University of the Philippines
SCHOOL OF ECONOMICS

Discussion Paper 8401 February 1984

Multidimensional Choice and Preference Reversals

by

José Encarnación, Jr.

Abstract

Results of various experiments reported in recent literature have shown repeated violations of expected utility theory. In the model of this paper, expected utility is only the first of three criteria that determine choices under uncertainty--the second criterion is the probability of doing better than or at least maintaining the status quo, and the third is the maximum possible gain. Choice being thus multidimensional, the observed violations get accounted for: the Allais and Ellsberg paradoxes, probabilistic insurance, risk seeking with negative prospects, translation effects, preference reversals, and Tversky intransitivities.

Multidimensional Choice and Preference Reversals

By José Encarnación, Jr.*

Recent papers by Paul Schoemaker (1982) and by Paul Slovic and Sarah Lichtenstein (1983) have made even more pronounced the difficulties for existing theory regarding choice under uncertainty that David Grether and Charles Plott (1979) and also David Kahneman and Amos Tversky (1979) had brought to the attention of economists. In addition to "preference reversals", "intransitivities" call for an explanation. Much earlier of course, the Allais paradox was an embarassment to the von Neumann-Morgenstern expected utility model, as also the pattern of choices observed by Daniel Ellsberg (1961). If the broad outlines of expected utility theory are to be maintained, some reformulation is necessary in order to accomodate the puzzling facts that have been observed.

Section I presents a model of binary choice that provides in Section II straightforward explanations of most of the preference puzzles. Testing the model is discussed in Section III, and Section IV considers the case of more than two alternatives. The Ellsberg paradox which belongs to a different class is treated in Section V. Section VI is a concluding remark.

I. A Model of Binary Choice

Let $u(x, s)$ be the von Neumann-Morgenstern utility of the consequence of alternative x if $s \in S$ is the true state of nature. Merely for notational simplicity, we define S so that $s \in S$ has a probability $p = p(s) > 0$. We will say that there is a positive prospect with the pair (x, y), or more briefly $\mu(x, y) > 0$, if $u(x, s) > u^0$ or $u(y, s) > u^0$

for some $s \in S$, where u^0 is the utility of the status quo;[1/] otherwise, we will say that prospects are nonpositive. Putting $u = 0$ for the utility corresponding to "disaster", we will assume $u > 0$ throughout the following discussion.

Let

$$S'(x ; y) = \begin{cases} \{s \in S \mid u(x, s) > u^0\} & \text{if } \mu(x, y) > 0 \\ \{s \in S \mid u(x, s) = u^0\} & \text{otherwise} \end{cases}$$

and define the probability

$$b(x; y) = \sum_{s \in S'(x ; y)} p(s) .$$

Note that $b(x ; x)$ is simply the probability $\Pr\{u(x, s) > u^0\}$ if the latter is positive; otherwise, $b(x ; x) = \Pr\{u(x, s) = u^0\}$. For notational convenience we will write $b(x) = b(x ; x)$. We will denote the expected utility of x by

$$a(x) = \sum_{s \in S} p(s)\, u(x, s)$$

and write

$$c(x) = \max_{s \in S} u(x, s)$$

for the maximum utility possible with x.

While $a(x)$ and $c(x)$ depend only on x given $p = p(s)$, $b(x ; y)$ depends also on y because of the way $S'(x ; y)$ is defined. If there is a positive prospect so there is a chance of doing better than the status quo, it is plausible that the probability of doing so would be a criterion of choice in some circumstances; if prospects are nonpositive however, one would be concerned instead with the probability of maintaining the status quo. Clearly, one would rather have b higher than lower, and similarly with c.

Let α^* $(0 < \alpha^* < 1)$ and β^* $(0 < \beta^* < 1)$ be given for the moment. In order to define the choice on $\{x, y\}$, write

$$U_1(x\,;y) = \begin{cases} (a(x) + a(y))/2 & \text{if } \alpha(x, y) \leq \alpha^* \\ a(x) & \text{otherwise} \end{cases}$$

$$U_2(x\,;y) = \begin{cases} (b(x\,;y) + b(y\,;x))/2 & \text{if } \beta(x, y) \leq \beta^* \\ b(x\,;y) & \text{otherwise} \end{cases}$$

$$U_3(x\,;y) = c(x)$$

where $\alpha(x, y) = |a(x) - a(y)|/\max\{a(x), a(y)\}$ and $\beta(x, y) = |b(x\,;y) - b(y\,;x)|$. We note that $\alpha(x, y)$ could be small even if the absolute difference $|a(x) - a(y)|$ is large provided that $\max\{a(x), a(y)\}$ is large enough; also, $U_1(x\,;y) = U_1(y\,;x)$ if $\alpha(x, y) \leq \alpha^*$, and similarly, $U_2(x\,;y) = U_2(y\,;x)$ if $\beta(x, y) \leq \beta^*$.

