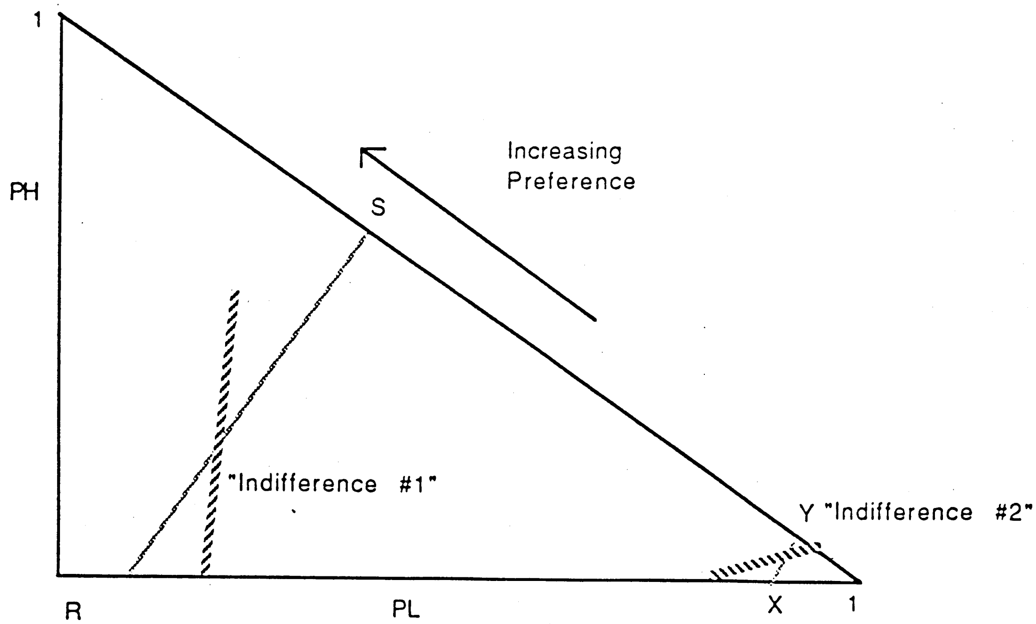
PAIR 1:

A:	vs.	B:
$3000 prob. 1.0		$4000 prob. .8
		$ 0 prob. .2

PAIR 2:

N.	vs.	O:
$3000 prob. .25		$4000 prob. .20
$ 0 prob. .75		$ 0 prob. .80

Figure 3: COMMON RATIO EFFECT



PAIR 1:

R:	vs.	S:
$3000 prob. .9		$6000 prob. .45
$ 0 prob. .1		$ 0 prob. .55

PAIR 2:

X:	vs.	Y:
$3000 prob. .002		$6000 prob. .001
$ 0 prob. .998		$ 0 prob. .999

FIGURE 4:
CUMMULATIVE
DISTRIBUTION
FUNCTIONS.

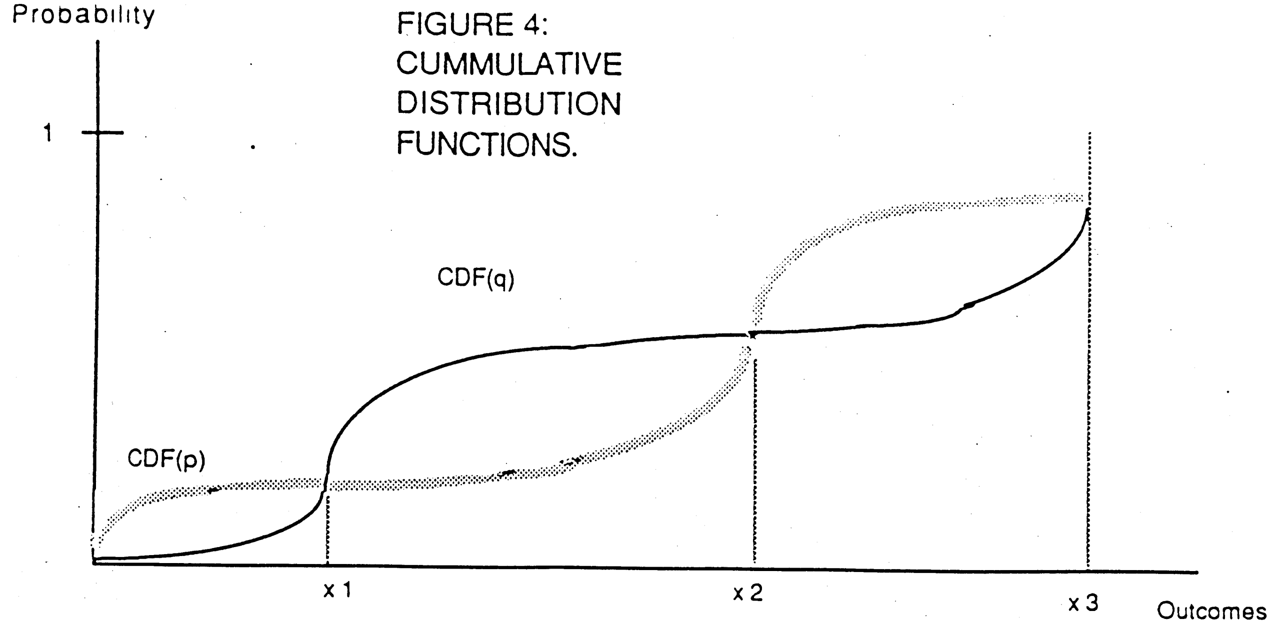
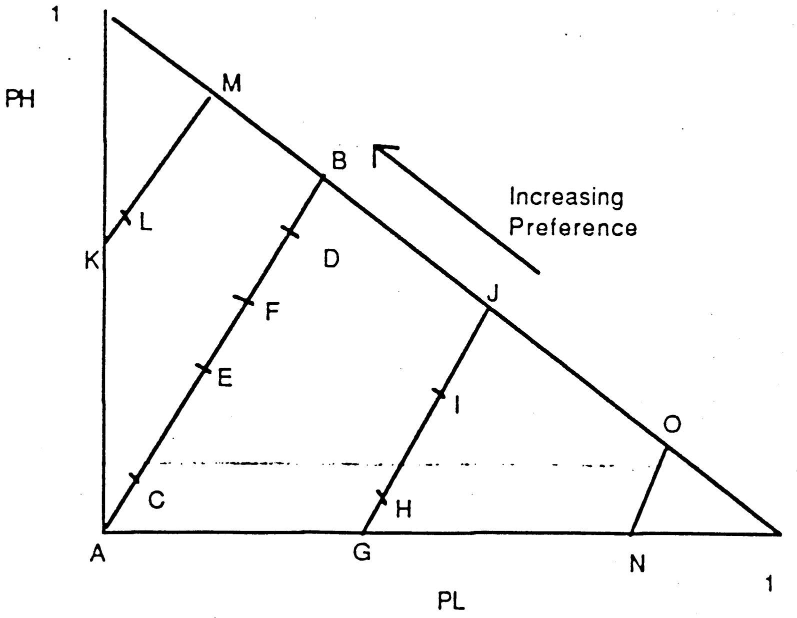


