*On the Bounds of the Economic Lore of Nicely Calculated Less or More for Natural Environments**

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I. Introduction. Joan Robinson (1962, p. 29) tells us that though *value* is "just a word," it is "one of the great metaphysical ideas in economics." It implies that scarcity pervades our beings and that available resources must therefore be allocated among competing uses. But, like all metaphysical concepts, its exact meaning is hard to pin down. Robinson would likely still be bewildered if she were to consider the contending current economic and noneconomic views about the origins of value. This bewilderment might be heightened by the evolving tensions within economics about the appropriate reach of what has become a singular concept of value within the discipline.

This paper reviews and evaluates noneconomic and economic perspectives on the origins and measures of value in natural environments. It tries to go beyond the standard recitation of the economic tools of benefit-cost analysis in environmental settings in order to look behind the scenes at the limits and strengths of these tools. The next section speaks to the basic noneconomic perspectives. In a third section, we discuss the limits and strengths of the constrained utility maximization paradigm upon which economics relies. We argue the paradigm applies at the level of the exchange institution or medium rather than at the level of the individual. A fourth section evaluates the standard economic analytical tools and data gathering devices by the extent to which they place the individual in proximity to an exchange institution of her own choosing. A fifth section treats participation in exchange institutions as a choice variable for the individual and considers the impact of this endogeneity upon valuation criteria. In conclusion, we argue that the motivation for valuing natural environments can be adequately serviced only if the value expressions in the nonmarket exchange institutions that people use to articulate their preferences and to negotiate preference satisfaction are granted more-or-less equal weight with the value indicators that the solitary individual utility maximization paradigm produces. This position is founded upon two demonstrations. First, value expressions are sensitive to the presence

* With apologies to William Wordsworth (1770-1850)

or absence of opportunities for the individual to articulate preferences and to negotiate with others, and to the context (the exchange institution) within which the articulation and negotiation occurs. Second, though the incomplete optimization in which the individual may engage away from an exchange institution can result in only trivial losses for the individual, this same incompleteness can induce major deadweight welfare losses for an economy.

II. Perspectives on Value. Four core perspectives dominate discussions about the value of natural environments. One view denies the valuation problem for nature on grounds that nature has a dignity and integrity that is beyond price. Wordsworth's *Ecclesiastical Sonnet, Number XLIII*, vividly captures the position:

> *Tax not the royal Saint with vain expense...*
> *Give all thou canst; high Heaven rejects the lore*
> *Of nicely-calculated less or more...*

Also witness Little (1975, pg. 50)

> *Landscape perception and the impulse to preservation of place is, perhaps, no more or less an authentic existential act, free of deterministic rationalism, undertaken as a way to dignify a man and to make his surroundings more humane.... What further argument for landscape presentation is needed?*

Nature and its protection is a fundamental value or it evokes fundamental values such as love, nobility, honor, heroism, and commitment that morally allow no substitutes. Nature must therefore never be instrumentalized. It is a categorical imperative that takes precedence over all goods. Anderson (1990, 1993) relaxes this noninstrumentalist view somewhat. She readily grants that the elements of the natural world are scarce and must therefore be actively valued and managed. She objects to the "commoditization" of nature, however, especially as embodied in the instrumentalist market criteria which she says benefit-cost analysis employs. According to Anderson, by trying to force all environmental valuation expressions into an uncritical instrumentalist mode, benefit-cost analysis fails to recognize that not all value is personal and calculating. Personal wants, such as love, honor, and awe of respect for the restraint with nature, are more worthy of other's appreciation and encouragement than are fish for food and timber for housing. Just as economists recognize that markets do not define efficiency, they must recognize that markets do not define all values. Indeed, markets corrode the very moral foundations they need for their effectiveness (Hirsh, 1976). Market criteria inadequately represent the plurality of ways in which people value their relationships to "the unity of nature."[1] So as to capture full expressions of value, Anderson asks that the legitimacy of the means by which environmental

values are established be evaluated—whether or not a gain is ill-gotten, for example. In addition to assessing values in terms of the roles that people play as producers and consumers, she insists, as did Marglin (1963), that values toward nature are also captured in people's public personas—their roles as equal citizens and moral agents in shared settings where they mutually articulate, hear, weigh, and respond to each other's ideals and principles and to the nonmarket norms which may inform them (Sagoff, 1988). Markets and market standards do not express all of the values associated with environmental assets nor do they always appreciate or encourage appropriate social norms.

A third value perspective would have "objective" bases for value which involve neither the tastes and knowledge of individuals nor their institutional mediates. Adherents want "... to rest their structure on a quantity...outside the system of price-variables, and independent of them" (Dobb, 1937, p. 12). Values are said to inhere in things generally by the mass and energy they embody (Georgescu-Roegan, 1971, Chap. 5). These embodiments constitute thermodynamically limited potentials or reservoirs of services, i.e., "work."[2] Because neither ecosystem functions nor expressions of subjective human preferences can be realized without this potential work, these embodiments are thought more fundamental and thus more worthy of being used as a normative standard and a numeraire.

The value measure which dominates economics clashes sharply with the preceding three approaches and measures. In contrast to an objective mass or energetic measure, the economic measure is subjective. Value expresses extant human purposes. Choice, whether or not it is ill-conceived and the opportunity to make it ill-gotten, is the exercise of these purposes. Value thus reflects the instantaneous subjective preferences and private and common knowledge of individuals. It is revealed in and mediated by the exchange institutions through which the individual expresses credible commitments to others (Samuelson, 1938). These institutions can but need not allow everything to be traded against everything else. Individuals, through their repeated institutional interactions, are presumed to be better judges than anyone else of the consequences of their choices for their own well-beings. Social value, as revealed through individuals' choices mediated through exchange institutions, is simply an aggregate of individual human dispositions. These dispositions can be made to encompass altruistic motives as well as narrowly defined self-interest (Bergstrom, 1995).

As one device to defend their subjective approach to value, economists point out the flaws in the three noneconomic approaches to value. The noninstrumentalist perspective is immediately recognized as a lexical preference ordering in which the individual views one asset bundle as better than another if the one contains more of the most preferred component than does the other bundle. Other bundle components do not matter to this ranking of bundles. As is well-known, because the continuity axiom is then not fulfilled, a lexical preference ordering cannot be represented by a utility function (Bower, 1968), implying that the

two bundles are incommensurable and that the economist's standard tools to measure demand and supply and thus to infer value are therefore inappropriate.

Incommensurability arguments elicit two responses from economists.[3] First is the Robinson (1962) response that scarcity pervades our beings and that the provision of any asset involves an alternative use forgone. A choice of resource use or preservation involves an opportunity cost, regardless of how one makes the decision. Prices, and thus values, are implicit in the process of choice, and the relevant question is the validity of the rules that determine prices. Societies may wall up certain assets and prohibit their exchange. Their price, however, is the exchange foregone. Value must exceed this price; otherwise the exchange would not be foregone. Contrary to noninstrumentalist arguments like Anderson's, value and price are not synonymous to the economist.

