Evolutionary Economics and Environmental Policy

Survival of the Greenest

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NEW HORIZONS IN INSTITUTIONAL AND EVOLUTIONARY ECONOMICS

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Jeroen C.J.M. van den Bergh

Faculty of Economics and Business Administration, and Institute for Environmental Studies, Free University, Amsterdam

Albert Faber

Netherlands Environmental Assessment Agency, Bilthoven

Annemarth M. Idenburg

DHV Group, Amersfoort, formerly, Netherlands Environmental Assessment Agency, Bilthoven

Frans H. Oosterhuis

Institute for Environmental Studies, Free University, Amsterdam

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Evolutionary Economics and Environmental Policy

NEW HORIZONS IN INSTITUTIONAL AND EVOLUTIONARY ECONOMICS

Series Editor: Geoffrey M. Hodgson
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Evolutionary Economics and Environmental Policy
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Preface

This book is the result of a joint effort of the Netherlands Environmental Assessment Agency, the Faculty of Economics and Business Administration of the Free University (Vrije Universiteit) in Amsterdam, and the university's Institute for Environmental Studies. This has led to a thorough search for the potential contribution of evolutionary economics to understanding innovations and transitions in the context of energy and sustainable development. This in turn has given rise to practical suggestions as to the role of the government and the design of public policies aimed at making a transition to a sustainable development. Current policies in a number of relevant areas are critically examined against the background of lessons learned from the application of evolutionary economics. In addition, three specific energy technologies – namely, fuel cells, nuclear fusion and photovoltaic energy – are examined in detail within the adopted evolutionary-economic framework. A glossary of the evolutionary-economic terminology employed here is included at the end of the book.

We are very grateful to many colleagues for constructive comments on earlier drafts of the text: René Kemp (MERIT, Maastricht), Frank Dietz (Ministry of Housing, Spatial Planning and the Environment), Marlouke Durville (Ministry of Economic Affairs), Marjan Hofkes (Institute for Environmental Studies) and Rob Maas, Fred Langeweg, Leon Janssen, Jan Ros, Harry Wilting, Eric Drissen and Jacco Farla (all Netherlands Environmental Assessment Agency). Frans Kooymans translated the text from Dutch into English.

It is our hope that this book will serve as a stimulus for future research on the implications of evolutionary economic thought for environmental policy and transition management.

Jeroen van den Bergh
Albert Faber
Annemarth Idenburg
Frans Oosterhuis

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1. Introduction

Economic premises and principles play a major role in the shaping of environmental policy. In traditional neoclassical economics, concepts such as rationality, efficiency and optimization are dominant. This leads to an approach that turns out to be unsuitable for the analysis and interpretation of major system changes (transitions) and innovations. Other economic theories provide complementary but sometimes contradictory viewpoints. The most valuable theoretical framework for the study of innovations and transitions is *evolutionary economics*, with its key concepts of diversity, innovation and selection. The starting premise of evolutionary economics is that human beings act according to bounded rationality, which takes the form of routines, imitation and a limited time horizon. Especially in studies of technological development and innovations, evolutionary economics plays an increasingly important role. In this study we are especially interested in the common grounds of environmental and innovation policy. The key question of this book can be formulated as:

> *What insights does evolutionary economics theory provide for the design of environmental policy that aims to stimulate innovations and a transition to a long-term environmentally sustainable economy?*

In this study we will focus our attention on energy; in particular, on policies for energy innovation and an 'energy transition' to a sustainable energy provision. The key question is therefore translated into three subordinate questions:

1. What concepts and ideas from evolutionary economics can be applied to develop a vision on environmental policy and transition management, how can these concepts be applied and which results can thus be derived?
2. To what extent are the views on policy with regard to stimulation of energy innovations – as reflected in today's policy documents and advice – in line with the insights of evolutionary economics?
3. How can the development of specific energy technologies be understood from an evolutionary-economic perspective?