Figure 5: TESTS OVER THE CERTAINTY EFFECT SIMPLEX

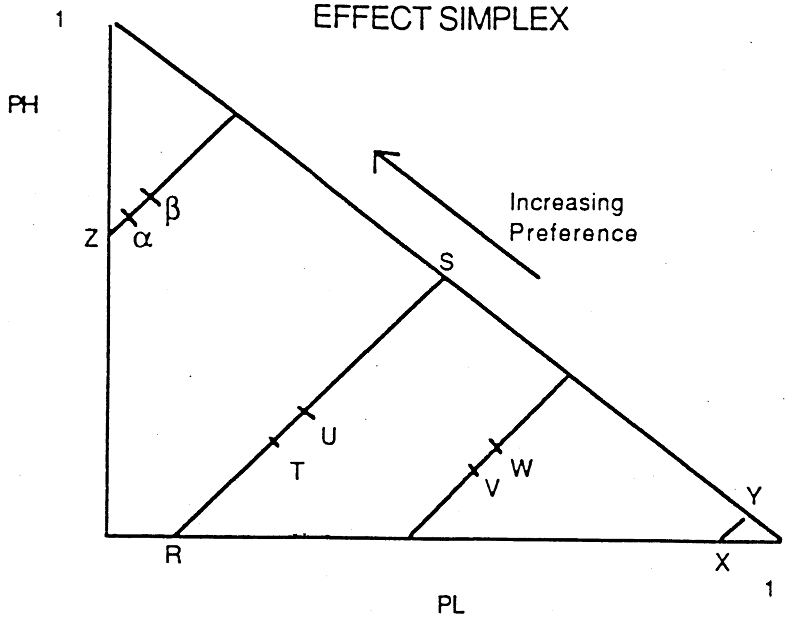


EXAMPLES:

E:		VS.	F:	
$4000 PROB.	.32		$4000 PROB.	.48
$3000 PROB.	.60		$3000 PROB.	.40
$ 0 PROB.	.08		$ 0 PROB.	.12

K:		VS.	L:	
$4000 PROB.	.20		$4000 PROB.	.28
$3000 PROB.	.80		$3000 PROB.	.70
			$ 0 PROB.	.02

FIGURE 6: TESTS OVER THE COMMON RATIO EFFECT SIMPLEX



EXAMPLES:

T:		VS.	U:	
$ 6000 PROB.	.3		$6000 PROB.	.301
$ 3000 PROB.	.3		$3000 PROB.	.298
$ 0 PROB.	.4		$ 0 PROB.	.401

FIGURE 7
DISSIMILARITY/RISKY CHOICE

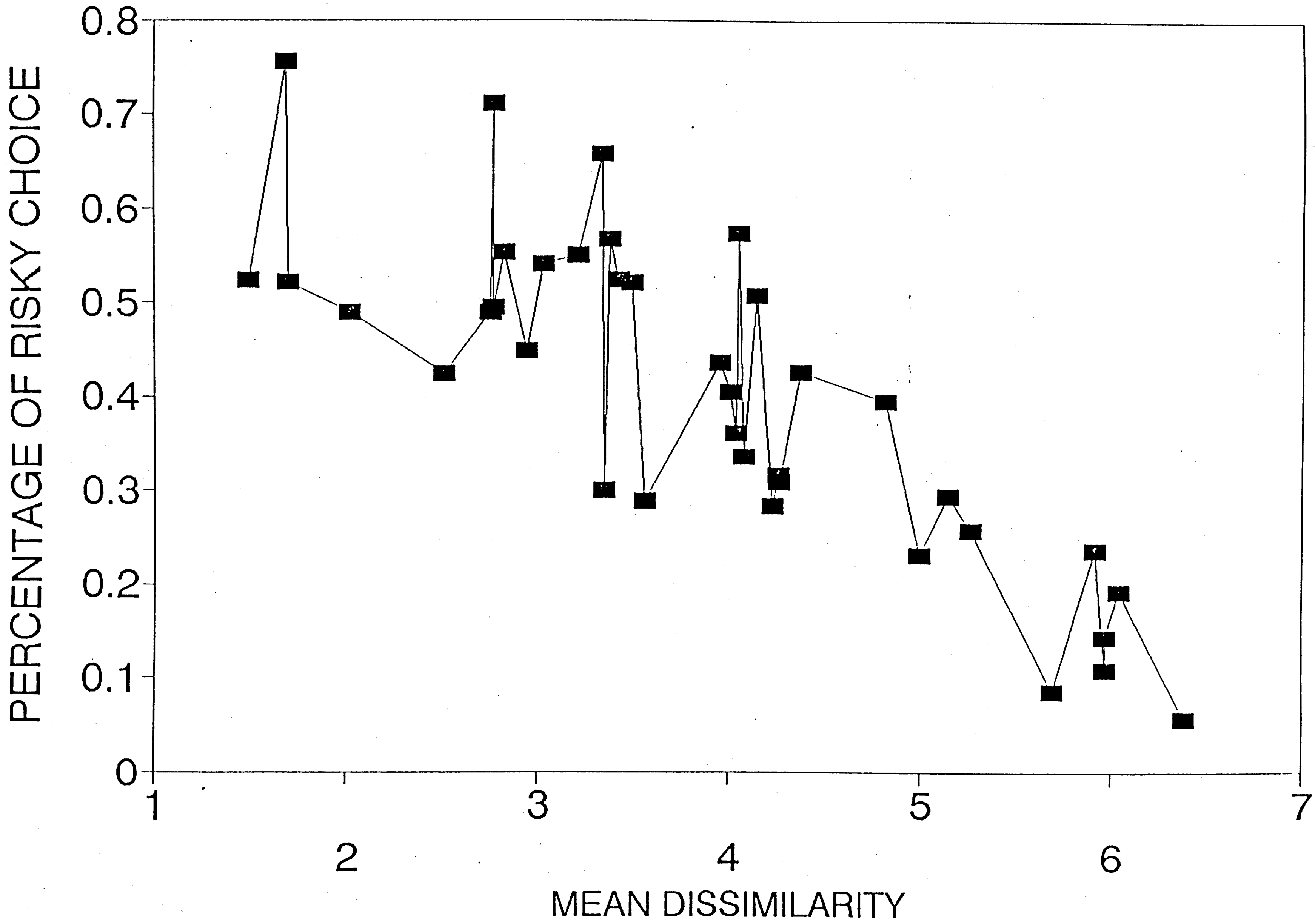


TABLE 1A: CERTAINTY EFFECT PATTERN FOR RISKY CHOICE.

P_i, Q_i DEFINED ON X_i = {\$0,\$3000,\$4000}

#	PAIR	P_1	P_2	P_3	Q_1	Q_2	Q_3	% RISKY	MEAN DISSIM.
1	AB	.0	1.0	.0	.2	.0	.8	.08	5.69
2	NO	.75	.25	.0	.8	.0	.2	.55	2.83
3	AC	.0	1.0	.0	.04	.8	.16	.19	6.05
4	CD	.04	.8	.16	.16	.2	.64	.34	4.27
5	EF	.08	.6	.32	.12	.4	.48	.57	3.37
6	CF	.04	.8	.16	.12	.4	.48	.34	4.08
7	CE	.04	.8	.16	.08	.6	.32	.52	3.43
8	GH	.5	.5	.0	.54	.3	.16	.55	3.21
9	GJ	.5	.5	.0	.6	.0	.4	.45	2.94
10	HI	.54	.3	.16	.56	.2	.24	.71	2.77
11	HJ	.54	.3	.16	.6	.0	.4	.54	3.03
12	KL	.0	.8	.2	.02	.7	.28	.36	4.04
13	KM	.0	.8	.2	.16	.0	.84	.23	5.92
14	CB	.04	.8	.16	.2	.0	.8	.26	5.00
15	LM	.02	.7	.28	.16	.0	.84	.32	5.27
16	BD	.2	.0	.8	.16	.2	.64	.51	4.15
17	FB	.12	.4	.48	.2	.0	.8	.40	4.02
18	AD	.0	1.0	0	.16	.2	.64	.10	5.97
19	AF	.0	1.0	.0	.12	.4	.48	.14	5.97
20	ED	.08	.6	.32	.16	.2	.64	.43	4.38
21	EB	.08	.6	.32	.2	.0	.8	.28	4.23
22	GI	.5	.5	.0	.56	.2	.24	.44	3.96
23	FD	.12	.4	.48	.16	.2	.64	.66	3.33
24	IJ	.56	.2	.24	.6	.0	.4	.56	7.00

TABLE 1B: RISKY CHOICE PAIRS THAT ARE DIMENSIONAL VARIANTS OF THE CERTAINTY EFFECT PATTERN.

