1. Introduction and overview

John Foster and Werner Hölzl

Modern evolutionary economics is just over two decades old and its research programme continues to expand in innovative directions. A key development in recent years is the move away from the traditional focus on processes of selection towards the dynamics of complex systems (Foster and Metcalfe 2001). Increasingly, the economy and its components are seen as complex adaptive systems that change qualitatively in historical time. This shift in perspective has led to suggestions that new analytical tools and different empirical research methodologies are necessary. In the natural sciences, approaches to the development and functioning of systems, which apply both evolutionary and self-organization theory in a consistent and compatible way, have proven to be fruitful in recent years (see Kauffman 1993, Depew and Weber 1995). However, the economy, as a system with component sub-systems, is different in important ways to those found in physio-chemical and biological contexts. The challenge is not only to discover analytical representations of economic evolution but also to be able to connect them with empirical research.

New and innovative methodologies and methods of empirical research are being developed by applied evolutionary economists. It is these that are of primary interest in this volume. Consequently, it is not the purpose here to review the literature on modern evolutionary economics, nor to provide a systematic account of empirical research methodologies that are still in their infancy. What is offered in the chapters that follow is, necessarily, selective, exploratory and illustrative. However, before providing an overview of these contributions, it is worth giving a short summary assessment of the connections between evolutionary economics and complex systems theory.

1. EVOLUTIONARY ECONOMICS

Evolutionary economists see the economy as a scientific domain characterized by non-equilibrium processes in which economic agents create and adapt to novelty through learning rather than as a system in which there are disequilibrating shocks to stable equilibrium states (see Witt 1993, Nelson 1995, Saviotti 1996, Foster and Metcalfe 2001, Fagerberg 2003). In the natural sciences, equilibrium is either a state that exists in a completely connected force field (Mirowski 1989) or it is a state of maximal disconnection, for example thermodynamic equilibrium. The former concept of equilibrium is used to address the real world through the application of experimental controls which localize such a force-field equilibrium in space and time. Neoclassical economists have adopted this kind of conception of equilibrium but reversed its role, whereby a set of controls (assumptions) is proposed in a logical setting and analytical experiments are conducted that involve the successive relaxation of these controls. This, of course, does not necessarily get us closer to reality.

The latter case of equilibrium is quite realistic but empty as an analytical tool – it is something to which systems tend in the presence of processes such as entropy. This is a form of equilibrium towards which systems try to resist moving, and it is this resistance and the associated flows of energy and information that self-organization theory seeks to address. Such a vision of the dynamics of systems of the economic kind was grasped in an intuitive way by Joseph Schumpeter (Foster 2000). Correspondingly, the contributions in this volume are strongly influenced by his work.

Schumpeter considered economic evolution as an open-ended process of qualitative change. Evolutionary economics, as it is conceived of in this volume, takes his line of reasoning. In this sense it is different from other strands of economics that use the term 'evolutionary', as, for example, in evolutionary game theory. Evolution, in the context of this volume, is economic development over time and is an open-ended dynamic process over an open state space. Although there are overlaps with evolutionary biology, the Schumpeterian perspective is quite distinct. However, some general principles are shared, for example, replicator dynamic processes which have provided a core for modern evolutionary economics following on from the contribution of Nelson and Winter (1982).

Building on this seminal contribution, modern evolutionary economics came to be based upon the interaction of processes of behavioural variation in a population of heterogeneous economic agents characterized by a certain degree of inertia (heredity), selection and replication. Accordingly, for most evolutionary economists competition is a process of successive selection, where the least efficient products and firms are driven out of the market. What makes a firm competitive are its technological and organizational attributes, which make it worse or better adapted to a specific economic environment, and its capability to learn and innovate, which allows it to improve its position in relation to other firms in the market.

The adoption of replicator dynamics has been crucially important in establishing modern evolutionary economics as a credible and coherent force in economics. However, the strength of evolutionary economics does not rest exclusively on the application of these principles to the economic process. It also lies in the radical change in theoretical perspective that it has introduced into economics, away from concepts such as representative agents and individual optimization and an associated focus on understanding the properties of a possible equilibrium states towards a search for explanations of structural change in the economy. There is no one-to-one transfer of evolutionary analogies and metaphors from biology to economics.