The organization of the remainder of this book is as follows. Chapter 2 provides a general, theoretical overview of the principles and main insights of evolutionary economics. This culminates in a choice of key concepts and a synthetic framework for evolutionary-economic analysis. In Chapter 3 this framework is used to derive a number of suggestions for the design of environmental policy and transition management. Next, in Chapter 4 an evaluation of current energy and innovation policy in the Netherlands is carried out on the basis of the evolutionary-economic principles derived in the initial chapters. In Chapter 5 the general insights are illustrated and elaborated within three case studies that are relevant to the transition to a sustainable energy supply. Three technologies are looked at in detail; namely, fuel cells, nuclear fusion and photovoltaic energy. Chapter 6 summarizes and draws main conclusions from this study.

2. Evolutionary economics

2.1 EVOLUTIONARY THINKING

Evolution is nowadays widely regarded as both a general concept and a set of concrete mechanisms to comprehend structural change processes that affect human technologies, organizations and institutions (e.g. Ayres, 1994; Dennett, 1995). The application of evolutionary thinking to economics has made significant headway during the past 20 years. This is partly the result of dissatisfaction with the way technological development is presented in the neoclassical economic model of economic growth. Technology was originally viewed as an exogenous variable that develops outside the economic process. Later it came to be viewed as an endogenous variable that could be fitted rather easily into the framework of economic equilibrium analysis. More recent insights into the process of innovation, however, undermine this latter assumption. Technological development is now viewed as the outcome of a continuous interaction between generation (innovation) and selection of diversity in technologies and organizational structures. When we take this view as a starting point, the evolutionary approach provides a credible alternative to traditional theories of economic and technological change. The rational behaviour of individual persons and groups, which is assumed in traditional economic theory, is replaced in the evolutionary approach by bounded rationality, which can take the form of habits, routines, myopia and imitation (Nelson and Winter, 1982; Robson, 2001).

The following elements and processes play key and complementary roles within evolutionary economics:

- *Diversity* (variation): populations of strategies, products, technologies and organizational structures.
- *Selection*: processes that reduce existing diversity.
- *Innovation*: processes that create more (increase) diversity.
- *Transferability (transmission)*: replication by reproduction or copying (possibly imitation). This results in continuity, durability (retention) and cumulative processes.
- *Bounded rationality*: individuals and organizations (groups) largely behave according to fixed patterns that result from adjustments in the

past to a certain environment or that have been selected by this environment. Characteristic features of this are routine behaviour, imitation of others and myopia (a short time horizon).

Paying specific attention to diversity implies an approach that takes agent populations as the starting point. The representative agent, which is a customary assumption in neoclassical economic theory, thus no longer applies. A population approach can be translated into a formal model. The type of model depends heavily on the scope of aggregation. Evolutionary game theory, for example, depends on aggregate variables, so that the extent of diversity is generally confined to two or three characteristics. An alternative approach describes populations and related changes by means of probabilistic distributions. A third mode, the ultimate micro approach, describes individuals on the basis of unique characteristics. This results in the most detailed description of possible interactions between economic agents, also known as multi-agent systems. These can then be placed in a context of fully random interactions (a gas cloud) or of systematic interactions in a network or spatial (e.g. cellular grid) structure.

Despite the apparent simplicity of the underlying mechanisms, evolution is a powerful theory. In essence it consists of two diametrical forces or causal processes. One involves the creation of diversity through the application of various mechanisms, often combined under the terms discovery and innovation. This can be viewed as a force that stimulates imbalance. The second force is selection, which leads to a reduction of diversity. This can be regarded as a focused force that stimulates balance. Unlike a physical law such as the force of gravity, selection represents a taxonomy of a large number of processes that affect the fitness of individual elements, through their survival, reproduction and diffusion. In other words, it is an umbrella term. In an economic context it encompasses market competition, interactions between employers and employees (or trades unions), relationships with other pressure groups, mergers and acquisitions, financial requirements imposed by providers of capital (shareholders and banks), legislation and public regulation, and public opinion.