P_i, Q_i DEFINED ON X_i = {$0,$3000,$3800,$4000}

#	P_1	P_2	P_3	P_4	Q_1	Q_2	Q_3	Q_4	% RISKY	MEAN DISSIM.
25	.01	.2	.75	.04	.04	.05	.75	.16	.57	4.05
26	.03	.6	.25	.12	.12	.15	.25	.48	.32	4.26

25: 1/4 * C + 3/4 * [3800] vs. 1/4 * D + 3/4 * 3800

26: 3/4 * C + 1/4 * [3800] vs. 3/4 * D + 1/4 * 3800

P_i, Q_i DEFINED ON X_i = {$0,$200,$3000,$4000}

#	P_1	P_2	P_3	P_4	Q_1	Q_2	Q_3	Q_4	% RISKY	MEAN DISSIM.
27	.01	.75	.2	.04	.04	.75	.05	.16	.52	3.49
28	.03	.25	.6	.12	.12	.25	.15	.48	.29	3.56

27: 1/4 * C + 3/4 * [200] vs. 1/4 * D + 3/4 * 200

28: 3/4 * C + 1/4 * [200] vs. 3/4 * D + 1/4 * 200

TABLE 1D: RISKY CHOICE PAIRS USING THE COMMON RATIO EFFECT PATTERN.

P_i, Q_i DEFINED ON X_i={$0,$3000,$6000}

#	PAIR	P_1	P_2	P_3	Q_1	Q_2	Q_3	% RISKY	MEAN DISSIM.
33	RS	.1	.9	.0	.55	.0	.45	.06	6.38
34	XY	.998	.002	.0	.999	.0	.001	.76	1.68
35	TU	.4	.3	.3	.401	.298	.401	.53	1.70
36	VW	.72	.2	.08	.721	.198	.081	.53	1.49
37	Zα	.0	.5	.5	.001	.498	.501	.30	3.35
38	αβ	.001	.498	.501	.002	.496	.502	.42	2.51

P_i, Q_i DEFINED ON X_i={$0,$3000,$5800}

#	P_1	P_2	P_3	Q_1	Q_2	Q_3	% RISKY	MEAN DISSIM.
39	.998	.002	.0	.999	.0	.001	.61	2.02

TABLE 1C: RISKY CHOICE PAIRS USING PROBABILITIES FROM THE CERTAINTY EFFECT BUT WITH VARIED OUTCOMES.

PROBABILITIES AS IN QUESTION #1 (AB IN FIGURE 1)

$P^1 = (0,1.0,0)$ vs. $Q^1 = (.2,0,.8)$

#	OUTCOME VECTOR	POP. % RISKY	MEAN DISSIM.
1	X = ($0,$3000,$4000)	.08	6.05
29	X = ($0,$750,$1000)	.19	5.15
30	X = ($0,$12000,$16000)	.09	4.82

PROBABILITIES AS IN QUESTION #2 (NO IN FIGURE 1)

$P^2 = (.75,.25,0)$ vs. $Q^2 = (.8,0,.2)$

$= 1/4\ P^1 + 3/4 * (0)$ $= 1/4 * Q^1 + 3/4 * (0)$

#	OUTCOME VECTOR	POP. % RISKY	MEAN DISSIM.
2	X = ($0,$3000,$4000)	.55	2.83
31	X = ($0,$750,$1000)	.60	2.77
32	X = ($0,$12000,$16000)	.58	2.75

RESULTS REPORTED BY KAHNEMAN AND TVERSKY:

OUTCOMES (0,3000,4000) ISRAELI POUNDS.

PAIR	% CHOOSING RISKY
P^1,Q^1	.21
P^2,Q^2	.68

TABLE 2: PRACTICE QUESTIONS IN THE RISK SURVEY.

PRACTICE QUESTION 1.

I. Circle one of the following alternatives (A or B) that you would prefer to have:

A. Gives:	B. Gives:
$5000 with a 20% chance	$6000 with a 15% chance
$ 0 with an 80% chance.	$ 0 with a 85% chance.

****

****

PRACTICE QUESTION 2.

I. Circle one of the following alternatives (A or B) that you would prefer to have:

A. Gives:	B. Gives:
$5000 with a 5% chance	$5000 with a 10% chance
$4000 with a 15% chance	$4000 with a 5% chance
$ 0 with an 80% chance.	$ 0 with an 85% chance.

II. Mark a point on the scale from 0 (Similar) to 9 (Very Dissimilar) with a slash (/) mark to rate how DIFFERENT A and B seem to be:

DISSIMILARITY SCALE:

0	3	6	9
(Similar)	(Somewhat Diss.)	(Dissimilar)	(Very Dissimilar)

III. Mark a point on the scale from 0 (Indifferent) to 9 (Very Strong) with a slash (/) mark to rate how STRONGLY you would prefer to have the alternative (A or B) that you circled above.

STRENGTH OF CHOICE SCALE:

0	3	6	9
(Indifferent)	(Somewhat Strong)	(Strong)	(Very Strong)

****

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TABLE 3: EXPLANATORY VARIABLES FOR GENERALIZED LEAST SQUARES ON PERCEIVED QUESTION DISSIMILARITY.