In practice, those who make incommensurability arguments often make a composite (nature) of a set of individual assets, (e.g., mosquitoes, whales, and algae). Individuals are then asked to identify each component of the composite with the entire composite. An individual with this vector-order preference relation views one commodity bundle as being at least as good as another only if each of the components of one is at least as large as the corresponding components of the other. If a vector u offers more of some components and less of others than does the vector x, the individual cannot trade y and x because his preference criterion does not allow him to choose. Tradeoffs are therefore out of the question and the desired walling up of the composite commodity is achieved. One should not jump to the conclusion, however, that an inability to make trades and the incomplete preferences implied by the vector-order relation are synonymous. Preferences can be learned. The ability to compare, which is fundamental to the economist's world view, permits "I don't know right now" responses to opportunities to rank bundles y and x (Keynes, 1921). One may not have thought enough about the utility of x and therefore one might be unwilling to exchange y to get more x. But one can invest in learning about one's preference for x by participating in exchange institutions (Crocker and Shogren, 1991).

The flaws in the matter and energy approaches to value have been an especially inviting target for economists. First, the forms of energy and matter and its context—portability, storability, cleanliness, convenience, etc.—matter to biological and economic systems (Georgescu-Roegan, 1979). Different forms of energy and matter are impractical substitutes, nor can energy and matter be viewed in the aggregate as practical substitutes. Consequently, neither energy nor matter provide an invariant foundation upon which to measure system performance. Second, some kind of give and take must occur if the work potentials that embodied matter and energy represent are to be realized. This give and take is driven by existing combinations of psychologically motivated and genetically programmed purposes and perceptions (Hansson and Stuart, 1990; Rogers,

1994) and institutionally mediated expectations of what the involved individuals expect to gain or to avoid losing (Buchanan, 1969). Individuals' exchange behaviors are thus rooted in their subjective values rather than intrinsic matter and energy potentials.

Perhaps most troublesome for advocates of an energy theory of value for human activities is the specification of exactly how thermodynamic considerations are to replace or even to enrich economic analysis (Burness, et al., 1980). Given the inattention of thermodynamics to the demand side of allocation problems, it is hardly surprising that the conditions for the coincidence of physical efficiency and economic efficiency are quite stringent. For example, Berry, et al. (1978) establish the conditions for the coincidence with respect to efficiency in the second or entropy law.[4] Their result depends upon letting the "highest" thermodynamic use represent the opportunity cost of available work. In the same paper, they separately establish the coincidence conditions for the first or energy conservation law.

The crux of the problem for those who volunteer energy theories of value is that simultaneous attainment of energy conservation efficiency and entropy efficiency is an analytical impossibility. That is, the two types of physical efficiency are independent of each other and it is impossible to optimize jointly over two independent quantities.

Energy conservation efficiency for a physical process is defined as (Ford, et al., 1975 p. 26)

$$Z_1 = \frac{Y(K)}{X(K)}, \tag{2.1}$$

where Y is useful energy input or work performed, X is the total energy input, K is capital, and the unit of analysis is homogeneous calories. Capital or the specifics of the process determine the magnitude of (2.1), the portion of the input energy content delivered usefully to the process output.

Entropy efficiency tells a different story. It is defined as (Ford, et al., 1975, p. 27)

$$Z_2 = \frac{Y(K)}{Y(\text{Max})}, \tag{2.2}$$

where $Y(\text{Max})$ represents the maximum theoretical transfer of work with a given energy input for the *task* at hand. This theoretical maximization is defined without reference to any particular device or physical process. Equivalently, expression (2.2) defines efficiency as the ratio of the theoretically smallest available work that could have done the task relative to the available work actually used. The independence of (2.1) and (2.2) is easily demonstrated. Assume nonindependence such that (2.1) and (2.2) are related by

$$\frac{Y(K)}{Y(\text{Max})} = a + b\frac{Y(K)}{X(K)}, \tag{2.3}$$

so that

$$Y(\text{Max}) = \frac{X(K)Y(K)}{aX(K) + bY(K)}. \tag{2.4}$$

Differentiation of (2.4) with respect to $Y(K)$ gives

$$\frac{dY(\text{Max})}{dY(K)} = \frac{a[X(K)]^2}{[aX(K) + bY(K)]^2}, \tag{2.5}$$

implying that an increase in useful energy output of a particular process causes the maximum theoretical transfer of work for the task at hand to change by the ratio of squared terms on the right-hand-side. But this is impossible since $Y(\text{Max})$ is not process-specific—it refers to something like an ideal heat engine and is therefore independent of the specific real-time process to which energy conservation efficiency refers. In fact, because $Y(\text{Max})$ is calculated with respect to an infinitely slow, irreversible process, real-time processes introduce a tradeoff between time and entropy efficiency. The process accelerations required in real-time demand more useful energy. It follows that physical efficiency must, when applied to real-world problems, be second-best defined in terms of its very own criteria. As is well-known, second-best efficiency may be first-best inefficient.

III. Value and Exchange Institutions.

Behavior Anomalies. Economists do not rid themselves of well-known weaknesses in their subjective approach to value when they point out the flaws in others' approaches. The foundation of the economic approach is the expression of instantaneous dispositions through repeated give and take with others in the context of a coordinating exchange institution which prescribes uniform incentives and articulates knowledge and beliefs about relevant laws of nature and of man. The institution relates the individual's choices to the choices of others and to the consequences the sum of these choices produce. Institutions are collective habits. When they are absent, the individual must draw more intensely upon her personal resources.

Exchange institutions often—even usually—do not exist for environmental goods. Individuals must act as if their values will not be contested, dialog with others is absent, they are asocial, and therefore need not be accountable to others. Unless one makes the rather silly presumption that she is a complete image of a nonstrategic, anonymous competitive market, the individual lacks incentives to act in fashions from which all persons would benefit.

Psychological and economic evidence is overwhelming that, absent the arbitrage behaviors which exchange institutions urge, individuals frequently fail to behave in accordance with the dictates of utility maximization, the axiomatic foundation of the subjective approach to value. The evidence makes the utility maximization paradigm, when applied to the isolated individual, appear as

rather like a formal mathematical structure driven by its own imperatives of complete and consistent utility functions rather than as a device to bridge the gap between our conjectures and observations. Thaler (1992) explains a lengthy catalogue of violations of the continuity, completeness, and transitivity axioms, including endowment effects (goods in inventory are valued more highly than goods not in inventory), framing effects (problem context affects choices), preference reversal effects (the order in which people rank lotteries differs between when they do and do not have to pay for them), anchoring effects (status quo points affect choices), opportunity cost effects (out-of-pocket costs are given greater weight in choices than are opportunity costs), immediacy effects (recent events have greater weight in decisions than do distant events of similar magnitude), and many others. Psychologists explain these discrepancies in terms of the cognitive limits of individual human beings (Hogarth, 1987); economists generally try to identify ways in which the axiomatic foundations of utility maximization paradigm might be adapted in order to appropriate the anomalies (Machina, 1989). Much less frequently (e.g., Chu and Chu, 1990, on preference reversals; Gode and Sunder, 1993, on ignorance; and Shogren, 1990, on the certainty effect), has the question been asked of whether exchange institutions reduce or negate the propensity of individuals to make choices not in accord with the predictions of the utility maximization paradigm. We present limited empirical evidence below that the involvement of the individual in an exchange institution reduces these discrepancies.

