INTRODUCTION

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Economics and the social sciences are, in fact, the "hard" sciences, as Herbert Simon argued, because the complexity of the problems dealt with cannot simply be reduced to analytically solvable models or decomposed into separate subprocesses. Nevertheless, in recent years, the emerging interdisciplinary "sciences of complexity" have provided new methods and tools for tackling these problems, ranging from complex data analysis to sophisticated computer simulations. In particular, advanced methods developed in the natural sciences have recently been applied to social and economic problems.

The twenty-one chapters of this book reflect this modern development from various perspectives. They have been selected from previously published issues of *Advances in Complex Systems* (ACS),[a] "a quarterly journal that aims to provide a unique medium of communication for multidisciplinary approaches, either empirical or theoretical, to the study of complex systems." The eleven chapters that form the core of this selection come from a special issue on "Complex Dynamics in Economics" published in ACS as Volume 4, Number 1 (2001). They are supplemented by a selection of papers that extend the focus to the modeling of decision processes and the interaction in agent societies, topics of relevance for both economic and social systems. The current selection does of course not cover all papers with relations to economic or social systems published in ACS. For instance, papers dealing with rather formal methods or more general aspects of complexity in socio-economic systems have not been selected. The observant reader may also notice that for this book no papers from Volume 3 of ACS have been selected. This is due to the fact that these papers already appeared as a separate book containing the proceedings of the "2nd International Conference on Computer Simulations and the Social Sciences," held in Paris in September 2000.

With the current selection of contributions, this book presents an overview of advanced modeling approaches to complexity in economics and social systems, such as agent-based models, evolutionary game theory, reinforcement learning and neural network techniques, time series analysis, or non-equilibrium macroscopic dynamics.

[a]www.WorldSciNet.com/acs/acs.html

It is worth noticing that many of the authors have a background in the natural sciences, thus providing both fresh viewpoints and elaborated tools that are rather new for the study of socio-economic systems. In fact, the recent progress in the understanding of non-equilibrium phenomena in inanimated systems has also initiated a great deal of activity in analyzing, modeling and simulating "living" systems with methods from statistical physics. Already in the early 1970's physicists realized that these methods can help to understand social phenomena, such as opinion formation, migration and settlement formation. It is only very recently, however, that physicists have focussed their interdisciplinary interests on particular economic processes, such as trading, market dynamics or company growth.

Another interesting fact reflected in this book is the increasing role of computer simulations for tackling complexity in social and economic systems. Here, simulation is not meant to be just another tricky algorithm to solve — for example, difficult partial differential equations — it means that the interaction dynamics on the "microscopic" level is used to model the macroscopic system. The basic "entities" on the microlevel are, in general, denoted as agents, each already having their own complexity. A multi-agent system then may consist of a large number of agents, which can be also of different types. The agent power mainly results from their interaction in a larger environment. In particular, in fields such as economics, social science or population biology the major focus is rather on cooperative interaction instead of the autonomous actions of agents. Different examples of this can be found in this book.

Because of the broad range of applications, the chapters are grouped into five different sections: market dynamics; technological evolution; spatial dynamics and economic growth; decision processes; and agent societies.

In the first section, *market dynamics*, there is a particular focus on toy models to explain the dynamics of financial markets. This topic recently attracted considerable research interest within statistical physics. It is the availability of huge databases which makes this field so attractive and promising, since it allows one not only to perform empirical studies, but also to develop, calibrate and test models of economic dynamics. M. Marsili and D. Challet propose a model of agents trading in a toy market and investigate the influence of learning and the availability of public information on the performance. Other toy models of financial markets which also use the impact of physical models are investigated by D. Stauffer and by K. N. Ilinski, and A. S. Stepanenko. G. Zimmermann, R. Neuneier and R. Grothmann provide a dynamic approach to foreign exchange rates based on a neural network model of agent interaction. Artificial neural networks are also used by F. Castiglione to forecast financial time series, while A. Ilyinsky applies the spectral regularization method for trend identification in economic time series.

The second section, *technological evolution*, deals with the problem of how to describe the emergence and the spread of innovations and the discontinous dynamics of technological change. Here, approaches originally developed in the field of population biology and self-reproducing molecular systems have become very influential. W. Ebeling, Karmeshu and A. Scharnhorst show that technological evolution can be described by an optimization dynamics in a complex adaptive landscape. A. Arenas, A. Díaz-Guilera, X. Guardiola, M. Llas, G. Oron, C. J. Pérez and F. Vega-Redondo present a model of technological evolution that displays features of self-organized criticality. W. Kwasnicki investigates how bounded rational decisions of competing firms influence long-term industrial development and the emergence of innovations.

In the third section, *spatial dynamics and economic growth*, dynamic aspects of economic agglomeration and growth are investigated. With the rise of the "new economic geography" the spatial distribution of economically successful centers and the conditions for their coexistence and competition have become increasingly important. F. Schweitzer provides an agent-based model that shows the self-organized emergence of distinct economic centers that stably coexist at a critical distance while still following an internal eigendynamics. T. Brenner and N. Weigelt investigate the evolution of industrial clusters by simulating their spatial interaction and show the influence of technological spillovers on the spatial distribution of firms. J. Voit determines the distribution of size and growth rates of German business firms and shows correlations between the annual growth and business cycles, while M. Estola proposes a dynamic extension of the neoclassical theory of the firm.

The fourth section, *decision processes*, focuses on one of the basic and most important processes in economic and social systems. The interferences of individual decisions with a collective choice, the role of imitation in decisions, or the emergence of regularities in voting processes are interesting problems that are still under discussion. B. M. R. Stadler investigates a spatial voting model of multiple competing political parties, where parties are allowed to adapt their positions to get more votes. Popular album charts are analyzed by R. A. Bentley and H. D. G. Maschner, in order to reveal features of self-organized criticality, such as self-affinity and power law distributions. G. Weisbuch and G. Boudjema propose a model of social choice to explain the adoption of certain behavior in a heterogeneous agent community. D. Richards, B. D. McKay and W. A. Richards investigate the influence of mutual knowledge structures on the stable outcome of a collective choice process.

Finally, the last section, *agent societies*, pays closer attention to the interaction dynamics in artificial societies. Inspired by models of evolutionary game theory, V. Kvasnicka and J. Pospichal investigate the possibility of cooperation in hererogeneous agent societies consisting of different "ethnic" groups, while J.-L. Dessalles shows how an altruistic behavior of agents may emerge in the context of inter-group competition. D. H. Wolpert and K. Tumer demonstrate how to design large multi-agent systems to meet a pre-specified goal when each agent uses reinforcement learning to choose its action. H. Ishii, N. Wang and S. E. Page propose a model of heterogeneous purposive agents that organize on a sand pile and investigate under which circumstances self-organized critical states may occur.

With their various modeling approaches, the different chapters of this book jointly demonstrate a shift of perspective in economics and the social sciences that is allowing a new outlook in this field to emerge. It is the hope of the editor that this should stimulate further the discussion on socio-economic issues between scientists from various disciplines, for the mutual enhancement of ideas and approaches and for the benefit of the research in complex systems.