Evolutionary economists take into account specific aspects of the economic domain that are not relevant in the biological domain. In our view the three distinguishing and interrelated traits of evolutionary economics are:

1. While there is disagreement on the specific definitions, there is agreement that *knowledge and information* are central ingredients of the approach of evolutionary economics. Economic systems are knowledge-based. The primary interactions are exchanges between knowledge as a structure and information as a flow. Economic knowledge resides in the mind, both individually and collectively, and leads to the formation of rules, routines and other institutions that facilitate economic coordination. These are reinforced and reproduced through practice. If rules are unused they cease to be relevant and the associated knowledge disappears. It is the processes of knowledge creation and destruction that underpins and drives economic growth and qualitative change. The growth of knowledge cannot be meaningfully captured as a constellation of equilibrating forces (Metcalfe 1998, Foster and Metcalfe 2001, Fagerberg 2003).
2. Evolutionary economics takes a *population approach* instead of a typological approach based on representative agents. The heterogeneity of economic behaviour is based on the distribution of knowledge within the economy. The division of labour is deeply related to the division of knowledge (Hayek 1945). Heterogeneity drives economic change, which can be cast in terms of observable changes in the composition of populations of firms, technologies and industries. The economic system contains a large number of heterogeneous agents that act simultaneously. The interaction between economic agents takes the form of competition and cooperation. Together with spillovers, the decentralized organization creates not only the problem-solving capability of the economic system but also the capability to formulate new problems and new behaviour. Thus the link between aggregate growth and the

transformation of economic structures cannot be captured by employing a typological approach based on representative agents (Metcalfe et al. 2003).

3. The *interdependence between selection and development* is a primary characteristic of evolutionary economics. Competition as a replicator dynamic process structures economic activity (Metcalfe 1998) and selects the most productive techniques, the best organizational arrangements, the most capable human capital and the most attractive products. From the perspective of variety generation, markets are institutions that not only coordinate economic behaviour but facilitate change, entrepreneurship and challenges to established behaviours. Selection processes destroy variety. The generation of variety and the selection of variety interact in the process of development. In order to have economic development, variety needs to be constantly re-created. It is variety in the knowledge structure that permits the novel ideas that result in organizational and technological innovations to emerge.

Economic systems are subject to developments characterized by qualitative, structural and irreversible change. Although such systems can approach steady or even stationary states, these are not equilibrium states of the conventional type. Evolutionary economists do not see economics as a science that is primarily concerned with the analysis of the best use of given resources, that is, optimal outcomes, but, instead, seek analytical representations of the processes of consolidation and change in economic systems. In this respect, evolutionary economics revisits many of the questions asked by the classics (especially Adam Smith and Karl Marx), while the theme of qualitative change in the economic system raises issues considered in a largely intuitive manner by, for example, Alfred Marshall and Joseph Schumpeter, using new theoretical and empirical tools. The strong focus on technological and organizational change within evolutionary economics reflects these historical connections.

However, it has become apparent to many evolutionary economists that perceiving the economy as a set of interacting non-equilibrium processes that exhibit homeostatic tendencies requires a fundamental rethink as to how the complicatedness that we observe in the data can be simplified in a way that permits analysis. The mainstream favours simplistic, rather than simple, representations of the complicated real world and, indeed, such an approach is also favoured in some contributions in heterodox economics. There is a growing realization that, if the complicatedness that we observe is, in fact, due to the behaviour of interacting complex systems, then simple representations of the economy can be derived for the purposes of analysis (Foster 2003). So let us now examine what is meant by a 'complex system' and why this is fundamentally important in evolutionary economics.

2. COMPLEX SYSTEMS

The complicatedness of reality is a daunting prospect for anyone in search of tractable analytical principles. The great task is to provide a universally valid set of principles that can offer simple representations of the structures and processes in the real economy – not principles that avoid confronting this reality but those that acknowledge the fact that we are dealing with complex systems and related complex processes. By definition, such as set of principles is orthogonal to conventional ones as embodied, for example, in Walrasian general equilibrium theory. Such a theory is a simplistic, that is, not an analytical, representation of real processes since it deals with outcomes, not historical processes (Dopfer 2001).

Complex systems in the economy are, at the same time, complicated and organized in a way that permits them to absorb energy and information to create both physical and knowledge structures that allow them to maintain their structural integrity and to develop. Such systems can only be understood in a historical continuum and, as such, can be analysed in simple (not simplistic) ways that is not just historiography. The reduction of complexity to simple analytical representations is not an exercise in mathematical deduction but, rather, a question of understanding the endogenous tendencies that complex systems display and how such tendencies interconnect with those of other systems and the rules that arise from social, political and cultural origins. Applied evolutionary economics is concerned with the manner in which the unique dimensions of these interconnections in particular cases relate to general processes that complex systems all exhibit.

