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ANALYSIS

Reformulating the foundations of consumer choice theory and environmental valuation

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Abstract

The burgeoning field of environmental valuation has raised serious doubts about the fundamental axioms of consumer choice theory, the general validity of the Walrasian system and methodological individualism. This paper examines these aspects of consumer choice theory, paying particular attention to the pioneering contributions of Georgescu-Roegen. We argue that evidence from psychology, game theory, anthropology and contingent valuation surveys reveals a more complex pattern of decision-making than that described by neoclassical utility theory. We discuss the notions of the invariance of preferences, non-satiation, the principle of complementarity, lexicographic preferences and the hierarchy of wants with reference to environmental valuation. We also discuss the notion of marginal utility of money, the validity of the Walrasian system, and methodological individualism using scaling concept in hierarchy theory. We then address the conflict between theory and reality by introducing a probabilistic binary choice scheme under uncertainty about environmental attributes. We argue that these extensions are necessary to account for consumer choices revealed in environmental valuation surveys. We conclude with the hope that a reformulation of consumer choice theory based on realistic models of human behavior can be the basis for a viable alternative to neoclassical welfare economics.

Keywords: Binary choice; Contingent valuation method (CVM); Environmental value; Hesitation region; Hierarchy of wants; Lexicographic order; Satiation; Utility measure; Utility theory

1. Introduction

During the first half of the twentieth century the assumptions of neoclassical utility theory were hotly debated by economists (see, e.g. Samuelson, 1952; Alchian, 1953; Armstrong, 1958). But with the ascendance of the neoclassical synthesis in the decades following WWII most economists took

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the basic axioms of consumer choice as given and placed the question of 'tastes' outside the realm of economic analysis.[1] Preferences were taken to be given and constant and assumed to be adequately revealed in market choices. Armed with these axioms, economists turned their attention to refining applications within the neoclassical paradigm. Most contemporary microeconomic textbooks do not examine the validity of the axioms of consumer choice (for examples see van den Bergh et al., 2000). In recent years, however, attention has returned to some of the earlier controversies in utility theory because of questions about environmental valuation based on neoclassical axioms of consumer choice, particularly the contingent valuation method (CVM). We are aware of the rich body of theory extending neoclassical utility theory to include interpersonal comparisons of choice, altruism, lexicographic preferences, and other phenomena of human behavior. However, the general equilibrium framework driving neoclassical economic policy requires behavior conforming to the axioms of consumer choice discussed below. We argue that these axioms do not confirm the accepted models of human behavior verified from experimental and theoretical work in economics, psychology, anthropology and game theory.

The neoclassical theory of consumer choice describes the process by which an autonomous rational consumer allocates his/her income at the margin among an array of consumer goods. As any scientific model does, neoclassical utility theory describes some part of reality in the simplest way possible to explain the phenomena under consideration. Choice theory draws an 'analytical boundary' (Georgescu-Roegen, 1971) around an individual consumer, ignoring social and ecological context, to examine how he/she makes choices in a well-defined market. It is widely recognized that the axioms of consumer choice theory are quite restrictive, but defenders of the neoclassical approach argue that this simplification still captures basic features of decision-making and is necessary in any analytical representation of complex reality. In this paper, we challenge this view in the spirit of Wilson (1998) who argues for 'consilience' among the sciences, that is, the assumptions of any particular science should be consistent with the basic body of knowledge understood by other sciences. Theories that are consistent with solidly verified knowledge in other fields consistently perform better in terms of generality of explanation and in their ability to make accurate predictions. We argue that the basic axioms of neoclassical utility theory cannot be reconciled with the current state of knowledge in other relevant disciplines or in sub-disciplines of economics including game theory and behavioral economics. This has important negative implications for the neoclassical approach to environmental valuation. It is sometimes claimed that while neoclassical utility theory may ignore environmental and social context, demand theory does not. However, the neoclassical theory of demand is based on the axioms of consumer choice. Intermediate micro texts make this clear in deriving the demand curve from the price consumption curve. If consumer behavior does not conform to the set of axioms adopted in neoclassical theory, then one cannot make the leap from maximizing utility to constructing welfare measures of consumer surplus using Hicksian or Marshallian demand curves.

The origin of consumer choice theory can be traced back to the English empiricists such as Bacon, Bentham and Hobbes who, following the best science of their time, viewed human consciousness as a sort of file cabinet for past experiences. Ideas are stored in a logically consistent manner to be retrieved later. These experiences may fade with time but they stay logically ordered and constitute the context in which decisions are made. As we discuss below, this view of the human mind is not supported by current scientific

[1] G.S. Becker extended the neoclassical utility-maximizing approach to endogenous preferences, including personal and social capital (e.g. Stigler and Becker, 1977; Becker, 1996). According to Becker, this extended utility function can be assumed to remain constant over the period of analyses. In various formulations of a utility function he incorporated such anomalies as addictive behavior, social capital and advertising capital into the neoclassical framework. However, Becker and other neoclassical analysts do not consider the issue of relevant choices of the axioms underlying utility theory as discussed in this paper.

evidence. Other assumptions about human nature contained in the axioms of consumer choice, such as insatiable wants for commodities, a smooth and continuous utility function (ruling out lexicographic preferences), and the independence of individual choices, are also known to be at odds with current scientific knowledge. Perhaps one of the most basic failures of neoclassical utility theory is to treat all value as exchange value, thus ignoring the biological basis for human existence. In standard theory, biological needs are indistinguishable from whims of consumer choice.

