

Models of Individual Behaviour and Implications for Environmental Policy

Jeroen C.J.M. van den Bergh
Department of Spatial Economics
Free University
De Boelelaan, 1105
1081 HV Amsterdam
The Netherlands
jbergh@econ.vu.nl

Ada Ferrer-i-Carbonell
Department of Economics
School of Humanities and Social Sciences
Rensselaer Polytechnic Institute
Troy, NY, 12180
USA
ferrea@rpi.edu

Giuseppe Munda
Department of Economics and Economic History
Universitat Autònoma de Barcelona
Edifici B
08193 Bellaterra (Barcelona)
Spain
iehe7@cc.uab.es

Abstract

Most insights of environmental economics are in line with the standard neoclassical economic model of rational behaviour, formulated in terms of maximization of utility in general, or profits in particular. The standard theory of environmental policy is a case in point. However, the maximization hypothesis and its methodological foundation have been criticized on many grounds, related to a lack of either logical or empirical content. Moreover, over the years a great many alternative models of behaviour have been proposed. Both criticism and alternatives are surveyed here. In the context of environmental economics behavioural assumptions have been most significant for the development of economic valuation theory and environmental policy theory. The focus here will be on environmental policy theory.

1. Introduction

Most insights of environmental economics are based on the standard neoclassical model of rational behaviour: constrained maximization of utility or profits. However, the maximization hypothesis and its methodological foundation have been criticized on many grounds. Moreover, many alternative models of behaviour have been proposed in the last few decades. In this paper we examine the importance of the criticism and alternative models for environmental economics. Two main areas of research in environmental economics are dominated by the standard behavioural model. The first one is economic valuation, dealing with development and application of methods for estimating individuals' values for environmental changes, based on revealed and stated preferences. The other is the theory of environmental regulation, where efficiency is the guiding principle for selecting environmental policy instruments. The discussion here will focus on the implications of alternative behavioural assumptions for environmental policy theory. This article can only offer a first step in this relatively unexplored area of research.

It will not be argued that neoclassical behavioural theory should be completely rejected, in spite of doubts about its realism, accuracy and predictability. Consequently, it makes sense to follow a pluralist approach and consider alternative behavioural assumptions on an equal level. Many authors in "ecological economics" have expressed a discomfort with the neoclassical behavioural model, and some have even pointed out that it is partly responsible for setting the wrong agenda for environmental policy-making (Costanza, 1991). But although ecological economics is prospering as a field of integrated research, it has generated few new insights about the link between behaviour, environment and policy.

The organization of this paper is as follows. Section 2 summarizes the main assumptions of the standard microeconomic theory of consumer and producer behaviour. Section 3 provides a concise review of the essential criticism of the maximization hypothesis. Section 4 introduces several main alternative models of economic behaviour. Section 5 outlines the implications of a relaxation of neoclassical behavioural assumptions and a replacement by alternative behavioural assumptions for environmental policy theory. Section 6 presents conclusions.

2. Assumptions underlying maximizing behaviour

Here, we review the main issues in the debate on the realism and usefulness of the "utility maximization" model, which has been going on at least since Thorstein Veblen's writings a

century ago. The classic approach to the theory of consumer demand initiated by Slutsky in 1915, Hicks in 1939 and Samuelson in 1947, started from differentiable utility functions. The axiomatic approach was pioneered by Frisch's introduction of the concept of a preference relation in 1926, and further developed by Arrow and Debreu in the 1950s. Russell and Wilkinson (1979) refer to the first as the neoclassical or marginalist approach based on calculus, and the second as the modern approach based on set-theory and topology. Preference theory may be regarded as more general than, and the basis of, utility theory, which in turn is more general than, and the basis, of demand theory. When we speak of the neoclassical behavioural model it is meant to cover either of these approaches, which are essentially alternative presentations of the same thing.

It is noteworthy that many microeconomic textbooks, including the most influential ones, devote hardly a single line to support the maximization hypothesis. For instance, in an influential textbook from the seventies it is stated that the assumption "... the consumer chooses ... the optimal consumption bundle ... is ... so reasonable that it needs little discussion" (Russell and Wilkinson, 1979, p. 17). And in one of the most widely used textbooks during the last two decades not even a single motivation for profit and utility maximization is given. The most that is said is: "A basic assumption of most economic analyses of firm behaviour is that a firm acts so as to maximize its profits; ... This is the behavioural assumption that will be used throughout the book." (Varian, 1992, p23). This is as far as the motivation for profit maximization behaviour goes; utility maximization behaviour does not receive any motivation at all. Finally, a recent well-known textbook says: "... it is logical to take the assumption of preferences maximization as a primitive concept for the theory of consumer ..." (Mas-Colell *et al.*, 1995, pp. 152). Students may thus learn standard economic theory without being confronted with the question why we should assume maximizing behaviour. Given that microeconomic textbooks emphasize formal, mathematical proofs for any further statements beyond the core assumptions, it seems a bit out of balance — to say the least — that they skip any serious discussion of behavioural assumptions in economic theory.

The modern theory of consumer behaviour starts from the notion of "consumer preference". By imposing "rationality" conditions on these, the theory of choice is obtained (e.g., Deaton and Muellbauer, 1980; Varian, 1992). Rationality is regarded as consistent maximization of a well-ordered function (Becker, 1962; Hirschleifer, 1985). The main requirements are that preferences are complete and transitive, so that individuals behave consistently.

Maximization of utility can be phrased as choosing the bundle that is preferred to or no worse than all other bundles. Utility then represents all preference orderings by a specific consumer for all possible bundles or combinations of commodities. Thus it is assumed that a consumer always has a complete preference ordering, i.e. over all possible goods. The set of bundles that can be chosen is restricted to what can be purchased given income and prices of all goods, which together determine a budget constraint. The theory therefore characterizes the bundle of goods that will be chosen, the optimal consumption bundle, as the preferred subset of the budget set. In addition, it allows the prediction of how the optimal choice will change in response to changes in the feasible set.

The preference relation is the fundamental element of utility theory. A common set of assumptions (or axioms) underlying preference relations is as follows: “completeness”, i.e. for any pair of bundles the consumer is always able to express a preference or indifference relation (consumption bundle a is strictly preferred to b , or b is strictly preferred to a , or the consumer is indifferent between them); “reflexivity” which is a trivial statement (any bundle is preferred or indifferent to itself); “transitivity” which is a consistency requirement (if a is preferred to b , and b to c , then a must be preferred to c ; and if a consumer is indifferent between a and b , and between b and c , then also between a and c). Many economists regard these assumptions of consumer theory as the result of searching for the minimum or weakest assumptions to maximize the generality of the abstract theory.

Now an optimum consumption bundle exists when these conditions hold, and in addition prices and income are positive, and a “regularity” or “continuity” assumption holds. The latter states that complete substitution between goods is always possible, and rules out certain discontinuous behaviour or indifference classes that consist of single points. Continuity is not satisfied, for instance, by the lexicographic ordering (discussed later). Another assumption frequently made is “monotony” (weak or strong): more of any good is preferred, i.e. all goods are desirable or is always possible to redefine a non-desirable good as the absence of it. This implies well-ordering of preferences. In order to make sure that all income is spent in the optimum, a “non-satiation” assumption is added, which states that one consumption bundle is always preferred to another if it has more of one good and equal amounts of all other goods. In other words, the optimum then lies on the budget constraint. A final assumption necessary to complete the theory is that preference relations are convex, or that indifference curves associated with particular levels of utility for a given utility function are convex. Together with monotony, this assumption assures that the constrained utility maximization subject to a budget

restriction has a unique solution for given levels of income and prices. Convexity of indifference curves also implies that the consumer would always prefer middle points of the indifference curve to extreme ones and that the marginal rate of substitution (slope of the indifference curve) is decreasing. Although a mapping of indifference sets to utility levels can take any form, usually it is assumed that U can be written in analytical form. This implies ordinal utility theory, in which utility has no logical, measurable units.