Thus the dynamics of complex systems are, in part, explainable and predictable in so far as they behave on average in a representative (average) manner, and, in part, inexplicable and unpredictable, as they act also in non-representative and non-ergodic ways. A defining characteristic of complex systems is the interdependence of the elements that make up any system. A system containing a number of elements cannot be reduced to systems with a lower number of elements without changing the defining character of the system since the connective structure will be altered (Potts 2000). Complex systems are only partially decomposable. Thus the quest for simple analytical principles is quite different from the conventional reductionist approach. What is sought is an understanding of the temporal and spatial patterns exhibited by complex systems that can be represented in a simple and tractable manner – this lies at the heart of all evolutionary economic analysis.

All this is in stark contrast to mainstream approaches that place the optimizing behaviour of economic agents at the core of economic analysis. Of course, this does not deny that economic agents try to optimize; the crucial issue is the context in which such behaviour occurs. If the economic system is a complex and open system, this has fundamental implications for the behavioural characteristics of economic agents. In the face of the complicated geometry of economic interactions (Potts 2000), economic problems are computationally demanding. So economic agents must be viewed as having limited computational power. In trying to explain phenomena in historical reality, they cannot be just viewed generally as optimizing agents with perfect information or rational expectations. In a complicated reality inhabited by complex systems, rationality becomes a procedural and limited notion, or as Herbert Simon called it, bounded rationality. Such rationality manifests itself when economic agents attempt to solve problems in economic processes directed towards goals or aspirations that need not be rationally constructed because they are formed in uncertain circumstances.

The implications of computational difficulty are not confined to the behavioural attributes of economic agents. Such difficulty also places inherent limits on the ability of economists to model the behaviour of complex systems. It is striking just how quickly conventional 'simplistic' linear models of economic behaviour become mathematically complicated and intractable simply by introducing an element of non-linearity. Complicated mathematics is generally unhelpful in understanding the behaviour of economic systems. The complex systems perspective involves recognition that there is a large self-organizational element in the behaviour of economic systems over time that can be summarized in mathematical terms, that is, in terms of growth rates. Thus the behaviour of complex systems can be simply represented in terms of tendencies that are punctuated by exogenous impacts. The theory that lies behind such tendencies is concerned with the emergence of rules, routines and other connections between individuals and groups that result in economic value (Dopfer et al. 2004).

The rule-based interactions of agents result in emergent features at the macroeconomic level of the economy. The challenge for evolutionary economists is not to prove the stability or existence of equilibrium in the economic system, but to explain and understand which rules govern the interaction between the agents and which processes and interactions change the rules of the economic game over time, enabling the system to evolve. Even if a complex economic system cannot be exactly decomposed into modular independent subsystems, the notion of nearly decomposable systems allows complexity to be analysed in systematic ways. Thus components of the economic system can be dealt with as self-organizing entities where replicator dynamic representations can be used to capture evolutionary tendencies both within such components and between them (Foster and Metcalfe 2001). However, much has to be done before a unified and simple analytical framework, built from complexity theory, can emerge in evolutionary economics. The future of economics as a discipline would seem to lie in such endeavours and the contributions in this book represent clear progress in this direction.

3. OVERVIEW

The authors of the chapters in this book take up the challenge of discovering an empirically based evolutionary economics based on complex system theory. The first set of contributions deals with empirical research methodologies, discussing econometric techniques and practices, as well as new methodologies. The other chapters deal with the application of evolutionary principles and ideas to economic questions.

In Chapter 2, Foster explores, in a critical way, the current conventional practice and methodologies of time-series econometrics from an evolutionary perspective. He assesses the vector error correction modelling methodology (VECM) prevalent in time-series econometrics. The main goal of the VECM is to isolate stable long-run parameters. By allowing the unknown disequilibrium dynamics to be captured, proponents of the VECM argue that their methodology is dynamic. However, as Foster remarks, structural change associated with regulatory change and innovations cannot be captured in such an approach. He points out that this methodology diminishes the extent to which time-series econometrics can be used to discover new explanations of economic phenomena that reflect the evolutionary character of the economic system. By drawing on joint work with Phillip Wild (Foster and Wild 1999), he shows that a quite general econometric methodology grounded in evolutionary economics can be specified. Foster uses the consumption function as an example and shows how evolutionary economics, understood as a set of theories concerning economic processes, is able to provide a different econometric methodology which respects economic history, captures selection processes, and reflects the self-organizational nature of the economy. The equilibrium/disequilibrium constructs of the VECM time-series econometrics are replaced by non-equilibrium visions of economic change at the macroeconomic level. Foster suggests that this provides not only a theoretical agenda for evolutionary economics but also an empirical one. Only by showing the relevance of evolutionary economics in applied work – especially at aggregate levels – can the habit of applied economists to rely on long-run equilibrium constructs be broken. The proposed empirical methodology allows economic history into macroeconomics, which becomes a body of theory concerned with systemic connections and the dynamics of structural change.