We first present the set of axioms used in consumer choice theory. We discuss the implications of the following five behavioral aspects contained in this set of axioms for environmental valuation, (i) the invariance of preferences; (ii) non-satiation; (iii) the principle of complementarity; (iv) lexicographic preferences and the hierarchical nature of wants. We also discuss the notion of marginal utility of money, the general validity of the Walrasian system, and methodological individualism using scaling concept in hierarchy theory. We then introduce a new scheme based on probabilistic binary choice to illuminate some important issues concerning environmental valuation under uncertainty.

2. The axioms of consumer choice

Economic valuation of environmental features is based on the well-known set of axioms which constitute the neoclassical theory of consumer behavior.[2] The description of the consumer as Homo oeconomicus (*HO*) is based on various versions (Frisch, 1926; Georgescu-Roegen, 1954b; Jehle, 1991; Mas-Colell et al., 1995) of the following set of axioms.[3]

1. *HO* is faced with alternative combinations of various quantity-measurable commodities that involve neither risk nor uncertainty. Every point $C=(x_1, x_2, \ldots x_n)$ in the commodity space is an alternative.
2. Given two commodity bundle alternatives C^1 and C^2, *HO* will either prefer one to the other, or regard the two alternatives as indifferent. Indifference is a symmetric relation, but preference is not. We write C^1PC^2 for preference and C^1IC^2 for indifference.
3. The preferences of *HO* do not change during the time period of analysis.
4. There is no saturation. This is sometimes called the axiom of monotonicity. Given any C^1, C^2 is preferred to C^1 if C^2 is obtained by adding to C^1 more of at least one commodity.
5. The relation of non-preference $\bar{P}$ (the negation of P) is transitive. That is, if $C^1\bar{P}C^2$ and $C^2\bar{P}C^3$, then $C^1\bar{P}C^3$ ($C^1\bar{P}C^2$ means either C^2PC^1 or C^1IC^2).
6. If $C^1\bar{P}C^2$ and $C^1\bar{P}C^3$, then $C^1\bar{P}[aC^2+(1-a)C^3]$ where $0\le a\le 1$. It means that C^1 is not preferred to a mix of C^2 and C^3 no matter what the composition of the combination.

Although axiom 2 allows for a region of indifference, it is not strong enough to guarantee that an indifference region actually exists. Consequently, axiom 7, the indifference postulate, is necessary to construct a complete ordinal measure of utility (Georgescu-Roegen, 1936).

7. A set (C^α) is called *a preferential set* if α takes all the values of an interval of real numbers and if $C^\beta PC^\gamma$ whenever $\beta>\gamma$. If the preferential set (C^α) contains C^β and C^γ, and if $C^\beta PC$ and CPC^γ, then the preferential set contains a combination indifferent to C.

[2] Many interesting modifications of neoclassical theory have been made since the basic postulates of consumer choice were laid out decades ago. Game theory and rational expectations, for example, have enriched the standard paradigm. These approaches, however, are still grounded in a system of optimal allocation in a near-to-equilibrium framework. Some promising work is currently being done under the general topic of the economics of complexity which promises to move economic theory to a more general out-of-equilibrium framework (e.g. Arthur, 1999; van den Bergh and Gowdy, 2001), but it is beyond the scope of this paper to discuss such approaches.

[3] When Georgescu-Roegen (1954b) discussed this particular set of axioms, he did not consider its relationship to environmental valuation.

3. Environmental valuation and the axioms of consumer choice

Results from CVM surveys show a mismatch between theory and reality. A large percentage of responses to CVM questions do not conform to the assumptions of the utility theory model into which they are placed. This does not necessarily mean, as neoclassical critics of CVM argue, that responses to questionnaires are less 'real' than choices made in markets. That is, just because CVM responses do not conform to the axioms of consumer choice, this does not imply that the choices of consumers actually buying things do conform to those axioms.

Hanemann (1994), in a defense of CVM, points out that traditional consumer choice theory assumes a 'top-down' or 'stored-rule' decision-making process. This 'filing cabinet' conception of the mind still holds sway in economics but has been abandoned by those studying how the human mind actually works (see Bettman, 1988; Martin and Tesser, 1992). Psychologists now see cognition as a constructive process depending on context and history. How choices are actually made depends on time, place, and immediate past experiences (Knetsch, 1992; Hanemann, 1994). It has been shown that consumer choices, including those made in 'real' markets, are made using a 'bottom-up' decision process (Olshavsky and Granbois, 1979). Consumer choices are not based on a file cabinet of rational and consistent behavioral memories but are based on rules invoked on-the-spot for each situation. This is as true of market decisions involving monetary transactions as it is of survey responses. The problem is not that CVM responses are not real, but rather that humans may not act according to the axioms of consumer choice theory. Because they are based on axioms developed for mathematical tractability, not realism, market valuation methods do not conform to observed behavior.

