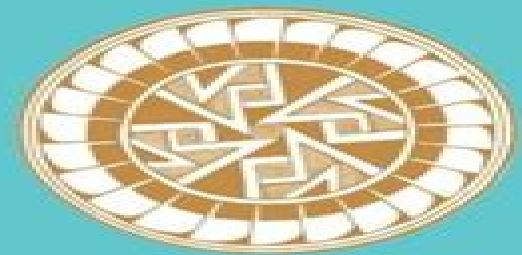


# NONLINEAR DYNAMICS, MATHEMATICAL BIOLOGY, AND SOCIAL SCIENCE

Joshua M. Epstein



A LECTURE NOTES VOLUME IN THE

SANTA FE INSTITUTE STUDIES IN THE SCIENCES OF COMPLEXITY

**ABP**

# Nonlinear Dynamics Mathematical Biology And Social Science

**Marc Mangel**



## **Nonlinear Dynamics Mathematical Biology And Social Science:**

*Nonlinear Dynamics, Mathematical Biology, And Social Science* Joshua M. Epstein, 2018-03-08 This book is based on a series of lectures on mathematical biology the essential dynamics of complex and crucially important social systems and the unifying power of mathematics and nonlinear dynamical systems theory [Nonlinear Dynamics in Economics and Social Sciences](#) Franco Gori, Lucio Geronazzo, Marcello Galeotti, 2012-12-06 This volume constitutes the Proceedings of the Nonlinear Dynamics in Economics and Social Sciences Meeting held at the Certosa di Pontignano Siena on May 27 30 1991 The Meeting was organized by the National Group Modelli Nonlineari in Economia e Dinamiche Complesse of the Italian Ministry of University and Scientific Research M U R S T The aim of the Conference which followed a previous analogous initiative taking place in the very same Certosa on January 1988 was the one of offering a come together opportunity to economists interested in a new mathematical approach to the modelling of economical processes through the use of more advanced analytical techniques and mathematicians acting in the field of global dynamical systems theory and applications A basic underlying idea drove the organizers the necessity of focusing on the use that recent methods and results as those commonly referred to the overpopularized label of Chaotic Dynamics did find in the social sciences domain and thus to check their actual relevance in the research program of modelling economic phenomena in order to individuate and stress promising perspectives as well as to curb excessive hopes and criticize not infrequent cases where research reduces to mechanical ad hoc applications of a la mode techniques In a word we felt the need of looking about the state of the arts in non linear systems theory applications to economics and social processes hence the title of the workshop and the volume

**Generative Social Science** Joshua M. Epstein, 2012-01-02 Agent based computational modeling is changing the face of social science In *Generative Social Science* Joshua Epstein argues that this powerful novel technique permits the social sciences to meet a fundamentally new standard of explanation in which one grows the phenomenon of interest in an artificial society of interacting agents heterogeneous boundedly rational actors represented as mathematical or software objects After elaborating this notion of generative explanation in a pair of overarching foundational chapters Epstein illustrates it with examples chosen from such far flung fields as archaeology civil conflict the evolution of norms epidemiology retirement economics spatial games and organizational adaptation In elegant chapter preludes he explains how these widely diverse modeling studies support his sweeping case for generative explanation This book represents a powerful consolidation of Epstein's interdisciplinary research activities in the decade since the publication of his and Robert Axtell's landmark volume *Growing Artificial Societies* Beautifully illustrated *Generative Social Science* includes a CD that contains animated movies of core model runs and programs allowing users to easily change assumptions and explore models making it an invaluable text for courses in modeling at all levels **Nonlinear Dynamics in Economics, Finance and the Social Sciences** Gian Italo Bischi, Carl Chiarella, Laura Gardini, 2009-12-15 Over the last two decades there has been a great deal of research into