Let xCy mean that x is chosen over y. Our fundamental assumption is that xCy if the first nonvanishing difference $U_i(x\,;y) - U_i(y\,;x)$, $i = 1, 2, 3$, is positive. We will write xR_iy if $U_i(x\,;y) \geq U_i(y\,;x)$ and $U_j(x\,;y) = U_j(y\,;x)$ for all $j < i$; and xC_iy if xR_iy and not yR_ix. Thus, under our assumption, xCy if xC_1y or xC_2y or xC_3y. We will say that criterion a is effective in the choice of x over y if xC_1y; similarly, b is effective if xC_2y and c if xC_3y.

In the above lexicographic formulation, the first criterion of choice is expected utility a. If α, the relative difference between the expected utilities, is larger than α^*, the alternative with the higher a is chosen and that is the end of the matter. However if α is sufficiently small, i.e. $\alpha(x, y) \leq \alpha^*$, then U_1 is the same for both alternatives and does not distinguish between them. We will say then that x and y are within α^* of each other, or that x and y are effectively indifferent with respect to a, so that one turns to the second criterion: the probability b of doing better than the status quo if possible, or at least maintaining the status quo if not. In effect we are assuming expected utility indifference bands that get wider with higher $\max\{a(x), a(y)\}$. Suppose a high $a(x) > a(y)$. Then with α^* not too large, a(y) would also be relatively high if y is within α^* of x, and one would be willing to forego the higher a with x if a larger b can be had with y. The larger is α^*, the greater is the extent to which a person is willing to give up a larger a for the sake of a higher b.

A similar situation holds in regard to b when $\alpha \leq \alpha^*$. If β exceeds β^*, the alternative with the higher b is chosen. If β is sufficiently small however, so that x and y are effectively indifferent as regards b as well as a, one turns to the third criterion: the maximal c that is possible. The larger is β^*, the more a person is willing to trade a larger b for a higher c.

We consider α^* as a tradeoff parameter whose value is an individual characteristic and independent of any particular decision problem. A person with a higher α^* is simply willing to trade off more a for b. The number β^* is different. Let $q(x) = \min_{s \in S} u(x, s)$ and write $Q(x, y) = |q(x) -$

$q(y)|/\min\{q(x), q(y)\}$. The larger is Q, i.e. the larger is the relative difference between the worst possible outcomes, the greater would be the regret if the alternative with the higher q is rejected and what turns out is the worst possible outcome of the one chosen. We therefore postulate that $\beta^* = h(Q)$ with $h'(Q) < 0$ so that $\beta^* = \beta^*(x, y)$ is a function of x and y. If the worst possible outcomes are the same so $Q = 0$, the possibility of regret in our sense does not arise. The value of the trade-off parameter $\beta^* = h(0)$ thus indicates the extent to which a person is willing to trade off b for c, uncomplicated by any regret aspects. We consider the function h to be characteristic of an individual, in the same way that a person's indifference map in consumer theory is an individual characteristic.

Our assumption is that $0 < \alpha^* < 1$ and $0 < \beta^* < 1$. Consider, however, the more general specification $0 \leq \alpha^* \leq 1$ and $0 \leq \beta^* \leq 1$. The standard expected utility model can be subsumed under the special case $\alpha^* = 0$ where the alternative with the higher a will always be chosen, and only when a is the same for both alternatives would the second criterion become effective. Another special case obtains with $\alpha^* = 1$ and $\beta^* = 0$ identically. Here, expected utility does not count because $\alpha \leq \alpha^*$; the alternative with the higher b will always be chosen, and only when b is the same could c be effective. A third special case is had with $\alpha^* = 1$ and $\beta^* = 1$ where, since $\beta \leq \beta^*$, c is always the effective criterion. Each special case is thus extremal in its own way.

II. Explanations

Using the model of Section I, a wide range of observations, including some not necessarily in conflict with expected utility theory but interesting nonetheless, can be easily explained.

