Evolutionary Economics and Chaos Theory: New Directions in Technology Studies

Loet Leydesdorff and Peter Van den Besselaar (eds.). Pinter, London, 1994. xiii + 215 pp.

Review for *Research Policy* by Esben Sloth Andersen

In this book Leydesdorff and Besselaar have collected 14 papers which address the issues of technological change by means of the perspectives and methods of complex dynamic systems. In the best traditions of evolutionary economics the book transcends disciplinary borders and includes verbal expositions, formal modelling, and simulation experiments. It thus allows the non-specialist to have a look at the research activities which are presently transforming our understanding of Schumpeterian competition and of technology policy.

Apart from an introductory chapter (by Allen) and an epilogue (by Leydesdorff), the book consists of four parts which each have three chapters. Part I deals with the elaboration of existing evolutionary models (papers by Nelson, Brunner, and Greiber/Kugler). Part II is entitled 'Technology dynamics: competing technologies' (papers by Bhargava/Mukherjee, David/Foray, and Bruckner/Ebeling/Montaño/Scharnhorst). Papers on 'Modelling the evolution of economic-technological systems' are contained in part III (Reggiani/Nijkamp, Kampmann/Haxholdt/Mosekilde/Sterman, and Allen/Phang). Finally, we find 'Contributions from the sociology of technology' in part IV (Etzkowitz, Blauwhof, Lee). This organisation of the contributions is not the only possible one, and readers will probably find their own grouping and focus. This will also be done in the present review. The emphasis on specific papers does not imply any statement about the scientific quality of the rest of the papers.

For many readers of *Research Policy* the paper by Dick Nelson (ch. 2) may function as an appropriate starting point. More than 10 years after the path-breaking book he write with Winter, Nelson wants to return to systematic evolutionary modelling and asks 'what are the key issues that I, right now, would like to explore with a carefully constructed formal model?' (p. 31) The answer to this question is quite sketchy, but its main elements are clear. First, the focus is on the evolutionary dynamics of specific types of industry rather than on the general mechanisms of sectoral evolution or macroeconomic growth. This emphasis allows a bridge between formal modelling and case-oriented economic history. Second, the model will try to formalise and test some of the ideas of the life-cycle theory of technologies and industries – especially the possible emergence of dominant designs. Third, there is often a coevolution between on the one hand technologies and industries and on the other hand supporting institutions. This coevolution is very complex because of time-lags and interest-group conflict, and the result may be major differences between different countries. These three issues suggest a serious reworking of the original Nelson-and-Winter models. For instance, the new model should include diverse customers as well as diverse firms, and there should be different types of dynamic increasing returns. Even the emergence of new academic disciplines or new laws should as far as possible be dealt with.

The book presents several types of model which may help to implement these ideas. Nelson clearly prefers 'real' evolutionary models which explicitly deal with the generation and selective retention of variety at the micro-level. His approach is thus not directly compatible with models with homogeneous sectors and with a deterministic behaviour. Even if such models have supplied such concepts as non-linearity, path-dependency, chaos, and self-organisation, and even if they are able to deal with the formation of 'long waves' (ch. 9) and with the 'ecological' interaction partly competing technologies (ch. 8), they are not directly applicable in evolutionary economic analysis. In this respect Nelson appears to agree with Peter Allen who (in ch. 1) clearly describes the dilemma of the study of complex systems. If we on the one hand take the basic structure of the system as given, this allows the construction of non-linear models whose dynamics can easily be

simulated. If we on the other hand recognise the obvious fact that the basic structure of a complex system is changeable, then the very possibility of modelling exercises becomes dubious. However, dynamic models which depict possible life-stories of systems with a changing structure are very enlightening. They demonstrate the importance of a continuing innovative activity which explores the ever-changing possibilities in the system. This evolutionary mode of managing uncertainty is further explored in the paper by Allen and Phang (ch. 10).

There is also another way in which Allen's approach to evolutionary complex systems may support Nelson. His models demonstrate that in very complex systems, cooperation and mutual learning are just as important as competition. The industry life cycle may be seen as reflecting such a process of self-organisation. However, the emergence and coevolution of different types of behaviour are not without problems. This is demonstrated by several papers on problems of standardisation and niche creation. The applied formalisms include stochastic cellular automata (ch. 5) and a master-equation approach to non-linear systems (ch. 7). To illustrate such approaches we shall, however, take the contribution by David and Foray (ch. 6) which starts from the observation that two standards may sometimes coexist, although one standard would be better seen from an overall point of view (e.g. the opposing American and European standards in electronic data interchange). The well-known 'Pólya urn models' are too primitive to explain this phenomenon. Instead the paper suggests new techniques (Markov random fields and 'percolation theory') which recognises the locally bounded positive feedbacks that stems from the firm's integration in a specific network. By recognising that a firm is placed in an economic space where a few firms are 'neighbours' while other firms are placed at larger distances, we can model how different standards 'percolate' through the system. The policy conclusion from the analysis is that to promote a unified standard, it is more effective to ease the transition of firms from one standard to another than to increase the number of links between firms. The opposite policy would create room for different standards or market niches.

Compared with Nelson's vision of a treatment of the complex evolutionary dynamics of industries and their supporting institutions, the studies of standards and niches are quite limited. This modesty is, however, reflecting the present state of art in evolutionary economics. Here we find a trade-off between more or less full-blown evolutionary models of simple phenomena and deterministic or verbal models which reflect complex stories. The latter part of the trade-off is chosen in the above-mentioned systems-dynamic models (chs. 8-9) as well as in the sociological contributions to the study of technical change (chs. 11-14). Through his insistence of the need to overcome the trade-off, Nelson suggests new standards of evolutionary economics which are not easy to follow.