In Chapter 3, Bevilacqua and van Zon provide evidence that does not support real business cycle theory which, in a number of respects, represents the worst recent example of simplistic theorizing in economics. They present robust evidence that serially uncorrelated residuals of many economic time series contain non-linear signals. First, they apply statistical tools to artificially generated time series that have dynamics similar to a random walk. They show that there is a large information gain by modelling such data using non-linear methods. They go on to apply the same methods to a large number of US time series and show that there is still relevant information in the residuals of time series. Their findings imply that the standard econometric practice, grounded in real business cycle theory, of interpreting the data using linear models that are disturbed by exogenous random shocks is not warranted. The dynamics of macroeconomic time series appear to be intrinsically non-linear. They conclude that real business cycle theory, and unit root autoregressive models are generally inadequate devices for understanding economic time series and argue that their results provide evidence for the hypothesis that economic variables may not follow a stationary path even in the absence of external shocks. The observed non-linearity and non-stationary are what we would expect if economic systems were complex and self-organizational in character.

In Chapter 4, Ebersberger and Pyka argue that genetic programming provides a useful modelling methodology to add to the toolbox of evolutionary economics for both theoretical and empirical research. While it is well known that genetic programming is an appropriate modelling strategy to capture the learning of agents with limited computational power, Ebersberger and Pyka suggest that genetic programming can be used to improve existing models and support the generation of new economic models that can be related to empirical observations. The selection and rearrangement of rules can be modelled with genetic programming. By asking what modelling is, they show that the learning of agents needs to be modelled as a modelling process. They discuss how an economist can be modelled as a bounded rational agent in search of principles that can explain empirical regularities, and show how genetic programming was employed to make a theoretical model, concerned with the presence of twin peaks in world income distribution, more parsimonious. Regarding the applicability of genetic programming techniques to empirical analysis, Ebersberger and Pyka note that genetic programming is especially suitable in applied evolutionary economics, as it provides a non-parametric framework, can take a priori knowledge into account, allows for heterogeneity and can be used to detect structural breaks.

In Chapter 5, Frenken and Nuvolari show how the NK model of evolutionary biology can be employed in empirical studies of technical change through the use of entropy statistics. The NK model developed by Stuart Kauffman (see Kauffman 1993) is a simple, formal model that illustrates the role of systemic interdependencies in complex systems. Many scholars have recognized that interdependencies between technological components are the prime source of design complexity. The NK model can represent the design process employed in producing a complex technological artefact as a trial-and-error process that is bound to end up in a local optimum. While the NK model has received considerable attention, empirical applications are relatively scarce. Frenken and Nuvolari show how the use of entropy statistics allows a relatively straightforward application of the NK model to empirical studies of technological change. The approach enables the study of evolutionary patterns in technological change to be examined in terms of variety and differentiation. They propose a number of generalizations of the original NK model to account for the specific attributes of technological evolution. They conclude that the evolutionary development of a complex technology, following the (generalized) NK model, is expected to be characterized by both an increasing degree of variety and an increasing degree of differentiation, when the complex nature of technological artefacts and heterogeneous demand is taken in account. They provide applications of this approach to the design dimensions for three different technologies, namely aeroplane, helicopter and early steam-engine technologies. Their conjecture of increasing variety through differentiation is confirmed for aircraft and steam engines – both aircraft technology and early steam-engine technology were affected by the introduction of a revolutionary design (the jet engine and Watt's engine, respectively). However, in both industries this did not lead to a substitution process but to a process of progressive differentiation into different design families. The case of helicopter technology shows the opposite of a differentiation process. Here Frenken and Nuvolari argue that this can be attributed to the presence of competing aircraft models. Their empirical results offer an important insight. The evidence for aircraft and steam engines shows that the evolution of complex technologies is better described as an evolutionary process of differentiation than by the model of linear substitution. This is entirely in accord with complexity theory.