An Experiment. We focus on the Vickrey (1961) second-price auction to illustrate how an exchange institution can reduce differences between an individual's critically informed value expressions and her anomalous behaviors or naive expectations. The second-price auction implies that the highest bidder wins the auction and pays the second highest bid. Vickrey introduced the second-price auction to eliminate the least plausible assumption in game-theoretic models of auction behavior—the common knowledge assumption about each bidder's values, rationality, beliefs, and strategies. Regardless of the private strategies of other bidders, an individual's dominant strategy in the second-price auction is to reveal her true value for the good since what she pays is independent of what she bids. To see this, assume there are N bidders with private valuations, $v_1 \geq v_2 \geq v_n \geq 0$, for a risk reduction from the lottery $E\varphi_i = \pi_i v_i + (1-\pi_i)\vartheta_i$, where $v_i \geq \vartheta_i$, and $\pi_i \in [0,1]$. Each bidder submits a sealed bid, $b_i \in [0,+\infty)$, where the highest bidder wins the auction and pays the second-highest bidder's bid, thereby receiving the payoff, $v_i - \max_{j\neq i} b_j$. The bidder's payoff function is

$$u_i = \begin{cases} v_i - \max_{j\neq i} b_j & b_i > \max_{j\neq i} b_j \\ E\varphi_i & b_i < \max_{j\neq i} b_j. \end{cases}$$

If bidder i bids more than her valuation, v_i, she increases the likelihood ex post that she will ex ante pay more than she wanted to for the good, $b_i > \max_{j\neq i} b_j >$

v_i. If she bids lower than v_i, she increases the likelihood that she will miss what proves to be a good deal, $v_i > \max_{j \neq i} b_j > b_i$. Therefore, revealing one's true valuation $b_i = v_i$ weakly dominates all other strategies.

The one-shot second price auction, however, does not necessarily remove anomalous behaviors or naive expectations from an individual's value expressions. Often, experience is needed before a bidder learns her true preferences or forms reasonable beliefs or realizes that her best strategy is to reveal these preferences truthfully. For this reason the vast majority of experimental markets use numerous trials. These extra trials provide an opportunity for the bidder to revise her bid as she gains experience with the auction and the signal set by the reigning market price. The evidence suggests that subjects take full advantage of this opportunity to revise their bid, often removing the anomalies that appear in the initial trial (see, for example, Coppinger et al., 1980; 1982; Kagel et al., 1987). For example, Shogren et al. (1994) observed that repeated trials were necessary before willingness to accept and willingness to pay measures of value for goods with numerous substitutes would converge, as predicted by theory. Repeated experience is needed to discipline and shape amorphous behavior, thereby improving the correspondence between theory and observed behavior.

But the exact process of why and how a person adjusts her bid with experience is not well understood. In an incentive compatible auction such as the second-price auction, a subject revises her bid for one of four reasons—impulse, myopia, confusion, experimentation, or boredom; updates her true preferences or beliefs given the information conveyed by the market price (Crocker and Shogren, 1991); learns that strategic bidding by misrepresenting true preferences pays; or learns that strategic behavior does not pay and that truthful revelation of value is the best strategy. This observation is consistent with Plott's (1995) "discovered preference" hypothesis. This hypothesis advances the idea that behavior in experimental markets goes through three stages: initial myopia, stable preferences formed with incentives and practice, and finally, rationality in which individual decisions incorporate the degree of rationality of others into their own choices. The exchange institution plays a critical role in the attainment of this third stage of rationality. Consequently, one trial often does not provide enough practice to achieve this level of rationality; repeated trials with the exchange institution may be necessary so that a bidder can update her preferences and beliefs given the information conveyed by the market price.

The dominate strategy in a second-price auction repeated over several trials, however, is now more complicated as there is now a history of bidding and market prices (Shogren et al., 1994). The set of strategies is a Bayesian Nash equilibrium if for each v_i the strategy solves

$$\max_{b_i(t)} \Bigg[E \Bigg[\Bigg\{ \Bigg(v_i - \max_{j \neq i} b_i(t) \Bigg) \bullet \text{Prob} \Bigg\{ b_i(t) > \max_{j \neq i} b_j(t) \Bigg\} | W(t) \} \Bigg| \beta(t) = 1 \Bigg] \tag{3.2}$$

$$+ E \Bigg[E_{\varphi_i} \bullet \text{Prob} \Bigg\{ b_i(t) < \max_{j \neq i} b_j(t) \Bigg\} | W(t) \} \Bigg| \beta(t) = 1 \Bigg],$$

where $\beta(t) = 1$ implies trial t is binding and $\beta(t) = 0$ implies trail t is not binding. $\Omega(t)$ reflects the history of the repeated markets

$$\Omega(t) = \left\{ b^2_{\min}(t), b^2_{\max}(t), \varphi(t) \right\}, \tag{3.3}$$

where

$$b^2_{\min}(t) = \min \left\{ b^2(t-1),\ b^2(t-2),\ b^2(t-3), \ldots \right\}$$

$$b_{\max}(t) = \max \left\{ b^2(t-1),\ b^2(t-2),\ b^2(t-3), \ldots \right\}$$

reflects the support of posted market prices, $b^2(t-k)$, at time t, and $\varphi(t)$ represents bidder i's history of auction successes and failures up to time t. "Success" is the number of times her bid was the highest but less than or equal to her true value, while "failure" is the number of times she was the high bidder but the price exceeded her true value or when she was not high bidder and the market price was less than her value. The repeated signal sent by the market price creates a common information pool on the upper end of the value distribution, thereby supplying information of the implicit set of preferences and beliefs behind those bids. This experience with the exchange institution is intended to help the bidder achieve a level of rationality in which she recognizes that strategic bidding is futile.

Now to see how repeated experience with a second-price auction affects values consider Hayes et al.'s (1995) experiment to value safer food. As part of a broader design, Hayes, et al. elicited the value of reduced risk for a foodborne pathogen, *Salmonella*, given six alternative levels of risk, to determine how individuals respond to increases in the probability of illness, holding the severity of the illness constant. The only difference in the six treatments was in the probability of illness provided to the subjects after trial 10. In the first treatments, the odds of becoming sick were reported as 1 in 13.7, and in each of the five subsequent treatments, these odds were decreased by a factor of 10 to a risk of 1 in 1,370,000.

All experimental treatments followed a common ten-step procedure. The experiment instructions are available in Shogren et al. (1994). Step 1 surveyed each of the 12 to 15 subjects in each treatment to obtain a set of priors regarding experience with food poisoning, the opportunity cost of illness, and how often

he or she ate red meat, poultry, and fish. Step 2 introduced the value measure used in the experiment—the option price. Step 3 explained the Vickrey auction for a familiar market good to give subjects experience. Before bidding began, each subject was given a $3 capital allocation and asked to state on a recording card his or her option price (or compensation) to upgrade a small piece of candy to a large candy bar over five trials.