3.1. The invariance of preferences

Axiom 3 states that consumer preferences may be assumed to be constant over the relevant time period of analysis. Psychologists have found, however, that individual preference for a particular item may vary considerably depending on context. Many of the criticisms of CVM by economists have centered on the ephemeral nature of consumer tastes as expressed in survey responses. Diamond and Hausman (1994), for example, criticize CVM because the responses to CVM questions depend upon the sequence in which the questions are asked. They also criticize contingent valuation because it captures a variety of 'non-market' consumer reactions including 'warm glow' effects, 'protest bids', 'part–whole bias' and 'embedding'. The 'warm glow' criticism is that in CVM surveys individuals may be expressing support for good causes in general rather than for the specific item being evaluated. In protest bids individuals may be expressing a variety of reactions to the questions asked, for example, a reaction to a recent specific environmental event such as an oil spill rather than focusing on the specific item under consideration. The part–whole bias problem is that the sum of the valuations of component part exceeds the valuation of the whole (Bateman et al., 1997a). These examinations of CVM studies undermine the foundations of consumer choice theory in general. As marketing and advertising experts know, warm glow and many other feelings are a part of almost all consumer choices. The existence of reference dependent preferences is now well-documented even in the mainstream literature (Tversky and Kahneman, 1991; Benartzi and Thaler, 1995; Bateman et al., 1997a,b; Bohnet and Frey, 1999). Preferences are embedded in specific social and environmental contexts and theories that take this into account consistently do a better job of predicting human behavior (Bateman et al., 1997a,b).

3.2. Non-satiation

Axiom 4 is sometimes referred to as non-satiation or monotonicity. This axiom is relevant to environmental valuation because without the assumption of non-satiation, CVM loses operational meaning as a practical tool of monetary evaluation of environmental services. The notion that human wants are infinite is inconsistent with evidence from a number of human societies. The

craving for material goods as a dominant feature of human societies evidently began with the agricultural revolution (Sahlins, 1972; Gowdy, 1998). Indeed, in some societies the morbid craving for goods is considered to be a serious disease (Sahlins, 1996). The non-satiation postulate has been criticized by ecological economists because many if not most of the environmental services provided by ecosystems (water, food, oxygen, etc.) have a saturation region. For example, the composition of gases in the atmosphere must fall within a certain range to support human life. If there is too little oxygen we will die of asphyxiation; too much oxygen will cause the Earth's organic material to burn uncontrollably. Other atmospheric gases must also be present in fairly fixed amounts. The level of nitrogen, for example, is critical for the regulation of breathing in animals. It is well-known that small changes in the level of CO_2 in the earth's atmosphere can have a dramatic effect on the earth's temperature. As consumers we can choose whatever we want but these choices may be inconsistent with survival in the context of our biophysical existence.

Many environmental services must be present within a narrow range to support human life. Such services cannot be characterized by a single saturation point nor can the effect of changing their amounts be delineated into continuous marginal quantities. Individual preferences have some grounding in biophysical reality. They are not independent of the biological and social worlds surrounding the decision-maker. Many attempts to place an economic value on nature's services may be meaningless because of the lack of biophysical context of the valuation (Costanza et al., 1997; Gowdy, 1997; Toman, 1998).

A weaker version of the monotonicity or non-saturation rule is local non-satiation (Jehle, 1991; Mas-Colell et al., 1995). The local non-satiation axiom rules out the possibility of having an area in which all the points are indifferent. But as the above examples show, the local non-satiation axiom cannot apply to some environmental goods. In addition to this difficulty, we must define a particular metric space in order to define the notion of 'vicinity'. To proceed independently of a particular metric space, a more rigorous definition is needed. So, we must define a saturation point S as a point such that the direction to S is a preference direction from any non-saturation point. For simplicity's sake, we may also assume that there is only one such point (in general, the set of saturation points is a convex set, but the conclusion is not affected). If we adopt this assumption, we have an integral curve which has a spiral form around a saturation point even for the two commodities case (Mayumi, 2001). Fig. 1 shows such curves around a saturation point.[4] Given some amount of the first commodity, there are many values of the amount of the second commodity which result in the same utility index. Hence, we cannot build a unique index of utility even with the weaker version of non-satiation.

3.3. The principle of complementarity

Axiom 6 is referred to by Georgescu-Roegen (1954a) as the principle of complementarity. This axiom is slightly weaker than the axiom of convexity usually adopted in advanced texts (Jehle, 1991; Mas-Colell et al., 1995). In the two commodity case, the convexity axiom is equivalent to the principle of decreasing marginal rate of substitution, one of the theoretical lynchpins of utility theory. In general, indifference maps convex to the origin imply a decreasing marginal rate of

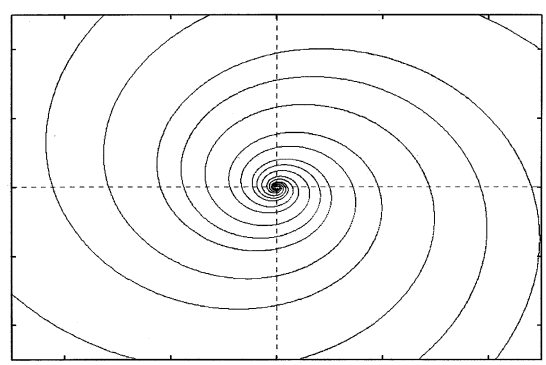

Fig. 1. Integral curves around a saturation point.

[4] These curves are not spiral forms as Georgescu-Roegen (1936) believed. He apparently overlooked the reflective symmetry of the integral curves involving the saturation point (Mayumi, 2001).

substitution between any two commodities. Axiom 6 has no meaning if the commodities are only ordinally measurable. For example, 'half' of a commodity would not be uniquely defined without some notion of cardinality. Neoclassical texts usually argue that any scale is as good as another, that is, only ordinal rankings of commodity bundles are necessary. But the following example shows that this argument is not universally valid. The utility function $U=\sqrt{xy}$ exhibits a decreasing marginal rate of substitution. Let us adopt a new scale by the monotonic transformation, $x=e^{-1/u}$ for $0\leq x\leq e^{-1}$, and $x=e^{u^2-2}$ for $e^{-1}\leq x$. We use the same transformation for y into v. We obtain the new utility function $U=e^{u^2+v^2-4/2}$ in the domain $u,\ v\leq 1$. Thus, if we monotonically transform this utility function again, we obtain a new utility function whose indifference function is $u^2+v^2=\text{constant}$. The principle of decreasing marginal rate of substitution does not hold for this new utility function. This example shows that without axiom 6, we cannot determine even theoretically what is an appropriate scale of monotonic transformation in the commodity space to obtain a utility index. This points to an inconsistency in the claim that ordinal utility is sufficient to construct a consistent theory of consumer choice. The axiomatic system needed for utility theory includes an axiom, which is inconsistent with the ordinality claim.