In Table 1, the entries $M > m > 0$ are the money payoffs corresponding to different options and states of nature, the latter labeled by their probabilities $p_1 < p_2 < p_3$. ($\Sigma p_i = 1$ in Table 1 and in the other tables to follow.) According to the "independence axiom",[2/] so named by Paul Samuelson (1952), the choice between x and y should be independent of the payoffs in the p_3 column where they are the same, and similarly for x' and y'. Since x and x' are identical except for their p_3 payoffs, and the same is true about y and y', one must then have $x'Cy'$ if xCy. Yet, which is the Allais' paradox, most persons indicate xCy but $y'Cx'$ for some specifications of the probabilities and payoffs (m relatively large compared to annual income). We note that $a(x) - a(y) = a(x') - a(y')$ so $\alpha(x, y) > \alpha(x', y')$ since $\max\{a(x), a(y)\} < \max\{a(x'), a(y')\}$. One can therefore have $\alpha(x, y) > \alpha^* \geq \alpha(x', y')$ whence, if $a(x) > a(y)$, xC_1y but the second criterion could be effective in the choice on $\{x', y'\}$. With m large, $Q(x', y')$ would be large and β^* small, and if $\beta(x', y') > \beta^*$ as seems likely, $y'C_2x'$. The Allais paradox is thus resolved with criterion a effective in the choice on $\{x, y\}$ and b in $\{x', y'\}$.

An experiment of Kahneman and Tversky shows that a majority of persons who might buy regular insurance would not buy what they call probabilistic insurance. In Table 2, x is the purchase of regular insurance for a price m to protect against the possible loss of M whose (low) probability is $p_2 + p_3$ where $p_2 = p_3$ (the amounts m and M need not be the same in different tables); y is the option of being uninsured; and x' is the purchase of an insurance policy where the probability of coverage in the event of loss is 1/2. If the utility function is concave in the relevant range and xCy, one must also have x'Cy in the expected utility model. The usual pattern observed is yCx' if xCy. In the experiment, the subjects had a supposedly bare preference for x over y. Accordingly, suppose xC_1y with $\alpha(x, y)$ barely larger than α^*. Since $\alpha(x', y) < \alpha(x, y)$, one would then have $\alpha(x', y) \leq \alpha^*$, and yC_2x' might be expected since p_1 is large and therefore $\beta(x', y) > \beta^*$ is likely.

Kahneman and Tversky have also drawn attention to the fact that people who exhibit risk aversion when the possible payoffs are nonnegative often choose the riskier alternative when the payoffs are multiplied by -1. In Table 3 where $M > m > 0$ and $p_1 \geq p_2 > p_3$, the expected values of x and y are about the same; the expected values of x' and y' are therefore also about the same. The typical response is y'Cx' if xCy. Considering the expected values involved, suppose $\alpha \leq \alpha^*$ in {x, y} and {x', y'}. Then the simple explanation would be that b is effective in both cases: xC_2y and $y'C_2x'$.

A similar account suffices for the effect observed by John Payne, Dan Laughhunn and Roy Crum (1980, 1981). In their experiments the expected values of x and y are the same, the range of outcomes of y falls within that of x, and x has a larger probability of a positive payoff than does y. Specifically, suppose the outcomes of x are m_1, m_3 and m_5, those of y are m_2, m_3 and m_4, and $m_1 < \ldots < m_4 < 0 < m_5$. Consider a "translation" of {x, y} to {x', y'} by adding a constant k to the outcomes of x and y to define x' and y' respectively, such that

$m_1 + k < 0 < m_2 + k$. All payoffs of y' are then positive while x' has a possible negative outcome. The usual pattern of choices is xCy and y'Cx', which is explainable by xC_2y and $y'C_2x'$.

Table 4 has $p_1 = p_2$, an advance bonus of 2m being awarded in the choice on {x, y} and 4m on {x', y'}. In terms of payoffs plus bonuses, x and x' are thus identical, as are y and y'. Kahneman and Tversky have found, however, that the common pattern is xCy and y'Cx'. Evidently the advance bonus which is independent of one's choice, is in each case considered as part of the status quo. Suppose that in both cases, $\alpha \leqq \alpha^*$ and $\beta^* < 1/2$, which do not seem unlikely. Then one has xC_2y and $y'C_2x'$, explaining the observed choices. Prospects being nonpositive with {x', y'}, one is concerned with the probability of the status quo which is 1/2 for y' and 0 for x'.[3/]

In Table 5, $p_1 = p_2 > p_4 = p_5$, p_1 is sizeable and p_4 small (Kahneman and Tversky used $p_1 = 0.45$ and $p_4 = 0.001$ in their experiment). Looking at the probabilities and payoffs involved, expected utility theory requires x'Cy' if xCy. However, the majority pattern is xCy and y'Cx'. It is straightforward to show that $\alpha(x, y) \leqq \alpha^*$ implies $\alpha(x', y') \leqq \alpha^*$. Suppose a is not effective in {x, y} so it is also not effective in {x', y'}. Since $\beta(x', y')$ is much smaller than $\beta(x, y)$, one can easily have $\beta(x', y') \leqq \beta^* < \beta(x, y)$ in which case xC_2y and $y'C_3x'$.