The foregoing preference and utility assumptions imply certain features of consumer demand functions, also referred to as (income) uncompensated, Marshallian or demand functions in “directly observable” prices and quantities. Such functions for each commodity or service follow from the first-order conditions for an interior optimum implied by the mathematical form of the utility maximization problem, and are dependent on the price of the respective good, the prices of all other goods, and the income of the (respective) consumer. First, they are homogeneous of degree zero in prices and income. This means that multiplying all prices and income with the same scalar will leave demand unchanged, so there is no money illusion. This is consistent with the idea that prices and income should always be seen in relative terms.

Deaton and Muellbauer (1980) argue that limits to choice should receive more attention and state that: “Unlike preferences, the opportunities for choice are often directly observable so that, to the extent that variations in behaviour can be traced to variations in opportunities, we have a straightforward and objective explanation of observed phenomena. It is our view that much can so be explained and that the part played by preferences in determining behaviour tends to be overestimated.” (Deaton and Muellbauer, 1980, p3); and: “... the presence of indivisibilities, kinks, and other nonlinearities may limit choice to the extent that only very mild additional assumptions are required to describe behavior completely.” (p21). Implicitly, they argue in favour of consistent and fixed preferences. But the weakness of the whole argument is that most of neoclassical economic analysis is based on linear constraints, largely due to the fact that nonlinear ones can often create insoluble analytical problems. Nonlinear budget constraints are possible due to taxation, benefit systems, labour/leisure decisions, information asymmetry, distribution impacts on individual behaviour, household production functions, imperfect capital markets, etc. Interestingly, Deaton and Muellbauer (p87) explicitly state that they use the term “neoclassical” models “... to label the assumption of linear budget constraints with fixed, known prices.”

3. Criticism of the maximization hypothesis

A few insights from the philosophy of science

The philosophy of science is dominated by the longer tradition in and consequently more mature level of research in natural sciences, in particular physics. This was the main reason why empirical and logical positivism entered economics, with its focus on pure logic, refined controlled experiments and measurements, and prediction. Recently, in biology it is realized that this type of science philosophy may be inadequate to address particularities of modern biology, especially evolutionary theory and natural history. As a result, biology has developed separate perspectives on methodology (e.g., Ruse, 1986; Mayr, 1988). Likewise, engineering and medicine are sometimes mentioned as requiring different science philosophies as well. Such alternative methodologies may be relevant for social sciences including economics, whose “realities” are dominated by evolution, where controlled experimentation is extremely limited, and whose aims are linked to policy and management. However, given the history of economics, we will focus here on the more traditional understanding of science philosophy dominated by Popper and Kuhn.

A long debate over whether the neoclassical behavioural assumptions can be actually tested, or whether their implications should be tested, is related to this Popperian view of science. A fundamental problem in this context is known as the so-called Duhem-Quine thesis, which states that it is not possible to falsify a single hypothesis because it is invariably conjunctions of hypotheses which are being tested. In these circumstances it is difficult to falsify theories according to Popperian criteria: “According to the Duhem-Quine thesis we can never be sure that the main hypothesis has been put open to falsification on its own, and that other auxiliary hypotheses are not involved” (Hodgson, 1988, p. 40). Rival philosophies of science have been developed by Kuhn, Lakatos and Feyerabend. Thomas Kuhn does not regard scientists as truth-gathers of the positivist tradition, nor the heroic conjecturalists of Popper, but as ordinary people, trying to solve specific research problems within an unquestioned setting of concepts and methods. Scientific progress alternates between “gradual” and “revolutionary” phases. (Ravetz, 1990, p. 187). Later on, Lakatos, and Feyerabend in his famous book “Against Method”, stimulated a variety of social science approaches to scientific knowledge, all of which argued that scientific knowledge is a social construct, characterized by a large degree of arbitrariness. (Ravetz, 1990).

Popperian falsificationism and the maximization hypothesis

In one of the most forceful defences of the maximisation hypothesis, Friedman (1953) states that “truly important and significant hypotheses will be found to have 'assumptions' that are widely inaccurate, descriptive representations of reality, and in general, the more significant the theory, the more unrealistic the assumptions (in this sense)”. To show that this statement is perhaps not as extreme as thought upon first glance, it may be noted that Friedman immediately adds a footnote stating that “The converse of the proposition does not of course hold: assumptions that are unrealistic (in this sense) do not guarantee a significant theory.” A last citation may complete the Friedman perspective: “To be important, therefore, a hypothesis must be descriptively false in its assumptions”.¹ In essence, Friedman believes that the validity of a theory (i.e. its non-falsification) depends on its consequences, and that the empirical unrealism of the hypotheses (its “assumptions”) is not relevant.

Friedman’s work has generated extensive discussion among economists and philosophers. Caldwell (1984) offers a collection of the main contributions. In one of these, Boland (1979, p. 508) states that “Since no one has yet solved the problem of induction, one is always required to assume the truth of his premises or assumptions.”² In other words, every theory requires untestable axioms.³ Therefore instrumentalism may guide science, which means that the theory which is best in terms of conditional or future prediction is most desirable, irrespective of whether it is “realistic” in some sense.⁴ Acceptance of instrumentalism rules out the possibility of falsification in science (Popper 1965, pp. 113-114). From a theoretical point of view, within strict instrumentalism a theory is neither true nor false,

¹ Samuelson (1963) responded to this statement with: “... I notice that in the luckier exact sciences, no one dreams of making such a claim”.

² Boland makes the following (incomplete) distinction with regard to the different views of the relationship between logic, truth and theories (see also Caldwell, 1980): (1) inductivists say that theories can be true and all true theories are the result of applying inductive logic to observations; (2) conventionalists deny that a theory can be inductively proven, and regard theories as efficient systems for storing and organizing empirical information; (3) instrumentalist, such as Friedman in his 1953 essay, are only concerned with the usefulness of the conclusions derived from any theory.

³ In economics this is particular relevant for macro theories, since due to aggregation problems no straightforward testing of axioms is feasible.

⁴ It should be noted that a definition of “realism”, often used in a loose way, has frustrated the greatest minds in philosophy. It does not seem a very useful criterion therefore to judge theories. One may, however, regard realism as related to the amount of descriptive detail and attention devoted to observed cause-effect mechanisms in the system under study. This is how ecological economics would interpret “realism” (see Costanza *et al.*, 1993).

but merely adequate or inadequate for a given real-world problem. However, predictive success is really a very limited conception over a longer period of time. A good example of the latter is the optimistic conclusion regarding “sustainable growth” based on the neoclassical growth model, namely the fact that the immediate past has allowed much growth and technological progress, does not mean the same holds for an indefinite period of time into the future. Consequently, concluding the “growth debate” on the basis of empirical studies will be impossible.

According to the Popperian perspective, we should not hope to find any evidence for the maximisation hypothesis, but at best refutations stating that decisions were inconsistent with maximisation. The Duhem-Quine thesis is relevant here: for instance, if the auxiliary hypothesis of fixed preferences is incorrect, one cannot test consistency of behaviour over time, unless one has precise information about the changes in preferences.

Musgrave (1981) makes a distinction between negligibility assumptions, domain assumptions and heuristic assumptions. The first type is required to simplify and focus on the essence of the phenomena studied. These are not “descriptively false”, in the language of Friedman, but merely irrelevant. The second type of assumptions is needed when applying a theory — in an abstract or empirical way —, namely to specify the domain of applicability. Musgrave notes that the more unrealistic this type of assumptions, the less testable and significant the theory is. The third type of assumptions is needed when a theory cannot be directly tested, or when the essential (regarded) assumptions lead to a too complex model that (successive) approximation is required. One might see this as pure theory for the sake of learning about limits to the relationship between understandable implications and complexity.