What is the relevance of axiom 6 to environmental valuation? Axiom 6 suggests that any economic law describing the structure of consumer choice depends on the special type of measure used for commodities. But how can people determine one specific measure when they evaluate various environmental services in a CVM scheme? What is the relation between commodity scale and the monetary metric used in CVM? Even ordinal measurability does not fit in the simplest picture of a utility function.

3.4. Lexicographic preferences and the hierarchy of wants

Ordinalists once believed that axioms 1–6 are sufficient to build a utility function which is an ordinal measure of the preference of HO. But suppose we drop axiom 7 (the indifference postulate) and retain all the others. It can be demonstrated that without axiom 7, we cannot obtain an ordinal measure of utility. In fact, this axiom is necessary to preclude a lexicographic ordering of preferences. Lexicographic preferences mean that even if alternatives can be compared, this does not imply that an ordinal measure can be obtained.

As Georgescu-Roegen pointed out, lexicographic choice is reflected in the hierarchy of human wants, termed by him the principle of irreducibility of wants. Lexicographic preferences imply that consumers are not necessarily willing to substitute one object of utility for another. Everyday observations, as well as empirical tests, show that lexicographic ordering is ubiquitous, bread cannot save someone dying of thirst; life in a luxurious palace cannot substitute for food (Georgescu-Roegen, 1954b). It is impossible to represent a lexicographic ordering in terms of a single linear, dimension-preserving utility index. Mathematically, lexicographic ordering is not a linear continuous series. A linear continuous series satisfies the following three postulates (1) the dedekind postulate, (2) the density postulate, and (3) the linearity postulate. It has been long known that lexicographic ordering does not satisfy the linearity postulate (Huntington, 1917). This prevents us from establishing an ordinal index of utility for a lexicographic preference set.

Lexicographic preference is more than a theoretical curiosity. Such preferences are pervasive in CVM surveys but when they occur, they are discarded from the surveys. Spash and Hanley (1995) argue that valuation methods, which elicit bids for biodiversity preservation fail as measures of welfare changes due to the prevalence of lexicographic preferences. They found that a significant number of respondents refuse to make trade-offs between biodiversity and market goods. Stevens et al. (1991) also found evidence for lexicographic preferences in a study estimating the value of wildlife in New England. Forty-four percent of respondents agreed with the statement 'preservation of wildlife should not be determined by how much money can be spent'. Sixty-seven percent agreed with the statement '[a]s much wildlife as possible should be preserved no matter what the

cost' (Stevens et al., 1991). Lockwood (1999) in a survey of the contributions of environmental psychology, economics and environmental philosophy to the debate about the human valuation of nature concludes that when non-compensatory preferences are present (meaning that a change in one alternative cannot be compensated by a change in another alternative) a multifaceted valuation framework is necessary.

As Arrow (1997) points out, lexicographic preferences need not be inconsistent with neoclassical utility theory if marginal valuation is possible. For example, we may place an infinite value on our own lives, but we may accept an increased risk of death for a price. The neoclassical explanation of lexicographic preferences would be that high risks do not have a monetary equivalent (Arrow, 1997). Another explanation is that in cases where people are willing to risk their lives, the risk is perceived to be so small it is assumed to be zero. The problem of lexicographic ordering revolves around the appropriateness of marginal valuation.

The seven axioms of consumer choice are inconsistent with a hierarchical ordering of human wants or the evolution of preferences over time. According to Georgescu-Roegen, the existence of a hierarchy of wants is necessary to explain the principle of decreasing marginal utility. Different levels of needs have different degrees of importance to us. But we should note that what can be generally described as the hierarchy of human wants involves several other principles. The satisfaction of every want 'lower' on the scale creates a desire of 'higher' character. That is, the satisfaction of a lower want permits the higher want to manifest itself.[5] In a way, the satisfaction of lower wants enhances the perception of wants higher in the hierarchy. Georgescu-Roegen (1954b) terms this the principle of subordination of wants. We know that as a rule humans must reach satiety before the next want can manifest itself. Regardless of whether or not we accept the idea that wants have an intensity, it is hard to deny the existence of another related principle listed by Georgescu-Roegen (1954b), the principle of satiable wants. Due to the fact that the hierarchy of wants is open-ended, as soon as humans manage to get close to the satiation of a new want, there is always another want higher on the ladder. This is Georgescu-Roegen's principle of the growth of wants, which refers to the absence of absolute saturation of human ability to want more. Of course, this principle has an evolutionary character as well as being culturally specific. Marginal utility theory has ignored all these principles except the principle of satiable wants, which is the essence of the principle of diminishing marginal utility.