QUESTION CHARACTERISTICS:

PROBABILITY DISTANCE MEASURE (METRIC OR CDF BASED)
DISTANCE SQUARED, DISTANCE CUBED,
INDICATOR VARIABLE FOR PSEUDO-CERTAINTY ($P_1=0$ OR $Q_1=0$),
INDICATOR VARIABLE FOR EQUI-DIMENSIONAL SUPPORT,
THE ORDER OF THE ALTERNATIVE PAIR IN THE SURVEY,
THE DIFFERENCE IN THE ALTERNATIVES' EXPECTED VALUES,
THE MINIMUM OF THE EXPECTED VALUES OF THE ALTERNATIVES,
THE RATIO OF THE EV DIFFERENCE OVER THE MINIMUM EV.

INDIVIDUAL CHARACTERISTICS:

AGE,
PERSONAL INDICATOR VARIABLES:
- GENDER (1=MALE),
- INDICATOR FOR UNDERGRADUATES,
- INDICATOR FOR NON-ACADEMICS AND NON-UNDERGRADS,

EDUCATION INDICATORS: (HIGH SCHOOL GRADUATE BASE):
- SOME COLLEGE
- COLLEGE GRADUATE
- GRADUATE OR PROFESSIONAL STUDIES,

SURVEY TEST GROUP INDICATOR:
- GROUP 1 (INITIALLY MORE LOW-DISTANCE PAIRS)
- GROUP 2 (INITIALLY MORE HIGH-DISTANCE PAIRS).

INTERACTION TERMS, COMBINATION QUESTION/INDIVIDUAL VARIABLES:

- METRIC MEASURE * UNDERGRADUATE INDICATOR,
- METRIC MEASURE * NON-ACADEMIC INDICATOR,
- PSEUDO-CERTAINTY IND. * UNDERGRADUATE INDICATOR,
- PSEUDO-CERTAINTY IND. * NON-ACADEMIC INDICATOR,
- EQUI-DIMENSIONAL SUPPORT IND. * UNDERGRAD. IND.,
- EQUI-DIMENSIONAL SUPPORT IND. * NON-ACADEMIC IND.,
- EXPECTED VALUE DIFFERENCE * UNDERGRADUATE IND.,
- EXPECTED VALUE DIFFERENCE * NON-ACADEMIC IND.,
- MINIMUM EXPECTED VALUE * UNDERGRADUATE INDICATOR,
- MINIMUM EXPECTED VALUE * NON-ACADEMIC INDICATOR.
- RELATIVE DIFFERENCE IN EXPECTED VALUES* UNDERGRADUATE INDICATOR,
- RELATIVE DIFFERENCE IN EXPECTED VALUES* NON-ACADEMIC INDICATOR,

TABLE 4A: RESULTS OF GENERALIZED LEAST SQUARES ON PERCEIVED QUESTION DISSIMILARITY, THE METRIC MEASURE.

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 1171 DF
QUESTION CHARACTERISTICS			
METRIC	13.144	1.0588	12.415
METRIC SQUARED	-12.644	1.8794	-6.7279
METRIC CUBED	5.0889	0.97414	5.2240
PSEUDO-CERT IND.	1.0078	0.18694	5.3911
EQUI-DIM. IND.	-0.48851	0.16195	-3.0165
ORDER	0.28E-02	0.01355	0.20683
EV DIFFERENCE	0.26E-03	0.11E-02	0.23996
MINIMUM EV	0.28E-04	0.58E-04	0.47754
EV DIFF./MIN. EV	-37.587	5.6115	-6.6981
PERSONAL CHARACTERISTICS:			
GENDER	-0.03160	0.10718	-0.29485
AGE	-0.99E-02	0.47E-02	2.0879
EDUC. LEVEL 3	0.58556	0.39905	1.4674
EDUC. LEVEL 4	0.23920	0.36600	0.65353
EDUC. LEVEL 5	0.18143	0.32238	0.56278
NON-ACADEMIC	1.7611	0.55998	3.1449
UNDERGRADUATE	1.1206	0.40287	2.7814
TEST GROUP1	0.59161	0.13315	4.4433
TEST GROUP2	0.21754	0.12524	1.7369
INTERACTION TERMS:			
METRIC*UNDER.	-1.1042	0.39071	-2.8261
METRIC*NON-ACAD.	-1.5596	0.44687	-3.4899
PSEUDO-CERT.*UN.	0.40228	0.30426	1.3221
PSEUDO-CERT.*NA.	-0.16738	0.31102	-0.53816
EQUI-DIM.*UNDER.	0.30911	0.26485	1.1671
EQUI-DIM.*NON-AC.	-0.21209	0.27585	-0.76886
MIN EV*UNDER.	-0.43E-04	0.96E-04	-0.45832
MIN EV*NON-ACAD.	0.33E-02	0.13E-03	0.24574
EV DIFF.*UNDER	0.80E-03	0.18E-02	0.44447
EV DIFF*NON-ACAD.	-0.32E-02	0.30E-02	-1.0667
[EV DIFF/MIN EV]*UN.	4.2201	10.650	0.39625
[EV DIFF/MIN EV]*NA.	0.40531	8.8978	0.04555
CONSTANT	0.11395	0.08221	1.3860

R-SQUARE = 0.6060 R-SQUARE ADJUSTED = 0.5959

TABLE 4B: RESULTS OF GENERALIZED LEAST SQUARES ON PERCEIVED QUESTION DISSIMILARITY, THE CDF BASED MEASURE.