Boland (1979) reviews the main critiques on the maximisation hypothesis. First, it is impossible to fulfil all the necessary conditions, like acquiring perfect and complete information. This type of fundamental (or epistemological) critique was offered, among others, by such great economists as Hayek, Keynes and Shackle. But Boland argues that complete and perfect information is not essential, among other thing, because true knowledge is not necessary for maximisation, as the individual has only to believe that his information is complete and perfect in which case he will not deviate from his decision. Boland (1981) essentially argues that neoclassical theory cannot be empirically tested since preferences are non-observable, and empirical surveys, introspection and direct observations are unreliable. Thus the maximisation

hypothesis in reality is just a metaphysical assumption which has not to be subjected to any empirical test: it is the “paradigm” (Kuhn, 1962) of neoclassical economics.

Methodological individualism

Using the utility maximizing model as the foundation of economics is an example of methodological individualism. Admittedly, this is a somewhat ambiguous term, which for our purpose may be formulated as: all explanations of social phenomena start from descriptions of individuals.⁵ This can be opposed to the “... allegedly untenable principle of *methodological holism*, according to which social wholes are postulated to have purposes or functions that cannot be reduced to the beliefs, attitudes, and actions of the individuals that make them up.” (Blaug, 1992, p44). This relates to Keynes’ suggestion of “fallacy of composition”, i.e. the whole is not the sum of its parts. In recent years this idea has been developed and enriched via the “theory of systems”, which focuses on chaotic behaviour, qualitative change and “ordinary” and “emergent” complexity for explaining real-world phenomena and guiding policy-making (Casti, 1986; Funtowicz *et al.*, 1997).

In the use by Hodgson (1988, Ch. 3), even more is implied by methodological individualism, namely static representations of individuals (fixed preferences) and static rules of interaction between individuals (markets). In other words, he criticises the approach for offering no feedback from the system as a whole to individuals, that is why they are in a sense “isolated”. He mentions culture and social psychology as not being considered, and in this context uses terminology like “institutional individualism” and “psychological individualism”. His other main worry may be more generally stated as that the methodological individualism is not taken as far as it should, i.e. it stops quite dogmatically at the level of individuals, and does not dive beneath the surface of real individual behaviour, i.e. the psychological motivations and processes.

It may be added that the individuals in the economic theory are usually not even real individual people but groups like households, communities, firms, and many other organizations with a specific formal, informal, hierarchical or other structure; or even less

⁵ According to Blaug (1992, p42-45) Schumpeter seems to have invented the terminology, while Popper announced the doctrine of “methodological monism” and defined in that context the principle of “methodological individualism” as “... the task of social theory is to construct and analyse our sociological models carefully in descriptive or nominalist terms, that is to say, *in terms of individuals*, of their attitudes, expectations, relations, etc.”

organized aggregates like sectors. All of these are often assumed to act like isolated individuals in various economic theories. Furthermore, the decision-makers in firms may not necessarily agree about corporate goals or act consistently over time (profit), while households (utility) may be regarded as involved in a sort of complex game without necessarily a simple or consistent outcome. Preferences of households making decisions based on the majority rule will not satisfy the transitivity axiom, even if those of each individuals in the household do (Hodgson, 1988). And aggregation of individual maximizing behaviour does not imply maximizing behaviour of the aggregate system. The only phenomenon that weakens these arguments may be the trend in many developed countries towards individualistic life-styles.

An issue related to methodological individualism as a “positive method” is that of consumer sovereignty as a normative concept: i.e. consumers are assumed to know best what is beneficial for them, and from their ideas follows then possibly what “society” thinks is good, i.e. the social goals. However, what a person as a consumer would do is not necessary the same that as what the same person would do as a citizen, i.e. the political-ethical-cultural context will influence individuals’ decisions (Sagoff, 1988). Microeconomic theory is based on what we do as isolated consumers, but can say little about what we do as political citizens with ethical-social concerns. It would not be surprising that a political citizen would vote for a political party that encourages income distribution through increasing taxes, even if the same citizen would — as a consumer — try fraud in paying own taxes. Mohr (1994) studies the role of environmental norms — such as recycling or consumer’s boycott for fair trade or environmental reasons — for environmental policy and sustainable societies. He maintains that the most widespread norms are not necessarily the most efficient ones, and that environmental norms have less and less room in a high-technology society, since norms need to be based in common knowledge. Ackerman (1997) argues that recycling can be considered a case of pure altruism or citizen behaviour, since people make efforts and costs to collect and transport materials, discarded products and packaging waste without any direct benefits. This cannot be explained on the basis of standard economic behaviour.

Consumer sovereignty may be regarded a methodological assumption that defines the discipline and, perhaps most importantly, keeps models analytically solvable. It may be noted that Norton et al. (1998) distinguish between 4 degrees of consumer sovereignty: (a) unchanging preferences (Stigler and Becker, 1977, p.76); (b) given preferences (disciplinary boundaries); (c) preference evaluation, critique and policy are inconsistent with democratic principles; and (d) democratically decided policies aimed at changing preferences. This

surmounts to “endogenously changing preferences”. This has received little attention from inside economics, partly because it undercuts the basic assumptions of the neoclassical behavioural model. For instance, it implies that there is no deterministic relationship anymore between prices and income on the one hand, and decisions on the other hand. Another reason is that in the case of endogenous preferences (static variable or dynamic) equilibria may be nonexistent or analytically intractable.

Another issue related to methodological individualism is that welfare is relative, i.e. utility is dependent on the welfare or income distribution in a relevant population (regional, national). Approached differently, individual valuation is not only culturally determined but also dependent on the respective individual’s relative welfare position (“keepin up with the Jones’”, reference-dependent preferences). This implies that efficiency and equity are inseparable. Correcting for this is possible, but would make economic models extremely complex, and may prevent the existence or uniqueness of a market equilibrium (see Martinez-Alier and O’Connor, 1998).

Interestingly, altruism and envy, though one might think they have no place in a framework based on methodological individualism, have been considered in a utilitarian context: own utility is based on other people’s — e.g., descendants’ or friends’ — consumption or utility (e.g. Becker 1976). In other words, altruism is just another good giving utility. In this perspective the altruist is very rational and would be altruistic until his marginal utility equals the other’s marginal utility. Altruism in human behaviour is a much debated issue which has been addressed by economists, psychologists and sociobiologists, among others. It should be noted that a definition of altruism is controversial. In environmental economics the neoclassical type of altruism has been modelled in various papers by Horwarth and Norgaard (e.g. 1995). They show that too few intergenerational transfers result, due to the presence of positive externalities. These result from altruism by parents towards their children that also benefits the parents of the spouses of these children.

Blaug’s conclusion on the issue of methodological individualism is worth repeating: “Let us, by all means, commend methodological individualism as a heuristic postulate: in principle, it is highly desirable to define all holistic concepts, macroscopic factors, aggregate variables, or whatever they are called, in terms of individual behaviour if and when this is possible. But when it is not possible, let us not lapse into silence on the grounds that we may not defy the principle of methodological individualism.”

Other criticism

It is impossible to give a complete account here of the wide range of criticisms that can be raised against the neoclassical utility maximization hypothesis. The following is a selection:

1. Substitutability in utility is a strong assumption: certain environmental functions have no human-made substitutes: climate regulation, hydrological cycles, nutrient cycling, etc (Stern, 1997).
2. Transitivity of preferences is rejected by many observations of actual behaviour (May 1954; Luce and Raiffa, 1957).
3. Experimental economics has provided evidence that individuals are less free-riding than predicted on the basis of the neoclassical theory. Some explanation is based on “other-regarding” and reciprocal fairness, where people reward and punish the behaviour of others instead of acting strategically and self-interestedly (Gintis, 1998). Reciprocity may even include the case of individuals expecting others to behave “irrationally” and responding to this by similar irrational acts, as happens regularly in financial markets (Camerer, 1997).
4. It has also been shown that intertemporal decision-making based on discounted utilitarianism and positive time preference is not always consistent with actual behaviour in experimental settings (Loewenstein, 1987).
5. Consumers get satisfaction not only from the good itself (“functional demand”). It depends on the way it is obtained (Georgescu-Roegen, 1968) and on the social context (“nonfunctional demand”). Leibenstein (1950) mentions the “bandwagon”, “snob” and “Veblen effects”. Such nonfunctional demand or “feedback effects” raises a “non-additivity” problem: market demand is not the aggregation of independent individual demands.
6. In the neoclassical economic behavioural model consumers are supposed to act so as to maximize their utility function subject to a budget constraint. There can be a number of constraints added to the problem of economic choice, e.g.: “time budget”, social rules (family visits, altruistic behaviour, social rules and norms in general), and institutional constraints (office hours, holiday periods). In this sense the complete focus on a budget constraint in the standard model is a bit narrow and specific. In addition, criticism is possible on more specific elements of the model in theoretical or empirical applications, such as separable utility functions, or specific functional specifications adopted.