Economic valuation assumes the existence of a common essence of all wants, a unique want into which all wants can be merged into a mono-dimensional definition of utility. As a consequence of this procedure, very important issues, which cannot be answered without addressing some of the questions above, could be ignored. Economists could argue that since their theory is in this way basically transformed into 'choice theory', which no longer uses the utility concept, our criticisms above are not relevant. Unfortunately, the metamorphosis from utility theory to consumer choice theory was based on a progressive focus on relations among goods themselves and on the axiomatic aspects of the formulation. Arguments for the plausibility of the existence of a common denominator (in terms of utility or ultimately in terms of money as a possible encoding for the quality to be mapped) have never been seriously made, perhaps because in real-world markets everything is in fact reduced to a common monetary denominator. The neoclassical theory of choice contains all the consequences of the belief in the reducibility of all wants into money. Martinez-Alier et al. (1998) argue that the assumption of commensurability of wants is the key feature that separates neoclassical and ecological economics (see the discussion by Radin, 1996; Arrow, 1997).

[5] There is a hint of this in Becker's (1996) work on tastes as an investment. For example, classical music is appreciated more after an investment of time in listening to it.

4. The marginal utility of money, Walrasian system and methodological individualism

The basic ideas behind CVM may be traced back to the Dupuit–Marshall principle which holds that the amount of money a person is willing to pay for satisfaction rather than doing without satisfaction is the economic measure of that person's satisfaction. In practical terms, utility can be measured by money. In the Dupuit–Marshall scheme or the CVM scheme, utility of money that an individual has to pay for each additional 'util' must always increase because money is drawn away from increasingly important uses.

CVM must assume, as Marshall does, that the marginal utility of money is quasi-constant. However, this hypothesis deserves analysis. Marshall's aim is to analyze the economic reality of his own time and space, but according to Georgescu-Roegen (1968), the assumption of quasi-constancy of marginal utility of money is compatible with a society consisting of 'middle class individuals', a society typical of developed countries where a substantial part of personal income is spent on numerous mere conveniences. Most mere conveniences are connected with marginal expenditures in relation to total income. So, variation in income causes one of these mere convenience items to disappear from the budget or to appear as a new entry in the list of expenditure. In such conditions, it is reasonable to assume that the utility of money among convenience items can be considered to be the same because individuals find it difficult to decide whether to buy one convenience item or another. However, it is questionable whether or not CVM can evaluate environmental services in developing countries because in such countries, a minimal part of the consumer budget is spent on mere conveniences.

The mathematical solution of the Walrasian system investigated by Arrow and Debreau (1954) may not be suitable for the economic situation facing developing countries (Georgescu-Roegen, 1960). But certainly, assessing trade-offs between economic growth and ecological constraint in developing countries is crucial in the debate on sustainability issues. Arrow and Debreau (1954) assume that 'every individual could consume out of his initial stock in some feasible way and still have a positive amount of each commodity available for trading in the market'. But they confess that this 'assumption is clearly unrealistic' (Arrow and Debreau, 1954). Arrow and Debreau have to make such an assumption because equilibrium requires each individual to possess at least one commodity commanding a positive price at equilibrium. This assumption sets aside the sustainability issues from the beginning! People in developing countries may be so poor that, for example, 'deforestation and the depletion of fuel wood supplies, forces poor households to divert dung for use as fuel rather than for fertilizer and present value of the dung as fuel is higher than its value as a soil nutrient' (Barbier and Markandya, 1990) resulting in a much worse ecosystem condition. In developing countries short-term biophysical needs may take precedence over the long-term sustainability. In developed countries, the situation is entirely different, so Costanza et al. (1997) assume that 'wealthy nations (could) value their coasts 100 times as much as poorer ones, making the latter's contribution relatively tiny (in monetary terms)' (Pimm, 1997).

Neoclassical economists adopted the Walrasian system which assumes sufficient initial endowments. But according to Georgescu-Roegen (1982), the doctrine of neoclassical economics was molded on an economic reality of abundance after the industrial revolution and in this framework what is scarce is demand for each kind of product. Utility is regarded as the source of value and incorporated into consumption theory, allowing neoclassical economists to include things like ecological services to be included in the utility function and analyzed by economic tools including CVM. The neoclassical assumption of limitless substitution justifies monetary valuation.

Much of the criticism of neoclassical economics is directed at the notion that humans are rational calculating individuals. According to neoclassical economists Homo oeconomicus lies at the heart of consumer choice theory. In connection with the rationale of Homo oeconomicus, Arrow (1997) recalls a skit performed by graduate students at the University of Chicago in the late 1940s. The

leading character, rational economic man, stands with a slide rule prepared to answer all questions. He is asked 'How much would you charge to kill your grandmother'? and after some calculations he looks up and asks, 'Do I have to dispose of the remains?' The fact that this skit is taken by the audience to be satire shows that the graduate students were aware of the limits of the rationality assumption in a set of axioms of consumer choice theory. Still, economists consider the individual to be a sort of mechanical calculator of pleasure and pain and this caricature of human behavior lies at the center of economic analysis.

The notion of individual self-interest is elevated to a moral position by many economists. The argument is that each individual knows what is best for her or himself, and any attempt to override individual choice by any form of collective action is met with charges of totalitarianism. As Randall (1988), puts it, ''mainstream economic approach is doggedly non-judgmental about people's preferences, what the individual wants is presumed to be good for that individual''. Georgescu-Roegen is eloquent in discussing the point that what is good for an individual with a finite life span, acting at a particular point in time, may not be best for society as a whole.