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	T-RATIO 1390 DF
QUESTION CHARACTERISTICS			
CDF MEASURE	35.071	3.6099	9.7152
CDF SQUARED	-115.52	22.787	-5.0695
CDF CUBED	162.59	39.946	4.0703
PSEUDO-CERT IND.	0.89124	0.20323	4.3853
EQUI-DIM. IND.	-0.37E-02	0.17464	-0.0212
ORDER	0.93E-02	0.01393	0.66955
EV DIFFERENCE	0.29E-02	0.11E-02	2.5606
MINIMUM EV	-0.62E-05	0.61E-04	-0.10174
EV DIFF./MIN. EV	-19.593	5.7303	-3.4193
PERSONAL CHARACTERISTICS:			
GENDER	-0.85E-02	0.11117	-0.07603
AGE	0.92E-02	0.47E-02	1.9612
EDUC. LEVEL 3	0.44531	0.41061	1.0845
EDUC. LEVEL 4	0.04117	0.37765	0.10845
EDUC. LEVEL 5	-0.09441	0.34291	-0.27532
NON-ACADEMIC	1.9431	0.61138	3.1782
UNDERGRADUATE	1.0797	0.41053	2.6301
TEST GROUP 1	0.51230	0.13528	3.7868
TEST GROUP 2	0.33628	0.13180	2.5515
INTERACTION TERMS:			
CDF MEAS.*UNDER.	-3.4844	1.3724	-2.5390
CDF MEAS.*NA.	-5.1003	1.5988	-3.1901
PSEUDO-CERT.*UN.	0.36896	0.31560	1.1691
PSEUDO-CERT.*NA.	-0.12990	0.32198	-0.40345
EQUI-DIM.*UN.	0.18835	0.28007	0.67250
EQUI-DIM.*NA.	-0.33281	0.29544	-1.1265
EV DIFF.*UNDER	0.45E-03	0.18E-02	0.25453
EV DIFF*NON-ACAD.	-0.19E-02	0.30E-02	-0.63261
MIN EV*UNDER.	-0.87E-04	0.97E-04	-0.89369
MIN EV*NON-ACAD.	0.38E-04	0.15E-03	0.26266
[EV DIFF/MIN EV]*UN.	-4.9271	10.792	-0.45656
[EV DIFF/MIN EV]*NA.	-2.49031	8.6731	-0.28713
CONSTANT	0.21309	0.08452	2.5211

R-SQUARE = 0.5920 R-SQUARE ADJUSTED = 0.5816

TABLE 5: LOGIT MODEL 1 REGRESSIONS ON RISKY CHOICE; DEPENDENT VARIABLE EQUALS ONE FOR RISKIER SELECTION.

QUESTION CHARACTERISTICS:

- THE ESTIMATED DISSIMILARITY OF THE ALTERNATIVES
- THE DIFFERENCE BETWEEN THE TWO EXPECTED VALUES,
- THE LOWER OF THE TWO EXPECTED VALUES, A MEASURE OF THE (HYPOTHETICAL) STAKES INVOLVED,
- THE RATIO OF THE DIFFERENCE IN THE EXPECTED VALUES OF THE ALTERNATIVES OVER THE LOWER OF THE EXPECTED VALUES.
- THE ORDER OF THE QUESTION.

PERSONAL CHARACTERISTICS:

- BASE CHOICE BETWEEN A DISSIMILAR PAIR
- AGE,
- PERSONAL INDICATOR VARIABLES:
  - GENDER (1=MALE),
  - INDICATOR FOR MARRIED INDIVIDUALS,
  - INDICATOR FOR INDIVIDUALS WITH CHILDREN,
  - INDICATOR FOR UNDERGRADUATES,
  - INDICATOR FOR NON-ACADEMICS,
  - EDUCATION INDICATORS: (HIGH SCHOOL GRADUATE BASE):
    - SOME COLLEGE
    - COLLEGE GRADUATE
    - GRADUATE OR PROFESSIONAL STUDIES,
  - INCOME (1991) LEVEL INDICATOR ($0-$10000 AS BASE):
    - $10,000 TO $30,000 INDICATOR,
    - $30,000 TO $50,000 INDICATOR,
    - $50,000 TO $100,000 INDICATOR,
    - OVER $100,000 INDICATOR.
- SURVEY TEST GROUP INDICATORS:
  - GROUP 1 (INITIALLY MORE LOW-DISTANCE PAIRS),
  - GROUP 2 (INITIALLY MORE HIGH-DISTANCE PAIRS).

INTERACTION EFFECTS, COMBINATION QUESTION/INDIVIDUAL VARIABLES:

- DISSIMILARITY ESTIMATE * UNDERGRADUATE INDICATOR,
- DISSIMILARITY ESTIMATE * NON-ACADEMIC INDICATOR,
- BASE CHOICE*UNDERGRADUATE INDICATOR,
- BASE CHOICE*NON-ACADEMIC INDICATOR,
- EXPECTED VALUE DIFFERENCE * UNDERGRADUATE INDICATOR,
- EXPECTED VALUE DIFFERENCE * NON-ACADEMIC INDICATOR,
- MINIMUM EXPECTED VALUE * UNDERGRADUATE INDICATOR,
- MINIMUM EXPECTED VALUE * NON-ACADEMIC INDICATOR,
- RELATIVE EXPECTED VALUE DIFFERENCE * UNDERGRAD. IND.,
- RELATIVE EXPECTED VALUE DIFFERENCE * NON-ACADEMIC IND.