The Grether and Plott (1979) results corroborate those of the Lichtenstein and Slovic (1971) experiment on preference reversals. Lottery ticket x gives a relatively high probability of a moderate payoff, and y gives a middling probability of a larger payoff. With either ticket the possible loss is relatively small, and the expected values are about the same. In situation (i) the subjects are made to choose between x and y; in (ii) they are asked to indicate their minimum selling prices separately for x and y. It turns out that many persons who choose x over y in (i) place a higher value on y in (ii). We observe that since (ii) does not involve a choice on $\{x, y\}$ but requires specific valuations of x and y instead, it would be natural to express the latter in terms of $a(x)$ and $a(y)$ to determine the selling prices. If $a(y) > a(x)$, one would therefore quote a higher price for y. If $\alpha(x, y) \leqq \alpha^*$ however, which would be likely, xC_2y in (i) is explained.

Following Tversky (1969), let us say that x is adjacent to y if x gives a slightly smaller probability of a somewhat larger payoff compared to y, other possible outcomes being zero. Accordingly, if x is adjacent to y, $Q(x, y) = 0$ and $\beta^* = h(0)$. Suppose x is adjacent to y, y to z, and z to w. Tversky's experiment shows that one can have xCy, yCz and zCw but wCx, which may be called a 4-cycle. C is thus not transitive and, more strongly, some binary choices produce cycles. We note that if x is adjacent to y, it would be likely that $\alpha(x, y) \leqq \alpha^*$ and $\beta(x, y) \leqq \beta^*$, in which case xC_3y, yC_3z and zC_3w. But w is not adjacent to x, and although $\alpha(w, x) \leqq \alpha^*$ would also be likely, so would $\beta(w, x) > \beta^* = h(0)$ in which case wC_2x since w has a higher b. In what might be called a Tversky cycle, c is effective in each binary choice except the last where b is effective and a cycle is produced.

III. Tests and Parameter Estimation

According to our model, Lichtenstein-Slovic reversals will not occur if $\alpha(x, y)$ is large enough. An experiment recently reported by Werner Pommerehne, Friedrich Schneider and Peter Zweifel (1982) seems to suggest that reversals are less frequent if the payoffs of x and y are more differentiated, but as Grether and Plott (1982) point out, experimental results under different conditions need not be comparable. In terms of our model, a lower frequency of reversals would be due to the fact that $\alpha \leqq \alpha^*$ is satisfied less often, but this requires the same group of subjects.

Suppose that in a Grether-Plott type of experiment, one finds that for a number of subjects, xCy in situation (i) and a higher value for y in (ii). Call this Phase I of a larger experiment. To simplify matters, include in the experimental group G for Phase II only those subjects in Phase I who placed a higher value for y in (ii). Accordingly, $a(y) > a(x)$ for the subjects in G, where the frequency of reversals is given by the xCy cases among them. Let there be a new option x' in place of x, such that x' offers a somewhat smaller payoff than x but is otherwise the same as x in regard to the possible loss and the probabilities involved, so that $a(x') < a(x)$. With $a(x) < a(y)$ we then have $\alpha(x', y) > \alpha(x, y)$, so if $\alpha(x, y) \leqq \alpha^* < \alpha(x', y)$ in which case yC_1x', there would be no reversals in Phase II. Thus a higher frequency of reversals in Phase II would falsify the model, and a lower frequency would mean that some persons in G who showed reversals in Phase I (for whom $\alpha(x, y) \leqq \alpha^*$) do not show reversals in Phase II ($\alpha(x', y) > \alpha^*$). For such a person, the shift from a reversal to a nonreversal then provides an interval estimate of his α^* given $a(x)$, $a(y)$ and $a(x')$. (The utility function would have to be inferred from experiments where $\alpha > \alpha^*$ in order that expected utility would be the effective criterion.)