> It is utterly inept to transpose to the entire human species, even to a nation, the laws of conduct of a single individual. It is understandable that an individual should be impatient (or myopic), i.e. to prefer an apple now over an apple tomorrow. The individual is mortal. But the human species or a nation has no reason to be myopic. They must act as if they were immortal, because with the immediate horizon they are so. The present turning point in mankind's evolution calls for the individual to understand that he is part of a quasi immortal body and hence must get rid of his myopia (Georgescu-Roegen, 1976).

In neoclassical utility theory, only individual perceptions count. There is no social, biological or physical reality outside the individual, only the subjective feelings of unconnected utility maximizers. The methodological individualism of consumer choice theory systematically ignores the hierarchical nature of social and ecological systems when preferences and utility are aggregated within social systems. In nested hierarchical systems, the characteristics of higher level elements cannot be deduced by only considering characteristics of lower level elements. In hierarchy theory literature the problem of such extrapolation is known as 'scaling' (see e.g. Allen and Starr, 1982). Scaling implies that crossing a hierarchical level of organization requires consideration of 'emergent' behavior and such emergent behavior cannot be deduced by using only information gathered at the lower level.

The limitations of methodological individualism due to the hierarchical nature of social systems may be illuminated by the following example of three individuals choosing a restaurant (Giampietro and Mayumi, 2001; Mayumi, 2001). Individual A prefers Chinese food rather than fast-food or Japanese food. B prefers fast-food rather than Japanese food or Chinese food. C prefers Japanese food rather than Chinese food or fast-food. If the three people decide to eat out together they must choose a restaurant which serves only one kind of food. Economists who ignore the hierarchical nature of social systems believe that the information gathered about their individual preferences for restaurants can predict where they will end up eating.

In real-life situations such a prediction cannot be made without additional information. For example, because of the existence of cross constraints the group might well end up eating in a 'generic restaurant' compatible with the 'aggregate' constraints. Group behavior can escape the restrictions imposed by each member of that group. Using the landscape fitness analysis metaphor — the larger the group, the easier it settles on lower peaks on the fitness landscape (Kauffman, 1993). Using the common-sense approach of choosing a generic restaurant implies a hypothesis that the aggregate preference curve of the group is not something that can be defined 'once and for all' using only information about the independent preferences of the individual members of the group. Consider the following

possible alternative situations in which the three individuals decide to eat out together for dinner.

Situation 1. No special attribute affects the aggregation of preferences. The set of individual constraints will operate without weighting factors. In this case, the same set of attributes that leads to the preference of Chinese food, fast-food or Japanese food no longer operates. There is another crucial attribute, that of spending the night with others rather than eating alone. However, this new attribute opens the door to myriad of unexpected complications.

Situation 2. In this situation dinner is planned in a day which is the birthday of one of the three people. In this case, the group can decide to please the person celebrating by going to that person's favorite restaurant.

Situation 3. In this situation some social hierarchy operates among the three. For example, one of the three is a VIP to be considered 'special' by the other two.

Situation 4. In this situation some special event such as the winning of a lottery or a job promotion affects the usual preference structure of one or more persons. The special event centered on a particular person could remove constraints among the group members that usually operate, and therefore overall preference structure might change dramatically.

In all four situations, the curve of preference of the group is the result of social processes emerging from the complex web of effects determined by large scale processes and small scale details.

5. Probabilistic binary choice and environmental valuation under uncertainty

As a step toward overcoming some of the difficulties raised regarding consumer choice theory we propose in this section an extension of the neoclassical utility axioms to include a region of hesitation in which choices cannot be categorized as more preferred, less preferred, or indifferent under uncertainty about environmental attributes. We do this by incorporating the assumptions of a 'psychological threshold' (leading to a region of hesitation) proposed by Georgescu-Roegen. Axioms 2, 3, and 7 above exclude such a region of hesitation by making *HO* a perfect choosing instrument. But hesitation is a common feature of choices made under conditions of pure uncertainty as shown regularly in CVM surveys. Uncertainty as to the characteristics of environmental attributes and as to the consequences of choices are prevalent in the case of environmental services. Such services are characterized by what Vatn and Bromley (1994) call 'functional transparency'. That is, we do not know the effect of altering an ecosystem until after the alteration is made. Designing an experiment to directly test the validity of axiom 7 (the indifference postulate) seems impossible because there are no means for testing assertions involving the continuum between more preferred and less preferred. In a sense, the questions involved in the indifference postulate cannot be settled solely in terms of observable facts. This confronts us with the more difficult question as to whether or not indifference may be defined in such a way as to avoid all references to introspection so as to base the definition only on direct observation. As shown below, if axioms 2, 3, and 7 are modified to incorporate a hesitation region, *HO* cannot make choices without considerable doubt. If we accept the presence of this type of region, the choice between C^1 and C^2 may not always show a consistent preference ordering. Following Georgescu-Roegen's (1936)Georgescu-Roegen (1958) scheme, we introduce a New Homo oeconomicus (*NHO*) and adopt the following set of axioms for *NHO*.

1. Given two points, $A(a_1, a_2, \ldots, a_n)$ and $B(b_1, b_2, \ldots, b_n)$ in the environmental attributes space, $w(A, B) + w(B, A) = 1$, where $w(A, B)$ is the probability that A be chosen.
2. If $A \geq B$, then $w(A, B) = 1$. $A \geq B$ means if $a_i \geq b_i$, $i = 1, \ldots, n$ and $a_j > b_j$ for at least one j.
3. The probability $w(X, A)$ is a continuous function of X, except for $X = A$, where $w(X, A)$ can take any value in the closed interval [0, 1].
4. If $A \leq B$, then $w(A, C) \leq w(B, C)$, the equality sign holding only if $w(A, C) = 1$ or $w(B, C) = 0$.
5. Pseudo-transitivity, if $w(A, B) = w(B, C) = p \geq 1/2$, then $w(A, C) \geq p$.