Saving maximizing behaviour by the Alchian-Friedman selection argument

The names of Alchian (1950), Friedman (1953) and Winter (1964) are associated with a debate on the behaviour of firms in economics (for a recent evaluation, see Hodgson 1994). Alchian argued that it is not necessary to assume profit maximizing or even profit seeking as a fundamental and universal characteristic of firms. Firms that are profit seekers and are successful in realizing profits are selected (Alchian uses the term “adopted”) by the market mechanism and survive. Whether firms are successful is to a large extent dependent on random circumstances, apart from whether they are seeking profits or not, and the more uncertain the world, the more winning will depend on pure luck rather than calculated profit seeking.

Friedman (1953) argues that profit maximization is selected by the market, thus trying to find support for the idea that profit maximization, although not universal, will be the sure outcome of selection by the market. In this way he can come to his famous conclusion that the postulates of standard economics on firms' behaviour do not necessarily have to be realistic, as long as they are predictive (see earlier discussion in this section).

Winter criticizes both previous authors for using the selection analogy from biology without complementing it with a clear inheritance mechanism or sustaining feature. This would mean that even without randomness of firm behaviour or the economic environment, i.e. even with 'habitual behaviour', it is not possible to select firms that consistently realize (let alone maximize) profits over time. The reason is that selection will be based on the outcome (“phenotype” in evolutionary biology terms) which has no relationship with some inheritance unit (“genotype”). In less technical jargon, one can say that winning in one period is unrelated to winning in another period. If profit seeking or maximizing is not deliberate or conscious, then it cannot be passed on to, or learned by, others (see Hodgson, 1988, p78); i.e. winning remains a random process.

Furthermore, if such an inheritance unit is present but its relation with the phenotype of the firms (the observed or actual behaviour) is weak due to randomness in the economic environment, then the market will neither be able to select consistent profit realizers or maximizers. Finally, one may also add considerations weakening the selection mechanism itself. For instance, in the case of lax competition, selective pressure will be weak. Furthermore, additional selective forces may counteract the market forces, such as political or policy constraints, including environmental regulation (Foss, 1993).

All in all, the defence by selection argument is not very convincing. But most importantly perhaps, neither Alchian nor Friedman devote any attention to utility

maximisation.⁶ It does not seem clear that an analogous firm selection argument holds for consumer behaviour. A consumer not maximizing utility would not have a clear disadvantage over other consumers that do maximize their utility. Survival seems to depend on satisfying basic needs rather than seeking fulfillment or maximization of desires beyond those. So even if one accepts the Alchian-Friedman thesis, the consumer behaviour model of neoclassical economics remains yet to be saved by some additional, and possibly entirely different type of argumentation. Hodgson (1988, p78) seems to be the only source that also notes this crucial point, but surprisingly does not spend more than a few sentences on this issue.

4. Alternative behavioural models

There is nowadays a rich field of alternative views on economic behaviour, encompassing two areas, namely “economic psychology”, closer to psychology, and “behavioural economics”, closer to economics. A broad overview is offered by van Raaij *et al.* (1988). Here we offer a selection of some characteristic alternative models of economic behaviour.

Bounded rationality, procedural rationality, and satisficing behaviour

According to Simon (1964, 1972), a distinction should be made between substantive or procedural rationality. This terminology can be used to distinguish between the rationality of a decision — results of the choice — considered independently of the manner in which it is made, and the rationality of a decision in terms of the manner in which it is made. Neoclassical economic analysis rests on two fundamental assumptions. The first assumption is that the economic actor has a particular goal, for example, utility maximization or profit maximization. The second assumption is that the economic actor is substantively rational.” (Simon 1976, pp 130-131).

The “principle of bounded rationality” is defined by Simon (1957, p. 198) as “The capacity of the human mind for formulating and solving complex problems is very small compared with the size of the problems whose solution is required for objectively rational behaviour in the real world — or even for a reasonable approximation to such objective

⁶ In footnote 3 Alchian (1950) notes that "In the following we shall discuss only profit maximisation, although everything said is applicable equally to utility maximisation by consumers." However, no reference is given to any supporting analysis.

rationality”. It is important to note the distinction that Simon draws between bounded rationality incorporating realism — especially regarding computational abilities (see also Heiner, 1983) — and irrational behaviour driven by passions.

Simon (1957) has proposed the “satisficing” principle: trying to attain acceptable levels of welfare or profit or whatever indicator is used. “Satisficing” is the fundament of the “principle of bounded rationality”. The term is an integration of “satisfaction” and “optimizing”, creating some confusion possibly as it is not locked into an optimization approach. The concept is consistent with attaching much importance to transaction costs and information gathering in making economic decisions, based on the earlier mentioned notion of limited human brain capacity. Together these create insurmountable problems, and “satisficing” reflects a cost-minimizing or cost-effective approach. As Hodgson notes: “In part it is a habitual response by mainstream economic theorists who, having being taught that a key feature of economic life is that all commodities are scarce, regard information to be generally scarce as well. Accepting, however, that crucial information is usually scarce, the problem is more complex because sense data itself is not in shortage but in over-abundance.” (Hodgson, 1988, p9).

Hierarchies of decision making and lexicographic preferences

Some economists have studied human behaviour as driven by the achievement and search of human needs (e.g., Georgescu-Roegen, 1966; Lutz and Lux, 1979; Hodgson, 1988; Max-Neef, 1995; Jackson and Marks, 1996; Røpke, 1996). Utility theory is in contradiction with such a needs perspective and other insights of psychology. An alternative approach is lexicographic preferences, which has recently been discussed in the context of environmental economics (Stern, 1997).

Substitutability of goods implies that consumers can maintain an initial level of utility by reducing consumption of one good or service but increasing the consumption of another good or service. This does not apply to all combinations of goods and services. From a “hierarchy of needs” perspective (Maslow, 1970) it is argued that needs have a hierarchical order, with lower and higher needs. Higher needs would not appear before the lower needs are covered. Hence, a hungry person cannot substitute a car for food and maintain his level of utility. In other words, the elasticity of substitution between food and cars is zero. Substitution among goods probably makes more sense for richer individuals that have covered their lower needs, than for poorer ones (Georgescu-Roegen, 1966). Lower needs may have to be covered

even before higher needs appear, i.e. goods are consumed up to satiation. If this is the case, more of some good would not always increase utility. Neoclassical theory, however, assumes that there is strong monotony, namely more of any good is always better, and consumers can always increase utility by consuming more of one good.

Neoclassical economics has justified the decreasing marginal utility with the hierarchy of needs (Georgescu-Roegen, 1966, ch. 3). However, this may not always apply: some goods may not give utility below a minimum quantity, while “the second cocktail ... may yield greater satisfaction than the first” (Georgescu-Roegen, 1968, p240). Scitovsky (1976) has stressed the distinction between comfort/satisfaction, which is limited, and pleasure which may be unlimited.

