Chapter XVI
Modeling Qualitative Development

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ABSTRACT

This chapter introduces agent-based modeling as a methodology to study qualitative change in economic systems. The need to focus on qualitative developments is derived from evolutionary economics, where the quantitative orientation of mainstream economic approaches is strongly criticized. It is shown that agent-based models can cope with the challenges of an evolutionary setting and fulfill the requirements of modeling qualitative change. In particular agent-based models allow a detailed representation of knowledge and the underlying dynamics, which are considered the major driving force of economic growth and development. The chapter also gives an illustrative example of an agent-based model of innovation processes organized in networks of actors.

INTRODUCTION

The tremendous development of and easy access to computational power within the last 30 years has led to the widespread use of numerical approaches in almost all scientific disciplines. While the engineering sciences focused on the applied use of simulation techniques from the very beginning, in the social sciences most of the early examples of numerical approaches were purely theoretical.

There are two reasons for this. First, since the middle of the 20th century, starting with economics, equilibrium-oriented analytical techniques flourished and were developed to a highly sophisticated level. This led to the widely shared view that within the elegant and formal framework of linear analysis offered by neoclassical economics, the social sciences could reach a level of accuracy not previously thought to be possible.

Second, within the same period, new phenomena of structural change exerted a strong influence on the social and economic realms. Despite the mainstream neoclassical successes in shifting the social sciences to a more mathematical foundation, an increasing dissatisfaction with this approach emerged. For example,

by the 1970s the benchmark of atomistic competition in neoclassical economics had already been replaced by the idea of monopolistic and oligopolistic structures. A similar development emphasizing positive feedback effects and increasing returns to scale caused by innovation led to the attribute "new" in macroeconomic growth theory in the 1980s.

In addition to these stepwise renewals of mainstream methodology, an increasingly larger group claimed that the general toolbox of economic theory, emphasizing rational behavior and equilibrium, is no longer suitable for the analysis of complex social and economic changes. In a speech at the International Conference on Complex Systems organized by the New England Complex Systems Institute in 2000, Kenneth Arrow stated that until the 1980s, the "sea of truth" in economics lay in simplicity, whereas since then it has become recognized that "the sea of truth lies in complexity." Adequate tools have to include the heterogeneous composition of agents (e.g., Saviotti, 1996), the possibility of multilevel feedback effects (e.g., Cantner & Pyka, 1998), and a realistic representation of dynamic processes in historical time (e.g., Arthur, 1988). These requirements are congruent with the possibilities offered by simulation approaches. It is not surprising that within economics the first numerical exercises were within evolutionary economics, where phenomena of qualitative change and development are at the front of the research program.

The first generation simulation models were highly stylized and did not focus on empirical phenomena. Instead, they were designed to analyze the logic of dynamic economic and social processes, exploring the possibilities of complex systems behavior. However, since the end of the 1990s, more and more specific simulation models aiming at empirically observed phenomena have been developed focusing on the interaction of heterogeneous actors responsible for qualitative change and development processes. Modelers have had to wrestle with an unavoidable trade-off between the demands of a general theoretical approach and the descriptive accuracy required to model a particular phenomenon. A new class of simulation models has shown to be well adapted to this challenge, basically by shifting outwards this trade-off (e.g., Gilbert & Troitzsch, 1999): so-called agent-based models are increasingly used for the modeling of socioeconomic developments.

This chapter deals with the changed requirements for modeling caused by the necessity to focus on qualitative developments which is generally highlighted within evolutionary economics and the possibilities given by agent-based models. The next section is concerned with the importance of an analysis of qualitative development, and it is shown that evolutionary economics is offering an adequate framework for this. A focus on agent-based-modeling as *the* tool that allows incorporating endogenously caused development processes follows, and the next section gives an illustrative example. Finally, the whole story is summarized.

QUALITATIVE CHANGE IN AN EVOLUTIONARY ECONOMICS PERSPECTIVE

When concerned with the examination of change and development within industrialized economies, economists usually focus on the movement of certain variables they consider a good description of the basic effects of economic growth and development. In mainstream economics, the phenomenon of economic development is, for example, empirically analyzed on the macro level as the improvement of total factor productivity in time, which lowers prices and leads to the growth of incomes. Accordingly, most often the GDP per capita is used as an indicator describing economic development