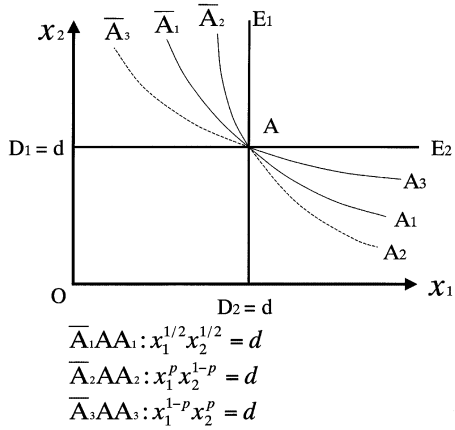

Fig. 2. Probabilistic binary choice mapping.

6. General principle of persisting non-preference direction, if $C = \lambda A + (1-\lambda)B$, with $0 < \lambda < 1$, then $w(A, B) \leq w(C, B)$.

From this set of axioms, a simple model with two parameters, p and d, can be constructed. Here, the parameter p is taken as probability $w(X, A)$ given the point A. The point (d, d) is taken as the reference point A. One possible model is the following one-parameter family of differential equations satisfying the classical conditions of indifference directions (convexity) and $\partial/\partial p(-\mathrm{d}x_2/\mathrm{d}x_1) > 0$.

$$p x_1^{p-1} x_2^{1-p}\,\mathrm{d}x_1 + (1-p) x_1^{p} x_2^{-p}\,\mathrm{d}x_2 = 0. \tag{1}$$

We can solve this equation to obtain a two-parameter family of integral curves (Eq. (3) below). Assuming that $x_1^p x_2^{1-p} < (x_1^*)^p (x_2^*)^{1-p}$ for $(x_1, x_2) < (x_1^*, x_2^*)$, the other values of $w(X, A)$ can be defined according to the following rules:

1. $w(X, A) = p$, if either $x_1^p x_2^{1-p} = d$, or $x_1^{1-p} x_2^p = d$, and $x_1^{1/2} x_2^{1/2} > d$ when $1/2 < p < 1$;
2. $w(X, A) = p$, if either $x_1^p x_2^{1-p} = d$, or $x_1^{1-p} x_2^p = d$, and $x_1^{1/2} x_2^{1/2} < d$ when $0 < p < 1/2$;
3. $w(X, A) = 1$, if $x_1 \geq d$, $x_2 \geq d$, and $x_1^{1/2} x_2^{1/2} > d$;
4. $w(X, A) = 0$, if $x_1 \leq d$, $x_2 \leq d$, and $x_1^{1/2} x_2^{1/2} > d$.

It is relatively easy to show that this model satisfies the set of axioms for *NHO*.

In Fig. 2 the three curves, $\bar{A}_1 A A_1$, $\bar{A}_2 A A_2$, and $\bar{A}_3 A A_3$ represent the following three equations in turn;

$$x_1^{1/2} x_2^{1/2} = d, \tag{2}$$

$$x_1^{p} x_2^{1-p} = d, \tag{3}$$

and

$$x_1^{1-p} x_2^{p} = d. \tag{4}$$

The curve $\bar{A}_1 A A_1$ in Fig. 2 represents the locus with $w(X, A) = 1/2 - X$ and A are perfectly indifferent. This smooth differentiable curve $\bar{A}_1 A A_1$ is similar to the one obtained in the neoclassical utility theory. On the other hand, the curve $\bar{A}_2 A A_3$ represents the locus with $w(X, A) = p$ where $1/2 < p < 1$. However, this curve $\bar{A}_2 A A_3$ is not differentiable, but still convex toward the origin. The case in which $0 < p < 1/2$ can be depicted in a similar way. We should note that the case for which either $w(X, A) = 1$ or $w(X, A) = 0$ is represented by the areas $E_1 A E_2$ or $D_1 A D_2 O$. The limiting lines relative to A ($x_1 = d$ and $x_2 = d$) can be obtained if p approaches either 0 or 1 in Eq. (3). The areas $E_1 A D_1$ and $E_2 A D_2$ may be termed as *hesitation region* relative to the point A in which $w(X, A)$ is neither 0 nor 1, for all price lines within this angle, *NHO* can only attach some probability of selecting a direction from the initial position A. In Georgescu-Roegen's words, we "should also be aware of the possibility of interpreting as 'indifferent states' those which man cannot order without a great deal of hesitation or without some inconsistency. Such cases are the symptoms of imperfections in the mechanism of choice caused by a psychological threshold which is absent" (Georgescu-Roegen, 1954b) in *HO*. This is not indifference but rather an inability to choose, as in the case of Buridan's donkey, which starved to death between two identical piles of hay (Georgescu-Roegen, 1973).