Lexicographic preferences have been used to model the hierarchical ordering of needs, the existence of satiation and non-substitutability. Lexicographic preferences are not smooth, are non-homothetic, and have zero elasticity of substitution (Stern, 1997; Spash and Hanley, 1995). The first economist who introduced lexicographic ordering and needs was Menger (Georgescu-Roegen, 1968) and ever since then it has been used by economists who rely on human needs and psychology to explain human behaviour and choices. Lutz *et al.* (1979, p322) affirm that lexicographic preferences “have to be seen as the most basic and the most relevant model of human choice and behaviour”.

Habitual behaviour and imperfect/asymmetric information

Small changes in consumer spending over time may be regarded as support for either stable preferences or for habitual behaviour (Hodgson, 1988). It is not easy to test for this. Anyway, it can be shown that neoclassical household production with durable goods and human capital can generate some types of habitual behaviour (Deaton and Muellbauer, 1980). Nelson and Winter (1982) have developed the notion of “routines” as the organizational memory of the firm. Habits and routines are regarded as a straightforward approach to meet complexity and uncertainty. Routines may also be regarded as consistent with procedural rationality. Routines, often in relation to transaction costs, are also stressed in neo-Keynesian economics (Hargreaves Heap, 1992).

Various theories of firm behaviour can be related to the notion of habitual behaviour, often related to imperfect and asymmetric information. For instance, Leibenstein (1966) has proposed X-inefficiency, where “X” denotes an unknown factor or influence in production affecting the (technical) efficiency of production. An important assumption is that information

is imperfect. He makes a distinction between intra-plant motivational efficiency and nonmarket input efficiency. Principal-agent theory studies incentive schemes that can reduce the problem of moral hazard: owners being unable to control managers, due to different goals and asymmetric information. The evolutionary theory by Nelson and Winter (1982) entails routine-like behaviour, which may be regarded an example of habitual behaviour. And finally, various contractual theories offer a legal constraints perspective on firm behaviour (Foss, 1993).

Incommensurability and decisions based on multicriteria evaluation

The use of a single unit (utility) to measure human choices or behaviour has been stated to violate the “principle of reducibility of wants” (Georgescu-Roegen, 1966, ch. 3). The aggregation of all wants is associated with two main problems: the aggregation of contradictory objectives, and the measurability (cardinal utility) or comparability (ordinal utility) of all arguments included in the utility function. The term “incommensurability” has been used to denote the fact that it is not possible to reduce all relevant features of an object, service or system to a single dimension. This implies the rejection not just of monetary reductionism but also any physical reductionism, as in ecological or energy-based valuation (Martinez-Alier *et al.*, 1998). Incommensurability can be considered the epistemological foundation of multicriteria evaluation.

There are various theories that try to describe and formalise commonly understood human behaviour as based on a set of multiple and conflicting criteria. For example, in the so-called “ideal point approaches” it is assumed that the rationale of human choice is that alternatives that are closer to an “ideal or utopian situation” are preferred to those that are further away (Zeleny, 1974). Another approach is “multiattribute utility theory” which assumes that for any decision problem a real valued function can be defined on the set of feasible alternatives (Keeney and Raiffa, 1976). This theory thus shares the axiomatic elegance of conventional utility maximization and is sensitive to the same criticism. Other multicriteria approaches are based on possibly more realistic behavioural assumptions, such as pairwise comparison of alternatives and hierarchical structuring. These include “outranking approaches” (Roy, 1985) and “analytic hierarchy processes” (Saaty, 1980).

Behaviour and decisions under risk and uncertainty

Von Neumann and Morgenstern (1944) showed that under risk, if an agent is guided by *expected utility maximization*, he is acting according to his true tastes — provided that there is

an element of consistency in his tastes. Basically they adapted the axioms of the case under certainty (transitivity, continuity, monotony, substitutability) to the case of lotteries — i.e. combinations of outcomes with respective probabilities (Luce and Raiffa, 1957). The basic decision rule is thus that one alternative is preferred to another if and only if the expected utility of the former is larger than the expected utility of the latter.

One should note that all the preference information is summarized by the expected value of utility, in particular, utility variance has no meaning. The latter is emphasized in the *Allais paradox* (Allais, 1953). Individuals who are risk averse in some situations may become risk loving when the probabilities are low and the variance among quantities is large. This undermines the consistency and transitivity features of preferences. Possible explanations are that individuals understate probabilities associated with beneficial events and overstate those of harmful or costly events, or, people reduce or minimize potential regret (see below).

As far as real decisions are concerned, one has to doubt the adequacy of the expected utility approaches for the major problems involving environmental uncertainty. It is unsatisfactory partly because the range and the distribution of future environmental effects of economic activities is not known in advance (and may be unknowable), and partly because people do not necessarily act to maximize an expected value calculated ‘as if’ it is known (knowable). Other approaches including fuzzy set based approaches may be useful then (Froger and Zyla 1997; Froger and Munda, 1998; Vercelli 1997).

Regret theory (Loomes and Sugden, 1982) argues that expected utility analysis represents a restrictive interpretation of rationality which does not take account of the notion of ‘regret’. The absence of systematic ex-post mistakes, which is the distinctive feature of “substantive rationality” (see above), is only plausible when the decision maker faces a stationary stochastic process which has persisted long enough to allow the decision maker to fully adjust to it.

Prospect theory (Kahneman and Tversky, 1979) identifies a certainty effect (people prefer certain outcomes over probabilistic ones), a reflection effect (individuals are risk averse when the outcome is positive and risk seeking when the outcome is negative), and an isolation effect (individuals do not consider the characteristics of the prospect that are shared between all prospects that are being evaluated; instead, decisions are purely based on differentiating characteristics). It has been argued, for instance, that these effects can explain the differences between empirical measures of willingness-to-pay and willingness-to-accept.

Girardian economics (Orléan, 1988) is focused on problems of addressing pervasive uncertainty, based on human desires being unstable, humans being ignorant, and events being unpredictable. Market signals (prices, interest rates) provide uncertain clues for decision making, although prices may be regarded as an indication of quality in highly uncertain markets. Desire and behaviour become mimetic, examples of which are panic selling, spiralling inflation, speculation. This means that diversity of behaviour and features at the individual level is reduced. Another implication of uncertainty is the desire for wealth, as an explicit goal and means to reach self-sufficiency. Wealth allows the freedom not to imitate others and to be safe in the face of surprises. This goal of wealth also leads to envy (see Roe, 1996).

Other models and ideas about behaviour

A variety of other behavioural models can be mentioned briefly (see also Hodgson, 1988; and Gintis, 1998). The topic of changing and endogenous preferences was discussed previously, and offers an interesting area of research (see Norton *et al.*, 1998). According to Hodgson (1988, pp. 10, 11, 57) there seem to be many decisions based on unconscious and non-purposeful actions, due to psychological states (stress, fear, surprise, excitement, aggression, depression, grief, social pressure, blind rage, etc.) or due to inherent limitations and characteristics of the human mind and behaviour. The latter may be the result of evolution of individual and social behaviour over the last few million years, such as is propagated by biological theories of individual behaviour (ethology) and social behaviour (sociobiology).⁷ Finally, in psychology cognitive dissonance is regarded as a relevant perspective: preferences adapt to decisions rather than the other way around.

5. Behavioural assumptions and environmental policy

Basic implications

A preliminary critique of the deterministic neoclassical behavioural model is that it leaves an impression that choices are easily predictable since individuals are assumed to show consistent behaviour in different situations and periods. Together with the belief that changes in behaviour

⁷ Interestingly, though social science as the study of “culture” or “nurture” is often regarded as the antithesis of sociobiology as the study of “genetic constraints” or “nature”, here they may support the same insight, namely that individual behaviour can only be understood in a social context. While sociobiology has focused on the commonality of human nature rather than cultural differences, the debate among supporters and opponents has been more about the degree of biological or genetic determinism, creating much confusion (see Ruse, 1979).

depend entirely on income and prices — following from the assumption that preferences are exogenous and invariant — it is concluded that policy makers can modify consumers' demand in any desired direction by influencing prices or income. Similarly, in environmental policy theory one finds such an optimistic attitude towards price-based instruments (Baumol and Oates, 1988). Consequently, dropping the basic neoclassical behavioural assumptions means that less importance will be given to such price-based instruments.