Step 5 introduced the food safety stage of the experiment. Each subject was given a second capital allotment of $15, and a warm, breaded meat sandwich wrapped in paper to eat at the end of the experiment. In the option price treatments, this "test product" had a typical chance of being contaminated by the pathogen–"typical" implied the odds of illness were similar to those for the same sandwich purchased from a local source. One "stringently controlled" sandwich for which the objective risk was a 1 to 100 million chance of suffering from the pathogen in question from eating the sandwich was then displayed in a glass container. Step 6 ran the Vickrey auction, eliciting "naive" bids for ten trials. Step 7 reported the objective odds of illness, while step 8 elicited "informed" bids over ten more trials. Step 9 selected the binding trial, with each trial having the same chance of being selected. Step 10 required that all subjects eat their sandwich, either typical or stringently controlled, before receiving their take-home pay.

Figure 1 presents the average bid plus/minus one standard deviation by trial. Although average bids differed by group between trials 1 and 10 (between $0.44 and $1.32), the effect of market experience on the dispersion of bids decreases with experience in all treatments. The distribution of bids tightens with market experience as subjects adjusted their bids toward the market signal. Low bids are driven up, high bids are driven down. In trial 11, figure 1 reveals that the dispersion of bids increases with the information shock. Again additional experience reduces the dispersion of bids, except in the 1-in-137 treatment where some subjects appear to be in a bidding war.

This evidence suggests that individual choices evolve within an exchange institution; incentives and practice influence bidding behavior in the direction of more, rather than less, rational choices. Choices made without experience often can be improved if one gets a second chance. If a person is more comfortable with her bid after some experience, what remains to be established is (i) whether experience with an exchange institution tempers or promotes anomalous bidding behavior, (ii) whether this learning process can or should be modeled and measured, and (iii) whether learning one's preference/belief, or learning to be or not to be strategic is the predominant behavior pattern.

More generally, empirical research into those properties of exchange institutions which will maximize valuations for collections of interacting individuals is imperative if environmental assets are to be appropriately valued relative to everyday, commercial goods. This will require that considerably more research attention than heretofore be devoted to understanding how individual choices

and the individual idiosyncrasies which drive them evolve into rational exchange institution outcomes.

IV. Subjective Approaches to Valuation. The above experiments provide yet another illustration that maximization is performed at the level of the exchange institution rather than at the level of the individual (Nau and McCardle, 1991). Because utility maximization is necessary to the logical working of the subjective approach, applications to environmental assets try to infer what preference expressions would be revealed if the individual were repeatedly subjected to the discipline of an exchange institution with known desirable incentive and information properties, i.e., the nonstrategic, anonymous, competitive market. Preferences are operationally defined in terms of credible commitments to trade in this exchange institution. Detailed technical treatments of the subjective approach tools that can be used to value environmental assets are available in Braden and Kolstad (1991) and Freeman (1993). These tools can be arrayed by the distance that the behaviors which they employ to infer value are socially impoverished, i.e., are removed from the arbitraging offered by exchange media that coordinate individuals' choices. The less a tool uses data from arbitrages, the more likely is it that the data will simply summarize the extent to which the individual's merely anomalous motivations will have been publicly revealed. A simple diagrammatic device also used by Nau and McCardle (1991) provides a useful elaboration of these ideas.

Consider an individual's greatest buying price and least selling price for the risk reduction lottery in Section III. This discrepancy in prices can be attributed to endowment effects, opportunity cost effects, or other motivational anomalies. In Figure 2a, π represents this individual's risk of *Salmonella*-induced illness, and $\pi_2 = 1 - \pi_1$ her absence of illness. Let h_i and ℓ_i then respectively represent the aforementioned greatest and least prices for claims to a lottery on state i, $i = 1, 2$. For simplicity, assume that this individual, A, is risk neutral and that the money equivalent of the realization of state i is \$1. The set of the individual's risk neutral distributions for the realization of state i is then the set $\{\pi_1, \pi_2\}$ satisfying $\ell_i \leq \pi_i \leq h_i$. This set is the intersection of the cross-hatched bands in Figure 2a. By self-insuring or self-protecting, the individual might be able to reduce the distribution to the blackened area.[5] If she is free of anomalous motivations or if she can fully self-insure, the blackened area will collapse to a point.

Now presume that the illness and the absence of illness claims for \$1 are held by two individuals. Note that because the events i are additive, some third individual can purchase an illness claim at price ℓ_1 and an absence of illness claim at price ℓ_2, bundle them, and sell the claims bundle at price $\ell_1 + \ell_2$ to the fabled Marshallian "representative" individual who issues from an exchange institution. The set of acceptable gambles for this representative will be the sum

of the acceptable gambles for the real, perhaps irrationally motivated individuals. Diagrammatically, this sum will be the union of acceptable gambles for each real individual. The union thus represents the representative's arbitrage opportunities.

Finally, introduce two additional individuals, B and C, who confront the identical *Salmonella* problem but who have different motivations from each other and from A or who differ in their abilities to self-insure. The three circles in Figure 2b represent each individual's version of the blackened area in Figure 2a. Their intersection corresponds to the representative's set of acceptable gambles, i.e., her arbitrage opportunities. Note that the discrepancy between this representative's greatest buying price, h_i^*, and least selling price ℓ_i^*, is less than that for any individual agent. The representative or the exchange institution has reduced the impact of any anomalous motivations or naive expectations upon observed valuations, to the extent that the details of the anomalies can be represented by discrepancies in individuals' buying and selling prices. If the blackened area in Figure 2b were to collapse to a point, then the data on choices and prices that the exchange institution offered any observers would display no evidence whatsoever of naive expectations even though each participating individual's expectations fail some of the axioms of utility maximization. All opportunities to gain by exploiting others' anomalies will have been exhausted. If these anomalies are costly to exploit, the blackened area of Figure 2b is unlikely to collapse to a point. However, persistence of any given type of anomaly will induce a search for ways to reduce these costs, thus putting competitive pressures on anomaly practitioners to disappear. The gains which thereby accrue to exploiters may sometimes appear to be ill-conceived and ill-gotten according to proponents of the incommensurability of environmental assets and commercial goods. For example, developers may exploit the endowment effect by surreptitiously pushing a road, and a lack of good substitutes makes otherwise indifferent local people who are susceptible to this effect urge that the new road by retained.

Consider the extent to which four of the most commonly used subjective approach methods—travel costs, hedonic pricing, contingent valuation, and laboratory experiments—are likely to allow individuals to exhibit the anomalous behaviors which invalidate the utility maximization paradigm on which these methods base their interpretations of observed data.

The travel cost method uses the costs the individual incurs to acquire and to keep access to a recreation site to infer her willingness-to-pay for site access. Access costs, including opportunity costs, travel outlays, and entry fees, very inversely with willingness-to-pay. Opportunity costs include access costs to substitute sites and the wage foregone due to travel time and length of stay. Direct travel outlays and entry fees clearly reflect the real individual's repeated involvement in everyday exchange institutions which exhibit uniform incentives and convey common knowledge about price. But, implementation of the travel cost method nearly always requires introduction of strong auxiliary conditions about

the exchange institutions which determine the availability of substitute sites for the individual, her allocation of joint costs among sites, and the structure of her foregone wage, if any. The imposed exchange institutions may be utterly foreign to her and may therefore throw open to question whether she would actually engage in utility maximizing behavior if she were to involve them. She is unsure about how others would behave under the posited institutional rules. For example, infrequent one-on-one bargaining rather than smooth substitutability between non-work and work time dominates actual job conditions.