The Tversky type of experiment where cycles appear can also be used to test the model or provide parameter estimates. Recall that there, some subjects exhibited a 4-cycle. Call that Phase I of a larger experiment. To simplify matters, exclude from the experimental group G in Phase II those subjects who produced 3-cycles (e.g., xCy, yCz and zCx) in Phase I. Consider a new option w' in place of w, such that z is adjacent to w' and w' is closer to z (in an obvious sense) than is w, so that where $\alpha(z, w) \leqq \alpha^*$ and $\beta(z, w) \leqq \beta^*$, we also have $\alpha(z, w') \leqq \alpha^*$ and $\beta(z, w') \leqq \beta^*$, in which case zC_3w'. But now if $\beta(w', x) \leqq \beta^* < \beta(w, x)$ so that xC_3w', there would be no cycles in Phase II. Thus a higher frequency of cycles in Phase II would falsify the model, and a lower frequency would mean that some persons in G who produced cycles in Phase I (for whom $\beta(w, x) > \beta^*$) do not produce cycles in Phase II ($\beta(w', x) \leqq \beta^*$). For such a person, the shift from a cycle to a noncycle then provides an interval estimate of his $\beta^* = h(0)$. (Fixing Q in an appropriately modified Tversky experiment, one would also be able to estimate $\beta^* = h(Q)$.)

Suppose that following the above procedures, we have obtained estimates of α^* and $\beta^* = h(0)$. We can then formulate appropriate options x, y and z with zero minimum payoffs, so $\beta^* = h(0)$ throughout, such that

$$a(x) < a(y) < a(z), \quad b(x) > b(y) > b(z)$$

$$\alpha(x, y) \leqq \alpha^*, \quad \alpha(y, z) \leqq \alpha^*, \quad \alpha(x, z) > \alpha^*$$

$$\beta(x, y) > \beta^*, \quad \beta(y, z) > \beta^*.$$

According to the model, we will have a 3-cycle : xCy, yCz and zCx, because xC_2y, yC_2z and zC_1x, which thus provides another test.

IV. The Choice Function

The fact that some binary choices produce cycles raises the question of choice on a set of more than two alternatives. In the model of Section I, criterion a has first priority and only when the two alternatives considered are within α^* of each other does criterion b come into play, and only when they are also within β^* of each other does criterion c get to be effective. Such considerations can be easily extended to the case of more than two alternatives.

Denoting the set of alternatives by A, which for simplicity we take to be finite, let

$$A_i = \{x \in A_{i-1} | \forall y \in A_{i-1}: xR_i y\} \quad i = 1, 2, 3$$

where $A_0 = A$ and R_i is as defined in Section I. Our assumption is that $g(A)$, the set of elements chosen in A, is given by

$$g(A) = A_1 \cap A_2 \cap A_3 = A_3.$$

Writing $a(x_1) = \max\{a(x) | x \in A\}$, we have $A_1 = \{x \in A | \alpha(x_1, x) \leq \alpha^*\}$; i.e., A_1 is the set of elements in A that are within α^* of x_1, which has maximal expected utility. If A_1 is not a singleton, R_2 narrows the choice to A_2. Let $A^+ = \{x \in A | \exists s \in S: u(x, s) > u^0\}$ and write

$$b(x_2) = \begin{cases} \max\{b(x) | x \in A_1 \cap A^+\} & \text{if } A_1 \cap A^+ \neq \emptyset \\ \max\{b(x) | x \in A_1\} & \text{otherwise.} \end{cases}$$

In other words, x_2 maximizes the probability of improving on the status quo if there is a positive prospect with A_1; otherwise, x_2 maximizes the probability of maintaining the status quo. Thus $A_2 = \{x \in A_1 | \beta(x_2, x) \leq \beta^*(x_2, x)\}$. Finally, if A_2 is still not a singleton, R_3 narrows down the choice to $A_3 = \{x \in A_2 | c(x) = \max\}$.

Given any feasible A, the choice g(a) is thus well defined. The implication for the Tversky cycle is that $g(\{x, y, z, w\}) = \{w\}$, which can be tested.

Consider now what $g(\{x, y, z\})$ might be if y is a probability mixture of x and z such that $a(y) = (a(x) + a(z))/2$. Expected utility theory requires that $g(\{x, y, z\}) \neq \{y\}$; i.e., the "in-between" y can never be the choice. In Table 6, $0 < m_1 < \ldots < m_4$ and the probability of each state is 0.25. Gordon Becker, Morris DeGroot and Jacob Marschak (1963) have found that some subjects choose y. Suppose $a(x) < a(z)$. Since $a(z) - a(y) = a(y) - a(x)$, $\alpha(y, z) \leq \alpha^* < \alpha(x, y)$ is possible, in which case yC_1x and either yC_2z or yC_3z.