Equally fundamental is the lesson that when maximizing behaviour — by either firms or consumers — is not assumed, the 1st and 2nd main welfare theorems no longer hold. This means that there is no direct relation between a market equilibrium and a social welfare optimum, and in particular for environmental policy theory that there is no simple relationship between externalities and environmental policy instruments. In other words, there is no “optimal policy”. Even more fundamental is the insight that, in the presence of externalities, an endogenous social optimum due to Coasian negotiations between generators and victims of the externality is not, or imperfectly, realized if individuals do not maximize utility or profits. Another implication is, for instance, that international trade allocation and relocation effects due to stringent environmental regulations are less significant when firms do not maximize profits.

There are more implications of dropping the maximizing behaviour hypothesis. The notion of externalities can be maintained, as it depends merely on the existence of utility and production functions, and requires neither maximizing behaviour nor specific assumptions regarding preference or production structures. However, one can no longer assume that people respond to “marginal values”, i.e. since prices are not equal to marginal values. This means that both economic valuation and cost-benefit analysis lose relevance or at least accuracy. However, behaviour of firms aimed at minimizing costs (cost-effectiveness goal) might preserve the marginal cost concept.

If utility maximization does not hold, demand relationships — i.e. quantities versus prices — are no longer uniquely determined. One may directly assume specific signs of relationships — demand responding negatively to prices — but theoretical accuracy is lost. Moreover, price policies — whether applied to producers/suppliers or consumers/demanders — become less attractive relative to other instruments. Of course, this is not to say that price policy does not affect choices, but that regulators have to face a more uncertain system to be

regulated, which will make price instruments less effective. The logical response to this uncertainty would be to implement instruments that are more effective, i.e. a preference for standards such as technical requirements and quantity regulation.

Utility maximization is surrounded with more uncertainty than profit maximization. Therefore environmental policy aimed at an efficient allocation of resources can better be directed at producers than consumers. For instance, an energy tax policy applied only to small-users, mainly consumers — as has been implemented in the Netherlands — is, given the foregoing implications, neither efficient nor effective.

Some implications of alternative behavioural models

From the perspective of satisficing and routine-like behavioural models, responses to environmental regulation will not be as evident as in the case of maximizing behaviour. Transaction costs are present everywhere, and imply that satisficing may be more adequate than optimizing behaviour, as the latter would involve an infinite regression of searching and checking whether all the relevant information has been acquired and used. Satisficing is consistent with striving for cost-effectiveness, i.e. minimizing costs to attain a given goal: tradable permits and individual standards are attractive in such a setting. Both habitual behaviour and satisficing can explain the “energy gap”, i.e. the unrealed economic benefits associated with potential energy conservation measures inside many firms. Van Raaij (1988) discusses this issue in the context of models of consumer behaviour that take account of issues like visibility, demonstration value, environmental concern, relational knowledge (information), habits and socio-demographic determinants.

Behaviour according to lexicographic preferences implies that substitution of regulated commodities is not always possible. Endogenous preferences in combination with lexicographic preferences suggest that economic growth does not necessarily generate more social welfare from more abundant commodities. The assumption of “more material goods is always better” (monotony) is one of the fundamental questions in the economic growth debate. On the basis of empirical research for 19 countries during the 1980s, Max-Neef (1995) states the “threshold hypothesis”: “for every society there seems to be a period in which economic growth ... brings about an improvement in the quality of life ... but only up to a point ... beyond which, if there is more economic growth, quality of life may begin to deteriorate” Max-Neef (1995, p117). This is supported by some of the corrected GNP calculations, e.g. the ISEW indicator (Daly and Cobb, 1989). Although this research is on a macro level, it can be seen as consistent with some

of the micro level behavioural theories, such as lexicographic preferences. The idea is that more material consumption, a higher need, has occurred at the cost of some lower needs, such as rest, stress, personal contacts, social life, serenity (no noise), no violence, etc. A related implication of lexicographic preferences for environmental economics is that individuals are unable to make a continuous trade-off between environmental functions or resources and economic goods, and consequently cannot determine a willingness-to-pay measure (Spash *et al.*, 1995; Stern, 1997). Therefore, lexicographic preferences can be related to the notion of strong sustainability, where complementarity, uniqueness and essentiality of life support functions, climate regulation, and nature in general are emphasized. Consequently, policies that try to make trade-offs in an environmental context based on individual preferences may find that individuals are not willing to make such trade-offs. Multicriteria analysis and incommensurability underpin this conclusion. A synthetic overview of multicriteria approaches in the context of environmental evaluation is given by Munda *et al.* (1994).

The idea mentioned in Section 3 that consumers get satisfaction not only from goods themselves but also from the social context (“nonfunctional demand”) has implications for environmental economics. An example is that of the Western Atlantic bluefin tuna. This represents status food in Japan: demand has increased despite the increase of its price (McDaniel and Gowdy 1998). Such effects imply that environmental policy may have counter-intuitive effects. For instance, taxation can cause an increase in demand, or no response at all.

Uncertainty, behaviour and environmental economics

Economic-environmental interactions are characterized by complexity and strong irreversibility. Often no simple stationary stochastic process can be posited in such a case, as even the range and distribution of environmental effects is uncertain. No simple expected utility or Bayesian learning model can be applied. Fuzzy set models and related approaches may be useful in this respect (Froger and Zyla 1997; Froger and Munda, 1998). Quasi-option value is the closest that environmental economics has come to addressing fundamental uncertainty issues related to irreversibility and generation of new information (Graham-Tomasi, 1995). However, again this is based on expected utility theory.

Prospect theory, regret theory, and the Allais paradox stress the asymmetry with which individuals perceive and deal with gains and losses. This may affect how individuals negotiate: Coasian negotiations between polluters and victims; negotiations between countries about

environmental agreements; or negotiations between regulators and polluters about the initial distribution of permits. This will also affect public decisions aimed at curbing rent-seeking.

Roe (1996) applies the earlier discussed Girardian economics that starts from pervasive uncertainty. Mimetic behaviour (imitation) is seen as resulting from it, leading to reduced economic diversity of behaviour, strategies, activities, ideas, products, etc. This model is applied to the problem of sustainable development (SD), which leads to the following conclusions: SD is a social convention which for a time stabilizes decision-making under high uncertainty; the response should be to reduce uncertainty that drives the crises of undifferentiation (due to imitation). Some specific elements of such a strategy are: buffer or decouple resource systems and their management from environmental uncertainty; encourage diversity, via evolution and diffusion of more than one kind of SD; and treat SD on a case-by-case basis. The latter links to the discussion on biodiversity, where maximum diversity keeps most options open and maximizes resilience of any system.

Changing and endogeneous preferences

The idea that preferences are not invariant and endogenous has led Norton *et al.* (1998) to argue that changing consumers' preferences can be an instrument of environmental policy. In particular they state that stable preferences are at best realistic over short periods of time, and that sovereign preferences are inconsistent with long-run goals of sustainability. Consequently, public discussion about ethical consumption and sustainability should be stimulated via education, advertising rules, cultural norms, etc. Changing consumers' preferences through democratic processes could be used to encourage environmentally conscious consumption in a way that consumers would not feel "... deprived and unhappy ..." but "... enlightened and happy after being educated into the joys ..." (Norton *et al.*, 1998, p203). Similarly Söderbaum (1994) defends the possibility of changing preferences as an option for environmental policy: "Rather than assuming that world views, ideologies and paradigms are unproblematic or given from outside, economists and other scholars should contribute to a debate in society about alternative world views, alternative ideologies and alternative economics" (Söderbaum, 1994, p55). It is accepted that decisions are constrained and influenced, so why not preferences. We also try to influence norms that are regarded as criminal, racist or otherwise undemocratic. The

main question is how preferences change. Economists know little about this. This indicates the need for multidisciplinary research and interactions in this area.⁸

Rauscher (1997) considers the situation where voluntary emission reductions are socially rewarded, but someone who abates more than required by law does not receive any social reward. He argues that explicit consideration of social determinants of individual behaviour is needed to take into account the possible impact of environmental policies to undermine socially desirable behaviour. In other words, the purely economic approach to human behaviour can lead to misleading results, i.e. the Pigouvian tax rate is no longer optimal.