Hedonic pricing is another favorite subjective approach. It works as follows. Suppose you have a choice of two jobs, which differ in their on-job levels of environmental quality. If environmental quality has value, the job with the better quality will pay less. The higher quality compensates for the lesser wage. The wage differences can then be related to the value of higher environmental quality. Given that this quality is bundled with other complex contractual job attributes (e.g., work-time discretion) and that job markets exist, various analytical and statistical devices can be used to extract the value of on-job environmental quality. Generally the devices require that multiple markets exist in which the individual can participate. The trick is to distinguish the markets, a task fraught with opportunities for arbitrary formulations (Atkinson and Crocker, 1993) about the physical and contractual features of the job and housing markets which attract most hedonic pricing studies. However, these studies do involve individuals as they repeatedly engage in a give and take which provides uniform incentives and common knowledge and beliefs about a variety of job and housing conditions.

The increasingly popular contingent valuation method (CVM) gathers its data via social science survey techniques rather than via observed behaviors. It is most often applied to settings in which the individual is asked to employ unfamiliar exchange institutions to value unfamiliar environmental assets. After having asked the individual to imagine an exchange institution and to visualize her and others' participation in it, the CVM practitioner elicits her one-time willingness-to-pay or willingness-to-accept. Ironically, though CVM employs a data gathering instrument that psychologists and sociologists use to study the cognitive processes that generate individuals' choices, its economist practitioners disregard the general reluctance of these other disciplines to use the utility maximization paradigm to explain isolated behaviors of individuals. These noneconomic disciplines prefer to downplay the quantitative features of a decision problem in order to focus upon its framing, learning about it, generating opinions, clarifying ambiguities, etc. These are functions an effective exchange institution performs for the individual. Though the full verdict is not yet in, enough empirical evidence is available to arouse considerable skepticism that simply asking an isolated individual to visualize her and others active participation in a repeated give and take situation with uniform incentives will be

sufficient to cause her to behave for one time in accordance with the utility maximization paradigm (see Plott, 1986; Desvousges, et al., 1992; Neill, et al., 1994, for example). However poor her grasp of the context of the problem, perhaps she cannot resist the strategic opportunity to be a solipsist or dictator for the day. Or, more likely, a polite request to visualize a nonexistent market does not cause the mutual recognition of rationality among individuals to rub off onto her. Polite requests to visualize one-time participation in a hypothetical market cannot induce common knowledge about world states and others' preferences. Nor can simple one-time visualization by isolated individuals cause expectations to converge or the representative individual to emerge. In effect, CVM introduces a new asset into the individual's (hypothetical) market choice set. Individuals will in general disagree about its price. This implies that the asset or conditions of access to it would be arbitraged. But CVM allows no arbitrage to occur, whether that arbitrage takes place in a market or in the extended social discussion and validation which precedes informed voting. Given anomalous motivations, CVM thus cannot make it clear that the state with the new asset is Pareto-superior or inferior to the old state. Remember, however, that the individual participates only once or very infrequently in many real markets for environmental assets. Consider, for example, the frequency of visits to a national park many thousand of miles form one's home. Low levels of actual market participation may also do little to temper anomalous behaviors.[6]

Experimental markets in controlled laboratory settings involve real and repeated give-and-take but, as in Section III, within highly stylized contractual contexts. While using auctions whose conformity to the utility maximization paradigm is well understood, experimental markets can elicit values over several intensities and types of markets. Market laboratory experiments isolate and control how different auctions and market settings affect publicly revealed values. Since the conditions of the experiment can be made to correspond exactly to the conditions of the theory, a judgment that the experiment is too artificial to be of practical use amounts to a judgment that the theory which the experiment is designed to test is too artificial. Alternatively, a theory which fails in a simple, controlled experimental setting cannot provide robust explanations about the complex everyday, nonexperimental world (Plott, 1989). Experiments, which fail to reject theory, advance confidence about one's ability to predict behaviors in the broader world. The travel cost, hedonic pricing, and CVM methods maintain the utility maximization hypothesis. Only experiments allow its testing. Experiments have repeatedly shown that the hypothesis is often violated when self-contained individual must value goods. It is thus likely that experiments will point the way toward new foundations for valuing goods when individuals are self-contained.

V. Choosing Exchange Institutions. In addition to executing exchanges, an institution pressures the individual to behave in accordance with institutional norms. Arbitrage provides guideposts. These pressures exist only in real, practicing exchange institutions. The pressures or guideposts may not always be viewed unequivocally by the individual. Individuals differ considerably in their willingness to submit their preferences to others and to contest these preferences. Competitive markets may compel the individual to answer to others more than she would like and in frantic ways for which she does not care. She may obtain greater value from an environmental good and be better able to exercise critical intelligence through an alternative exchange institution such as self-provisioning, a democracy, or a bureaucracy (Knight, 1960). These alternative institutions may provide less costly and more acceptable ways to interact with others and may thus lead to a lesser incidence of anomalous behaviors. In short the value the individual attaches to an environmental asset will differ according to the exchange medium through which it is expressed if only because different mediums are more or less effective in erasing anomalous behaviors.

More specifically, let ϑ_{ij} be a factor representing the capacity of the jth exchange institution, $j = 1,\ldots,m$, in the ith state, $i = 1,\ldots,n$, to capture all gains from trade of an environmental asset in a world devoid of motivational anomalies. The asset might be access to a state at a particular public land site or a lottery on a Salmonella-induced personal health state. Hypothetical CVM markets, Vickery second-price auctions, the exchanges involved in travel outlays and job bargaining, focus groups, or the public hearings associated with an environmental impact statement qualify as alternative exchange media. ϑ_{ij} can be viewed as a measure of the inertia due to informational and incentive compatibility issues that are associated with the representative individual's initial property claims and access to environmental goods.

For a given exchange medium and environmental state the representative agent maximizes the difference, W, between the surplus, K_i, that would be generated in a world of nonstrategic, anonymous, competitive markets and a world of less-than-ideal exchange media and the real individual's motivational anomalies.[7] W is the analog of the part of the blackened area in Figure 2a that the arbitrage activities depicted in Figure 2b remove. The representative agent's problem is then to maximize.

$$W = \sum_i \sum_j \left[K_i - (1-\vartheta_{ij})\Delta_{ij}(\vartheta_{ij}) - C_j(\vartheta_{ij})\right], \tag{5.1}$$

where $\Delta_{ij}(\vartheta_{ij})$ is the monetary consequences of the agent's naive expectations defined in terms of the (h_i^*, ℓ_i^*) spread, and $C_j(\vartheta_{ij})$ is the cost of operating the jth exchange institution. $\Delta_{ij}(\vartheta)$ is thus the opportunity cost of naive expectations and $C_j(\vartheta)$ is the cost of organizing exchange institutions to pressure the

anomalies that these expectations produce. Assume $\vartheta_{ij} \in [0,1]$, where the upper bound implies that the exchange institution exhausts all gains from trade and the lower bound implies that no gains are captured. Further assume that $\Delta'_{ij} \equiv d\Delta_{ij}/d\vartheta < 0$ and $C'_j \equiv dC/d\vartheta > 0$. Finally, allow $\Delta''_{ij} < 0$, and $C''_{ij} > 0$. These assumptions imply that the trade exhaustion capacity of the exchange institution influences anomalous behaviors and the costs organizing the institution in a well-behaved fashion.