The result of these opposing forces of innovation and selection is a process of continuous change, without this necessarily leading to a state of equilibrium. Only with limited innovation or no innovation at all can a system converge under the influence of selection processes to a state of balance. This is the approach followed by evolutionary game theory. Diversity will then necessarily decrease until it reaches a minimum level. In a state of balance between selective and innovative forces, diversity will sometimes increase and at other times decrease, but will never be fully eliminated. In addition, the dynamics of evolution depends on the existing

diversity. The reason is that the outcomes of both innovation and selection processes depend on, or are limited by, the current state of diversity. In the case of innovation this is clear from the fact that many innovations are the result of combining already existing elements from a pool characterized by internal diversity ('recombination'). From the foregoing it is evident that neglecting to describe diversity in an evolutionary system would lead to incomplete comprehension of the dynamics of such a system.

An important consequence of evolution over an extended period of time is that structure and complexity come about. Evolutionary theory thus explains how processes at a single level generate new structures at a higher level. This is sometimes identified by terms, not altogether sharply defined, such as self-organization and emergence (Kauffman, 1993; Holland, 1998). Evolutionary theory provides an important overall basis for explanations of these phenomena. The success of evolutionary theory is evident not only within biology, its traditional area of application. The field of evolutionary computation within computer and information sciences, which solves design and optimization problems through the application of evolutionary algorithms, is an example of the effectiveness and practical usefulness of evolutionary theory and modelling (Bäck, 1996).

If an evolutionary system involves a great deal of internal diversity – in other words, a large population with many different elements or individuals – it is very unlikely, on the basis of mere probability theory, that the system will return to a previous state. We can then in fact speak of a situation of irreversibility, which implies that history is introduced. A major feature of the evolutionary approach is indeed that it merges theoretical and historical perspectives, notably since it incorporates causal mechanisms such as innovation, selection and accumulation. The theoretical consequences of this are path dependence and lock-in, which are described in detail later in this book.

The power and appeal of an evolutionary approach is that, despite its rather simple conceptual starting point, complex structures can be understood and explained on the basis of partially endogenous processes (innovation, and to a lesser extent, selection) that convert simple systems into complex ones. It can therefore safely be asserted that evolution is one of the most powerful and comprehensive ideas that science has brought about (Ayres, 1994; Dennett, 1995). As evidence of this, evolutionary theory has been extensively applied within modern biology for more than half a century and with tremendous success. For several decades there has also been a growing acknowledgement of the potential of evolutionary thinking within the social sciences. A fascinating application of evolutionary (multi-agent) modelling, for example, is the by now famous Sugarscape model of Epstein and Axtell (1996), which describes the development of

a complex socio-economic system, combining elements from economics, demography, sociology and biology. Comparable evolutionary models have meanwhile also been successfully applied to the financial markets (Levy et al., 2000). This book, which focuses on the analysis of environmental and energy policy, is in line with these developments.

2.2 A BRIEF OVERVIEW OF IDEAS AND CONCEPTS WITHIN EVOLUTIONARY ECONOMICS

Evolutionary economics builds upon the general evolutionary principles that have been outlined in the previous section. The development of this field features a great variety of contributions that have led to new concepts and ideas that may be useful in research on environmental and transition policy. This section presents a brief overview of the main contributions and insights within evolutionary economics. A complete and detailed overview can be found in Hodgson (1993). An accessible introduction in Dutch is presented in Boschma et al. (2002).

2.2.1 Origins

Veblen (1898) is often regarded as the first evolutionary economist, based mainly on the fact that he used the term 'evolution' explicitly in a discussion of how to approach the study of economics. In particular, he considered the question of why economics had not developed into an evolutionary science. Veblen's approach was very sociological, as he emphasized the behaviour of entrepreneurs. He paid much attention to technological change, the pace of which was rapid around 1900, but which altogether lacked a coherent theory. His suggestion of evolutionary economics was one of a causal process, an unfolding of phases, an accumulation of effects.

Joseph Schumpeter was the most influential of all early evolutionary economists, both because of his reputation within the European and American economic communities and because of the many concepts and ideas that sprang from his mind. Schumpeter questioned the dominance of the static approach to economic science. This linked up with a considerable interest in the dynamics of economics; in particular, the development of the capitalist system (as also studied by Karl Marx), which was evident in all of his important works (Schumpeter, 1934, 1939, 1942). In his book *The Theory of Economic Development* (Schumpeter, 1934; originally published in German in 1911) he viewed qualitative economic and technological change within the broader context of social change, with an emphasis on psychological aspects relating to the influence of innovative