The three different regions of this model are shown in Fig. 3. If we take any path moving toward a preferred ($w(X, A) = 1$) or non-preferred ($w(X, A) = 0$) direction, the choice in these two regions is consistent, i.e. transitive. However, in the hesitation region choice is not transitive in general. This situation is shown in Fig. 3 where we might move from A to J and from J to L, but L is preferred to A. The lack of transitivity with respect to hesitation is obvious because there is a range of probability ($0 < p < 1$) between any two commodities in the case of hesitation. We encoun-

ter this type of hesitation whenever a new situation is given to a consumer. So, in a sense, the state of mind described by indifference in neoclassical economics is rather strange. We share the view of Georgescu-Roegen that the states of mind, that could be called indifference should be those which we cannot order without a great deal of hesitation or without some inconsistency. The behavior described by *NHO* shows exactly these sorts of indifferent states with great hesitation rather than the states of mind willing to trade described by the CVM. The notion of a hesitation region discussed in this section can be regarded as a consequence of the inability of humans to visualize an imaginary situation exactly as we will feel it after many experiences of the situation.

The basic issue discussed in this section, the consumer's inability to choose among alternatives in many situations, has plagued CVM researchers since the inception of that survey method. Consumers frequently are unable to choose among alternatives because of incongruity (Martinez-Alier et al., 1998), difficulties in conceptualizing discounted streams of cost and benefit (see the discussions Hausman, 1993), and functional transparency (Vatn and Bromley, 1994). These problems are usually swept under the rug by invoking the revealed preferences argument. That is, when people spend actual money in actual markets it must be assumed that they are acting 'rationally', in contrast to the 'irrational' responses given in hypothetical surveys. There is no reason to believe, however, that people somehow suddenly become a strictly rational, calculating economic persons as soon as they enter the marketplace. Rather than to invoke restrictive ad hoc explanations as a matter of pure faith, we believe that seeking a more realistic foundation for consumer choice theory is a more fruitful approach.

6. Conclusion

Following the triumph of neoclassical theory after WWII, criticisms of the basic axioms of consumer choice were more or less limited to those outside the mainstream of the economics profession. Economists were for the most part satisfied with the Stigler and Becker (1977) position that tastes were not a matter of dispute, and with the Friedman (1953) argument that the realism of the assumptions of economic theory was not a matter of concern as long as the theory could be used to make accurate predictions. With the weakening of economic orthodoxy following the energy price shocks of the 1970s and the global financial instability in the 1980s and 1990s, some of the basic tenets of economic theory came under attack as never before. Within the field of environmental economics major crises such as global climate change and the worldwide loss of biodiversity called into question the theoretical foundations of the basic tools of economic analysis used in environmental policy. A number of environmental policy failures have led to new approaches, for example, Bromley (1989), Ostrom (1990), Hanna (1997), and many others argue for the reformulation of institutions for democratic collective action as a means to manage environmental resources.

In the past, a number of methodological breakthroughs in economics have been the direct result

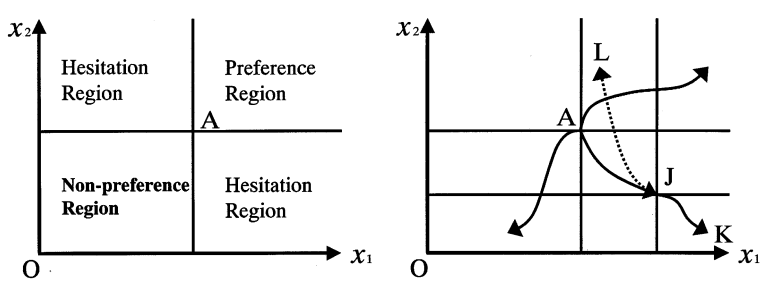

Fig. 3. Hesitation region and violation of transitivity.

of policy failures, a notable example being Keynes' *General Theory*. It is our hope that some of the current controversies surrounding environmental valuation will convince economists of the importance of reconciling economic theory with basic knowledge in other sciences (Wilson, 1998). It is our belief that some of the fundamental assumptions of neoclassical utility theory, non-satiation, the indifference postulate, the commensurability of wants, and indeed methodological individualism itself are not only unrealistic but also have had unforeseen and unfortunate consequences for environmental and social policy. Furthermore, predictions based on the axioms of consumer choice have proved to be less accurate than those based on more realistic assumptions of human behavior (see the examples in Gintis, 2000, chapter 11). It is hoped that a reformulation of consumer choice theory to allow for phenomena consistently found in consumer surveys can lead to more effective environmental policies. Findings from experimental economics not only call into question some of the basic assumptions of neoclassical theory, they also provide the basis for a mixed methodological approach to valuation and policy. These studies are not coming from the fringe of economic theory, they are being published in the major mainstream journals (Tversky and Kahneman, 1991; Andreoni, 1995; Benartzi and Thaler, 1995; Bateman et al., 1997a,b, 2000). Likewise, the field of game theory, once a bastion of orthodoxy, is providing extremely valuable insights into economic behavior (Gintis, 2000). Game theoretic models of altruism, for example, are proving to be better predictors of human behavior than models based on the axioms of consumer choice (Friedman, 1991; Bergstrom and Stark, 1993; Bowles and Gintis, 1997; Bohnet and Frey, 1999; Gächter and Fehr, 1999).

In the mid-1980s ecological economics was a pioneer in interdisciplinary thinking. The rest of the world is rapidly catching up and one dilemma ecological economists now face is how to move from criticism of mainstream theory to providing a real alternative to the welfare economics core of neoclassical theory. The problem is how to use economic analysis without becoming trapped in the general equilibrium framework that has given the world so many unrealistic and sterile policy recommendations. Tremendous gains have been made within the economics profession during the last two decades. Economic journals now routinely publish papers questioning the standard characterization of human nature, the standard representation of economic production, and even the standard assumption of growth as progress. The time is ripe of a unification of insights from various heterodox schools of economics, and from other social and natural sciences in a way that can provide a viable alternative to neoclassical dogma.

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