nonlinear dynamic models in economics finance and the social sciences This book contains twenty papers that range over very recent applications in these areas Topics covered include structural change and economic growth disequilibrium dynamics and economic policy as well as models with boundedly rational agents The book illustrates some of the most recent research tools in this area and will be of interest to economists working in economic dynamics and to mathematicians interested in seeing ideas from nonlinear dynamics and complexity theory applied to the economic sciences The Evolution of Intelligent Systems K. Richardson, 2010-10-20 How could something as seemingly transcendental as the human mind have arisen from far simpler material beginnings This book provides a comprehensive overview of evolution from pre life and early life forms through increasing complexity to advanced cognitive systems using a new framework based on dynamic systems theory **Collectives and the Design of Complex Systems** Kagan Tumer, David Wolpert, 2012-12-06 Many complex systems found in nature can be viewed as function optimizers In particular they can be viewed as such optimizers of functions in extremely high dimensional spaces Given the difficulty of performing such high dimensional optimization with modern computers there has been a lot of exploration of computational algorithms that try to emulate those naturally occurring function optimizers Examples include simulated annealing SA 15 18 genetic algorithms GAs and evolutionary computation 2 3 9 11 20 22 24 28 The ultimate goal of this work is an algorithm that can for any provided high dimensional function come close to extremizing that function Particularly desirable would be such an algorithm that works in an adaptive and robust manner without any explicit knowledge of the form of the function being optimized In particular such an algorithm could be used for distributed adaptive control one of the most important tasks engineers will face in the future when the systems they design will be massively distributed and horribly messy congeries of computational systems

**Applications of Chaos and Nonlinear Dynamics in Science and Engineering - Vol. 3** Santo Banerjee, Lamberto Rondoni, 2013-06-12 Chaos and nonlinear dynamics initially developed as a new emergent field with its foundation in physics and applied mathematics The highly generic interdisciplinary quality of the insights gained in the last few decades has spawned myriad applications in almost all branches of science and technology and even well beyond Wherever quantitative modeling and analysis of complex nonlinear phenomena is required chaos theory and its methods can play a key role This third volume concentrates on reviewing further relevant contemporary applications of chaotic nonlinear systems as they apply to the various cutting edge branches of engineering This encompasses but is not limited to topics such fluctuation relations and chaotic dynamics in physics fractals and their applications in epileptic seizures as well as chaos synchronization Featuring contributions from active and leading research groups this collection is ideal both as a reference and as a recipe book full of tried and tested successful engineering applications **Structural Equation Modeling** Bruce H. Pugesek, Adrian Tomer, Alexander von Eye, 2003-01-23 Structural equation modelling SEM is a technique that is used to estimate analyse and test models that specify relationships among variables The ability to conduct such analyses is essential

for many problems in ecology and evolutionary biology This book begins by explaining the theory behind the statistical methodology including chapters on conceptual issues the implementation of an SEM study and the history of the development of SEM The second section provides examples of analyses on biological data including multi group models means models P technique and time series The final section of the book deals with computer applications and contrasts three popular SEM software packages Aimed specifically at biological researchers and graduate students this book will serve as valuable resource for both learning and teaching the SEM methodology Moreover data sets and programs that are presented in the book can also be downloaded from a website to assist the learning process

**Pattern Formation In The Physical And Biological Sciences** H. Frederick Nijhout, 2018-02-19 This Lecture Notes Volume represents the first time any of the

summer school lectures have been collected and published on a discrete subject rather than grouping all of a season's lectures together This volume provides a broad survey of current thought on the problem of pattern formation Spanning six years of summer school lectures it includes articles which examine the origin and evolution of spatial patterns in physio chemical and biological systems from a great diversity of theoretical and mechanistic perspectives In addition most of these pieces have been updated by their authors and three articles never previously published have been added