Garvie (1997) offers an analysis of self-regulation of industrial pollution emissions. He allows for endogenous preferences. In particular, if consumers become better informed about environmental consequences, they are willing to pay more for less polluting products, and more for products the production of which involves toxic pollutants. As a result, firms can create market power, notably by voluntary codes. The welfare loss is more significant (but the anti-competitiveness effects smaller) for more competitive industries and less toxic pollutants.

Surely, much more can be said about the implications of alternative models of individual behaviour for environmental policy. This was just an effort to paint in broad brush strokes, and thus show how fruitful such an approach can be, for yielding new insights or underpinning known facts that the standard neoclassical model cannot explain satisfactorily.

6. Conclusions

Many traditionally educated economists may perhaps be sceptical about the purpose of this article. It should be realized, however, that the neoclassical assumptions of economic behaviour have never been really empirically tested — which is not to be confused with “applied”. Since the assumptions of the neoclassical behavioural model are untestable, intellectual honesty requires room for sensitivity analysis and pluralism. The implications for environmental valuation of such a broader perspective on behaviour have already created a vast literature,

⁸ Norton *et al.* (1998) argue that fear of a “totalitarian government” from following preference changing policies is unnecessary for several reasons: preferences are already unconsciously manipulated by all sorts of other policies; they are influenced purposefully “behind the scenes” by all sorts of stakeholders; commercial companies have since long influenced preferences via the media, out of pure profit motivation. Most importantly perhaps, preference-influencing environmental policies may be based on democratic decisions.

notably in the context of contingent valuation (Spash and Hanley, 1995; Kriström, 1998). The present paper has examined some major implications of alternative behavioural assumptions for environmental policy theory.

Various alternative models of individual behaviour have been alluded to here. The presentation has been necessarily concise and incomplete. Still, the approaches focusing on satisficing, lexicographic preferences, habitual behaviour, uncertainty, and changing preferences offer quite a range of aspects to be improved upon in modelling behaviour. Undeniably, some of the implications — e.g., satisficing behaviour, altruism and habits — can also be obtained with particular maximizing utility models, but this still leaves the problem of unnecessary assumptions, so why then not immediately adopt the implied results. In a similar vein, behavioural game theory — focusing on players that respond to fairness and show reciprocal behaviour— and evolutionary game theory — focusing on selection of, different behaviours or strategies — may be useful to incorporate some of the criticism into the standard approach. This needs a separate and thorough treatment (Camerer, 1997; Gintis, 1998). Lastly, it is not implied here that the neoclassical model is not useful at all. It provides in any case an analytical benchmark.

Some broad insights result from dropping the neoclassical maximization hypothesis and adopting alternative assumptions. Much more can be learned from applying the various alternative models. However, this requires detailed, specific projects, possibly using formalized approaches and empirical testing. Some environmental policy insights obtained are: price-based policies become less attractive; policy should focus on producers rather than consumers; moral suasion should be aimed at long-run sustainability; in the latter context more attention should be given to self-regulation, social context and preference change; In the context of uncertainty, imitation, pursuit of wealth, and striving for diversity emerge as important implications.

Acknowledgements

We are grateful to John Gowdy, Paul Hohenberg and Peter Nijkamp for useful comments.

References

- Ackerman, F., 1997. *Why Do We Recycle? Markets, Values, and Public Policy*. Island Press, Washington D.C.
- Alchian, A., 1950. Uncertainty, evolution and economic theory. *Journal of Political Economy* 58: 211-22. (reprinted in Witt, 1993).

- Allais, M., 1953. Le comportement de l'Homme Rationnel devant le risque, critique des postulats et axiomes de l'école Américaine. *Econometrica* 21: 503-546.
- Baumol, W.J. and W.E. Oates, 1988, *The Theory of Environmental Policy*. 2nd ed. Cambridge University Press, Cambridge, UK.
- Becker. G.S., 1962, Irrational behaviour and economic theory, *The Journal of Political Economy* 70: 1-13.
- Becker. G.S., 1976, Altruism, egoism, and genetic fitness: economics and sociobiology, *Journal of Economic Literature* 14: 817-826.
- Blaug, M., 1992. *The Methodology of Economics — Or How Economists Explain*. 2nd ed. Cambridge University Press, Cambridge.
- Boland, L., 1979. A critique of Friedman's critics. *Journal of Economic Literature* 17: 503-22.
- Boland, L., 1981. On the futility of criticizing the neoclassical maximization hypothesis. *American Economic Review* 71: 1031-1036 (also in B. Caldwell, 1984).
- Caldwell, B., 1984. *Appraisal and Criticism in Economics: A Book of Readings*. Allen and Unwin, Boston.
- Camerer, C.F., 1997. Progress in behavioral game theory. *Journal of Economic Perspectives* 11: 167-188.
- Casti, J. L., 1986. On system complexity. Identification, measurement and management. In: J.L. Casti and A. Karlquist (eds.). *Complexity, Language and Life: Mathematical Approaches*. Springer-Verlag, Heidelberg.
- Costanza, R. (red.), 1991. *Ecological Economics: The science and Management of Sustainability*. Columbia University Press, New York.
- Daly, H.E. and W. Cobb, 1989. *For the Common Good: Redirecting the Economy Toward Community, the Environment and a Sustainable Future*. Beacon Press, Boston.
- Deaton, A., and J. Muellbauer, 1980. *Economics and Consumer Behaviour*. Cambridge University Press, Cambridge.
- Froger G. and Munda G., 1998. Methodology for environmental decision support, in S. Faucheux and M.O'Connor (eds.), *Valuation for Sustainable Development: Methods and policy indicators*, Edward Elgar, Aldershot.
- Froger, G. and Zyla, 1997. Towards a decision making framework to address sustainable development issues, in S. Faucheux, M. O'Connor and J. van der Straaten (eds.), *Sustainable Development: Concepts, Rationalities and Strategies*, Kluwer Academic Publishers, Dordrecht.
- Foss, N.J., 1993. Theories of the firm: contractual and competence perspectives. *Journal of Evolutionary Economics* 3: 127-144.
- Friedman, M., 1953. On the methodology of positive economics. In: *Essays in Positive Economics*. University of Chicago Press, Chicago. (reprinted in B. Caldwell, 1984).
- Funtowicz S., O'Connor M. and Ravetz J., 1997. Emergent complexity and ecological economics. In: J.C.J.M. van den Bergh and J. van der Straaten (eds.), *Economy and Ecosystems in Change. Analytical and Historical Approaches*. Edward Elgar, Cheltenham, pp. 75-95.
- Garvie, D., 1997. Self-regulation of pollution: the role of market structure and consumer information. FEEM Nota di lavoro 59.97.
- Georgescu-Roegen, N., 1966. *Analytical Economics*. Harvard University Press, Cambridge.
- Georgescu-Roegen, N., 1968. Utility. In: D.L. Sills (ed.). *International Encyclopaedia of the Social Sciences*, vol. 16: 236-267. The Macmillan Company & The Free Press, New York.
- Gintis, H., 1998. The individual in economic theory: a research agenda. Unpublished paper. Dept. of Economics, University of Massachusetts, Amherst, MA.