The first-order condition for (5.1) with respect to ϑ_{ij} is

$$\varphi = \sum_i \sum_j \left[\Delta_{ij}(\vartheta_{ij}) - (1-\vartheta_{ij})\Delta'_{ij} - C'_j\right] \leq 0, \tag{5.2}$$

$$\vartheta_{ij} \geq 0, \text{ and } \vartheta_{ij}\varphi = 0.$$

The first two bracketed terms are respectively the indirect and the direct benefits of changing the trade exhaustion capacity of the exchange institution. An increase in capacity reduces the opportunity costs of naive expectations. The last bracketed term is the marginal cost of organizing this capacity. Expression (5.2) therefore says nothing more than that the indirect and direct benefits of organizing an exchange institution to reduce anomalous behaviors must exceed the marginal costs of organization. The inequality implies that a given exchange institution will not be worth organizing in all states.

At least three interesting implications of (5.2) readily follow. First, the higher the cost for its participants of organizing an exchange institution, the greater the influence that anomalous behaviors will exercise over observed or stated choice data derived from that institution. Complete rationality defined in terms of utility maximization will concede to organizational costs. Second, the greater are naive expectations, the more likely is it that an organizing effort will be worthwhile. The greater the naive expectations, the greater the opportunity stakes from not organizing. Third, there will be states where the exchange institution is not worth organizing. Valuation techniques which impose this exchange institution in these states will allow full exercise of the powers of naive expectations.

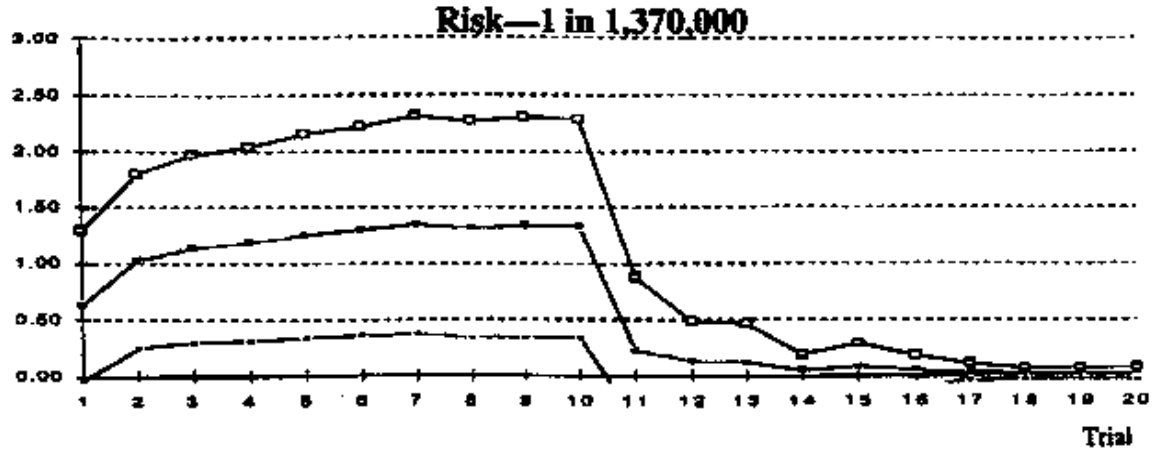
Expansions of the dimensionality of (5.1) are relatively easy. For example, a dynamic element can be introduced by allowing the representative individual to invest in organization today in order to reduce the future opportunity cost of naive expectations (Crocker and Shogren, 1991). In addition, the benefits, in terms of reduced opportunity costs, might be made a function of the sequence of past organizing efforts. In a static setting, a difference among individuals in naive expectations or in the costs of organizing an exchange institution can be accounted for by indexing either the naive expectations function $\Delta_{ij}(\cdot)$, the organizational cost of function, $C_j(\cdot)$, or both. The analyst can then model the conditions under which real individuals' organizing efforts will reinforce or discourage individuals' naive expectations.

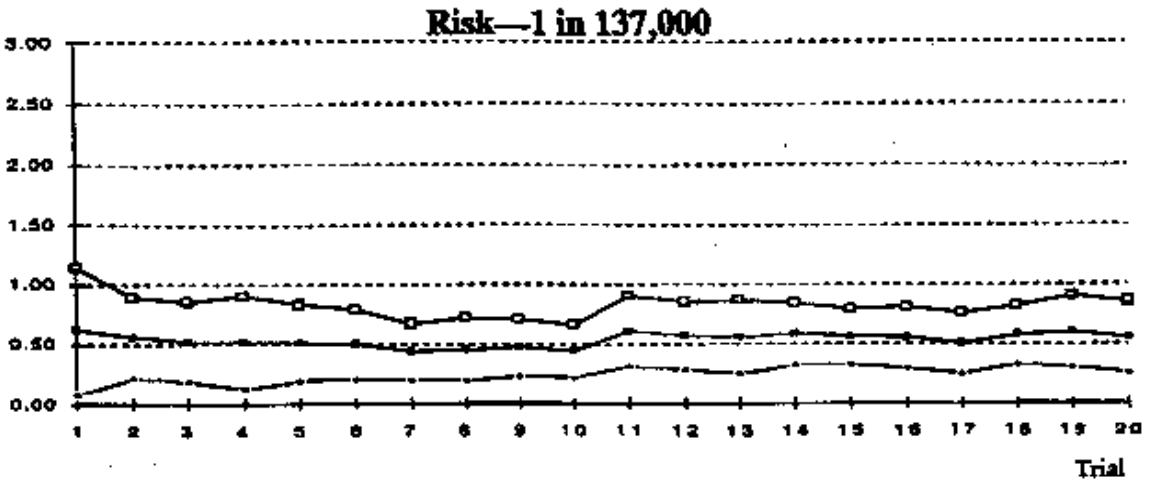
An obvious and significant static extension of (5.1) involves consideration of multiple exchange institutions differing in their arbitrage capacities and in their costs of organizing. Exchange media differ in their capacities to use arbitrage to translate anomalous behaviors into surpluses. Because of the costs of organizing exchange institutions, these differences may persist in degree even when the world is devoid of anomalous motivations. Each medium will be used only so long as the gain in surplus for reducing the price discrepancies that motivational anomalies cause is greater than the transaction and other costs of using the medium. Given that these gains and costs differ across media and that the net gains in one medium do not dominate those in all other media, this implies that the representative individual will diversify her arbitrage activities such that the net surpluses generated are equal across media. It then follows that the total value of an environmental asset is the sum of the surplusses that arbitrage generates in multiple media rather than the surplus generated in any single medium. This implies that analyses of the value of environmental change must explain changes in how people choose among the various exchange media through which they express their values for environmental assets as well as the values they express in a particular medium. Simple Le Chatelier-type reasoning says that a singular focus on the market medium will cause the value of environmental improvements to be underestimated and the value of environmental decay to be overestimated.