**Fighting The Virus: How Disease Modeling Can Enhance Cybersecurity** Marc Mangel, 2025-05-27 Many of the words used to describe disease infection transmission virus are also used to characterize cyber security for example a computer is infected by a virus that can be transmitted to other current uninfected computers This correspondence is much more than a convenient metaphor and the aim of this book is to show how the models developed to understand the dynamics of infection recovery and possible reinfection in disease can be applied to understand attack compromise and recovery of components of a cyber system and how such attacks affect performance of the cyber system or its dependent enabled physical system

**The Economy As An Evolving Complex System II** W. Brian Arthur, Steven N Durlauf, David Lane, 2018-05-04 A new view of the economy as an evolving complex system has been pioneered at the Santa Fe Institute over the last ten years This volume is a collection of articles that shape and define this view a view of the economy as emerging from the interactions of individual agents whose behavior constantly evolves whose strategies and actions are always adapting The traditional framework in economics portrays activity within an equilibrium steady state The interacting agents in the economy are typically homogenous solve well defined problems using perfect rationality and act within given legal and social structures The complexity approach by contrast sees economic activity as continually changing continually in process The interacting agents are typically heterogeneous they must cognitively interpret the problems they face and together they create the structures markets legal and social institutions price patterns expectations to which they individually react Such structures may never settle down Agents may forever adapt and explore and evolve their behaviors within structures that continually emerge and change and disappear structures these behaviors co create This complexity approach does not replace the equilibrium one it

complements it The papers here collected originated at a recent conference at the Santa Fe Institute which was called to follow up the well known 1987 SFI conference organized by Philip Anderson Kenneth Arrow and David Pines They survey the new study of complexity and the economy They apply this approach to real economic problems and they show the extent to which the initial vision of the 1987 conference has come to fruition **Theoretical Immunology, Part Two** Alan S.

Perelson,2018-02-19 Assuming that the complex phenomena underlying the operation of the immune system may be better understood through the collaborative efforts of theorists and experimentalists viewing the same phenomena in different ways the Santa Fe Institute and the Theoretical Division of Los Alamos National Laboratory cosponsored a workshop entitled Theoretical Immunology The workshop focused on themes spanning the field of immunology with emphasis on areas where the theorists have made the most progress This book covers the discussions at that workshop on the topics of immune surveillance mathematical models of HIV infection complexities of antigen antibody systems immune suppression and tolerance and idiotypic networks In each of these areas there is reason to believe that advances can be made either through interactions among experimentalists and theorists or through the critical look experimentalists and theorists will bring to bear upon one another's work **The Economy As An Evolving Complex System** Philip W. Anderson,2018-03-12 This

book proceeds from a meeting at the Santa Fe Institute where economists and physical and biological scientists came together to discuss a conceptual framework incorporating a more appropriate mathematics with a greatly strengthened capacity to deal simultaneously with multiple variables nonlinearity incomplete information and dynamical processes *The Mind, The Brain And Complex Adaptive Systems* Harold J. Morowitz,2018-03-08 Based upon a conference held in May 1993 this book discusses the intersection of neurobiology cognitive psychology and computational approaches to cognition

Models, Simulations, and Representations Paul Humphreys,Cyrille Imbert,2013-03-01 Although scientific models and simulations differ in numerous ways they are similar in so far as they are posing essentially philosophical problems about the nature of representation This collection is designed to bring together some of the best work on the nature of representation being done by both established senior philosophers of science and younger researchers Most of the pieces while appealing to existing traditions of scientific representation explore new types of questions such as how understanding can be developed within computational science how the format of representations matters for their use be it for the purpose of research or education how the concepts of emergence and supervenience can be further analyzed by taking into account computational science or how the emphasis upon tractability a particularly important issue in computational science sheds new light on the philosophical analysis of scientific reasoning *Natural Security* Dr. Raphael Sagarin,Terrence Taylor,2008-02-01 Arms races among invertebrates intelligence gathering by the immune system and alarm calls by marmots are but a few of nature's security strategies that have been tested and modified over billions of years This provocative book applies lessons from nature to our own toughest security problems from global terrorism to the rise of infectious disease to natural disasters