TABLE 6: LOGIT REGRESSION MODEL 1 RESULTS, FITTED DISSIMILARITY AS AN INDEPENDENT VARIABLE.

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	ASYMPTOTIC T-RATIO
QUESTION CHARACTERISTICS:			
EST. DISSIMILARITY	-0.61485	0.055624	-11.054
ORDER	-0.18E-02	0.29E-02	-0.61482
EV DIFFERENCE	-0.20E-02	0.16E-02	-1.2404
MINIMUM EV	0.39E-05	0.39E-04	0.0994
EV DIFF./MIN EV	7.4735	4.1830	1.7866
PERSONAL CHARACTERISTICS:			
BASE CHOICE	1.4295	0.12685	11.270
GENDER	0.26713	0.08378	3.1885
MARRIAGE	-0.02031	0.13642	-0.14890
CHILDREN	0.33824	0.12233	2.7649
AGE	-0.01712	0.46E-02	-2.3362
EDUCATION LEVEL 3	0.44217	0.38074	1.1613
EDUCATION LEVEL 4	-0.06338	0.37369	-0.16959
EDUCATION LEVEL 5	0.31803	0.37665	0.84435
NON-ACADEMIC	1.45491	0.46120	3.1545
UNDERGRADUATE	0.49583	0.50831	0.97544
TEST GROUP1	0.47242	0.09892	4.7759
TEST GROUP2	0.38152	0.09296	4.1040
INCOME LEVEL 2	-0.25228	0.14970	-1.6853
INCOME LEVEL 3	-0.04659	0.18645	-0.24985
INCOME LEVEL 4	-0.07726	0.18581	-0.41579
INCOME LEVEL 5	-0.45165	0.25812	-1.7498
INTERACTION VARIABLES:			
EST. DISS.*UNDER.	0.06925	0.08683	0.79755
EST. DISS.*NON-AC.	-0.28E-02	0.11113	-0.02556
EV DIFF.*UNDER	0.12E-02	0.23E-02	0.53735
EV DIFF*NON-ACAD.	-0.13E-02	0.27E-02	-0.47174
MIN EV*UNDER.	-0.49E-04	0.59E-04	-0.83765
MIN EV*NON-ACAD.	0.21E-04	0.69E-04	0.30746
[EV DIFF/MIN EV]*UN	-7.3360	6.2290	-1.1777
[EV DIFF/MIN EV]*NA	-9.6983	7.5024	-1.2927
BASE*UNDER	-0.40E-02	0.19740	-0.02032
BASE*NON-AC.	-0.05155	0.22105	-0.23320
CONSTANT	0.76503	0.48093	1.5907

LIKELIHOOD RATIO TEST = 731.631 WITH 31 D.F.

PREDICTION SUCCESS TABLE

		ACTUAL 0	ACTUAL 1
PREDICTED	0	1887.	794.
PREDICTED	1	448.	871.

PERCENTAGE OF RIGHT PREDICTIONS = 0.68950

TABLE 7: LOGIT MODEL 2 REGRESSIONS ON RISKY CHOICE; DEPENDENT VARIABLE EQUALS ONE FOR RISKIER SELECTION.

QUESTION CHARACTERISTICS:

- METRIC, METRIC SQUARED AND METRIC CUBED,
- INDICATOR FOR PSEUDO-CERTAINTY,
- INDICATOR FOR EQUI-DIMENSIONAL SUPPORT
- ABSOLUTE DIFFERENCE IN THE ALTERNATIVES' EXPECTED VALUES,
- MINIMUM EXPECTED VALUE OF THE ALTERNATIVES,
- RELATIVE ABSOLUTE EXPECTED VALUE DIFFERENCE,
- THE ORDER OF THE SURVEY QUESTION.

PERSONAL CHARACTERISTICS

- BASE CHOICE MEASURE FOR A RELATIVELY DISSIMILAR PAIR,
- GENDER INDICATOR (1=MALE),
- INDICATOR FOR MARRIAGE,
- INDICATOR FOR CHILDREN,
- THE AGE OF THE INDIVIDUAL,
- EDUCATION LEVEL INDICATORS:
  - LEVEL 3 (SOME COLLEGE)
  - LEVEL 4 (COLLEGE GRADUATE)
  - LEVEL 5 (GRADUATE OR PROFESSIONAL STUDIES),
  - INDICATOR FOR NON-ACADEMICS,
  - INDICATOR FOR UNDERGRADUATES,
  - TEST GROUP 1 (INITIALLY MORE LOW-METRIC QUESTIONS),
  - TEST GROUP 2 (INITIALLY MORE LARGE-METRIC QUESTIONS)

INTERACTION TERMS:

- BASE CHOICE * UNDERGRADUATE INDICATOR,
- BASE CHOICE * NON-ACADEMIC INDICATOR,
- METRIC*UNDERGRADUATE INDICATOR
- METRIC*NON-ACADEMIC INDICATOR
- PSEUDO-CERTAINTY*UNDERGRADUATE INDICATOR
- PSEUDO-CERTAINTY*NON-ACADEMIC INDICATOR
- EXPECTED VALUE DIFFERENCE*UNDERGRAD. INDICATOR
- EXPECTED VALUE DIFFERENCE*NON-ACADEMIC INDICATOR
- MINIMUM EXPECTED VALUE*UNDERGRADUATE INDICATOR
- MINIMUM EXPECTED VALUE*NON-ACADEMIC INDICATOR
- RELATIVE DIFFERENCE IN EXPECTED VALUES*UNDERGRAD. INDICATOR,
- RELATIVE DIFFERENCE IN EXPECTED VALUES*NON-ACADEMIC INDICATOR.