VI. Summary and Conclusions. Noneconomic approaches to value have obvious logical and practical flaws. They also have an aura of elitism about them. Nevertheless, though it may be thoroughly logical within the confines of the conditions it imposes, the empirical evidence is overwhelming that the subjective utility maximization paradigm applies most readily to exchange institutions rather than to the everyday individual. The unsocialized individual commonly engages in anomalous behaviors or naive expectations inconsistent with the paradigm when no exchange institution provides the gravity to hold her rationality together. Valuation and choice can readily be two inconsistent activities in the absence of arbitrage. Deviation from the conclusions of arbitrage brings its own punishment that will not occur when the individual is left to flail or perhaps dither alone in a black box. Exchange institutions and the arbitrage which they encourage discourage naive expectations and unreliable beliefs. Anomaly removal generates value, i.e., surplus in economic terms. Because the most viable and well understood exchange institution, the competitive market, has relatively little role in arbitraging environmental assets, anomalies perhaps have a more prominent role in an individual's value expressions for environmental assets. Alternatively, in the absence of the market, individuals may seek out a variety of distinctive institutional arbitrage devices such as public dialogue and other "nonmarket" forms of social activity that reconcile different value perceptions.[8] In either case, a public policy focus for environmental assets upon

the findings of benefit-cost analysis narrowly interpreted in terms of the real individual's utility maximization is highly problematic and plausibly self-defeating. It likely neglects many economically efficient avenues through which values are expressed and arbitraged and therefore made observable. Constraining people to use market avenues when they prefer to express their values via other avenues causes the value of environmental improvements to be underestimated. Public policymakers who disregard the values expressed in these alternative avenues of arbitrage and who fail to alert people to opportunities for their formation likely exhibit their own anomalous motivations because they forego opportunities to generate surplus. As Akerlof and Yellen (1985) show, nonmaximizing behavior which results in only trivial losses for the individual can, when some individuals are not held accountable for their choices, cause major deadweight losses for the society. Nonmaximizing behaviors by public policymakers who insist that the competitive market interpreted strictly as a manifestation of the utility maximization paradigm is the sole legitimate form of value expression could increase these deadweight losses by orders of magnitude. Finally, recognition of the opportunities that exchange institutions in addition to the competitive market provide for arbitrage and rational, critical value articulation obviates the demand to invent and accept value schemes built upon incommensurability and "objective" phenomena. Such recognition has the potential to devolve environmental decisionmaking from would-be cultural elites or centralized bureaucracies peopled by benefit-cost technocrats to gatherings of ordinary people who have been encouraged to engage in arbitrage.

Figure 1a. Average Values +/- 1 S.D.





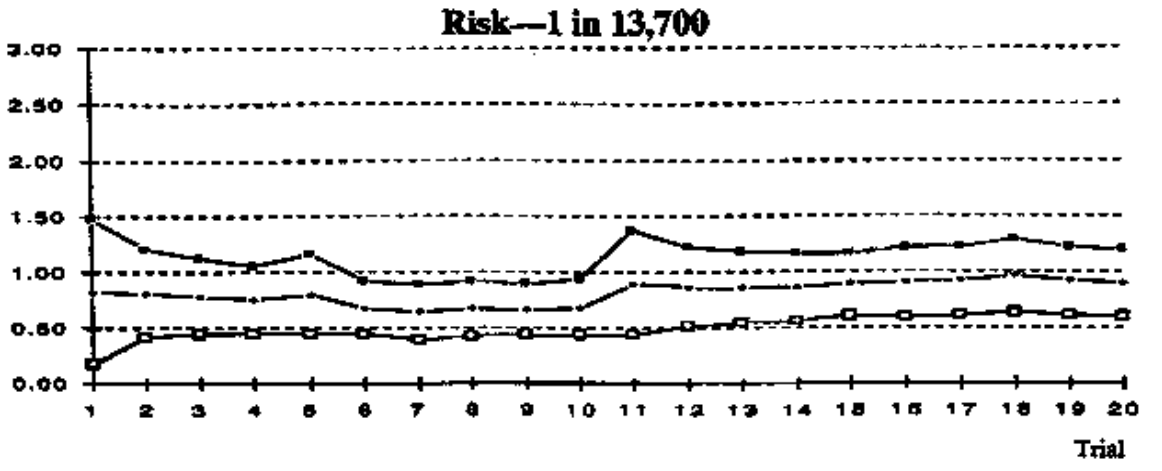


Figure 1b. Average Values +/- 1 S.D.