In Chapter 6, Reinstaller and Hölzl present an analytical framework that deals with induced innovation to study the nature of recombinant search based on the NK model. They take issue with the view that technological search is essentially a random process and outline a framework where interdependencies between production processes and inputs drive the adoption of new processes. Complementarity makes the production system nonseparable and complex. Strong interdependencies between specific elements create a 'core' process technology. The 'core' can be understood as akin to a dominant design for production processes. The property of the core is that it restricts the search space for variety generation. The search for variations of the design is limited to the neighbourhood of the core. A change of elements in the core would increase the likelihood that changes in one element would affect the overall performance. Thereby, technological uncertainty is reduced. The other side of complementary relations is that they may cause imbalances and turn into binding constraints. The break-up of complementary relations increases technological uncertainty and triggers the search for new combinations. Complementarities assume the role of focusing devices. Reinstaller and Hölzl argue that strategies of problem decomposition and re-composition are applied in order to soften the constraints. This leads towards a modularization of activities. They apply their framework in a historical case study of the establishment of the first IT regime at the turn of the nineteenth century in the USA. They argue that both the accounting revolution and the adoption of office machinery were guided by complementary constraints.

In Chapter 7, Grebel, Pyka and Hanusch provide an eclectic, evolutionary model of entrepreneurship. The first part of the chapter contains an overview of the theory of entrepreneurship. From this they distil the most important aspects of entrepreneurship, which serve to locate their model in the literature. The building blocks of their model are bounded rational agents. These agents are modelled to have a specific set of attributes. Each agent is equipped with 'entrepreneurial spirit', human capital and venture capital. The 'entrepreneurial spirit' captures the entrepreneurial function emphasized in Schumpeter's theory of entrepreneurship. This feature describes the tendency to become an entrepreneur or an employee. Human capital refers to the investment in knowledge and know-how in the agent. According to their theory, human capital is the crucial productive element that decides the fate of the entrepreneurial firm once it is established. Venture capital refers to the financial means necessary to set up a new firm. New firms are set up by networks of agents. A random matching process brings the agents together and this coalition evaluates the possibility that a new firm can be formed. The survival of the newly founded firm depends on human and venture capital. The authors use a simulation study to show that firms do not enter all at once and that turbulence is greatest in states of emergence. As time goes by, it becomes more and more difficult to enter. This is captured by the entry threshold, which relies negatively on the growth rate of the sector's turnover and positively on exit. By using evidence for the set-up of new Internet/e-commerce firms in Germany, Grebel, Pyka and Hanusch are able to show that the results of their model fit the facts of new firm formation in newly emerging sectors.

In Chapter 8, Krafft offers a critical perspective on the concept of shakeout in the industry dynamics and industry life cycle literature. Many industries evolve according to a life cycle, and firms in those industries eventually face a shakeout as the opportunities for variety generation decline and a dominant design is established. Such a shakeout follows on from a process of competitive escalation in advertising and/or R&D. However, as Krafft shows, a number of industries do not evolve along a typical life cycle trajectory, either because they are essentially knowledge-driven instead of technology-driven, or because they exhibit patterns of evolution that do not involve shakeout. Krafft points out that knowledge-driven industries, in particular, often show pronounced non-shakeout patterns in their industrial dynamics. She shows that there have been no real shakeout patterns in the chemical, telecommunications and the medical instruments industries. In those industries, networks, clusters and alliances prevented a shakeout from occurring. Krafft argues that shakeouts that do occur in knowledge-driven industries have different patterns from those in technology-driven industries. This is because knowledge-driven industries have different network structures. Using the evidence from selected industries, Krafft argues for a wider research agenda in the study of industrial dynamics. To understand the main determinants of industry evolution, we cannot restrict attention to aspects of product and process technologies. Relationships between firms, suppliers and customers are vitally important in examining specific cases of industrial dynamics, as is the diversity in the institutional set-up between countries. In essence, Krafft shows that taking complexity seriously in examining industrial dynamics means that the life cycle, which is an analogy drawn from biology, is not an adequate representation of the self-organizational and interconnected dynamics of firms and industries.