TABLE 8: RESULTS FOR LOGISTIC REGRESSION MODEL 2 ON CHOICE; DEPENDENT VARIABLE IS ONE FOR RISKIER SELECTION.

VARIABLE	ESTIMATED COEFFICIENT	STANDARD ERROR	ASYMPTOTIC T-RATIO
QUESTION CHARACTERISTICS:			
METRIC	-3.2150	0.90821	-3.5399
METRIC SQUARED	-1.8878	1.6335	-1.1557
METRIC CUBED	1.5912	0.89658	1.7747
ORDER	-0.30E-02	0.29E-02	-1.0279
PSEUDO-CERTAINTY	-0.80557	0.14677	-5.4888
EQUI-DIMENSION	0.09233	0.09570	0.96472
EV DIFFERENCE	0.12E-03	0.17E-02	0.07335
MINIMUM EV	-0.28E-04	0.39E-04	-0.71584
EV DIFF./MIN EV	24.275	4.6621	5.2070
PERSONAL CHARACTERISTICS:			
BASE CHOICE	1.4062	0.12926	10.878
GENDER	0.29652	0.08426	3.5190
MARRIAGE IND.	-0.20E-01	0.13745	-0.14449
CHILDREN IND.	0.35223	0.12256	2.8739
AGE	-0.01727	0.46E-02	-3.7709
EDUCATION LEVEL 3	0.09970	0.38173	0.26117
EDUCATION LEVEL 4	-0.26472	0.37458	-0.70670
EDUCATION LEVEL 5	0.11160	0.37863	0.29475
NON-ACADEMIC IND.	0.51081	0.31452	1.6241
UNDERGRADUATE IND.	-0.16235	0.46123	-0.35199
TEST GROUP 1 IND.	0.07121	0.09630	0.73945
TEST GROUP 2 IND.	0.26847	0.09279	2.8932
INCOME LEVEL 2	-0.25405	0.15050	-1.6881
INCOME LEVEL 3	-0.05741	0.18779	-0.30569
INCOME LEVEL 4	-0.07199	0.18704	-0.38489
INCOME LEVEL 5	-0.45278	0.25952	-1.7447
INTERACTION TERMS:			
METRIC*NON-ACAM.	0.30472	0.55969	0.54444
METRIC*UNDER.	0.68867	0.47116	1.4617
PSEUDO-CERT*UNDER	0.27478	0.20085	1.3681
PSEUDO-CERT*NON-AC	-0.05256	0.24356	-0.21581
BASE*UNDER	0.03554	0.20234	0.17565
BASE*NON-ACAM	0.30E-02	0.22586	-0.01348
EV DIFF.*UNDER	0.14E-02	0.25E-02	0.58245
EV DIFF*NON-ACAD.	0.34E-02	0.30E-02	1.1178
MIN EV*UNDER.	-0.28E-04	0.39E-04	-0.71584
MIN EV*NON-ACAD.	0.10E-04	0.69E-04	-0.14623
[EV DIFF/MIN EV]*UN	-9.7534	6.5833	-1.4815
[EV DIFF/MIN EV]*NA	-12.044	7.9376	-1.5174
BASE*UNDER	0.03554	0.20234	0.17565
BASE*NON-ACAM	-0.30E-02	0.30E-02	1.1178
CONSTANT	0.51938	0.47901	1.0843

LIKELIHOOD RATIO TEST = 792.139 WITH 37 D.F.

PREDICTION SUCCESS TABLE

		ACTUAL 0	ACTUAL 1
PREDICTED	0	1900	768
	1	435	897

PERCENTAGE OF RIGHT PREDICTIONS = 0.69925

TABLE 9: PATTERNS OF INTRANSITIVE CHOICE SUGGESTED BY THE SIMILARITY MODEL:

PATTERN 1:

E CHOSEN OVER C,
F CHOSEN OVER E,
D CHOSEN OVER F,
B CHOSEN OVER D,
but C CHOSEN OVER B,

PATTERN 2:

F CHOSEN OVER E
D CHOSEN OVER F
B CHOSEN OVER D
but E CHOSEN OVER B

		N	MEAN	ST. DEV
INTRANSITIVITY PATTERN 1		117	0.094	0.293
T-VALUES,	HO: $\mu=0$	3.47		
	HO: $\mu=(.5)^5$	2.32		

		N	MEAN	ST. DEV
INTRANSITIVITY PATTERN 2		115	0.096	0.295
T-VALUES,	HO: $\mu=0$	3.48		
	HO: $\mu=(.5)^4$	1.22		