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SPECIAL ISSUE

THE HUMAN ACTOR IN ECOLOGICAL-ECONOMIC MODELS

PREFACE

Changing current consumption and production patterns into a more sustainable pathway requires explicit inclusion of behavioural aspects of the human actor. However, human behaviour is one of the most complex phenomena of analysis. The various disciplines studying human behaviour, like economics, sociology, anthropology and psychology, are rather fragmented, offering distinct theories for every topic. A frequently used tool for analysis of ecological economic systems is the formal mathematical model. Actually, the use of formal models is mainly restricted to mainstream economics. These models are useful for the consistent analysis of relations between human activities and consequences for the environment. However, when formal models are developed, not every nuance of our limited understanding can be included.

In recent years a number of promising developments took place in various fields that are involved in modelling human behaviour in relation to environmental problems. Briefly, these developments are: (1) the recognition by ecologists that the analysis of ecosystems requires the explicit inclusion of human activities, (2) the increasing recognition within economics of the limits of the rigid rational actor, and (3) the emergence of new mathematical and software tools that facilitated the use of simulation models by social scientists.

Ecological science traditionally studies ecosystems. Recently, an increasing number of ecologists argue that ecosystems cannot be studied anymore in isolation (Gunderson et al., 1995, 2000). Human activities have impacts on every ecosystem all over the world. Even ecosystems in relatively isolated parts of the world, like the arctic regions, contain toxic particles and are affected by stratospheric ozone depletion and possible climate change. Furthermore, due to the increasing pressure of population growth and the resulting economic activities, conflicts between human needs and ecosystem values lead to a need for integrated analysis of ecosystems and human activities. New streams of science, like ecosystem management and political ecology, explicitly focus on the integrated analysis of man and the environment.

Traditionally, economics is the social science in which many formal models of human behaviour have been designed. Conventional economic theory makes use of rational actors, the *Homo economicus*, to study human behaviour. The rational actors are self-regarding individuals maximising their own well-being. However, the powerful concept of the rational actor seems to be invalid according to experimental research in economics and psychology (Thaler, 1994; Loomes, 1998).

Deliberation about an economic decision is a costly activity in terms of time and cognitive effort, and many social scientists argue that peo-

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ple often employ simpler decision rules, aimed at satisficing rather than optimising. Models of bounded rationality have been used as an alternative in economics (Simon, 1957; Sargent, 1993). Still other important dimensions of the economic agents have been excluded, such as emotions, motivations, and perceptions. In order to include this dimension of behaviour we have to enter the domain of psychology.

Psychology and many other social sciences are originally focused on experimental research of individual and group behaviour. Since the early 1950s social scientists have used computers to simulate behavioural and social processes, although the real breakthrough came in the late 1980s due to the development of new simulation techniques like cellular automata, genetic algorithms and neural networks, and the widespread availability of personal computers. Computers became laboratories, allowing simulating behaviour theories in virtual environments. Overviews of this new, rapidly developing area can be found in Conte et al. (1997), Liebrand et al. (1998) and Gilbert and Troitzsch (1999). The general features of this new research area are the use of simulation models of interacting agents to study social processes in simple and complex environments.

Recent papers in this journal discuss the limitations of the rational-actor paradigm (Sieberhüner, 2000; van den Bergh et al., 2000). Our interest is to explore interesting possible alternative descriptions of the human actor in ecological economics. More specifically, we focus on descriptions of human behaviour that can be implemented in ecological economic models. We have invited scholars of various streams who practice innovative ways to study human behaviour in relation with environmental issues. Although the focus of this special issue is on computer modelling, the contributions are written for a wide audience. Technical details of the models discussed can be found in separate publications of the contributors.

In the first contribution, Gintis discusses empirical evidence from experimental economics that shows limitations of the traditional rational-actor paradigm with a special focus on environmental policies. Laboratory studies show that economic actors are not self-regarding, but cooperate in many circumstances. Gintis argues that an alternative model to the *H. economicus*, the *Homo reciprocans* will be more accurate for ecological economics.

According to Peterson, ecology cannot be studied without explicit inclusion of the human species. He shows that the current work in the field of political ecology, which aims at the interaction of human activities and ecology, is not suitable. The resilience concept of Holling (1986) is introduced as an overarching framework for interactions between social, economic, and ecological systems.

Bossel discusses his work on basic orientors as a way to represent human actors within ecological economic models. Basic orientors reflect the normative orientation people may have regarding their interaction with the environment they live in. Bossel shows that the inclusion of basic orientors in modelling the interaction between people and the environment improves our understanding of how normative orientations determine issues of sustainable development.

The agents in the model of Jager and colleagues are based on social-psychology. These agents differ from the rational-actor paradigm since they use different cognitive processes in different situations, such as repetition, deliberation, imitation and social comparison. Experiments with an ecological economic model are used to compare the differences between inclusion of *H. economicus* and *Homo psychologicus*.

Weisbuch is using interacting agents to simulate the emergence and role of institutions in relation to environmental issues. In his contribution, Weisbuch conceptualises institutions as shared norms and beliefs. He demonstrates that this approach yields different predictions of system behaviour than using unbounded rationality from neoclassical economics.

Finally, Anderies uses a stylised dynamical systems model to explore resource exploration of traditional societies in New Guinea and Easter Island. Bifurcation analysis is used to understand under which conditions the behaviour of the system structurally changes. Anderies concludes that

the ability of agents to intensify the exploration of the resource base to attempt to meet demand is a fundamental destabilising force.

Evaluating the contributions of this special issue, we can conclude that three factors emerge as important ingredients in more comprehensive descriptions of human actors in ecological economics models: multi-agent modelling, social interactions and mental models.

Instead of assuming homogeneity among actors, which can be aggregated into one economic actor in traditional models, heterogeneity of characteristics is a crucial element in alternative models of human behaviour. Actors can differ in place, abilities, preferences, mental models, cognitive processes, attitudes, available information in their memory, and the like. Only multi-agent models are able to cope with this heterogeneity. Instead of analytical models, multi-agent models are often simulation models, and lead therefore to a different type of analysis. Instead of describing the best possible policy, multi-agent models are used to explore the consequences of alternative assumptions.

Social interaction is an important element of the multi-agent models. Besides individual-based decisions, agents compare their behaviour with other agents, imitate other's behaviour or want to distinguish themselves from the others. This can lead to fashions and fads in social networks.

The alternative models of human actors explicitly assume bounded rationality. Not only are the agents limited in their capacity to predict the future, they also can have biased perceptions or orientations of reality. This fits very well with the use of different world views in the literature of sustainable development (Rayner and Malone, 1998; Janssen and de Vries, 1998; Costanza, 2000). Furthermore, it relates to the notion of adaptive management, which stimulates a continuous active learning process of system dynamics (Holling, 1978; Walters, 1986).

To conclude, compared with the traditional *H. economicus*, various alternative models of human behaviour exist that can more explicitly address diversity between economic actors and uncertainty of future developments. We hope the examples as described in this special issue will stimulate improvement of the representation of human behaviour in ecological economic models.

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