In Chapter 9, Peneder deals with the so-called 'Austrian Paradox'. This involves an ambiguity between pronounced deficits in an industrial structure and a general perception of its good macroeconomic performance. Peneder reviews evidence which confirms that Austria has, in comparison with other developed countries, low shares of technologically progressive industries and low R&D levels. This negative assessment is in sharp contrast to Austria's strong macroeconomic performance, with comparatively high levels of labour productivity and income, high GDP growth and below-average unemployment rates. The Austrian experience seems to conflict with the basic evolutionary thesis that structural change drives economic growth. Peneder then provides evidence that the particular path of Austria's successful macroeconomic development can be explained by specific geographical, socio-political and institutional factors, especially (i) industrial relations, shaped by the corporatist institution of social partnership which promotes aggregate wage flexibility, (ii) close proximity to the dynamic high-income regions of southern Germany and northern Italy, (iii) the presence of anti-cyclical fiscal policy through built-in stabilizers in the generous system of social security, public investment and accelerated investment schemes and (iv) a strong currency, which has kept inflation under control. Taken together, these policies stabilized expectations and created a favourable climate for private investment. Good macroeconomic performance is related to the unconventional finding that macroeconomic stabilization has had a lasting impact on the level of GDP per capita. Peneder then goes on to show that the long-term coherence between macroeconomic policies and institutions is no longer given. The membership in the Economic and Monetary Union led to a loss in autonomy in the formulation of national macroeconomic policies. However, even before this, the growth regime had lost much of its lustre. But, given the constraints, Peneder argues, a new policy mix will have to be based primarily on the supply side; that is, industrial policy will have to be used. Peneder goes on to present an outline of an evolutionary (Schumpeterian) perspective on industrial policy which projects evolutionary dynamics into a coherent set of policies directed towards structural change and growth. This set of policies is derived from the evolutionary principles of variety generation, diffusion and selection. For Peneder, industrial policy in an evolutionary spirit should foster (i) novelty generation through entrepreneurship and innovation, (ii) the accumulation of productive resources through knowledge creation and diffusion, and (iii) open and competitive markets to provide an effective means of selection.

In Chapter 10, Tappi deals with structural change and development at the regional level. She has studied changes in industrial specialization in the Italian Marches region from the production of musical instruments towards electronics. She interprets this change as an outcome of a process of self-organization based on the differential behaviour of firms. With the exception of the presence of the University of Ancona, which guaranteed a high-quality labour force with engineering know-how, Tappi argues that the changes were orchestrated by the (unintended) heterogeneity of behaviour and strategies and also organizational forms of the single firms. Larger firms were instrumental in providing the absorptive capacity of the regional economy. However, the collective learning process, which embedded new technological knowledge into the regional competence set, was largely driven by small start-up firms. She provides evidence for the thesis that localized competence and localized collective learning processes are an important factor in cushioning the risk of entrepreneurial activity. Networking, which is central in complexity theory, is fundamental in this case and, through careful research, Tappi has demonstrated that the more conventional selection models favoured in evolutionary economics are not rich enough to capture the regional developments that she has studied.

In Chapter 11, van den Bergh examines the interrelations between ecological and evolutionary economics. He emphasizes the relevance of evolutionary thinking to the understanding of environmental problems and provides a concise overview of key issues in environmental and resource economics. He argues that ecological economics is a field that emerged in the 1980s because of concerns with the sustainability of economic development and, as multidisciplinary analysis, he sees it as close in spirit to evolutionary economics. The relationship between evolutionary economics and environmental economics is highlighted by focusing on the themes of economic growth, environmental quality and the role of resource management in major structural changes. The most fundamental task that van den Bergh identifies is the formulation of an evolutionary theory of growth which takes environmental resources and needs, as well as a spatial dimension, explicitly into account. The spatial dimension is especially important for environmental and resource problems, as they are spatially heterogeneous. This has to be considered in the formulation of any environmental policy. However, there is a problem in using evolutionary economics as a theoretical basis for the formulation of policy instruments, as van den Bergh remarks. That is, there is no normative evolutionary welfare theory that can match neoclassical welfare theory. However, policy suggestions can be derived from evolutionary economics, especially if bounded rationality, endogenous preferences, path dependency and the variety (knowledge) generation are considered to form the core of evolutionary economics. Once again, complexity theory is likely to be helpful in enriching evolutionary economics in a way that can lead to a better understanding of policy advice. Conceptualizing policy formulation is a dimension of knowledge formation and is, itself, a complex and fragile process of communication and consensus building. Van den Bergh provides what can be viewed as a first step towards more integration of economic and environmental policies built up from a more consistent set of analytical principles.

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