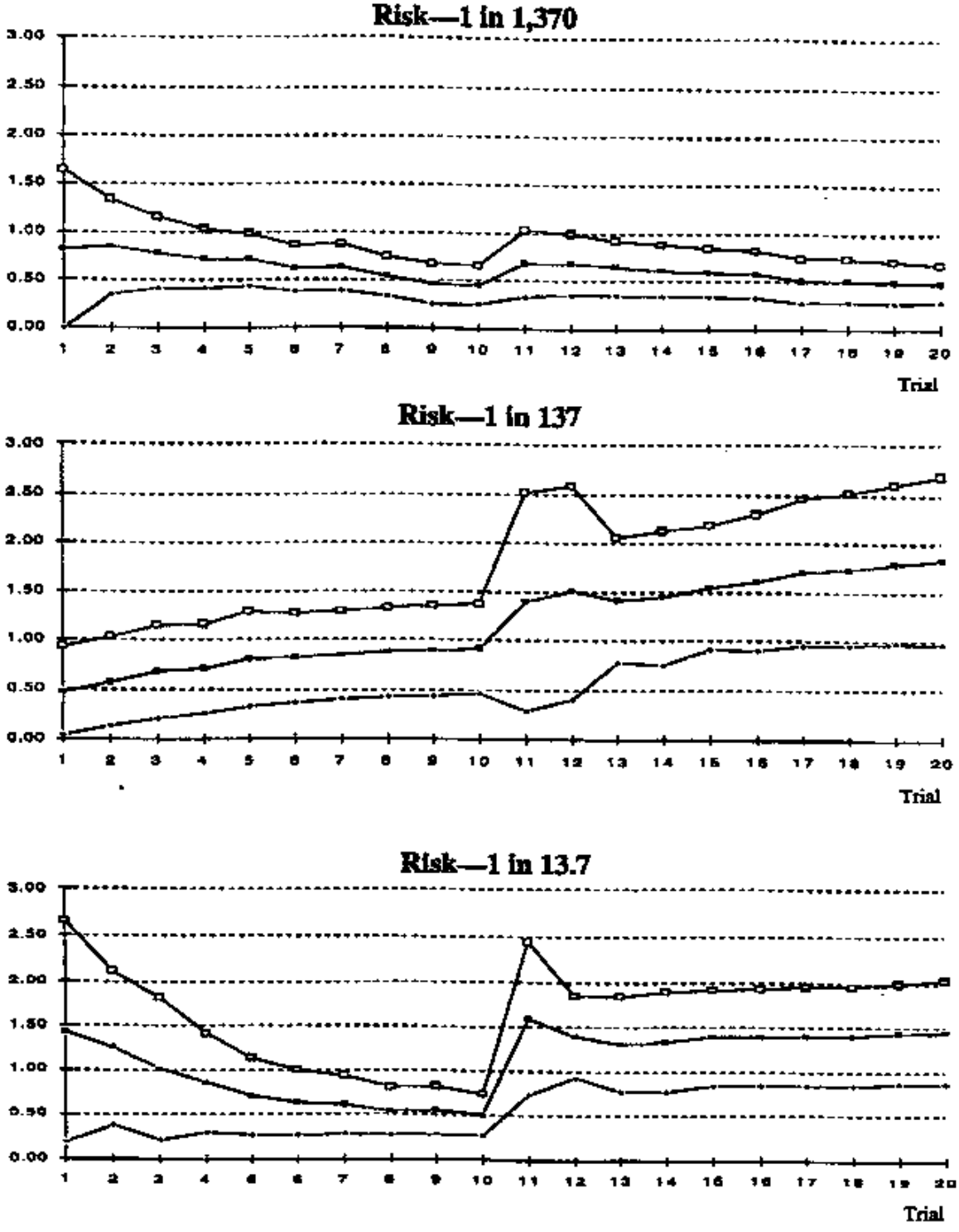


Figure 2a. Anomalies and the Real Individual

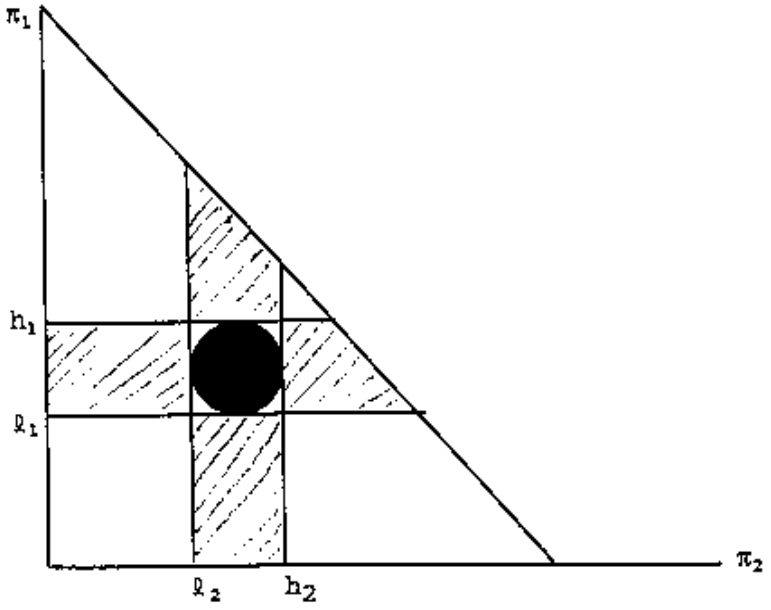
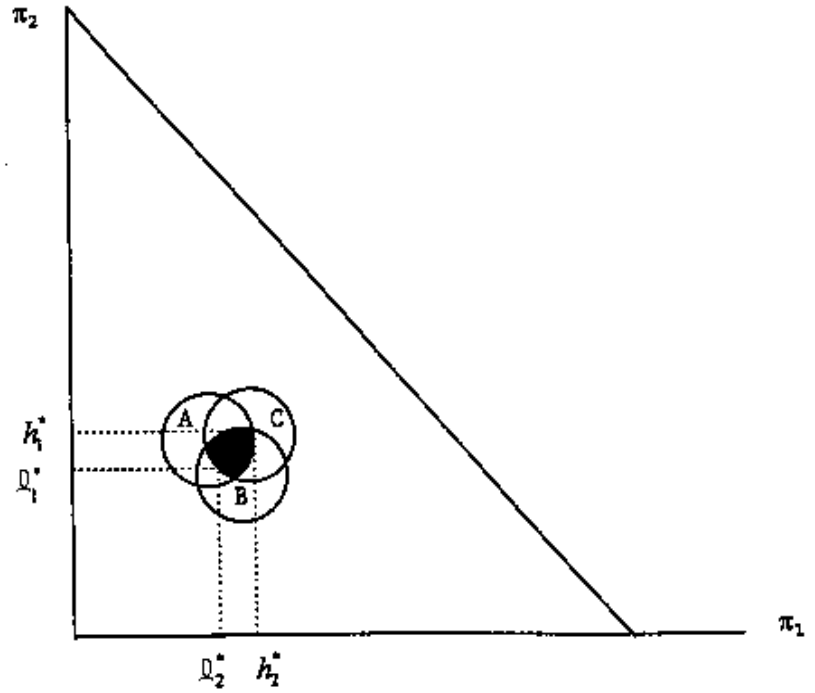


Figure 2b. Anomolies and the Representative Individual



Footnotes

1. Anderson (1990, 1993) overstates her case somewhat. In fact, economists have devoted considerable effort to uncovering and structuring noninstrumentalist sources of value for the natural environment. On scientific, bequest, and especially existence values, see Krutilla (1967). Existence value is conferred simply by the existence of a resource. See Weisbrod (1964) on the value of having an option to have future use of a resource, and Arrow and Fisher (1974) on the value of the information provided by resource preservation. Randall (1991) provides an up-to-date review of the economic literature on noninstrumentalist or nonuse environmental values. Contrary to Anderson, none of this literature forbids tradeoffs between use and nonuse values.

2. Without attempting to draw out any value implications, Samuelson (1983) discusses the close parallels that exist between formal and economic theory and thermodynamics. Analytical exploration of these formal parallels is otherwise rare.

3. See Berlin (1969). Levi (1986) and Sen (1980-81) for future Incommensurability arguments.

4. Energy conservation is the first law. It states that the stock of energy is neither created nor destroyed. It is simply transformed. The second law states that the flow of unavailable energy (entropy) in any closed system (e.g., the universe) moves irreversibly and continuously toward a maximum. Thus the first law accounts for internal energy in terms of heat and work, while the second specifies the maximum work that any energy transformation can produce.

5. Some assets cannot be self-produced or traded in context, but self-protection allows their function to be obtained.

6. This implies that many efforts to transfer specific studies of the benefits or costs of environmental control across time or space may be problematic. The lack of exchange institutions for environmental assets implies that anomalies play a significant role in observed choices involving these assets. Benefits transfer efforts assume that all of the variance among the study's fixed effects other than sampling variance can be explained deterministically as a function of settings, restrictions, and methods, e.g., Smith and Kaoru, (1990). The presence of anomalies, which are by definition "irrational" and thus nonsystematic, implies that stochastic sources if variation are influential. Atkinson, et al. (1992) suggest empirical Bayes estimates to deal with this stochasticity.

7. Note the parallel between the notion of economic efficiency set forth in expression (5.2) and the entropy efficiency notion in expression (2.2). Each expression

involves a term, Y (Max) in (2.2) and KI in (5.2) which describes a theoretical ideal for the task at hand.

8. "...it is easier to make heroic decisions as member of a committee than as a sole decisionmaker" (Boulding, 1969, p. 12).

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