Written by a truly multidisciplinary group including paleobiologists anthropologists psychologists ecologists and national security experts it considers how models and ideas from evolutionary biology can improve national security strategies ranging from risk assessment security analysis and public policy to long term strategic goals *State Learning and International Change* Andrew Farkas,2010-08-27 Explaining change in the behavior of states and other international actors is at the core of the study of international relations The proficiency with which states respond to changes in the international environment has important consequences for world peace and the world economy as well as domestic politics and well being One way to understand changes in behavior is to consider whether and how states learn Key to understanding this is considering how the groups responsible for making decisions learn and make decisions Andrew Farkas presents an evolutionary theory of how states adjust their foreign policies in response to international changes Employing both formal models and computer simulations Farkas explores the relative efficacy of a wide range of alternative strategies for dealing with unanticipated changes in the international environment and goes a long way toward reconciling the success of rational choice modeling with criticism from psychological studies of decision making Farkas looks at the way small groups charged with making policy decisions work He explicitly models the process of search and policy selection He demonstrates how a group of disparate individuals can act as if it were a unitary rational actor and provides the first endogenous account of when and why groups curtail their search for satisfactory policies Farkas uses the general model to explore the effects of different institutional designs on the decisionmaking process This book will be of interest to scholars of international relations learning models and group processes Andrew Farkas is Assistant Professor of Political Science Rutgers University **The Origin of Wealth** Eric D. Beinhocker,2006 Beinhocker has written this work in order to introduce a broad audience to what he believes is a revolutionary new paradigm in economics and its implications for our understanding of the creation of wealth He describes how the growing field of complexity theory allows for evolutionary understanding of wealth creation in which business designs co evolve with the evolution of technologies and organizational innovations In addition to giving his audience a tour of this field of complexity economics he discusses its implications for real world issues of business

**Toward a Containment Strategy for Smallpox Bioterror** Joshua M. Epstein,Derek A. T. Cummings,Shubha Chakravarty,2004-04-22 In the United States routine smallpox vaccination ended in 1972 The level of immunity remaining in the U S population is uncertain but is generally assumed to be quite low Smallpox is a deadly and infectious pathogen with a fatality rate of 30 percent If smallpox were successfully deployed as an agent of bioterrorism today the public health and economic consequences could be devastating Toward a Containment Strategy for Smallpox Bioterror describes the scientific results and policy implications of a simulation of a smallpox epidemic in a two town county The model was developed by an interdisciplinary team from the Johns Hopkins Bloomberg School of Public Health and the Brookings Institution Center on Social and Economic Dynamics employing agent based and other advanced computational techniques Such models are

playing a critical role in the crafting of a national strategy for the containment of smallpox by providing public health policymakers with a variety of novel and feasible approaches to vaccination and isolation under different circumstances The extension of these techniques to the containment of emerging pathogens such as SARS is discussed About the Authors Joshua M Epstein and Shubha Chakravarty are with the Brookings Institution Derek A T Cummings Ramesh M Singha and Donald S Burke are with the Johns Hopkins Bloomberg School of Public Health

### **Agent-Based Models of Geographical Systems**

Alison J. Heppenstall, Andrew T. Crooks, Linda M. See, Michael Batty, 2011-11-24 This unique book brings together a comprehensive set of papers on the background theory technical issues and applications of agent based modelling ABM within geographical systems This collection of papers is an invaluable reference point for the experienced agent based modeller as well those new to the area Specific geographical issues such as handling scale and space are dealt with as well as practical advice from leading experts about designing and creating ABMs handling complexity visualising and validating model outputs With contributions from many of the world s leading research institutions the latest applied research micro and macro applications from around the globe exemplify what can be achieved in geographical context This book is relevant to researchers postgraduate and advanced undergraduate students and professionals in the areas of quantitative geography spatial analysis spatial modelling social simulation modelling and geographical information sciences



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