- Graham-Tomasi, T., 1995. Quasi-option value. In: D.W. Bromley (ed.). *The Handbook of Environmental Economics*. Basil Blackwell, Oxford, UK., and Cambridge, USA.
- Hargreaves Heap, S.P., 1992. *The New Keynesian Macroeconomics*, Edward Elgar, Aldershot 1992.
- Heiner, R.A., 1983. The origin of predictable behavior. *American Economic Review* 73: 560-595.
- Hirshleifer, J., 1985, The expanding domain of economics, *American Economic Review*, 75: 53-68.
- Hodgson, G.M., 1988. *Economics and institutions*. Polity Press, Cambridge.
- Hodgson, G.M., 1994. Optimisation and evolution: Winter's critique of Friedman revisited. *Cambridge Journal of Economics* 18: 413-30.
- Howarth, R.B., and R.B. Norgaard, 1995. Intergenerational choices under global environmental change. In: D.W. Bromley (ed.). *Handbook of Environmental Economics*. Blackwell, Oxford.
- Jackson, T., and Marks, N., 1996. Consumption, Sustainable Welfare, and Human Needs -an Examination of UK Expenditures Patterns 1954-1994. Presented at the European Society for Ecological Economics Conference, Versailles, May.
- Kahneman, D. and A. Tversky, 1979, Prospect theory: an analysis of decision under risk. *Econometrica* 47: 263-291.
- Keeney R.L. and H. Raiffa, 1976. *Decisions with multiple objectives. Preferences and value trade-offs*, Wiley, New york.
- Kriström, B. 1998. Contingent Valuation. In: J.C.J.M. van den Bergh (ed.). *Handbook of Environmental and Resource Economics*. Edward Elgar, Cheltenham.
- Kuhn T., 1962. *The Structure of Scientific Revolutions*. Chicago University Press, Chicago.
- Leibenstein, H., 1950, Bandwagon, snob and Veblen effects in the theory of consumers' demand, *The Quarterly Journal of Economics* 65: 183-207.
- Leibenstein, H., 1966, Allocative efficiency vs "X-efficiency", *American Economic Review* 56: 392-415.
- Loewenstein, G., 1987. Anticipation and the valuation of delayed consumption. *The Economic Journal* 97: 666-684.
- Loomes, G. and R. Sugden, 1982. Regret theory: an alternative theory of rational choice under uncertainty, *The Economic Journal* 92: 805-824.
- Luce R. D., and Raiffa H., 1957. *Games and Decisions*. Wiley, New York.
- Lutz, M.A. and K. Lux, 1979. *The Challenge of Humanistic Economics*. The Benjamin/Cummings Publishing Company, Inc.
- Martinez-Alier, J., and M. O'Connor, 1998. Distributional issues: an overview. In: J.C.J.M. van den Bergh (ed.). *Handbook of Environmental and Resource Economics*. Edward Elgar, Cheltenham.
- Martinez-Alier, J., G. Munda and J.O'Neill, 1998. Weak comparability of values as a foundation for ecological economics. *Ecological Economics* 26: 277-286.
- Mas-Colell, A., M.D. Whinston and J.R. Green, 1995. *Microeconomic Theory*. Oxford University Press, New York.
- Maslow, A.H., 1970, *Motivation and Personality*, Harper and Row publishers, 2nd edition.
- May, K.O., 1954. Intransitivity, utility, and the aggregation of preference patterns, *Econometrica* 22: 1-13.
- Mayr, E., 1988. *Towards a New Philosophy of Biology: Observations of an Evolutionist*. Harvard University Press, Cambridge, MA.
- Max-Neef, M., 1995, Economic growth and quality of life: a threshold hypothesis. *Ecological Economics* 15: 115-118.

- McDaniel, C.N. and J.M. Gowdy, 1998. Markets and biodiversity Loss: some case studies and policy considerations, *International Journal of Social Economics* 25: 1454-1465.
- Mohr, 1994. Environmental norms, society, and economics. *Ecological Economics* 9, 229-239.
- Munda G., P. Nijkamp and P. Rietveld, 1994. Qualitative multicriteria evaluation for environmental management. *Ecological Economics* 10: 97-112.
- Musgrave, A., 1981. "Unreal assumptions" in economic theory: The F-Twist untwisted. *Kyklos*, vol. 34: 377-87. (also in B. Caldwell, 1984).
- Norton, B., R. Costanza and R.C. Bishop, 1998. The evolution of preferences. Why 'sovereign' preferences may not lead to sustainable policies and what to do about it", *Ecological Economics* 24: 193-211.
- Orléan, 1988. Money and mimetic speculation. In: P. Dumouchel (ed.). *Violence and Truth*. Stanford University Press, Stanford, CA.
- Popper, 1965. *Conjectures and Refutations: The Growth of Scientific Knowledge*. Routledge, London.
- Raaij, W.F. van, G.M. van Veldhoven and K.E. Wärneryd (eds.), 1988. *Handbook of Economic Psychology*. Kluwer Academic Publishers, Dordrecht.
- Raaij, W.F. van, 1988. The use of natural resources. In: W.F. van Raaij, G.M. van Veldhoven and K.E. Wärneryd (eds.). *Handbook of Economic Psychology*. Kluwer Academic Publishers, Dordrecht.
- Ravetz J., 1990. *The Merger of Knowledge with Power*, Mansell, London.
- Rauscher, M., 1997. Voluntary emission reductions, social rewards, and environmental policy. FEEM Note di lavoro 45.97.
- Roe, E.M., 1996. Sustainable development and Girardian economics. *Ecological Economics* 16: 87-93.
- Roy, B., 1985. *Methodologie multicritere d' aide a la decision*. Economica, Paris.
- Røpke, I., 1996, Consumption, environment and quality of life. Presented at the 1st conference of the European Society for Ecological Economics, Versailles.
- Ruse, M., 1979. *Sociobiology: Sense or Nonsense*. Reidel Publishing Co., Dordrecht.
- Ruse, M., 1986. *Taking Darwin Seriously: A Naturalistic Approach to Philosophy*. Basil Blackwell, Cambridge, MA.
- Russell, R.R., and M. Wilkinson, 1979. *Microeconomics: A Synthesis of Modern and Neoclassical Theory*. Wiley, New York.
- Saaty, T., 1980. *The Analytic Hierarchy Process*, McGraw Hill, New York.
- Sagoff, 1988. *The Economy of the Earth*, Cambridge University Press, Cambridge.
- Scitovsky, T., 1976. *The Joyless Economy: An Inquiry into Human Satisfaction and Consumer Dissatisfaction*. Oxford University Press, Oxford.
- Simon, H.A., 1957. *Models of man. Social and Rational*. Wiley, New York.
- Simon, H.A., 1964. Rationality. In: J. Gould and W.L. Kolb (eds.). *A Dictionary of the Social Sciences*. The Free Press, Glencoe.
- Simon, H.A., 1972. Theories of bounded rationality, in C.B. Radner and Radner R. (eds.), *Decision and Organization*, North-Holland, Amsterdam.
- Simon, H.A., 1976. From substantive to procedural rationality. In: S. Latsis (ed.). *Methods and Appraisal in Economics*. Cambridge University Press
- Spash, C.L. and N. Hanley, 1995. Preferences, information and biodiversity preservation. *Ecological Economics* 12: 191-208.
- Söderbaum, P., 1994. Actors, ideology, markets. Neoclassical and institutional perspectives on environmental policy. *Ecological Economics* 10: 47-60.
- Stern, D., 1997. Limits to substitution and irreversibility in production and consumption: a neoclassical interpretation of ecological economics. *Ecological Economics* 22: 197-215.

- Stigler, G.J and G.S. Becker, 1977, De gustibus non est disputandum, *American Economic Review* 67: 76-90.
- Varian, H.R., 1992. *Microeconomic Analysis*, 3rd ed. Norton, New York.
- Von Neumann, J., and O. Morgenstern. 1944. *Theory of Games and Economic Behaviour*. Princeton University Press, Princeton.
- Winter, S.G., 1964. Economic 'natural selection' and the theory of the firm. *Yale Economic Essays* 4: 225-72.
- Zeleny, M., 1974. A concept of compromise solutions and the method of the displaced ideal, *Computers and Operations Research* 1: 479-496.