V. Ambiguous Probabilities

The preceding discussion has assumed that in each case there is a unique probability function $p = p(s)$ that is used as the basis for the calculations that determine choice. The p used is a matter of subjective belief--it is the most credible--even if usually grounded on observed relative frequencies or stated "objective" probabilities. But consider Table 7 where $p_1 = 1/3$ is known while p_2 and p_3 are unknown. This puts the matter in a different class, and Ellsberg has found that the typical responses are xCy and y'Cx', violating the independence axiom. Permitting zero probabilities, apparently it is a relevant consideration that on $\{x, y\}$ one is assured of a 1/3 probability of winning with x while the probability with y could be 0 (it could be 2/3 but one does not know); on the other hand, on $\{x', y'\}$ the probability is 2/3 with y' but possibly only 1/3 with x' (it could be 3/3 but again, one does not know). The probabilities are "ambiguous", as Ellsberg put it.

Let $\lambda(p)$ be the degree of belief in p, and write $B = \{p | \lambda(p) = \max\}$. B need not be a singleton, so we now make the conservative assumption that

$$a(x) = \min_{p \in B} \{\sum_{s \in S} p(s) \ u(x, s)\}.$$

The criteria b and c can be similarly defined in terms of $\min_{p \in B}$. Suppose that in the Ellsberg paradox, every p satisfying $p_1 = 1/3$ has the same credibility. Then $a(x) > a(y)$ and $a(y') > a(x')$, whence xC_1y and $y'C_1x'$ if $\alpha \leqq \alpha^*$, which seems likely.

VI. Concluding Remark

In the model of this paper, a person faced with a choice under uncertainty follows three criteria in order of priority. Confronted with a set of alternatives, he first selects that subset of effectively indifferent alternatives that includes maximal elements with respect to expected utility. If the result is a singleton, the expected utility criterion suffices. If not, as happens in most of the preference puzzles, he narrows down the selection by looking at the probability of doing better than the status quo if possible, or at least maintaining the status quo. One would of course prefer that this probability be higher than lower. He thus picks out from the first subset that subset of effectively indifferent alternatives that includes maximal elements with respect to this probability. The end of it all, however, is the maximal gain possible, which becomes the effective criterion when the first two criteria do not yield a singleton. Choice being thus multidimensional, different criteria apply in different circumstances, and a broad range of observations can be accounted for.[4/]

For alternative approaches, see the recent contributions by Kahneman and Tversky, Graham Loomes and Robert Sugden (1982), Mark Machina (1982), and David Bell (1982). These other theories explain some but not all of the phenomena referred to in this paper.

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Notes

*School of Economics, University of the Philippines.

1. The status quo is independently "given" for the decision problem at hand. It is that which, ceteris paribus, a person would want to improve on or at least maintain.

2. Equivalent to the formal postulate P2 of Leonard Savage (1954), this is different from Savage's nonformal "sure-thing principle"; see José Encarnación (1969).

3. "Framing" effects (Tversky and Kahneman, 1981), where apparently equivalent decision problems evoke different responses depending on how they are formulated, can also be explained in terms of what is considered the status quo.

4. Standard expected utility theory, where the utility function is bounded, suffices to dispose of the well known St. Petersburg paradox; see Kenneth Arrow (1971, ch. 2).

Table 1

	P_1	P_2	P_3
x :	0	M	0
y :	m	m	0
x':	0	M	m
y':	m	m	m

Table 2

	P_1	P_2	P_3
x :	-m	-m	-m
y :	0	-M	-M
z :	-m/2	-m	-M

Table 3

	P_1	P_2	P_3
x :	m	m	0
y :	M	0	M
x':	-m	-m	0
y':	-M	0	-M

Table 4

	P_1	P_2
x :	m	m
y :	2m	0
x':	-m	-m
y':	-2m	0

Table 5

	p_1	p_2	p_3	p_4	p_5
x :	m	m	0	0	0
y :	2m	0	0	0	0
x':	0	0	0	m	m
y':	0	0	0	2m	0

Table 6

	p_1	p_2	p_3	p_4
x :	m_1	m_1	m_4	m_4
y :	m_1	m_2	m_3	m_4
z :	m_2	m_2	m_3	m_3

Table 7

	p_1	p_2	p_3
x :	m	0	0
y :	0	m	0
x':	m	0	m
y':	0	m	m